CERIAS Tech Report 2005-60

DIGITAL IDENTITY MANAGEMENT DOMAIN FOR ONTOLOGICAL SEMANTICS: DOMAIN ACQUISITION METHODOLOGY AND PRACTICE

by Evguenia A. Malaia

Center for Education and Research in
Information Assurance and Security,
Purdue University, West Lafayette, IN 47907-2086

DIGITAL IDENTITY MANAGEMENT DOMAIN FOR ONTOLOGICAL SEMANTICS: DOMAIN ACQUISITION METHODOLOGY AND PRACTICE

A Dissertation
Submitted to the Faculty
of
Purdue University
by
Evguenia A. Malaia

In Partial Fulfillment of the
Requirements for the Degree
of
Doctor of Philosophy

August 2005

□□□.□

ACKNOWLEDGEMENTS

I would like to thank, most of all, my Father, to whom this dissertation is dedicated, and my Mother, for their constant support and encouragement throughout my studies and academic career.

Many thanks are due to my mentor and advisor, Dr. Victor Raskin, for his invaluable advice and constant availability for consultation and support all through my studies and research.

A great inspiration to me was Dr. Ronnie Wilbur, who to me represents the very ideal of a woman in research sciences. I owe much gratitude to her for her time, patience, and support during my studies at Purdue.

The ontological semantics workgroup, and event structure reading group have contributed enormously to the developments of the project, and I am very grateful to the student participants of both.

Much credit is due to Josh, who has helped me immensely overall – both with the code for lexicon filtering, and with his encouragement during the entire project.

The research was supported by ITR initiative funded by NSF grant 0428554.

TABLE OF CONTENTS

Page

LIST OF TABLES

ABSTRACT

Malaia, Evguenia Ph.D., Purdue University, August 2005. Digital Identity Management Domain for Ontological Semantics: Domain Acquisition Methodology and Practice.
Major Professor: Dr. Victor Raskin.

This work focuses on ontological efforts to support information security applications – more specifically, engineering natural language processing technology – in the domain of Digital Identity Management (DIM). The present paper deals with the methodology and practice in domain acquisition for two of the static knowledge sources, the ontology and the lexicon, including:

1) Delimitation of the expanding digital identity management textual corpus with volatile vocabulary;

2) Extraction of lexical items pertaining to the domain;

3) Building ontological support for lexical items; introduction of necessary attributes and relations.

I propose a domain-specific topic-source variability matrix, which can be used as an external validity source for ontological description of a "storming" domain. I have also divided sources into non-profits, academic research, industry groups or companies, US government agencies and international organizations. For the corpus, I have taken texts from each topic-source combination.

Based on the corpus, I have made the decision to use a two-pronged approach to lexical and ontological domain acquisition: concept-based initial acquisition (including adding new properties) followed by corpus-based acquisition.

The described process enables the acquirers to ensure external validity and internal consistency of the ontology and the lexicon, and aids in faster saturation of the lexicon of a particular domain. While the topic-source subdivision is necessarily domain-

specific, the two-prong methodology is applicable to ontological and lexical acquisition for any domain.

The rest of the work is devoted to the scripts of lexical and ontological items acquired for the domain, and to the elaboration on the choices and decisions in lexical and ontological acquisition.

CHAPTER I.
OVERARCHING FRAMEWORK: ONTOLOGICAL SEMANTICS

As the world becomes more and more connected through a global information infrastructure, many activities – from shopping and entertainment to business transactions and scientific collaboration – transfer into the domain of remote goods and services, where the participating parties interact with little or no knowledge about each other. Social structures, moving online, bring with them the need for trust negotiations and identity establishment, and with a different approach than in real world.

Digital identity is a representation of information known about an agent in an online interaction. Identity can be used for different purposes: to establish permissions (as in logging on to business intranets), to claim a certain identity (online role-playing games and chat rooms); one physical person can have multiple online identities and vise versa (a "company representative" in a chat room can be represented in reality by several people). A combination of identity properties (such as birth date, pseudonym, credit card number, SSN, etc.) can be used to create a temporary identity for a specific purpose. The Proof-of-concept identity-management frameworks, such as Microsoft .NET passport and PGP signatures, still need much improvement in terms of their social flexibility and cross-domain applicability.

Because digital identities have such varied uses and meanings, and because the social implications of digital identity management policies are far-reaching into domains of free speech, privacy and accountability online, it is necessary to develop a universal vocabulary for digital identity framework development and policy language. I propose the framework of ontological semantic processing and text meaning representation as a possible solution for this key concern.

The present work scopes over several different problems. The initial goal of the work was to expand the static resources of the Purdue ontological semantics project to the domain of Digital Identity Management, augmenting and modifying the lexical and ontological databases. For that, I have developed a two-pronged approach to corpus processing, in order to account for the quality and quantity of domain acquisition, and ensure its compatibility with existing resources and internal consistency. For the corpus itself, I have adopted a "topic-source" matrix, with the texts on either one of several dominant topics in the domain originating from multiple sources, and representing diverging viewpoints on the subject.

Besides expanding the lexicon and the ontology, I have offered a way to account for event structure by means of static resources of ontological semantics. This came out of my initial desire to account for telicity (with further intention of tracking events in natural language texts); at some point it became apparent, that while theoretical ramifications of introducing the concept of telicity into an ontological semantic system would entail dynamic processing at the stage of Text Meaning Representation, the event structure of the verb can and should be already accounted for in the static resources. This is a novel and significant proposal, which is elaborated in detail in the following chapters. I have also accomplished the latter for the domain of Digital Identity Management, and would suggest adopting the approach for other domains.

1.1. Ontological semantics approach to Natural Language Processing

In this chapter, I present the background on the overarching framework of the present paper – ontological semantics, as developed by Raskin and Nirenburg (2004). I compare it to other semantic approaches to describing meaning in language, establish the main premises of the theory (which will have a bearing on the way I make choices in representations of the domain of Digital Identity Management in Chapter 3) and elaborate on the architecture of ontological semantics, static and dynamics resources it employs, as well as introduce KBAE-avoider – a software application instrumental to acquisition of ontological concepts.

1.2. Overview of the ontological semantics approach.

The goal of ontological semantics approach to Natural Language Processing is to represent the meaning in natural languages in a way that is possible to process by computer applications. Central to this goal is the employment of the ontology, or a constructed model of the world, as a language-independent static resource, which is used to construct text meaning representation of the processed texts.

An implemented system of ontological semantics natural language processing employs the following resources:

1) The ontology, which is language-independent;
2) Lexicons of the languages that the system has to be working with (which are connected to the ontology);
3) Fact database and onomasticon, or depository of proper names, which contain instantiations of ontological concepts;
4) Text processing modules, most prominently a semantics text analyzer (which is intended for constructing text meaning representations from natural language texts) and semantic text generator (intended for a reverse process, constructing natural language texts on the basis of text meaning representations).

The first NLP projects based on Ontological Semantics were constructed starting in the 1980s by Raskin, Nirenburg and colleagues (Nirenburg et al. 1986, Goodman and Nirenburg 1991, Monarch et al. 1989, Meyer at al. 1990, Farwell et al. 1994, Beale et al. 1997, Oflazer and Nirenburg 1999); their applications included knowledge-based machine translation, semantic analysis, information extraction, and question answering, and were specialized for work with several languages: English, Spanish, and Japanese. The current implementation, the Legacy Ontology (2002-present), for which the Digital Identity Management domain is covered in the present paper, is being expanded with a focus on static resources (ontology and English lexicon) to allow for applications to texts in specific domains.

Overall, ontological semantics is an approach to developing an exhaustive and detailed theory of meaning that is sufficient for natural language processing by computers. Thus, its goals include ecological, syntactic, morphological, semantic and

pragmatic processing of texts (semantic being the central one leading to creation of text meaning representation), and further manipulation of the text meaning representation for various purposes. The approach is theory-based, even if the applications developed on the basis of ontological semantics are goal-driven. Ontological semantics itself, however, is first of all a linguistic theory of meaning.

1.3. Specifics of Ontological Semantics approach compared to other semantics theories

It is important to note several differences between ontological semantics and other semantic theories in linguistics.

First of all, the coverage of natural language phenomena that ontological semantics strives to achieve includes lexical and sentential semantics, pragmatics and discourse analysis. This is more than a single theory of meaning attempted before.

Secondly, the validity criterion for ontological semantics is not its explanatory adequacy, which is an understood test for other linguistic theories, but the success of its applications. In natural language processing, it is not sufficient to describe the general phenomena, but it is necessary to exhaustively catalogue all phenomena present in the language, in order to be able to process it. Only then it becomes possible to employ the full power of knowledge-based semantics for reasoning applications and other complex tasks.

Third, being a language-independent theory, ontological semantics intends to represent world-knowledge universals in its ontology. In its architecture, ontological semantics approach to natural language processing presumes that only the lexicon and the dynamic knowledge sources (ecological, morphological, syntactical processors) need to be adjusted in order to process a text in a particular language.

1.4. How is meaning represented in Ontological Semantics?

1.4.1. Metaphor of intelligent agent

Ontological semantics as a computational model of natural language processing operates on the metaphor of an intelligent agent; i.e., what an ontological semantics

system needs to do is what an intelligent agent (a self-interested agent with goals and plans for carrying out actions, and capable of natural language discourse) does in communication. We can view the intelligent agent as acting in two different communicative roles: as a discourse producer, and as a discourse consumer. In both cases, the agent operates based on some knowledge of the world (world-view model, or ontology), which influences its language processing capabilities. The world-view model is complemented with a fact database, containing instances of events and objects, which is continually supplemented by facts arising in discourse.

These language-independent knowledge sources of an intelligent agent are complemented by linguistic ones, namely:

- phonological, prosodic (segmental and supra-segmental), morphological, syntactic, and "ecological" (punctuation, format for dates, names, etc.) rules of a particular language (as the ontology currently deals predominantly with written texts, phonological and prosodic rules are not mentioned any further);
- semantic interpretation of the lexicon, based on its relation to the world-view model of the particular agent (it is not necessary or presumed that the ontologies of different agents is the same);
- discourse-related styles and modes of interaction, as they relate to the situation and the lexical part of meaning representation.

These language-independent and language-dependent knowledge sources are complemented by the goals that the discourse producer sets for communication. The goals are always aimed at discourse consumer, and can vary significantly: from the goal of conveying information (i.e. adding to discourse consumer's fact database), to the goal of modifying the discourse consumer's action plan (e.g. by issuing a command), to the goal of modifying the consumer's "model" of the producer (which can be done accidentally through conveying novel information about the producer, or intentionally by expressing producer's attitude toward a fact.).

Thus, in constructing discourse, the discourse producer generates the text meaning it intends to convey in accordance with discourse goals, and uses lexical connections and syntactic, morphological and ecological rules of the language in order to construct a

message. As shown below, the "discourse producer" metaphor is the basis for text generator module of the architecture of ontological semantics application.

Discourse consumer, on the other hand, carries out the process of text meaning extraction from a natural language text by means of performing similar tasks, in an inverse order:

- analyzing the syntactic, morphological and ecological dependencies in the message;
- disambiguating the use of lexical constituents on the basis of selectional restrictions present in the lexicon and the ontology, and resolving sentential and textual co-references (deictic and elliptical constructions);
- constructing a text meaning representation, using its own ontology;
- finally, reasoning as to the discourse producer's goals in constructing the message under consideration.

1.4.2. Theoretical premises of ontological semantics

Nirenburg and Raskin (2004: 78-81) posit the following premises to the study of meaning in ontological semantics:

1) "The meaning should be studied and represented".

This is the fundamental premise of the theory of ontological semantics, as well as its goal. It also follows that studying the syntactic component of language is not sufficient for meaning representation, and that lexical meaning is necessarily tied to world knowledge.

2) "The need for ontology"

In other words, the meaning of lexical units is necessarily tied to world knowledge. Herein lies the most important difference of ontological semantics from formal semantics, which uses one's ability to determine "truth value" of a statement as a test for one's understanding of its meaning. In Ontological Semantics, linguistic meaning is not tied to reality, but to the world-view of an agent that uses natural language. Meaning of a sentence in ontological semantics is constructed by creating its text meaning representation, which is based on the predicate (or predicates, as most sentences

have covert secondary predication, represented, e.g., by adjectives in English), anchored to an ontological EVENT.

3) "Meaning should be machine tractable"

If it is possible to represent the meaning of natural language texts (premise 1), then it should be possible to manipulate it using computer programs. This is, in a sense, the most important premise of the theory, since it closely matches its applications and reflects its goal. Ontological semantics aims at modeling human ability for text and discourse processing, including discourse planning, pragmatic extrapolations, logical reasoning, etc.. However, instead of trying to model human cognitive process directly, it subscribes to the "weak AI" approach, modeling instead the result of human ability to process natural language.

4) "Qualified compositionality".

Ontological semantics accepts the premise of compositionality, stating that the meaning of the whole (the sentence) is determined by the meaning of its parts (the lexical items). However, this premise is accepted with exceptions, most notable ones being phrasal units – thus, whenever necessary, the items in the lexicon are multi-word-expressions, according to the premise of qualified compositionality. The subject is further explored in Televnaja (2004) on the material of English phrasal verb and their treatment in ontological semantics.

5) "Justification".

The justification premise of ontological semantics states that in the process of developing ontological semantics applications and acquiring ontology and lexicon the only driving force is the possibility of exhaustively describing the phenomena of natural language. In other words, there is no preferred theory behind either way building the ontology or the lexicon, the ultimate test of either one being internal consistency and successful application. Nirenburg and Raskin (20040) note: "we see it [justification] as a process of reviewing the alternatives for a decision and making explicit the reasons for the choice of particular purview, or premises and of the specific statements in the body."

The premise as important for domain coverage as for the theory in general, and Chapter 3 (and partially Chapter 2) of the present work is devoted to justification of the ontological and lexical domain description laid out in Chapter 4.

1.4.3. Two kinds of meaning in ontological semantics

Ontological semantics aims to account for the meaning of and natural language text. However, meaning in language has two aspects to it: the static meaning, preserved in the lexicon of a language, and the dynamic meaning, arising in sentences (propositional meaning), texts, and discourse. Ontological semantics accounts for both aspects of meaning. The static meaning is represented through connecting the lexical items in the lexicon to the ontology and further specifying each lexical item using ontological concepts. The dynamics meaning is constructed through processing natural language texts and building text meaning representation using processing components of ontological semantics (text analyzer and text generator). The theory of ontological semantics also accounts for how to construct dynamic meaning of a text from static meanings of lexical items composing that text, while optimally preserving the information that a human would be able to derive from it.

1.4.4. Knowledge acquisition in ontological semantics

Knowledge acquisition process for ontological semantics necessarily proceeds in two directions: acquisition for static and for dynamic knowledge sources. At the present moment, both static knowledge sources, the ontology and the lexicon are built by humans, and this is what Chapter 4 of the present paper will lay out – the ontology and lexicon for a particular domain. Dynamic knowledge sources – the text analyzer and text generator – use static knowledge sources in order to construct text meaning representation. The remainder of this chapter is devoted to the resources (static and dynamic) of ontological semantics.

1.5. The resources of ontological semantics

The resources of ontological semantics are subdivided into static and dynamics. The static ones are:

1) the ontology proper, which is language-independent;
2) the lexicon, or, with the development of the resource, a lexicon for each language for which the system is implemented;
3) the onomasticon, or depository of proper names;
4) the fact database, also language independent.

The dynamic resources include:

1) text analyzer, responsible for converting a text into text meaning representation using the static resources of the ontology;
2) text generator, with the task of generating a text from text meaning representation;
3) world knowledge and reasoning module.

Since the current paper deals primarily with construction of static knowledge sources, I will describe the dynamics ones generally and devote more attention to the static sources at the end of the chapter.

1.5.1. Text Analyzer

The main task of a text analyzer is to define main meaning of a proposition (or several propositions) in the sentence, resolve lexical ambiguities, and resolve the text into text meaning representation. Thus, the necessary parts of the analyzer would include:

1) a tokenizer that breaks the text into processable strings and deals with all special characters, numbers, symbols, punctuation, and everything that falls under the "ecological" issues;
2) a morphological analyzer, dealing with grammatical morphemes and establishing their meaning to be further used in text meaning representation;
3) a semantic analyzer, which carries out the tasks of establishing propositional dependencies (using the syntactic information built into lexical item in the lexicon and semantic constraints), and also deals with the pragmatic aspects of the text: style, speaker attitude and goals, etc.

4) a module to construct text meaning representation using the information from the previous three modules.

Text processing proceeds as follows: at first, a tokenizer identifies "tokens" for further processing; this involves a number of auxiliary tasks, using language-specific ecological constraints: for example, a period after Ms. does not (in English) denote the end of the sentence. Punctuation (e.g. inverted question marks before questions in Spanish), processing of dates (e.g. US format dd-mm-yy vs. European mm-dd-yy, or more elaborate spelling-out of the name of the month, etc.), numbering (e.g. usage of commas vs. periods to denote the decimal part of the number) – all of this non-lexical material needs to be represented in standard textual form to be used further.

While ontological semantics, as an approach, is reliant (and interested in) mostly the meaning of natural texts, it is impossible and undesirable to dispose of dealing with non-semantic (morphological or syntactical) processing entirely. The output from the tokenizer, at first, and morphological analyzer, used at a later stage, enriches the semantic text meaning representation.

Further, a language-specific morphological analyzer reduces all the paradigmatic instances of one word to its main lexical entry: *worked* → *work*. (At this stage, a TMR can began formulating, since morphology is responsible for grammatical meanings, which are easily categorized. Also, depending on the richness of morphology in a particular language it can be necessary to allow morphological items modify property slots of the ontological concepts in the TMR.) It is possible for the morphological analyzer to render several possible variants of the original string. For instance, in English, -s and the end of the word can be a morpheme denoting plural noun; or a verb in the present tense third person singular; or it can be a part of the word itself - "yes". The ambiguity produced by the morphological analyzer can be reduced by lexical lookup at a later stage.

Once the tokens for processing are established, a parser begins to turn the text into TMR, or computational representation of the text's meaning. Words are looked up in the lexicon and onomasticon, or, in case some concept is referenced indirectly, in the fact database. The parsing is a recursive process: in cases, where it is impossible to find a

matching lexical entry, the restrictions on the conceptual connections are relaxed (the possibility for a need to use a word metaphorically is taken care of by a RELAXABLE-TO operator), and the process is then repeated. The text meaning representation, the output of the parser, is a computational description of the text's overall semantics. Once the TMR for the document is acquired, it can be used for a number of purposes – from translation and information extraction to semantic watermarking and data mining.

Syntactic analysis is incorporated into ontological semantics in order to determine clause-level dependency structures in the input document. Especially for predicates, the syntactic valency needs to be established - subjects, direct and indirect objects, adjuncts. Syntactic analysis is supported through syntactic structure specifications in the lexicon, as well as language-specific syntactic grammar in the syntactic processor (e.g. for English, strict word order is useful for syntactic processing). Depending on the language, morphological and syntactical processing are more or less useful and co-exist, as it were, in complementary distribution: the richer the morphology, the less reliable the syntactic structure, and vice versa.

The semantic analysis of the input text in ontological semantics proceeds using the input from both morphological and syntactic analyzers through building basic semantic dependencies in the text. The first step is to establish the propositional structure of the TMR through defining the predicate and filling out its valences through matching case role inventories and selectional restrictions on the candidate fillers from the sentence. When the procedure returns more than one possible TMR, the analysis goes back to selectional restrictions, specializing them (using the property slots in the ontology, which did not directly restrict the fillers previously). If there were not enough candidates to fill the propositional structure, the systems either needs to process ellipsis, filling out the candidates from the previous propositional structures, or to relax selectional restrictions, for example, in order to process metaphor.

In fact, in the above-mentioned system, the ecological, morphological, and syntactic analyses are really only the necessary pre-processing. Processing itself opens with semantic analysis of the text after the pre-processing has been performed. The emphasis in semantic analysis is on using the semantic descriptions provided by the

lexicon and the ontology in order to clarify syntactic and propositional structure of the text. Once semantic dependencies between text elements are established, they are mapped onto a text meaning representation template, which is the representation of the meaning of the sentence on the basis of the ontology.

Predicates, being in the center of propositional structure, are the elements around which the rest of the proposition (the words which do not form an event of their own, e.g. aspectual “start”, “finish”, modal “can”, “try”) is formed. This distinction does not quite correlate with part of speech differentiation; in fact, as shown above, not every verb forms an event of its own; events can also be formed by adjectives. Consider the sentence “This virus made my computer unusable”. The sentence, although containing one verb, includes two independent propositions: a virus affecting the computer and the computer not fit for use as a result of it.

Ontological semantics provides a flexible mechanism for constructing the proposition in case if there is a difficulty in matching the semantic dependencies in the text. Both lexical and ontological items use a three-tier selectional restriction structure for their semantic connections. Information on possible loosening of selectional restrictions is expressed through the facets DEFAULT, SEM, RELAXABLE-TO. DEFAULT states preferential ontological restriction, SEM states the possible (but looser) meanings of the word that is filling the propositional structure, and RELAXABLE-TO facet allows for metaphorical extension of the proposition. This three-tier mechanism allows for economy of representation and reflects the proximity of senses of one word. For example, in this partial semantic structure:

```
(digital-certificate…
        (SEM-STRUC (CERTIFICATE
        (IDENTIFIES-WHAT (DEFAULT (SOFTWARE) SEM (OBJECT)))
        (IDENTIFYING-INFORMATION-ISSUED-BY (CERTIFICATE-
AUTHORITY))))
))
```

Here, digital certificate is presumed, by default, to identify software; however, in the extended meaning it can modify any OBJECT (which, being the second-level node in the ontology, encompasses anything that is not an EVENT or PROPERTY, so RELAXABLE-TO facet is not needed).

Selectional restrictions do not apply exclusively to predicates and their arguments; they are used in any pairs of governing and dependent elements in the input. For instance, the meaning of adjectives is dependent the noun that they modify; thus, “Colorless green ideas” would fail to render a TMR, since the adjectives do not satisfy the selectional restrictions on the noun.

The goal of processing in ontological semantics is, ultimately, generation and matching of the script for the complex events (taking place in the text). Based in Shank and Abelson (1977), Fillmore (1985), Raskin (1986), ontological semantics is a script-oriented approach to natural language processing. The events that get instantiated in the ontology at the earlier stage of text processing have a direct bearing on the interpretation of the later events.

1.5.2. Text Generator

The text generator is used to create a text in natural language using text meaning representation as an input (other kinds of input may be used, for example, numerical data, which needs to be presented as a text; these other kinds of inputs require corresponding modules for their processing into TMR). Overall, the text generator performs the tasks similar to that of the analyzer, but in reverse order.

The basic generator should include:

1) content specification module to determine what can be said (what are the limits on information available; what the discourse consumer knows already);
2) text structure module, planning out the sentences in the text and ordering them;
3) lexical selection module, choosing appropriate vocabulary for the text;
4) syntactic module, ordering the words in the sentence for a specific language;
5) morphological module, for the languages with overt morphology.

This description of the dynamic resources of ontological semantics is cursory due to the fact that the main focus of the present paper is in extending static knowledge sources, which are described further.

1.6. Static ontological resources

1.6.1. Ontology

1.6.1.1. Principles of ontological organization of encyclopedic knowledge

As noted earlier, the dynamic resources of the ontological semantic system operate on the static sources, the most important of which is the ontology. Nirenburg and Raskin (2004: 28-29) note, that the ontology, aside from merely being an inventory of concepts about the "real world", is a detailed constructed world model, containing information on:

- model of the physical world;
- model of discourse participants (including their attitudes to the facts in the ontology, e.g. "Victor does not approve of generative syntax")
- knowledge about the communicative situation.

The main function of the ontology is provide conceptual, categorical description of the real world, so that it is possible (in application of ontological semantics to various languages) to describe lexical items of those languages in a consistent, non-arbitrary way. There are several decision-making points in ontology-building process, which human ontology acquirers encounter. The first one is sufficient granularity of description. As will be shown in Chapter 3, sometimes the existing properties are sufficient for description of novel concepts in the ontology, and sometimes new ones need to be added. The second one is the necessity to draw boundaries between events, objects, and properties. As mentioned before, grammatical categories (e.g. part of speech) are not very useful, and sometimes misleading in this decision-making process. The third difficulty is the description of complex events (e.g. 'upload', ' log-off'), which point out not only to a process or state, but to its result. Chapter 3 elaborates on this also. However, I would like to extensively quote Nirenburg and Raskin on the standpoint they take in regard to quality control of machine-oriented and human-produced ontological description:

> "Parsimony [in ontological description - EM] is desirable and justified only if the completeness and clarity of the description is not jeopardized. Indeed, parsimony often stands in a trade-off relation wit the simplicity of knowledge formulation and ease of its manipulation. In other words, in practical approaches, it may be well worth ones' while to allow larger sets of primitives in exchange for being able to represent meaning using

> simpler and more transparent expressions. It is clear from the above that we believe that, as in software engineering, where programs must be readily understandable by both computers and people, ontological (and other static) knowledge in an ontological semantic system must be readily comprehensible to people who acquire and inspect it as well as to computer programs that are supposed to manipulate it".

1.6.1.2. Concept organization in the ontology

Ontology starts its tree-structure with the node ALL, which splits into three branches: EVENT, OBJECT, and PROPERTY. Those branch into more specific categories (e.g. EVENTS are subdivided into PHYSICAL-EVENT, MENTAL-EVENT, and SOCIAL-EVENT), until each end-node in the hierarchy represents a specific concept. The main feature of the ontological tree-graph is inheritance. Each new branch validates its existence by brining in connections and features, which are different from its parent node. Each final "leaf" on the branching is a separate concept, with many features inherited from parent nodes, and some only applied to the concept itself. Level transition is accomplished via two specific ontological slots: IS-A and SUBCLASSES. IS-A is a necessary slot for each concept in the ontology (with the exception of the node ALL); its filler is the node from which the concept is derived. Every concept, that has further concepts derived from it has a slot SUBCLASSES, enumerating its child-nodes. End-nodes, of course, do not have this slot.

The inheritance hierarchy allows a new concept to inherit all the property slots from the mother-node. It is, however, possible to both block inheritance of a property (using filler NOTHING), or block the inheritance of a property filler (property value). Multiple inheritance is also possible, even though, due to multiple properties in the current ontology implementation, is it unclear, whether such concept organization would be a very productive method.

It is important to differentiate "part of speech" organization (which ontology is not) and conceptual organization of the "universe". For practical purposes, the ontology subscribes to the negation of Sapir-Whorf hypothesis: there is one conceptual system, to which the lexicons of particular languages are tied. The conceptual structure serves as a "buffer" between languages, and as a common ground for text meaning representation.

The lexical items from the lexicon are not necessarily tied "one-to-one" to ontological concepts; a lexical item often needs several conceptual nodes to aid in its full meaning realization. Computationally, ontological semantics takes a "weak AI" approach to natural language processing (it models the result of human language processing ability, and not the processing ability itself), the ontology itself is built using cognitively-based structure. While ontology is constructed using cognitive categories, it is possible that in some languages, a concept would correspond to a phrasal instead of a word.

While the node-concepts in the Ontology do carry verbal labels in English, it is a purely conventional practice to aid in human acquisition of lexicon and ontology. The semantic information, that each entry (both the lexical and the ontological) carries, is contained in its relation to other conceptual nodes and the values of its property slots. This approach provides language-independent text meaning representation, and underlines cognitive processes involved in classification and abstraction of human perceptually based experience.

Concept is structured as a set of pairs listing a property with its value for the concept. The specification of descriptive slots for each concepts allows for incorporation of such components as modality (e.g. as a semantic component of predicates), speaker attitude, stylistic level, and more (This mechanism is further described below). Thus, the system itself is composed as a complex graph, with the potential ability to exhaustively describe the universe of human experience and to allow for full semantic processing of natural texts.

Connections between the ontology and the lexicon (or lexicons of several languages – in which case the connections would not, by any means, be identical; the more structurally and typologically different the languages are, the more difference in vocabulary-concept organization there should be expected) are not described as one-to-one correspondence, but as a complex relation of natural language vocabulary to conceptual structures. Several lexical items can be linked to one conceptual node, and vice versa, as shown in section 1.6.2.

Each concept in the ontology, besides being defined by properties (the mechanism of which process is described in 1.6.1.3.) has several slots, which do not have semantic properties, but rather serve as organizing measures of the ontology itself.

DEFINITION is the main (and mandatory) for all concepts in the ontology. It provides the definition of the concept for human acquirers. Since the concepts, for ease of human acquisition, have labels in natural language, acquirers are often tempted to use their intuition as to the operational range of the concept, which invariably leads to serious mistakes. For instance, OUTCOME and EFFECT are both children of INVERSE-CONDITION-OF-CHANGE concept; however, one (EFFECT) takes events as both its domain and range, while the other one (OUTCOME) only takes mental objects as its range, and is, therefore, not applicable to descriptions of complex events.

IS-A and SUBCLASSES slots are the instruments of inheritance, and were introduces above in this section.

INSTANCES and INSTANCE-OF are slot relating ontological concepts to the instantiations of these concepts in Fact Database, and are not used for the purposes of the present paper.

There are also three ontological slots, which are specific to properties (which themselves serve as slots for other concepts): INVERSE, DOMAIN, and RANGE.

INVERSE slot is only used for relations, in order to cross-reference them, and only has a VALUE facet (meaning that only one concept can fill it; more on facets in section 1.6.1.2.). For example, CAUSED-BY and EFFECT are the inverse of each other, which is specified by the use of this slot.

DOMAIN is the slot that is used to denote what concepts can have the particular property appear as a slot in them. For example, OBJECT-RELATION properties can only be applied to the domain of OBJECTS, and EVENT-RELATIONS pertain to EVENTS only.

RANGE slot, in relations, is filled by the concepts which can be in the range of particular relations; in attributes, by numerical or literal values of the attribute.

1.6.1.3. Properties; their function as concept slots in the ontology

Properties branch in the ontology is significantly different from the other two, EVENT and OBJECT. The purpose of the property branch in the ontology is distinctly different. As Nirenburg and Raskin (161) posit, "world model elements (i.e. events and object in the ontology – EM) should be interconnected through a set of properties, which will enable the world modeler to build descriptions of complex objects and processes in a compositional fashion, using as few basic primitive concepts as possible".

While EVENTs form the propositional centers in text meaning representation, and OBJECTs are independently instantiated in connection with events, properties are only used to further describe ontological or lexical items. Thus, they function as slots in ontological descriptions. The branch of properties, note Nirenburg and Raskin (165) is intended to function as "ontology's conceptual primitives", "the mechanisms used to represent relationships between concepts". With the use of properties for description of ontological concepts, the grain size of the world experience can be broken down into minimal semes, and put together in text meaning representation without references to a grammar of a specific language. Thus, the real primitives of ontological semantics are not the concepts, but the properties of concepts.

Properties in the ontology are divided into ATTRIBUTEs (properties, descriptive of a concept) and RELATIONs (properties, connecting one or more concepts). ATTRIBUTEs are further subdivided into SCALAR and LITERAL, which differ on the basis of their possible ranges: SCALAR attributes usually have a numerical range (sometimes 0 to 1), and LITERAL attributes have literals in their RANGE slot, e.g. MALE and FEMALE for the GENDER attribute.

1.6.1.4. Facets and fillers of concept slots

Each slot in ontological description has two parameters: facet and filler. Facets are, in essence, predicates in the meta-language of ontology. The permissible facets for the extant implementation of ontology are the following:

1) VALUE

This facet takes in actual values – numerical, word-strings (all definitions for human consumption, notes, etc. are introduced by this facet), instances of concepts from the fact database, etc. This facet "grounds" the property to something very specific.

2) SEM

This facet is the ontological equivalent of mathematical = (equals sign); it introduces selectional restrictions for the particular slot. There are several facets, which can be considered its variations: DEFAULT, RELAXABLE-TO, and NOT. NOT excludes specific concepts from serving as fillers (equivalent to □), and sets all other concepts as permissible. DEFAULT and RELAXABLE-TO denote, respectively, the most preferred filler of the slot, and the extent of possible violation of the SEM restriction. The combination of the tree facets (not necessarily used in conjunction in one entry) serves as a tool for disambiguation and metaphor treatment.

3) DEFAULT-MEASURE

A rather narrowed-down facet, used to specify the concept serving as a measuring unit for the number (or numerical range) that fills one of the above-mentioned facets.

4) INV

The facet is used to show that the particular filler for the slot was "deduced" by finding an inverse relation from another concept.

1.6.1.5. Case roles as connectors of propositions and their arguments

Besides the semantic properties, which are used in ontological semantics in order to describe the nature of objects and events, there is a special set of properties that help to relate objects and events to each other. In other words, since the dynamic text meaning representation is predicate- or proposition-centered, there is an inherent need to relate the center of the proposition (often, the verb, but also, for example, an adjective) to its arguments (or adjuncts and complements, between which ontological semantics does not necessarily draw a line). To help relate events and objects to each other, we use a practical application of case grammar, first introduced by Fillmore (1968), and further developed in generative grammar from the viewpoint of syntax.

There are two issues that arise in connection with using case roles, or typical arguments taken by the verb. First of all, a finite inventory of case roles is a subject of considerable debate. Even the case roles of obligatory arguments of the verb are not always agreed upon (see Fillmore, 1968; Talmy, 1976; Lakoff, 1977; Talmy, 1978; Ladusaw and Dowty, 1988; Jackendoff, 1990; and Talmy, 2001), and we are trying to use case roles for both arguments (or complements) and adjuncts. The second issue is that most research into case role inventories (e.g.) is language-specific and syntactically-oriented, and does not talk about language-independent properties of events. So, ontological semantics uses the premise of justification in constructing its case role inventory. It is expected, that future applications of ontological semantics might modify the inventory of case roles currently used. The case roles that were used in the present paper (and are represented in KBAE-avoider) are listed below.

It is important to note that most of the time the event itself has restrictions on what case roles can be filled with regard to it, or which ones are preferable or necessary. All of it is reflected in the lexical or ontological entry for the verb (in the lexicon) or EVENT (in the ontology). On the other hand, objects and nouns also sometimes have semantic restrictions as to what case roles they might fill for certain events; in this case, the CASE-ROLE-INVERSE is used in the script for the noun or OBJECT (in the lexicon or ontology, correspondingly) to announce this selectional restriction

1) Agent

Agents are entities causing events. Initially, only volitional agents were considered for this case role ("**I** worked on the assignment"); later, this restriction was lowered to include natural forces ("**The wind** opened the window"), and, by metaphorical extension, organizations ("**The Nobel Prize committee** announced this year's winners"). Syntactically, agent is often the subject of the sentence, and in languages with overt case system is marked accordingly (by nominative, ergative or absolutive case).

2) Theme

The entity that is manipulated by an action, e.g. "We evaluated new **software**". Indirect objects are often themes. Themes are not human (the case role of patient is reserved for

similar treatment of humans) they can, however, contain entire propositions: “I forgot **that you were out of town this week**”.

3) Patient (in some applications also realized as two independent roles of beneficiary and experiencer)

Patient is a human entity affected by the action, as in “I sent **my professor** an email”, or “**I** saw my computer suddenly turn off.” (In this particular type of sentence, the role can be argued to be an experiencer role in a non-volitional event)

4) Instrument

Instrumental case describes an object or event used for executing another event, e.g. “I opened the door with a spare **key**”.

5) Source

Source case role describes a starting point of various types of movement, e.g. “We are flying from **Chicago** tomorrow”. This case role does allow for metaphorical extensions, and constrains its fillers to objects, and not events. (As in “He shied away **from appearing at the dances after that**” – here, the sentence is interpreted as containing two propositions and treated accordingly.)

6) Location

This case role describes a place where an event takes place or object exists (e.g. “I slept in **the basement**”. The syntactic clues for it include prepositions with spatial meaning (in, by, at, behind, above, below) or morphological case in languages that have grammaticalized locative meaning (Eastern Slavic, Finnish, Chuvash (Altaic), etc.)

7) Destination

The case role of destination describes an end point for various types of location change, transfer of possession, etc. (E.g. “He accompanied her to **the show**”). Syntactically, English offers prepositions “to, towards” as clues to this case role.

8) Path

Path is a route which an object (in ontological, not syntactic, sense) travels, and can be a metaphorical extension of meaning, e.g. “He went through **a lot of hardship** then.” Path is usually an object itself.

9) Manner

The case role of manner describes the style in which something is done. It is, typically, a scalar attribute and is triggered by adverbials, e.g. “She writes **well**”. This case role is used as a generic for all event modifiers that cannot be assigned to other case roles.

Syntactic clues accompanying the descriptions of case roles here are not meant as the rules used by the system, but rather as language-specific defeasible constraints. The lexicon does make use of syntactic structure for evaluating case roles in preposition reconstruction, and ontological entries establish selectional restriction on semantics of case role fillers, but it is the interaction of both which makes the final judgment as to the filling case roles in text meaning representation.

1.6.1.6. Knowledge acquisition for the ontology

Raskin and Nirenburg (2004) suggest the following 3-step methodology for ontological acquisition:

1) Determining, whether a meaning (presumably, of a lexical entry that needs to be tied to a concept within the ontology) warrants the introduction of a new concept (which can be, considering full property specifications, a laborious task);

2) Locating the new concept within the ontological hierarchy, i.e. finding parent and sibling nodes (with a possibility of having more than one of either), which would best serve to provide thorough connection for the new concept. This is done with the help of KBAE-avoider software.

3) Providing full specification for the new ontological concept. For each new concept, there should be meaningful distinctions from both parent and sibling concept nodes through introduction, specification, or blockage of property slots.

The major difference between introducing a new lexical item (described further), and a new ontological concept is that while all lexical items are legitimate members of the lexicon, not all possible concepts need to be introduced to the ontology. If the difference between two concepts is only in specifications of some property slots, those can be specified in the lexical entry script, and no new ontological concept is needed: e.g., *palomino, bay, chestnut, sabino, paint* as applicable to colors of horses, do not need

to be introduced as separate “color” concepts: it is sufficient to restrict their application, as lexical items, to the THEME “horse”.

1.6.2. Lexicon

1.6.2.1. Composition of a lexical entry

The lexicon, the second static-knowledge source, consists of lexical entries - vocabulary of each particular language. Each lexical entry consists of four parts: the word itself, the definition of the vocabulary item (used, essentially, for the ease of acquisition, not for any computational purpose), the syntactic structure (or the syntactic environment, in which the particular vocabulary item may be encountered), and the semantic structure, which ties a particular word to one or several concepts in the ontology. It is not necessary that a single word is treated as one vocabulary item; for example, in some multi-word expressions, like phrasal verbs, it is useful to treat several words, forming an item with non-compositional semantics, as one lexical entry. For example, a phrasal verb “take up” has a meaning “use” or “occupy”, which is non-compositional. An entry for it would (and indeed, does) look as follows:

```
(take-up-v1
  (anno
    (def "to use certain space")
    (ex "This table takes up too much room”)
    (comments ""))
  (syn-struc
      (np ((root $var1) (cat np)))
      (v (root $var0) (cat v))
      (prep ((root up) (cat prep)))
      (np ((root $var2) (cat np))))
  (sem-struc
    (USE-RESOURCE
      (agent (value ^$var1) (sem OBJECT))
      (theme (value ^$var2) (sem NATURAL-OBJECT))
   ))
```

Each lexical entry is thus tied to several ontological concepts: once the main ontological connection (in this case, USE-RESOURCE) is established, it is possible to further narrow down the meaning of the lexical entry. For instance, for an entry “to try

on", as in "I tried on a blue sweater", it is possible to further specify the agent as a human being, and the theme as an item of clothing:

```
(try-on-v1
  (anno
    (def "put a piece of clothing on to see if it fits")
    (ex "I tried on several dresses. ")
    (comments ""))
  (syn-struc
     (1
      (np ((root $var1) (cat np)))
      (v (root $var0) (cat v))
      (np ((root $var2) (cat np)))
      (prep ((root on) (cat prep))))
     (2
      (np ((root $var1) (cat np)))
      (v (root $var0) (cat v)
      (prep ((root on) (cat prep)))
      (np ((root $var2) (cat np)))))
  (sem-struc
    (1 2)
    (TEST
      (agent (value ^$var1) (sem HUMAN))
      (theme (value ^$var2) (sem CLOTHING-ARTIFACT))
   ))
)
```

It is also possible for each lexical "string" to have more than one instantiation in the lexicon (e.g. "a tie" and "to tie"): a vocabulary item might have more than one meaning, leading to the two instances of one "string" to be used in different syntactic and semantic environment. The strength of the ontological semantic processing is that since both the semantic and syntactic environments for an entry are specified, it is possible to recursively process a sentence and disambiguate the meaning through reference to the environment of the particular lexical item.

1.6.2.2. Semantic parameters used in the lexicon.

In the sem-struc field of the lexicon, any of the concepts present in the ontology can be introduces in order to further specify the meaning of a lexical entry. Besides ontological concepts, lexical items can also be described with the help of modality and aspect parameters. Fundamentally the features of text meaning representation, they are

sometimes contributed not only by grammatical means, but by lexical ones also, which is why they are indispensable in lexicon acquisition.

1.6.2.3. Modality and its implementation in ontological semantics.

Ontological semantics defines modality as the meaning contributed to the proposition by the attitude on the part of the speaker. In the present implementation of ontological semantics there are seven types of modality, used to express distinct speaker-centered situational attitudes.

Epistemic modality describes the speaker's attitude toward the factivity of the proposition; its value is 1 if the speaker is assured of the reality of event, 0 in case of negation, and somewhere in between if the event is somewhat likely (the two instances of "some" corresponding to a scale measurement). For every proposition in the text meaning there can be epistemic modality scoping over it (interestingly, for example, in a case where a reporting agent is deemed non-trustworthy; thus the all information coming from the source would be in doubt, and, possibly, a lie). It also captures negation, when assigned a value of zero (the event did not take place).

Epiteuctic modality (from Classical Greek for 'success') describes "the degree of success in attaining the results of the event in its scope" (Nirenburg and Raskin, 2004: 250). It is instrumental in accounting for such terms as *try, attempt, succeed, fail, achieve, accomplish, almost, nearly* etc.

Volitive modality corresponds to the desirability of the event and, as such, can only be assigned to events with volitional (at least metaphorically) agents. It can be used in the lexical entries, for example, a phrasal verb "turn to", as in "turn to someone for help":

```
(turn-to-v1
  (anno
    (def "to start relying on a person/some practice in  one's life")
    (ex "He turned to religion during difficult times. ")
    (comments ""))
  (syn-struc
     (np ((root $var1) (cat np)))
     (v (root $var0) (cat v)
     (prep ((root to) (cat prep)))
```

```
    (np ((root $var2) (cat np))))
  (sem-struc
   (1 2)
   (ENTRUST-WITH
    (agent (value ^$var1) (sem HUMAN))
    (theme (value ^$var2) (sem OBJECT))
    (modality (type volitive) (value 1) (scope HUMAN))
   ))
)
```

Deontic modality is responsible for the semantic meanings of obligation and permission; it is a measure of the amount of free will, exercised by the agent. For example, the lexical entry "must" mandates the deontic modality of the event to be assigned the value of 1.

Potential modality deals with the agent's ability (other than desire or need) to perform an action: lexical items such as *can, could, capable, able*, etc. are direct carriers of this type of modality.

Evaluative modality expresses an agent's attitude to events, objects, and properties (i.e. virtually anything). In English, lexical items that carry this type of modality are *like, enjoy, appreciate, good, bad*, etc. From the point of view of ontological semantics, sentences such as "I read a good book" and "I liked the book I read" carry an identical modality element. As Raskin and Nirenburg (1995, 1998) have shown, the meaning of such adjectives as "good" and "bad" express evaluative modality, and do not, in any way, modify the meaning of the noun they accompany syntactically.

Saliency modality is used to express the importance of a certain component of the text from the point of view of the speaker. Lexically, the clues to the modality are such items as *important, unimportant, relevant*, etc. Saliency, like evaluative modality, does not scope over the entire proposition, or at least not necessarily so. It is also used in ontological semantics to make topic/comment (or theme/rheme, or salient information from non-salient) distinction. For example, in English, articles "a" and "the" can provide clues as to whether the component is new and salient (the former normally marks new nouns in the text; the latter, the ones already introduced). Topic saliency information is, of course, not limited to lexical items, and can be rather difficult to capture in a given text.

1.6.2.4. Aspect and its implementation in ontological semantics.

Aspect, which is mostly a feature of text meaning representation in ontological semantics, is currently implemented as a combination of one of the four PHASEes: begin, continue, end, and begin/continue/end (momentary events) and ITERATION, which can have a numeric value or indefinite value MULTIPLE.

Aspectual meaning can be contributed both by lexical items and by grammatical structures (participles in English). Here is an expanded example of a lexical item incorporating aspectual meaning, English phrasal verb “dam up”:

```
(dam-up-v1
  (anno
    (def "stop water in river, stream, etc. by blocking it")
    (ex "The river has been dammed up to form a series of lakes”)
    (comments "..."))
  (syn-struc
     (1
      (np ((root $var1) (cat np)))
      (v (root $var0) (cat v))
      (np ((root $var2) (cat np)))
      (prep ((root up) (cat prep))))
     (2
      (np ((root $var1) (cat np)))
      (v (root $var0) (cat v))
      (prep ((root up) (cat prep)))
      (np ((root $var2) (cat np)))))
  (sem-struc
    ((1 2)
    (OBSTRUCT
      (agent (value ^$var1) (sem HUMAN))
      (theme (value ^$var2) (sem RIVER))
      (aspect (phase end))))
)
```

Here, the semantic structure of the phrasal verb overtly states the end-phase of the event, as opposed to the simple “dam”, which does not carry this aspectual meaning. It is possible to argue, that aspect, in this regard, also states the end-result of an event. This will be elaborated in Chapter 3.

Depending on the way (lexical or grammatical) a particular language incorporates

aspect, aspect can be realized either chiefly through the dynamic knowledge sources (the analyzer and the generator) or in the lexicon (e.g. for Russian, where each verb is specified for its aspectual meaning), or both (as the case is for English, where many phrasal verbs carry aspectual particles – for more on this, see Televnaja (2004)).

1.6.2.5. Knowledge acquisition for the lexicon

Raskin and Nirenburg (2004) suggest a step-by-step procedure in lexical acquisition. First of all, each lexical entry has to undergo polysemy reduction, in order to use the minimal necessary number of senses for each entry (whether it is one word or a multi-word expression, as in the case of phrasal verbs) while preserving all the senses.
On the other hand, when expanding the lexicon for application to a new domain, one has to make sure that all the necessary word senses are already included (cf. the two meanings of the word “server”: as a job and as a part of computer network).

Each word-sense, decided upon after polysemy reduction is numbered and provided with an annotation field (anno), which includes the definition of the particular word sense, examples of its use, and a comment field (for use by acquirers to leave notes concerning the entry).

Second field of a lexical entry (syn-struc) contains its syntactic description: a script for every possible valency combination of a given entry.

The third field is the actual semantic description (sem-struc). Each lexical item is connected to an ontological concept, and specified by means of adjusting lexical constraints (introducing new properties, limiting the semantics of existing properties, specifying modality, etc.). In the semantic field, syntactic description is linked to the semantic one, as exemplified in the following lexical entry:

```
(take-down-v1                    one of the possible senses after polysemy reduction
(anno
   (def "write down")
   (ex "Let me take down your name and phone number”)
   (comments ""))
  (syn-struc                          syntactic description
    (1
     (np ((root $var1) (cat np)))
     (v (root $var0) (cat v))
```

```
    (np ((root $var2) (cat np)))
    (prep ((root down) (cat prep))))
   (2
    (np ((root $var1) (cat np)))
    (v (root $var0) (cat v)
    (prep ((root down) (cat prep)))
    (np ((root $var2) (cat np)))))
 (sem-struc                                  linking semantic and
  (1 2)                                      syntactic structure, adjusting constraints
  (RECORD-INFORMATION
   (agent (value ^$var1) (sem HUMAN))
   (theme (sem INFORMATION))
  ))
)
```

The sense reduction and disambiguation procedures need to take into account the grain size of the semantic description necessary for each entry.

1.6.2.6. Complementarity between lexicon and ontology

During acquisition, there is always a question of whether it is necessary to introduce a new ontological item for a specific lexical entry, or whether it would suffice to connect it to an existing, albeit generic entry that is already in the ontology. For example, is it necessary to further branch STORAGE-DEVICE (defined as computer memory) into MAGNETIC, SEMICONDUCTOR and OPTICAL, is it possible to leave this specifications to the lexical item, or is it a necessary piece of information at all?

The answer involves several criteria that need to be considered. First of all, what is the grain size that the present application of the ontology has to satisfy? If there are no pressing time-efficiency or processing limitation constraints, it is beneficial for the application to have information present in the system. The decision of where this piece of semantic information belongs – in the lexicon or in the ontology – can be made on the basis of whether expanding the ontology is justified. Would a new concept be used in specifying other lexical items besides the one in question? Would it be useful for specifying other ontological items? What is the grain size of semantic description the present system is aiming for? Are there concepts available to further specify the lexical

item, or would those also need to be added? How general are those concepts, can they be further used for ontology and lexicon?

In case of STORAGE-DEVICE, further expansion of the STORAGE-DEVICE branch of ontology is beneficial, since there is more than one lexical item that can be defined through each of the new concepts (e.g. semiconductor-storage-device is a anchor concept for lexical entries “flash memory”, “bios chip” and “smartcard”). However, the decision in such matters always lies with the acquirer.

1.6.3. Onomasticon

Ontology and lexicon are complemented with fact database and language-specific onomasticon (a depository of proper names). Along with the lexicon, the onomasticon serves as token database for text processing, the only difference being that while lexicon contains only common nouns, the onomasticon is only concerned with proper nouns. For example, the lexical entry “city” in the English lexicon can correspond to “New York, London, Tokyo” in the English onomasticon. The entry in the onomasticon is tied both to the ontological category, to which it belongs (as an instance of a concept), and to the facts in the Fact Database (which carry more information about the specifics of the entry).

All instances of proper nouns in onomasticon are grouped into one of four categories: animate, organization, time-period, and geographical-entity. In the present paper, I was not concerned with adding entries to onomasticon; in the few instances that it was necessary for definitions of lexical items (for defining the difference in architecture of MAC and PC hardware), I listed the necessary items to be added to the onomasticon in the appendix.

1.6.4. Fact Database

Fact database is storage of instantiations of events and objects, which is used for text processing and helps in disambiguation. It is, like onomasticon, a collection of instances of generic ontological concepts, connected to the concepts by means of INSTANCE operator in ontology and, inversely, INSTANCE-OF operator in fact

database. Instantiations in the fact database are numbered, thus, if an object has a proper name (e.g. the United Nation), it is simply a numbered instance of an organization for the fact database, co-indexed with its proper name in the onomasticon. The information about the organization, on the other hand (e.g. year it was founded, members, legal rights, etc.) is the domain of the fact database.

Ideally, fact database would be enriched automatically from each processed text; such system would allow for machine learning and knowledge accumulation. As noted by Nirenburg and Raskin (2004: 29, 191) the larger the fact database for a particular implementation of ontological semantics, the better for the application.

The present work is not concerned with knowledge acquisition for this particular resource, so the above elaboration of functions and connections of the fact database to other resources of ontological semantics will suffice.

1.7. Benefits of ontological semantics approach to Natural Language Processing

Ontological semantics, as easily observable from the above examples, does not support separation among traditionally stand-alone aspects of linguistic inquiry such as topic/focus location, modality, event and argument structure, etc. On the contrary, during the preparatory stage (in lexicon and ontology acquisition) and text processing itself, every effort is made to enrich TMR with every piece of semantic information, which is (literally) humanly possible to extract. If, for instance, after reading a document, a human would conclude that it was written by someone who has little respect for the work of some another author, the TMR should reflect that information as well.

The above described general framework, along with the expanding static knowledge sources, and the developing dynamic processing algorithms constitute the ontological semantic approach to natural language processing. Ontological semantics allows for introduction of other theories and micro-theories into the general framework; it is based on the constantly open optional refinement of the processing algorithms. However, the basis for the computational approach to NLP processing, on which such flexible framework can be built, is the separation of lexical items and their representation in the ontology.

The ontology is a constructed engineering model of reality, a domain theory. It is a highly structured system of complex relations, the grain size of which is determined by needs of applications and computational complexity. Formally, ontology is a tangled hierarchy of conceptual nodes, each of which is characterized by (at least) one or (preferably) more properties. While the choice of properties, as ontological primitives, and the decisions on hierarchical structure (e.g. whether to divide all instances of the concept VEHICLE into air-, water-, and land-vehicles, or into passenger and cargo vehicles earlier in the hierarchy) are important for acquisition, it is not, ultimately, the main work that is important in ontological semantics. As Raskin and Nirenburg note,

> "It is important to realize that the differences in the topology of the ontological hierarchy and in the distribution of knowledge among the ontology, TMR parameters and the lexicon are relatively unimportant. What is much more crucial is the focus on coverage and on finding the most appropriate grain size of semantic description relative to the needs of an application" (Raskin & Nirenburg, 2004: 163).

Ontological Semantics provides a way of concept/lexicon organization and interaction, which is applicable across domains and allows for both concept specification and script realization. Ontology itself is a way to organize conceptual information for supporting natural text processing and various IT applications built for this purpose. This project focuses on ontological efforts to support information security applications – more specifically, applied natural language processing of Digital Identity Management domain.

CHAPTER II.
LINGUISTIC CORPUS-BASED APPROACH TO THE DOMAIN OF DIGITAL IDENTITY MANAGEMENT FOR LEXICAL AND ONTOLOGICAL ACQUISITION.

2.1. Digital identity management: defining the domain.

In order to survey the domain of digital identity management comprehensively, I chose to subdivide it into several areas and identify major influences in each one, using them as sources for corpora in the specific subdomain. A general overview of the problems and developments of public policy in the area has allowed me to single out the following sub-domains: social aspects of identity management, technical architectures proposed for identity management by various sources, psychological issues arising from the uses of digital identities, legal frameworks governing the use of digital identities (mostly implemented as laws pursuant to personal data handling), and biometrics as an emerging and controversial field allowing, in many cases, unique identification, but prone to problems specific for the field. The following sections elaborate on each of the sub-domains, defining their tentative limits and introducing the subjects that the textual corpus of the subdomain deals with, and noting how different actors strategically frame the debate using their own policy language.

2.1.1. Social aspects of DIM.

The three parties which are concerned with identity management in today's society are individuals, businesses, and government. Most of the documents, devoted to the issue of identity management are written with the objectives to benefit one or more of those groups. Sometimes the partisan purposes are stated explicitly, sometimes not;

however, the interests are also in interaction: businesses and individuals may side heavily on the privacy part of the identity management balance equation, while government, interested in security, has objectives which conflict directly with individuals' right to privacy. Thus, while dealing with the corpus of literature on digital identity management, it is important to keep an eye on whose interests are at stake, and to what extent they are represented in the document.

Hal Abelson and Lawrence Lessig give a thorough overview of the social landscape of the digital identity management architecture debate in their white paper *Digital Identity in Cyberspace*, which I will briefly examine it here. It has interesting aspects, in that it explicitly states the interests of all agentive forces and conflicts of interests that arise in the area of digital identity management.

First, Abelson and Lessig define cyberspace as "a realm in which communication and interaction between two individuals or between an individual and a computer is facilitated by digital data exchanged over computer networks"; identity is defined as "essential and unique characteristics of an entity". Such treatment of identity as a set of characteristics allows them to posit for two types of identity – on one hand, a social security number is a unique identifier for a person, but does not (in itself) reveal anything about the person at all; on the other hand, "is allowed to drive" and "has brown eyes" are possible identifiers of many different people; while the characteristics are informative, they are not exclusive. I would also like to note, that a further distinction between uniquely person-identifying information (such as various biometrics) and non-unique knowledge tokens (such as social security numbers) needs to be drawn, in order to correctly model the processes of digital identity management. Biometrics are also treated separately from other identifiers under law (pertaining both to their processing and identifying power).

Abelson and Lessig posit unbundling - that is, dissociation of various features of identity in cyberspace – as the most salient feature of digital communication. They state:

> "ones and zeroes do not inherently carry any separate information along with them; a real space transaction carries along inseparable secondary information. Digital transmission can only transmit; there is no secondary information encoded in the transmission unless explicitly put there. Thus, for authentication

> purposes, additional information needs to be carried with cyberspace transaction for identity purposes."

Further, they distinguish between identity revealing and identity verification, stating, that identity does not need to be fully revealed or transmitted in order to be verified (in the same way as "one touch" ATMs do not store fingerprints in digital form, but merely compare the "mnemonic" number for a user's fingerprint with the actual one, provided at the moment of transaction).

Abelson and Lessig insist, that the architecture of choice for digital identity management cannot depend on the technology alone, because the interaction of accountability and anonymity within the architecture are significant choices, which can affect commerce, society, and government in profound ways (a lack of anonymity, for instance, having a "chilling effect" on free speech).

Traceability facilitation (or mandated traceability) is one way to ensure accountability; however, direct traceability often comes into conflict with private social and commercial interests. Also, the danger of businesses sharing information about the consumers and re-creating their identities for marketing purposes is very important and has to be factored into any digital identity management system.

Abelson and Lessig also note, that there are many kinds of transactions, which do not require full identity verification. For example, a driver's license, in its original sense, only furnishes the proof that the possessor of it is eligible to drive in a certain area or country (the use of driver's license as identifying document, as opposed to its initial purpose as a driving authorization document, has led to multiple problems, including facilitating the ease of identity theft, further elaborated on in section 2.1.3). Or, in order to purchase alcohol, the customer only needs to furnish the proof of being over a certain age – and does not need to disclose full identity.

The business world, however, is inclined to treat identity as a commodity – information to be traded more or less publicly, and complied into databases that can be consequently used for market research. Not only do such databases threaten the privacy interests of consumers, they are also potentially psychologically damaging. As Abelson and Lessig state: "Some people are psychologically bothered by the idea that someone

can find out information about them without having to get all of the information directly and explicitly from them. Depending on the power imbalance between parties, the commodity nature of identity may exacerbate the feelings of lack of control, importance, and purpose about which many individuals of modern society complain that they suffer."

Abelson and Lessig identify several functions that any digital identity architecture would have to perform:

1) authentication-ensuring (the message if indeed sent by the person who claims to be the sender);
2) integrity-providing (nothing changed in a message along the way to the recipient);
3) non-repudiation-ensuring (the sender cannot deny that the message has originated with him/her);
4) confidentiality-providing (through use of some encryption method), so that the sender and the recipient can ensure no one else can read the message.

The methods which are normally used for identity verification - passwords, email addresses, cookies or IP addresses do not, in fact, ensure that the author of the message is the person who is claimed to be so in the message. IP addresses link only to machines, and even then can be dynamic; email address can be forged, and a password only ensures that the person knows the password – and not that the person is a particular individual. Such methods are termed by Abelson and Lessig as "under-revealing". On the other hand, at the present point, credit card numbers and social security numbers, when used for identity verification, are over-revealing, as they allow access to much personal information through consumer credit reporting databases.

Abelson and Lessig propose two types of unbundling (meant as dissociation of information), in order to facilitate digital identity management. The first type is loosening the link between various characteristics of identity; it allows shifting from complete revelation of identity to complete anonymity (which the authors suggest might be unreasonable for law enforcement purposes). The second type of unbundling is loosening the link between real-world identity and cyberspace identity. Taken to extreme, (no link) this unbundling allows for multiple cyber-identities, completely non-related to the real-

world person. This is what actually happens in role-playing online communities (MUDs), and the users of cyberspace have become used to enjoying unlimited anonymity in this respect. Or, as Abelson and Lessig put it, “with the technical ability to be unbundled, we theoretically are able to choose any degree of privacy or anonymity represented along the two spectra, including perfect privacy and perfect anonymity”. Yet, they warn that “design features may mask social choices of profound significance”.

Crime can ran rampant in the system with perfect anonymity and no accountability. Government institutions, such as police, that are concerned with crime prevention, would definitely prefer a system allowing perfect traceability; however, society is at the same time concerned with protecting itself from the same law enforcement that is called to protect it. Abelson and Lessig term it as “the classic conflict between liberty and order.” They suggest, that “law enforcement will push to gain as many privileges as possible so as to guarantee their effectiveness in fighting crime, whereas society will fight to limit law enforcement’s power to only those things which it deems critical to performing its duties.” Thus, the value system, which includes privacy, anonymity, and accountability needs to be built into a digital identity system in a balanced way. To provide law-enforcement, government would need some sort of structure that provides access to a real-world user - a “link structure”. On the other hand, the requirements of both open commerce and free speech require anonymity, of which Abelson and Lessig distinguish two types – transient and persistent. Transient anonymity allows one-time anonymous action (a post, akin to real-world leafleting, for example); persistent anonymity allows for construction of cyberspace identity which remains real-world anonymous while being consistent in cyberspace. As Abelson and Lessig conclude, “persistent anonymity is likely to be more generally useful”, since it allows an individual the time for social construction of identity (building trust and reputation in an online community, akin to real-world interactions).

The international nature of cyberspace brings in serious issues with respect to link or no-link digital identity management architecture. Freedom of speech is by no means a part of a world-wide value system (most currently exemplified by China, which prohibits access to sites containing politically dissenting materials), and if countries take opposing

viewpoints on the digital identity management approach, even in the degree of linking, this could present potential problems and, according to Abelson and Lessig, “even threaten the global nature of the Internet”.

No-link architecture, on the other hand, provides full protection for free speech, but also removes any accountability – toward social norms, legal duties, or business obligations. Dangers such as libel and child pornography are allowed to exist freely in no-link architecture.

Therefore, in order to prevent crime and at the same time keep the possibility of stifling freedom of speech to a minimum, it might be useful to further dissociate the information from the individual during online communication. For example, separation of encrypted content information from transaction information (sender, recipient, and so on) can effectively facilitate both traceability and free communication. Government has for a long time argued the necessity of controlled encryption, but the societal danger is too high for this to be a possible solution. A law overview regarding the First and Forth Amendments and their application to cyberspace allows Abelson and Lessig to conclude that a traceability requirement is “likely to be deemed constitutional”, provided “a warrant is required for access to identity information”. What is important, the ability to maintain full anonymity and privacy is preserved in this way in regard to every entity, excluding subpoenaed law enforcement. Such a solution is acceptable societally and implementable using the current technology.

The business-related aspect of digital identity management, note Abelson and Lessig, mostly concerns privacy rights of the consumers/users. The most important aspect of a business-consumer relationship is the balance of power, in which either the consumers can enforce businesses providing digital certificates of authenticity or aspects of their business ethics (e.g. that the products are not tested on animals, etc.), or the businesses can elicit identity and profile information from the consumers. Some such information is relatively harmless – for example, requiring disclosure of customer location, so that the product can be taxed at the appropriate rate – such a scenario is mandated legally and is not intended for the singular benefit of the company, or for building individual user’s profiles.

While profile-building rarely is a singular pursuit of a business, most companies offer incentives for their customers revealing private information, including social security number, full legal address, phone number, income bracket, age, and household details (including children's ages and genders – even though it would be illegal to collect such information from children directly, especially if they are 12 and under). Approaches to the collection of such information include discount card offers, sampling programs, point accumulation, sweepstakes, and other marketing tools. The usual argumentation is that the consumer can decide on an ad-hoc basis, whether the service or discount offered is valuable enough to furnish identity-disclosing information. However, with widespread consumer profiling and database trading, it is impossible for the end-user to know, how much personal information can be collected in a single profile. As Abelson and Lessig note, "there exist reasons to doubt whether a consumer fully considers the ramifications of providing a company with information about his identity… A consumer who is comfortable with company A knowing ten aspects of his identity, but no more, must understand that the only way to ensure company A never acquires more than those ten traits is to never reveal to any other corporation a different set of traits."

There are other aspects of identity management which are important for businesses. Besides end-users, businesses also deal with employee identity management issues and business-to-business identity management. Abelson and Lessig suggest that the latter relationship should not be problematic. They write: "both parties to an agreement already know each other's identity. It is difficult to think of what interests company might have in not revealing its full identity as its reputation and brand name is one of its most valuable assets". However, PingID (a Colorado-based company, specializing in providing business-to-business solutions) suggests, that "while every company's risk tolerance is different, each company must evaluate for themselves how much they are willing to invest to reduce risk… on a company by company basis…". Therefore, the identity management policies, which any given company adopts toward its end-user customers and employees, can have a significant potential effect on business-to-business interactions.

2.1.2. Technical aspects of DIM.

There are several important considerations to be implemented in any digital identity management architecture. The first one is a requirement of “non-flow of biometric information” – that is, by legal requirements (e.g. in Texas) biometric information cannot be stored or transmitted, but only compared inside an identifying system. Such techniques are somewhat involved, since biometric data in most cases (fingerprint, retina scan, and hand geometry) is approximate. The second requirement (frequently ignored by industry implementations, such as the Microsoft Passport identity management scheme) is that full access to uniquely identifying information is available only to law enforcement and through specific legal means (subpoenaed by court) or as a result of specific illegal activities (in threshold-based systems). This can be more reliably achieved through a distributed identity management system (such as the current Public Key Infrastructure hierarchy), than in a federated one (governmental or industrial). Another important technical aspect to consider is that any identifying system is only as reliable as the initial enrollment into the system. If initial enrollment is non-reliable (e.g. currently banking systems heavily rely on knowledge tokens even in cases of applications for loans and mortgages), it defies the purpose of the system (see more on it in the discussion for biometric identifiers in section 2.1.6.). A useful implementation of an identity management system has to ensure the impossibility or at least the extreme difficulty of identity theft.

Out of the technological approaches available for implementation of traceability, Abelson and Lessig propose the use of digital certificates. SearchSecurity.com defines a digital certificate as “an electronic "credit card" that establishes your credentials when doing business or other transactions on the Web. It is issued by a certification authority (□□). It contains [an individual’s] name, a serial number, expiration dates, a copy of the certificate holder's public key (used for encrypting messages and digital signatures), and the digital signature of the certificate-issuing authority so that a recipient can verify that the certificate is real. Digital certificates can be kept in registries so that authenticating users can look up other users' public keys”. VeriSign and thawte.com are examples of certification authorities. While the Internet was created for information exchange, and did

not include any provisions for privacy or security, digital certificates act as keys to a trusted system, within which users (both individuals and legal entities, such as banks and businesses) can engage in activities which require a higher level of trusts (financial transactions, etc.) and which are impossible online without some security measures.

Abelson and Lessig note, however, that the usefulness of the certificates is subject to the standard technology threshold: the more entities use them, the more useful and valuable the technology becomes. While the threshold of "most" people or entities using digital certificates is not achieved, their usefulness is artificially low. After all, to use encryption, both parties have to support the encryption technology, to have and use their public keys.

Another useful feature of digital certificates is that they can efficiently unbundle information (e.g. a separate certificate is used as proof of age; another one as proof of identity; and so on), which provides a clear link between the real-world and cyberspace identities. In other words, Abelson and Lessig's type I unbundling is fully supported, while type II is not. While certificates do not make full use of the unbundling feature, is it definitely possible technologically. Public Key Infrastructure (PKI - the hierarchies of Certificate Authorities in the United States and internationally) could adopt unbundling certificates in order to keep end-user information more secure.

However, the weakest link in the certification scheme remains with the end-users. The major problem is one of preventing end-users from sharing and duplicating their keys. Password-protection is notoriously insecure, the problem beginning with breakability, and not changing passwords nearly often enough, all the way to users writing passwords down, and sharing them. Other methods of securing digital certificates exist, such as SmartCards, which can be made so that their duplication is impossible. Yet another way is biometrics - anything from fingerprint to retina scans. Needless to say, such information cannot be stored on the system. Also, the Certification Authorities can provide varied products to support end-user authentication for various environments. For example, as of the fall of 2004, VeriSign's PKI Applications included Smart Card Authentication solutions; trusted messaging; cable modem services; and digital IDs for secure Instant Messaging.

Unbundled certificates can provide anonymity as well. Abelson and Lessig suggest an example of an anonymous re-mailer, which requires a certificate for logon. The person using it would remain anonymous to the "outside world", but in a kind of "persistent anonymity": the correspondents would not have a direct link to each other's real-world identities, but they would be assured that the communication originated consistently with the same person.

Abelson and Lessig see the strength of Certificate Authorities to lie in the hierarchy of entities that can grant digital certificates, and in the possibilities of un-bundling the individual characteristics of identity. Two possible scenarios of the latter include multiple digital IDs use for a single person, where the information contained in each ID is limited to, for instance, proof of age or proof of financial ability for obtain an item of a certain value. The second scenario, providing the end-user with more anonymity, is ad-hoc certificate issuance under a pseudonym; in this case, the Certificate Authority tracks the pseudonym information, and the vendor, for which the pseudonym is used, carries the transaction information. Neither has full knowledge of a real-world transaction, as information is distributed, and while the transaction in its entirety remains traceable (possibly under a warrant), the scenario as a whole presents higher anonymity opportunities to the end-user. Abelson and Lessig offer a hypothetical scenario for such transaction:

> "Bob wishes to purchase a product from the web site that requires him to be 18. Previously, Bib has obtained a "Bob is 18+" certificate from the CA. Bob enters negotiation with the web site, which wishes to know if he is 18. Bob creates a pseudonym, in this case "ghost", to shield his identity. The pseudonym is then signed by his CA indicating its authenticity. The CA now knows that Bob is attached to the pseudonym "ghost". Bob can then request from the CA a "ghost is 18+" certificate. Bob then engages with the web-site store, sending them the signed public key for "ghost" (alternatively, Bob can provide a public key server with ghost's signed public key and the web-site can obtain it from the public key server) and the signed "ghost is 18+" certificate. Using the signed public key, the web-site can verify that the user presenting ghost's public key is the holder of ghost's private key. Successful verification indicates that the transaction can be completed. The key features of this architecture are that the web site can verify the needed information without knowing the real world identity of "ghost", and the certificate authority knows the real-world identity of "ghost", but not the transaction in which "ghost" engages".

It is interesting to compare the technical model offered by Abelson and Lessig to the identity management model developed by a coalition of industry groups, Liberty Alliance. The model, currently in the rollout stage of implementation, is drastically different from the socially conscious model in Abelson and Lessig's white paper and is heavily reliant on lack of legal of private information in the United States.

Liberty Alliance architecture distinguishes between traits and attributes. Traits are defined as "supported" identities – e.g. ones issued by the government (passports, driver's licenses, etc.), and companies (university ID card, bank card, intranet sign-on login and password), or the identity features unique to an individual (namely, one's biometric characteristics, including fingerprints and retinal scans). Attributes, on the other hand, are the individual preferences and history of interaction with the world. Medical history, shopping history, and musical and literary preferences fall into this category. Traits and attributes are distinguished mainly on the basis of usability in the business world. While "traits", as defined by Liberty Alliance, are useful in establishing unique contact with an individual, "attributes" directly contribute to market research data and therefore are more valuable to businesses, so long as they can be, in some way, tied to demographic characteristics – note, no "trait", or unique identity is needed (or is legally obtainable) for that purpose.

Liberty Alliance proposes a "circle of trust" with clearly-defined attribute-sharing policies:

- defined agreement between service providers;
- notification of the user of collected information;
- consent-granting on the part of the user (for types of information; it is unclear how specifically or loosely these types would be defined);
- keeping a record, where possible, of both notice and consent in an auditable fashion.

The Liberty Alliance's growth from 20 companies in 2001 to more than 160 in 2003 reflects concern among businesses for digital manageability of customer identity. It also suggests that businesses have significant interest in digital identity management architectures that satisfy their needs.

Interestingly, Liberty Alliance is advocating a wide availability of traits, or unique identities, in some of its services:

> "The first ID-SIS to be made available will be the Personal Profile Identity Service (ID-Personal Profile). This service defines schemas for basic profile information of a user. This usually includes name, legal identity, legal domicile, home and work addresses and can also include phone numbers, email addresses, and some demographic information, public key details, and other online contact information. By providing organizations with a standard set of attribute fields and expected values, they will have a dictionary or a common language to speak to each other and offer interoperable services".

The question that is not addressed in the paragraph is how, exactly, this might be beneficial for the user – if it will be – and what possible privacy infringement can arise from wide availability of uniquely identifying traits. Interestingly, the question of the creation of traits for businesses is not addressed in the document at all. That is a disappointment, because such a feature can be very useful for the users – for instance, it can eliminate the question of spam, if all companies are required to sign their correspondence with a traceable identifying key; it would be sufficient to tune one's mailbox so that it does not accept any un-signed correspondence.

Also, the one feature of the web-accounts, which require some sort of identity, is their un-linked nature. Users are fully aware of their spreading much information about themselves among various online services. The linking of just some of them (e.g. bank cards, emails, and blogs or interest groups) would pose a threat for both online and offline user privacy. Gmail's automated processing of email content and targeted advertising caused much concern upon its introduction; and it was not in any sense "linking". Actual collection of identity information by various interested sources would be a justified cause for alarm.

2.1.3. Psychological aspects of DIM.

Writings on psychological aspects of using online identities mostly originate within academia, since there is no compelling reason for industry or government to be interested in these aspects. However, psychological issues of digital identity management need to be taken into account while introducing technical and economic plans for digital identity management schemes. In the present section, I briefly discuss available research

on the use of multiple online identities and the psychological aftermath of identity theft, which is becoming the fastest-growing crime in the United States.

One of the most prominent researchers of identities in cyberspace, Sherry Turkle, who is an Abby Rockefeller Mauzé Professor in the Program of Science, Technology, and Society, and the founder and current director of the MIT Initiative on Technology and Self, has repeatedly argued that results of people's using multiple online identities can be both positive and negative, and regulations of cyberspace to reduce the possibility of anonymous identity-building would not be the solution to identity-related cyber crimes. However, she suggests that introduction of virtual communities and multiple identities into the everyday life of an individual raise multiple questions about social interactions, both online and offline:

> "And once we take virtuality seriously as a way of life, we need a new language for talking about the simplest things. Each individual must ask: What is the nature of my relationships? What are the limits of my responsibility? And even more basic: Who and what am I? What is the connection between my physical and virtual bodies? And is it different in different cyberspaces? These questions are equally central for thinking about community. What is the nature of our social ties? What kind of accountability do we have for our actions in real life and in cyberspace? What kind of society or societies are we creating, both on and off the screen?"

Every online identity construction, such as undertaken in MUDs (Multi-User Dungeons, which are online communities/game portals, where individual identity is socially constructed by discourse and interaction with other players/identities), can be interpreted as an enriching social experience. Depending what one chooses to do with it, it can have positive or negative effect on real life.

On the positive side, Turkle (1998) notes, "I think that we are just at this point now with the computer, as people come to realize that this technology offers dramatic new possibilities for personal growth, for developing personal senses of mastery, for forming new kinds of relationships." Through the use of different online identities, individual psychological identity becomes a distributed and changing system, with multiple instantiations in "possible worlds" – online chats, MUDs, forums and portals, each time negotiated anew. Turkle argues that in many cases such experience in identity construction can help people practice skills they lack in real life, like assertiveness, or "get in the shoes" of an individual from a different social group or gender. Some of

Turkle's female subjects note, that when they assume a male online identity, people stop offering them help in problematic situations in MUDs.

On the other hand, even positive online experiences are not always socially enriching. Online identities and their construction can be both a learning environment, safe from criticism, and an escape from reality, albeit not a complete one, which makes an individual shun his/her everyday problems. In several cases Turkle describes an individual's alienation from "unsuccessful instantiation" of self in real life, whereas an online identity is perceived as a better, unrealized self.

As follows from the above examples, identity management issues on the Internet and during online interactions are only a reflection of what goes on in society at large. Therefore, merely regulating online interactions Turkle insists, "…they (legislators – EM) focus on censorship, on pornography, on filters. Similarly, people despair about the state of education and look to the Internet for a technological fix. It would be better if we faced our real fears."

While there obviously can be both therapeutic effects of building multiple online identities, and dangers of doing so, Turkle does separate the psychological aspect of identity-building from the online transactions that can have non-psychological impact on reality:

> "It (online environments – EM.) is a place where people experiment with identity… As long as we know that it's a space for that kind of play…it's good. Now, you don't want that on the site where your American Express card is processed. As long as we keep these spaces separate, I think that the Internet as a place for identity play is good."

This brings about the questions of identity management for prevention of identity theft. At a time when individuals conducted all or most of their business transactions in person, such crime simply did not exist. However, the more individual identity is described by or tied to several numbers, as in the case of a Social Security number, the more vulnerable one becomes to identity theft. Even the simplest biometrics – signature – is most often not used in telecommunication transactions, thus completely dissociating identity (which at this point consists only of knowledge tokens) from the physical individual. The knowledge token information combined into "identity" can then be used for financial identity fraud (constituting, according to the 2004 Identity Theft Resource

Center survey, 88% of all identity theft cases), e.g. to open new accounts (for which the physical individual is accountable), start new utility services, apply for loans, governmental assistance, or tax returns. Two other kinds of identity theft - criminal (where an arrested person provides the information of someone else as their own identity) and cloning identity (where an identity thief actually lives and works under the identity of another person) incur even more severe damages to the victim. While most victims of identity theft suffer sever financial damages (as the 2004 report by the Identity Theft Resource Center shows, fraudulent charges averaged $90,000 per case), in all cases the emotional damage is equivalent to that of victims of violent crime.

Since knowledge tokens are not, strictly speaking, "identifying" in any way, and are not tied to any physical item, they are very easy to use for identity theft. However, it is not the individuals themselves that let their information be known to perpetrators, as the following quote from the 2004 report by Identity Theft Resource Center shows:

> "It is also clear that in the majority of identity theft situations victims were not responsible for the loss. Most of these situations started because a business or governmental entity allowed the thief access either directly or indirectly to personal identifying information. This includes databases, cards carried in wallets that included one's SSN or via items mailed to victims with account or SSN information (allowing access through mail theft, dumpster diving or theft), or unsafe information gathering or handling practices. The reality is there are only two things that a victim can do to directly facilitate identity theft: carry a Social Security card in one's wallet or fall victim to a telephone or Internet scam. In all other situations direct links to a business entity can be drawn."

Even if it were possible for a victim to clear their credit history (41% of victims considered their case unresolved after two years since the discovery of the crime; 27% reported the same after 3 years), people experience negative emotions, the severity of which can be qualified as Post Traumatic Stress Disorder. According to the 2004 survey by Identity Theft Resource Center, over 60% of victims of identity theft report "deep fears regarding financial security", "sense of powerlessness and helplessness", "feelings of betrayal", "rage or anger", or a "change in feeling that you are protected by law enforcement or the law". Identity theft also has a serious effect on victim's relationships. According to the same survey, 50% of victims experienced stress in family life as a result of identity theft; in 30% of cases this had effect on children also.

The existence of crimes related to identity theft was made possible due to inherent flaws in the current identity systems employed by the US government and industry (based for the most part solely on knowledge tokens), mishandling of private information by businesses and organizations (Purdue University alone had several security breaches in the last 3 years where student, alumnae, and employee information was compromised, the most recent occurring in March 2005), and the widespread use of a driver's license as an identifying document (for which it was not intended).

2.1.4. Economic aspects of DIM.

While the US legal system defers the task of consumer data privacy to businesses, it also leaves the question of identity management for industry purposes completely at will of the companies. Industry, however, is struggling with implementation of identity management schemes that answer to the requirements of businesses and are economically manageable (and there are viable business schemes built on the exact opposite of secure and customer-sensitive identity management, such as customer database trading and data mining, involving even credit bureaus).

The requirements for a global identity management service, proposed at the W3C workshop on Web Services, can serve as a good representation of what the global business standard of identity management is expected to achieve:

1) Portability and interoperability, so that it can be used across platforms and language-independently;
2) Extensibility, so that the service could support new vocabulary for both identity attributes and control structures;
3) Negotiated privacy and security, so that identity owners could control their own information, while allowing for anonymity and pseudonymity;
4) Accountability (termed also as traceability) based on legal principles (which, has to be added, are still very much in the process of development themselves);
5) Distributed registration and certification authorities, in compliance with hierarchical model, which would allow for free competition among the authorities themselves;

6) Independent governing authority, independent of any particular government or business entity, to preclude conflict of interest and abuse of power in such a crucial question as digital identity management.

The benefits of a strategic implementation of identity management for businesses are defined in a white paper by Global Risk Management Solutions, a division of PriceWaterHouse Coopers, as follows: “improve the security through… real-time auditing to remove security risks; remove terminated users and revoke their access rights; use centralized source of user identities”.

The major item on the benefits of identity management scheme implementation list is the lowering of costs, both through the automation of an identity issuing service and the elimination of personnel with identity management task; the last item mentioned is to maintain compliance with policies of external governing bodies (e.g. health companies are legally responsible for non-disclosure of patient information by the Health Insurance Portability and Accountability Act) and the enterprise itself.

The barriers that companies currently face in implementing their own identity management systems are listed by the same source as follows:

> “1.Costs.
> Cost savings may be problematic to quantify – except at the highest levels of organizations – due to administrative costs dispersed throughout many departments;
> Identity management is a multiyear project; not all projects will achieve return on investment in less than a year.
> 2. Undervalued benefits.
> The benefits of even dramatically improved security and administration processes relative to costs may be misunderstood and undervalued, making costs difficult to justify.
> 3. Prioritization
> Resources are limited and often allocated to other business priorities;
> Current levels of system and user administration are viewed as “good enough”
> 4. Complexity
> Understanding current workflows and data architecture for identity management makes such a project seem overwhelming.”

However, the same white paper points out that implementation of identity management with single sign-on and reliable user authentication drastically improves productivity, decreases helpdesk inquiries (most of which are, necessarily, for lost and

misplaced passwords), and practically increases productivity of the employees. GRMS also mentions, that "enterprises are requiring their trading partners to live up to a certain level of security in order to maintain their relationships", and suggests that these requirements need to be considered for data privacy and identity management practices within the company.

Of course, it would be convenient to operate on assumption that businesses are immediately dependent on the trust that customers and partners put in them, and that in the absence of a reliable identity management schemes for customers and data protection measures in place for private information, businesses can hardly expect to survive. Yet, for example, as reports on identity fraud show, it is much more cost-efficient for businesses to "write off the loss", as opposed to investigating the problem or offering the solution to it. As one victim of identity theft observed in the 2004 survey by the Identity Theft Resource Center:

> "My (then) bank, Wells Fargo was unable and unwilling to help me or stop it. They said they could not. As they credited money back into my account (daily) they suggested getting to the bank to withdraw it BEFORE it was taken out of my account again by the thieves. This was their solution."

2.1.5. Legal aspects of DIM.

The two major communities interested in introducing digital identity management, and developing legislation governing the use of digital identities are the United States and the European Union. Thus, this section focuses primarily on the similarities and differences in legal approaches to digital identity management in the two communities.

Approaches to legal regulations of the digital world in the US and European countries are significantly different. The US has adopted a policy of allowing self-regulation in the areas of data privacy (according to its case-based legal system) along with some level of governmental control, and full governmental control in the areas deemed important for counter-terrorist measures. Europe, on the other hand, is consecutively passing comprehensive legislation on data privacy and cyber crime; moreover, the overall inclination of this legislature is toward exclusion of the non-

acceding countries from European digital space. These differences have caused significant contention.

The single most important European treaty on the regulation of digital data is the Convention for the Protection of Individuals with Regard to Automatic Processing of Personal Data (most commonly referred to as Convention 108) of January 1981, which entered into force in1988. Major provisions of the convention include:

- Prohibition of the processing of individual sensitive data, including race, political and religious beliefs, information about health and sexual life;
- Provisions for individuals to know what information is being stored about them, and have it corrected, as well as allowing individuals be compensated for erroneous data;
- Restrictions of trans-border data flow to countries that do not have equivalent legal protections in place.

Recommendations and resolutions passed in conjunction with the Convention scope over personal data collected for insurance purposes, statistical purposes, payment operations and social security purposes, and scientific research; as well as medical data, data in the area of telecommunications (and especially telephone) services, personal data used for, and electronic data banks in the public and private sector.

The European Directive on the Protection of Individuals with Regard to the Processing of personal data and on the Free Movement of Such Data, which came into force in EU in 1998, also places strict limitations on collection and use of personal data, and mandates that companies which transfer or collect such information be registered with independent national data authorities. Adequate data management practices (including companies guaranteeing security of data against unauthorized access) are required, with potential sanctions ranging from fines to criminal penalties in some member countries.

Another European piece of legislation pertaining to digital identity management is the EU Convention on Cybercrime, which entered into force in 2001. It is the first international treaty on crimes committed online, dealing with computer-related fraud, child pornography, violations of network security, and intellectual property issues.

While privacy in general, and specifically individual data privacy is considered an important issue in the US, federal regulations about it are few, and mostly focused on the public sector, with the private sector left to undergo self-regulation. The most important of all federal laws, Health Insurance Portability & Accountability Act (HIPPA), security compliance with which is required on April 20th 2005, protects an individuals' medical data from disclosure to unauthorized parties and charges medical record holders, such as hospitals, with protecting this information. Another piece of legislation pertaining to individuals' data is the Fair Credit Reporting Act, which allows consumers to have yearly access to their credit information collected by three major credit agencies, and to opt-out of receiving credit card and insurance offers based on their credit score for five years (there is no opt-in option to begin with). Another piece of legislation, the Family Education Rights and Privacy Act, allows students and their parents the right to access a student's educational records. The Cable TV Privacy Act allows TV viewers to limit disclosure of their mail address for solicitation purposes by opting out. The Driver's Privacy Protection Act protects individual information collected by DMV's, the Video Privacy Protection Act allows individuals to opt out of profiling of their viewing habits, the Children's Online Privacy Protection Act requires "verifiable parental consent" to data collection from children (the latter at the moment can be limited to the company sending an email to the address provided as "parental" in the initial data collection form), and the Electronic Communications Privacy Act prohibits unauthorized access to electronic communication, including communications in transmission. Overall, the protection of personal data in the US is regulated by a mosaic of federal, state, statutory and case law, without any overarching comprehensive legislation.

On the other hand, there is a significant legal momentum in the US for the government to employ biometrics as unique identifiers for, first of all, non-citizens seeking entry into US (Sec. 403(c) of the USA-PATRIOT Act, The Illegal Immigration Reform and Immigrant Responsibility Act of 1996, Enhanced Border Security and Visa Entry Reform Act of 2002, Sec. 303(b)(1), requiring use of biometric identifiers for aliens by October 26, 2004) and secondly, citizens (Personal Responsibility and Work Opportunity Act of 1995 (PRWOA), a welfare reform law covering, for example, the

Food Stamps program; the Truck and Bus Safety and Regulatory Reform Act of 1988 (TBSRRA) requiring "minimum uniform standards for the biometric identification of commercial drivers.")

2.1.6. Biometrics in Digital Identity Management.

There are several reasons why I had to consider biometrics as a separate issue in the domain of digital identity management. First of all, biometrics-based identification is highly liable to digital handling and interfacing with databases. Secondly, it raises intensely debated social controversies whenever it is applied on a large scale, e.g. nationally or internationally. Third of all, biometrics-based technologies are unique identity management tools, which offer unique advantages over all other identity management architectures. In this section, I will cover the unique features of biometric systems and show how they are covered in the ontology. I will also provide justification for the choice of the corpus covering this aspect of Digital Identity Management.

First of all, what is included in the area of biometric-based identity management? Dr. Wayman, the director of the National Biometrics Test Center, offers the following definition for biometrics (Wayman, 2005): “The term "biometric authentication" (which is what we take to be biometric-based identity management, though not necessarily authentication - EM) refers to the automatic identification, or identity verification, of living individuals using physiological and behavioral characteristics.”

Biometrics-based technology is unique in terms of being able to accomplish the task of negative identification, i.e. establishing that the person/user does not belong to a certain group of people (e.g. criminals in the law-enforcement database), or, as Dr. Wayman puts it, “To prove you are not who you say you are not.” Since no specific identification has to be issued by the individual in order to use a “negative identification” biometric-based system, it is widely applicable, so long as the issue of trust is resolved (in other words, it is established that the biometric sample collected for the purposes of negative identification does not remain in the database). Positive identification (i.e. establishing that the individual does belong to a specific limited group of people) can, on the other hand, be accomplished using other technologies as well.

Historically, the first biometrics-based identification method was signature collection. In the course of its use, a signature has come to be regarded (legally as well as commonly) not only as authentication method, but also as an authorization tool. The latest technologies of biometrics-based identification are much more varied, including voice- and fingerprinting, hand- and face-geometry systems, DNA sampling, gait and keystroke dynamics, iris and retina scans, etc.

The two main benefits of using biometric identification are:

- reliable identification of individuals without using any specific forms of ID or prior data collection;
- difficulty of identity fraud. As to whether identity fraud is at all possible with wide use of biometrics-based technologies, remains to be determined; the idea of its possibility, however, was already entertained at least by Hollywood (movie "Gattaca", 1997).

However, the benefits are, at the present moment significantly outnumbered by social, technological and legal concerns regarding specific implementations of biometrics-based identification systems. The following problems have been cited by various researchers and organizations:

- since biometrics-based technology is inherently individuating, it can also be very damaging where privacy is concerned (this pertains to technologies such as fingerprinting, which guarantee reliable identification), and has a "chilling effect" on social and political activity in the society;
- biometrics-based architectures are only as thorough as is their initial enrollment – the strength of identification depends entirely on the database with which comparison is conducted (thus biometrics does not necessarily eliminate a possible problem of identity fraud);
- not all biometrics necessarily apply to every individual (with the obvious exception of DNA-sampling), and thus a biometrics-based identification architecture can be discriminatory; this problem becomes significant when a system is applied on a large scale;

- biometrics-based identity management is, by default, digital, since the technology involved requires data processing; any such technology interfaces easily with databases, and thus data mining becomes a major concern. "Social surveillance" from the government, as mentioned in section 2.1.1., if a national biometrics-based positive identification architecture is implemented, becomes too easy to accomplish and difficult to resist on a part of an ordinary citizen. (In non-democratic countries, biometrics is currently the most promising approach to total governmental control of the citizens.)
- Voluntarity of providing some of the biometric data is not necessary. It can be "grabbed" without individual's knowledge or prior consent: this includes fingerprints, voiceprints, and face geometry. Other biometrics, such as signature, are easily obtainable due to their pervasiveness in everyday transactions.

As William Abernathy and Lee Tien (2005) note on Electronic Frontier Foundation's web site, "In today's public arena, biometric technologies are being marketed as a "silver bullet" for terrorism; however, very little independent, objective scientific testing of biometrics has been done. Deploying biometric systems without sufficient attention to their dangers makes them likely to be used in a way dangerous to civil liberties."

Besides social concerns, there are also technological aspects to be considered in the implementation of biometric systems:

1) whether the user surrenders biometric data willingly and easily (due to custom, as in with signature, or due to ease-of-capture, as with voice, fingerprints, and face geometry) or the biometrics requires consent for collection, since the task is obtrusive.

I have considered using this as a parameter for the ontological description of biometrics-related concepts and have reasoned against it on the basis that the technology might change, and some implementations of data collection might be less obtrusive than others.

2) how unique the biometric identifier is; this is based on two parameters – how much the data changes (DNA does not; voice print might; signature does change, but is still traceable).

Both of these parameters are represented in the ontology, by way of UNIQUENESS for the first and INVARIABILITY-ATTRIBUTE for the second, e.g.

```
(DNA-SAMPLE
(DEFINITION (VALUE ("a physical quality of DNA that can be used to identify a
human ")))
(IS-A (VALUE (BIOMETRICS))
(IDENTIFIES-WHAT (SEM (DEAFULT (USER-COMPUTER) RELAXABLE-TO
(HUMAN))))
(ORIGIN (SEM (DNA)))
(INVARIABILITY-ATTRIBUTE (VALUE (1)))
(UNIQUENESS (VALUE (1)))
)
```

As to the classification of biometrics-based technologies, there have been multiple dimensions offered for consideration in technology assessment. Dr. James Wayman, director of the National Biometric Test Center at San Jose State University, offered to use the following features for classifying biometric information in the population (Wayman, 2005):

- Robustness: repeatable, not liable to significant changes (cf. INVARIABILITY-ATTRIBUTE in ontology).
- Distinctiveness: there are significant differences in the pattern among people. (cf. UNIQUENESS in ontology).
- Accessibility: easily presented to an appropriate sensor (not used in the ontology, since conceptual properties depend on the interaction of biometric information and the sensor, and can vary significantly).
- Acceptability: perceived as non-intrusive by the user (not used in the ontology, due to lack of research information).
- Availability: a user may present more than one independent measurable feature (not used in the ontology, as it is dependent on system architecture).

Dr. Wayman also suggests characterizing biometric applications in terms of such variables as cooperative vs. non-cooperative, overt vs. covert (refers to user being aware of sampling being performed), habituated vs. non-habituated (used for human factor

analysis), attended vs. non-attended (also human factor), public vs. private (as to whether the application is used for employees, or public), open vs. closed (pertains to data safety). However, these being application-specific, did not apply to the conceptual formulations of biometrics-based technologies and therefore were not used for the ontology.

Since the main problem with all information-token identification techniques is the possibility of sharing those tokens, and biometric techniques, even the least precise ones, solve this problem easily, there have been many attempts to combine biometrics with other identifying techniques for more precise user identification. This also allows controllers to set a high threshold for error in the biometric system and still achieve better result in overall identification. Some examples of this include the use of keystroke dynamics combined with passwords in the parental control software NetNanny, or a combination of password and hand-geometry in systems where token-sharing is a significant disadvantage (implemented in San Diego State University Recreational Center and University, Georgia Food Service Center; under testing at Purdue Recreational Sports Center) .

As Wayman (2005) reasons: "…the use of passwords, PINs, keys and tokens carries the security problem of verifying that the presenter is the authorized user, and not an unauthorized holder. Consequently, passwords and tokens can be used in conjunction with biometric identification to mitigate their vulnerability to unauthorized use."

The organizations concerned with various aspects of the use of biometrics-based technologies include non-profits (Biometrics Consortium, Electronic Frontier Foundation, National Biometric Security Project), businesses (Precise Biometrics, BioPassword, Cognitech, Florentis, Ingersoll-Rand, etc.), US government agencies (Department of State, Biometrics Consortium), international organizations (OECD), and research institutions (International Biometric Society, US National Biometric Test Center). Each "agent-type" has to be represented in the corpus used for the biometrics sub-domain representation in the ontology.

2.2. Ensuring validity of the corpus: source variability in the "storming" domain.

From the aspect of ontology acquisition, the literature and conceptual white papers on digital identity management serve two purposes – first of all, they provide the

necessary clarification to emerging concepts in the field and validate the most important ones. They are easy to spot, since values such as “anonymity”, “privacy”, “security”, and “traceability” appear across the literature in the field; while authors differ in making value judgments upon them, the concepts which contribute to the understanding of digital identity management are made clear. Also the DIM literature is a source for corpora – both for the lexicon and ontology – provided that we can ensure cross-validation of both the use of lexical items and concepts in the field through the use of multiple sources. One of the problems, which an acquirer faces in such a rapidly developing field as digital identity management, is the need to distinguish emerging concepts and cross-applicable vocabulary from the lexical items invented ad-hoc (and not very meaningful) by vendors and researchers, which will not be used by anyone else[1].

It is important to keep track of from where the particular corpora are coming. The rhetoric used in the corporate world is different from the one used by governmental organizations, and that is still different from the one coming from non-profit organizations (overtly partisan), international organizations, and academic research. Also, depending on the aspect of digital identity management in question, the interests and goals of the various agents in the field might change. For instance, it is difficult to find anything on psychological issues arising from the use of digital identity, outside of academic research – at the moment, it is simply a non-controversial topic. The use of biometrics, however, is the subject of heated debate and is viewed (and described) very differently by businesses providing biometric technology, government interested in crime prevention, and NGOs protecting the rights of citizens. The difference is not simply the terminology (which can be, in some cases, quite similar), but the attention to particular aspects of transactions involved in digital identity management. From the linguistic standpoint, however, the interest lies in accurate semantic and world-view-information descriptions of all the terminology pertaining to the domain (which involves the

[1] I would like to point out that, while aware of methodologies and approaches developed by corpus linguistics, I did not expect any to be particularly useful for the current undertaking, which consisted, for the most part, of building ontological semantic resources. Thus, I have refrained from using any specifically, and have closely followed the goals of resource development (and corpus processing needed for it) instead.

ontological support hierarchy and "peripheral" terms, which, even if not overtly present in a particular text, surface in the semantic description of the domain).

2.3. Delimiting the corpus: source-topic variability matrix.

For the above reasons, I have constructed the topic-source variability matrix, which deals with all aspects of digital identity management. The top row (sources) represents the agents involved in a particular topic. The topics are represented by the vertical left column, and cover all aspects of digital identity management. Note, that "biometrics and its usage" was separated into a topic in itself, since this is one of the most controversial topics in the digital identity management domain, and includes (unlike some others) all possible actors as corpus sources.

In the matrix, I strived to fill in every topic-source intersection. Some did not have any sources available (e.g. the psychology of deployment of digital identities has not yet become a focus of attention outside of academia and preliminary business research by IBM). Others were represented by more than one organization.

Table 1. Corpus-based approach to lexicon acquisition: source-topic variability matrix

Source **Topic**	**Non-profit organizations**	**Business and industry groups**	**US government agencies**	**International organizations**	**Academic research**
Biometrics and its usage	Biometrics Consortium; Electronic Frontier Foundation; National Biometric Security Project	Precise Biometrics, BioPassword, Cognitech, Florentis, Ingersoll-Rand	US Dept. of State; Biometrics Consortium	OECD, Council of Europe	International Biometric Society; US National Biometric Test Center
Psychology of digital identity deployment	Identity Theft Resource Center	IBM	NA	NA	Sherry Turkle
Technical implementation of	W3C, ThePrivacyPlace.org,	Liberty Alliance; IBM; RSA		OECD, IEEE	Mike Atallah

identity management schemes	Association for Automatic Identification and Data Capture Technologies	Security; Motorola; VeriSign			
Economic viability of identity management schemes	TRUSTe	Microsoft, Siemens, Applied Digital	Federal Trade Commission	OECD	Mills
Social aspects of using various DI schemes	Consumer Professionals for Social Responsibility, Electronic Frontier Foundation, Electronic Privacy Information Center	Liberty Alliance, Microsoft	NA	United Nations, The Global Internet Liberty Campaign	Howard Sypher
Legal aspects of DI usage	American Civil Liberties Union, Electronic Frontier Foundation	RSA Security (advisory)	US Department of State, Federal Trace Commission	United Nations	Lawrence Lessig

2.4 Corpus-based pre-acquisition methodology.

2.4.1. Two-prong approach to acquisition methodology

2.4.1.1. Overall considerations in domain acquisition.

There are several important considerations in new domain acquisition that the acquirer must face and solve during the process.

The first one is the question of how to keep the ontology for the domain consistent with the rest of the ontology, which is already available. The ontology, as described in Chapter 1, is built so that it can potentially accommodate any domain;

however, it sometimes becomes necessary to add new properties (while keeping the overall number of properties down and avoiding cumbersome concept representations in the lexicon) or to introduce new categorical divisions inside ontological branches.

The second important question is which concepts need to be added to facilitate lexical acquisition for the new domain; the "justification" principle.

Since the goal of quality acquisition is to use the minimal number of concepts, simply proliferating the ontology is very rarely the answer to domain acquisition. Once the most necessary conceptual framework for the domain has been "fleshed out" in ontological concepts, the rest of the work is necessarily based on adding new lexical items to the domain. Also, lexical items are the ones that are directly available from the corpus, as opposed to concepts, which need to be determined on the basis of their general contribution to the ontology (this is especially true for properties, due to their specificity, as described in section 1.6.1.3 of Chapter 1) and further placed within the ontological hierarchy.

2.4.1.2. Drawing the line between lexical and ontological items during acquisition.

The third question, and the one that often has to be solved during the acquisition process, is how to delimit the boundary between an ontological and lexical item, which need acquiring. Is an item sufficiently different conceptually to be introduced as an ontological item, or can it be kept to the domain of the lexicon? This question, pertaining to the parsimony of the ontology, for the purposes of the present work is solved on the basis of the following criteria:

1) Introduction of the new concept is justified, if it can be used for other lexical items besides the one in question;

2) Introduction of the new concept is justified, if it can be used for other ontological items;

3) The grain size of the semantic description that the present system is aiming for is smaller than the current ontological description and further specification is needed, so introduction of the new concept is justified for reasons of granularity of semantic description;

4) Alternative methods of semantic description of a lexical item involve concepts which are not members of the ontology either and also need to be added;

5) Criteria 1 and 2 (general applicability of the concept to ontological and lexical descriptions) are in favor of the previously considered concept.

If most of the following criteria are applied and resolved in favor of the concept, it is then added to the ontology. Otherwise, the lexical item in question is specified through already-available concepts in the ontology. An example of this algorithm for solving a complementarity problem is the number of lexical entries for educational degrees, e.g. Bachelor of Science:

```
(BACHELOR-OF-SCIENCE
 (BACHELOR-OF-SCIENCE-N1 (CAT N)
(SYNONYMS “BS, BS degree”)
  (ANNO
   (DEF “an educational degree granted for the successful completion of a college
program in science.")
   (EX "") (COMMENTS ""))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
  (SEM-STRUC (SEM (EDUCATIONAL-LEVEL
  (FIELD-OF-STUDY (SEM SCIENCE))
  (YEARS-OF-EDUCATION (VALUE > 15))))
))
```

Other educational degrees are defined similarly. Here, instead of introducing new concepts for educational level (a PROPERTY pertaining to humans, which is still another motivation to restrict conceptual proliferation), we have specified the lexical item sufficiently for preserving all the semantics of the expression, and avoided introducing a new concept. So far, it was not considered necessary to restrict the application of the lexical item to the educational system in the United States, although this is also possible.

It can sometimes be necessary to drastically limit the size of the ontology in an application due to temporal (e.g. in a search engine) or storage (limited capacity in small devices) constraints. In this case, the constraints described above are tightened to allow for a consequentially semantically shallower ontological description. However, the present work was not restricted by such constraints, and is mainly driven by the justification principle of the ontology, and the following reasoning from Nirenburg and Raskin (2004: 161):

> "…having the complete description of a world as its main objective, an ontological semanticist will not have the motivation or inclination to spend time on searching for the smallest set of basic concepts that could be combined to provide a complete description of the world. Parsimony is desirable and justified only if the completeness and clarity of the description is not jeopardized. Indeed, parsimony often stands in a trade-off relation with the simplicity of knowledge formulation and ease of its manipulation. In other words, in practical approaches, it may be well worth one's while to allow larger sets of primitives in exchange for being able to represent meaning using simpler and more transparent expressions. It is clear from the above that we believe that, as in software engineering, where programs must be readily understandable by both computers and people, ontological (and other static) knowledge is an ontological semantic system must be readily comprehensible to people who acquire and inspect it as well as to the computer programs that are supposed to manipulate it."

2.4.1.3. Lexical acquisition for a new domain.

Nirenburg and Raskin (2004: 274-280) describe two main approaches to lexical acquisition. The first one is "rapid propagation", where a single template is used for a large lexical class of items (e.g. phrasal verbs in English) with minimal modifications for each item – different ontological connection and a few modified property slots at most. The second, "lexical rules" approach is based on the systematic relationships between classes of lexical entries, such as derivation (e.g. the verb *abhor* and the adjective *abhorrent)*. Then, the rule is to formulate the lexical meaning of entries as identical, but modify the syntactic structure and valencies (this approach does not always allow for an easy acquisition solution; cf. *criticize/critical*).

Corpus-driven methodology, in which lexical items, specific to the domain, are extracted from a collection of texts, is the third approach, and the most applicable to the case in hand. While it is possible to employ the "lexical rules" acquisition in some cases (anonymity/anonymous, etc.), in general the field of digital identity management has rather a varied vocabulary, and does not lend itself to this method.

Based on the corpus, as discussed above, I had to make methodological decisions on how to best approach acquisition. First of all, it was clear, that it would be necessary to introduce new properties to the ontology in order for the entries to specify the pathways of information exchange before starting corpus-based acquisition. Secondly, it was immediately obvious that the entire domain of "virtual world" was not represented in the ontology and had to be added before further acquisition was possible. Besides these

two major necessary additions to the ontology, there was an apparent need for the description of hardware and software involved in digital identity management. Thus, I have made the decision to use a two-pronged approach to lexical and ontological domain acquisition: concept-based initial acquisition (including adding new properties) followed by corpus-based acquisition.

2.4.1.4. Pre-acquisition methodology

Before acquisition of ontology and lexicon for the domain can begin, it is necessary to create the basic structure for the ontological sub-trees and determine the lexical items that need to be added. Table 2 contains the flowchart for pre-acquisition methodology.

Table 2. Methodological approaches to domain pre-acquisition.

Top-down methodology	**Bottom-up methodology**
1. Delimit **the corpus**, dealing with all the aspects of DIM (topic-source matrix). Split it in two parts for validity check?	1. Run an item from each square of the source matrix **corpus through the available lexicon** and filter out lexemes that are not available yet
2. Map out an ontological tree for the most important concepts for each subdomain; establish the **necessary properties** for the domain overall and acquire those that are not already in the ontology	2. **Sort the lexical items** as to whether they belong to Digital Identity Management domain.
3. Create ontological **sub-hierarchies** needed to support subdomains	
4. Decide on **multi-word expressions** (phrasals) necessary for the vocabulary.	3. **Acquire** lexical items. Add non-domain lexical items to "IOU"/common word-stock list (also used for running the corpus through).
5. Check for **multiple meanings** of available items in the lexicon, so that the senses in DIM be represented	4. If necessary, expand the corpus (2, 3 items from each source-topic) for another **validity check**.
6. Result: ontological hierarchy and lexicon for Digital Identity Management domain	

Let me elaborate on the reasons for and outputs of each step in pre-acquisition methodology.

2.4.2. Top-down (ontological necessities) methodology.

The top-down acquisition involved, first of all, adding new properties to the ontology. The property list is the one that, on one hand, allows for a rigorous description of concepts in the ontology, but on the other hand has to be limited in size for the purposes of thorough description. The acquisition of properties is driven by both the question of grain size for the ontological description and the need for deep semantics in the description of lexical and ontological entries. However, it is advantageous for the list to be limited, both for the purpose of non-proliferating limited-use concepts, and for the ease of any future acquisition effort. Thus, the list of necessary attributes and relations needed for the description of a domain is the first one on which a decision has to be made.

The properties I have added for the purposes of DIM domain acquisition are listed in Table 3. (The table only lists the hierarchical representation for the structure of the sub-trees; the full representations for these ontological items are given in Chapter 4).

Table 3. Ontological hierarchy for digital identity management.

Properties…
- …object-relation
  - Representational-information-relation
    - has-identifying-information
    - collects-identifying-information
    - stores-identifying-information
    - requests-identifying-information
    - matches-identifying-information
    - issues-identifying-information
    - identifies-what
  - inverse-representational-information-relation
    - identifying-information-issued-by
    - identified-by
    - furnishes-identifying-information
- …scalar-object-attribute
  - invariability-attribute (0 to 1 (constant))
  - authenticity (0 to 1 (likelihood of being unaltered self))
- …literal-human-attribute
  - has-eye-color
  - has-hair-color
  - user-identifying-attribute
    - temporary-user-attributes
      - geographical-location

avatar
email-address
address
phone-number
knowledge-token
PIN-number
username
password
constant-user-attributes
biometrics
retina-scan
iris-scan
finger-print
voice-print
foot-print
DNA-print
hand-geometry
saliva-sample
signature
keystroke-dynamics
facial-geometry
gait-attribute
documentary-user-representations
passport
visa
state-ID
driver's-license
PGP-signature
insurance-number
social-security-number
…literal-object-attribute
birth-day
birth-year
birth-month
birth-date
social-role-attribute
marital-status
educational-level
race
income-level
group-membership

Besides those properties, I have also made additions to the representational-objects branch, and created a virtual-environment branch. Plus, some minor additions

were needed among information-appliances and software. Both of these additions are a part of the third step in ontological acquisition, creating sub-hierarchies in order to support subdomains. Table 4. lists the necessary additions to the subdomain in hierarchical order (again, full ontological scripts for these items are presented in Chapter 4).

Table 4. Ontological hierarchy for digital identity management.

…representational-object…
identifying-information
URL (for web-pages)
timestamp
document-identifying-information
document-number
document-expiration-date
document-issue-date
software-identifying-information
serial-number
digital-certificate
hardware-identifying-information
serial-number
SIM-card-number
IP-address(for computers)
static-IP (unique)
dynamic-IP (non-unique)
storage-device
semiconductor-storage-device
FLASH-memory
bios-chip
smart-digital-card
information-appliance
smartcard
SIM-card
smartphone
palmtop
mobile-computer
palmtop (palm-pilot, palm, PDA)
laptop
identity-establishing-hardware
reticle
fingerprint-sampling-unit
utility-corporation
Internet-service-provider
software
program-types

adware
spyware
malware
middleware
shareware
P2p
financial-object
debit-card
credit-card
gift-card
identity-issuing-organizations (organizations, and specify issues identity)
DMV
embassy
department-of-state
social-security-administration
virtual-environment
newsgroup
online-forum
online-store
chat-programs
chatroom
internet-relay-chat
instant-messaging

It is worth noting that some subdomains (e.g. legal subdomain, organizational structure subdomain, encryption branch, properties necessary for descriptions of humans, etc.) in the ontology were sufficiently developed, and I did not have to expand them immediately for the purposes of the domain. This did not mean that there were absolutely no additions or changes to be made to them, but only that those were made only on the "have to" basis, when the conceptual representation (e.g. for the encryption branch, as presented in Chapter 4) turned out to be of lower-than-intended grain size or lacked important members (e.g. STORAGE-DEVICE branch, representing various types of computer-used memory devices; also see Chapter 4).

The last step in ontological acquisition was to check on whether all necessary meanings of lexical items were represented in the items already in the lexicon. The filtering program (described in section 2.4.3.) used for corpus-based pre-acquisition was not intended for the creation of text meaning representations, so in the absence of an analyzer it was necessary to check that each lexical item in the lexicon had its meanings

for the domain listed in its semantic description, and tied to the ontological concepts necessary for the domain. This step could be done at any time, even after corpus-based (bottom-up) acquisition, and it concluded the top-down process of domain acquisition.

2.4.3. Bottom-up (corpus-based) pre-acquisition methodology

In order to extract the lexical items from the corpus, I wrote a small program that runs the corpus (one article at a time) through the already-existing lexicon. It also does minimal morphological analysis, eliminating some of the morphological forms of existing words (regular past tense, present tense singular and participles for verbs, plural for nouns). Admittedly, from purely linguistic standpoint that is a somewhat problematic approach. For example, the word "caring" would be filtered out in the first cycle of the program on the basis of whether the character string without the –ing suffix existed in the lexicon ("car"), which is, of course, the wrong lexical item; and only the second cycle takes into account the spelling rules for morphology. However, the main purpose of the program is to keep track of already-acquired lexical items, so I did not attempt to solve these problems, and relied on the fact that most of the items in the domain of digital identity management are more complex entries (longer words or even idiomatic expressions) not prone to this "hole" in the filtering algorithm.

The output of the program is a file with all the words that were not found in the main lexicon or "common words" file. The "Common words" file at the moment contains: all contractions (isn't, it's, etc.), ten sed irregular verbs, pronouns, conjunctions and other closed-class lexical items that will eventually be processed by the analyzer and contribute to text meaning representation. For the purposes of the present work, I keep them filtered out, since I aim to acquire the vocabulary and ontology for the domain.

The lexical items from the output file are consecutively sorted into "domain" and "non-domain" items. It is a flexible division, based on the following criteria:

1) Can the lexical item be ontologically described using the properties added for the domain of digital identity management? (using for example, the representational-information-relations described in section 2.4.2.)

2) Is it conceptually related (at least in one of its senses) to the lexical items already acquired? (e.g. “odor” was necessary for the domain of biometrics).
3) Does it appear more than once in the articles pertaining to the domain?
4) Does it contain semantic information belonging, fundamentally, to text meaning representation (e.g. irregular tensed verbs or some adverbs), in which case the lexical item has to be processed by the analyzer and does not have to be a part of the lexicon?

If the answer to the first three questions is positive, the item is resolved as belonging to the domain and is acquired, unless the answer to the last question is also “yes”. In all other cases, the item is relegated to the “common words” file, and consequently “filtered out” of the corpus.

Acquisition of lexical items is thoroughly explained in Chapter 3 and presented in Chapter 4, and I will not dwell on it in the present section.

The last step of the corpus-based approach is the validity check for the domain. Optimally, it would be best to ensure that all the lexical items occurring in the domain are accounted for in the lexicon. However, receiving an “empty output” file from the filtering program is problematic for two reasons:

3) The morphological analyzer is not sophisticated enough to account for all of English morphology;
4) The common word-stock of English is sufficiently varied, especially across subdomains, so that unaccounted-for common words do surface in a large enough corpus.

The main purpose of the filtering program is to aid in lexical acquisition, and not prove that the domain is sufficiently covered. For the purposes of the present work, I rely mainly on the topic-source matrix to provide reliability for domain coverage. The other important measure of validity in lexical and ontological acquisition is the coherence of the domain in the ontology and deep semantic description of lexical items belonging to the domain. These questions fall into the purview of the following chapter.

CHAPTER III.
ACQUISITION: THEORY AND TEMPLATES

3.1. Predication in OS: events as fundamentals of text meaning representation

The main function of all static and dynamics sources of ontological semantics is construction and manipulation of TMR, or text meaning representation. The TMR is constructed by means of processing a natural language text with the analyzer, and using the available lexicon (or lexicons) and ontology in order to construct representations of predicates, centered around sentence-level predication. Thus, the verbs in the sentence serve as "crystallization points" for the rest of the information contained in the sentence. The process is described in detail in sections 6.2 and 6.7 of Raskin & Nirenburg (2004). In this chapter, I focus mainly on what information the static resources (ontology and lexicon) need to contain in order to best facilitate TMR creation, and how that information is introduced in the templates for lexical items or ontological concepts (as I have mentioned in Chapter 2, and will show later in this chapter, the semantic representations in the lexicon and the ontology are complementary, and there is no clear-cut distinction as to whether a particular piece of semantic meaning needs to be represented in either one – outside, of course, the non-proliferation requirement for ontological representation). In my description of event structure, I am following the spirit of Raskin and Nirenburg's treatment of adjectives for ontological semantics (1995), dispensing with some parts of the theory of event structure that are not useful for applying practically, and focusing on the parts that can yield practical advances to the system.

Section 3.1. deals with argument structure (including case roles introduced in the ontology and used in the present work) and noun templates. In section 3.2. I lay out the treatment of predication in ontological semantics, focusing mainly on event structure representation, the verbs and their templates (even though the verbs are not the only source of predication in language or in ontological semantics). Section 3.3. covers adjectives – both as modifiers and sources of predication, where I follow Raskin (1995), and their possible templates. Finally, section 3.4. is a case study of ontological acquisition, complete with the algorithm for the decision-making process and examples from the digital identity management domain.

3.1.1. Expression of primary and secondary predication in Ontological Semantics

As will be obvious from the templates for various parts of speech described below, predication serves as the central point for creation of text meaning representation using the static resources of ontological semantics. Each sentence is processed based on its propositional structure, where predication plays a central role. Both primary (in English, predication expressed by the main verb) and secondary predication (e.g. adjectival description of objects, use of resultatives and depictives, etc.) serve as sources of "crystallization" for the rest of the sentence, when possible candidates for filling in propositional templates are checked against the possible meaning representations for the TMR template, and the best candidates are chosen to fill each meaning-slot in the TMR. Raskin and Nirenburg (2004: 212) describe the process as follows:

> The initial big step in semantic analysis is building basic semantic dependencies for the input text. Proceeding from the lexical, morphological and syntactic information available after the preprocessing stage for a textual input, on the one hand, and an empty TMR template, on the other, we establish the propositional structure of the future TMR, determine the elements that will become heads of the TMR propositions, fill out the property slots of the propositions by matching case role inventories and selectional restrictions on sets of candidate fillers.

At this point, it would suffice to note that the templates and rules for all representations in the lexicon and ontology are driven by the need to eventually establish the basic semantic dependencies, and this is the reason for which we strive to represent the semantics and semantic valency of each word and expression as thoroughly at

possible. While the procedure for building semantic dependencies uses the specifications offered in static resources as defeasible constraints (especially when the basic procedure returns no result), those constraints are still the main resource for the construction of TMR, and should be expressed thoroughly.

3.1.2. Event structure in semantic descriptions for ontological semantics

I propose a general addition to the structure the of acquisition of verbs, which would cover event structure. The change does not entail any significant changes in the processing of the acquired lexicon, or to the fundamentals of ontology; however, it provides for more rigorous processing of sentential propositional structure. This rigorous description can be achieved by categorizing verbs into event structure types with corresponding syntactic-semantic processing templates.

The fundamental purpose of the ontological description of the semantics of lexical entries lies in the closest possible "description" of a real-world event. That involves pre- and postconditions, effects, end-points, etc. There is a vast body of theoretical work in event structure (Pustejovsky 1991 and 1995, Levin 1993, Ramchand 2003 etc.). While some of the above-mentioned approaches are purely syntactic, and others tend to a more cognitive-based description, they all converge on the distinction of event types, even if they differ in the final inventory of those types. Using the efficiency vs. depth of a semantic description measure as a basis for the decision, I would like to suggest the following schema for event description for use in this work.

The typical event type taxonomy, described in the above-mentioned literature, deals with 4 event types: state (S), process (P), achievement (a process terminating in a state, P → S), and accomplishment (a state change S→ S). From the point of view of real-world knowledge, it is important to retain the information as to whether the final state was achieved ("He almost climbed the mountain"), in what state the theme (or undergoer, in Ramchand's terms) of the event exists after the event itself is completed ("He painted the house red"), and whether the event itself had a completion point (is telic) and a result or not (cf. "I wiped the table for 5 minutes" and "I wiped the table clean").

Processes and states, from the point of view of event structure, are not very different – they are homogenous events, with the exception of one of them being static (state), and the other one being dynamic. Raskin and Nirenburg (2004) mention that the possibility of a high-level ontological differentiation between those was discussed in one of the implementations of the ontology, but subsequently dropped due to the fact that information about the type of homogenous event did not contribute any relevant distinctions to the text meaning representation processing capabilities of the system.

Accomplishments and achievements, as non-homogenous events, on the other hand, are more complex and share several important traits:

1) they consist of more than one part, the initial state or process being a necessary precondition for the resultant state;
2) they can be telic (finished) or atelic;
3) when finished, they result in a certain state for the undergoer of the event, which is sometimes overtly specified in the sentence ("wiped the table clean"), and sometimes is only assumed (e.g. table being clean would be an implied result of wiping it, unless specified otherwise : "She wiped the table, but it was still dirty").

I suggest the following extensions to the ontological semantics treatment of the verbs:

1) differentiating between processes and states on one hand, and accomplishments and achievements on the other;

2) using explicit templates (provided below) for rigorous treatment of accomplishments and achievements. These templates allow one to keep track of what goes on before (using the ontological concepts of PRECONDITION-OF and PRECONDITION) and after the state change (using the concepts of EFFECT and more rarely OUTCOME), and thus allow the processing system to both "remember" and "imply" the result of achievement and accomplishment event types.

I would like to make a disclaimer here, that I am not suggesting that the event structure encoded by the verb is the only possibility to express the result end-point. For instance, Filip (2000) and Van Hout (2000) note, that only quantified noun phrases can serve as end-point themes: cf. "I ate the fish" and "I eat fish every day". Also, the 'path

PP or a location /goal', when present in the structure of the verbal phrase, facilitates a "change of state", or "telic" reading, e.g. 'John ran along the river' (atelic) and 'John ran to the store'. In syntactic-based approaches to language, Van Hout (2000) and Borer (2001) go as far as suggest a feature [+ telic] to be checked only by quantified noun phrases.

Given the above, I maintain that while quantization (for languages such as English) or use of grammatical case (e.g. in languages like Finnish and Russian) are important for processing event types, in an ontological semantics approach to natural language processing they can be relegated to the stage of dynamic analysis, and processed on a language-specific basis. However, the event structure as pertains to verbs, especially homogeneous/non-homogenous event dichotomy, needs to be present in the static resources, and in some cases raised to the level of ontological representation.

3.1.2.1. Implicature processing using event structure

One of the useful consequences of the thorough event-structure-based semantic description of the predicates is the fact that such description is necessary for processing one of the types of implicature. Consider the following example: "I downloaded the file". In order for a complex processing to take place, the system has to "know" not only what the process of downloading is, but also what it entails – in our case, a change of state from "lack of possession" of the file to "possession", with the agent owning the file as a result of this event. If this information is available to the system, it can appropriately keep track of the file for use in script-based processing of situations. A template for complex events that would contain this information is sufficient to cover the notions of both telicity and resultativity.

The achievement of the end-point (in general terms), or the realization of the existential modality of the EFFECT (in ontological terms) can, of course, be modified or blocked in a sentence all together. For example, in processing the sentence "I almost downloaded the file", the modality, contributed by "almost", renders the sentence non-complete from the point of view of telicity, and marks the "possession" EFFECT of the event unrealized. Thus, the use of event-based verbal templates allows for a more thorough semantic processing at a later stage.

3.1.3. Verb templates in the lexicon and their modifications.

I have already introduced some examples of lexical verb entries in sections 1.6.2.3. and 1.6.2.4., so I would just like to offer a generalized version of a verbal template at this point. A generic template for a lexical entry of a verb would look as follows:

```
(lexical-item
(lexical-item-V1 (cat V)
(synonyms "")
(anno  (def "")
(ex "")
(comments ""))
(syn-struc
(subject ((root $VAR1) (cat N)))
((root $VAR0) (can V))
(object ((root $VAR2) (cat N)))
(pp-adjunct ((root prep) (cat PREP)(obj ((root root)))))
)
(sem-struc (CONCEPT
(slot (facet filler)) // optional, used for case roles, etc.
(slot (value value))  //optional, used for scalar or binary property
)))
```

The head of the entry (line 1) is the lexical item itself. Since some lexical items have more than one meaning, and span more than one part of speech, all of these senses are united under one word. The second line tells what part of speech is described in this part of the entry. This is followed by the synonyms field (synonyms), including synonymical expressions, and annotation field (anno), containing definition (def), examples (ex), and comment field, which for verbs includes an indication of transitivity.

Syntactic structure (syn-struc) introduces the possible argument structure of the entry. For English, we rely mainly on word-order, in order to specify the syntactico-semantic connections. The words surrounding the verb (which is always given a 0-label, $VAR0), are assigned variable numbers. It does not really matter what those are, so long as the variables introduced in the syntactic structure are referenced and specified in the semantic structure as well. Usually, they are fit into the argument structure using case role assignment – i.e. each of the possible arguments introduced in the syntactic structure

is specified for its case-role, licensed by the verb, in the semantic structure field. Most typical case roles are AGENT (or PATIENT for non-agentive verbs) and THEME for transitive verbs; others are used as necessary (see section 3.2.1 on case role inventory and its use).

Syntactic structure allows for both direct and indirect (prepositional) objects, as shown above; there can be more than one potential indirect object (e.g. introduced by a different preposition).

The semantic structure of the lexical entry for the verb is determined by the event type, as discussed below; overall, there is one major concept, to which the entry is connected, and further specifications using other ontological slots.

I have incorporated the event-type structure information of the verbs in the digital identity management domain into their semantic descriptions. As noted above, process/state distinction is extant in ontological semantics, so for both of the simple event types I have used the basic structure.

In the semantic structure part of the entry, verbs of the English lexicon can be tied to various ontological concepts: EVENTs (the most frequent connection), PROPERTY, or can be mapped to MODALITY (e.g. the verb “to try”) or ASPECT (e.g. “to begin”). Since modality and aspect are addressed in sections 1.6.2.3. and 1.6.2.4., I will not go into detail here.

3.1.3.1. Templates for non-homogenous event types.

Non-homogeneous events, i.e. accomplishments and achievements, in widespread terminology, can be captured by means of ontological semantics in various ways. One of the ways already employed was the use of aspect: i.e. a non-homogeneous event can be interpreted as a beginning or ending of a process or state, for example:

```
(log-out
(log-out-V1 (cat V)
(SYNONYMS “sign off” “log off” “log out”)
    (anno  (def "to terminate a session on a computer, for which authorization is
required")
    (ex "I logged myself out and left the lab.") (comments ""))
(syn-struc
```

```
        ((subject ((root $VAR1) (cat N)))
        (root $VAR0) (cat V)))
(sem-struc (ACCESS-COMPUTER-NETWORK
        (ASPECT (PHASE FINISH))
        (AGENT (value ^$VAR1))))
))
```

Logically, there is nothing wrong with it. Moreover, in some cases – for example, in those phrasal verbs, where the particle represents an actual aspectual marker – this is a useful way to interpret the meaning of the lexical entry.

However, after careful consideration, I decided to make this interpretation marginal, and use it only if necessary. The rationale behind it was that if we do end up with aspectual marker on a non-homogeneous event like that (e.g. "I'm logging out; it's taking a while on ITaP computers"), then the analyzer would be in an unnecessary loop as to the interpretation of a conflicting double aspectual representation in the TMR. To avoid this, and to facilitate deep semantic representation, I decided to invoke the "event-switch tracing" mechanism provided by ontological semantics.

There are several event-relation concepts in the ontology, which are useful for relating events to each other in a causative manner. They are located in CONDITION-OF-CHANGE and INVERSE-CONDITION-OF-CHANGE branches. Both CAUSED-BY and PRECONDITION from the first branch tie together two simple events; in the case of CAUSED-BY, one event has to be an immediate cause of the other, PRECONDITION identifies an event that is a necessary condition for the occurrence of another.

From the second branch, EFFECT is defined as "the result of a causing act, state change, force application, etc."; PRECONDITION-OF is "the relation that describes a state or property that sets up the precondition" (so it can be used with both predicative types of concepts in the ontology). They are the inverse of CAUSED-BY and PRECONDITION-OF, respectively. OUTCOME, from the same branch, is less useful, because it connects an event with a mental object only.

I have chosen EFFECT and PRECONDITION as default (and most general, semantically) ontological connections for the first and second, respectively, parts of non-

homogeneous events. Other above-mentioned concepts can be used when the semantics of the verb requires it.

Since we are not making process/state distinction, this approach is intended to treat both accomplishments (verbs expressing changes of state) and achievements (in many cases, the end-point for the process is provided externally by the direct object). Examples for both are given below.

First, here is an alternative representation of the example given at the beginning of this section. The verb denotes a change of state, e.g. from being online to offline. Here is how the entry is treated under proposed approach:

```
(log-out
(log-out-V1 (cat V)
(synonyms “sign off” “log off” “log out”)
   (anno (def "To enter into a computer the command to end a session.") (ex
"After you are done working, log out to avoid a derf.") (comments ""))
 (syn-struc
          ((subject ((root $VAR1) (cat N)))
          (object ((root $VAR2) (cat N) (opt +)))
          (root $VAR0) (cat V)))
 (sem-struc (CHANGE-EVENT
          (EFFECT (sem BE-OFFLINE))
          (PRECONDITION (sem BE-ONLINE)
                   (AGENT (value ^$VAR1)))
                   (THEME (value ^$VAR2))))
))
```

For an achievement, e.g. “to type” vs. “to type a letter”, we need to specify a syn-struc that, in the presence of an object, would culminate the event in a resultant state of for the object. That is, while technically speaking, the object is optional for the verb, the type of event in the presence and in the absence of the direct object is different. Without the object, the event is a process; with the object, the event is an accomplishment, resulting in existence of the object:

```
(TYPE
(TYPE-V1 (cat V)
        (anno (def "To write (something) with a typewriter; typewrite. ")
        (ex "I type 50 words a minute.")
        (comments "intransitive variant"))
```

```
 (syn-struc
        ((SUBJECT ((root $VAR1) (cat N)))
        (root $VAR0) (cat V)
 (sem-struc
        (TYPE (AGENT (value ^$VAR1)))
        (AGENT (value ^$VAR1))
(TYPE-V2 (cat V)
(anno (def " To write (something) using a keyboard; typewriter")
        (ex "He typed all his letters on the computer")
        (comments ""))
 (syn-struc
        ((SUBJECT ((root $VAR1) (cat N)))
        (root $VAR0) (cat V)
        (OBJECT ((root $VAR2) (cat N))))))
(sem-struc (PRODUCE
        (AGENT (value ^$VAR1))
        (THEME (value ^$VAR2))))
        (MANNER (sem TYPE)))
))
```

Above, I describe the use of lexicon templates in order to specify the event type. However, as noted in section 2.4.1.2. above, the information about the semantic structure of an entry can be divided between the ontological concept that the lexical item is tied to, and its lexical template in the lexicon. Thus, when the ontological item that the lexical item (verb, in this case) denoting the even it tied to, is sufficiently specific in describing the event structure, we would not need to specify this further in the lexical template. For example, the verb “update” does not need event type specification in the lexicon, because the ontological item it is tied to, UPDATE, already contains the necessary information; cf. lexical and ontological entries given below:

```
(UPDATE
(UPDATE-N1 (cat N)
(anno (def “Information that updates something.”)
(ex "news update")
(comments ""))
(syn-struc ((root $VAR0) (cat N)))
  (sem-struc (INFORMATION
        (ADD-TO (THEME (sem INFORMATION))))
(UPDATE-N2 (cat N)
(anno (def “An updated version of software.”)(ex "news update") (comments ""))
(syn-struc ((root $VAR0) (cat N)))
  (sem-struc (SOFTWARE
```

```
        (THEME-OF (sem UPDATE))))
        (UPDATE-V1 (cat V)
 (syn-struc
          ((subject ((root $VAR1) (cat N))) (root $VAR0) (cat V)
         (object ((root $VAR2) (cat N) (OPT +)))))
 (sem-struc (UPDATE
        (AGENT (value ^$VAR1))
        (THEME (value ^$VAR2))))
))

(UPDATE
(DEFINITION (value ("to change smth (information, software) to a newer version")))
(INSTRUMENT (sem (OBJECT)))
(IS-A (value (CHANGE-EVENT)))
(EFFECT (OWN (AGENT (sem (HUMAN) RELAXABLE-TO (ORGANIZATION))
(THEME (sem (INFORMATION SOFTWARE) RELAXABLE-TO (object)))
(PRECONDITION (LACK (AGENT (sem (HUMAN) RELAXABLE-TO
(ORGANIZATION)))
)
```

The branch of ontology CHANGE-EVENT can be both useful and not quite so for the representation of the event structure. The concept it represents is “an event that represents a change in state, quality, etc. and that can be described in terms of preconditions and after-effects”. However, some of the children of this concept are not, per se, non-homogeneous events: cf. FLUCTUATE, MAINTAIN (the latter if one of the children of an ABSENCE-OF-CHANGE-EVENT, labeled misleadingly, since it also includes such children as STABILIZE and RESTORE, which are, apparently, non-homogeneous events).

It does not, however, matter significantly at what level the distinction is made for the event type. As shown above, it can be specified in the lexical entry or in the ontological concept. Within the ontology itself, the requirement for event-type distinction can be made at a higher or lower level. As long as there are no pushing memory-size or processing-time requirements (and an application which would have to process implicature would need to have both resources), the distinction can be made at any level and still be processed accurately and give the user the same advantage.

3.1.3.2. Phrasal verb templates

In my treatment of phrasal verbs I relied on the Televnaja's work (2004), which dealt specifically with acquisition of phrasal verbs for ontological semantic resources. She has worked on developing a classification of phrasal verbs based both on their syntactic and semantic properties. Semantically, she has compositional, metaphorical, and non-compositional phrasal verbs, basing the classification on the kind of meaning that either of the components of the phrasal (the verb or the particle) contributed to the meaning of the entity. Syntactically, she has based her acquisition on the patterns of phrasal verb construction in English, and their interruptability by optional elements (such as noun phrases, pronouns, etc.). The four templates she has developed (Televnaja, 94), and that I use for acquisition as well, are as follows (the details, specific for each verb, e.g. the particle or the ontological connection, are italicized):

Template 1: verb with an optional noun phrase between verb and particle or after particle

```
(verb-particle-v1
  (anno
    (def "…")
    (ex  "…")
    (comments "…"))
(syn-struc
   (1
     (subject ((root $var1) (cat np)))
     (root $var0) (cat v)
     (object ((root $var2) (cat np)))
     (prep ((root up) (cat prep))))
   (2
     (subject ((root $var1) (cat np)))
     (root $var0) (cat v)
     (prep ((root up) (cat prep))))
     (object  ((root $var2) (cat np) (opt +)))))   ;; final np optional
(sem-struc
  ((1 2)
  (EVENT
     (agent (value ^$var1) (sem HUMAN))
     (theme (value ^$var2) (sem EVENT OBJECT))
    (…))))
)
```

Template 2: verb with obligatory np between verb and particle or after particle

(*verb-particle*-v1
  (anno
    (def "…")
    (ex "…")
    (comments "…"))
(syn-struc
   (1
     ((subject ((root $var1) (cat np)))
     (root $var0) (cat v)
     (object ((root $var2) (cat np)))
     (prep ((root *up*) (cat prep))))
   (2
     ((subject ((root $var1) (cat np)))
     (root $var0) (cat v)
     (prep ((root *up*) (cat prep))))
     (object ((root $var2) (cat np)))))
(sem-struc
  ((1 2)
  (EVENT
     (agent (value ^$var1) (sem HUMAN))
     (theme (value ^$var2) (sem EVENT OBJECT))
    (…))))
)

Template 3: verb with obligatory np only after particle

 (*verb-particle*-v1
  (anno
    (def "…")
    (ex "…")
    (comments "…"))
(syn-struc
     ((subject ((root $var1) (cat np)))
     (root $var0) (cat v)
     (prep ((root *up*) (cat prep))))
     (object ((root $var2) (cat np))))
(sem-struc
  (EVENT
     (agent (value ^$var1) (sem HUMAN))
     (theme (value ^$var2) (sem EVENT OBJECT))
)

Template 4: intransitive verb

(*verb-particle*-v1
  (anno
    (def "…")
    (ex "…")
    (comments "…"))
(syn-struc
     ((subject ((root $var1) (cat np)))
     (root $var0) (cat v)
     (prep ((root *up*) (cat prep))))
 (sem-struc
  (EVENT
     (agent (value ^$var1) (sem HUMAN))
     (theme (sem EVENT OBJECT))
    (…)))
)

Here is an example of my use of one of the templates:

(*log-off*-v1
  (anno
    (def "To end an authenticated session, undoing what happens when one logs in. This is primarily to prevent other users gaining access to the logged in session, e.g. at an unattended computer, but typically also terminates any processes and network connections started as part of the session.")
    (ex "Please log off before you go home")
    (comments "used synonymically with *log out*"))
(syn-struc
   (1
     ((subject ((root $var1) (cat np)))
     (root $var0) (cat v)
     (object ((root $var2) (cat np)))
     (prep ((root *up*) (cat prep))))
   (2
     ((subject ((root $var1) (cat np)))
     (root $var0) (cat v)
     (prep ((root *up*) (cat prep))))
     (object ((root $var2) (cat np) (opt +)))))   ;; final np optional
(sem-struc
  ((1 2)
     (EFFECT (sem BE-OFFLINE))
     (PRECONDITION (sem BE-ONLINE)
     (agent (value ^$var1) (sem HUMAN))
     (theme (value ^$var2) (sem COMPUTER-NETWORK WEB-PAGE))
)

The most frequent modifiers of the semantics structure of a phrasal verb, as well as any other, are modality and aspect; they were sufficiently discussed above, so I will not discuss them here.

Julia has also treated phrasal verbs with more than one preposition following the verb (e.g. make away with), but I have not had a necessity to employ those templates, so I will not discuss them either. The same goes for phrasals, which only combine with specific nouns (e.g. "pave the way"): the nouns are introduced in the template.

3.2. Argument structure in OS.

The argument structure specification built into the static resources of ontological semantics is responsible for several things:

a) matching the overt syntax of the proposition with the available arguments;

b) specifying potential valencies of arguments in propositions;

c) restricting the semantics of lexical items as to the potential senses in TMR.

Thus, the traces of it can be found in both lexical and ontological entries. In order to have constraints for TMR building, we use both specifications of fillers for given case roles (for verbs) or case-licensing propositions (for nouns). Thus, there are two sets of specifiers for case: CASE-ROLE and CASE-ROLE-INVERSE. The first set is used to describe the heads of propositions or verbs, and to limit the senses of possible case-fillers. The second set is used to specify the potential valencies of arguments (nouns). In what follows, I list the current case inventory for the ontology, and, where applicable, offer examples from the digital identity management lexicon I have acquired.

3.2.1. Case role inventory and most frequently used cases.

It is important to note that most of the time the event itself has restrictions on what case roles can be filled with regard to it, or which ones are preferable or necessary. All of it is reflected in the lexical or ontological entry for the verb (in the lexicon) or EVENT (in the ontology). On the other hand, objects and nouns also sometimes have semantic restrictions as to what case roles they might fill for certain events; in this case,

the CASE-ROLE-INVERSE is used in the script for the noun or OBJECT (in the lexicon or ontology, correspondingly) to announce this selectional restriction

1) Agent

Agents are entities causing events. Initially, only volitional agents were considered for this case role ("**I** worked on the assignment"); later, this restriction was lowered to include natural forces ("**The wind** opened the window"), and, by metaphorical extension, organizations ("**The Nobel Prize committee** announced this year's winners"). Syntactically, the agent is often the subject of the sentence, and in languages with overt case systems it is marked accordingly (by nominative, ergative or absolutive case). Here is an example of the use of this case role in a template of a lexical item:

```
(sign-on
(sign-on-V1 (cat V)
(SYNONYMS "sign in")
    (anno (def "") (ex "") (comments "synonymous to sign in, but far less widespread:
used in 8mln cases on Google, vs. 33mln for sign in."))
    ((np ((root $var1) (cat np)))
    (root $var0) (cat v)
    (np ((root $var2) (cat np) (opt+)))
    (prep ((root on) (cat prep))))
    (EFFECT (sem BE-ONLINE))
    (PRECONDITION (sem BE-OFFLINE)
    (agent (value ^$var1) (sem HUMAN))
    (theme (value ^$var2) (sem HUMAN))
))
```

An inverse of AGENT case role, agent-of, can be used to further specify the meaning of a noun, e.g.

```
(end-user
(end-user-n1 (cat N)
  (anno (def "the person who uses a product. The end-user may differ from the customer,
who might buy the product, but doesn't necessarily use it. Legally, the term refers to a
non-seller.")
(ex "This link refers you to download page for end-users")(comments ""))
  (SYN-STRUC
   ((root $VAR0) (cat N))
(sem-struc (USER
(AGENT-OF (NOT SELL))))
))
```

2) Theme

The entity that is manipulated by an action, e.g. “We evaluated new **software**”. Indirect objects are often themes. Themes are not human (the case role of patient is reserved for similar treatment of humans) they can, however, contain entire propositions: “I forgot **that you were out of town this week**”. Here is an example of the use of this case role:

(Shrink-wrap-contract
(Shrink-wrap-contract-n1 (cat N)
(anno
(def "agreements or other terms and conditions of a (putatively) contractual nature which can only be read and accepted by the consumer after opening the product.")
(ex "")
(comments ""))
(SYN-STRUC
((root $VAR0) (cat N))
(sem-struc (CONTRACT
*(MADE-OF (sem *NOTHING*))*
(PRECONDITION (sem REFESEM1))))
(REFSEM1 (sem OPEN
(THEME (sem MANUFACTURED-CONTAINER (CONTAINS (sem (SOFTWARE) RELAXABLE-TO (OBJECT)))))))
))

An example of the use of inverse case role:

(end-user-license-agreement
(end-user-license-agreement-n1 (cat N)(SYNONYMS “EULA”)
(anno (def "**software license**, a type of proprietary or gratuitous license as well as a memorandum of contract between a producer and a user of software that specifies the perimeters of the permission granted by the owner to the user.") (ex "")
(comments ""))
(SYN-STRUC
((root $VAR0) (cat N))
(sem-struc (CONTRACT
(CONTAINED-IN (sem SOFTWARE)
(MADE-OF (sem *NOTHING*))
(THEME-OF (sem REFESEM1))))
(REFSEM1 (sem AGREE
(PRECONDITION-OF (sem INSTALL-DEVICE (THEME (sem SOFTWARE))))))
))

3) Patient (in some applications also realized as two independent roles of beneficiary and experiencer)

Patient is a human entity affected by the action, as in “I sent **my professor** an email”, or “**I** saw my computer suddenly turn off.” (In this particular type of sentence, the role can be argued to be an experiencer role in a non-volitional event), for example:

```
(SMELL
 (SMELL-V1 (cat V)
  (anno (def "") (ex "He smelled fire [dinner cooking]") (comments ""))
  (SYN-STRUC
   ((SUBJECT ((root $VAR1) (cat N))) (root $VAR0) (cat V)
    (DIRECTOBJECT ((root $VAR2) (cat N)))))
  (SEM-STRUC
   (INVOLUNTARY-OLFACTORY-EVENT
   (PATIENT (value ^$VAR1))
    (THEME (value ^$VAR2))
))))
```

4) Instrument

Instrumental case describes an object or event used for executing another event, e.g. “I opened the door with a spare **key**”. Example of its use from DIM lexicon:

```
(INTEROPERABILITY
(INTEROPERABILITY-N1 (cat N)
(anno (def " the ability to exchange and use information (usually in a large heterogeneous network made up of several local area networks). The ability of software and hardware on multiple machines from multiple vendors to communicate.”)(comments "") (ex ""))
  (syn-struc ((root $VAR0) (cat N)))
 (sem-struc (EXCHANGE
(THEME (SEM INFORMATION))
(INSTRUMENT (SEM SOFTWARE HARDWARE))
))))
```

An inverse of this case role, instrument-of, is used to specify the meaning of nouns:

```
(ADWARE
 (ADWARE-N1 (cat N)
  (ANNO
   (def “software application in which advertisements are displayed while the program is running ")
   (comments "") (ex ""))
  (syn-struc ((root $VAR0) (cat N)))
(sem-struc (SOFTWARE
(INSTRUMENT-OF (sem REFSEM1))))
(REFSEM1 (ADVERTISE
(DESTINATION (USER-COMPUTER))))
```

))

5) Source

Source case role describes a starting point of various types of movement, e.g. “We are flying from **Chicago** tomorrow”. This case role does allow for metaphorical extensions, and constrains its fillers to objects, and not events. (As in “He shied away **from appearing at dances after that**” – here, the sentence is interpreted as containing two propositions and treated accordingly.) An example of its use from the DIM lexicon:

```
(COOKIE
 (COOKIE-N1 (cat N)
  (ANNO
   (def "a packet of information sent by a server to a  browser and then sent back by the
browser each time it accesses that server. ")
   (ex "") (comments ""))
  (syn-struc ((root $VAR0) (cat N)))
  (sem-struc (COMPUTER-FILE
(IDENTIFIES-WHAT (sem COMPUTER))
(STORES-IDENTIFYING-INFORMATION (sem SESSION-INFORMATION))
(SOURCE (sem NETWORK-SERVER))))
))
```

6) Location

This case role describes a place where an event takes place or object exists (e.g. “I slept in **the basement**”. The syntactic clues for it include prepositions with spatial meaning (in, by, at, behind, above, below) or morphological case in languages that have grammaticalized locative meaning (Eastern Slavic, Finnish, Chuvash (Altaic), etc.) An example of its use (note the metaphorical extension of meaning) from DIM lexicon:

```
(ONLINE-STORE
 (ONLINE-STORE-N1 (cat N)
(anno (COMMENT "I went to the store to buy some groceries"))
  (syn-struc ((root $VAR0) (cat N)))
(sem-struc (STORE
(LOCATION (value INTERNET)
(REPRESENTED-BY (value WEB-PAGE))
))
```

An inverse case role LOCATION-OF is, again, used here with metaphorical extension:

```
(THRESHOLD
(THRESHOLD-N1 (cat N)
```

```
(anno (def “a fixed location or value where an abrupt change is observed.”)(ex "")
(comments ""))
(syn-struc ((root $VAR0) (cat N)))
  (sem-struc (REPRESENTATIONAL-OBJECT
(LOCATION-OF (sem CHANGE-EVENT))))
))
```

7) Destination

The case role of destination describes an end point for various types of location change, transfer of possession, etc. (E.g. “He accompanied her to **the show**”). Syntactically, English offers prepositions “to, towards” as clues to this case role. Here is an example of the use of this case role:

```
(ADWARE
 (ADWARE-N1 (cat N)
  (ANNO
   (def “software application in which advertisement are displayed while the program is
running ")
   (comments "") (ex ""))
  (syn-struc ((root $VAR0) (cat N)))
(sem-struc (SOFTWARE
(INSTRUMENT-OF (sem REFSEM1))))
(REFSEM1 (ADVERTISE
(DESTINATION (USER-COMPUTER))))
))
```

8) Beneficiary

The case-role is filled by the nonagentive party in an event, which involves transfer of objects. Technically speaking, the person can be a “maleficiary”, as well as “beneficiary” – in this way the case role is consistent with the use of “beneficiary case” in languages that have it.

9) Path

Path is a route which an object (in ontological, not syntactic, sense) travels, and can be a metaphorical extension of meaning, e.g. “He went through **a lot of hardship** then.” Path is usually an object itself.

10) Manner

The case role of manner describes the style in which something is done. It is, typically, a scalar attribute and is triggered by adverbials, e.g. “She writes **well**”. This case role is used as a generic for all event modifiers that cannot be assigned to other case roles.

Neither one of the latter two case roles was used in the digital identity management lexicon, so I will omit examples here.

Syntactic clues accompanying the descriptions of case roles here are not meant as the rules used by the system, but rather as language-specific defeasible constraints. The lexicon does make use of syntactic structure for evaluating case roles in preposition reconstruction, and ontological entries establish selectional restriction on semantics of case role fillers, but it is the interaction of both which makes the final judgment as to the filling case roles in text meaning representation.

3.2.2. Argument constraints using ontological connections.

The constraints for the case roles, or rather, preferable case roles and valencies for a particular noun do not have to be explicitly introduced in its lexical entry only. It is possible to specify some of the case roles in the ontological concept, to which the lexical entry is tied – in TMR creation, a combination of information contained in the lexical entry and its ontological connections is used, so instead of being treated as separate information from two static databases, all information on a parsed-out word is treated as a single entity. Hence, it is sometimes preferable to define argument structure on a higher lever of the ontology, and sometimes on a lower level, in the lexicon. For example:

```
(download (is-a (value (TRANSFER-COMPUTER-DATA)))
(definition (value ("file transfer event, initiated by the receiving side")))
(destination (sem (NETWORK-CLIENT))
(inv (NETWORK-CLIENT)))
(source (sem (NETWORK-SERVER)))
(theme (sem (COMPUTER-DATA)))
(patient (sem (agent-of (range (sem (ACQUIRE))))))
)
```

Here, the potential semantics of the THEME, SOURCE, DESTINATION, and PATIENT arguments is defined not it the lexical template, but in the ontological

concept. It is useful in the cases when the ontological concept is used in multiple lexical and ontological items, thus the potential argument structure for it is specified only once: in its ontological entry. Cf. other uses of this concept:

```
(CLICK-WRAP-AGREEMENT
(CLICK-WRAP-AGREEMENT-n1 (cat N)
(synonyms “web-wrap agreement” “browse-wrap agreement”)
(anno (def " to license agreements in software which is downloaded or used over the
internet.")
(ex "")
(comments ""))
(syn-struc
  ((root $VAR0) (cat N))
(sem-struc (CONTRACT
        (PRECONDITION (sem REFESEM1))))
        (REFSEM1 (sem CLICK
        (REPRESENTS (sem AGREE))
        (PRECONDITION-OF (sem DOWNLOAD)))))
))
```

3.2.3. Noun template in the lexicon and its modifications

A generic noun template in the lexicon looks as follows:

```
(lexical-item
(lexical-item-N1 (cat n)
 (synonyms "")
(anno (def "")
        (ex "")
        (comments ""))
(syn-struc ((root $VAR0) (can n)))
(sem-struc (CONCEPT
        (slot (facet filler)) // optional, used for case roles, etc.
        (slot (value value))  // optional, used for scalar or binary property
)))
```

Most of the generic fields in the entry, such as annotation (anno), definition (def), example (ex), comment field (comments), semantic and syntactic structure (syn-struc and sem-struc, respectively) are the same as those of verbal entries, described above.

In syntactic-structure, most often the nouns are simply defined as a noun – since TMR is “crystallized” around a predicate, nouns are “collected” around a relevant

predicate according to how well they fit possible case roles. Thus, no further specification is necessary.

In sem-struc, nouns can be mapped to OBJECTs, EVENTs, PROPERTY, or SET. Examples of each kind of mapping are shown below. The most trivial noun mapping is to an object. I would like to present an example of a noun with two possible meanings, mapped to two objects:

```
(AVATAR
 (AVATAR-N1 (cat N)
  (anno
   (def "an icon or representation of a user in a shared virtual reality. ")
   (ex "I changed my avatar to a picture of the evening sky.")
(comments ""))
  (syn-struc
        ((root $VAR0) (cat N)))
  (sem-struc (AVATAR)))
(AVATAR-N2 (cat N)
  (anno
   (def "a type of robot or interactive computer program which is design to teach, or help
to learn ")
   (ex "Our lab is working on the Signing Bunny avatar that could teach deaf children
math.")
(comments ""))
  (syn-struc ((root $VAR0) (cat N)))
  (sem-struc (CHATTERBOT)))
)
```

Here is an example of mapping a noun to an event:

```
(ODOR
(ODOR-N1 (cat N)
(synonyms “smell”)
  (anno
   (def "a chemical quality of objects, which is perceived with olfactory organs")
   (ex "The lab was filled with a strong unidentifiable odor.")
(comments ""))
(syn-struc
        ((root $VAR0) (cat N)
        (pp-adjunct ((root OF) (cat PREP) (OPT +)
        (np ((root $var1))))))
(sem-struc (INVOLUNTARY-OLFACTORY-EVENT
        (THEME (value $VAR1))))
))
```

Mapping of a noun to a PROPERTY (more specifically, ATTRIBUTE)

```
(GAIT
(GAIT-N1 (cat N)
(anno (def "a physical quality of walking manner that can be used to identify a human
with certain reliability.")
(ex "")
(comments ""))
(syn-struc
        ((N ((root $VAR1) (cat N) (POSSESSIVE +) (opt +)))
        (room $VAR0) (cat N)))
(sem-struc (GAIT-ATTRIBUTE
        (IDENTIFIES-WHAT (value ^$VAR1))))
))
```

Mapping of a noun to a SET (a combination of possible members, or, in this particular case, attributes):

```
(IDENTITY
 (IDENTITY-N1 (cat N)
         (syn-struc ((root $VAR0) (cat N)))
        (sem-struc (MATHEMATICAL-OBJECT)))
(IDENTITY-N2 (cat N)
        (syn-struc
                ((root $var0) (cat N)
                (pp-adjunct ((root of) (at PREP) (opt +) (obj ((root $VAR2)))))))
        (sem-struc (CHARACTERISTIC))))
(IDENTITY-N3 (cat N)
        (syn-struc ((root $VAR0) (cat N)))
        (sem-struc (set (member-type USER-IDENTIFYING-ATTRIBUTE)))
))
```

3.3. Modifiers in Ontological Semantics

3.3.1. Adjectives and their templates

In the treatment of adjectives, I mostly followed Raskin's microtheory of adjectival meaning developed specifically for ontological semantics. It treats adjectives not as a homogeneous class (part of speech), but subdivides them into subclasses and

connects them to all three major branches of ontology based on the meaning of the adjective.

Syntactic properties of adjectives are relevant (and as such are attempted to be exhaustively described in the syn-struc part of the adjective template), but not crucial. The same adjective, used both attributively and predicatively, can carry the same meaning.

As such, adjectives are subdivided by Raskin & Nirenburg (1995, 25) into:

1) Scalar adjectives, whose meanings are based on property ontological concepts;

2) Denominal adjectives, whose meanings are based on object ontological concepts;

3) Deverbal adjectives, whose meanings are based on process (event) ontological concepts.

In what follows, I am going to give some examples of how adjectives from various groups are treated.

For example, an adjective “hazel”, pertaining to eye color, is tied to the ontological concept color-attribute. Note, that the syntactic structure allows for both predicative and attributive usage, united under the same semantics structure:

```
(HAZEL
 (HAZEL-ADJ1 (cat ADJ)
 (anno (def "an eye color")
 (ex " She has hazel eyes ")
 (comments ""))
  (syn-struc
(1  ((root $VAR1) (cat N)
  (MODS ((root $VAR0) (cat ADJ)))))
(2 ((root $var0) (cat adj)
    (subj ((root $var1) (cat n))))))
(SEM-STRUC
   ((1 2)
   ($VAR1 (INSTANCE-OF (sem EYE))
   (COLOR-ATTRIBUTE (sem HAZEL))))
))
```

An adjective like *unique* is also treated as a property, but a different one: scalar, as opposed to the previous, literal one:

```
(UNIQUE
 (UNIQUE-ADJ1 (cat ADJ)
(anno (def "Being the only one of its kind ")
 (ex "Chicago is no less unique an American city than New York or San Francisco.")
 (comments "A literal attribute"))
  (syn-struc
(1  ((root $VAR1) (cat N)
  (MODS ((root $VAR0) (cat ADJ)))))
(2 ((root $var0) (cat adj)
    (subj ((root $var1) (cat n))))))
  (SEM-STRUC
   (^$VAR1 (INSTANCE-OF (sem OBJECT))
   (UNIQUENESS (value 1))
)))
```

Denominal adjectives, which are rarer in English than in other languages (e.g. French or Russian) due to a widespread phenomenon of nouns characterizing nouns (so-called “stone wall” problem), can be treated using various relations; in the worst-case scenario, a “catch-all” relation of PERTAIN-TO is used. Whenever it is possible to specify more precisely (in the absence of grain-size limitations), this option is exercised:

```
(DIGITAL
(DIGITAL-ADJ1 (cat ADJ)
 (anno (def " Expressed in numerical form, especially for use by a computer.")
 (ex "Please send me the picture in any digital format.")
 (comments "acquire other meanings outside of DIM domain"))
(syn-struc
(1  ((root $VAR1) (cat N)
  (MODS ((root $VAR0) (cat ADJ)))))
(2 ((root $var0) (cat adj)
    (subj ((root $var1) (cat n))))))
  (SEM-STRUC
   (^$VAR1 (INSTANCE-OF (sem OBJECT))
    (REPRESENTED-BY (sem BIT-STRING))))
))
```

As for deverbal adjectives, I have not had the need to acquire any for the domain. It would suffice to mention that the entries for them are derived from verbal entries (as in abuse: abusive) by way of identifying whether the adjective describes the event itself or one of its arguments, and representing the semantic structure accordingly. For further treatment, see Raskin and Nirenburg 1995.

3.4. Ontological acquisition - a case study

The previous sections of this chapter dealt primarily with acquisition of lexical items. However, for a new domain, new ontological items need to be acquired as well. The pre-acquisition process, outlined in section 2.4.2, dealt with acquisition of "ontological necessities" for the domain. Here, I will elaborate on the acquisition of ontological items, needed for an adequate description of the corpus.

At some point in the acquisition, I have come across a question as to whether there was a need for a single meaningful concept to connect smart-card, bios chip, and flash memory cards – all needed for the lexicon. A simple search in the ontology yielded MEMORY as "all the addressable space in the computing processing unit" (which is interesting by way of how ontology was being developed – apparently, a need for a concept for a computer memory came before a need of one describing human memory), and RAM as a child of a STORAGE-DEVICE, two other children of which included OPTICAL-STORAGE-DEVICE and MAGNETIC-STORAGE-DEVICE.

"Sliding down" the ontology is also recommended as a second method, in order to avoid a danger of missing a relevant concept, since concept labels are not entirely descriptive. Starting with the node ALL, we find OBJECT PHYSICAL-OBJECT INANIMATE ARTIFACT DEVICE (or MEDIA-ARTIFACT) DEPENDENT-DEVICE (or STORAGE-DEVICE, if we are sliding down the second path) COMPUTER-HARDWARE (or COMPUTER-MEDIA-ARTIFACT) STORAGE-DEVICE. Apparently, this is the node containing closest matching senses to what we are looking for. A KBAE-avoider representation of this concept is shown in Table 5 (note the double inheritance).

Table 5. STORAGE-DEVICE concept in the KBAE-avoider.

Neither one of them fit the lexical items, however, since all were semiconductor-based computer-accessible memory, and did not need (unlike RAM) a continuous voltage supply in order to function.

As mentioned above in section 2.4.1.2, a decision to acquire an ontological item starts with answering several questions, which I addressed as follows:

1) Can a new concept be used for more than one lexical item? - Yes.

2) Can a new concept be used for other ontological items? - Yes: an entry for any system using semiconductor storage devices could be further described with the use of this concept; it can also subsume the RANDOM-ACCESS-MEMORY concept with further specifications.

3) Is the grain size of the concept adequate to the task in hand? - Yes, since there is a significant difference (both in material and functioning) between the existing memory concepts and the new one;

4) What alternative methods of semantic description are there? - I could specify the material for the semiconductor-based memory devices, but this way the STORAGE-DEVICE branch will be out of balance (too many lexical items specified too generally).

5) Is introduction of the concept in question preferable to alternative methods of semantic description? - Yes, since the benefits of introducing the concept and defining several lexical and ontological items through it outweigh the alternative possibility, which runs the risk of underspecification in semantic description.

Having made the decision on acquiring a new concept, we decide on its name (SEMICONDUCTOR-STORAGE-DEVICE seems informative enough and in line with the labels for other children in this branch of ontology), and we check the representation of the parent in the ontology file. Here it is:

```
(STORAGE-DEVICE
(DEFINITION (value ("part of a computer that stores information for subsequent use or retrieval")))
 (IS-A (value (COMPUTER-HARDWARE COMPUTER-MEDIA-ARTIFACT)))
(HAS-EVENT-AS-PART (sem (*NOTHING*)))
(SUBCLASSES
        (value (OPTICAL-STORAGE-DEVICE MAGNETIC-STORAGE-DEVICE RANDOM-ACCESS-MEMORY)))
(SOURCE-OF
        (INV (RETRIEVE-COMPUTER-DATA BACKUP-COMPUTER-DATA)))
(DESTINATION-OF
        (INV (SAVE-COMPUTER-DATA BACKUP-COMPUTER-DATA))))
(DOMAIN-OF (INV (CONTAINS)))
```

The information that we want to add in order to define a new concept includes:

a) the material used in semiconductors;

b) that no power is necessary for this type of memory to function.

The ontology already has a concept for the material of the semiconductor-based memory: SILICON, so we can simple specify that for the new concept. The second specification, on consideration, does not belong in the new concept: on the contrary, it makes sense to specify which memory-devices do, in fact, need a voltage in order to function. As mentioned earlier, we would subsume the RANDOM-ACCESS-MEMORY concept under SEMICONDUCTOR-STORAGE-DEVICE, but not that it needs a voltage to function. Thus, we would need to modify RANDOM-ACCESS-MEMORY, for

example, by way of noting VOLTAGE as a ENABLEMENT for it (all capitalized concepts are already contained in the ontology)[2]:

(RANDOM-ACCESS-MEMORY
(IS-A (value (SEMICONDUCTOR-STORAGE-DEVICE)))
(DEFINITION (value ("A memory device in which information can be accessed in any order, which needs a voltage supply to function and carry information.")))
(DESTINATION-OF (INV (RETRIEVE-COMPUTER-DATA)))
(SOURCE-OF (INV (SAVE-COMPUTER-DATA)))
(ENABLEMENT (sem (VOLTAGE)))
)

Note the change in inheritance slot: now the RANDOM-ACCESS-MEMORY concept is a child of SEMICONDUCTOR STORAGE-DEVICE, inheriting its material properties.

For the SEMICONDUCTOR-STORAGE-DEVICE, I also found it useful to specify the similarity between MEMORY and STORAGE-DEVICE, since, for instance, flash-drives can be moved from one computer to another and function as an external memory for either one; a bios-chip is also a semiconductor-based memory that is “on” at all times.

The final representation in the ontology of a generic concept semiconductor-storage device is as follows:

(SEMICONDUCTOR-STORAGE-DEVICE
(IS-A (value (STORAGE-DEVICE)))
(DEFINITION (value ("computer storage device that reads and writes information using transistors")))
(SUBCLASSES (value (RANDOM-ACCESS-MEMORY)))
(MATERIAL (sem (SILICON)))
(FUNCTIONS-LIKE (sem (MEMORY)))
)

[2] Accidentally, ENABLEMENT is a somewhat vague concept, defined as follows: "In an enablement relation, the situation represented in the range is unrealized. The action represented in the domain increases the chances of the situation in the range being realized. Usually, the domain represents the satellite of the relation, although the relation may also be multinuclear". Its domain encompasses both EVENTs and OBJECTs, and its range is ALL, so it’s possible to use it in this particular way. However, while applicable, it is somewhat vague and not an optimal candidate for use. Here, it only serves as an example of a decision-making chain leading to specification of existing concepts.

Other potential subclasses (for which the decision-making process described above has to be repeated) for this ontological node could include:

(SUBCLASSES (value (RANDOM-ACCESS-MEMORY FLASH-MEMORY BIOS-CHIP SECURE-DIGITAL-CARD)))

An acquisition decision process, similar to the one discussed here, was repeated for each of the ontological items, which are presented in the second part of Chapter 4.

CHAPTER IV.
SCRIPTS FOR DIGITAL IDENTITY MANAGEMENT DOMAIN

In this chapter, I present the scripts for Digital Identity Management domain additions for both static knowledge sources, the lexicon and the ontology. Section 4.1. is devoted to the lexicon, and brakes the acquired material down in to nouns, verbs and adjectives, for ease of human review. I have not divided the verbs into homogeneous and non-homogeneous event types, since this distinction can be expressed both in the lexicon and the ontology, and thus did not warrant a distinction purely at the level of the lexicon. The entries that span several parts of speech are separated under the category of "combined entries".

Section 4.2. contains scripts for ontological items, without any subdivision; both modified and new entries are given in the as-acquired order.

4.1. Digital Identity Management lexicon

4.1.1. Nouns

```
(STATIC-IP
 (STATIC-IP-N1 (CAT N)
  (ANNO
   (DEF "Static IP addresses are numeric addresses that uniquely identify a computer(s) on the Internet..")
   (EX "I have a static IP address") (COMMENTS ""))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
  (SEM-STRUC (IP-ADDRESS
  (TEMPORAL-OBJECT-ATTRIBUTE (VALUE 1))))
))

(DYNAMIC-IP
 (DYNAMIC-IP-N1 (CAT N)
  (ANNO  (DEF "An IP address for a computer that changes every time with login.")
   (EX "It is more difficult to track down a user with a dynamic IP.") (COMMENTS ""))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
  (SEM-STRUC (IP-ADDRESS)))
```

```
  (TEMPORAL-OBJECT-ATTRIBUTE (VALUE .2))
))

(PASSWORD
 (PASSWORD-N1 (CAT N)
  (ANNO  (DEF "A secret word or phrase that one uses to gain admittance or access to information.")
   (EX  "Don't tell you username or password to any one.") (COMMENTS ""))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
  (SEM-STRUC (PASSWORD))
))

(PIN
 (PIN-N1 (CAT N) (SYNONYMS "PIN-number")
  (ANNO  (DEF  "A secret number combination that one uses to gain admittance or access to information.
")
   (EX  "Enter your pin.") (COMMENTS ""))
  (SYN-STRUC ((ROOT $VAR0) (CAT N))) (SEM-STRUC (PIN-NUMBER))
))

(URL
 (URL-N1 (CAT N) (SYNONYMS "Universal-resource-locator, web-address")
  (ANNO  (DEF  "A unique address of a web-page. ")
   (EX "The URL of our web-page is… ") (COMMENTS ""))
  (SYN-STRUC ((ROOT $VAR0) (CAT N))) (SEM-STRUC (web-address))
))

(IP
 (IP-N1 (CAT N) (SYNONYMS "IP-address")
  (ANNO  (DEF  "A unique number-string, identifying physical location of a computer. ")
   (EX "On this forum, each time you make a post, your IP is recorded.") (COMMENTS ""))
  (SYN-STRUC ((ROOT $VAR0) (CAT N))) (SEM-STRUC (IP-ADDRESS))
))

(ISP
 (ISP-N1 (CAT N) (SYNONYMS "Internet service provider")
  (ANNO (DEF "A corporation providing access to Internet service to the public. ")
   (EX "My ISP does not allow the use of P2P software.") (COMMENTS ""))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
 (SEM-STRUC (INTERNET-SERVICE-PROVIDER))
))

(PHONE-NUMBER
 (PHONE-NUMBER-N1 (CAT N)
  (ANNO (DEF "A phone number a human or an organization can be reached at.")
   (EX "What is your phone number?") (COMMENTS ""))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
  (SEM-STRUC (PHONE-NUMBER
  (TEMPORAL-OBJECT-ATTRIBUTE (VALUE .5))))
))

 (USERNAME
 (USERNAME-N1 (CAT N) (SYNONYMS "LOGIN")
  (ANNO (DEF "A string of letters and numbers remembered by the system as part of user identity,
knowledge token for the user.")
```

```
   (EX "How can I change my username on this system?") (COMMENTS ""))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
  (SEM-STRUC (USER-NAME))
))

(LOGIN
 (LOGIN-N1 (CAT N) (SYNONYMS “USERNAME”)
  (ANNO (DEF "A string of letters and numbers remembered by the system as part of user identity,
knowledge token for the user.")
   (EX "Use you last name as your login for the university library accounts") (COMMENTS ""))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
  (SEM-STRUC (USER-NAME))
))

(EMAIL-ADDRESS-N1 (CAT N) (SYNONYMS "E-MAIL-ADDRESS")
  (ANNO  (DEF “an address identifying the origin of the email with a degree of certainty, but forgeable")
   (COMMENTS "I just opened a new account with gmail, and use their email address now.") (EX ""))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
  (SEM-STRUC (EMAIL-ADDRESS))
))

(SERIAL-NUMBER-N1 (CAT N)
  (ANNO (DEF “a number identifying a piece of hardware or software”)
   (COMMENTS "We need to know your computer’s seria l number in order to issue a rebate.") (EX ""))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
  (SEM-STRUC (NUMBER)))
(IDENTIFIES-WHAT (DEVICE SOFTWARE
(IDENTIFYING-INFORMATION-ISSUED-BY (PRODUCER-OF $VAR0))))
))

(SIM-CARD-NUMBER-N1 (CAT N)
  (ANNO (DEF "a number identifying a SIM-card”)
   (COMMENTS "") (EX "The number printed directly on the SIM card is a SIM card number."))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
  (SEM-STRUC (NUMBER
(IDENTIFIES-WHAT (SIM-CARD))
(IDENTIFYING-INFORMATION-ISSUED-BY (PRODUCER-OF $VAR0))))
))

(SIM-CARD-N1 (CAT N)
  (ANNO
   (DEF “a smartcard securely storing the key identifying a mobile subscriber.")
   (COMMENTS "SIM = subscriber identity module") (EX "You can change the SIM card in your phone
after it is unlocked by the manufacturer."))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
  (SEM-STRUC (SIM-CARD))
))

(DIGITAL-CERTIFICATE-N1 (CAT N)
  (ANNO  (DEF "a certificate which uses a digital signature to bind together a public key with an identity”)
   (COMMENTS "") (EX "What can I do to obtain a digital certificate?"))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
  (SEM-STRUC (CERTIFICATE
(IDENTIFIES-WHAT (DEFAULT (SOFTWARE) SEM (OBJECT)))
```

```
(IDENTIFYING-INFORMATION-ISSUED-BY (CERTIFICATE-AUTHORITY))))
))

(AVATAR
 (AVATAR-N1 (CAT N)
  (ANNO (DEF "an icon or representation of a user in a shared virtual reality. ")
   (EX "I like your new avatar.") (COMMENTS ""))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
  (SEM-STRUC (AVATAR)))
(AVATAR-N2 (CAT N)
  (ANNO
   (DEF "a type of robots or interactive computer programs, which was design to teach, or help to learn ")
   (EX "The signing bunny avatar is intended for teaching math to students in ASL. ") (COMMENTS ""))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
  (SEM-STRUC (CHATTERBOT)))
)

(ODOR
(ODOR-N1 (CAT N)
(SYNONYMS “smell”)
  (ANNO  (DEF "The property or quality of a thing that affects, stimulates, or is perceived by the sense of
smell. ")
   (EX "What’s that strange odor?") (COMMENTS ""))
  (SYN-STRUC
   ((ROOT $VAR0) (CAT N)
    (PP-ADJUNCT ((ROOT OF) (CAT PREP) (OPT +) (OBJ ((ROOT $VAR2))))))
  (SEM-STRUC (INVOLUNTARY-OLFACTORY-EVENT (THEME (VALUE $VAR2))))
))

(COOKIE
 (COOKIE-N1 (CAT N)
  (ANNO (DEF "a packet of information sent by a server to a  browser and then sent back by the browser
each time it accesses that server. ")
   (EX "Cookies were implemented to allow user-side customization of Web information. ") (COMMENTS
""))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
  (SEM-STRUC (COMPUTER-FILE
(IDENTIFIES-WHAT (SEM COMPUTER))
(STORES-IDENTIFYING-INFORMATION (SEM SESSION-INFORMATION))
(SOURCE (SEM NETWORK-SERVER))))
))

(KEYSTROKE-DYNAMICS
 (KEYSTROKE-DYNAMICS-N1 (CAT N) (ANNO (DEF "the rhythms with which one types at a
keyboard ") (EX "Keyboard dynamics systems can measure one's keyboard input up to 1000 times per
second. ") (COMMENTS ""))
  (SYN-STRUC
   ((N ((ROOT $VAR1) (CAT N) (POSSESSIVE +) (OPT +))) (ROOT $VAR0) (CAT N)))
  (SEM-STRUC (KEYSTROKE-DYNAMICS (IDENTIFIES-WHAT (VALUE ^$VAR1))))
))

(SALIVA
 (SALIVA-N1 (CAT N)
```

```
  (ANNO  (DEF "a clear liquid secreted into the mouth by the salivary glands and mucous glands of the
mouth; moistens the mouth and starts the digestion." ) (EX "Saliva is produced in and secreted from
salivary glands. ") (COMMENTS ""))
  (SYN-STRUC
   ((N ((ROOT $VAR1) (CAT N) (POSSESSIVE +) (OPT +))) (ROOT $VAR0) (CAT N)))
  (SEM-STRUC (SALIVA))
))

(SALIVA-SAMPLE
 (SALIVA-SAMPLE-N1 (CAT N) (ANNO (DEF "a physical quality of human saliva that can be used to
identify a human.") (EX  "Saliva samples can be used for DNA comparison.") (COMMENTS ""))
  (SYN-STRUC
   ((N ((ROOT $VAR1) (CAT N) (POSSESSIVE +) (OPT +))) (ROOT $VAR0) (CAT N)))
  (SEM-STRUC (SALIVA-SAMPLE (IDENTIFIES-WHAT (VALUE ^$VAR1))))
))

(HAND-GEOMETRY
 (HAND-GEOMETRY-N1 (CAT N) (ANNO (DEF "a physical quality of human hand that can be used to
identify a human.") (EX "") (COMMENTS ""))
  (SYN-STRUC
   ((N ((ROOT $VAR1) (CAT N) (POSSESSIVE +) (OPT +))) (ROOT $VAR0) (CAT N)))
  (SEM-STRUC (HAND-GEOMETRY (IDENTIFIES-WHAT (VALUE ^$VAR1))))
))

 (DNA-SAMPLE
 (DNA-SAMPLE-N1 (CAT N) (ANNO (DEF "a physical quality of human DNA that can be used to
uniquely identify a human.") (EX "") (COMMENTS ""))
  (SYN-STRUC
   ((N ((ROOT $VAR1) (CAT N) (POSSESSIVE +) (OPT +))) (ROOT $VAR0) (CAT N)))
  (SEM-STRUC (DNA-SAMPLE (IDENTIFIES-WHAT (VALUE ^$VAR1))))
))

(FOOTPRINT
 (FOOTPRINT-N1 (CAT N)
 (SYNONYMS "FOOT-PRINT")
 (ANNO (DEF "a physical quality of human foot that can be used to identify a human.") (EX "Footprints
can be used in the same manner as fingerprints by law enforcement.") (COMMENTS ""))
  (SYN-STRUC
   ((N ((ROOT $VAR1) (CAT N) (POSSESSIVE +) (OPT +))) (ROOT $VAR0) (CAT N)))
  (SEM-STRUC (FOOT-PRINT (IDENTIFIES-WHAT (VALUE ^$VAR1))))
))

(VOICE-PRINT
 (VOICE-PRINT-N1 (CAT N)
  (ANNO (DEF "("a physical quality of human voice that can be used to identify a human.") (EX "You
voice print is as unique as your fingerprint.") (COMMENTS ""))
  (SYN-STRUC
   ((N ((ROOT $VAR1) (CAT N) (POSSESSIVE +) (OPT +))) (ROOT $VAR0) (CAT N)))
  (SEM-STRUC (VOICE-PRINT (IDENTIFIES-WHAT (VALUE ^$VAR1))))
))

(FINGERPRINT
 (FINGERPRINT-N1 (CAT N)
```

```
 (ANNO (DEF "a physical quality of human finger that can be used to identify a human.") (EX "")
(COMMENTS ""))
  (SYN-STRUC
   ((N ((ROOT $VAR1) (CAT N) (POSSESSIVE +) (OPT +))) (ROOT $VAR0) (CAT N)))
  (SEM-STRUC (FINGER-PRINT (IDENTIFIES-WHAT (VALUE ^$VAR1))
)
 (FINGERPRINT-V1 (CAT V)
(ANNO (DEF "an act of obtaining fingerprints.") (EX "It's illegal to fingerprint anyone without their
explicit consent.") (COMMENTS ""))
  (SYN-STRUC
   ((ROOT $VAR0) (CAT V) (SUBJECT ((ROOT $VAR2)))
    (DIRECTOBJECT ((ROOT $VAR3))))
  (SEM-STRUC (ACQUIRE
(AGENT (VALUE $VAR2))
(THEME (VALUE REFSEM1))))
(REFSEM1 (SEM FINGERPRINT
(IDENTIFIES-WHAT (VALUE $VAR3))))
))

(IRIS-SCAN
 (IRIS-SCAN-N1 (CAT N)
 (ANNO (DEF "a physical quality of human iris that can be used to identify a human.") (EX "iris scans
analyze the features that exist in the colored tissue surrounding the pupil which has more than 200 points
that can be used for comparison, including rings, furrows and freckles.") (COMMENTS ""))
  (SYN-STRUC
   ((N ((ROOT $VAR1) (CAT N) (POSSESSIVE +) (OPT +))) (ROOT $VAR0) (CAT N)))
  (SEM-STRUC (IRIS-SCAN (IDENTIFIES-WHAT (VALUE ^$VAR1))))
))

(RETINAL-SCAN
(RETINAL-SCAN-N1 (CAT N)
(ANNO (DEF "a physical quality of human retina that can be used to identify a human.") (EX "Retinal
scanning analyses the layer of blood vessels at the back of the eye. ") (COMMENTS ""))
  (SYN-STRUC
   ((N ((ROOT $VAR1) (CAT N) (POSSESSIVE +) (OPT +))) (ROOT $VAR0) (CAT N)))
  (SEM-STRUC (RETINA-SCAN
(IDENTIFIES-WHAT (VALUE ^$VAR1)))
))

(GAIT
(GAIT-N1 (CAT N)
(ANNO (DEF "a physical quality of walking manner that can be used to identify a human with some
reliability.") (EX "Recognition by the way someone walk (their gait), the shape of their ears,  and the
rhythm they make when they tap all have the potential to raise the stock of biometric techniques.")
(COMMENTS ""))
  (SYN-STRUC
   ((N ((ROOT $VAR1) (CAT N) (POSSESSIVE +) (OPT +))) (ROOT $VAR0) (CAT N)))
  (SEM-STRUC (GAIT-ATTRIBUTE
(IDENTIFIES-WHAT (VALUE ^$VAR1))))
))

(BIOMETRICS
(BIOMETRICS-N1 (CAT N)
```

```
(ANNO (DEF “a physical quality that may be used to identify its carrier.") (EX "Retinal scans, finger printing or facial recognition get most of the publicity but researchers across the world are quietly laboring away at alternative types of biometrics.") (COMMENTS ""))
  (SYN-STRUC
   ((N ((ROOT $VAR1) (CAT N) (POSSESSIVE +) (OPT +))) (ROOT $VAR0) (CAT N)))
  (SEM-STRUC (INSTANCE-OF (BIOMETRICS)))
))

(PGP-SIGNATURE
 (PGP-N1 (CAT N)
  (ANNO
   (DEF "A digital key with asymmetric key encription, allows to cipher messages.")(EX "If you download the sendmail distribution you MUST verify the PGP signature.") (COMMENTS ""))
     ((N ((ROOT $VAR1) (CAT N) (POSSESSIVE +) (OPT +))) (ROOT $VAR0) (CAT N)))
  (SEM-STRUC (PGP-SIGNATURE
(IDENTIFIES-WHAT (VALUE ^$VAR1))))
))

(INSURANCE-POLICY
 (INSURANCE-POLICY-NUMBER-N1 (CAT N)
  (ANNO (DEF “The unique identifying number on one’s insurance policy.")(EX "Even in case of emergency, any hospital will ask you to provide your insurance policy number.") (COMMENTS ""))
   ((N ((ROOT $VAR1) (CAT N) (POSSESSIVE +) (OPT +))) (ROOT $VAR0) (CAT N)))
  (SEM-STRUC (INSURANCE-POLICY
(OWNED-BY (VALUE ^$VAR1))))
))

(DRIVER’S-LICENSE
 (DRIVER’S-LICENSE-N1 (CAT N)
  (ANNO
   (DEF “a document that allows its owner to drive and provides proof of identity.")
   (EX "I would like to see your driver’s license." ) (COMMENTS ""))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
  (SEM-STRUC (DRIVER’S-LICENSE))
))

(SOCIAL-SECURITY-CARD
 (SOCIAL-SECURITY-N1 (CAT N)
  (ANNO
   (DEF “The document that allows its owner to work and gives access to state social security resources.")
   (EX "Do not keep your social security card in your wallet.") (COMMENTS ""))
   ((N ((ROOT $VAR1) (CAT N) (POSSESSIVE +) (OPT +))) (ROOT $VAR0) (CAT N)))
  (SEM-STRUC (SOCIAL-SECURITY-CARD
(IDENTIFIES-WHAT (VALUE ^$VAR1))))
))

(STATE-IDENTITY-CARD
 (STATE-IDENTITY-CARD-N1 (CAT N)
(SYNONYMS “STATE-ID, Personal identification card, PID”)
  (ANNO (DEF “The document that allows its owner to work and gives access to state social security resources.")
   (EX "Even if you don’t drive, you can still get  a state identity card.") (COMMENTS ""))
   ((N ((ROOT $VAR1) (CAT N) (POSSESSIVE +) (OPT +))) (ROOT $VAR0) (CAT N)))
  (SEM-STRUC (STATE-IDENTITY-CARD
```

```
  (IDENTIFIES-WHAT (VALUE ^$VAR1))))
))

(BOT
 (BOT-N1 (CAT N)
   (ANNO (DEF "a software program that is a software agent.")
   (EX "A software program that imitates the behavior of a human, as by querying search engines or
participating in chatroom or IRC discussions.") (COMMENTS ""))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
  (SEM-STRUC (SOFTWARE-AGENT))
)

(BACHELOR-OF-SCIENCE
 (BACHELOR-OF-SCIENCE-N1 (CAT N)
(SYNONYMS “BS, BS degree”)
  (ANNO (DEF “an educational degree granted for the successful completion of a college program in
science.")
   (EX "He earned his bachelor of science at Purdue.") (COMMENTS ""))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
  (SEM-STRUC (SEM (EDUCATIONAL-LEVEL
  (FIELD-OF-STUDY (SEM SCIENCE))
  (YEARS-OF-EDUCATION (VALUE > 15))))
))

(BACHELOR-OF-ARTS
 (BACHELOR-OF-ARTS-N1 (CAT N)
(SYNONYMS “BA, BA degree”)
  (ANNO (DEF “an educational degree granted for the successful completion of a college program in
liberal arts.")
   (EX "She has a Bachelor of Arts in classics.") (COMMENTS ""))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
  (SEM-STRUC (EDUCATIONAL-LEVEL
  (FIELD-OF-STUDY (SEM LIBERAL-ARTS))
  (YEARS-OF-EDUCATION (VALUE > 15))))
))

(ASSOCIATE-OF-ARTS
 (ASSOCIATE-OF-ARTS-N1 (CAT N)
(SYNONYMS “AA, AA degree”)
  (ANNO (DEF “an educational degree granted for the successful completion of a 2-year college program
in liberal arts.")
   (EX "") (COMMENTS ""))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
  (SEM-STRUC (EDUCATIONAL-LEVEL
  (FIELD-OF-STUDY (SEM LIBERAL-ARTS))
  (YEARS-OF-EDUCATION (VALUE > 13))))
))

(ASSOCIATE-OF-SCIENCES
 (ASSOCIATE-OF-ARTS-N1 (CAT N)
(SYNONYMS “AS, AS degree”)
  (ANNO (DEF “an educational degree granted for the successful completion of a 2-year college program
in SCIENCE.")
   (EX "") (COMMENTS ""))
```

```
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
  (SEM-STRUC (EDUCATIONAL-LEVEL
  (FIELD-OF-STUDY (SEM SCIENCE))
  (YEARS-OF-EDUCATION (VALUE > 13))))
))

(MASTER-OF-SCIENCES
 (MASTER-OF-SCIENCES-N1 (CAT N)
(SYNONYMS “MS, MS degree”)
  (ANNO
   (DEF “an educational degree granted for the successful completion of a Master's program in science.")
   (EX "") (COMMENTS ""))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
  (SEM-STRUC (EDUCATIONAL-LEVEL
  (FIELD-OF-STUDY (SCIENCE))
  (YEARS-OF-EDUCATION (VALUE > 17))))
))

(MASTER-OF-ARTS
 (MASTER-OF-ARTS-N1 (CAT N)
(SYNONYMS “MA, MA degree”)
  (ANNO
   (DEF “an educational degree granted for the successful completion of a Master's program in liberal arts.")
   (EX "") (COMMENTS ""))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
  (SEM-STRUC (EDUCATIONAL-LEVEL
  (FIELD-OF-STUDY (SEM LIBERAL-ARTS))
  (YEARS-OF-EDUCATION (VALUE > 17))))
))

(MASTER-OF-FINE-ARTS
 (MASTER-OF-FINE-ARTS-N1 (CAT N)
(SYNONYMS “MFA, MFA degree”)
  (ANNO
   (DEF “an educational degree granted for the successful completion of a Master's program in fine arts.")
   (EX "") (COMMENTS ""))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
  (SEM-STRUC (EDUCATIONAL-LEVEL
  (FIELD-OF-STUDY (SEM FINE-ARTS))
  (YEARS-OF-EDUCATION (VALUE > 17))))
))

(DOCTOR-OF-PHILOSOPHY
 (DOCTOR-OF-PHILOSOPHY-N1 (CAT N)
(SYNONYMS “Ph.D., Ph.D.degree”)
  (ANNO
   (DEF “an educational degree granted for the successful completion of a doctoral program.")
   (EX "") (COMMENTS ""))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
  (SEM-STRUC (EDUCATIONAL-LEVEL
  (YEARS-OF-EDUCATION (VALUE > 20))))
))

(DOCTOR-OF-PHARMACY
```

```
 (DOCTOR-OF-PHARMACY-N1 (CAT N)
(SYNONYMS “Pharm.D., Pharm.D.degree”)
  (ANNO
   (DEF “an educational degree granted for the successful completion of a doctoral program in pharmacy.")
   (EX "") (COMMENTS ""))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
  (SEM-STRUC (EDUCATIONAL-LEVEL
  (FIELD-OF-STUDY (SEM PHARMACEUTICS))
  (YEARS-OF-EDUCATION (VALUE > 20))))
))

(JURIS-DOCTOR
 (JURIS-DOCTOR-N1 (CAT N)
(SYNONYMS “J.D., J.D.degree”)
  (ANNO
   (DEF “an educational degree granted for the successful completion of a law school.")
   (EX "") (COMMENTS ""))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
  (SEM-STRUC (EDUCATIONAL-LEVEL))
  (FIELD-OF-STUDY (SEM FIELD-OF-LAW))
  (YEARS-OF-EDUCATION (VALUE > 19))))
))

(DOCTOR-OF-MEDICINE
 (DOCTOR-OF-MEDICINE-N1 (CAT N)
(SYNONYMS “M.D.”)
  (ANNO
   (DEF “an educational degree granted for the successful completion of a medical school.")
   (EX "") (COMMENTS ""))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
  (SEM-STRUC (EDUCATIONAL-LEVEL
  (FIELD-OF-STUDY (SEM MEDICINE))
  (YEARS-OF-EDUCATION (VALUE > 24))))
))

(MASTER-OF-BUSINESS-ADMINISTRATION
 (MASTER-OF-BUSINESS-ADMINISTRATION-N1 (CAT N)
(SYNONYMS “MBA”)
  (ANNO
   (DEF “an educational degree granted for the successful completion of a medical school.")
   (EX "") (COMMENTS ""))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
  (SEM-STRUC (EDUCATIONAL-LEVEL
  (FIELD-OF-STUDY (SEM FINANCE BUSINESS))
  (YEARS-OF-EDUCATION (VALUE > 18))
  (YEARS-OF-EXPERIENCE (VALUE >2))))
))

(EXPIRATION-DATE
 (EXPIRATION-DATE-N1 (CAT N)
  (ANNO (DEF “a date by which a product should be used.")
   (EX "This yoghurt’s expiration date has passed." ) (COMMENTS ""))
(SYN-STRUC
   ((ROOT $VAR0) (CAT N)
```

```
    (PP ((ROOT OF) (ROOT $VAR1)))))
  (SEM-STRUC (AFTER REFSEM1 DATE))
 (REFSEM1 (BE-AVAILABLE (THEME (VALUE $VAR1)))
))

(ISSUE-DATE
 (ISSUE-DATE-N1 (CAT N)
  (ANNO (DEF “a date after which a product is available.")
   (EX "I sorted the magazines by issue dates.") (COMMENTS ""))
(SYN-STRUC
   ((ROOT $VAR0) (CAT N)
    (PP ((ROOT OF) (ROOT $VAR1)))))
  (SEM-STRUC (AFTER DATE REFSEM1))
 (REFSEM1 (BE-AVAILABLE (THEME (VALUE $VAR1)))
))

(BIRTH-DATE
 (BIRTH-DATE-N1 (CAT N)
  (ANNO (DEF “a date when an animal/human is born.")
   (EX "This site contains information from birth records with birth dates of over 100 years of age.")
(COMMENTS ""))
(SYN-STRUC
   ((ROOT $VAR0) (CAT N)
    (PP ((ROOT OF) (ROOT $VAR1)))))
  (SEM-STRUC (DATE
 (THEME (SEM REFSEM1))
(REFSEM1 (BE-BORN (EXPERIENCER (VALUE $VAR1))))
))

(BIRTH-YEAR
 (BIRTH-YEAR-N1 (CAT N)
  (ANNO(DEF “a YEAR when an animal/human is born.")(EX "") (COMMENTS ""))
(SYN-STRUC
   ((ROOT $VAR0) (CAT N)
    (PP ((ROOT OF) (ROOT $VAR1)))))
  (SEM-STRUC (DURING YEAR REFSEM1))
 (REFSEM1(BE-BORN (THEME (VALUE $VAR1)))
))

(BIRTH-DAY
 (BIRTH-DAY-N1 (CAT N)
  (ANNO(DEF “a day when an animal/human is born.")
   (EX "") (COMMENTS ""))
(SYN-STRUC
   ((ROOT $VAR0) (CAT N)
    (PP ((ROOT OF) (ROOT $VAR1)))))
  (SEM-STRUC (DURING DAY REFSEM1))
 (REFSEM1 (BE-BORN
(THEME (VALUE $VAR1)))
))

(BIRTH-MONTH
 (BIRTH-MONTH-N1 (CAT N)
  (ANNO
```

```
   (DEF “a month when an animal/human is born.")
   (EX "") (COMMENTS ""))
(SYN-STRUC
   ((ROOT $VAR0) (CAT N)
    (PP ((ROOT OF) (ROOT $VAR1)))))
  (SEM-STRUC (DURING MONTH REFSEM1))
 (REFSEM1 (BE-BORN
(THEME (VALUE $VAR1)))
))

(HUMANITIES
 (HUMANITIES-N1 (CAT N)
(SYNONYMS “Liberal arts”)
  (ANNO (DEF "Academic disciplines, such as languages, literature, history, philosophy, mathematics, and
science, that provide information of general cultural concern.")
   (EX "I studied humanities in college.") (COMMENTS ""))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
  (SEM-STRUC (LIBERAL-ARTS))
))

(LIBERAL-ARTS
 (LIBERAL-ARTS-N1 (CAT N)
(SYNONYMS “Humanities”)
  (ANNO (DEF "Academic disciplines, such as languages, literature, history, philosophy, mathematics, and
science, that provide information of general cultural concern.")
   (EX "The college of liberal arts is comprised of many departments.") (COMMENTS ""))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
  (SEM-STRUC (LIBERAL-ARTS))
))

(MOBILE-PHONE
 (MOBILE-PHONE -N1 (CAT N)
(SYNONYMS “mobile, cell phone, cell”)
  (ANNO (DEF ("a mobile radiotelephone that is controlled by a computer system.") (EX "I’m thinking of
buying a mobile phone.") (COMMENTS ""))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
  (SEM-STRUC (CELL-PHONE))
))

(LAPTOP
 (LAPTOP-N1 (CAT N)
(SYNONYMS “Notebook, notebook computer”)
  (ANNO
   (DEF "a computer that is light enough to be taken around by a human")(EX "My laptop weighs 2
pounds.") (COMMENTS ""))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
  (SEM-STRUC (LAPTOP))
))

(NOTEBOOK
 (LAPTOP-N1 (CAT N)
(SYNONYMS “laptop, notebook computer”)
  (ANNO (DEF "a computer that is light enough to be taken around by a human") (EX "Notebooks are
becoming popular on campus.") (COMMENTS ""))
```

```
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
  (SEM-STRUC (LAPTOP))
(NOTEBOOK-N2 (CAT N)
  (ANNO
   (DEF "a bound pile of paper used for taking notes")
   (EX "") (COMMENTS ""))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
  (SEM-STRUC (PAPER-PRODUCT)))
)

(DESKNOTE-N1 (CAT N)
  (ANNO (DEF "a computer that is light enough to be taken around by a human") (EX "Desknotes are
crosses between desktop computers and notebook computers.") (COMMENTS ""))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
  (SEM-STRUC (MOBILE-COMPUTER
(WEIGHT-ATTRIBUTE(VALUE <> 2 7))
(MEASURED-IN (SEM LB))))
))

(PERSONAL-DIGITAL-ASSISTANT
 (PERSONAL-DIGITAL-ASSISTANT-N1 (CAT N)
(SYNONYMS “palm, PDA, palmtop, handheld”)
  (ANNO (DEF ("palmtop computer or personal digital assistant; a major advantage of PDAs is their ability
to synchronize data with other computers.") (EX "The main purpose of a personal digital assistant is to act
as an electronic organizer or day planner that is portable, easy to use and capable of sharing information
with your PC. ") (COMMENTS ""))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
  (SEM-STRUC (PALMTOP))
))

(HANDHELD
 (HANDHELD-N1 (CAT N)
(SYNONYMS “palm, PDA, personal digital assistant, handheld”)
  (ANNO (DEF ("palmtop computer or personal digital assistant; a major advantage of PDAs is their ability
to synchronize data with other computers.") (EX "Where did I put my handheld?") (COMMENTS ""))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
  (SEM-STRUC (PALMTOP))
))

(PDA
 (PDA-N1 (CAT N)
(SYNONYMS “palm, PDA, palmtop, handheld”)
  (ANNO (DEF ("palmtop computer or personal digital assistant; a major advantage of PDAs is their ability
to synchronize data with other computers.")(EX "He wants a PDA for his Birthday.") (COMMENTS ""))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
  (SEM-STRUC (PALMTOP))
))

(PALM
 (PALM-N1 (CAT N)
(SYNONYMS “palm, PDA, palmtop, handheld”)
  (ANNO (DEF ("palmtop computer or personal digital assistant; a major advantage of PDAs is their ability
to synchronize data with other computers.") (EX "My palm comes handy at the airports to get some work
done.") (COMMENTS ""))
```

```
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
  (SEM-STRUC (PALMTOP))
))

(DIGITAL-CAMERA
 (DIGITAL-CAMERA-N1 (CAT N)
(ANNO (DEF ("a camera that takes pictures and converts them to files")
   (EX "Eastman Kodak Co. is delaying its launch of a highly touted digital camera that will use wireless
technology to transfer images to computers or printers.") (COMMENTS ""))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
  (SEM-STRUC (STILL-CAMERA
(HAS-OBJECT-AS-PART (SEM SEMICONDUCTOR-STORAGE-DEVICE))))
))

(FLASH-MEMORY
 (FLASH-MEMORY-N1 (CAT N)
 (ANNO (DEF ("one of the formats of file storage based on a transistor, which allows multiple memory
location to be written in one programming operation")(EX "Flash memory is used for easy and fast
information storage in such devices as digital cameras and home video game consoles. ") (COMMENTS
""))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
  (SEM-STRUC (SEMICONDUCTOR-STORAGE-DEVICE))
))

(SECURE-DIGITAL-CARD
 (SECURE-DIGITAL-CARD-N1 (CAT N)
(SYNONYMS "SD, Secure Digital")
 (ANNO (DEF ("one of the formats of file storage based on a transistor, which allows multiple memory
location to be written in one programming operation") (EX "Typically, an Secure digital card is used as
storage media for a portable device, in a form that can easily be removed for access by a PC. ")
(COMMENTS ""))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
  (SEM-STRUC (INDEPENDENT-DEVICE
(CONTAINS (SEM FLASH-MEMORY))))
))

(FINGERPRINT-SAMPLING-UNIT
 (FINGERPRINT-SAMPLING-UNIT-N1 (CAT N)
(ANNO (DEF ("device that is used for identification of humans by sampling their fingerprints") (EX
"Finally, fingerprint sampling units are accurate, sturdy, compact, and less susceptible to forgery. ")
(COMMENTS ""))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
  (SEM-STRUC (FINGERPRINT-SAMPLING-UNIT))
))

(STYLUS
 (STYLUS-N1 (CAT N)
(ANNO (DEF "a narrow, elongated staff, similar to a pen, used as an input device in palmtops")(EX "The
stylus for my PDA is so small, I keep loosing it.") (COMMENTS ""))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
  (SEM-STRUC (STYLUS))
))

(SMARTCARD
```

```
(SMARTCARD-N1 (CAT N)
(ANNO (DEF "a secure microprocessor embedded within a credit card-sized or smaller card.")(EX
"Giesecke & Devrient, a leading smartcard supplier, has begun shipping to U.S. services supplier
Halliburton what G&D claims is the industry's first USB token using biometric authentication, a smart card
IC and on-card matching technologies.") (COMMENTS ""))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
  (SEM-STRUC (SMARTCARD))
))

(SMARTPHONE
(SMARTPHONE-N1 (CAT N)
(ANNO (DEF "any handheld device that integrates personal information management and mobile phone
capabilities in the same device.")
   (EX "My new smartphone is so smart, I need a tutorial for using it.") (COMMENTS ""))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
  (SEM-STRUC (SMARTPHONE))
))

(BIOS-CHIP
(BIOS-CHIP-N1 (CAT N)
(SYNONYMS “BIOS memory, BIOS”)
(ANNO (DEF “semiconductor memory used for booting the computer")
(EX "graphics cards often have their own BIOS chips.") (COMMENTS ""))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
  (SEM-STRUC (BIOS-CHIP))
))

(SPYWARE
 (SPYWARE-N1 (CAT N)
  (ANNO (DEF "software that gathers and reports information about a computer user without the user's
knowledge or consent.")
   (COMMENTS "") (EX "The House of Representatives voted overwhelmingly for two bills which clamp
down on spyware programs."))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
(SEM-STRUC (SOFTWARE
(INSTRUMENT-OF (SEM REFSEM1)))
(REFSEM1 (SPY-ON (THEME (SEM USER-COMPUTER))))
))

(ADWARE
 (ADWARE-N1 (CAT N)
  (ANNO(DEF “software application in which advertisement are displayed while the program is running
")(COMMENTS "") (EX "A software can be Adware and Spyware at the same time."))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
(SEM-STRUC (SOFTWARE
(INSTRUMENT-OF (SEM REFSEM1))))
(REFSEM1 (ADVERTISE
(DESTINATION (USER-COMPUTER))))
))

(MALWARE
(MALWARE-N1 (CAT N)
```

```
  (ANNO (DEF “any software developed for the purpose of doing harm to a computer system.")
(COMMENTS "") (EX "Malware can be classified based on how it is executed, how it spreads, and/or what
it does. "))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
(SEM-STRUC (SOFTWARE
(INSTRUMENT-OF (SEM REFSEM1))))
(REFSEM1 (INCUR-DAMAGE
(BENEFICIARY (COMPUTER USER-COMPUTER))))
))

(MIDDLEWARE
(MIDDLWARE-N1 (CAT N)
  (ANNO (DEF “software agents acting as an intermediary between different application components.")
(COMMENTS "") (EX "Nationwide is rolling out a middleware platform to simplify the deployment of
applications across its automatic teller machines, kiosks and bank teller systems."))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
(SEM-STRUC (SOFTWARE-AGENT
(INSTRUMENT-OF (SEM INTEGRATE)
(THEME (SEM SOFTWARE))))
))

(SHAREWARE
(SHAREWARE-N1 (CAT N)
  (ANNO (DEF “software that is distributed to end-user for free. ")
   (COMMENTS "") (EX "Shareware is also known as try before you buy, demoware, trialware and many
other names."))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
(SEM-STRUC (SOFTWARE
(COST (VALUE 0))))
))

(P2P
(P2P-N1 (CAT N)
(SYNONYMS “Peer-to-peer network”)
  (ANNO (DEF “peer-to-peer (or P2P) computer network is any network that does not rely on dedicated
servers for communication but instead mostly uses direct connections between clients (peers). ")
   (COMMENTS "") (EX "P2P networks are used for sharing content like audio, video, data or anything in
digital format."))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
(SEM-STRUC (SOFTWARE
(INSTRUMENT-OF (SEM INTEGRATE)
(THEME (SEM COMPUTER-NETWORK))
(HAS-PARTS (NOT NETWORK-SERVER))))
))

(FACE-RECOGNITION
(FACE-RECOGNITION-N1 (CAT N)
  (ANNO (DEF “methodology allowing to identify a human by its facial geometry
biometric.")(COMMENTS "") (EX "This assignment, given in the fall semester of 1994 for the Machine
Learning class at Carnegie Mellon, involves face recognition using neural networks."))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
(SEM-STRUC (METHOD
(INSTRUMENT-OF (SEM REFSEM1))))
(REFSEM1 (OBTAIN-INFORMATION
```

```
(THEME (FACIAL-GEOMETRY))))
))

(EIGENFACE-COMPARISON
(EIGENFACE-COMPARISON-N1 (CAT N)
  (ANNO (DEF “methodology allowing to identify a human by its facial geometry biometric.")
(COMMENTS "") (EX "Depending upon the technology used, the system will extract a facial image using
local feature extraction, Eigenface comparison or other method to isolate unique aspects. "))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
(SEM-STRUC (ALGORIHM
(INSTRUMENT-OF (SEM REFSEM1))))
(REFSEM1 (OBTAIN-INFORMATION
(THEME (SEM FACIAL-GEOMETRY))))
))

(UNIX
(UNIX-N1 (CAT N)
  (ANNO (DEF “portable, multi-task and multi-user computer operating system.") (COMMENTS "") (EX
"Experience with UNIX is preferable."))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
(SEM-STRUC (OPERATING-SYSTEM)))
))

(LINUX
(LINUX-N1 (CAT N)
  (ANNO (DEF “open-source operating system.")(COMMENTS "") (EX "I have both Windows and Linux
running on my computer."))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
(SEM-STRUC (OPERATING-SYSTEM
(COST (VALUE 0))
(PRODUCED-BY (SEM PROGRAMMER))))
(LINUX-N2 (CAT N)
  (ANNO   (DEF “portable, multi-task and multi-user computer operating system.")  (COMMENTS "") (EX
""))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
(SEM-STRUC (SOFTWARE-KERNEL
(COST (VALUE 0))
(PRODUCED-BY (SEM PROGRAMMER))))
))

(WINDOWS
(WINDOWS-N1 (CAT N)
  (ANNO (DEF “an GUI-oriented operating system for personal computers.")(COMMENTS "") (EX ""))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
(SEM-STRUC (OPERATING-SYSTEM
(LOCATION (SEM PERSONAL-COMPUTER))
(PRODUCED-BY (VALUE SOFTWARE-DEVELOPMENT-CORPORATION-2))))
))

(MAC
(MAC-N1 (CAT N)
(SYNONYMS “Macintosh, Mac operating system, Mac OS, Mac OS X”)
  (ANNO(DEF “an GUI-oriented operating system for personal computers based on Apple hardware.")
   (COMMENTS "") (EX ""))
```

```
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
(SEM-STRUC (OPERATING-SYSTEM
(PRODUCED-BY (VALUE SOFTWARE-DEVELOPMENT-CORPORATION-1))))
))

(FLASH-CARD
(FLASH-CARD-N1 (CAT N)
  (ANNO(DEF “a portable memory card based on Flash memory.")
   (COMMENTS "") (EX "Take your flash card with dissertation files with you when you go to deposit."))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
(SEM-STRUC (INDEPENDENT-DEVICE
(CONTAINS (SEM FLASH-MEMORY))))
))

(MULTIMEDIA-CARD
(MULTIMEDIA-CARD-N1 (CAT N)
  (ANNO (DEF “a portable memory card based on Flash memory.")
   (COMMENTS "") (EX "The Multimedia Cards are approximately the size of a postage stamp with the
thickness of about 1 mm."))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
(SEM-STRUC (INDEPENDENT-DEVICE
 (CONTAINS (SEM FLASH-CARD))))
))

(ATM-CARD
(ATM-CARD-N1 (CAT N)
(SYNONYMS “debit card, bank card”)
  (ANNO (DEF “a card that can be used to access a debit account.")
   (COMMENTS "") (EX "Just as the various logos that appear on ATM cards tell you where they can be
used to get cash or make banking transactions at ATMs, they also indicate where your card can be used to
make purchases. "))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
(SEM-STRUC (DEBIT-CARD))
))

(DEBIT-CARD
(DEBIT-CARD-N1 (CAT N)
(SYNONYMS “ATM card, bank card”)
  (ANNO (DEF “a card that can be used to access a debit account.")
   (COMMENTS "") (EX "Debit cards look like credit cards or ATM (automated teller machine) cards, but
operate like cash or a personal check."))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
(SEM-STRUC (DEBIT-CARD))
))

(BANK-CARD
(BANK-CARD-N1 (CAT N)
(SYNONYMS “debit card, ATM card”)
  (ANNO (DEF “a card that can be used to access a debit account.")
   (COMMENTS "") (EX "Equipment being installed on front of existing bank card slot."))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
(SEM-STRUC (DEBIT-CARD))
))
```

```
(GIFT-CARD
(GIFT-CARD-N1 (CAT N)
  (ANNO (DEF “a card that has a pre-set amount of money on it, which can usually be re-
loaded.")(COMMENTS "") (EX "If you don’t know what  to buy for his birthday, get a gift-card from a
reputable store."))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
(SEM-STRUC (GIFT-CARD))
))

(MESSAGE
(MESSAGE-N1 (CAT N)
(ANNO (DEF "A usually short communication transmitted by words, signals, or other means from one
person, station, or group to another.") (EX "I gestured to a waiter, who got the message and brought the
bill. ") (COMMENTS ""))
(SYN-STRUC ((ROOT $VAR0) (CAT N)))
(SEM-STRUC (MESSAGE))
))

(VIRTUAL-ENVIRONMENT
(VIRTUAL-ENVIRONMENT-N1 (CAT N)
(ANNO (DEF "environment that is simulated by a computer. ") (EX "Most virtual environments are
primarily visual experiences, displayed either on a computer screen or through special stereoscopic
goggles, but some simulations include additional sensory information, such as sound through speakers. ")
(COMMENTS ""))
(SYN-STRUC ((ROOT $VAR0) (CAT N)))
(SEM-STRUC (VIRTUAL-ENVIRONMENT))
))

(NEWSGROUP
(NEWSGROUP-N1 (CAT N)
(ANNO (DEF "A newsgroup is a repository, usually within the Usenet system, for messages posted from
many users at different locations. ") (EX "Newsgroups are often arranged into hierarchies, theoretically
making it simpler to find related groups.") (COMMENTS ""))
(SYN-STRUC ((ROOT $VAR0) (CAT N)))
(SEM-STRUC (NEWSGROUP))
))

(INTERNET
(INTERNET-N1 (CAT N)
(ANNO (DEF "publicly available worldwide system of interconnected computer networks that transmit
data by packet switching using a standardized Internet Protocol (IP) and many other protocols. ") (EX "The
Internet is also having a profound impact on work, knowledge and worldviews. ") (COMMENTS ""))
(SYN-STRUC ((ROOT $VAR0) (CAT N)))
(SEM-STRUC (INTERNET))
))

(CHAT-PROGRAM
(CHAT-PROGRAM-N1 (CAT N)
(ANNO (DEF "a program used to enter chatroom.") (EX "If it is a very popular chat room, then you can get
on the computer, open your chat program, and go to that page, and someone will be there to talk to. ")
(COMMENTS ""))
(SYN-STRUC ((ROOT $VAR0) (CAT N)))
(SEM-STRUC (CHAT-PROGRAM))
))
```

```
(VIRTUAL-REALITY
(VIRTUAL-REALITY-N1 (CAT N)
(ANNO (DEF "environment that is simulated by a computer. ") (EX "Virtual reality originally denoted a fully immersive system, although it has since been used to describe systems lacking cybergloves etc.. ")
(COMMENTS ""))
(ANNO (DEF "") (EX "") (COMMENTS ""))
(SYN-STRUC ((ROOT $VAR0) (CAT N)))
(SEM-STRUC (VIRTUAL-REALITY))
))

(WEB-PAGE
(WEB-PAGE-N1 (CAT N)
(ANNO (DEF "a "page" of the World Wide Web, usually in HTML/XHTML format (the file extensions are typically htm or html) and with hypertext links to enable navigation from one page or section to another. ") (EX "A web page is displayed using a web browser.") (COMMENTS ""))
(SYN-STRUC ((ROOT $VAR0) (CAT N)))
(SEM-STRUC (WEB-PAGE))
))

(CHATROOM
(CHATROOM-N1 (CAT N)
(ANNO (DEF "an online forum where people can chat online (talk by broadcasting messages to people on the same forum in real time).") (EX "Chatrooms are often confused (especially by the popular media) with discussion groups, which are similar but do not take place in real time and are usually run over the World Wide Web. ") (COMMENTS ""))
(SYN-STRUC ((ROOT $VAR0) (CAT N)))
(SEM-STRUC (CHATROOM))
))

(DISCUSSION-FORUM
(SYNONYMS “Internet forum, online forum, message board, discussion board”)
(ANNO (DEF ". ") (EX “The discussion forum named ABUJAmobile, is to serve as a rallying point for Nigerian mobile users to meet and discuss issues related to the mobile phone industry in Nigeria.")
(COMMENTS ""))
(DISCUSSION-FORUM-N1 (CAT N)
(ANNO (DEF "") (EX "") (COMMENTS ""))
(SYN-STRUC ((ROOT $VAR0) (CAT N)))
(SEM-STRUC (DISCUSSION-FORUM))
))

(DISCUSSION-BOARD
(SYNONYMS “Internet forum, message board, discussion forum, online forum”)
(ANNO (DEF "any sort of system which provides discussion using the World Wide Web, often for online communities.") (EX "Madagascar travel forum and discussion board launched at WildMadagascar.org.")
(COMMENTS ""))
(DISCUSSION-BOARD-N1 (CAT N)
(ANNO (DEF "") (EX "") (COMMENTS ""))
(SYN-STRUC ((ROOT $VAR0) (CAT N)))
(SEM-STRUC (DISCUSSION-FORUM))
))

(INTERNET-FORUM
(SYNONYMS “online forum, discussion forum, message board, discussion board”)
```

```
(ANNO (DEF " any sort of system which provides discussion using the World Wide Web, often for online communities. ") (EX " Internet forums are prevalent in several developed countries..") (COMMENTS ""))
(INTERNET-FORUM-N1 (CAT N)
(ANNO (DEF "") (EX "") (COMMENTS ""))
(SYN-STRUC ((ROOT $VAR0) (CAT N)))
(SEM-STRUC (DISCUSSION-FORUM))
))

(ONLINE-FORUM
(SYNONYMS “discussion forum, internet forum, message board, discussion board”)
(ANNO (DEF " any sort of system which provides discussion using the World Wide Web, often for online communities. ") (EX "The Macromedia Online Forums are for the Macromedia Community’s peer–to-peer discussions of Macromedia products..") (COMMENTS ""))
(ONLINE-FORUM-N1 (CAT N)
(ANNO (DEF "") (EX "") (COMMENTS ""))
(SYN-STRUC ((ROOT $VAR0) (CAT N)))
(SEM-STRUC (DISCUSSION-FORUM))
))

(MESSAGE-BOARD
(SYNONYMS “online forum, discussion forum, internet forum, discussion board”)
(ANNO (DEF " any sort of system which provides discussion using the World Wide Web, often for online communities. ") (EX " Get more out of Message Boards: take our tour for a step-by-step introduction to our newest tools and features.") (COMMENTS ""))
(MESSAGE-BOARD -N1 (CAT N)
(ANNO (DEF "") (EX "") (COMMENTS ""))
(SYN-STRUC ((ROOT $VAR0) (CAT N)))
(SEM-STRUC (DISCUSSION-FORUM))
))

(CERTIFICATE-AUTHORITY
(CERTIFICATE-AUTHORITY-N1 (CAT N)
(ANNO (DEF "an entity which issues digital certificates for use by other parties. ") (EX "Certificate Authority is an example of trusted third party.") (COMMENTS ""))
(SYN-STRUC ((ROOT $VAR0) (CAT N)))
(SEM-STRUC (CERTIFICATE-AUTHORITY ))
))

(FIRMWARE
(FIRMWARE-N1 (CAT N)
(ANNO (DEF "software that is embedded in a hardware device, that allows reading and executing the software, and can be edited ") (EX "This program is a complete rewrite and uses no fragments of the original firmware ") (COMMENTS ""))
(SYN-STRUC ((ROOT $VAR0) (CAT N)))
(SEM-STRUC (SOFTWARE
(THEME-OF (NOT REFSEM1))))
(REFSEM1 (SEM MODIFY
(AGENT (USER-COMPUTER))
))

(DEPARTMENT-OF-MOTOR-VEHICLES
(DEPARTMENT-OF-MOTOR-VEHICLES-N1 (CAT N)
(SYNONYMS “DMV”)
```

(ANNO (DEF "a government department which handles matters related to automobiles, such as issuing license plates and driver's licenses. ") (EX "Usually, all long-term residents of a state must possess a driver's license issued by their state DMV, and their vehicles must show license plates (and current registration tags or stickers) issued by that agency. ") (COMMENTS ""))
(SYN-STRUC ((ROOT $VAR0) (CAT N)))
(SEM-STRUC (DEPARTMENT-OF-MOTOR-VEHICLES))
))

(EMBASSY
(EMBASSY-N1 (CAT N)
(ANNO (DEF "a group of people from one nation state present in another nation state to represent the sending state in the receiving State. ") (EX "In order to receive a visa, you need to send your documents to the embassy first.") (COMMENTS ""))
(SYN-STRUC ((ROOT $VAR0) (CAT N)))
(SEM-STRUC (EMBASSY))
))

(SOCIAL-SECURITY-ADMINISTRATION
(SOCIAL-SECURITY-ADMINISTRATION-N1 (CAT N)
(SYNONYMS “SSA”)
(ANNO (DEF "A US governmental organization manages the United States' social insurance program, consisting of retirement, disability, and survivors benefits. ") (EX "The Social Security Administration administers these social insurance programs, which provide monthly benefits to retired or disabled workers, their spouses and children, and to the survivors of insured workers. ") (COMMENTS ""))
(SYN-STRUC ((ROOT $VAR0) (CAT N)))
(SEM-STRUC (SOCIAL-SECURITY-ADMINISTRATION))
))

(PUBLIC-KEY-INFRASTRUCTURE
(PUBLIC-KEY-INFRASTRUCTURE-N1 (CAT N)
(SYNONYMS “PKI”)
(ANNO (DEF "an arrangement which provides for third-party vetting of, and vouching for, user identities.") (EX "PKI arrangements enable users to be authenticated to each other ") (COMMENTS ""))
(SYN-STRUC ((ROOT $VAR0) (CAT N)))
(SEM-STRUC (PUBLIC-KEY-INFRASTRUCTURE))
))

(SESSION-INFORMATION
(SESSION-INFORMATION-N1 (CAT N)
(ANNO (DEF "information concerning online activity of a user") (EX "We save your session information so that you could easily find the products you were interested in on our site.") (COMMENTS ""))
(SYN-STRUC ((ROOT $VAR0) (CAT N)))
(SEM-STRUC (SESSION-INFORMATION))
))

(STORE
 (STORE-N1 (CAT N)
(ANNO (DEF “a mercantile establishment for the retail sale of goods or services”) (EX “he bought it at a store on Cape Cod”)(COMMENT "I went to the store to buy some groceries"))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
(SEM-STRUC (STORE))
))

(ONLINE-STORE

```
 (ONLINE-STORE-N1 (CAT N)
(ANNO (DEF “A web site that accepts direct payments in exchange for goods and services.”) (EX
“Business looks good for beauty products online store”)(COMMENT ""))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
(SEM-STRUC (STORE
(LOCATION (VALUE INTERNET)
(REPRESENTED-BY (VALUE WEB-PAGE))
))

(WORLD-WIDE-WEB
 (WORLD-WIDE-WEB-N1 (CAT N)
(SYNONYMS “WWW, world-wide web”)
(ANNO (DEF “is an information space in which the items of interest, referred to as resources, are identified
by global identifiers”)(COMMENT "") (EX “The term www is often mistakenly used as a synonym for the
Internet, but the Web is actually a service that operates over the Internet.”))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
(SEM-STRUC (INTERNET))
))

(HYPERTEXT
 (HYPERTEXT-N1 (CAT N)
 (ANNO (DEF “a user interface paradigm for displaying documents which contain automated cross-
references to other documents (hyperlinks).”) (EX “The point of hypertext is to deal with the problem of
information overload.”)(COMMENT ""))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
(SEM-STRUC (HYPERTEXT))
))

(HYPERLINK
(SYNONYMS “link”)
 (HYPERLINK-N1 (CAT N)
 (ANNO (DEF “reference in a hypertext document to another document or other resource.”)(EX “There are
a number of ways to format and present hyperlinks on a web page.”)(COMMENT ""))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
(SEM-STRUC (HYPERLINK))
))

(INTERNET-RELAY-CHAT
(SYNONYMS “IRC”)
(ANNO (DEF “a form of instant communication over the Internet. It is mainly designed for group (many-
to-many) communication in discussion forums called channels, but also allows one-to-one
communication.")(EX "What IRC channel do you normally use?") (COMMENT ""))
 (INTERNET-RELAY-CHAT-N1 (CAT N)
 (ANNO (COMMENT ""))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
(SEM-STRUC (CHATROOM))
(COLLECTS-IDENTIFYING-INFORMATION (SEM USERNAME PASSWORD))
))

(INSTANT-MESSAGE
(SYNONYMS “IM”)
(ANNO (DEF “a message sent using a client which allows instant text communication between two or
more people through a network such as the Internet.")(EX "I got an IM that there is a party tonight.")
(COMMENT ""))
```

```
 (INSTANT-MESSAGE-N1 (CAT N)
 (ANNO (COMMENT ""))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
(SEM-STRUC (MESSAGE
(FUNCTIONS-LIKE (SEM CHATROOM))
))

(SHORT-MESSAGE-SERVICE
(SYNONYMS “SMS”)
 (SHORT-MESSAGE-SERVICE-N1 (CAT N)
 (ANNO (DEF “short messages sent between mobile phones and other handheld devices.”) (EX “SEND
ME AN SMS REMINDER”)(COMMENT ""))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
(SEM-STRUC (MESSAGE
(SOURCE (SEM CELLULAR-PHONE))
(HAS-IDENTIFYING-INFORMATION (SEM PHONE-NUMBER))
))

(AUDIT-LOG
(AUDIT-LOG-N1 (CAT N)
 (ANNO (DEF "A simple log of changes, intended to be easily written and non-intrusive.") (EX "Audit Log
is easy to write but harder to read, especially as it grows large.")(COMMENT ""))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
(SEM-STRUC (AUDIT-LOG))
))

(DOMAIN-NAME-SYSTEM
(SYNONYMS “DNS”)
(DOMAIN-NAME-SYSTEM-N1 (CAT N)
(ANNO (DEF "a system that stores information about host names and domain names in a kind of
distributed database on networks, such as the Internet; provides an IP address for each host name, and lists
the mail exchange servers accepting e-mail for each domain.”) (EX "The DNS provides a vital service on
the Internet, because while computers and network hardware work with IP addresses to perform tasks such
as addressing and routing, humans generally find it easier to work with hostnames and domain names ")
(COMMENTS ""))
(SYN-STRUC ((ROOT $VAR0) (CAT N)))
(SEM-STRUC (DOMAIN-NAME-SYSTEM))
))

(DIGITAL-WATERMARK
(DIGITAL-WATERMARK-N1 (CAT N)
 (ANNO (DEF “a group of bits describing information pertaining to the signal or to the creator of the signal
(name, place, etc.)") (EX "The company's digital watermark is used to identify, track and manage visual
communications for such applications as image identification and brand management.")(COMMENT ""))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
(SEM-STRUC (DIGITAL-WATERMARK))
))

(PSYCHOGRAPHIC-DATA
(PSYCHOGRAPHIC-DATA-N1 (CAT N)
 (ANNO (DEF “data about a computer user’s hobbies,  interests, etc.”) (EX "You have to gather
demographic data (age, sex, household income, family size, number of credit cards, media preferences and
so on) and psychographic data (value system, primary hot button, behavioral style, response mechanisms,
fears, passions and so on).")(COMMENT ""))
```

```
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
(SEM-STRUC (PSYCHOGRAPHIC-DATA))
))

(DATA-MINING
 (DATA-MINING-N1 (CAT N)
 (ANNO (DEF “he process of extracting trends or patterns from data.) (EX "Using a combination of
machine learning, statistical analysis, modeling techniques and database technology, data mining finds
patterns and subtle relationships in data and infers rules that allow the prediction of future results..
")(COMMENT ""))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
(SEM-STRUC (DATA-MINING))
))

(KNOWLEDGE-DISCOVERY
 (KNOWLEDGE-DISCOVERY -N1 (CAT N)
 (ANNO (DEF “he non-trivial extraction of implicit, unknown, and potentially useful information from
data.”) (EX "There are many knowledge discovery methodologies in use and under development.
")(COMMENT ""))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
(SEM-STRUC (KNOWLEDGE-DISCOVERY))
))

(STEGANOGRAPHY
 (STEGANOGRAPHY-N1 (CAT N)
 (ANNO (DEF “Writing hidden messages in such a way that no one apart from the intended recipient
knows of the existence of the message.”) (EX "In general, using an extremely high compression rate makes
steganography difficult, but not impossible.")(COMMENT ""))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
(SEM-STRUC (STEGANOGRAPHY))
))

(STEGANALYSIS
 (STEGANALYSIS-N1 (CAT N)
 (ANNO (DEF “The detection of steganographically encoded packages.”) (EX "")(COMMENT "The goal
of steganalysis is to identify suspected packages, determine whether or not they have a payload encoded
into them, and, if possible, recover that payload."))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
(SEM-STRUC (STEGANALISYS))
))

(FORENSICS
 (FORENSICS-N1 (CAT N)
 (ANNO (DEF “The application of science to questions which are of interest to the legal system.”) (EX
"")(COMMENT "also need to define “forensic” as “legal”, as “debates”, and identify different types of
forensics (computer forensics done)"))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
(SEM-STRUC (FORENSICS))
))

(BAR-CODE
(BAR-CODE-N1 (CAT N)
```

```
  (ANNO (DEF “a machine-readable representation of information in a visual format on a
surface.")(COMMENTS "") (EX "Barcodes can be read by optical scanners called barcode readers or
scanned from an image by special software. "))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
 (SEM-STRUC (BAR-CODE))
))

(PIN
 (PIN-N1 (CAT N) (SYNONYMS “PIN-number”)
  (ANNO
   (DEF "A secret number combination that one uses to gain admittance or access to information. ")
   (EX "You PIN should not be easily guessed.") (COMMENTS ""))
  (SYN-STRUC ((ROOT $VAR0) (CAT N))) (SEM-STRUC (PIN-NUMBER))
))

(UNIVERSAL-RESOURCE-LOCATOR
((UNIVERSAL-RESOURCE-LOCATOR-N1 (CAT N) (SYNONYMS “URL, web-address”)
  (ANNO (DEF "A unique address of a web-page. ")
   (EX "") (COMMENTS ""))
  (SYN-STRUC ((ROOT $VAR0) (CAT N))) (SEM-STRUC (web-address))
))

(IP-address
 (IP-address-N1 (CAT N) (SYNONYMS “IP”)
  (ANNO
   (DEF "A unique number-string, identifying physical location of a computer. ")(EX "I have a static IP
address.") (COMMENTS ""))
  (SYN-STRUC ((ROOT $VAR0) (CAT N))) (SEM-STRUC (IP-ADDRESS))
))

(INTERNET-SERVICE-PROVIDER
(INTERNET-SERVICE-PROVIDER-N1 (CAT N) (SYNONYMS “ISP”)
  (ANNO (DEF "A corporation providing access to Internet service to the public. ") (EX "What internet
service provider are you using?") (COMMENTS ""))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
 (SEM-STRUC (INTERNET-SERVICE-PROVIDER))
))

(FOOT-PRINT
 (FOOT-PRINT-N1 (CAT N)
 (SYNONYMS "FOOTPRINT")
 (ANNO (DEF "a physical quality of human foot that can be used to identify a human.") (EX "Leave no
footprints.") (COMMENTS ""))
  (SYN-STRUC
   ((N ((ROOT $VAR1) (CAT N) (POSSESSIVE +) (OPT +))) (ROOT $VAR0) (CAT N)))
  (SEM-STRUC (FOOT-PRINT (IDENTIFIES-WHAT (VALUE ^$VAR1))))
))

(STATE-ID
 (STATE-ID-N1 (CAT N)
(SYNONYMS “State identity card, Personal identification card, PID”)
  (ANNO   (DEF “The document that allows its owner to work and gives access to state social security
resources.")   (EX "If you don’t have a driver’s li cense, you should are least get a State ID.")
(COMMENTS ""))
```

```
  ((N ((ROOT $VAR1) (CAT N) (POSSESSIVE +) (OPT +))) (ROOT $VAR0) (CAT N)))
 (SEM-STRUC (STATE-IDENTITY-CARD
 (IDENTIFIES-WHAT (VALUE ^$VAR1))))
))

(PERSONAL-IDENTIFICATION-CARD
 (PERSONAL-IDENTIFICATION-CARD-N1 (CAT N)
(SYNONYMS “State identity card, State ID, PID”)
 (ANNO (DEF “The document that allows its owner to work and gives access to state social security
resources.")(EX "") (COMMENTS ""))
  ((N ((ROOT $VAR1) (CAT N) (POSSESSIVE +) (OPT +))) (ROOT $VAR0) (CAT N)))
 (SEM-STRUC (STATE-IDENTITY-CARD
 (IDENTIFIES-WHAT (VALUE ^$VAR1))))
))

(PID
 (PID-N1 (CAT N)
(SYNONYMS “State identity card, State ID, Personal identification card”)
 (ANNO (DEF “The document that allows its owner to work and gives access to state social security
resources.") (EX "") (COMMENTS ""))
  ((N ((ROOT $VAR1) (CAT N) (POSSESSIVE +) (OPT +))) (ROOT $VAR0) (CAT N)))
 (SEM-STRUC (STATE-IDENTITY-CARD
 (IDENTIFIES-WHAT (VALUE ^$VAR1))))
))

(IRC
(SYNONYMS “ITERNET RELAY CHAT”)
(ANNO (DEF “a form of instant communication over the Internet. It is mainly designed for group (many-
to-many) communication in discussion forums called channels, but also allows one-to-one
communication.")(EX "What IRC channel do you normally use?") (COMMENT ""))
 (IRC-N1 (CAT N)
 (ANNO (COMMENT ""))
 (SYN-STRUC ((ROOT $VAR0) (CAT N)))
(SEM-STRUC (CHATROOM))
(COLLECTS-IDENTIFYING-INFORMATION (SEM USERNAME PASSWORD))
))

(IM
(SYNONYMS “Instant message”)
 (IM-N1 (CAT N)
 (ANNO (DEF “a message sent using a client which allows instant text communication between two or
more people through a network such as the Internet.")(EX "I got an IM that there is a party tonight.")
(COMMENT ""))
 (SYN-STRUC ((ROOT $VAR0) (CAT N)))
(SEM-STRUC (MESSAGE
(FUNCTIONS-LIKE (SEM CHATROOM))
))

(SMS
(SYNONYMS “Short message service”)
 (SMS-N1 (CAT N)
 (ANNO (DEF “short messages sent between mobile phones and other handheld devices.”) (EX “SEND
ME AN SMS REMINDER”)(COMMENT ""))
 (SYN-STRUC ((ROOT $VAR0) (CAT N)))
```

```
(SEM-STRUC (MESSAGE
(SOURCE (SEM CELLULAR-PHONE))
(HAS-IDENTIFYING-INFORMATION (SEM PHONE-NUMBER))
))

(DNS
(SYNONYMS “Domain name system”)
(DNS-N1 (CAT N)
(ANNO (DEF "a system that stores information about host names and domain names in a kind of
distributed database on networks, such as the Internet; provides an IP address for each host name, and lists
the mail exchange servers accepting e-mail for each domain.”) (EX "If one DNS server doesn't know how
to translate a particular domain name, it asks another one, and so on, until the correct IP address is returned.
") (COMMENTS ""))
(SYN-STRUC ((ROOT $VAR0) (CAT N)))
(SEM-STRUC (DOMAIN-NAME-SYSTEM))
))

(BS-DEGREE
 (BS-DEGREE-N1 (CAT N)
(SYNONYMS “BS, Bachelor of Science”)
  (ANNO
   (DEF “an educational degree granted for the successful completion of a college program in science.")
   (EX "") (COMMENTS ""))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
  (SEM-STRUC (SEM (EDUCATIONAL-LEVEL
  (FIELD-OF-STUDY (SEM SCIENCE))
  (YEARS-OF-EDUCATION (VALUE > 15))))
))

(BS
 (BS-N1 (CAT N)
(SYNONYMS “BS degree, Bachelor of Science”)
  (ANNO
   (DEF “an educational degree granted for the successful completion of a college program in science.")
   (EX "") (COMMENTS ""))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
  (SEM-STRUC (SEM (EDUCATIONAL-LEVEL
  (FIELD-OF-STUDY (SEM SCIENCE))
  (YEARS-OF-EDUCATION (VALUE > 15))))
))

(BA
 (BA-N1 (CAT N)
(SYNONYMS “Bachelor of Arts, BA degree”)
  (ANNO
   (DEF “an educational degree granted for the successful completion of a college program in liberal arts.")
   (EX "") (COMMENTS ""))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
  (SEM-STRUC (EDUCATIONAL-LEVEL
  (FIELD-OF-STUDY (SEM LIBERAL-ARTS))
  (YEARS-OF-EDUCATION (VALUE > 15))))
))

(BA-DEGREE
```

```
 (BA-DEGREE-N1 (CAT N)
(SYNONYMS “Bachelor of Arts, BA degree”)
  (ANNO
   (DEF “an educational degree granted for the successful completion of a college program in liberal arts.")
   (EX "") (COMMENTS ""))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
  (SEM-STRUC (EDUCATIONAL-LEVEL
  (FIELD-OF-STUDY (SEM LIBERAL-ARTS))
  (YEARS-OF-EDUCATION (VALUE > 15))))
))

(AA
 (AA-N1 (CAT N)
(SYNONYMS “Associate of Arts, AA degree”)
  (ANNO
   (DEF “an educational degree granted for the successful completion of a 2-year college program in liberal
arts.")
   (EX "") (COMMENTS ""))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
  (SEM-STRUC (EDUCATIONAL-LEVEL
  (FIELD-OF-STUDY (SEM LIBERAL-ARTS))
  (YEARS-OF-EDUCATION (VALUE > 13))))
))

(AA-DEGREE
 (AA-DEGREE-N1 (CAT N)
(SYNONYMS “Associate of Arts, AA”)
  (ANNO
   (DEF “an educational degree granted for the successful completion of a 2-year college program in liberal
arts.")
   (EX "") (COMMENTS ""))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
  (SEM-STRUC (EDUCATIONAL-LEVEL
  (FIELD-OF-STUDY (SEM LIBERAL-ARTS))
  (YEARS-OF-EDUCATION (VALUE > 13))))
))

(AS
 (AS-N1 (CAT N)
(SYNONYMS “Associate of Science, AS degree”)
  (ANNO
   (DEF “an educational degree granted for the successful completion of a 2-year college program in
SCIENCE.")
   (EX "") (COMMENTS ""))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
  (SEM-STRUC (EDUCATIONAL-LEVEL
  (FIELD-OF-STUDY (SEM SCIENCE))
  (YEARS-OF-EDUCATION (VALUE > 13))))
))

(AS-DEGREE
 (AS-DEGREE-N1 (CAT N)
(SYNONYMS “Associate of Sciences, AS”)
  (ANNO
```

```
   (DEF “an educational degree granted for the successful completion of a 2-year college program in
SCIENCE.")
   (EX "") (COMMENTS ""))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
  (SEM-STRUC (EDUCATIONAL-LEVEL
  (FIELD-OF-STUDY (SEM SCIENCE))
  (YEARS-OF-EDUCATION (VALUE > 13))))
))

(MS
 (MS-N1 (CAT N)
(SYNONYMS “Master of Science, MS degree”)
  (ANNO
   (DEF “an educational degree granted for the successful completion of a Master's program in science.")
   (EX "") (COMMENTS ""))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
  (SEM-STRUC (EDUCATIONAL-LEVEL
  (FIELD-OF-STUDY (SCIENCE))
  (YEARS-OF-EDUCATION (VALUE > 17))))
))

(MS-DEGREE
 (MS-DEGREE-N1 (CAT N)
(SYNONYMS “MS, MS degree”)
  (ANNO
   (DEF “an educational degree granted for the successful completion of a Master's program in science.")
   (EX "") (COMMENTS ""))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
  (SEM-STRUC (EDUCATIONAL-LEVEL
  (FIELD-OF-STUDY (SCIENCE))
  (YEARS-OF-EDUCATION (VALUE > 17))))
))

(MA-DEGREE
 (MA-DEGREE-N1 (CAT N)
(SYNONYMS “Master of Arts, MA”)
  (ANNO
   (DEF “an educational degree granted for the successful completion of a Master's program in liberal arts.")
   (EX "") (COMMENTS ""))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
  (SEM-STRUC (EDUCATIONAL-LEVEL
  (FIELD-OF-STUDY (SEM LIBERAL-ARTS))
  (YEARS-OF-EDUCATION (VALUE > 17))))
))

(MA
 (MA-N1 (CAT N)
(SYNONYMS “Master of Arts, MA degree”)
  (ANNO
   (DEF “an educational degree granted for the successful completion of a Master's program in liberal arts.")
   (EX "") (COMMENTS ""))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
  (SEM-STRUC (EDUCATIONAL-LEVEL
  (FIELD-OF-STUDY (SEM LIBERAL-ARTS))
```

```
  (YEARS-OF-EDUCATION (VALUE > 17))))
))

(MFA
 (MFA-N1 (CAT N)
(SYNONYMS “Master of Fine Arts, MFA degree”)
  (ANNO
   (DEF “an educational degree granted for the successful completion of a Master's program in fine arts.")
   (EX "") (COMMENTS ""))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
  (SEM-STRUC (EDUCATIONAL-LEVEL
  (FIELD-OF-STUDY (SEM FINE-ARTS))
  (YEARS-OF-EDUCATION (VALUE > 17))))
))

(MFA-DEGREE
 (MFA-DEGREE-N1 (CAT N)
(SYNONYMS “Master of Fine Arts, MFA”)
  (ANNO
   (DEF “an educational degree granted for the successful completion of a Master's program in fine arts.")
   (EX "") (COMMENTS ""))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
  (SEM-STRUC (EDUCATIONAL-LEVEL
  (FIELD-OF-STUDY (SEM FINE-ARTS))
  (YEARS-OF-EDUCATION (VALUE > 17))))
))

(MBA
 (MBA-N1 (CAT N)
(SYNONYMS “Master of Business Administration”)
  (ANNO
   (DEF “an educational degree granted for the successful completion of a medical school.")
   (EX "") (COMMENTS ""))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
  (SEM-STRUC (EDUCATIONAL-LEVEL
  (FIELD-OF-STUDY (SEM FINANCE BUSINESS))
  (YEARS-OF-EDUCATION (VALUE > 18))
  (YEARS-OF-EXPERIENCE (VALUE >2))))
))

(PHD
 (PHD -N1 (CAT N)
(SYNONYMS “Doctor of Philosophy, PhD degree”)
  (ANNO
   (DEF “an educational degree granted for the successful completion of a doctoral program.")
   (EX "") (COMMENTS ""))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
  (SEM-STRUC (EDUCATIONAL-LEVEL
  (YEARS-OF-EDUCATION (VALUE > 20))))
))

(PHD-DEGREE
 (PHD-DEGREE-N1 (CAT N)
(SYNONYMS “Doctor of Philosophy, PhD”)
```

```
  (ANNO
   (DEF “an educational degree granted for the successful completion of a doctoral program.")
   (EX "") (COMMENTS ""))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
  (SEM-STRUC (EDUCATIONAL-LEVEL
  (YEARS-OF-EDUCATION (VALUE > 20))))
))

(PHARMD-DEGREE
 (PHARMD-DEGREE-N1 (CAT N)
(SYNONYMS “Doctor of Pharmacy, PharmD”)
  (ANNO
   (DEF “an educational degree granted for the successful completion of a doctoral program in pharmacy.")
   (EX "") (COMMENTS ""))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
  (SEM-STRUC (EDUCATIONAL-LEVEL
  (FIELD-OF-STUDY (SEM PHARMACEUTICS))
  (YEARS-OF-EDUCATION (VALUE > 20))))
))

(PHARMD
 (PHARMD-N1 (CAT N)
(SYNONYMS “Doctor of Pharmacy, PharmD degree”)
  (ANNO
   (DEF “an educational degree granted for the successful completion of a doctoral program in pharmacy.")
   (EX "") (COMMENTS ""))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
  (SEM-STRUC (EDUCATIONAL-LEVEL
  (FIELD-OF-STUDY (SEM PHARMACEUTICS))
  (YEARS-OF-EDUCATION (VALUE > 20))))
))

(JD
 (JD-N1 (CAT N)
(SYNONYMS “Juris Doctor, J.D.degree”)
  (ANNO
   (DEF “an educational degree granted for the successful completion of a law school.")
   (EX "") (COMMENTS ""))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
  (SEM-STRUC (EDUCATIONAL-LEVEL))
  (FIELD-OF-STUDY (SEM FIELD-OF-LAW))
  (YEARS-OF-EDUCATION (VALUE > 19))))
))

(JD-DEGREE
 (JD-DEGREE-N1 (CAT N)
(SYNONYMS “Juris Doctor, JD”)
  (ANNO (DEF “an educational degree granted for the successful completion of a law school.")
   (EX "") (COMMENTS ""))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
  (SEM-STRUC (EDUCATIONAL-LEVEL))
  (FIELD-OF-STUDY (SEM FIELD-OF-LAW))
  (YEARS-OF-EDUCATION (VALUE > 19))))
))
```

```
(MD
 (MD-N1 (CAT N)
(SYNONYMS “Doctor of Medicine”)
  (ANNO (DEF “an educational degree granted for the successful completion of a medical school.")
   (EX "") (COMMENTS ""))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
  (SEM-STRUC (EDUCATIONAL-LEVEL
  (FIELD-OF-STUDY (SEM MEDICINE))
  (YEARS-OF-EDUCATION (VALUE > 24))))
))

(COMPUTER-FORENSICS
 (COMPUTER-FORENSICS-N1 (CAT N)
 (ANNO (DEF “analysis of data processing equipment-- typically a home computer, laptop, server, or
office workstation - to determine if the equipment has been used for illegal, unauthorized, or unusual
activities; can also include monitoring a network for the same purpose.”) (EX "Computer forensics is
simply the application of computer investigation and analysis techniques in the interests of determining
potential legal evidence.")(COMMENT ""))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
(SEM-STRUC (FORENSICS
(THEME (SEM COMPUTER COMPUTER-NETWORK))
))

(DERF
 (DERF-N1 (CAT N)
 (ANNO (DEF “act of exploiting someone else’s termi nal that another person is logged on.”) (EX "I am a
derf.")(COMMENT ""))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
(SEM-STRUC (ABUSE
(BENEFICIARY (SEM REFSEM1))))
(REFSEM1 (SEM USER-COMPUTER
(IDENTIFYING-INFORMATION (SEM LOGIN PASSWORD))
))

(APPLICATION
 (APPLICATION-N1 (CAT N)
  (ANNO (DEF "a document used to apply for a job, etc.") (EX "") (COMMENTS ""))
  (SYN-STRUC ((ROOT $VAR0) (CAT N))) (SEM-STRUC (APPLICATION-FORM)))
(APPLICATION-N2 (CAT N)
  (ANNO (DEF "the act of applying sth. to sth., spreading on, etc.")
   (EX "the application of paint to the wall with a brush by John")
   (COMMENTS ""))
  (SYN-STRUC
   ((ROOT $VAR0) (CAT N)
    (PP-ADJUNCT
     ((ROOT OF) (ROOT $VAR1) (CAT PREP) (OPT +) (OBJ ((ROOT $VAR2) (CAT N)))))
    (PP-ADJUNCT
     ((ROOT TO) (ROOT $VAR3) (CAT PREP) (OPT +) (OBJ ((ROOT $VAR4) (CAT N)))))
    (PP-ADJUNCT
     ((ROOT WITH) (ROOT $VAR5) (CAT PREP) (OPT +)
      (OBJ ((ROOT $VAR6) (CAT N)))))
    (PP-ADJUNCT
     ((ROOT BY) (ROOT $VAR7) (CAT PREP) (OPT +)
```

```
     (OBJ ((ROOT $VAR8) (CAT N)))))))
  (SEM-STRUC
   (APPLY (AGENT (VALUE ^$VAR8))
         (THEME (VALUE ^$VAR2))
         (LOCATION (VALUE ^$VAR4))
         (INSTRUMENT (VALUE ^$VAR6)))
   (^$VAR5 (NULL-SEM +)) (^$VAR3 (NULL-SEM +)) (^$VAR1 (NULL-SEM +))
   (^$VAR7 (NULL-SEM +))))
(APPLICATION-N3 (CAT N)
  (ANNO (DEF "the act of applying for sth., like a job or loan")
   (EX "his application for a job") (COMMENTS ""))
  (SYN-STRUC
   ((N ((ROOT $VAR1) (CAT N) (POSSESSIVE +))) (ROOT $VAR0) (CAT N)
    (PP-ADJUNCT
     ((ROOT FOR) (ROOT $VAR2) (CAT PREP) (OPT +)
      (OBJ ((ROOT $VAR3) (CAT N)))))))
  (SEM-STRUC (APPLY-FOR (AGENT (VALUE ^$VAR1)) (THEME (VALUE ^$VAR3)))
   (^$VAR2 (NULL-SEM +))))
 (APPLICATION-N4 (CAT N)
  (ANNO (DEF "the act of applying a law, etc.")
   (EX "the application of the law to all citizens") (COMMENTS ""))
  (SYN-STRUC
   ((ROOT $VAR0) (CAT N)
    (PP-ADJUNCT
     ((ROOT OF) (ROOT $VAR1) (CAT PREP) (OBJ ((ROOT $VAR2) (CAT N)))))
    (PP-ADJUNCT
     ((ROOT TO) (ROOT $VAR3) (CAT PREP) (OPT +)
      (OBJ ((ROOT $VAR4) (CAT N)))))))
  (SEM-STRUC (APPLIES-TO (DOMAIN (VALUE ^$VAR2)) (RANGE (VALUE ^$VAR4)))
   (^$VAR1 (NULL-SEM +)) (^$VAR3 (NULL-SEM +))))
 (APPLICATION-N5 (CAT N)
(SYNONYMS “software application”)
  (ANNO (DEF "a piece of software with a certain defined function") (EX "") (COMMENTS "The
application shut down on my just as I was about to save the project."))
  (SYN-STRUC ((ROOT $VAR0) (CAT N))) (SEM-STRUC (computer-program)))
)

(SOFTWARE-APPLICATION
(SOFTWARE-APPLICATION-N1 (CAT N)
(SYNONYMS “application”)
  (ANNO (DEF "a piece of software with a certain defined function") (EX "What spreadsheet software
applications are available at the lab?") (COMMENTS ""))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
  (SEM-STRUC (computer-program))
))

(ARCHITECTURE
(ARCHITECTURE-N1 (CAT N)
 (ANNO (DEF "art and science of designing the total built environment, from the macrolevel of town
planning, etc.") (EX “I love that city’s architectu re!”) (COMMENTS “wider definition”))
 (SYN-STRUC ((ROOT $VAR0) (CAT N)))
  (SEM-STRUC (URBAN-PLANNING)))
 (ARCHITECTURE-N2 (CAT N)
```

```
(ANNO (DEF "A style and method of design and construction ")(EX “byzantine architecture”)
(COMMENTS “”))
(SYN-STRUC ((ROOT $VAR0) (CAT N)))
  (SEM-STRUC (ARCHITECTURAL-STYLE)))
(ARCHITECTURE-N3 (CAT N)
(SYNONYMS“computer architecture”)
(ANNO (DEF "design of a computer; set of machine attributes that a programmer should understand in
order to successfully program the specific computer (i.e., being able to reason about what the program will
do when executed).")(EX “Computer Architecture is the science and art of selecting and interconnecting
hardware components to create computers that meet functional, performance and cost goals.”)
(COMMENTS “”))
 (SYN-STRUC ((ROOT $VAR0) (CAT N)))
  (SEM-STRUC (DESIGN
(THEME (SEM COMPUTER-HARDWARE)))
)

(COMPUTER-ARCHITECTURE
(COMPUTER-ARCHITECTURE-N1 (CAT N)
(SYNONYMS “architecture”)
(ANNO (DEF "design of a computer; set of machine attributes that a programmer should understand in
order to successfully program the specific computer (i.e., being able to reason about what the program will
do when executed)." (EX “Computer Architecture is the science and art of selecting and interconnecting
hardware components to create computers that meet functional, performance and cost goals.”)
(COMMENTS “”))
 (SYN-STRUC ((ROOT $VAR0) (CAT N)))
  (SEM-STRUC (DESIGN
(THEME (SEM COMPUTER-HARDWARE)))
)

(AUTHENTICATION
(AUTHENTICATION (CAT N)
 (ANNO (DEF "he process by which a computer, computer program, or another user attempts to confirm
that the computer, computer program, or user from whom the second party has received some
communication is, or is not, the claimed first party." (EX "Each user knows her or his password, each
service program knows its password, and there's an AUTHENTICATION SERVICE that knows ALL
passwords--each user's password, and each service's password..") (COMMENTS ""))
((ROOT $VAR0) (CAT N)
   (PP-ADJUNCT ((ROOT OF) (CAT PREP) (OPT +) (OBJ ((ROOT $VAR2)))))))
  (SEM-STRUC (AUTHENTICATE
(BENEFICIARY (SEM $VAR2))
(THEME (SEM $VAR2)))
))

(AUTHENTICITY
(AUTHENTICITY-N1 (CAT N)
(ANNO (DEF "The quality or condition of being authentic, trustworthy, or genuine." (EX "Authenticity in
a Digital Environment") (COMMENTS ""))
  (SYN-STRUC
   ((ROOT $VAR0) (CAT N)
    (PP-ADJUNCT ((ROOT OF) (CAT PREP) (OPT +) (OBJ ((ROOT $VAR1)))))))
   ((N ((ROOT $VAR1) (CAT N) (POSSESSIVE +) (OPT +))) (ROOT $VAR0) (CAT N)))
  (SEM-STRUC (AUTHENTICITY (VALUE 1) (DOMAIN (SEM $VAR1))
))
```

```
(AVAILABILITY
(AVAILABILITY-N1 (CAT N)
  (ANNO (DEF "the state of being present for use, obtainable")
   (EX "We want to check on availability of flights to London.") (COMMENTS ""))
  (SYN-STRUC
   ((ROOT $VAR0) (CAT N)
    (PP-ADJUNCT ((ROOT OF) (CAT PREP) (OPT +) (OBJ ((ROOT $VAR1)))))))
   ((N ((ROOT $VAR1) (CAT N) (POSSESSIVE +) (OPT +))) (ROOT $VAR0) (CAT N)))
  (SEM-STRUC (BE-AVAILABLE
(DOMAIN (VALUE $VAR1))))
))

(ENCRYPTION
 (ENCRYPTION-N1 (CAT N)
  (ANNO (DEF "THE PROCESS OF OBSCURING INFORMATION TO MAKE IT UNREADABLE
WITHOUT SPECIAL KNOWLEDGE.") (EX "THIS SITE USES ENCRYPTION TO SECURE YOUR
INFORMATION.") (COMMENTS ""))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
 (SEM-STRUC (ENCRYPT-ALGORYTHM)))
)

(INTERMEDIARY
 (INTERMEDIARY-N1 (CAT N)
  (ANNO (DEF "THE PERSON OR PROGRAM WHICH ACTS AS A GO-BETWEEN THE AGENTS IN
AN EVENT") (EX "a reinsurance intermediary ") (COMMENTS ""))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
 (SEM-STRUC (MEDIATOR)))
)

(MULTIPLE-KEY-ENCRYPTION
 (MULTIPLE-KEY-ENCRYPTION-N1 (CAT N)
  (ANNO (DEF "THE PROCESS OF OBSCURING INFORMATION TO MAKE IT UNREADABLE
WITHOUT SPECIAL KNOWLEDGE.") (EX "Automatic selection of decryption key for multiple-key
encryption systems") (COMMENTS ""))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
 (SEM-STRUC (ASYMMETRIC-KEY-ENCRYPTION-ALGORYTHM)))
)

(PROTOCOL
 (PROTOCOL-N1 (CAT N)
  (ANNO(DEF "the ceremonial forms accepted as correct in official dealings, as between heads of state or
diplomats")
   (COMMENTS "") (EX "academic protocol "))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
 (SEM-STRUC (PROTOCOL))
)
(PROTOCOL-N2 (POS N)
  (ANNO(DEF "a convention or standard that controls or enables the connection, communication, and data
transfer between two computing endpoints.")
   (COMMENTS "") (EX " Protocols may be implemented by hardware, software, or a combination of the
two."))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
 (SEM-STRUC (COMPUTING-PROTOCOL))
))
```

```
(CRYPTOGRAPHIC-PROTOCOL
(CRYPTOGRAPHIC-PROTOCOL-N1 (CAT N)
  (ANNO
   (DEF "abstract or concrete protocol that performs a security-related function and applies cryptographic
methods.")
   (COMMENTS "") (EX "The most widely used cryptographic protocols are protocols for secure
application-level data transport."))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
 (SEM-STRUC (COMPUTING-PROTOCOL
(HAS-OBJECT-AS-PART (SEM CIPER))))
))

(NETWORK-PROTOCOL
(NETWORK-PROTOCOL-N1 (CAT N)
  (ANNO (DEF "communications protocol or network protocol is the specification of a set of rules for a
particular type of communication.")(COMMENTS "") (EX "What network protocol are you using?"))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
 (SEM-STRUC (COMPUTING-PROTOCOL
(APPLIES-TO (SEM COMPUTER-NETWORK))))
))

(CREDENTIAL
(CREDENTIAL-N1 (CAT N)
(ANNO (DEF "a document or token attesting to the truth of certain stated facts.")(COMMENTS "") (EX
"Rather than proving the credential owner's identity, these credentials assert that their owner possesses
certain attributes."))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
 (SEM-STRUC (CERTIFICATE))
))


(BLIND-CREDENTIAL
(BLIND-CREDENTIAL-N1 (CAT N)
(ANNO (DEF "a token asserting that someone qualifies under some criteria or has some status or right,
without revealing "who" that person is — without including their name or address, for instance. It is used in
maintaining medical privacy and increasingly for consumer privacy.")(COMMENTS "") (EX "A blind
credential, in contrast, does not establish identity at all, but only a narrow right or status of the user or
program."))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
 (SEM-STRUC (BLIND-CREDENTIAL))
))

(pseudonym
(pseudonym-N1 (CAT N)
(SYNONYMS “ALLONYM”)
(ANNO (DEF "a name (sometimes legally adopted, sometimes purely fictitious) used by an individual as
an alternative to their birth name.")(COMMENTS "") (EX "One author may have several pseudonyms
depending on the genre. "))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
 (SEM-STRUC (pseudonym))
))

(allonym
```

```
(allonym-N1 (CAT N)
(SYNONYMS “pseudonym”)
(ANNO (DEF "a name (sometimes legally adopted, sometimes purely fictitious) used by an individual as an alternative to their birth name.")(COMMENTS "") (EX "The problems posed above are easily cleared up by accepting that Shakespeare was the Earl of Oxford's allonym, which he had set up in 1592, with William Shaxpere's connivance. "))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
 (SEM-STRUC (pseudonym))
))

(PSEUDONYMITY
(PSEUDONYMITY-N1 (CAT N)
 (ANNO (DEF "the ability to prove a consistent identity without revealing oneself, instead using a pseudonym.")(COMMENTS "") (EX "Pseudonymity is a state which combines many of the advantages of having a known identity with the advantages of anonymity. "))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
 (SEM-STRUC (PSEUDONYMITY))
))

(ANONYMITY
(ANONYMITY-N1 (CAT N)
 (ANNO (DEF "state of undisclosed and/or untraceable identity.")(COMMENTS "") (EX "The donor wished to preserve anonymity."))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
 (SEM-STRUC (ANONYMITY))
))

(PSEUDONYMOUS-REMAILER
(PSEUDONYMOUS-REMAILER-N1 (CAT N)
(SYNONYMS “nym server”)
 (ANNO (DEF "a server that takes messages addressed to the pseudonym and sends them to the pseudonym's 'real' email address, while forwarding messages addressed to others as though from pseudonym's address on the server.”)(COMMENTS "") (EX "Primordial pseudonymous remailers once recorded enough information to trace the identity of the real user, making it is possible for someone to obtain the identity the real user through legal or illegal means. "))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
 (SEM-STRUC (NETWORK-SERVER
(ISSUES-IDENTIFYING-INFORMATION (SEM PSEUDONYM EMAIL))
(REQUESTS-IDENTIFYING-INFORMATUION (SEM EMAIL))
))

(NYM-SERVER
(NYM-SERVER-N1 (CAT N)
(SYNONYMS “pseudonymous remailer”)
 (ANNO (DEF "a server that takes messages addressed to the pseudonym and sends them to the pseudonym's 'real' email address, while forwarding messages addressed to others as though from pseudonym's address on the server.”)(COMMENTS "") (EX "A nym server provides an untraceable e-mail address, such that neither the nym server operator nor the operators of the remailers involved can discover which nym corresponds to which real identity. "))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
 (SEM-STRUC (NETWORK-SERVER
(ISSUES-IDENTIFYING-INFORMATION (SEM PSEUDONYM EMAIL))
(REQUESTS-IDENTIFYING-INFORMATUION (SEM EMAIL))
))
```

```
(IDENTITY
(IDENTITY-N1 (CAT N)
(ANNO (DEF "The quality or condition of being the same as something else.”)(COMMENTS "") (EX
"character evidence of a suspect's past crimes may be admitted to prove the identity of a crime's
perpetrator"))
 (SYN-STRUC ((ROOT $VAR0) (CAT N)
(PP-ADJUNCT ((ROOT OF) (CAT PREP) (OPT +) (OBJ ((ROOT $VAR2)))))))
(SEM-STRUC ($VAR2 (EQUAL-TO (SEM OBJECT)))))
(IDENTITY-N2 (CAT N) (SYN-STRUC ((ROOT $VAR0) (CAT N)))
(ANNO (DEF "An equation that is satisfied by any number that replaces the letter for which the equation is
defined.”)(COMMENTS "") (EX "the identity under numerical multiplication is 1."))
 (SEM-STRUC (MATHEMATICAL-OBJECT)))
(IDENTITY-N3 (CAT N)
(ANNO (DEF “The distinct personality of an individual regarded as a persisting entity;
individuality.”)(COMMENTS "") (EX "If the broadcast group is the financial guts of the company, the
news division is its public identity."))
 (SYN-STRUC ((ROOT $VAR0) (CAT N)))
        (SEM-STRUC (CHARACTERISTIC))))
(IDENTITY-N4 (CAT N)
(ANNO (DEF "The collective aspect of the set of characteristics by which a thing is definitively
recognizable or known.”)(COMMENTS "") (EX "is required to reveal the identity of an informer."))
 (SYN-STRUC ((ROOT $VAR0) (CAT N)))
        (SEM-STRUC (SET (MEMBER-TYPE USER-IDENTIFYING-ATTRIBUTE)))
))

(INTEROPERABILITY
(INTEROPERABILITY-N1 (CAT N)
(ANNO (DEF "the ability to exchange and use information (usually in a large heterogeneous network made
up of several local area networks).”)(COMMENTS "") (EX " Dedicated to facilitating simulation
interoperability across a wide spectrum, SISO provides forums, educates the M&S community on
implementation, and supports standards development."))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
 (SEM-STRUC (EXCHANGE
(THEME (SEM INFORMATION))
(INSTRUMENT (SEM SOFTWARE HARDWARE))
))

(INTRUSION
 (INTRUSION-N1 (CAT N)
 (ANNO (DEF "act of acquiring unauthorized access to a computer system with a purpose of obtaining,
altering, or erasing information.”)(COMMENTS "") (EX "If the individual moves outside of the pre-
defined Geofence, the Command & Control application software immediately initiates an alert and actions
(defined by a set of rules) can be taken to respond to the event."))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
 (SEM-STRUC (INFORMATION-SECURITY-ATTACK))
(HAS-EVENT-AS-PART (NOT AUTHORIZE))
))))

(GEOFENCE
 (GEOFENCE-N1 (CAT N)
 (ANNO (DEF "a virtual border defined by the authorized location of GPS-tracking device (e.g. cell
phone)”)(COMMENTS "") (EX ""))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
```

```
 (SEM-STRUC (REPRESENTATIONAL-OBJECT))
(REPRESENTS (SEM BORDER))
))

(GLOBAL-POSITIONING-SYSTEM
 (GLOBAL-POSITIONING-SYSTEM-N1 (CAT N)
(SYNONYMS “GPS”)
 (ANNO (DEF "a physical system that uses 24 satellites constantly orbiting the earth to determine the position, speed and direction of an object on earth.)”)(COMMENTS "") (EX "global positioning system is used extensively in tracking moving objects, mainly vehicles and assets."))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
 (SEM-STRUC (GLOBAL-POSITIONING-SYSTEM))
))

(GPS
 (GPS-N1 (CAT N)
(SYNONYMS “Global Positioning System”)
 (ANNO (DEF "a physical system that uses 24 satellites constantly orbiting the earth to determine the position, speed and direction of an object on earth.)”)(COMMENTS "") (EX "GPS can be accurate to approximately 10 meters, or less so can be used to provide geo-fencing capabilities."))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
 (SEM-STRUC (GLOBAL-POSITIONING-SYSTEM))
))

(USER
(USER-N1 (CAT N)
(ANNO (DEF “the one who uses”)(COMMENTS " a user of public transportation ") (EX ""))
 (SYN-STRUC ((ROOT $VAR0) (CAT N)))
(SEM-STRUC (USER)))
 (USER-N2 (CAT N)
(ANNO (DEF "a consumer.”)(COMMENTS "") (EX "drug user"))
  (SYN-STRUC
   ((ROOT $VAR0) (CAT N)
    (PP-ADJUNCT ((ROOT OF) (CAT PREP) (OPT +) (OBJ ((ROOT $VAR2)))))))
  (SEM-STRUC (HUMAN (AGENT-OF (SEM CONSUMPTION)) (THEME (VALUE $VAR2))))))
(USER-N3 (CAT N)
(ANNO (DEF "a computer user.)”)(COMMENTS "") (EX "Each user is assigned a login and a password."))
 (SYN-STRUC ((ROOT $VAR0) (CAT N)))
(SEM-STRUC (USER-COMPUTER)))

(TRUST-NEGOTIATION
(TRUST-NEGOTIATION-N1 (CAT N)
(ANNO (DEF ("Trust negotiation is the process of a client and a server exchanging digital credentials and policies with one another to gradually build trust.”) (EX” A trust negotiation strategy controls the exact content of. the messages exchanged during trust negotiation.”)(COMMENTS ""))
(SYN-STRUC ((ROOT $VAR0) (CAT N)))
(SEM-STRUC (COMMUICATION-ACTIVITY
(RESULT (SEM MEASURE (THEME (SEM CREDIBILITY)))))
)

(REVOCATION
(REVOCATION-N1 (CAT N)
```

```
(ANNO (DEF ("The act or an instance of revoking. ")(EX " We'll have to insist on revocation of his
license.") (COMMENTS ""))
 (SYN-STRUC ((ROOT $VAR0) (CAT N)))
(SEM-STRUC (RESULT-OF (REVOKE)))
)

(PALMTOP
 (PALMTOP-N1 (CAT N)
(SYNONYMS "palm, PDA, Personal digital assistant, handheld")
  (ANNO (DEF ("palmtop computer or personal digital assistant; a major advantage of PDAs is their ability
to synchronize data with other computers.")
   (EX " Compared to full-size computers, palmtops are severely limited, but they are practical for certain
functions such as phone books and calendars.") (COMMENTS ""))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
  (SEM-STRUC (PALMTOP))
))

(RETINA-SCANNING-DEVICE
 (RETINA-SCANNING-DEVICE-N1(CAT N)
(SYNONYMS "Reticle")
(ANNO (DEF ("device that is used for identification of humans by scanning their retina") (EX " As a
result, further research and development was conducted, which subsequently yielded the first true prototype
of a retina scanning device in 1981. ") (COMMENTS ""))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
  (SEM-STRUC (RETINA-SCAN-DEVICE))
))

(SD
 (SD-N1 (CAT N)
(SYNONYMS "Secure Digital, Secure Digital card")
 (ANNO
   (DEF ("one of the formats of file storage based on a transistor, which allows multiple memory location to
be written in one programming operation") (EX " The SD Memory Card is a groundbreaking new bridge
media that's helping to pave the way for tomorrow's fully networked society.") (COMMENTS ""))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
  (SEM-STRUC (INDEPENDENT-DEVICE
(CONTAINS (SEM FLASH-MEMORY))))
))

(SECURE-DIGITAL
 (SD-N1 (CAT N)
(SYNONYMS "SD, Secure Digital card")
 (ANNO
   (DEF ("one of the formats of file storage based on a transistor, which allows multiple memory location to
be written in one programming operation")(EX "Secure Digital Memory Card is a highly-sophisticated
memory device about the size of a postage stamp.") (COMMENTS ""))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
  (SEM-STRUC (INDEPENDENT-DEVICE
(CONTAINS (SEM FLASH-MEMORY))))
))

(BIOS
(BIOS-N1 (CAT N)
(SYNONYMS "BIOS memory, BIOS chip")
```

```
(ANNO (DEF “semiconductor memory used for booting the computer")
   (EX " The BIOS is typically placed in a ROM chip that comes with the computer.") (COMMENTS ""))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
  (SEM-STRUC (BIOS-CHIP))
))

(BIOS-MEMORY
(BIOS-N1 (CAT N)
(SYNONYMS “BIOS, BIOS chip”)
(ANNO (DEF “semiconductor memory used for booting the computer")
   (EX "need to disable bios memory options") (COMMENTS ""))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
  (SEM-STRUC (BIOS-CHIP))
))

(PEER-TO-PEER-NETWORK
(PEER-TO-PEER-NETWORK-N1 (CAT N)
(SYNONYMS “P2P, Peer to peer”)
  (ANNO (DEF “any network that does not rely on dedicated servers for communication but instead mostly
uses direct connections between clients (peers). ")
   (COMMENTS "") (EX " An important goal in peer-to-peer networks is that the bandwidth of all clients
can be used."))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
(SEM-STRUC (SOFTWARE
(INSTRUMENT-OF (SEM INTEGRATE)
(THEME (SEM COMPUTER-NETWORK))
(HAS-PARTS (NOT NETWORK-SERVER))))
))

(PEER-TO-PEER
(PEER-TO-PEER-N1 (CAT N)
(SYNONYMS “P2P, Peer to peer network”)
  (ANNO
   (DEF “any network that does not rely on dedicated servers for communication but instead mostly uses
direct connections between clients (peers). ") (COMMENTS "") (EX " A pure peer-to-peer file transfer
network does not have the notion of clients or servers, but only equal peer nodes that simultaneously
function as both "clients" and "servers" to the other nodes on the network."))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
(SEM-STRUC (SOFTWARE
(INSTRUMENT-OF (SEM INTEGRATE)
(THEME (SEM COMPUTER-NETWORK))
(HAS-PARTS (NOT NETWORK-SERVER))))
))

(MACINTOSH
(MACINTOSH-N1 (CAT N)
(SYNONYMS “Mac, Mac operating system, Mac OS”)
  (ANNO
   (DEF “an GUI-oriented operating system for personal computers based on Apple
hardware.")(COMMENTS "") (EX "Macintosh computers are still used widely in schools."))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
(SEM-STRUC (OPERATING-SYSTEM
(PRODUCED-BY (VALUE SOFTWARE-DEVELOPMENT-CORPORATION-1))))
))
```

```
(MAC-OPERATING-SYSTEM
(MAC-OPERATING-SYSTEM-N1 (CAT N)
(SYNONYMS “Mac, Macintosh, Mac OS”)
  (ANNO
   (DEF “an GUI-oriented operating system for personal computers based on Apple hardware.")
   (COMMENTS "") (EX ""))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
(SEM-STRUC (OPERATING-SYSTEM
(PRODUCED-BY (VALUE SOFTWARE-DEVELOPMENT-CORPORATION-1))))
))

(MAC-OS
(MAC-OS-N1 (CAT N)
(SYNONYMS “Mac, Macintosh, Mac operating system”)
  (ANNO (DEF “an GUI-oriented operating system for personal computers based on Apple
hardware.")(COMMENTS "") (EX "Are you a Mac user?"))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
(SEM-STRUC (OPERATING-SYSTEM
(PRODUCED-BY (VALUE SOFTWARE-DEVELOPMENT-CORPORATION-1))))
))

(WWW
 (WWW-N1 (CAT N)
(SYNONYMS “WWW, world-wide web”)
(ANNO (DEF “is an information space in which the items of interest, referred to as resources, are identified
by global identifiers”)(COMMENT "") (EX “The term www is often mistakenly used as a synonym for the
Internet, but the Web is actually a service that operates over the Internet.”))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
(SEM-STRUC (INTERNET))
))

(SERVICE-PACK-N1 (CAT N)
(SYNONYMS “SP”)
  (ANNO (DEF "Service Pack (more commonly, SP) is a software program that corrects known bugs,
problems, or adds new features.") (EX "You cannot use the program without downloading the latest service
pack.") (COMMENTS ""))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
(SEM-STRUC (SOFTWARE
(PURPOSE-OF (SEM DEBUG-PROGRAM))))
)

(SP
(SP-N1 (CAT N)
(SYNONYMS “Service Pack”)
  (ANNO (DEF "Service Pack (more commonly, SP) is a software program that corrects known bugs,
problems, or adds new features.") (EX " You cannot use the program without downloading the latest SP.")
(COMMENTS ""))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
(SEM-STRUC (SOFTWARE
(PURPOSE-OF (SEM DEBUG-PROGRAM))))
))

(DIGITAL-SIGNATURE
```

```
 (DIGITAL-SIGNATURE-N1 (CAT N)
(SYNONYMS “Service Pack”)
  (ANNO (DEF “a method of authenticating digital information often treated as analogous to a physical signature on paper.") (EX " Digital signature verification is the process of checking the digital signature by reference to the original message and a given public key, thereby determining whether the digital signature was created for that same message using the private key that corresponds to the referenced public key.") (COMMENTS ""))
(SYN-STRUC ((ROOT $VAR0) (CAT N)))
(SEM-STRUC (BIT-STRING
(IDENTIFIES-WHAT (SEM USER-COMPUTER))
(REPRESENTS (SEM SIGNATURE)))
)

(ELECTRONIC-SIGNATURE
(SYNONYMS “Service Pack”)
 (ELECTRONIC-SIGNATURE-N1 (CAT N)
  (ANNO (DEF “a method of authenticating digital information often treated as analogous to a physical signature on paper. ") (EX " In common law, such electronic signatures have included cable and Telex addresses, as well as FAX transmission of handwritten signatures on a paper document..") (COMMENTS ""))
(SYN-STRUC ((ROOT $VAR0) (CAT N)))
(SEM-STRUC (BIT-STRING
(REPRESENTS (SEM SIGNATURE))
(LEGALITY-ATTRIBUTE (VALUE YES)))
)

(USER-PROFILE
(USER-PROFILE-N1 (CAT N)
ANNO (DEF “information about the user and user’s au thority within a particular system.”)(EX "change your user profile") (COMMENTS ""))
(SYN-STRUC ((ROOT $VAR0) (CAT N)))
  (SEM-STRUC (INFORMATION
(IDENTIFIES-WHAT (USER-COMPUTER))
(HAS-OBJECT-AS-PART (SEM USER-IDENTIFYING-ATTRIBUTE))))
))

(VALIDITY
(VALIDITY-N1 (CAT N)
ANNO (DEF “quality of being legally binding or authentic.”)(EX "We need to assure the validity of this digital signature") (COMMENTS ""))
(SYN-STRUC
 (ROOT $VAR0) (CAT N)))
    (PP-ADJUNCT ((ROOT OF) (CAT PREP) (OPT +) (OBJ ((ROOT $VAR1)))))
  (SEM-STRUC (VALIDITY (DOMAIN (VALUE ^$VAR1)) (RANGE (< 0.8))))))
)

(VULNERABILITY
 (VULNERABILITY-N1 (CAT N)
  (ANNO (DEF "vulnerability of  sth. - this sense requires the of-clause") (EX "his vulnerability to litigation")
   (COMMENTS ""))
  (SYN-STRUC
   ((ROOT $VAR0) (CAT N)
    (PP-ADJUNCT
```

```
    ((ROOT OF) (ROOT $VAR1) (CAT PREP) (OBJ ((ROOT $VAR2) (CAT N)))))))
  (SEM-STRUC (^$VAR2 (POTENTIAL (<> 0.5 1)) (SAFETY-ATTRIBUTE (< 0.4)))))
 (VULNERABILITY-N2 (CAT N)
  (ANNO (DEF "vulnerability as an abstract construct") (EX "") (COMMENTS ""))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
  (SEM-STRUC
   (ABSTRACT-IDEA (POTENTIAL (<> 0.5 0.9)) (SAFETY-ATTRIBUTE (< 0.2))))))

(likes
 (likes-N1 (CAT N)
  (ANNO (DEF "preferences")
   (EX "likes and dislikes") (COMMENTS ""))
  (SYN-STRUC
   ((N ((ROOT $VAR1) (CAT N) (OPT +) (POSSESSIVE +))) (ROOT $VAR0) (CAT N)))
  (SEM-STRUC
   (REFSEM1
    (MODALITY (ATTRIBUTED-TO (VALUE ^$VAR1)) (VALUE >.8)  (TYPE EVALUATIVE)
     (SCOPE (SEM OBJECT))))
))

(dislikes
 (dislikes-N1 (CAT N)
  (ANNO (DEF "preferences")
   (EX "likes and dislikes") (COMMENTS ""))
  (SYN-STRUC
   ((N ((ROOT $VAR1) (CAT N) (OPT +) (POSSESSIVE +))) (ROOT $VAR0) (CAT N)))
  (SEM-STRUC
   (REFSEM1
    (MODALITY (ATTRIBUTED-TO (VALUE ^$VAR1)) (VALUE <.4)  (TYPE EVALUATIVE)
     (SCOPE (SEM OBJECT))))
))

(longevity
(longevity-N1 (CAT N)
(ANNO (DEF “the property of being long-lived”) (EX "His longevity vexed his heirs ") (COMMENTS ""))
(SYN-STRUC ((ROOT $VAR0) (CAT N)))
  (SEM-STRUC (age
(DOMAIN (SEM ANIMAL))
(RANGE (VALUE (> DURATION-TYPICAL))
(longevity-N2 (CAT N)
(ANNO (DEF “duration of service.”)(EX “had unusual longevity in the company”) (COMMENTS ""))
(SYN-STRUC ((ROOT $VAR0) (CAT N)))
  (SEM-STRUC (SENIORITY
(DOMAIN (SEM HUMAN))))
))

(vendor
 (vendor-N1 (CAT N)
(ANNO (DEF “someone who promotes or exchanges goods or services for money.”)(EX “a street vendor”)
(COMMENTS ""))
(SYN-STRUC ((ROOT $VAR0) (CAT N)))
  (SEM-STRUC (SELLER))
(vendor-N1 (CAT N)
```

```
(ANNO (DEF “an organization involved in selling goods.”)(EX “a vendor of software products on the
Web.”) (COMMENTS ""))
(SYN-STRUC ((ROOT $VAR0) (CAT N)))
  (SEM-STRUC (FOR-PROFIT-ORGANIZATION
(instrument-of (sem SELL))))
))

(directory
(directory-N1 (CAT N)
  (ANNO (DEF "a list of something including names, addresses, phone numbers, etc. ") (EX "A directory
of local doctors")
   (COMMENTS ""))
  (SYN-STRUC
   ((ROOT $VAR0) (CAT N)
    (PP-ADJUNCT
     ((ROOT OF) (ROOT $VAR1) (CAT PREP) (OPT +)
      (OBJ ((ROOT $VAR2) (CAT N)))))))
  (SEM-STRUC (DIRECTORY (HAS-IDENTIFYING-INFORMATION (DOMAIN ^$VAR2))) (^$VAR1
(NULL-SEM +)))))

(end-user
(end-user-n1 (CAT N)
  (ANNO (DEF "the person who uses a product. The end-user may differ from the customer, who might
buy the product, but doesn't necessarily use it. Legally, the term refers to a non-seller.")
(EX "This link refers you to download page for end-users")
   (COMMENTS ""))
  (SYN-STRUC
   ((ROOT $VAR0) (CAT N))
(SEM-STRUC (USER
(AGENT-OF (NOT SELL))))
))

(end-user-license-agreement
(end-user-license-agreement-n1 (CAT N)(SYNONYMS “EULA”)
  (ANNO (DEF "software license, a type of proprietary or gratuitous license as well as a memorandum of
contract between a producer and a user of software that specifies the perimeters of the permission granted
by the owner to the user.") (EX "End-User License Agreement is the type of license used for most
software.")
   (COMMENTS ""))
  (SYN-STRUC
   ((ROOT $VAR0) (CAT N))
(SEM-STRUC (CONTRACT
(CONTAINED-IN (SEM SOFTWARE)
(MADE-OF (SEM *NOTHING*))
(THEME-OF (SEM REFESEM1))))
(REFSEM1 (SEM AGREE
(PRECONDITION-OF (SEM INSTALL-DEVICE (THEME (SEM SOFTWARE))))))
))

(EULA
(EULA-n1 (CAT N)(SYNONYMS “end-user-license-agreement”)
  (ANNO (DEF "software license, a type of proprietary or gratuitous license as well as a memorandum of
contract between a producer and a user of software that specifies the perimeters of the permission granted
```

```
by the owner to the user.") (EX "The EULA details how the software can and cannot be used and any
restrictions that the manufacturer imposes.")
   (COMMENTS ""))
  (SYN-STRUC
   ((ROOT $VAR0) (CAT N))
(SEM-STRUC (CONTRACT
(CONTAINED-IN (SEM SOFTWARE)
(MADE-OF (SEM *NOTHING*))
(THEME-OF (SEM REFESEM1))))
(REFSEM1 (SEM AGREE
(PRECONDITION-OF (SEM INSTALL-DEVICE (THEME (SEM SOFTWARE))))))
))

(SOFTWARE-LICENSE
(SOFTWARE-LICENSE-n1 (CAT N)
  (ANNO (DEF "a type of proprietary license or contract between a producer and a user of software that
specifies the perimeters of the permission granted by the owner to the user.") (EX "The proliferation of
different free software licenses means increased work for users in understanding the licenses□")
   (COMMENTS ""))
  (SYN-STRUC
   ((ROOT $VAR0) (CAT N))
(SEM-STRUC (CONTRACT
(CONTAINED-IN (SEM SOFTWARE)
(MADE-OF (SEM *NOTHING*))
))

(freedom
(freedom-n1 (CAT N)
(SYNONYMS “liberty”)
  (ANNO (DEF "The condition of being free of restraints.") (EX "We have the freedom to do as we please
all afternoon.")
   (COMMENTS ""))
  (SYN-STRUC
   ((ROOT $VAR0) (CAT N)
    (PP-ADJUNCT ((ROOT OF) (CAT PREP) (OPT +) (OBJ ((ROOT $VAR2)))
(SEM-STRUC (freedom
(APPLIES-TO (SEM $VAR1))
))

(liberty
(liberty-n1 (CAT N)
(SYNONYMS “freedom”)
  (ANNO (DEF "The condition of being free from restriction or control.") (EX "the right to a fair trial is a
fundamental liberty secured by the Fourteenth Amendment.")
   (COMMENTS ""))
  (SYN-STRUC
   ((ROOT $VAR0) (CAT N))
(SEM-STRUC (freedom))
))

(ATM
(ATM-n1 (CAT N)
(SYNONYMS “automatic teller machine” “automated teller machine” “cash machine” “money machine”)
```

```
  (ANNO (DEF "An unattended electronic machine in a public place, connected to a data system and
related equipment and activated by a bank customer to obtain cash withdrawals and other banking
services.") (EX "The first ATMs were off-line machines, meaning money was not automatically withdrawn
from an account. ")
   (COMMENTS ""))
  (SYN-STRUC
   ((ROOT $VAR0) (CAT N))
(SEM-STRUC (AUTOMATED-TELLER-MACHINE))
))

(AUTOMATIC-TELLER-MACHINE
(AUTOMATIC-TELLER-MACHINE-n1 (CAT N)
(SYNONYMS “ATM” “automated teller machine” “cash machine” “money machine”)
  (ANNO (DEF "An unattended electronic machine in a public place, connected to a data system and
related equipment and activated by a bank customer to obtain cash withdrawals and other banking
services.") (EX "")
   (COMMENTS ""))
  (SYN-STRUC
   ((ROOT $VAR0) (CAT N))
(SEM-STRUC (AUTOMATED-TELLER-MACHINE))
))

(AUTOMATED-TELLER-MACHINE
(AUTOMATED-TELLER-MACHINE-n1 (CAT N)
(SYNONYMS “ATM” “automatic teller machine” “cash machine” “money machine”)
  (ANNO (DEF "An unattended electronic machine in a public place, connected to a data system and
related equipment and activated by a bank customer to obtain cash withdrawals and other banking
services.") (EX "")
   (COMMENTS ""))
  (SYN-STRUC
   ((ROOT $VAR0) (CAT N))
(SEM-STRUC (AUTOMATED-TELLER-MACHINE))
))


(CASH-MACHINE
(CASH-MACHINE-n1 (CAT N)
(SYNONYMS “ATM” “automatic teller machine” “automated teller machine” “money machine”)
  (ANNO (DEF "An unattended electronic machine in a public place, connected to a data system and
related equipment and activated by a bank customer to obtain cash withdrawals and other banking
services.") (EX "")
   (COMMENTS ""))
  (SYN-STRUC
   ((ROOT $VAR0) (CAT N))
(SEM-STRUC (AUTOMATED-TELLER-MACHINE))
))


(money-machine
 (money-machine-n1 (CAT N)
          (SYNONYMS “ATM” “automatic teller machine” “automated teller machine” “cash machine”)
  (ANNO (DEF "An unattended electronic machine in a public place, connected to a data system and
related equipment and activated by a bank customer to obtain cash withdrawals and other banking
services.") (EX "")
```

```
  (COMMENTS ""))
 (SYN-STRUC
  ((ROOT $VAR0) (CAT N))
(SEM-STRUC (AUTOMATED-TELLER-MACHINE))
))

(SHRINK-WRAP-CONTRACT
 (SHRINK-WRAP-CONTRACT-n1 (CAT N)
 (ANNO (DEF "agreements or other terms and conditions of a (putatively) contractual nature which can
only be read and accepted by the consumer after opening the product.") (EX "The legal status of shrink
wrap contracts in the US is somewhat unclear. ")
  (COMMENTS ""))
 (SYN-STRUC
  ((ROOT $VAR0) (CAT N))
(SEM-STRUC (CONTRACT
(MADE-OF (SEM *NOTHING*))
(PRECONDITION (SEM REFESEM1))))
(REFSEM1 (SEM OPEN
(THEME (SEM MANUFACTURED-CONTAINER (CONTAINS (SEM (SOFTWARE) RELAXABLE-
TO (OBJECT)))))))
))

(WEB-WRAP-AGREEMENT
 (WEB-wrap-agreement-n1 (CAT N)
(SYNONYMS “click-wrap agreement”)
 (ANNO (DEF "a license agreement in software which is downloaded or used over the internet.") (EX
"")(COMMENTS ""))
 (SYN-STRUC
  ((ROOT $VAR0) (CAT N))
(SEM-STRUC (CONTRACT
(MADE-OF (SEM *NOTHING*))
(PRECONDITION (SEM REFESEM1))))
(REFSEM1 (SEM CLICK
(REPRESENTS (SEM AGREE))))))
))

(CLICK-WRAP-AGREEMENT
 (CLICK-WRAP-AGREEMENT-n1 (CAT N)
(SYNONYMS “web-wrap agreement” “browse-wrap agreement”)
 (ANNO (DEF "A license agreements in software which is downloaded or used over the internet.") (EX
"")(COMMENTS ""))
 (SYN-STRUC
  ((ROOT $VAR0) (CAT N))
(SEM-STRUC (CONTRACT
(MADE-OF (SEM *NOTHING*))
(PRECONDITION (SEM REFESEM1))))
(REFSEM1 (SEM CLICK
(REPRESENTS (SEM AGREE))
(PRECONDITION-OF (SEM DOWNLOAD)))))
))

(BROWSE-WRAP-AGREEMENT
 (BROWSE-WRAP-AGREEMENT-n1 (CAT N)
 (SYNONYMS “browse-wrap agreement”)
```

```
 (ANNO (DEF "A license agreements in software which is  used over the internet: browsing is considered a
sufficient agreement notification.") (EX "many agreements are of the kind known as browse-wrap
agreements, where there is no direct way of signaling assent, and any acceptance of the agreement, if it
comes, must be contingent on the mere act of browsing the site.")(COMMENTS ""))
  (SYN-STRUC
   ((ROOT $VAR0) (CAT N))
 (SEM-STRUC (CONTRACT
 (MADE-OF (SEM *NOTHING*))
 (PRECONDITION (SEM REFESEM1))))
 (REFSEM1 (SEM BROWSE
 (REPRESENTS (SEM AGREE))
 (PRECONDITION-OF (SEM DOWNLOAD)))))
))

(UTILITY
 (UTILITY-n1 (CAT N)
(ANNO (DEF "utility in software domain.") (EX "a system defragmenting utility")(COMMENTS ""))
  (SYN-STRUC
   ((ROOT $VAR0) (CAT N))
(SEM-STRUC (COMPUTER-PROGRAM)))
(UTILITY-n2 (CAT N)
(ANNO (DEF "utility in economics, a measure of the happiness or satisfaction gained from a good or
service.") (EX "")(COMMENTS ""))
  (SYN-STRUC
   ((ROOT $VAR0) (CAT N)
    (PP-ADJUNCT ((ROOT OF) (CAT PREP) (OPT +) (OBJ ((ROOT $VAR1)))))
  (SEM-STRUC (UTILITY-ATTRIBUTE (DOMAIN (VALUE ^$VAR1))))
))

(PUBLIC-UTILITY
(PUBLIC-UTILITY-n1 (CAT N)
(ANNO (DEF "A public utility is a company that maintains the infrastructure for a public service.”) (EX
Public utilities often involve natural monopolies, and as a result are often government monopolies, or (if
privately owned) treated as specially regulated sectors.")(COMMENTS ""))
  (SYN-STRUC
   ((ROOT $VAR0) (CAT N))
(SEM-STRUC (UTILITY-CORPORATION))
))

(SIGNIFICANCE
 (SIGNIFICANCE-N1 (CAT N)
(ANNO (DEF “The quality or condition of being significant.”)(EX "It is hard to overestimate the
significance of a new child on family life. ") (COMMENTS ""))
  (SYN-STRUC
   ((ROOT $VAR0) (CAT N)
    (PP-ADJUNCT ((ROOT OF) (CAT PREP) (OPT +) (OBJ ((ROOT $VAR2)))))))
  (SEM-STRUC ($VAR2 (SALIENCY (VALUE (> 0.5)))))))

(wireless-network
 (wireless-network-N1 (CAT N)
  (ANNO (DEF "telephone or computer networks that use radio as their carrier or physical layer.")
   (EX "I have no access to your wireless network.") (COMMENTS ""))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
  (SEM-STRUC (COMPUTER-NETWORK
```

```
  (TRANSMITTER-OF (SEM SIGNAL))))
))

(SENSITIVITY
 (SENSITIVITY-N1 (CAT N)
(ANNO (DEF “The quality or condition of being sensitive.”)(EX "a galvanometer of extreme sensitivity ")
(COMMENTS ""))
 (SYN-STRUC
 (ROOT $VAR0) (CAT N)))
    (PP-ADJUNCT ((ROOT OF) (CAT PREP) (OPT +) (OBJ ((ROOT $VAR1)))))
  (SEM-STRUC (SENSITIVITY (DOMAIN (VALUE ^$VAR1)) (RANGE (< 0.8))))))
)

(SYSTEM
 (SYSTEM-N1 (CAT N)
  (ANNO (DEF “an assemblage of inter-related elements comprising a unified whole.”)(EX " A system
typically consists of components (or elements) which are connected together in order to facilitate the flow
of information, matter or energy. ") (COMMENTS "The term is often used to describe a set of entities
which interact, and for which a mathematical model can often be constructed."))
(SYN-STRUC ((ROOT $VAR0) (CAT N)))
  (SEM-STRUC (PHYSICAL-SYSTEM))))
 (SYSTEM-N2 (CAT N)
(ANNO (DEF “a part of computer which contains processing unit and devices.”)(EX "") (COMMENTS
""))
(SYN-STRUC ((ROOT $VAR0) (CAT N)))
  (SEM-STRUC (SYSTEM-UNIT))))

(SUB-SYSTEM
(SUB-SYSTEM-N1 (CAT N)
(ANNO (DEF “a system which is part of another system.”) (EX "The air-supply sub-system is
malfunctioning.") (COMMENTS ""))
(SYN-STRUC ((ROOT $VAR0) (CAT N)))
  (SEM-STRUC (PHYSICAL-SYSTEM
(PART-OF-OBJECT (SEM PHYSICAL-SYSTEM)))
))

(THRESHOLD
(THRESHOLD-N1 (CAT N)
(ANNO (DEF “a fixed location or value where an abrupt change is observed.”)(EX "a low threshold of
pain. ") (COMMENTS ""))
(SYN-STRUC ((ROOT $VAR0) (CAT N)))
  (SEM-STRUC (REPRESENTATIONAL-OBJECT
(LOCATION-OF (SEM CHANGE-EVENT))))
))

(TOKEN
(TOKEN-N1 (CAT N)
(ANNO (DEF “an object, substitute for currency.”)(EX "casino token") (COMMENTS ""))
(SYN-STRUC ((ROOT $VAR0) (CAT N)))
  (SEM-STRUC (OBJECT
(REPRESENTS (SEM CURRENCY))))
(TOKEN-N2 (CAT N)
(ANNO (DEF “an object used for authorization; can by a physical object or a representational one (e.g.
virtual object in computing).”)(EX "") (COMMENTS "still need to include a social meaning: as business or
```

```
politics, where a token can be a single person of a disadvantaged group hired very publicly so the
organization can claim to be inclusive or representative. Mostly used as an adjective."))
(SYN-STRUC ((ROOT $VAR0) (CAT N)))
  (SEM-STRUC (OBJECT
(INSTRUMENT-OF (SEM ALLOW))))
))

(FACIAL-RECOGNITION
(FACIAL-RECOGNITION-N1 (CAT N)
(SYNONYMS “face recognition”)
  (ANNO (DEF “methodology allowing to identify a human by its facial geometry biometric.")
   (COMMENTS "") (EX "Facial recognition is successfully used at airports and stadiums to enhance
security."))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
(SEM-STRUC (METHOD
(INSTRUMENT-OF (SEM REFSEM1))))
(REFSEM1 (OBTAIN-INFORMATION
(THEME (FACIAL-GEOMETRY))))
))

(error
(ERROR-N1 (CAT N)
  (ANNO (DEF “a mistake") (EX “I get an error every time I run this program”) (COMMENTS “”))
 (SYN-STRUC ((ROOT $VAR0) (CAT N)))
  (SEM-STRUC (SELECT (SUCCESS-ATTRIBUTE (VALUE (0)))))
))

(RESPONSIBILITY
  (ANNO (DEF “The state, quality, or fact of being responsible. ") (EX “he holds a position of great
responsibility”) (COMMENTS “”))
(RESPONSIBILITY-N1 (CAT N)
  (SYN-STRUC
   ((ROOT $VAR0) (CAT N)))
  (SEM-STRUC (RESPONSIBILITY))
))

(interception
 (interception-N1 (CAT N)
(ANNO (DEF "act of stopping smth on its way and gaining possession of it") (EX "he claimed that the
interception of one missile by another would be impossible") (COMMENTS ""))
  (SYN-STRUC
   ((ROOT $VAR0) (CAT N)))
  (SEM-STRUC (RESULT-OF (INTERCEPT))
))

(SSN
 (SSN-N1 (CAT N)
 (SYNONYMS “Social Security number”)
  (ANNO (DEF “The number on one’s social security c ard.")
   (EX "") (COMMENTS ""))
   ((N ((ROOT $VAR1) (CAT N) (POSSESSIVE +) (OPT +))) (ROOT $VAR0) (CAT N)))
  (SEM-STRUC (NUMBER
(IDENTIFIES-WHAT (SEM SOCIAL-SECURITY-CARD))))
))
```

```
(Social-Security-Number
 (Social-Secutiry-Number-N1 (CAT N)
 (SYNONYMS “SSN”)
  (ANNO (DEF “The number on one’s social security c ard.")
   (EX "Social Security Number is a very important piece of identity in the United States.") (COMMENTS
""))
   ((N ((ROOT $VAR1) (CAT N) (POSSESSIVE +) (OPT +))) (ROOT $VAR0) (CAT N)))
  (SEM-STRUC (NUMBER
(IDENTIFIES-WHAT (SEM SOCIAL-SECURITY-CARD))))
))

(HANDPRINT
 (HANDPRINT-N1 (CAT N)
 (ANNO (DEF "a physical quality of human hand that can be used to identify a human.") (EX "The same
would go for iris, face, voice or handprint biometrics. ") (COMMENTS ""))
  (SYN-STRUC
   ((N ((ROOT $VAR1) (CAT N) (POSSESSIVE +) (OPT +))) (ROOT $VAR0) (CAT N)))
  (SEM-STRUC (HAND-PRINT (IDENTIFIES-WHAT (VALUE ^$VAR1))))
))

(PUBLIC-KEY
 (PUBLIC-KEY-N1 (CAT N)
    (ANNO (DEF "Public-key algorithms typically use a pair of two related keys — one key is private and
must be kept secret, while the other is made public and can be widely distributed; it should not be possible
to deduce one key of a pair given the other.") (EX "Moreover, it is virtually impossible to deduce the
private key if you know the public key.") (COMMENTS ""))
  (SYN-STRUC
   ((ROOT $VAR0) (CAT N)))
  (SEM-STRUC (PUBLIC-KEY))
))

(PRIVATE-KEY
 (PRIVATE-KEY-N1 (CAT N)
    (ANNO (DEF "Public-key algorithms typically use a pair of two related keys — one key is private and
must be kept secret, while the other is made public and can be widely distributed; it should not be possible
to deduce one key of a pair given the other.") (EX "Moreover, it is virtually impossible to deduce the
private key if you know the public key..") (COMMENTS ""))
  (SYN-STRUC
   ((ROOT $VAR0) (CAT N)))
  (SEM-STRUC (PRIVATE-KEY))
))

(SINGLE-KEY-ENCRYPTION
 (SINGLE-KEY-ENCRYPTION-N1 (CAT N)
(SYNONYMS “Private key encryption”, “symmetric key algorithm”)
    (ANNO (DEF "a class of algorithms for cryptography that use trivially related cryptographic keys for
both decryption and encryption.") (EX " Single key encryption (conventional cryptography) uses a single
word or phrase as the key.") (COMMENTS ""))
  (SYN-STRUC
   ((ROOT $VAR0) (CAT N)))
  (SEM-STRUC (SYMMETRIC-KEY-ENCRYPTION-ALGORYTHM))
))
```

```
(PRIVATE-KEY-ENCRYPTION
 (PRIVATE-KEY-ENCRYPTION-N1 (CAT N)
(SYNONYMS “Single key encryption”, “symmetric key algorithm”)
    (ANNO (DEF "a class of algorithms for cryptography that use trivially related cryptographic keys for
both decryption and encryption.") (EX " The only difficulty with public-key encryption is that you need to
know the recipient's public key to encrypt a message for him or her.") (COMMENTS ""))
  (SYN-STRUC
   ((ROOT $VAR0) (CAT N)))
  (SEM-STRUC (SYMMETRIC-KEY-ENCRYPTION-ALGORYTHM))
))

(SYMMETRIC-KEY-ALGORYTHM
 (SYMMETRIC-KEY-ALGORYTHM-N1 (CAT N)
(SYNONYMS “Single key encryption”, “private key encryption”)
    (ANNO (DEF "a class of algorithms for cryptography that use trivially related cryptographic keys for
both decryption and encryption.") (EX " Symmetric-key algorithms can be divided into stream ciphers and
block ciphers.") (COMMENTS ""))
  (SYN-STRUC
   ((ROOT $VAR0) (CAT N)))
  (SEM-STRUC (SYMMETRIC-KEY-ENCRYPTION-ALGORYTHM))
))

(ASYMMETRIC-KEY-ALGORYTHM
 (SYMMETRIC-KEY-ALGORYTHM-N1 (CAT N)
    (ANNO (DEF "the algorithm that uses a pair of cryptographic keys to encrypt and decrypt. The two
keys are related mathematically; a message encrypted by the algorithm using one key can be decrypted by
the same algorithm using the other. In a sense, one key "locks" a lock (encrypts); but a different key is
required to unlock it (decrypt).") (EX "Not all asymmetric key algorithms operate in precisely this
fashion..") (COMMENTS ""))
  (SYN-STRUC
   ((ROOT $VAR0) (CAT N)))
  (SEM-STRUC (ASYMMETRIC-KEY-ENCRYPTION-ALGORYTHM))
))

(waiver
(waiver-N1 (CAT N)
    (ANNO (DEF "A dispensation, as from a rule or penalty.") (EX "We can issue a waiver for this fee if
you need it.") (COMMENTS ""))
  (SYN-STRUC
   ((ROOT $VAR0) (CAT N)))
  (SEM-STRUC (legal-permit
(instrument-of (sem waive)))
))

(spoofing
(spoofing-N1 (CAT N)
    (ANNO (DEF "A technique used to reduce network overhead, especially in
wide area networks (WAN).Spoofing reduces the required bandwidth by having devices, such as bridges or
routers, answer for the remote devices.") (EX "") (COMMENTS ""))
  (SYN-STRUC
   ((ROOT $VAR0) (CAT N)))
  (SEM-STRUC (method
(purpose-of (sem spoof)
))
```

```
(statute
(statute-N1 (CAT N)
    (ANNO (DEF "A law enacted by a legislature.") (EX "the statute of the International Court of Justice ")
(COMMENTS ""))
  (SYN-STRUC
   ((ROOT $VAR0) (CAT N)))
  (SEM-STRUC (statutory-law))
)
(statute-N2 (CAT N)
    (ANNO (DEF "A rule established in a corporation.") (EX "The statutory close corporation is created
under a supplemental state corporation statute. ") (COMMENTS ""))
  (SYN-STRUC
   ((ROOT $VAR0) (CAT N)))
  (SEM-STRUC (rule-of-conduct)
(APPLIES-TO (SEM CORPORATION))
))

(method
(method-N1 (CAT N)
    (ANNO (DEF "A means or manner of procedure, especially a regular and systematic way of
accomplishing something.") (EX "mediation as a method of solving disputes ") (COMMENTS ""))
  (SYN-STRUC
   ((ROOT $VAR0) (CAT N)))
  (SEM-STRUC (method))
)

(Cyberspace
(Cyberspace-N1 (CAT N)
    (ANNO (DEF "The electronic medium of computer networks, in which online communication takes
place.") (EX "These maps of Cyberspaces - cyber maps - help us visualize and comprehend the new digital
landscapes beyond our computer screen, in the wires of the global communications networks and vast
online information resources. ") (COMMENTS ""))
  (SYN-STRUC
   ((ROOT $VAR0) (CAT N)))
  (SEM-STRUC (VIRTUAL-REALITY))
))
```

4.1.2. Verbs

```
(sign-on
    (ANNO (DEF "to provide information in order to access a web-page that requires a form of
identification") (EX "I signed on to view my bank account.") (COMMENTS "synonymous to sign in, but
far less widespread: used in 8mln cases on Google, vs. 33mln for sign in."))
  (SYN-STRUC
(sign-on-V1 (CAT V)
(SYNONYMS “sign in”)
  ((SUBJECT ((ROOT $VAR1) (CAT N)))
  (ROOT $VAR0) (CAT V)))
  (SEM-STRUC (ACCESS-COMPUTER-NETWORK
(AGENT (VALUE ^$VAR1))))
))

(sign-in
```

```
(sign-in-V1 (CAT V)
(SYNONYMS “sign on”)
    (ANNO (DEF "to provide information to access a web-page that requires a form of identification ") (EX
"Please sign in to view your account information.") (COMMENTS ""))
  (SYN-STRUC
  ((SUBJECT ((ROOT $VAR1) (CAT N))) (ROOT $VAR0) (CAT V)))
  (SEM-STRUC (ACCESS-COMPUTER-NETWORK
(AGENT (VALUE ^$VAR1))))
))

(TYPE
(TYPE-V1 (cat V)
          (anno (def "To write (something) with a typewriter; typewrite. ")
          (ex "I type 50 words a minute.")
          (comments "intransitive variant"))
 (syn-struc
          ((SUBJECT ((root $VAR1) (cat N)))
          (root $VAR0) (cat V)
 (sem-struc
          (TYPE (AGENT (value ^$VAR1)))
          (AGENT (value ^$VAR1))
(TYPE-V2 (cat V)
(anno (def " To write (something) using a keyboard; typewriter")
          (ex "He typed all his letters on the computer")
          (comments ""))
 (syn-struc
          ((SUBJECT ((root $VAR1) (cat N)))
          (root $VAR0) (cat V)
          (OBJECT ((root $VAR2) (cat N))))))
(sem-struc (PRODUCE
          (AGENT (value ^$VAR1))
          (THEME (value ^$VAR2))))
          (MANNER (sem TYPE)))
))

(sign-off
(sign-off-V1 (CAT V)
(SYNONYMS  “sign out” “log off” “log out”)
    (anno (def "To enter into a computer the command to end a session.") (ex "Do not forget to sign out
after completing your work.") (comments ""))
  (syn-struc
            ((subject ((root $VAR1) (cat N)))
            (object ((root $VAR2) (cat N) (opt +)))
            (root $VAR0) (cat V)))
  (sem-struc (CHANGE-EVENT
           (EFFECT (sem BE-OFFLINE))
         (PRECONDITION (sem BE-ONLINE)
                  (AGENT (value ^$VAR1)))
                  (THEME (value ^$VAR2))))
))

(sign-out
(sign-out-V1 (CAT V)
(SYNONYMS “sign off” “log off” “log out”)
```

```
    (anno (def "To enter into a computer the command to end a session.") (ex "Do not forget to sign out
after completing your work.") (comments ""))
  (syn-struc
              ((subject ((root $VAR1) (cat N)))
              (object ((root $VAR2) (cat N) (opt +)))
              (root $VAR0) (cat V)))
  (sem-struc (CHANGE-EVENT
             (EFFECT (sem BE-OFFLINE))
            (PRECONDITION (sem BE-ONLINE)
                        (AGENT (value ^$VAR1)))
                        (THEME (value ^$VAR2))))
))

(log-off
(log-off-V1 (CAT V)
(SYNONYMS  “sign out” “log off” “log out”)
    (anno (def "To enter into a computer the command to end a session.") (ex "After you are done working,
log off to avoid a derf.") (comments ""))
  (syn-struc
              ((subject ((root $VAR1) (cat N)))
              (object ((root $VAR2) (cat N) (opt +)))
              (root $VAR0) (cat V)))
  (sem-struc (CHANGE-EVENT
             (EFFECT (sem BE-OFFLINE))
            (PRECONDITION (sem BE-ONLINE)
                        (AGENT (value ^$VAR1)))
                        (THEME (value ^$VAR2))))
))

(log-out
(log-out-V1 (cat V)
(synonyms “sign off” “log off” “log out”)
    (anno (def "To enter into a computer the command to end a session.") (ex "After you are done working,
log out to avoid a derf.") (comments ""))
  (syn-struc
              ((subject ((root $VAR1) (cat N)))
              (object ((root $VAR2) (cat N) (opt +)))
              (root $VAR0) (cat V)))
  (sem-struc (CHANGE-EVENT
             (EFFECT (sem BE-OFFLINE))
            (PRECONDITION (sem BE-ONLINE)
                        (AGENT (value ^$VAR1)))
                        (THEME (value ^$VAR2))))
))

(tamper-with-v1
  (anno    (def “To interfere in a harmful manner”)  (ex  “tried to tamper with the decedent's will”)
    (comments “”))
(syn-struc
    ((subject ((root $var1) (cat np)))
    (root $var0) (cat v)
    (prep ((root with) (cat prep))))
    (object ((root $var2) (cat np))))
(sem-struc
```

```
  (TAMPER
     (agent (value ^$var1) (sem HUMAN))
     (theme (value ^$var2) (sem ARTIFACT))
)

(tinker-with-v1
  (anno    (def “To manipulate experimentally”)  (ex “tinkered with the engine, hoping to discover the
trouble”)
    (comments “”))
(syn-struc
     ((subject ((root $var1) (cat np)))
     (root $var0) (cat v)
     (prep ((root with) (cat prep))))
     (object ((root $var2) (cat np))))
(sem-struc
  (TINKER
     (agent (value ^$var1) (sem HUMAN))
     (theme (value ^$var2) (sem ARTIFACT))
)

(track
(track-V1 (CAT V)
     (ANNO (DEF "To observe the progress of; follow") (EX "tracking the company's performance daily ")
(COMMENTS ""))
  (SYN-STRUC
  ((SUBJECT ((ROOT $VAR1) (CAT N))) (ROOT $VAR0) (CAT V)))
  (SEM-STRUC (OBTAIN-INFORMATION
(THEME (SEM LOCATION))
(AGENT (VALUE ^$VAR1))))
))
```

4.1.3. Adjectives

```
(HAZEL
 (HAZEL-ADJ1 (CAT ADJ)
 (ANNO (DEF "an eye color") (EX "Hazel eye color can be easily changed by using color contacts.")
(COMMENTS ""))
  (SYN-STRUC ((ROOT $VAR1) (CAT N) (MODS ((ROOT $VAR0) (CAT ADJ)))))
(SEM-STRUC
   ($VAR1 (INSTANCE-OF (SEM EYE)) (COLOR-ATTRIBUTE (SEM HAZEL))))
))

(BLOND
 (BLOND-ADJ1 (CAT ADJ) (SYNONYMS "BLONDE")
(ANNO (DEF "a hair color") (EX "I'll dye my hair blond next time.") (COMMENTS ""))
  (SYN-STRUC ((ROOT $VAR1) (CAT N) (MODS ((ROOT $VAR0) (CAT ADJ)))))
  (SEM-STRUC
($VAR1 (INSTANCE-OF (SEM HUMAN)) (HAS-HAIR-COLOR (SEM BLOND)))))
(BLOND-N1 (CAT N) (SYNONYMS "BLONDE")
  (ANNO (DEF "a human with blond hair color") (EX "a blond leads that exercise class")
   (COMMENTS " with no explicit modifyee "))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
  (SEM-STRUC (HUMAN
```

```
(HAS-HAIR-COLOR BLOND))))
))

(AUBURN
 (AUBURN-ADJ1 (CAT ADJ)
 (ANNO (DEF "a hair color") (EX "Auburn hair color is rarer than other colors") (COMMENTS ""))
  (SYN-STRUC ((ROOT $VAR1) (CAT N) (MODS ((ROOT $VAR0) (CAT ADJ)))))
  (SEM-STRUC (HAIR
(COLOR-ATTRIBUTE (SEM AUBURN))))
))

(BRUNETTE
 (BRUNETTE-ADJ1 (CAT ADJ)
(ANNO (DEF "a dark hair color") (EX "") (COMMENTS “”))
  (SYN-STRUC ((ROOT $VAR1) (CAT N) (MODS ((ROOT $VAR0) (CAT ADJ)))))
(SEM-STRUC ($VAR1 (INSTANCE-OF (SEM HUMAN
(HAS-HAIR-COLOR (SEM BRUNETTE)))))
 (BRUNETTEE-N1 (CAT N)
  (ANNO (DEF "a human with dark hair color") (EX "a BRUNETTE came in the door")(COMMENTS "
with no explicit modifyee "))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
  (SEM-STRUC (HUMAN
(HAS-HAIR-COLOR BRUNETTE))))
))

(UNIQUE
 (UNIQUE-ADJ1 (CAT ADJ)
  (ANNO (DEF  “Being the only one of its kind.") (EX “the unique existing example of Donne's
handwriting.”) (COMMENTS ""))
  (SYN-STRUC ((ROOT $VAR1) (CAT N) (MODS ((ROOT $VAR0) (CAT ADJ)))))
  (SEM-STRUC
   ($VAR1 (INSTANCE-OF (SEM ANIMAL)) (UNIQUENESS (VALUE 1)))))
 (UNIQUE-ADJ2 (CAT ADJ)
  (ANNO (DEF  “Being the only one of its kind.") (EX  “Everyone is unique. Just like everyone else.”)
(COMMENTS ""))
  (SYN-STRUC
   ((SUBJECT ((ROOT $VAR1) (CAT N))) (ROOT BE) (CAT V)
    (DIRECTOBJECT ((ROOT $VAR0) (CAT ADJ)))))
  (SEM-STRUC
   ($VAR1 (INSTANCE-OF (SEM ANIMAL)) (UNIQUENESS (VALUE 1))))
))

(ONLINE-ADJ1 (CAT ADJ)
  (ANNO (DEF "a metaphorical adjective of place meaning the user is using the Internet") (EX " I went to
an online dealer to order a new computer.") (COMMENTS ""))
  (SYN-STRUC
(1  ((ROOT $VAR1) (CAT N)
  (MODS ((ROOT $VAR0) (CAT ADJ)))))
(2 ((root $var0) (cat adj)
    (subj ((root $var1) (cat n))))))
  (SEM-STRUC (^$VAR1 (LOCATION INTERNET)))
))

(LEGAL
```

```
(LEGAL-ADJ1 (CAT ADJ)
(ANNO (DEF "Authorized by or based on law.") (EX "Legal entry.") (COMMENTS ""))
  (SYN-STRUC ((ROOT $VAR1) (CAT N) (MODS ((ROOT $VAR0) (CAT ADJ)))))
  (SEM-STRUC
   ($VAR1 (INSTANCE-OF (SEM OBJECT))
    (LEGALITY-ATTRIBUTE (VALUE YES))))
))

(DIGITAL
(DIGITAL-ADJ1 (CAT ADJ)
(ANNO (DEF "Expressed in numerical form, especially for use by a computer.") (EX "digital signature")
(COMMENTS ""))
  (SYN-STRUC ((ROOT $VAR1) (CAT N) (MODS ((ROOT $VAR0) (CAT ADJ)))))
  (SEM-STRUC
   ($VAR1 (INSTANCE-OF (SEM OBJECT))
    (REPRESENTED-BY (SEM BIT-STRING))))
))

(PSYCHOGRAPHIC
(PSYCHOGRAPHIC-ADJ1 (CAT ADJ)
(ANNO (DEF "pertaining to lifestyle and personal characteristics information.") (EX "Companies are often
interested in collecting psychographic information") (COMMENTS ""))
  (SYN-STRUC ((ROOT $VAR1) (CAT N) (MODS ((ROOT $VAR0) (CAT ADJ)))))
  (SEM-STRUC
   ($VAR1 (INSTANCE-OF (SEM OBJECT))
    (DESCRIBES (SEM SCALAR-SOCIAL-ATTRIBUTE (NOT DEMOGRAPHICS-ATTRIBUTE))))
))

(SENSITIVE
 (SENSITIVE-ADJ1 (CAT ADJ)
(ANNO (DEF "Easily responsive to external influences.") (EX "Sensitive skin.") (COMMENTS "Also
used metaphorically; next entry is for variance in syntactic structure"))
  (SYN-STRUC ((ROOT $VAR1) (CAT N) (MODS ((ROOT $VAR0) (CAT ADJ)))))
  (SEM-STRUC ($VAR1 (INSTANCE-OF (SEM OBJECT)) (SENSITIVITY (VALUE (> 0.9))))))
 (SENSITIVE-ADJ2 (CAT ADJ)
(ANNO (DEF "Easily responsive to external influences.") (EX "Sensitive skin.") (COMMENTS "Also
used metaphorically"))
  (SYN-STRUC
   ((SUBJECT ((ROOT $VAR1) (CAT N))) (ROOT BE) (CAT V)
    (DIRECTOBJECT ((ROOT $VAR0) (CAT ADJ)))))
  (SEM-STRUC ($VAR1 (INSTANCE-OF (SEM OBJECT)) (SENSITIVITY (VALUE (> 0.9))))))
 (SENSITIVE-ADJ3 (CAT ADJ)
(ANNO (DEF "Of or relating to classified information.") (EX "Sensitive defense data") (COMMENTS ""))
  (SYN-STRUC ((ROOT $VAR1) (CAT N) (MODS ((ROOT $VAR0) (CAT ADJ)))))
  (SEM-STRUC ($VAR1 (INSTANCE-OF (SEM INFORMATION (THEME-OF (REFSEM1))))))
(REFSEM1 (INFORM
(SAFETY-ATTRIBUTE (VALUE .1))))
))

(UNAUTHORIZED
 (UNAUTHORIZED-ADJ1 (POS ADJ)
(ANNO (DEF "lacking authorization or official quality") (EX “unauthorized intrusion”  ") (COMMENTS
""))
  (SYN-STRUC ((ROOT $VAR1) (CAT N) (MODS ((ROOT $VAR0) (CAT ADJ)))))
```

```
  (SEM-STRUC
   ($VAR1 (INSTANCE-OF (SEM OBJECT)) (INSTANCE-OF (SEM EVENT))
    (OFFICIAL-ATTRIBUTE (SEM NON-OFFICIAL))))
))

(VULNERABLE
 (VULNERABLE-ADJ1 (CAT ADJ)
(ANNO (DEF "Susceptible to attack ") (EX “We are vulnerable both by water and land, without either fleet
or army”  ") (COMMENTS ""))
  (SYN-STRUC ((ROOT $VAR1) (CAT N) (MODS ((ROOT $VAR0) (CAT ADJ)))))
  (SEM-STRUC ($VAR1 (SEM (OBJECT)) (SAFETY-ATTRIBUTE (< 0.3)))
))

(incremental
 (incremental-ADJ1 (CAT ADJ)
 (ANNO (DEF "change of quantity in quantized manner ") (EX "lecturers enjoy...steady incremental
growth in salary") (COMMENTS ""))
  (SYN-STRUC ((ROOT $VAR1) (CAT N) (MODS ((ROOT $VAR0) (CAT ADJ)))))
(SEM-STRUC
   ($VAR1 (INSTANCE-OF (SEM CHANGE-IN-QUANTITY))))
))

(wireless
 (wireless-ADJ1 (CAT ADJ)
(ANNO (DEF "method of transferring data using radio- and microwaves") (EX "I have a wireless router.")
(COMMENTS ""))
  (SYN-STRUC ((ROOT $VAR1) (CAT N) (MODS ((ROOT $VAR0) (CAT ADJ)))))
  (SEM-STRUC
($VAR1 (INSTANCE-OF (SEM COMPUTER-DATA
(TRANSMITTED-BY (SEM WAVE)))))
))

(phony
 (phony-ADJ1 (CAT ADJ)
(ANNO (DEF "fake, non-authentic") (EX "A teenager suspected of hacking into the database of a
LexisNexis subsidiary is believed to have accessed it using phony accounts set up through police
departments.") (COMMENTS ""))
  (SYN-STRUC ((ROOT $VAR1) (CAT N) (MODS ((ROOT $VAR0) (CAT ADJ)))))
  (SEM-STRUC
($VAR1 (authenticity (VALUE 0)))
))

(manipulable
 (manipulable-ADJ1 (CAT ADJ)
(ANNO (DEF "susceptible to change under influence") (EX "a manipulable populace ") (COMMENTS ""))
  (SYN-STRUC ((ROOT $VAR1) (CAT N) (MODS ((ROOT $VAR0) (CAT ADJ)))))
  (SEM-STRUC
($VAR1 (susceptibility
(applies-to CHANGE-EVENT) (VALUE 0)))
))

(tamper-resistant
 (tamper-resistant-ADJ1 (CAT ADJ)
```

```
(ANNO (DEF "resistant to change (tampering); of software and artifacts") (EX "Some tamper-resistant
devices do not permit certain keys to be exported outside the hardware. ") (COMMENTS ""))
  (SYN-STRUC ((ROOT $VAR1) (CAT N) (MODS ((ROOT $VAR0) (CAT ADJ)))))
  (SEM-STRUC
($VAR1 (RESISTANT (APPLIES-TO (SEM TAMPER
                    (THEME (SEM INFORMATION ARTIFACT))
                    (VALUE 1)))
))

(machine-readable
 (machine-readable-ADJ1 (CAT ADJ)
(ANNO (DEF "capable of being processed by a computer") (EX "The MARC formats are standards for the
representation and communication of bibliographic and related information in machine-readable form. ")
(COMMENTS ""))
  (SYN-STRUC ((ROOT $VAR1) (CAT N) (MODS ((ROOT $VAR0) (CAT ADJ)))))
  (SEM-STRUC
($VAR1 (TRANSFORM
(INSTRUMENT (SEM COMPUTER)))
))

(SIGNATURE-BASED
(SIGNATURE-BASED-ADJ1 (CAT ADJ)
    (ANNO (DEF "based on signature") (EX "Most credit card authorization is signature-based.")
(COMMENTS ""))
  (SYN-STRUC
  ((root $VAR0) (CAT adj)
 (N ((root $var1) (cat n)))
))
  (SEM-STRUC (^$var1
  (RELATION SIGNATURE)))
)

(COMPUTER-CENTRIC
(COMPUTER-CENTRIC-ADJ1 (CAT ADJ)
    (ANNO (DEF "concentrated around the use of computers") (EX "From a Computer Centric to a User
Centric Finder
") (COMMENTS ""))
  (SYN-STRUC
  ((root $VAR0) (CAT adj)
 (N ((root $var1) (cat n)))
))
  (SEM-STRUC (^$var1
  (RELATION COMPUTER)))
)

(CLIENT-SIDE
(CLIENT-SIDE-ADJ1 (CAT ADJ)
    (ANNO (DEF "pertaining to the client on the network.") (EX "The ASP translator is the client-side ASP
to PHP converter listed on php.net") (COMMENTS ""))
  (SYN-STRUC
  ((root $VAR0) (CAT adj)
 (N ((root $var1) (cat n)))
))
  (SEM-STRUC (^$var1
```

```
  (RELATION NETWORK-CLIENT)))
)

(HIGH-TECH
(HiGH-TECH-ADJ1 (CAT ADJ)
    (ANNO (DEF "pertaining to technology") (EX "He got some high-tech gadgets as toys for Christmas.")
(COMMENTS ""))
  (SYN-STRUC
  ((root $VAR0) (CAT adj)
 (N ((root $var1) (cat n)))
))
  (SEM-STRUC (^$var1
  (RELATION TECHNOLOGY)))
)

(token-based
(token-based-ADJ1 (CAT ADJ)
    (ANNO (DEF "a security scheme reliant on tokens") (EX "We have implemented a token-based scheme
to protect our software") (COMMENTS ""))
  (SYN-STRUC
  ((root $VAR0) (CAT adj)
 (N ((root $var1) (cat n)))
))
  (SEM-STRUC (^$var1
  (RELATION token)))
)

(password-sharing
 (password-sharing-N1 (CAT N)
    (ANNO (DEF "an act of letting others know one's password") (EX "What can be done to prevent
password-sharing among our users?") (COMMENTS ""))
  (SYN-STRUC
   ((ROOT $VAR0) (CAT N)))
  (SEM-STRUC (SHARE-EVENT
(THEME (SEM PASSWORD))
))

(optional
(optional-ADJ1 (CAT ADJ)
    (ANNO (DEF "possible but not necessary; left to personal choice") (EX "black tie optional")
(COMMENTS ""))
  (SYN-STRUC
  ((root $VAR0) (CAT adj)
 (N ((root $var1) (cat n)))
))
  (SEM-STRUC (^$var1
  (saliency (.1))))
)

(statutory
(statutory-ADJ1 (CAT ADJ)
    (ANNO (DEF "Of or relating to a statute.") (EX "a statutory provision ") (COMMENTS ""))
  (SYN-STRUC
  ((root $VAR0) (CAT adj)
```

```
 (N ((root $var1) (cat n)))
))
  (SEM-STRUC (^$var1
  (relation (sem statute))))
))

(tamper-proof
 (tamper-proof-ADJ1 (CAT ADJ)
(synonyms “tamper-resistant”)
(ANNO (DEF "resistant to change (tampering); of software and artifacts") (EX "This tape is tamper-proof
and cannot be altered by means of any software.") (COMMENTS ""))
  (SYN-STRUC ((ROOT $VAR1) (CAT N) (MODS ((ROOT $VAR0) (CAT ADJ)))))
  (SEM-STRUC
($VAR1 (RESISTANCE (APPLIES-TO (SEM TAMPER
                                          (THEME (SEM INFORMATION ARTIFACT))
                                          (VALUE 1)))
))

(multinational
 (multinational-ADJ1 (CAT ADJ)
 (ANNO (DEF "Of or involving more than two countries") (EX "a multinational project") (COMMENTS
""))
  (SYN-STRUC ((ROOT $VAR1) (CAT N) (MODS ((ROOT $VAR0) (CAT ADJ)))))
  (SEM-STRUC
($VAR1 (HAS-OBJECT-AS-PART (SEM NATION (CARDINALITY (>2))))))
))
```

4.1.4. Combined entries

```
(SMELL
 (SMELL-V1 (CAT V)
  (ANNO (DEF "To perceive the scent of (something) by means of the olfactory nerves.") (EX "He smelled
fire [dinner cooking]") (COMMENTS ""))
  (SYN-STRUC
   ((SUBJECT ((ROOT $VAR1) (CAT N))) (ROOT $VAR0) (CAT V)
    (DIRECTOBJECT ((ROOT $VAR2) (CAT N)))))
  (SEM-STRUC
   (INVOLUNTARY-OLFACTORY-EVENT
   (PATIENT (VALUE ^$VAR1))
    (THEME (VALUE ^$VAR2))
)))
(SMELL-V2 (CAT V)
  (ANNO (DEF "To produce scent.") (EX "He smelled of expensive perfume.") (COMMENTS ""))
  (SYN-STRUC
   ((NP ((ROOT $VAR1) (CAT N))) (ROOT $VAR0) (CAT V)
    (PP-ADJUNCT
     ((ROOT (OF)) (ROOT $VAR2) (CAT PREP)
      (OBJ ((ROOT $VAR3) (CAT N)))))))
  (SEM-STRUC
   (PRODUCE-ODOR (AGENT (VALUE ^$VAR1)) (THEME (VALUE ^$VAR3)))
(SMELL-N1 (CAT N)
(SYNONYMS “odor”)
```

```
  (ANNO (DEF " That quality of something that may be perceived by the olfactory sense..") (EX "Isn't
there a smell of fish here?") (COMMENTS ""))
  (SYN-STRUC
   ((ROOT $VAR0) (CAT N)
    (PP-ADJUNCT ((ROOT OF) (CAT PREP) (OPT +) (OBJ ((ROOT $VAR2))))))
  (SEM-STRUC (INVOLUNTARY-OLFACTORY-EVENT (THEME (VALUE $VAR2))))
))

(BLONDE
 (BLONDE-ADJ1 (CAT ADJ) (SYNONYMS "BLOND")
(ANNO (DEF "a hair color") (EX "I am going to dye my hair") (COMMENTS ""))
  (SYN-STRUC ((ROOT $VAR1) (CAT N) (MODS ((ROOT $VAR0) (CAT ADJ)))))
  (SEM-STRUC
($VAR1 (INSTANCE-OF (SEM HUMAN)) (HAS-HAIR-COLOR (SEM BLOND)))))
(BLONDE-N1 (CAT N) (SYNONYMS "BLOND")
  (ANNO (DEF "A human being with blond hair") (EX "there is a blonde there that leads her exercise
class")    (COMMENTS "when used with no explicit modifyee "))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
  (SEM-STRUC (HUMAN
(HAS-HAIR-COLOR BLOND))))
))

(MOBILE
 (MOBILE-N1 (CAT N)
(SYNONYMS “mobile, cell phone, cell, cellular phone”)
  (ANNO DEF ("a mobile radiotelephone that is controlled by a computer system.")(EX "") (COMMENTS
"overrides purely adj entry"))
  (SYN-STRUC ((ROOT $VAR0) (CAT N)))
  (SEM-STRUC (CELL-PHONE))
(MOBILE-ADJ1 (CAT ADJ)
  (ANNO DEF ("a moveable object.")(EX "I would like to have a mobile home.") (COMMENTS ""))
  (SYN-STRUC ((ROOT $VAR1) (CAT N) (MODS ((ROOT $VAR0) (CAT ADJ)))))
  (SEM-STRUC ($VAR1 (INSTANCE-OF (SEM PHYSICAL-OBJECT)) (MOVEABLE (SEM YES)))))
  (MOBILE-ADJ2 (CAT ADJ)
(ANNO DEF ("a moveable object.")(EX "This generation is very upwardly mobile.") (COMMENTS "can
be used metaphorically"))
  (SYN-STRUC
   ((SUBJECT ((ROOT $VAR1) (CAT N))) (ROOT BE) (CAT V)
    (DIRECTOBJECT ((ROOT $VAR0) (CAT ADJ)))))
  (SEM-STRUC ($VAR1 (INSTANCE-OF (SEM OBJECT)) (MOVEABLE (SEM YES))))
))

(LINK
 (LINK-V1 (CAT V)
       (ANNO (DEF "to connect events causally") (EX "In the book Freakonomics, the high crime rate is
linked to the ban on abortion 20 years prior.") (COMMENTS ""))
  (SYN-STRUC
   ((ROOT $VAR0) (CAT V) (SUBJECT ((ROOT $VAR2)))
    (DIRECTOBJECT ((ROOT $VAR1) (CAT N)))
    (PP-ADJUNCT ((ROOT TO) (CAT PREP) (OBJ ((ROOT $VAR3)))))))
  (SEM-STRUC
   (OBJECT-RELATION (DOMAIN (VALUE $VAR1)) (RANGE (VALUE $VAR3))
    (CAUSED-BY (VALUE $VAR2)))))
 (LINK-V1 (CAT V)
```

```
      (ANNO (DEF "to connect objects physically") (EX "We linked the rings to form a chain.")
(COMMENTS ""))
  (SYN-STRUC
   ((ROOT $VAR0) (CAT V) (SUBJECT ((ROOT $VAR2)))
    (DIRECTOBJECT ((ROOT $VAR3)))
    (PP-ADJUNCT ((ROOT WITH) (CAT PREP) (OBJ ((ROOT $VAR4)))))))
  (SEM-STRUC
   (FASTEN (AGENT (VALUE $VAR2)) (THEME (VALUE $VAR3))
    (INSTRUMENT (VALUE $VAR4)))))
 (LINK-N1 (CAT N)
      (ANNO (DEF "A connector in a circuit") (EX "") (COMMENTS ""))
 (SYN-STRUC ((ROOT $VAR0) (CAT N)))
  (SEM-STRUC (CONNECTOR (CONNECTS (SEM SIMPLE-CIRCUIT-MECHANISM)))))
 (LINK-N2 (CAT N)
      (ANNO (DEF "A unit in a communications system ") (EX "") (COMMENTS ""))
 (SYN-STRUC ((ROOT $VAR0) (CAT N)))
  (SEM-STRUC (CONNECTOR (CONNECTS (SEM COMMUNICATION-DEVICE)))))
 (LINK-N3 (CAT N)
      (ANNO (DEF "Any physical connector.") (EX "Researchers have detected a link between smoking
and heart disease.") (COMMENTS "Can be extended metaphorically"))
 (SYN-STRUC ((ROOT $VAR0) (CAT N)))
  (SEM-STRUC (PHYSICAL-OBJECT (CONNECTS (SEM PHYSICAL-OBJECT))))))
(LINK-N4 (CAT N)
      (ANNO (DEF "A segment of text or a graphical item that serves as a cross-reference between parts of
a hypertext document or between files or hypertext documents. ") (EX "Could you make a link to my
webpage from yours?") (COMMENTS ""))
 (SYN-STRUC ((ROOT $VAR0) (CAT N)))
  (SEM-STRUC (HYPERLINK))))
))

(FORMAT
(FORMAT-N1 (CAT N)
      (ANNO (DEF "the format of a text") (EX "") (COMMENTS ""))
      (SYN-STRUC ((ROOT $VAR0) (CAT N))) (SEM-STRUC (TEXT-FORMAT)))
(FORMAT-N2 (CAT N)
      (ANNO (DEF "a plan for the organization of something.")
      (EX "The network's repetitive news format is getting stale")
       (COMMENTS ""))
      (SYN-STRUC ((ROOT $VAR0) (CAT N))) (SEM-STRUC (TEXT-FORMAT))))
(FORMAT-V1 (CAT V)
(ANNO (DEF "set (printed matter) into a specific format.")
      (EX "Format this letter so it can be printed out.")
  (SYN-STRUC
   ((ROOT $VAR0) (CAT V) (SUBJECT ((ROOT $VAR1)))
    (DIRECTOBJECT ((ROOT $VAR2))))
  (SEM-STRUC (PREPARE-DOCUMENT
(AGENT (VALUE $VAR1))
(THEME (VALUE $VAR2))))
)
(FORMAT-V2 (CAT V)
(ANNO (DEF "divide (a disk) into marked sectors so that it may store data.")
      (EX "Please format this disk before entering data.")
  (SYN-STRUC
   ((ROOT $VAR0) (CAT V) (SUBJECT ((ROOT $VAR1)))
```

```
   (DIRECTOBJECT ((ROOT $VAR2))))
  (SEM-STRUC (INITIALIZE
(AGENT (VALUE $VAR1))
(THEME (VALUE $VAR2))))
))

(TRIGGER
(TRIGGER-N1 (CAT N)
  (ANNO (DEF "a cause")
   (EX "The trigger for the fighting was a nasty argument") (COMMENTS ""))
  (SYN-STRUC
   ((ROOT $VAR0) (CAT N)
    (PP-ADJUNCT
     ((ROOT FOR) (ROOT $VAR1) (CAT PREP) (OPT +)
      (OBJ ((ROOT $VAR2) (CAT N)))))))
  (SEM-STRUC (EVENT (EFFECT (VALUE ^$VAR2))) (^$VAR1 (NULL-SEM +))))
 (TRIGGER-N2 (CAT N)
  (ANNO (DEF "part of a firearm") (EX "I pulled the trigger on the gun.") (COMMENTS ""))
  (SYN-STRUC ((ROOT $VAR0) (CAT N))) (SEM-STRUC (TRIGGER))))
 (TRIGGER-V1 (CAT V)
  (ANNO (DEF "An act of causing/beginning smth") (EX "This might trigger a chain reaction.")
(COMMENTS ""))
  (SYN-STRUC
   ((NP ((ROOT $VAR1) (CAT N))) (ROOT $VAR0) (CAT V)
    (NP ((ROOT $VAR2) (CAT N)))))
  (SEM-STRUC
   (PHASE (DOMAIN (VALUE ^$VAR2) (SEM EVENT))
         (RANGE BEGIN)
         (CAUSED-BY (VALUE ^$VAR1))))
))

(UPDATE
(UPDATE-N1 (CAT N)
(ANNO (DEF “Information that updates something.”)(EX "news update") (COMMENTS ""))
(SYN-STRUC ((ROOT $VAR0) (CAT N)))
  (SEM-STRUC (INFORMATION
(ADD-TO (THEME (SEM INFORMATION))))
(UPDATE-N2 (CAT N)
(ANNO (DEF “An updated version of software.”)(EX "software update") (COMMENTS ""))
(SYN-STRUC ((ROOT $VAR0) (CAT N)))
  (SEM-STRUC (SOFTWARE
(THEME-OF (SEM UPDATE))))
(UPDATE-V1 (CAT V)
  (SYN-STRUC
  ((SUBJECT ((ROOT $VAR1) (CAT N))) (ROOT $VAR0) (CAT V)
  (DIRECTOBJECT ((ROOT $VAR2) (CAT N) (OPT +)))))
  (SEM-STRUC (UPDATE
(AGENT (VALUE ^$VAR1))
(THEME (VALUE ^$VAR2))))
))

(FIREWALL
(FIREWALL-n1 (CAT N)
```

```
  (ANNO (DEF "a piece of software which functions in a networked environment to prevent some
communications forbidden by the security policy.") (EX "In order to protect your computer, it's impera tive
to install a firewall if you are using a network.")
   (COMMENTS ""))
  (SYN-STRUC
   ((ROOT $VAR0) (CAT N))
(SEM-STRUC (SOFTWARE
(purpose-of (SEM refsem1))))
(refsem1 (SEM PREVENT (THEME (SEM INFORMATION-SECURITY-ATTACK)))))
(FIREWALL-n2 (CAT N)
  (ANNO (DEF "a piece of hardware which functions in a networked environment to prevent some
communications forbidden by the security policy.") (EX "My router has a firewall.")
   (COMMENTS ""))
  (SYN-STRUC
   ((ROOT $VAR0) (CAT N))
(SEM-STRUC (HARDWARE
(purpose-of (SEM refsem1)
(refsem1 (SEM PREVENT (THEME (SEM INFORMATION-SECURITY-ATTACK))))
))

(backup
(backup-N1 (CAT N)
     (ANNO (DEF "A copy of a program or file that is stored separately from the original.") (EX "I make
backups of my work every other day.") (COMMENTS ""))
  (SYN-STRUC
   ((ROOT $VAR0) (CAT N)))
  (SEM-STRUC (result-of (sem backup-computer-data)))
)
(backup-V1 (CAT V)
 (ANNO (DEF "An action of producing a backup copy.") (EX "Please backup your work at the end of the
day.")
  (SYN-STRUC
   ((ROOT $VAR0) (CAT V) (SUBJECT ((ROOT $VAR2)))
  (SEM-STRUC (backup-computer-data))
))
```

4.2. Digital Identity Management ontology

The ontological concepts are given in the as-acquired order; both the concepts which were added and which were changed are presented. The best way to view the additions would be to view them as additions to KBAE library; this printout version is purely for human overview.

```
(OBJECT-RELATION
        (DEFINITION (VALUE ("relations between objects")))
        (DOMAIN (SEM (OBJECT)))
        (IS-A (VALUE (RELATION)))
```

```
        (SUBCLASSES (VALUE (HAS-OBJECT-AS-PART REPLACEMENT-FOR-OBJECT
SOCIAL-OBJECT-RELATION HAS-RESIDENCE-CITY HAS-MILITARY-ORGANIZATION HAS-
EXPORT-COMMODITY HAS-COMPATIBILITY HAS-AGRICULTURAL-PRODUCT
COMPATIBILITY-OF HAS-BIRTHPLACE-CITY HAS-ETHNIC-GROUP HAS-IMPORT-
COMMODITY HAS-POLITICAL-PARTY PHYSICAL-OBJECT-RELATION HAS-COMMON-
FEATURE REPRESENTATIONAL-RELATION APPLIES-TO REPRESENTATIONAL-OBJECT-
RELATION)))
        (RANGE (NOT (EVENT)))
)

(REPRESENTATIONAL-OBJECT-RELATION
        (DEFINITION (VALUE ("relations that involve representational objects")))
         (IS-A (VALUE (OBJECT-RELATION)))
         (SUBCLASSES (VALUE (collects-identifying-information stores-identifying-information
requests-identifying-information matches-identifying-information issues-identifying-information identifies-
what))))
        (DOMAIN (SEM (REPRESENTATIONAL-OBJECT)))
        (RANGE (NOT (EVENT)))
)

(HAS-IDENTIFYING-INFORMATION
        (DEFINITION (VALUE ("the relation between an information collecting entity and identified
object, where the entity can potentially carry identifying information")))
         (IS-A (VALUE (REPRESENTATIONAL-OBJECT-RELATION)))
        (DOMAIN (SEM (IDENTIFYING-INFORMATION)))
        (RANGE (NOT (EVENT)))
)


(COLLECTS-IDENTIFYING-INFORMATION
        (DEFINITION (VALUE ("the relation between an information-collecting entity and identified
object, where the entity can potentially collect information")))
        (DOMAIN (SEM (IDENTIFYING-INFORMATION)))
        (IS-A (VALUE (REPRESENTATIONAL-OBJECT-RELATION)))
        (RANGE (NOT (EVENT)))
)

(STORES-IDENTIFYING-INFORMATION
        (DEFINITION (VALUE ("the relation between an information collecting entity and identified
object, where the entity can potentially store information")))
        (DOMAIN (SEM (IDENTIFYING-INFORMATION)))
        (IS-A (VALUE (REPRESENTATIONAL-OBJECT-RELATION)))
        (RANGE (NOT (EVENT)))
)

(REQUESTS-IDENTIFYING-INFORMATION
        (DEFINITION (VALUE ("the relation between an information collecting entity and identified
object, where the entity can potentially request information")))
        (DOMAIN (SEM (IDENTIFYING-INFORMATION)))
        (IS-A (VALUE (REPRESENTATIONAL-OBJECT-RELATION)))
        (INVERSE (VALUE (FURNISHES-IDENTIFYING-INFORMATION)))
        (RANGE (NOT (EVENT)))
)
```

```
(MATCHES-IDENTIFYING-INFORMATION
        (DEFINITION (VALUE ("the relation between an information collecting entity and identified
object, where the entity can potentially match information")))
        (DOMAIN (SEM (IDENTIFYING-INFORMATION)))
        (IS-A (VALUE (REPRESENTATIONAL-OBJECT-RELATION)))
        (RANGE (NOT (EVENT)))
)

(ISSIES-IDENTIFYING-INFORMATION
        (DEFINITION (VALUE ("the relation between an information collecting entity and identified
object, where the entity can potentially issue information")))
        (DOMAIN (SEM (IDENTIFYING-INFORMATION)))
        (IS-A (VALUE (REPRESENTATIONAL-OBJECT-RELATION)))
        (INVERSE (VALUE (IDENTIFYING-INFORMATION-ISSUED-BY)))
        (RANGE (NOT (EVENT)))
)

(IDENTIFIES-WHAT
        (DEFINITION (VALUE ("the relation between an information collecting entity and identified
object, where the entity can potentially identify an object")))
        (DOMAIN (SEM (IDENTIFYING-INFORMATION)))
        (IS-A (VALUE (REPRESENTATIONAL-OBJECT-RELATION)))
        (INVERSE (VALUE (IDENTIFIED-BY)))
        (RANGE (NOT (EVENT)))
)

(INVERSE-OBJECT-RELATION
        (DEFINITION (VALUE ("relations between objects opposite to other existing relations between
the same objects")))
        (IS-A (VALUE (RELATION)))
        (SUBCLASSES (VALUE (RESIDENCE-CITY-OF MILITARY-ORGANIZATION-OF
INVERSE-PHYSICAL-OBJECT-RELATION IMPORT-COMMODITY-OF ETHNIC-GROUP-OF
AGRICULTURAL-PRODUCT-OF BIRTHPLACE-CITY-OF EXPORT-COMMODITY-OF INVERSE-
MENTAL-OBJECT-RELATION INVERSE-SOCIAL-OBJECT-RELATION POLITICAL-PARTY-OF
PART-OF-OBJECT INVERSE-REPRESENTATIONAL-OBJECT-RELATION)))
        )

(INVERSE-REPRESENTATIONAL-OBJECT-RELATION
        (DEFINITION (VALUE ("inverses of relation involving representational-objects")))
        (DOMAIN (SEM (REPRESENTATIONAL-OBJECT)))
        (INVERSE (VALUE (REPRESENTATIONAL-OBJECT-RELATION)))
        (IS-A (VALUE (INVERSE-OBJECT-RELATION)))
        (RANGE (SEM (REPRESENTATION-OBJECT)))
        (SUBCLASSES (VALUE (IDENTIFIED-BY FURNISHES-IDENTIFYING-INFORMATION
IDENTIFYING-INFORMATION-ISSUED-BY)))
        )

(IDENTIFIED-BY
        (DEFINITION (VALUE ("the relation between an identified object and representational object,
where the information can potentially identify an object")))
        (DOMAIN (SEM (OBJECT)))
        (IS-A (VALUE (INVERSE-REPRESENTATIONAL-OBJECT-RELATION)))
        (INVERSE (VALUE (IDENTIFIES-WHAT)))
        (RANGE (DEFAULT (REPRESENTATIONAL-OBJECT)) SEM (OBJECT))
```

```
)

(FURNISHES-IDENTIFYING-INFORMATION
        (DEFINITION (VALUE ("the relation between an identified object and another object, where the
former provides representational information about its identity")))
        (DOMAIN (SEM (OBJECT)))
        (IS-A (VALUE (INVERSE-REPRESENTATIONAL-OBJECT-RELATION)))
        (INVERSE (VALUE (COLLECTS-IDENTIFYING-INFORMATION)))
        (RANGE (OBJECT))
)

(IDENTIFYING-INFORMATION-ISSUED-BY
        (DEFINITION (VALUE ("the relation between an identified object and identifying information,
showing what entity issued the information")))
        (DOMAIN (SEM (DEFAULT (ORGANIZATION) RELAXABLE-TO (OBJECT))))
        (IS-A (VALUE (INVERSE-REPRESENTATIONAL-OBJECT-RELATION)))
        (INVERSE (VALUE (ISSUES-IDENTIFYING-INFORMATION)))
        (RANGE (OBJECT))
)

(REPRESENTATIONAL-OBJECT
         (DEFINITION (VALUE ("mental objects which stand in a representational relation to some other
objects")))
        (DOMAIN-OF (INV (DESCRIBES DESCRIBED-BY EMBODIED-IN)))
        (IS-A (VALUE (MENTAL-OBJECT)))
        (OWNED-BY (SEM (HUMAN)))
        (SUBCLASSES (VALUE (MUSIC-RELATED-OBJECT NAME MEASURING-UNIT LEGAL-
OBJECT FINANCIAL-OBJECT CHARACTERISTIC ACADEMIC-DEGREE COMMERCIAL-OBJECT
LANGUAGE-RELATED-OBJECT MATHEMATICAL-OBJECT MEDIA-OBJECT SPORTS-RESULT-
COMPONENT ASTROLOGICAL-OBJECT IDENTIFYING-INFORMATION THRESHOLD)))
        (CAUSED-BY (INV (CLASSIFY)))
         (THEME-OF (INV (READ SCAN)))
)

(IDENTIFYING-INFORMATION
        (DEFINITION (VALUE ("a representational-object that identifies its location or carrier")))
        (IS-A (VALUE (REPRESENTATIONAL-OBJECT)))
        (SUBCLASSES (VALUE (WEB-ADDRESS TIMESTAMP-INFORMATION SOFTWARE-
IDENTIFYING-INFORMATION HARDWARE-IDENTIFYING-INFORMATION USER-
IDENTIFYING-ATTRIBUTE DOCUMENT-IDENTIFYING-INFORMATION)))
)

(WEB-ADDRESS
        (DEFINITION (VALUE ("the URL at the Internet where an organization or person can be
reached")))
        (IS-A (VALUE (IDENTIFYING-INFORMATION)))
        (PART-OF-OBJECT (SEM (WEB-PAGE)))
        (LOCATION (SEM (NETWORK-SERVER)))
        (OWNED-BY (SEM (HUMAN ORGANIZATION)))
 )

(TIMESTAMP-INFORMATION
        (DEFINITION (VALUE ("the date which information has last been modified, and identifying
feature of documents and software")))
```

```
        (IS-A (VALUE (IDENTIFYING-INFORMATION DATE)))
        (PART-OF-OBJECT (SEM (WEB-PAGE)))
        (LOCATION (SEM (DOCUMENT SOFTWARE)))
        (OWNED-BY (SEM (HUMAN ORGANIZATION)))
 )

(SOFTWARE-IDENTIFYING-INFORMATION
        (DEFINITION (VALUE “a representational-object identifying software")))
        (IS-A (VALUE (IDENTIFYING-INFORMATION)))
        (SUBCLASSES (VALUE (SERIAL-NUMBER DIGITAL-CERTIFICATE)))
        (IDENTIFIES-WHAT (SEM (SOFTWARE)))
        (IDENTIFYING-INFORMATION-ISSUED-BY (SOFTWARE-DEVELOPMENT-
CORPORATION))
        (OWNED-BY (SEM (HUMAN ORGANIZATION)))
)

(HARDWARE-IDENTIFYING-INFORMATION
        (DEFINITION (VALUE ("a representational object identifying hardware")))
        (IS-A (VALUE (IDENTIFYING-INFORMATION)))
        (SUBCLASSES (VALUE (IP-ADDRESS)))
        (IDENTIFIES-WHAT (SEM (INDEPENDENT-DEVICE)))
        (IDENTIFYING-INFORMATION-ISSUED-BY (ORGANIZATION))
        (OWNED-BY (SEM (HUMAN ORGANIZATION)))
)

(OWNED-BY
        (DEFINITION (VALUE ("ownership relation")))
        (DOMAIN (SEM (REPRESENTATIONAL-OBJECT PHYSICAL-OBJECT ORGANIZATION))
(NOT ( HUMAN)))
        (INVERSE (VALUE (OWNER-OF)))
        (IS-A (VALUE (CORPORATE-RELATION)))
        (RANGE (SEM (ORGANIZATION HUMAN SOCIETY)))
)

(USER-IDENTIFYING-ATTRIBUTE
        (DEFINITION (VALUE ("a representational object identifying a computer user")))
        (IS-A (VALUE (IDENTIFYING-INFORMATION)))
        (SUBCLASSES (VALUE (TEMPORARY-USER-ATTRIBUTES CONSTANT-USER-
ATTRIBUTES)))
        (IDENTIFIES-WHAT (SEM (USER-COMPUTER)))
        (IDENTIFYING-INFORMATION-ISSUED-BY (DEFAULT (ORGANIZATION)
RELAXABLE-TO (USER-COMPUTER)))
        (OWNED-BY (SEM (USER-COMPUTER ORGANIZATION)))
)

(USER-COMPUTER
        (IS-A (VALUE (COMPUTING-ROLE)))
        (DEFINITION (VALUE ("a person with low privileges using a computer system, but not
modifying it")))
        (OWNER-OF (INV (USER-NAME PASSWORD USER-ACCOUNT))) //?! Why INV??
        (AGENT-OF (INV (ACCESS-COMPUTER-NETWORK)))
        (IDENTIFIED-BY (USER-IDENTIFYING-ATTRIBUTE))
        (BENEFICIARY-OF (INV (AUTHORIZE)))
)
```

```
(IP-ADDRESS
        (DEFINITION (VALUE ("a representational object identifying hardware")))
        (IS-A (VALUE (HARDWARE-IDENTIFYING-INFORMATION)))
        (IDENTIFIES-WHAT (SEM (COMPUTER)))
        (IDENTIFYING-INFORMATION-ISSUED-BY (DEFAULT (INTERNET-SERVICE-
PROVIDER) RELAXABLE-TO (ORGANIZATION)))
        (OWNED-BY (SEM (COMPUTER ORGANIZATION)))
)

(UTILITY-CORPORATION
        (DEFINITION (VALUE ("a for-profit-service-corporation that provides the service of electric
power, gas, water, telephone, etc- to the public")))
        (IS-A (VALUE (FOR-PROFIT-SERVICE-CORPORATION)))
        (SUBCLASSES (VALUE (TELEPHONE-SERVICE-CORPORATION ELECTRIC-POWER-
CORPORATION GAS-UTILITY-CORPORATION WATER-UTILITY-CORPORATION INTERNET-
SERVICE-PROVIDER)))
        (HAS-MERCHANDISE (SEM (ELECTRICITY GAS WATER)))
)

(INTERNET-SERVICE-PROVIDER
        (DEFINITION (VALUE ("a communication-corporation that provides access to Internet service
for the public")))
        (IS-A (VALUE (COMMUNICATION-CORPORATION UTILITY-CORPORATION)))
        (HAS-MERCHANDISE (SEM (*NOTHING*)))
        (AREA-OF-BUSINESS-ACTIVITY (SEM (COMMUNICATION-SERVE)))
        (OBJECT-INVOLVED (SEM (COMPUTER NETWORK-SERVER USER-COMPUTER)))
        (CUSTOMER-OF (INV (TELECOMMUNICATION-EQUIPMENT-MANUFACTURING-
CORPORATION)))
)

(SCALAR-OBJECT-ATTRIBUTE
        (DEFINITION (VALUE ("Attributes that apply to objects, whether social, physical or mental")))
        (DOMAIN (SEM (OBJECT)))
        (IS-A (VALUE (SCALAR-ATTRIBUTE)))
        (SUBCLASSES (VALUE (AESTHETIC-ATTRIBUTE SHIRT-NUMBER CARDINALITY
WORK-POTENTIAL SCALAR-SOCIAL-ATTRIBUTE SCALAR-FINANCIAL-OBJECT-ATTRIBUTE
ROUNDNESS FLEXIBILITY CONVERSION-TO-STANDARD AGE AUTONOMY ENDURANCE
RESISTANCE SAFETY-ATTRIBUTE SCALAR-PHYSICAL-OBJECT-ATTRIBUTE SLOPE-
ATTRIBUTE ORDINALITY AMOUNT VISCOSITY SCALAR-ANIMAL-ATTRIBUTE
INVARIABILITY-ATTRIBUTE AUTHENTICITY-ATTRIBUTE SENSITIVITY VALIDITY
SUSCEPTIBILITY-ATTRIBUTE)))
)

(INVARIABILITY-ATTRIBUTE
        (IS-A (VALUE (SCALAR-OBJECT-ATTRIBUTE)))
        (DEFINITION (VALUE ("used to indicate how long the given type of object typically exists,
from 1 – constant, to 0 – non-existent")))
        (DOMAIN (RELAXABLE-TO (OBJECT)))
        (RANGE (VALUE (<> 0 1))))
)

(TEMPORARY-USER-ATTRIBUTE
        (DEFINITION (VALUE ("a representational object identifying a computer user")))
```

```
        (IS-A (VALUE (IDENTIFYING-INFORMATION)))
        (SUBCLASSES (VALUE (KNOWLEDGE-TOKEN GEOGRAPHICAL-LOCATION ADDRESS
PHONE-NUMBER AVATAR MARITAL-STATUS TENURE EDUCATIONAL-LEVEL INCOME-
LEVEL GROUP-MEMBERSHIP)))
        (IDENTIFIES-WHAT (SEM (DEAFULT (USER-COMPUTER) RELAXABLE-TO
(HUMAN))))
        (IDENTIFYING-INFORMATION-ISSUED-BY (DEFAULT (ORGANIZATION)
RELAXABLE-TO (USER-COMPUTER)))
        (OWNED-BY (SEM (DEFAULT (USER-COMPUTER) RELAXABLE-TO
(ORGANIZATION))))
        (INVARIABILITY-ATTRIBUTE (VALUE (< 0.5)))
)

(CONSTANT-USER-ATTRIBUTE
        (DEFINITION (VALUE ("a representational object, identifying a computer user")))
        (IS-A (VALUE (IDENTIFYING-INFORMATION)))
        (SUBCLASSES (VALUE (BIOMETIRCS DOCUMENTARY-USER-REPRESENTATION)))
        (IDENTIFIES-WHAT (SEM (DEAFULT (USER-COMPUTER) RELAXABLE-TO
(HUMAN))))
        (IDENTIFYING-INFORMATION-ISSUED-BY (DEFAULT (ORGANIZATION)
RELAXABLE-TO (USER-COMPUTER)))
        (OWNED-BY (SEM (SEM (USER-COMPUTER) RELAXABLE-TO (ORGANIZATION))))
         (INVARIABILITY-ATTRIBUTE (VALUE (1)))
)

(BIOMETRICS
        (DEFINITION (VALUE ("a physical quality that may be used to identify its carrier")))
        (IS-A (VALUE (CONSTANT-USER-ATTRIBUTE))
        (IDENTIFIES-WHAT (SEM (DEFAULT (USER-COMPUTER) SEM (HUMAN))))
        (OWNED-BY (SEM (HUMAN)))
        (LOCATION (SEM (BODY)))
        (INVARIABILITY-ATTRIBUTE (VALUE (.9)))
)

(LITERAL-OBJECT-ATTRIBUTE
        (DEFINITION (VALUE ("an attribute which applies only to objects and whose range is filled
with literals")))
        (DOMAIN (SEM (OBJECT)))
        (IS-A (VALUE (LITERAL-ATTRIBUTE)))
        (SUBCLASSES (VALUE (SOCIAL-ROLE-ATTRIBUTE PHYSICAL-OBJECT-ATTRIBUTE
GENRE MONOPOLY-ATTRIBUTE SOLVENCY LITERAL-HUMAN-ATTRIBUTE ANONYMITY
PUBLIC-ATTRIBUTE)))
)

(LITERAL-HUMAN-ATTRIBUTE
        (DEFINITION (VALUE ("an attribute which applies only to humans and whose range is filled
with literals")))
        (DOMAIN (SEM (HUMAN)))
        (IS-A (VALUE (LITERAL-ATTRIBUTE)))
        (SUBCLASSES (VALUE (HAS-NAME-PREFIX HAS-EYE-COLOR SOCIAL-ROLE-
ATTRIBUTE HAS-NAME-SUFFIX)))
)

(HAS-EYE-COLOR
```

```
        (DEFINITION (VALUE ("human attribute, identifying eye color")))
        (DOMAIN (SEM (DEFAULT (HUMAN) RELAXABLE-TO (ANIMAL))))
        (IS-A (VALUE (LITERAL-HUMAN-ATTRIBUTE)))
         (RANGE (SEM (EYE-COLOR)))
)

(HAS-HAIR-COLOR
        (DEFINITION (VALUE ("human attribute, identifying hair color ")))
        (DOMAIN (SEM (DEFAULT (HUMAN) SEM (ANIMAL))))
        (IS-A (VALUE (LITERAL-HUMAN-ATTRIBUTE)))
         (RANGE (SEM (HAIR-COLOR)))
)

(GEOGRAPHICAL-LOCATION
        (DEFINITION (VALUE ("a representational object identifying a human")))
        (IS-A (VALUE (TEMPORARY-USER-ATTRIBUTE)))
        (IDENTIFIES-WHAT (SEM (DEFAULT (USER-COMPUTER) SEM (HUMAN))))
        (INVARIABILITY-ATTRIBUTE (VALUE (< 0.2)))
)

(ADDRESS (DEFINITION (VALUE ("the location at which an organization or person can be reached")))
        (IS-A (VALUE (BUILDING-PLACE-PART TEMPORARY-USER-ATTRIBUTE)))
        (PART-OF-OBJECT (SEM (DIRECTORY BUILDING)))
        (LOCATION (SEM (FRONT-DOOR DOCUMENT)))
        (IDENTIFIES-WHAT (SEM (DEAFULT (USER-COMPUTER) RELAXABLE-TO
(HUMAN))))
        (IDENTIFYING-INFORMATION-ISSUED-BY (SEM (PUBLIC-ADMINISTRATION-
ORGANIZATION)))
)

(PHONE-NUMBER
        (DEFINITION (VALUE ("the phone number at which an organization or person can be
reached")))
        (IS-A (VALUE (NUMBER TEMPORARY-USER-ATTRIBUTE)))
        (IDENTIFIES-WHAT (SEM (DEAFULT (USER-COMPUTER) RELAXABLE-TO (HUMAN
organization))))
        (IDENTIFYING-INFORMATION-ISSUED-BY (SEM (TELEPHONE-SERVICE-
CORPORATION)))
)

(KNOWLEDGE-TOKEN
        (DEFINITION (VALUE ("a representational object which can be memorized for identifying a
computer user")))
        (IS-A (VALUE (TEMPORARY-USER-ATTRIBUTE)))
        (SUBCLASSES (VALUE (KNOWLEDGE-TOKEN GEOGRAPHICAL-LOCATION ADDRESS
PHONE-NUMBER)))
        (IDENTIFIES-WHAT (SEM (DEAFULT (USER-COMPUTER) RELAXABLE-TO
(HUMAN))))
        (LOCATION (SEM (HUMAN-MEMORY)))
        (IDENTIFYING-INFORMATION-ISSUED-BY (DEFAULT (ORGANIZATION)
RELAXABLE-TO (USER-COMPUTER)))
        (OWNED-BY (SEM (DEFAULT (USER-COMPUTER) RELAXABLE-TO
(ORGANIZATION))))
)
```

```
(USER-NAME
        (IS-A (VALUE (BIT-STRING KNOWLEDGE-TOKEN)))
        (DEFINITION (VALUE ("the character string representing a user")))
        (OWNED-BY (SEM (USER-COMPUTER)))
        (LOCATION-WITHIN-DOCUMENT (INV (USER-ACCOUNT)))
        (PART-OF-OBJECT (INV (CERTIFICATE USER-ACCOUNT)))
        (LOCATION (SEM (HUMAN-MEMORY)))
)

(PASSWORD
        (IS-A (VALUE (BIT-STRING KNOWLEDGE-TOKEN)))
        (DEFINITION (VALUE ("the instrument of authentication remembered by the user")))
        (OWNED-BY (SEM (USER-COMPUTER)))
        (LOCATION-WITHIN-DOCUMENT (INV (USER-ACCOUNT)))
        (PART-OF-OBJECT (INV (CERTIFICATE)))
        (INSTRUMENT-OF (SEM (AUTHENTICATE)))
)

(PIN-NUMBER
        (IS-A (VALUE (BIT-STRING KNOWLEDGE-TOKEN)))
        (DEFINITION (VALUE ("the instrument of authentication stored on hardware and remembered
by the user")))
        (OWNED-BY (SEM (human)))
        (FIRNISHES-IDENTIFYING-INFORMATION (DEFAULT (FIRMWARE) RELAXABLE-TO
(ORGANIZATION)))
        (LOCATION (SEM (HUMAN-MEMORY)))
        (PART-OF-OBJECT (SEM (CERTIFICATE)))
        (INSTRUMENT-OF (SEM (AUTHENTICATE)))
)

(EYE
        (IS-A (VALUE (EXTERNAL-ANIMAL-PART)))
        (DEFINITION (VALUE ("an organ of vision or of light sensitivity"))) (INSTRUMENT-OF (INV
        (INVOLUNTARY-VISUAL-EVENT VOLUNTARY-VISUAL-EVENT))) (PART-OF-OBJECT
        (INV (FACE)))
        (COLOR-ATTRIBUTE (SEM (EYE-COLOR)))
)

(HAIR
        (DEFINITION (VALUE ("a slender threadlike outgrowth of the skin of a mammal"))) (IS-A
        (VALUE (EXTERNAL-MAMMAL-PART)))
        (PART-OF-OBJECT (INV (PRIMATE)))
        (SUBCLASSES (VALUE (BEARD)))
        (THEME-OF (INV (DYE ARRANGE-HAIR)))
        (COLOR-ATTRIBUTE (SEM (HAIR-COLOR)))
)

(COLOR-ATTRIBUTE
        (DEFINITION (VALUE ("the property of reflecting light of a particular wavelength visible to the
unaided human eye")))
        (IS-A (VALUE (PHYSICAL-OBJECT-ATTRIBUTE)))
```

```
        (RANGE (VALUE (WHITE TAN PURPLE ORANGE NAVY-BLUE GREEN CYAN BROWN
BLACK BEIGE BLUE COLORLESS GRAY MAGENTA OFF-WHITE PINK RED VIOLET
YELLOW)))
        (SUBCLASSES (VALUE (EXTERIOR-COLOR COLOR INTERIOR-COLOR EYE-COLOR
        HAIR-COLOR)))
)

(EYE-COLOR
        (DEFINITION (VALUE ("the color of eye (animal-part)")))
        (IS-A (VALUE (COLOR-ATTRIBUTE)))
        (RANGE (VALUE (GREEN BLUE BROWN HAZEL GRAY)))
        (DOMAIN (SEM (EYE)))
)

(HAIR-COLOR
        (DEFINITION (VALUE ("the color of eye (animal-part)")))
        (IS-A (VALUE (COLOR-ATTRIBUTE)))
        (RANGE (VALUE (BLOND BLONDE BRUNETTE RED AUBURN BLACK BROWN)))
        (DOMAIN (SEM (HAIR)))
        (INSTRUMENT-OF (DYE (THEME (HAIR)))
)

 (GAIT-ATTRIBUTE
         (DEFINITION (VALUE ("a physical quality of walking manner that can be used to identify a
human with some reliability")))
        (IS-A (VALUE (BIOMETRICS))
        (IDENTIFIES-WHAT (SEM (DEAFULT (USER-COMPUTER) RELAXABLE-TO
(HUMAN))))
        (REPRESENTS (SEM (WALK)))
        (INVARIABILITY-ATTRIBUTE (VALUE (.8)))
        (UNIQUENESS (VALUE (.6)))
)

(SCALAR-ATTRIBUTE
        (DEFINITION (VALUE ("An attribute whose range has a scalar value-")))
        (DOMAIN-OF (INV (MEASURED-IN)))
        (IS-A (VALUE (ATTRIBUTE))) (MEASURED-IN (INV (MEASURING-UNIT)))
        (RANGE (VALUE (ANY-NUMBER "(<> 0 1)" ANY-RANGE)))
        (SUBCLASSES (VALUE (SECRECY-ATTRIBUTE TRUTH-VALUE VELOCITY SCALAR-
OBJECT-ATTRIBUTE COST SCALAR-EVENT-ATTRIBUTE TYPICALNESS-ATTRIBUTE
LENGTH-OF-STAY FORMALITY STATE-OF-AFFAIRS UNIQUENESS)))
)

(UNIQUENESS
        (DEFINITION (VALUE ("likelihood of existence of duplicating object")))
        (DOMAIN (SEM (OBJECT EVENT)))
        (IS-A (VALUE (SCALAR-ATTRIBUTE)))
        (RANGE (VALUE (<> 0 1)))
)

(RETINA-SCAN
        (DEFINITION (VALUE ("a physical quality of retina that can be used to identify a human ")))
        (IS-A (VALUE (BIOMETRICS))
```

```
	(IDENTIFIES-WHAT (SEM (DEAFULT (USER-COMPUTER) RELAXABLE-TO
(HUMAN))))
	(REPRESENTS (SEM (RETINA)))
	(INVARIABILITY-ATTRIBUTE (VALUE (.9)))
	(UNIQUENESS (VALUE (1)))
)

(IRIS-SCAN
	(DEFINITION (VALUE ("a physical quality of retina that can be used to identify a human ")))
	(IS-A (VALUE (BIOMETRICS))
	(IDENTIFIES-WHAT (SEM (DEAFULT (USER-COMPUTER) RELAXABLE-TO
(HUMAN))))
	(LOCATION (SEM (IRIS)))
	(INVARIABILITY-ATTRIBUTE (VALUE (.9)))
	(UNIQUENESS (VALUE (1)))
)

(FINGER-PRINT
	(DEFINITION (VALUE ("a physical quality describing the finger that can be used to identify a
human ")))
	(IS-A (VALUE (BIOMETRICS))
	(IDENTIFIES-WHAT (SEM (DEAFULT (USER-COMPUTER) RELAXABLE-TO
(HUMAN))))
	(ORIGIN (SEM (FINGER)))
	(INVARIABILITY-ATTRIBUTE (VALUE (.9)))
	(UNIQUENESS (VALUE (1)))
)

(VOICE-PRINT
	(DEFINITION (VALUE ("a physical quality of voice that can be used to identify a human ")))
	(IS-A (VALUE (BIOMETRICS))
	(IDENTIFIES-WHAT (SEM (DEAFULT (HUMAN-VOICE) RELAXABLE-TO (HUMAN))))
	(INSTRUMENT (SEM (VOCAL-FOLDS)))
	(INVARIABILITY-ATTRIBUTE (VALUE (.6)))
	(UNIQUENESS (VALUE (.9)))
)

(FOOT-PRINT
	(DEFINITION (VALUE ("a physical quality of a foot that can be used to identify a human ")))
	(IS-A (VALUE (BIOMETRICS))
	(IDENTIFIES-WHAT (SEM (DEFAULT (USER-COMPUTER) RELAXABLE-TO
(HUMAN))))
	(ORIGIN (SEM (FOOT)))
	(INVARIABILITY-ATTRIBUTE (VALUE (.9)))
	(UNIQUENESS (VALUE (1)))
)

(DNA-SAMPLE
	(DEFINITION (VALUE ("a physical quality of DNA that can be used to identify a human ")))
	(IS-A (VALUE (BIOMETRICS))
	(IDENTIFIES-WHAT (SEM (DEAFULT (USER-COMPUTER) RELAXABLE-TO
(HUMAN))))
	(ORIGIN (SEM (DNA)))
	(INVARIABILITY-ATTRIBUTE (VALUE (1)))
```

```
        (UNIQUENESS (VALUE (1)))
)

(HAND-GEOMETRY
        (DEFINITION (VALUE ("a physical quality of hand that can be used to identify a human ")))
        (IS-A (VALUE (BIOMETRICS))
        (IDENTIFIES-WHAT (SEM (DEAFULT (USER-COMPUTER) RELAXABLE-TO
(HUMAN))))
        (ORIGIN (SEM (HAND)))
        (INVARIABILITY-ATTRIBUTE (VALUE (.9)))
        (UNIQUENESS (VALUE (1)))
)

(SALIVA-SAMPLE
        (DEFINITION (VALUE ("a physical quality of human saliva that can be used to identify a
human.")))
        (IS-A (VALUE (BIOMETRICS))
        (IDENTIFIES-WHAT (SEM (HUMAN)))
        (LOCATION (SEM (SALIVA)))
        (INVARIABILITY-ATTRIBUTE (VALUE (.9)))
        (UNIQUENESS (VALUE (1)))
)

(INTERNAL-ANIMAL-SUBSTANCE
        (DEFINITION (VALUE ("internal fluids or other substances found in animals")))
        (IS-A (VALUE (INTERNAL-ANIMAL-PART)))
        (SUBCLASSES (VALUE (FECES HEMOGLOBIN ANTIBODY BLOOD HORMONE URINE
SALIVA)))
)

(SALIVA
        (DEFINITION (VALUE ("a clear liquid secreted into the mouth by the salivary glands and
mucous glands of the mouth; moistens the mouth and starts the digestion")))
        (IS-A (VALUE (INTERNAL-ANIMAL-SUBSTANCE)))
        (ORIGIN (MOUTH))
        (INSTRUMENT-OF (DIGEST))
)

(SIGNATURE
        (DEFINITION (VALUE ("written mark that is unique to a particular person")))
        (IS-A (VALUE (NAME BIOMETRICS)))
        (IDENTIFIES-WHAT (SEM (HUMAN)))
        (REPRESENTS (SEM (WRITE)))
        (INVARIABILITY-ATTRIBUTE (VALUE (.9)))
        (UNIQUENESS (VALUE (1)))
)

(KEYSTROKE-DYNAMICS
        (DEFINITION (VALUE ("keystroke dynamics that is unique to a particular person")))
        (IS-A (VALUE (NAME BIOMETRICS)))
        (IDENTIFIES-WHAT (SEM (DEFAULT (USER-COMPUTER) RELAXABLE-TO
(HUMAN))))
        (REPRESENTS (SEM (TYPE)))
        (INVARIABILITY-ATTRIBUTE (VALUE (.9)))
```

```
        (UNIQUENESS (VALUE (1)))
)

(GRAPHIC-EVENT
        (DEFINITION (VALUE ("to commit something to a graphic representation")))
        (IS-A (VALUE (NON-VERBAL-COMMUNICATIVE-ACT)))
        (SUBCLASSES (VALUE (RECORD-INFORMATION PAINT DRAW PRINT TAKE-
PHOTOGRAPH TYPE)))
        THEME (SEM (OBJECT)))
)

(TYPE
         (DEFINITION (VALUE ("to produce words, letters, documents, programs etc with a typewriter
or a computer)))
        (IS-A (VALUE (GRAPHIC-EVENT)))
        (AGENT (SEM (HUMAN)))
        (INSTRUMENT (SEM (COMPUTER TYPEWRITER)))
        (PURPOSE (DEFAULT (COMMUNICATIVE-EVENT)) (SEM (EVENT)))
        (THEME (DEFAULT (DOCUMENT PRINTED-MEDIA)))
)

(FACIAL-GEOMETRY
        (DEFINITION (VALUE ("a combination of physical qualities of a face that can be used to
identify a human ")))
        (IS-A (VALUE (BIOMETRICS))
        (IDENTIFIES-WHAT (SEM (DEAFULT (USER-COMPUTER) RELAXABLE-TO
(HUMAN))))
        (LOCATION (SEM (FACE)))
        (INVARIABILITY-ATTRIBUTE (VALUE (.9)))
        (UNIQUENESS (VALUE (.9)))
)

(HAS-BIRTH-DAY
        (DEFINITION (VALUE ("a birth date of a human")))
         (IS-A (VALUE (OBJECT-RELATION)))
        (DOMAIN (SEM (HUMAN)))
         (RANGE (SEM (DAY)))
        (IDENTIFIES-WHAT (SEM(HUMAN)))
        (UNIQUENESS (VALUE (.3)))
)

(HAS-BIRTH-MONTH
        (DEFINITION (VALUE ("a birth month of a human")))
         (IS-A (VALUE (OBJECT-RELATION)))
        (RANGE (SEM (MONTH)))
        (DOMAIN (SEM (HUMAN)))
         (IDENTIFIES-WHAT (SEM (HUMAN)))
        (UNIQUENESS (VALUE (.3)))
)

(HAS-BIRTH-YEAR
        (DEFINITION (VALUE ("a birth year of a human")))
         (IS-A (VALUE (OBJECT-RELATION)))
        (RANGE (SEM (YEAR)))
```

```
        (DOMAIN (SEM (HUMAN)))
        (IDENTIFIES-WHAT (SEM (HUMAN)))
        (UNIQUENESS (VALUE (.3)))
)

(HAS-GROUP-MEMBERSHIP
        (DEFINITION (VALUE ("a group membership characteristics of a human")))
        (DOMAIN (SEM (HUMAN)))
        (IS-A (VALUE (OBJECT-RELATION)))
        (RANGE (SEM (ORGANIZATION)))
        (IDENTIFIES-WHAT (SEM (HUMAN)))
        (UNIQUENESS (VALUE (.2)))
)

(HAS-INCOME-LEVEL
        (DEFINITION (VALUE ("an income level characteristic of a human")))
        (DOMAIN (SEM (HUMAN)))
        (IS-A (VALUE (OBJECT-RELATION)))
        (RANGE (SEM (AMOUNT (FINANCIAL-GAIN)))  - //IS THAT THE BEST WAY???
        (IDENTIFIES-WHAT (SEM (HUMAN)))
        (UNIQUENESS (VALUE (.2)))
        )

        (PRODUCE
         (DEFINITION (VALUE ("a change which brings something into being that was not there
before")))
        (IS-A (VALUE (PHYSICAL-EVENT WORK-ACTIVITY)))
        (INSTRUMENT (DEFAULT (DEVICE FACTORY)) (SEM (OBJECT)))
        (AGENT (SEM (DEFAULT (NATION HUMAN ORGANIZATION) RELAXABLE-TO
(OBJECT))))
        (LOCATION (DEFAULT (FACTORY)) (SEM (PLACE)))
        (THEME (SEM (OBJECT)))
        (PART-OF-EVENT (INV (HAVE-A-PRESENCE)))
        (SUBCLASSES (VALUE (CREATE-ARTIFACT PRODUCE-ODOR)))
)

(PRODUCE-ODOR
        (DEFINITION (VALUE ("to produce odor, to smell")))
        (IS-A (VALUE (PRODUCE)))
        (AGENT (SEM (OBJECT)))
        (THEME (SEM (ODOR)))
)

(AVATAR
        (DEFINITION (VALUE ("an icon or representation of a user in a shared virtual reality")))
        (IS-A (VALUE (TEMPORARY-USER-ATTRIBUTE PICTURE)))
        (PART-OF-OBJECT (SEM (USER-ACCOUNT)))
        (LOCATION (SEM (WEB-PAGE NETWORK-SERVER)))
        (IDENTIFIES-WHAT (SEM (DEAFULT (USER-COMPUTER) RELAXABLE-TO
(HUMAN))))
        (IDENTIFYING-INFORMATION-ISSUED-BY (SEM (USER)))
)

(COMPUTER-PROGRAM
```

```
	(DEFINITION (VALUE ("series of instructions that a computer can interpret and execute-
programs are also called software to distinguish them from hardware")))
	(IS-A (VALUE (SOFTWARE)))
	(SUBCLASSES (VALUE (WORD-PROCESSOR PROGRAMMING-LANGUAGE TEXT-
EDITOR COMPUTER-PROGRAM-FUNCTION SOFTWARE-AGENT)))
	(THEME-OF (INV (DEBUG-PROGRAM)))
	(HAS-OBJECT-AS-PART (SEM (COMPUTER-PROGRAM-FUNCTION)))
	(PRODUCED-BY (INV (PROGRAMMER)))
)

(SOFTWARE-AGENT
	(IS-A (VALUE (COMPUTER-PROGRAM)))
	(DEFINITION (VALUE ("a piece of autonomous or semi-autonomous proactive and reactive
computer software")))
	(SUBCLASSES (VALUE (CHATTERBOT)))
	(INSTRUMENT-OF (INV (COMUNICATIVE-EVENT)))
)

(CHATTERBOT
	(IS-A (VALUE (SOFTWARE-AGENT)))
	(DEFINITION (VALUE ("a software agent that communicates with other users of Internet-based
services via IM or another web interface")))
	 (INSTRUMENT (SEM (COMPUTER-NETWORK)))
)

(DOCUMENTARY-USER-REPRESENTATION
	(DEFINITION (VALUE ("a document, either virtual or real, that is issued by an entity to the user
as means of identification and authorization")))
	(IS-A (VALUE (CONSTANT-USER-ATTRIBUTE))
	(IDENTIFIES-WHAT (SEM (DEFAULT (USER-COMPUTER) RELAXABLE-TO
(HUMAN))))
	(OWNED-BY (SEM (HUMAN)))
	(ORIGIN (SEM (BODY)))
	(INVARIABILITY-ATTRIBUTE (VALUE (.9)))
)

(PASSPORT
	(DEFINITION (VALUE ("a government document carried by a citizen traveling abroad,
certifying identity and citizenship")))
	(IS-A (VALUE (BOOK-DOCUMENT DOCUMENTARY-USER-REPRESENTATION)))
	(CONTAINS (SEM (VISA)))
	(HAS-IDENTIFYING-INFORMATION (SEM (DOCUMENT-IDENTIFYING-INFORMATION
USER-IDENTIFYING-INFORMATION)))
	(IDENTIFIES-WHAT (SEM (HUMAN)))
	(OWNED-BY (SEM (CITIZEN)))
	(IDENTIFYING-INFORMATION-ISSUED-BY (SEM (FEDERAL-ORGANIZATION)))
)

(VISA
	(DEFINITION (VALUE ("an endorsement on a passport, granting entry to a country")))
	(IS-A (VALUE (DOCUMENT DOCUMENTARY-USER-REPRESENTATION)))
	(CONTAINED-IN (SEM (PASSPORT)))
	(HAS-IDENTIFYING-INFORMATION (SEM (DOCUMENT-IDENTIFYING-INFORMATION
USER-IDENTIFYING-INFORMATION)))
```

```
        (IDENTIFIES-WHAT (SEM (HUMAN)))
        (OWNED-BY (SEM (CITIZEN)))
        (IDENTIFYING-INFORMATION-ISSUED-BY (SEM (EMBASSY)))
        (FUNCTIONS-LIKE (SEM (PRIVILEGE)))
)

(STATE-IDENTITY-CARD
        (DEFINITION (VALUE ("an identifying document issued by a government organization within a
state")))
        (IS-A (VALUE (DOCUMENT DOCUMENTARY-USER-REPRESENTATION)))
        (HAS-IDENTIFYING-INFORMATION (SEM (DOCUMENT-IDENTIFYING-INFORMATION
USER-IDENTIFYING-INFORMATION)))
        (IDENTIFIES-WHAT (SEM (HUMAN)))
        (OWNED-BY (SEM (HUMAN)))
        (IDENTIFYING-INFORMATION-ISSUED-BY (SEM (STATE-ORGANIZATION)))
)

(DRIVER'S-LICENSE
        (DEFINITION (VALUE ("a document that allows its owner to drive and provides proof of
identity")))
        (IS-A (VALUE (DOCUMENT DOCUMENTARY-USER-REPRESENTATION)))
        (HAS-IDENTIFYING-INFORMATION (SEM (DOCUMENT-IDENTIFYING-INFORMATION
USER-IDENTIFYING-INFORMATION)))
        (IDENTIFIES-WHAT (SEM (DRIVER)))
        (OWNED-BY (SEM (DRIVER)))
        (IDENTIFYING-INFORMATION-ISSUED-BY (SEM (DEPARTMENT-OF-MOTOR-
VEHICLES)))
        (FUNCTIONS-LIKE (SEM (PRIVILEGE)))
)

(PGP-SIGNATURE
        (DEFINITION (VALUE ("a document that allows its owner to drive and provides proof of
identity")))
        (IS-A (VALUE (BIT-STRING DOCUMENTARY-USER-REPRESENTATION)))
        (CONTAINS (SEM (ENCRYPT-KEY)))
        (IDENTIFIES-WHAT (SEM (USER-COMPUTER)))
        (OWNED-BY (SEM (USER-COMPUTER)))
)

(SOCIAL-SECURITY-CARD
        (DEFINITION (VALUE ("a document that allows its owner to work and gives access to state
social security resources")))
        (IS-A (VALUE (DOCUMENT DOCUMENTARY-USER-REPRESENTATION)))
        (HAS-IDENTIFYING-INFORMATION (SEM (DOCUMENT-IDENTIFYING-INFORMATION
USER-IDENTIFYING-INFORMATION)))
        (IDENTIFIES-WHAT (SEM (HUMAN)))
        (OWNED-BY (SEM (HUMAN)))
        (IDENTIFYING-INFORMATION-ISSUED-BY (SEM (SOCIAL-SECURITY-
ADMINISTRATION)))
        (FUNCTIONS-LIKE (SEM (PRIVILEGE)))
)

(INSURANCE-CARD
        (DEFINITION (VALUE ("a document that confirms that its user has an insurance")))
```

```
        (IS-A (VALUE (DOCUMENT)))
        (HAS-IDENTIFYING-INFORMATION (SEM (DOCUMENT-IDENTIFYING-INFORMATION
USER-IDENTIFYING-INFORMATION)))
        (OWNED-BY (SEM (HUMAN)))
        (IDENTIFYING-INFORMATION-ISSUED-BY (SEM (INSURANCE-CORPORATION)))
        (FUNCTIONS-LIKE (SEM (INSURANCE-POLICY)))
)

(DOCUMENT-IDENTIFYING-INFORMATION
        (DEFINITION (VALUE ("a piece of information identifying a document")))
        (IS-A (VALUE (IDENTIFYING-INFORMATION)))
        (IDENTIFIES-WHAT (SEM (DOCUMENT DOCUMENTARY-USER-REPRESENTATION)))
        (IDENTIFYING-INFORMATION-ISSUED-BY (DEFAULT (ORGANIZATION)
RELAXABLE-TO (OBJECT)))
)

(DOCUMENT-NUMBER
        (DEFINITION (VALUE ("a number that identifies a document")))
        (IS-A (VALUE (NUMBER)))
        (CONTAINED-IN (SEM (DOCUMENT)))
        (IDENTIFIES-WHAT (SEM (DOCUMENT)))
        (IDENTIFYING-INFORMATION-ISSUED-BY (SEM (DEFAULT (ORGANIZATION)
RELAXABLE-TO (OBJECT))))
)

(DOCUMENT-EXPIRATION-DATE
        (DEFINITION (VALUE ("a date until which the document is valid")))
        (IS-A (VALUE (DATE)))
        (CONTAINED-IN (SEM (DOCUMENT)))
        (IDENTIFIES-WHAT (SEM (DOCUMENT)))
        (IDENTIFYING-INFORMATION-ISSUED-BY (SEM (DEFAULT (ORGANIZATION)
RELAXABLE-TO (OBJECT))))
)

(DOCUMENT-ISSUE-DATE
        (DEFINITION (VALUE ("a date after which the document is valid")))
        (IS-A (VALUE (DATE)))
        (CONTAINED-IN (SEM (DOCUMENT)))
        (IDENTIFIES-WHAT (SEM (DOCUMENT)))
        (IDENTIFYING-INFORMATION-ISSUED-BY (SEM (DEFAULT (ORGANIZATION)
RELAXABLE-TO (OBJECT))))
)

(MARITAL-STATUS
        (IS-A (VALUE (SOCIAL-ROLE-ATTRIBUTE)))
        (DEFINITION (VALUE ("single, married, widowed, divorced, separated"))) (DOMAIN (SEM
(HUMAN)))
        (RANGE (VALUE (WIDOWED SINGLE MARRIED DIVORCED SEPARATED)))
)

(RACE
        (IS-A (VALUE (SOCIAL-ROLE-ATTRIBUTE)))
        (DEFINITION (VALUE ("black, African American, Hispanic, white, Asian, Caucasian, other ")))
        (DOMAIN (SEM (HUMAN)))
```

```
        (RANGE (VALUE (BLACK AFRICAN-AMERICAN HISPANIC WHITE ASIAN
CAUCASIAN)))
)

(EDUCATIONAL-LEVEL
        (IS-A (VALUE (SOCIAL-ROLE-ATTRIBUTE)))
        (DEFINITION (VALUE ("bachelor of science, bachelor of arts, associate of arts, associate of
science, master of science, master of arts, master of fine arts, doctor of philosophy, Juris doctor, doctor of
medicine, master of business administration, doctor of pharmacy")))
        (DOMAIN (SEM (HUMAN)))
        (RANGE (VALUE (BACHELOR-OF-SCIENCE BACHELOR-OF-ARTS ASSOCIATE-OF-
ARTS ASSOCIATE-OF-SCIENCE MASTER-OF-SCIENCE MASTER-OF-ARTS MASTER-OF-FINE-
ARTS DOCTOR-OF-PHILOSOPHY JURIS-DOCTOR DOCTOR-OF-MEDICINE MASTER-OF-
BUSINESS-ADMINISTRATION DOCTOR-OF-PHARMACY)))
)

(NAME-HUMAN
        (DEFINITION (VALUE ("The name of a human being-")))
        (IS-A (VALUE (NAME)))
        (NAME-OF (SEM (HUMAN)))
        (PART-OF-OBJECT (SEM (DIRECTORY)))
        (IDENTIFIES-WHAT (SEM (HUMAN)))
        (UNIQUENESS (VALUE (.6)))
        (SUBCLASSES (VALUE (HONORIFIC-TITLE JOB-TITLE)))
)

(AUTHENTICITY-ATTRIBUTE
        (DEFINITION (VALUE ("Likelihood of an object being unaltered self")))
        (IS-A (VALUE (SCALAR-OBJECT-ATTRIBUTE)))
        (DOMAIN (SEM (ARTIFACT)))
        (RANGE (SEM ("(<> 0 1)"))
)

(FIELD-OF-STUDY
        (DEFINITION (VALUE ("a realm of knowledge or study in which a person may pursue
expertise")))
        (DOMAIN-OF (INV (OBJECT-STUDIED-IN-AREA ACTIVITY-IN-AREA ROLE-FOR-
AREA)))
        (HAS-OBJECT-AS-PART (SEM (*NOTHING*)))
        (IS-A (VALUE (ABSTRACT-OBJECT)))
        (PART-OF-OBJECT (SEM (*NOTHING*)))
        (PRECONDITION-OF (INV (ANALYTIC-COGNITIVE-EVENT)))
        (ROLE-FOR-AREA (SEM (ACADEMIC-ROLE)))
        (SUBCLASSES (VALUE (LINGUISTICS SOCIAL-SCIENCE PHILOSOPHY
OCEANOGRAPHY MILITARY-SCIENCE MATHEMATICS GENEALOGY FINANCE FIELD-OF-
MINING FIELD-OF-ARCHITECTURE COMPUTER-SCIENCE AVIATION AGRICULTURE
COMMUNICATION ENGINEERING FIELD-OF-LAW FIELD-OF-REAL-ESTATE FINE-ARTS
GEOGRAPHY MEDICINE NAVIGATION PHARMACEUTICS SCIENCE URBAN-PLANNING
INFORMATION-SECURITY-FIELD FIELD-OF-BUSINESS LIBERAL-ARTS)))
        (THEME-OF (SEM (ACTIVE-COGNITIVE-EVENT)))
)

(FIELD-OF-BUSINESS
        (DEFINITION (VALUE ("a field of study that deals with the business activities")))
```

```
        (IS-A (VALUE (FIELD-OF-STUDY)))
        (ROLE-FOR-AREA (INV (BUSINESS-ROLE)))
        (THEME-OF (INV (BUSINESS-ACTIVITY)))
)

(LIBERAL-ARTS
        (DEFINITION (VALUE ("Academic disciplines, such as languages, literature, history,
philosophy, mathematics, and science, that provide information of general cultural concern.")))
        (IS-A (VALUE (FIELD-OF-STUDY)))
        (SUBCLASSES (VALUE (LINGUISTICS PHILOSOPHY GENEALOGY COMMUNICATION
FINE-ARTS GEOGRAPHY URBAN-PLANNING)))
)

(LINGUISTICS (DEFINITION (VALUE ("the science of language"))) (IS-A (VALUE (FIELD-OF-
STUDY)))
        (ROLE-FOR-AREA (SEM (LINGUIST)))
        (SUBCLASSES (VALUE (NATURAL-LANGUAGE-PROCESSING)))
)

(PHILOSOPHY (DEFINITION (VALUE ("the study of the principles underlying conduct, thought, and the
nature of the universe")))
        (IS-A (VALUE (FIELD-OF-STUDY)))
        (SUBCLASSES (VALUE (CONFUCIANISM)))
)

(GENEALOGY (DEFINITION (VALUE ("the study of family descent")))
        (IS-A (VALUE (LIBERAL-ARTS)))
        (SUBCLASSES (VALUE (PEDIGREE)))
)

(FINE-ARTS
        (DEFINITION (VALUE ("the field of study that include any of the art forms such as painting,
sculpture, drawing, etc-")))
        (IS-A (VALUE (FIELD-OF-STUDY)))
        (ROLE-FOR-AREA (SEM (ARTISTIC-ROLE)))
        (SUBCLASSES (VALUE (FIELD-OF-MUSIC PHOTOGRAPHY)))
)

(COMMUNICATION
        (DEFINITION (VALUE ("The area of knowledge having to do with language, technology and
other forms of communication-")))
        (IS-A (VALUE (LIBERAL-ARTS)))
        (ACTIVITY-IN-AREA (SEM (COMMUNICATION-SERVE)))
        (ROLE-FOR-AREA (INV (REPORTER))
        (SEM (COMMUNICATION-ROLE)))
        (SUBCLASSES (VALUE (PUBLISHING)))
)

(GEOGRAPHY
        (DEFINITION (VALUE ("the science dealing with the earth's surface, its continents, climates,
plants, animals, resources, etc-"))) (IS-A (VALUE (LIBERAL-ARTS)))
        (ROLE-FOR-AREA (SEM (GEOGRAPHER)))
)
```

```
(DATE
        (DEFINITION (VALUE ("Time stated in terms of the day, month, and year; particular point or
period of time at which something happened or existed, or is expected to happen. ")))
        (IS-A (VALUE (SCALAR-ATTRIBUTE)))
        (HAS-OBJECT-AS-PART (SEM (DAY MONTH YEAR)))
        (RANGE (SEM ("(>= 0)")))
        (DOMAIN (SEM (EVENT OBJECT)))
        (THEME (SEM (EVENT)))
)

(SEMICONDUCTOR-STORAGE-DEVICE
        (IS-A (VALUE (STORAGE-DEVICE)))
        (DEFINITION (VALUE ("computer storage device that reads and writes information
magnetically")))
        (SUBCLASSES (VALUE (FLASH-MEMORY BIOS-CHIP SECURE-DIGITAL-CARD)))
        (MATERIAL (SEM (SILICON)))
        (FUNCTIONS-LIKE (SEM (MEMORY)))
)

(BIOS-CHIP
        (IS-A (VALUE (SEMICONDUCTOR-STORAGE-DEVICE)))
        (DEFINITION (VALUE ("computer storage device that reads and writes information
magnetically")))
        (PART-OF-OBJECT (SEM (COMPUTER)))
)

(COMPUTER
        (DEFINITION (VALUE ("an electronic machine that performs rapid, complex calculations and
compiles and stores data")))
        (HAS-OBJECT-AS-PART (SEM (COMPUTER-HARDWARE SOFTWARE)))
        (INSTRUMENT-OF (INV (PROGRAM RETRIEVE-COMPUTER-DATA PREPARE-
DOCUMENT CLERICAL-SERVE COMPUTING-SERVE AUTHORIZE WRITE-COMPUTER-DATA
WRITE)))
        (IS-A (VALUE (INDEPENDENT-DEVICE)))
        (PART-OF-OBJECT (INV (AIRPORT-CHECK-IN-FACILITY COMPUTER-NETWORK)))
        (SUBCLASSES (VALUE (NETWORK-CLIENT PERSONAL-COMPUTER NETWORK-
SERVER))) (THEME-OF (INV (SYSTEMS-ANALYSIS SYSTEMS-ADMINISTRATION USE-
COMPUTER))) (WORK-EQUIPMENT-OF (INV (COMPUTING-ROLE)))
        (SOURCE-OF (INV (EMAIL)))
)

(MOBILE-COMPUTER
        (DEFINITION (VALUE ("an computer that is light enough to be taken around by a human")))
        (IS-A (VALUE (INDEPENDENT-DEVICE)))
         (HAS-OBJECT-AS-PART (SEM (COMPUTER-HARDWARE SOFTWARE)))
         (PART-OF-OBJECT (INV (COMPUTER-NETWORK)))
        (SUBCLASSES (VALUE (LAPTOP PALMTOP)))
)

(LAPTOP
        (DEFINITION (VALUE ("a computer that is light enough to be taken around by a human")))
        (IS-A (VALUE (MOBILE-COMPUTER)))
        (WEIGHT-ATTRIBUTE (RANGE (VALUE (<> 2 7))) MEASURED-IN (SEM (LB)))
)
```

```
(PALMTOP
        (DEFINITION (VALUE ("palmtop computer or personal digital assistant; a major advantage of
PDAs is their ability to synchronize data with other computers.")))
        (IS-A (VALUE (MOBILE-COMPUTER INFORMATION-APPLIANCE)))
        (HAS-OBJECT-AS-PART (SEM (COMPUTER-HARDWARE SOFTWARE)))
        (PART-OF-OBJECT (INV (COMPUTER-NETWORK)))
        (WEIGHT-ATTRIBUTE (RANGE (VALUE (<> 0 2))) MEASURED-IN (SEM (LB)))
)

(COMMUNICATION-DEVICE
        (DEFINITION (VALUE ("device used for communication- e-g- a phone")))
        (IS-A (VALUE (INDEPENDENT-DEVICE)))
        (INSTRUMENT-OF (DEFAULT (COMMUNICATIVE-EVENT))(INV (COMMUNICATION-
        SERVE PRAY)))
         (SUBCLASSES (VALUE (SOUND-DISTORTION-DEVICE RADIO-RECEIVER PHONE-
RECEIVER PAGER FAX-MACHINE BUZZER AMPLIFIER ANTENNA COMPUTER-TERMINAL
MICROPHONE PHONE RADAR SHORT-WAVE-RADIO TRANSCEIVER INFORMATION-
APPLIANCE)))
)

(INFORMATION-APPLIANCE
        (DEFINITION (VALUE (“any class of devices that can process information, signals, graphics,
animation, video and audio, and can exchange such information with other IA devices.”)))
        (IS-A (VALUE (COMMUNICATION-DEVICE)))
        (SUBCLASSES (VALUE (SMARTPHONE PALMTOP SMARTCARD)))
        (FUNCTIONS-LIKE (SEM (COMPUTER)))
)

(SMARTPHONE
        (DEFINITION (VALUE (“any handheld device that integrates personal information management
and mobile phone capabilities in the same device.”)))
        (IS-A (VALUE (INFORMATION-APPLIANCE)))
        (FUNCTIONS-LILE (SEM (PALMTOP CELLULAR-PHONE)))
)

(SMARTCARD
        (DEFINITION (VALUE (“a secure microprocessor embedded within a credit card-sized or
smaller card.”)))
        (IS-A (VALUE (INFORMATION-APPLIANCE)))
        (HAS-OBJECT-AS-PART (SEM (MICROPROCESSOR)))
)

(KEYBOARD
        (IS-A (VALUE (INPUT-DEVICE)))
        (DEFINITION (VALUE ("an input device that converts keystrokes to electrical impulses in
ASCII format")))
        (PART-OF-OBJECT (SEM (COMPUTER)))
)

(STYLUS
        (IS-A (VALUE (INPUT-DEVICE)))
        (DEFINITION (VALUE ("a narrow, elongated staff, similar to a pen, used as an input device in
palmtops")))
```

```
        (PART-OF-OBJECT (SEM (PALMTOP)))
        (FUNCTIONS-LIKE (SEM (PENCIL)))
)

(INDEPENDENT-DEVICE
        (DEFINITION (VALUE ("device that stands on its own and is defined as itself by itself")))
        (IS-A (VALUE (DEVICE)))
        (SUBCLASSES (VALUE (WINE-GLASS-FOOT TINE SONAR PUMP-DEVICE OPTICAL-
INSTRUMENT INJECTOR INDEPENDENT-ENERGY-DEVICE FARM-EQUIPMENT ELECTRONIC-
MEDIA CONSUMER-DURABLE COMPUTER CASH-REGISTER CALENDAR-CLOCK BLADE
BUZZER CAN-OPENER COMMUNICATION-DEVICE COMPUTER-NETWORK DRILL-DEVICE
FAN HOUSEHOLD-APPLIANCE INDUSTRIAL-EQUIPMENT MANACLE PRONG RUNNER-
DEVICE SYSTEM-UNIT WEAPON WINE-GLASS-STEM IDENTITY-ESTABLISHING-DEVICE)))
        (THEME-OF (INV (CLOSE)))
)

(IDENTITY-ESTABLISHING-DEVICE
        (DEFINITION (VALUE ("device that is used for identification of objects")))
        (IS-A (VALUE (INDEPENDENT-DEVICE)))
        (SUBCLASSES (VALUE (RETINA-SCAN-DEVICE FINGERPRING-SAMPLING-UNIT)))
)

(RETINA-SCAN-DEVICE
        (DEFINITION (VALUE ("device that is used for identification of humans by scanning their
retina")))
        (IS-A (VALUE (IDENTITY-ESTABLISHING-DEVICE)))
        (COLLECTS-IDENTIFYING-INFORMATION (SEM (RETINA-SCAN)))
        (IDENTIFIES-WHAT (SEM (HUMAN)))
        (STORES-IDENTIFYING-INFORMATION (SEM (RETINA-SCAN)))
        (MATCHES-IDENTIFYING-INFORMATION (SEM (RETINA-SCAN)))
)

(FINGERPRINT-SAMPLING-UNIT
        (DEFINITION (VALUE ("device that is used for identification of humans by sampling their
fingerprints")))
        (IS-A (VALUE (IDENTITY-ESTABLISHING-DEVICE)))
        (COLLECTS-IDENTIFYING-INFORMATION (SEM (FINGER-PRINT)))
        (IDENTIFIES-WHAT (SEM (HUMAN)))
        (STORES-IDENTIFYING-INFORMATION (SEM (BIT-STRING)))
        (MATCHES-IDENTIFYING-INFORMATION (SEM (BIT-STRING)))
)

(ABSTRACT-OBJECT
        (DEFINITION (VALUE ("mental objects that are not inherently representational in nature, such
as ideas, beliefs, information"))) (HAS-ALIAS (SEM (*NOTHING*)))
        (IS-A (VALUE (MENTAL-OBJECT)))
        (MEASURED-IN (SEM (*NOTHING*)))
        (PRECONDITION-OF (INV (ACTUALIZE)))
        (SUBCLASSES (VALUE (FORMULA SUBJECT-AREA DEADLINE WORK THEORY
STANDARD RELIGION PROJECT PRIVILEGE MYTHICAL-OBJECT IDEOLOGY EDUCATION
CONSCIENCE ABSTRACT-IDEA CAREER CULTURE FIELD-OF-STUDY INFORMATION
OPPORTUNITY PROBLEM PUBLIC-DOMAIN SOCIOECONOMIC-CLASS THEOLOGICAL-
OBJECT THOUGHT RECREATION RESULT MODEL HUMAN-MEMORY)))
        (CAUSED-BY (SEM (*NOTHING*)))
```

```
        (THEME-OF (SEM (MENTAL-EVENT))
)

(HUMAN-MEMORY
        (IS-A (VALUE (ABSTRACT-OBJECT)))
        (DEFINITION (VALUE ("the mental faculty of retaining and recalling past experience,
knowledge, etc-")))
        (LOCATION-OF (SEM (INFORMATION)))
        (INSTRUMENT-OF (SEM (REMEMBER)))
)

(DURING
        (IS-A (VALUE (TEMPORAL-RELATION)))
        (DEFINITION (VALUE ("if X and Y are events and (during X Y) then the event X co-occurs in
time with event Y")))
)

(INCUR-DAMAGE
        (IS-A (VALUE (CHANGE-EVENT)))
        (DEFINITION (VALUE (“to cause damage to something or somebody”)))
        (BENEFICIARY (DEFAULT (HUMAN) SEM (OBJECT))))
        (THEME (SEM (OBJECT)))
        (EFFECT ( --- evaluative modality of the theme goes down???
)

(INFORMATION-OBTAIN
        (IS-A (VALUE (CHANGE-EVENT)))
        (DEFINITION (VALUE (“to obtain information about something or somebody”)))
        (AGENT (SEM (HUMAN)))
        (THEME (SEM (INFORMATION)))
        (EFFECT (SEM (AGENT (SEM (OWN (SEM (INFORMATION)))))))
        (PRECONDITION (SEM (AGENT (SEM (LACK (SEM (INFORMATION)))))))
)

(FINANCIAL-OBJECT
        (IS-A (VALUE (REPRESENTATIONAL-OBJECT)))
        (DEFINITION (VALUE ("An abstract object that represents a monetary value, including money,
stocks, bank account, bills, bonds, etc-")))
        (AMOUNT (DEFAULT-MEASURE (MONETARY-UNIT)) (SEM ((>=0))))
        (DOMAIN-OF (INV (FACE-VALUE BUDGET-REVENUE CORPORATE-ASSETS-OF
MONETARY-VALUE))
        (RELAXABLE-TO (RATING-ATTRIBUTE)))
        (INSTRUMENT-OF (INV (SPONSOR RECAPITALIZATION ECONOMIC-SUPPORT
FINANCING REDEMPTION SUBSIDIZE))
        (SEM (FINANCIAL-EVENT)))
        (OWNED-BY (INV (FINANCIAL-ROLE)) (SEM (HUMAN)))
        (SOURCE-OF (INV (WITHDRAW)))
        (SUBCLASSES (VALUE (PAYROLL FINANCIAL-BOOKS CONTRACT FINANCIAL-NOTE
TAX PROMISSORY-NOTE LIABILITY FINANCIAL-INDEX DEED COLLATERAL BILL ASSET
BILL-OF-EXCHANGE CREDIT-CARD ECONOMY LETTER-OF-CREDIT MARKET RECEIPT TOLL
FISCAL-QUARTER FINANCIAL-POINT EXPENSE PROFIT-MARGIN DEBIT-CARD GIFT-CARD)))
        (THEME-OF (INV (WITHHOLD MONEY-MANAGING-ACTIVITY EMBEZZLE
DISINTERMEDIATION BANKING-EVENT ARBITRAGE DISCOUNT ECONOMY-MANAGEMENT
INVESTMENT-EVENT REALIZATION OWE)))
```

```
        (MERCHANDISE-OF (INV (FINANCIAL-CORPORATION)))
)

(CREDIT-CARD
        (DEFINITION (VALUE ("a card entitling one to charge purchases, etc- at certain businesses")))
        (IS-A (VALUE (FINANCIAL-OBJECT)))
        (HAS-IDENTIFYING-INFORMATION (SEM (NUMBER EXPIRATION-DATE ISSUE-
DATE)))
        (IDENTIFIES-WHAT (SEM (HUMAN (AGE >18))))
        (IDENTIFYING-INFORMATION-ISSUED-BY (SEM (BANK)))
        (REPRESENTS (SEM (DEBT)))
)


(DEBIT-CARD
        (DEFINITION (VALUE ("a card linked to an actual bank account, entitling one to charge
purchases, etc- at certain businesses")))
        (IS-A (VALUE (FINANCIAL-OBJECT)))
        (HAS-IDENTIFYING-INFORMATION (SEM (NUMBER EXPIRATION-DATE ISSUE-
DATE)))
        (IDENTIFIES-WHAT (SEM (HUMAN)))
        (IDENTIFYING-INFORMATION-ISSUED-BY (SEM (BANK)))
        (REPRESENTS (SEM (BANK-ACCOUNT)))
)

(GIFT-CARD
        (DEFINITION (VALUE ("a card purchased at its monetary value, used for purchases")))
        (IS-A (VALUE (FINANCIAL-OBJECT)))
        (HAS-IDENTIFYING-INFORMATION (SEM (NUMBER)))
        (IDENTIFYING-INFORMATION-ISSUED-BY (SEM (FOR-PROFIT-CORPORATION)))
        (REPRESENTS (SEM (MONEY)))
)

(PHYSICAL-SYSTEM
        (IS-A (VALUE (PHYSICAL-OBJECT)))
        (DEFINITION (VALUE ("systematic interactions between physical objects")))
        (SUBCLASSES (VALUE (ECOSYSTEM VIRTUAL-ENVIRONMENT)))
)

(VIRTUAL-ENVIRONMENT
        (IS-A (VALUE (PHYSICAL-SYSTEM)))
        (DEFINITION (VALUE ("a virtual environment supported by computers or computer
networks")))
        (HAS-OBJECT-AS-PART (SEM (COMPUTER COMPUTER-NETWORK)))
        (SUBCLASSES (VALUE (NEWSGROUP INTERNET CHAT-PROGRAM)))
)

(NEWSGROUP
        (IS-A (VALUE (VIRTUAL-ENVIRONMENT)))
        (DEFINITION (VALUE ("A newsgroup is a repository, usually within the Usenet system, for
messages posted from many users at different locations. Newsgroups are technically distinct from, but
functionally similar to, discussion forums on the World Wide Web.")))
        (HAS-OBJECT-AS-PART (SEM (MESSAGE)))
)
```

```
(INTERNET
        (IS-A (VALUE (VIRTUAL-ENVIRONMENT COMPUTER-NETWORK)))
        (DEFINITION (VALUE ("The Internet is the publicly available worldwide system of
interconnected computer networks that transmit data by packet switching using a standardized Internet
Protocol(IP) ")))
        (SUBCLASSES (VALUE (WEB-PAGE)))
)

(CHAT-PROGRAM
        (IS-A (VALUE (VIRTUAL-ENVIRONMENT)))
        (DEFINITION (VALUE ("chat program as a generic term for instant messaging applications -
computer programs that enable two-way typing to connect users to each other.")))
        (REPRESENTS (SEM (CONVERSATION)))
)

(VIRTUAL-REALITY
        (IS-A (VALUE (VIRTUAL-ENVIRONMENT)))
        (DEFINITION (VALUE ("Virtual reality describes an environment that is simulated by a
computer. ")))
        (REPRESENTS (SEM (SPACE)))
)

(MESSAGE
        (IS-A (VALUE (COMMUNICATIVE-CONTENT)))
        (DEFINITION(VALUE (" Any thought or idea expressed briefly in a plain or secret language,
prepared in a form suitable for transmission by any means of communication; an arbitrary amount of
information whose beginning and end are defined or implied.")))
        (REPRESENTS (SEM (INFORMATION)))
)

(WEB-PAGE
        (IS-A (VALUE (INTERNET)))
        (DEFINITION (VALUE ("A part of Internet, usually in HTML/XHTML format and with
hypertext links to enable navigation from one page or section to another.")))
        (REPRESENTS (SEM (INFORMATION)))
        (HAS-OBJECT-AS-PART (SEM (WEB-ADDRESS)))
        (ISSUES-IDENTIFYING-INFORMATION (SEM (COOKIE)))
        (SUBCLASSES (SEM (CHATROOM DISCUSSION-FORUM)))
)

(CHATROOM
        (IS-A (VALUE (WEB-PAGE CHAT-PROGRAM)))
        (DEFINITION(VALUE ("A chat room is an online forum where people can talk by broadcasting
messages to people on the same forum in real time.")))
        (COLLECTS-IDENTIFYING-INFORMATION (SEM (LOGIN USERNAME)))
        (ISSUES-IDENTIFYING-INFORMATION (SEM (COOKIE)))
)

(DISCUSSION-FORUM
        (IS-A (VALUE (WEB-PAGE)))
        (DEFINITION (VALUE ("An online forum is a web application (resulting in a web-page) that
provides for online discussions.")))
        (COLLECTS-IDENTIFYING-INFORMATION (SEM (LOGIN USERNAME)))
```

```
        (ISSUES-IDENTIFYING-INFORMATION (SEM (COOKIE)))
)

(CERTIFICATE-AUTHORITY
        (IS-A (VALUE (PUBLIC-KEY-INFRASTRUCTURE)
        (DEFINITION (VALUE (“an entity which issues digital identity certificates for use by other
parties, an example of a trusted third party.”)))
        (ISSUES-IDENTIFYING-INFORMATION (SEM (DIGITAL-CERTIFICATE)))
)

(DEPARTMENT-OF-MOTOR-VEHICLES
        (IS-A (VALUE (STATE-ORGANIZATION)
        (DEFINITION (VALUE (“an entity which issues identifying information for vehicles and their
owners.”)))
        (ISSUES-IDENTIFYING-INFORMATION (SEM (DRIVER’S-LICENSE vehicle-registration)))
)

(VEHICLE-REGISTRATION
        (IS-A (VALUE (IDENTIFYING INFORMATION DOCUMENT)))
        (ISSUED-BY (SEM (DEPARTMENT-OF-MOTOR-VEHICLES))
        (IDENTIFIES-WHAT (SEM (VEHICLE)))
        (DURATION-TYPICAL (SEM (1)) (DEFAULT-MEASURE (YEAR)))
)

(EMBASSY
(IS-A (VALUE (FEDERAL-ORGANIZATION)
        (DEFINITION (VALUE (“an entity which issues identifying information for international
travelers to the country of embassy’s origin.”)))
        (LOCATION (SEM (EMBASSY-BUILDING)))
        (ISSUES-IDENTIFYING-INFORMATION (SEM (VISA)))
)

(SOCIAL-SECURITY-ADMINISTRATION
        (IS-A (VALUE (FEDERAL-ORGANIZATION)
        (DEFINITION (VALUE (“an entity which issues identifying information for US social security
program.”)))
        (LOCATION (SEM (EMBASSY-BUILDING)))
        (ISSUES-IDENTIFYING-INFORMATION (SEM (SOCIAL-SECURITY-CARD)))
)

(RANDOM-ACCESS-MEMORY
        (IS-A (VALUE (SEMICONDUCTOR-STORAGE-DEVICE)))
        (DEFINITION (VALUE ("A semiconductor memory device in which information can be accessed
in any order, which needs a supply of electric current to function and carry information.")))
        (DESTINATION-OF (INV (RETRIEVE-COMPUTER-DATA)))
        (SOURCE-OF (INV (SAVE-COMPUTER-DATA)))
        (ENABLEMENT (SEM (VOLTAGE)))
)

(FORGET
        (DEFINITION (VALUE ("To lose information from one's memory-")))
        (IS-A (VALUE (PASSIVE-COGNITIVE-EVENT LACK)))
        (THEME (SEM (INFORMATION) RELAXABLE-TO (OBJECT EVENT))))
)
```

```
(REMEMBER
        (DEFINITION (VALUE ("To retain information in one's memory-")))
        (IS-A (VALUE (PASSIVE-COGNITIVE-EVENT OWN)))
        (THEME (SEM (INFORMATION) RELAXABLE-TO (OBJECT EVENT))))
        (INSTRUMENT (INV (HUMAN-MEMORY)))
)

(PUBLIC-KEY-INFRASTRUCTURE
        (DEFINITION (VALUE ("an arrangement which provides for third-party vetting of, and vouching
for, user identities.")))
        (IS-A (VALUE (FOR-PROFIT-SERVICE-CORPORATION)))
        (SUBCLASSES (VALUE (CERTIFICATION-AUTHORITY)))
)

(SESSION-INFORMATION
        (DEFINITION (VALUE ("information about a user's beh avior in virtual environment, most often
on Internet.")))
        (IS-A (VALUE (IDENTIFYING-INFORMATION)))
        (IDENTIFIES-WHAT (SEM (EVENT USER-COMPUTER)))
        (HAS-OBJECT-AS-PART (SEM (COOKIE)))
)

(HYPERTEXT
        (DEFINITION (VALUE ("a user interface paradigm for displaying documents which contain
automated cross-references to other documents (hyperlinks).")))
        (IS-A (VALUE (TEXT)))
        (LOCATION (SEM (COMPUTER-TERMINAL)))
        (PART-OF-OBJECT (SEM (WEB-PAGE)))
        (HAS-OBJECT-AS-PART (SEM (HYPERLINK)))
)

(HYPERLINK
        (DEFINITION (VALUE ("a reference in a hypertext document to another document or other
resource.")))
        (IS-A (VALUE (TEXT)))
        (PART-OF-OBJECT (SEM (HYPERTEXT)))
        (FUNCTIONS-LILE (SEM (WEB-ADDRESS)))
)

(AUDIT-LOG
        (DEFINITION (VALUE ("a reference in a hypertext document to another document or other
resource.")))
        (IS-A (VALUE (INFORMATION)))
        (HAS-OBJECT-AS-PART (SEM (SESSION-INFORMATION)))
        (IDENTIFIES-WHAT(SEM (USER-COMPUTER)))
)

(DOMAIN-NAME-SYSTEM
        (DEFINITION (VALUE ("a system that stores information about host names and domain names
in a kind of distributed database on networks, such as the Internet; provides an IP address for each host
name, and lists the mail exchange servers accepting e-mail for each domain.")))
        (IS-A (VALUE (ALGORYTHM SOFTWARE)))
        (MATCHES-IDENTIFYING-INFORMATION (SEM (WEB-ADDRESS IP-ADDRESS)))
```

```
)

(DIGITAL-WATERMARK
        (DEFINITION (VALUE ("a group of bits describing information pertaining to the signal or to the
creator of the signal (name, place, etc.)")))
        (IS-A (VALUE (BIT-STRING)))
        (IDENTIFIES-WHAT (SEM (FILE) RELAXABLE-TO (DOCUMENT)))
)

(PSYCHOGRAPHIC-DATA
        (DEFINITION (VALUE ("data about a computer user's h obbies, interests, etc.")))
        (IS-A (VALUE (INFORMATION)))
        (IDENTIFIES-WHAT (SEM (USER-COMPUTER) RELAXABLE-TO (HUMAN)))
)

(DATA-MINING
        (DEFINITION (VALUE ("Data mining, also known as knowledge-discovery in databases (KDD),
is the practice of automatically searching large stores of data for patterns.")))
        (IS-A (VALUE (INFORMATION-OBTAIN)))
        (COLLECTS-IDENTIFYING-INFORMATION (SEM (EVENT OBJECT)))
        (MATCHES-IDENTIFYING-INFORMATION (SEM (EVENT OBJECT)))
)

(STEGANOGRAPHY
        (DEFINITION (VALUE ("writing hidden messages in such a way that no one apart from the
intended recipient knows of the existence of the message.")))
        (IS-A (VALUE (CIPHER-EVENT)))
        (INSTRUMENT-OF (SEM (HIDE)))
)

(STEGANALYSIS
        (DEFINITION (VALUE ("The detection of steganographically encoded packages.")))
        (IS-A (VALUE (CIPHER-EVENT)))
        (ISTRUMENT-OF (SEM (INFORMATION-OBTAIN)))
)

(FORENSICS
        (DEFINITION (VALUE ("application of science to questions which are of interest to the legal
system.")))
        (IS-A (VALUE (ANALYZE)))
        (THEME (SEM (EVENT OBJECT)))
        (INSTRUMENT-OF (SEM (INFORMATION-OBTAIN)))
        (LEGALITY-ATTRIBUTE (VALUE (YES)))
)

(BAR-CODE
        (DEFINITION (VALUE ("A barcode (also bar code) is a machine-readable representation of
information in a visual format on a surface.")))
        (IS-A (VALUE (IDENTIFYING-INFORMATION)))
        (IDENTIFIES-WHAT (SEM (ARTIFACT)))
        (INSTRUMENT-OF (SEM (INFORMATION-OBTAIN)))
)

(ANONYMITY
```

```
        (IS-A (VALUE (SCALAR-OBJECT-ATTRIBUTE)))
        (DEFINITION (VALUE ("the state of not being identifiable within a set")))
        (DOMAIN (SEM (HUMAN) RELAXABLE-TO (OBJECT)))
        (RANGE (VALUE (<> 0 1))))
)

(PUBLIC-ATTRIBUTE
        (DEFINITION (VALUE ("whether smth is public or private")))
        (IS-A (VALUE (LITERAL-OBJECT-ATTRIBUTE)))
        (RANGE (VALUE (PUBLIC PRIVATE)))
        (DOMAIN (SEM (ORGANIZATION HUMAN INFORMATION)))
)

(PUBLIC
        (DEFINITION (VALUE ("of or pertaining to the people; belonging to the people; relating to, or
affecting, a nation, state, or community ")))
        (IS-A (VALUE (PUBLIC-ATTRIBUTE)))
        (INVERSE (VALUE (PRIVATE)))
        (DOMAIN (SEM (ORGANIZATION HUMAN INFORMATION)))
)

(PRIVATE
(DEFINITION (VALUE ("whether smth is public or private")))
(IS-A (VALUE (PUBLIC-ATTRIBUTE)))
(INVERSE (VALUE (PUBLIC)))
 (DOMAIN (SEM (ORGANIZATION HUMAN INFORMATION)))
)

(COMPUTING-PROTOCOL
    (DEFINITION (VALUE ("convention or standard that controls or enables the connection,
    communication, and data transfer between two computing endpoints. Protocols may be implemented
    by hardware, software, or a combination of the two. At the lowest level, a protocol defines a hardware
    connection.")))
    (IS-A (VALUE (STANDARD)))
    (APPLIES-TO (SEM (COMPUTER-NETWORK COMPUTER SOFTWARE)))
)

(STANDARD
        (DEFINITION (VALUE ("something established for use as a rule or basis of comparison for
measuring quantity, quality, etc-")))
        (IS-A (VALUE (ABSTRACT-OBJECT)))
        (SUBCLASSES (VALUE (RULE-OF-CONDUCT GRADE CUSTOM ROUTINE CORBA
        COMPUTING-PROTOCOL)))
)

(BLIND-CREDENTIAL
        (DEFINITION (VALUE ("a token asserting that someone qualifies under some criteria or has
some status or right, without revealing "who" that person is — without including their name or address, for
instance. It is used in maintaining medical privacy and increasingly for consumer privacy.")))
        (IS-A (VALUE (USER-IDENTIFYING-ATTRIBUTE)))
        (SUBCLASSES (VALUE (PSEUDONYM)))
        (REPRESENTS (SEM (USER-COMPUTER) RELAXABLE-TO (HUMAN)))
        (ANONYMITY (VALUE (> .8)))
)
```

```
(PSEUDONYM
        (DEFINITION (VALUE ("a name (sometimes legally adopted, sometimes purely fictitious) used
by an individual as an alternative to their birth name.")))
        (IS-A (VALUE (BLIND-CREDENTIAL)))
        (REPRESENTS (SEM (HUMAN)))
        (ANONYMITY (VALUE (> .9)))
        (TEMPORAL-OBJECT-ATTRIBUTE (VALUE (>.7)))
)

(ABSTRACT-OBJECT
        (DEFINITION (VALUE ("mental objects that are not inherently representational in nature, such
as ideas, beliefs, information"))) (HAS-ALIAS (SEM (*NOTHING*)))
        (IS-A (VALUE (MENTAL-OBJECT)))
        (MEASURED-IN (SEM (*NOTHING*)))
        (PRECONDITION-OF (INV (ACTUALIZE))) (SUBCLASSES (VALUE (FORMULA
SUBJECT-AREA DEADLINE WORK THEORY STANDARD RELIGION PROJECT PRIVILEGE
MYTHICAL-OBJECT IDEOLOGY EDUCATION CONSCIENCE ABSTRACT-IDEA CAREER
CULTURE FIELD-OF-STUDY INFORMATION OPPORTUNITY PROBLEM PUBLIC-DOMAIN
SOCIOECONOMIC-CLASS THEOLOGICAL-OBJECT THOUGHT RECREATION RESULT MODEL
MEMORY PSEUDONYMITY)))
        (THEME-OF (SEM (MENTAL-EVENT)))
)

(PSEUDONYMITY
        (DEFINITION (VALUE ("a state which combines the advantages of having a known identity with
the advantages of anonymity.")))
        (IS-A (VALUE (ABSTRACT-OBJECT)))
        (REPRESENTS (SEM (HUMAN)))
        (ANONYMITY (VALUE (> .9)))
        (TEMPORAL-OBJECT-ATTRIBUTE (VALUE (>.7)))
)

(SCALAR-HUMAN-ATTRIBUTE
        (DEFINITION (VALUE ("scalar-attributes involving social-roles")))
        (IS-A (VALUE (SCALAR-ANIMAL-ATTRIBUTE)))
        (SUBCLASSES (VALUE (AMBITION PREJUDICE-ATTRIBUTE OPTIMISM YEARS-OF-
EDUCATION PIETY STUDIOUSNESS YEARS-OF-EXPERIENCE MORALITY EXPERTISE-
ATTRIBUTE SANITY-ATTRIBUTE ANONYMITY RESPONSIBILITY-ATTRIBUTE)))
        (DOMAIN (SEM (HUMAN)))
)


(ANONYMITY
        (DEFINITION (VALUE ("a state of undisclosed or untraceable identity.")))
        (IS-A (VALUE (SCALAR-HUMAN-ATTRIBUTE)))
        (RANGE (VALUE (<> 0 1)))
        (DOMAIN (SEM (HUMAN)))
)

(BORDER
        (DEFINITION (VALUE ("a virtual delimitation of a certain geographical location. Does not apply
only to states.")))
        (IS-A (VALUE (REPRESENTATIONAL-OBJECT)))
```

```
        (REPRESENTS (SEM (BARRIER-ARTIFACT)))
)

(TRACKING-EVENT
        (DEFINITION (VALUE ("event of .")))
        (IS-A (VALUE (INFORMATION-OBTAIN)))
        (RESULT (SEM (LOCATE)))
)

(GLOBAL-POSITIONING-SYSTEM
        (DEFINITION (VALUE ("a physical system that uses 24 satellites constantly orbiting the earth to
determine the position, speed and direction of an object on earth; used extensively in tracking moving
objects, mainly vehicles and assets. GPS is can be accurate to approximately 10 meters, or less so can be
used to provide geo-fencing capabilities.")))
        (IS-A (VALUE (PHYSICAL-SYSTEM)))
        (HAS-OBJECT-AS-PART (SEM (SATELLITE (CARDINALITY (24))))
        (INSTRUMENT-OF (SEM (TRACKING)))
        (MEASURING-DEVICE-FOR (SEM (VELOCITY)))
)

(FORMAT
        (DEFINITION (VALUE ("organization of information according to preset specifications (usually
for computer processing).")))
        (IS-A (VALUE (STANDARD)))
        (APPLIES-TO (SEM (COMPUTER-DATA) RELAXABLE-TO (MEDIA-ARTIFACT)))
)

(REVOKE
        (DEFINITION (VALUE ("to repeal or cancel a law")))
        (IS-A (VALUE (POLITICAL-EVENT)))
        (AGENT (SEM (POLITICAL-ENTITY JUDGE PUBLIC-ADMINISTRATION-
ORGANIZATION) RELAXABLE-TO (ORGANIZATION)) INV (SENATE)))
        (THEME (SEM (LAW) RELAXABLE-TO (PRIVILEDGE))
)

(SENSITIVITY
        (IS-A (VALUE (SCALAR-OBJECT-ATTRIBUTE)))
        (DEFINITION (VALUE ("used to indicate the responsiveness of an object to external influence.
NOT used as high-risk: apply safety-attribute to the event instead.")))
        (DOMAIN (SEM (ANIMAL) RELAXABLE-TO (OBJECT)))
        (RANGE (VALUE (<> 0 1))))
)

(OFFICIAL-ATTRIBUTE
        (IS-A (VALUE (LITERAL-OBJECT-ATTRIBUTE LITERAL-EVENT-ATTRIBUTE)))
        (DEFINITION (VALUE ("used to indicate how official object or event is. Can be useful for style
decisions later on, as well.")))
        (DOMAIN (SEM (ANIMAL) RELAXABLE-TO (OBJECT)))
        (RANGE (VALUE (OFFICIAL NON-OFFICIAL))))
)

(UPDATE
        (DEFINITION (value ("to change smth (information, software) to a newer version")))
        (INSTRUMENT (sem (OBJECT)))
```

```
        (IS-A (value (CHANGE-EVENT)))
        (EFFECT (OWN (AGENT (sem (HUMAN) RELAXABLE-TO (ORGANIZATION))
        (THEME (sem (INFORMATION SOFTWARE) relaxable-to (object)))
        (PRECONDITION (LACK (AGENT (sem (HUMAN) RELAXABLE-TO (ORGANIZATION)))
)

(DEVICE-EVENT
        (DEFINITION (VALUE ("events concerning the operation of devices"))) (IS-A (VALUE
(ARTIFACT-EVENT)))
        (SUBCLASSES (VALUE (WELD PEEL INSTALL-DEVICE FUNCTION DRILL DEVICE-
PERCEPTUAL-EVENT AIM DEMONSTRATE DISASSEMBLE FILE-EVENT INJECT OPERATE-
DEVICE SHARPEN TIGHTEN INITIALIZE)))
        (THEME (SEM (PHYSICAL-OBJECT)))
)

(INITIALIZE
        (DEFINITION (VALUE ("to prepare a computer memory storage device for usage")))
        (IS-A (VALUE (DEVICE-EVENT MAKE-READY)))
        (THEME (SEM (STORAGE-DEVICE)))
)

(VALIDITY
        (IS-A (VALUE (SCALAR-OBJECT-ATTRIBUTE)))
        (DEFINITION (VALUE ("used to indicate how valid smth is.")))
        (DOMAIN (RELAXABLE-TO (OBJECT)))
        (RANGE (VALUE (<> 0 1))))
)

(SOCIAL-ROLE
        (DEFINITION (VALUE ("The roles an individual person may have in a society")))
        (IS-A (VALUE (HUMAN)))
        (DOMAIN-OF (INV (PARTNER-OF HAS-WORK-EQUIPMENT YEARS-OF-EXPERIENCE
SUPERVISOR-OF SOCIAL-ROLE-ATTRIBUTE PUNCTUALITY INVERSE-SOCIAL-ROLE-
RELATION ESTABLISHED-BY EMPLOYED-BY CONTROLLED-BY AREA-OF-INTEREST
AUDIENCE-OF CONTROLS EMPLOYER-OF INVERSE-CREATION-RELATION LEADERSHIP
ROLE-FOR-ACTIVITY SUPERVISED-BY TEAM-MATE HEAD-OF HAS-PARTNER LANGUAGE-
USED)))
        (MEMBER-OF (INV (COMMITTEE)))
        (BENEFICIARY-OF (INV (BRIBERY VOTE)))
        (ROLE-FOR-ACTIVITY (SEM (WORK-ACTIVITY)))
        (SUBCLASSES (VALUE (OPPONENT TRADE-ROLE SERVICE-ROLE PUBLICATION
        ROLE INDUSTRIAL-ROLE FINANCIAL-ROLE COMPUTING-ROLE CELEBRITY
ARTISTIC-ROLE ACADEMIC-ROLE BUSINESS-ROLE COMMUNICATION-ROLE FAMILY-ROLE
GOVERNMENTAL-ROLE POLITICAL-ROLE RELIGIOUS-ROLE SPORTS-ROLE WORK-ROLE
PARTNER)))
        (THEME-OF (INV (RESIGN DISMISS)))
        (YEARS-OF-EXPERIENCE (SEM ("(>= 0)")))
        (AGE (SEM ("(<> 0 200)")))
        (NOTES (VALUE ("Specifying here that a human must be at least 15 years old in order to be
considered to have a social role (presumably other than " SOCIAL-ROLE-IS-CORRECTLY-PLACED-IN-
THIS-SUBTREE--IT-DOES-NOT-BELONG-IN-THE-SOCIAL-OBJECT-SUBTREE-BECAUSE-
SOCIAL-OBJECTS-ARE-ALL-COMPOSED-OF-MORE-THAN-ONE-INDIVIDUAL-)))
        (CUSTOMER-OF (INV (CREDIT-UNION)))
        (EMPLOYED-BY (INV (FAMILY-ARTIFACT-MANUFACTURING-CORPORATION)))
```

```
)

(ABSTRACT-IDEA
        (DEFINITION (VALUE (AN-ABSTRACT-OBJECT-WHOSE-SIGNIFICANCE-VARIES-
BASED-ON-PEOPLE)))
        (IS-A (VALUE (ABSTRACT-OBJECT)))
        (SUBCLASSES (VALUE (FRIENDSHIP TRUTH LIKELIHOOD DESTINY BEAUTY
BROTHERHOOD JUSTICE LUCK WISDOM EGO FREEDOM RESPONSIBILITY)))
        (CAUSED-BY (SEM (SOCIAL-EVENT)))
        (THEME-OF (INV (RESPECT)))
)

(DEPENDENT-DEVICE
        (DEFINITION (VALUE ("device that is a part of something- it cannot stand or be of use on its
own")))
        (IS-A (VALUE (DEVICE)))
        (SUBCLASSES (VALUE (ZIPPER RESISTOR PHONE-RECEIVER MODEM MICROPHONE
        LOCKING-DEVICE GUY-ROPE CONVEYOR-BELT CIRCUIT-BREAKER CRT LENS
        MAGNET MICROPROCESSOR PBX-DIGITAL PULLEY SECURITY-CHECK-DEVICE
        COMPUTER-HARDWARE AUTOMATED-TELLER-MACHINE)))
)

(AUTOMATED-TELLER-MACHINE
        (DEFINITION (VALUE ("unattended electronic machine in a public place, connected to a data
system and related equipment and activated by a bank customer to obtain cash withdrawals and other
banking services")))
        (IS-A (VALUE (DEPENDENT-DEVICE)))
        (PART-OF-OBJECT (SEM (COMPUTER-NETWORK)))
        (INSTRUMENT-OF (SEM (BANKING-EVENT)))
        (OWNED-BY (SEM (BANK)))
        (REQUESTS-IDENTIFYING-INFORMATION (SEM (USER-IDENTIFYING-ATTRIBUTE)))
        (MATCHES-IDENTIFYING-INFORMATION (SEM (USER-IDENTIFYING-ATTRIBUTE)))
)

(CIRCUIT-BREAKER
        (DEFINITION (VALUE ("a device that automatically interrupts the flow of an electric current")))
        (IS-A (VALUE (DEPENDENT-DEVICE)))
        (INSTRUMENT-OF (SEM (CUT-ELECTRICITY)))
        (NOTES (VALUE (circuit breaker is used to prevent the spread of electric fault on power lines
and networks, which needs to be represented in the meaning.  The ontological representation of the domain
is grossly underdeveloped at the moment.)))
)

(CLICK-LINK-ONLINE-EVENT (IS-A (VALUE (TRANSFER-COMPUTER-DATA)))
        (DEFINITION (VALUE ("to move from one web-page to another using the links on HTML
pages")))
        (DESTINATION (SEM (WEB-PAGE))
        (INV (WEB-PAGE)))
        (SOURCE (SEM (WEB-ADDRESS)))
        (THEME (SEM (ONLINE-LINK)))
)

(MEDIA-OBJECT (DEFINITION (VALUE ("a representational-object that pertains to the media, such as
television advertisements, radio programs, etc-")))
```

```
        (IS-A (VALUE (REPRESENTATIONAL-OBJECT)))
        (SUBCLASSES (VALUE (TELEVISION-CHANNEL TELECOMMUNICATION ICON
ADVERTISEMENT FILM-MEDIA RADIO-FREQUENCY TELEGRAM TELEVISION-
PROGRAMMING ONLINE-LINK))))

(ONLINE-LINK
        (DEFINITION (VALUE ("a representational-object that allows to navigate from one document
located online to another")))
        (IS-A (VALUE (REPRESENTATIONAL-OBJECT)))
        (HAS-ELEMENT (SEM (WEB-ADDRESS)))
        (THEME-OF (SEM (CLICK-LINK-ONLINE-EVENT)))
)

(TRANSFER-COMPUTER-DATA
        (IS-A (VALUE (WRITE-COMPUTER-DATA TRANSFER-OBJECT)))
        (DEFINITION (VALUE ("to send and receive computer-data, copying it from one computer onto
another")))
        (SUBCLASSES (VALUE(CLOCK-LINK-ONLINE-EVENT UPLOAD DOWNLOAD)
        (DESTINATION (SEM (NETWORK-CLIENT))
        (INV (NETWORK-CLIENT)))
        (SOURCE (SEM (NETWORK-SERVER)))
        (THEME (SEM (COMPUTER-DATA)))
)

(DOWNLOAD (IS-A (VALUE (TRANSFER-COMPUTER-DATA)))
        (DEFINITION (VALUE ("file transfer event, initiated by the receiving side")))
        (DESTINATION (SEM (NETWORK-CLIENT))
        (INV (NETWORK-CLIENT)))
        (SOURCE (SEM (NETWORK-SERVER)))
        (THEME (SEM (COMPUTER-DATA)))
        (BENEFICIARY (SEM (AGENT-OF (RANGE (SEM (ACQUIRE))))))
)

(UPLOAD (IS-A (VALUE (TRANSFER-COMPUTER-DATA)))
        (DEFINITION (VALUE ("file transfer event, initiated by the sending side")))
        (DESTINATION (SEM (NETWORK-CLIENT))
         (SOURCE (SEM (NETWORK-SERVER)))
        (THEME (SEM (COMPUTER-DATA)))
        (BENEFICIARY (SEM (AGENT-OF (RANGE (SEM (SEND))))))
)

(SUSCEPTIBILITY-ATTRIBUTE
        (IS-A (VALUE (SCALAR-OBJECT-ATTRIBUTE)))
        (DEFINITION (VALUE ("The capacity to be affected by smth, from 1 – very easily affected, to 0
– not at all affected")))
        (DOMAIN (RELAXABLE-TO (OBJECT)))
        (RANGE (VALUE (<> 0 1))))
)

(RESPONSIBILITY-ATTRIBUTE
        (DEFINITION (VALUE ("a form of trustworthiness; the trait of being answerable to someone for
something or being responsible for one's conduct.")))
        (IS-A (VALUE (SCALAR-HUMAN-ATTRIBUTE)))
        (RANGE (VALUE (<> 0 1)))
```

```
        (DOMAIN (SEM (HUMAN) RELAXABLE-TO (ORGANIZATION)))
)

(RESPONSIBILITY
        (DEFINITION (VALUE ("a form of trustworthiness; the trait of being answerable to someone for
something or being responsible for one's conduct")))
        (IS-A (VALUE (ABSTRACT-IDEA)))
        (ORIGIN (SEM (RESPONSIBILITY-ATTRIBUTE)))
)

(TAMPER
        (DEFINITION (VALUE ("to alter or interfere in an unauthorized or improper manner")))
        (IS-A (VALUE (INTERFERE CHANGE-EVENT)))
        (LEGALITY-ATTRIBUTE (VALUE (NO)))
)

(TINKER
        (DEFINITION (VALUE ("to manipulate and alter smth experimentally")))
        (IS-A (VALUE (INTERFERE CHANGE-EVENT)))
        (LEGALITY-ATTRIBUTE (VALUE (YES)))
)

(CONTROL-EVENT
        (DEFINITION (VALUE ("to exercise authority (over someone or something)- to direct")))
        (IS-A (VALUE (SOCIAL-EVENT)))
        (PURPOSE-OF (INV (STEER)))
        (AGENT (SEM (HUMAN)))
        (SUBCLASSES (VALUE (JEOPARDIZE REGULATE PROHIBIT IMPEL GOVERN
CONQUER BEHAVE ARREST ASSIGN COMMAND DELIMIT GUIDE IMPOSE PUNISH
SUPERVISE YIELD-TO INTERCEPT)))
)

(INTERCEPT
        (DEFINITION (VALUE ("to stop and seize smth")))
        (IS-A (VALUE (CONTROL-EVENT)))
        (THEME (SEM (INFORMATION) RELAXABLE-TO (OBJECT)))
        (AGENT (SEM (HUMAN)))
        (EFFECT (SEM (POSSESSION-EVENT)))
)

(HAND-PRINT
        (DEFINITION (VALUE ("a physical quality describing the hand that can be used to identify a
human ")))
        (IS-A (VALUE (BIOMETRICS))
        (IDENTIFIES-WHAT (SEM (DEAFULT (USER-COMPUTER) RELAXABLE-TO
(HUMAN))))
        (ORIGIN (SEM (HAND)))
        (INVARIABILITY-ATTRIBUTE (VALUE (.9)))
        (UNIQUENESS (VALUE (1)))
)

(CIPHER-EVENT
        (DEFINITION (VALUE ("to apply a cipher algorithm to a text")))
        (IS-A (VALUE (ALGORITHM REPLACE-OBJECT)))
```

```
	(SUBCLASSES (VALUE (SYMMETRIC-KEY-ENCRYPTION-ALGORYTHM
ASYMMETRIC-KEY-ENCRYPTION-ALGORYTHM TRANSPOSITION-CIPHER SUBSTITUTION-
CIPHER)))
	(THEME (SEM (INFORMATION-UNIT)))
)

(SYMMETRIC-KEY-ENCRYPTION-ALGORYTHM
	(IS-A (VALUE (CIPHER-EVENT)))
	(DEFINITION (VALUE ("en encryption algorithm, for which the sender and receiver must have a
shared key set up in advance and kept secret from all other parties; the sender uses this key for encryption,
and the receiver uses the same key for decryption")))
	(SUBCLASSES (VALUE (BLOCK-CIPHER STREAM-CIPHER)))
	(PRECONDITION (SEM (SHARE-EVENT (THEME (SEM (ENCRYPT-KEY))))))
)

(ASYMMETRIC-KEY-ENCRYPTION-ALGORYTHM
	(DEFINITION (VALUE ("an asymmetric key algorithm, there are two separate keys: a public key
is published and enables any sender to perform encryption, while a private key is kept secret by the receiver
and enables him to perform decryption. ")))
	(IS-A (VALUE (CIPHER-EVENT)))
	(HAS-OBJECT-AS-PART (VALUE (PRIVATE-KEY PUBLIC-KEY)))
)

(SUBSTITUTION-CIPHER
	(SUBCLASSES (VALUE (MONOALPHABETIC-CIPHER POLYALPHABETIC-CIPHER)))
	(DEFINITION (VALUE ("a simple cipher, which replaces each character with another")))
	(IS-A (VALUE (CIPHER-EVENT)))
)

(MONOALPHABETIC-CIPHER
	(SUBCLASSES (VALUE (CAESAR-CIPHER)))
	(DEFINITION (VALUE ("substitution cipher which only involves one alphabet")))
	(IS-A (VALUE (SUBSTITUTION-CIPHER)))
	(HAS-OBJECT-AS-PART (SEM (ALPHABET) CARDINALITY (1)))
)

(POLYALPHABETIC-CIPHER
	(DEFINITION (VALUE ("a cipher which uses multiple alphabets to obfuscate frequency
distributions")))
	(IS-A (VALUE (SUBSTITUTION-CIPHER)))
	(HAS-OBJECT-AS-PART (SEM (ALPHABET) CARDINALITY ( > 1)))
)

(TRANSPOSITION-CIPHER
	(DEFINITION (VALUE ("a cipher that changes one character from the plaintext to another (to
decrypt the reverse is done). That is, the order of the characters is changed.")))
	(IS-A (VALUE (CIPHER-EVENT)))
	(EFFECT  (SEM (DISPLACE (THEME (SEM TEXT-CHARACTER)))))
)

(STREAM-CIPHER
	(DEFINITION (VALUE ("a cipher in which the input data are encrypted one bit (sometimes one
byte) at a time.")))
	(IS-A (VALUE (SYMMETRIC-KEY-ENCRYPTION-ALGORYTHM)))
```

```
)

(BLOCK-CIPHER
        (SUBCLASSES (VALUE (KEYLESS-CIPHER PRODUCT-CIPHER VERNAM-CIPHER)))
        (DEFINITION (VALUE ("a type of symmetric key cipher which operates on groups of bits of a
fixed length, termed blocks.")))
        (IS-A (VALUE (SYMMETRIC-KEY-ENCRYPTION-ALGORYTHM)))
        (HAS-EVENT-AS-PART (SEM (DIVIDE)))
)

(VERNAM-CIPHER
        (DEFINITION (VALUE ("a cipher which incorporates a block of text into a random number
string-unbreakable without the original number")))
        (IS-A (VALUE (BLOCK-CIPHER)))
        (HAS-OBJECT-AS-PART (SEM (RANDOM-NUMBER)))
)

(KEYLESS-CIPHER
        (DEFINITION (VALUE ("a cipher which can be decrypted without a key")))
        (IS-A (VALUE (BLOCK-CIPHER)))
        (HAS-OBJECT-AS-PART (NOT (ENCRYPT-KEY)))
)

(PRODUCT-CIPHER
        (DEFINITION (VALUE ("a cipher which incorporates previously converted text into future
cipher events")))
        (IS-A (VALUE (BLOCK-CIPHER)))
        (PRECONDITION (SEM (CIPHER-EVENT)))
)

(PRIVATE-KEY
        (IS-A (VALUE (ENCRYPT-KEY)))
        (DEFINITION (VALUE ("one of the keys used in asymmetric key encryption, kept secret by the
receiver and enables him to perform decryption.")))
        (PART-OF-OBJECT (VALUE (ASYMMETRIC-KEY-ENCRYPTION-ALGORYTHM)))
        (PUBLIC-ATTRIBUTE (VALUE (PRIVATE)))
)

(PUBLIC-KEY
        (IS-A (VALUE (ENCRYPT-KEY)))
        (DEFINITION (VALUE ("one of the keys used in asymmetric key encryption, one that is
published and enables any sender to perform encryption.")))
        (PART-OF-OBJECT (VALUE (ASYMMETRIC-KEY-ENCRYPTION-ALGORYTHM)))
        (PUBLIC-ATTRIBUTE (VALUE (PUBLIC)))
)

(RANDOM-NUMBER
        (IS-A (VALUE (ANY-NUMBER)))
        (DEFINITION (VALUE ("a number that is generated randomly each time it is needed, statistically
changing every time")))
        (INVARIABILITY-ATTRIBUTE (VALUE (0)))
)
```

CHAPTER V.
POST-ACQUISITION REMARKS.

This chapter is concerned, mainly, with some issues I have encountered during acquisition, and the solutions for these issues I have proposed; also, the limitations of the present research and the roadmap for future work in the area of Ontological Semantics used for Natural Language Processing.

5.1. Troubleshooting and overcoming discrepancies in ontological expansion.

The beginning of a domain acquisition proved to be the most difficult part of the entire undertaking. Since ontological description is as much of a goal-driven "art-skill", as it is a theory-grounded scientific endeavor, laying the groundwork for the entire domain was a non-trivial task, which, to a great extent, could determine the overall quality of the domain description. After carefully reviewing the literature, I have, first of all, singled out several indispensable minimal events/properties necessary for the task[3].

To describe anything going on in the digital identity management domain, several properties appeared to be indispensable in the ontology, and those I have added and described as:

collects-identifying-information
stores-identifying-information
requests-identifying-information
matches-identifying-information

[3] In identifying the properties, I have made an attempt to both reduce the possible number of them by making the properties as basic and universally-applicable as possible, and yet encompassing enough information to be of immediate use to a human acquirer. In formulation of the PROPERTIES, I owe much debt to the advice of Dr. Wilbur (p.c.) on the minimal semantic meaning, and to guidance of Dr. Raskin on the usability of newly-added items.

issues-identifying-information
identifying-information-issued-by (inverse of the preceding one)
identifies-what
furnishes-identifying-information (inverse of the preceding one)

I had options as to where in the ontology to anchor these concepts. Here, I considered the following: the concepts dealing with identifying information are not always events, they are potential events. Therefore, I would need them to be described as PROPERTIES.

The search through properties rendered property relation object relation. I then added representational-object-relation sub-tree, and put the concepts for Digital Identity Management there, changing the object-relation tree correspondingly (since Chapter 4 describes the concepts in as-acquired order, one can co-reference the work in it in order to illustrate the present notes; it is not, however, necessary to do so to, since these are meant to be self-explanatory).

Creating a new sub-tree in object-relation meant I would have to create a new sub-tree in inverse-object-relations inverse-representational-object-relation. It was the anchor point for the inverse concepts, which described mirroring properties: furnishes-identifying-information, identifying-information-issued-by (useful for digital certificate description), and identified-by.

The number of inverse representational relations is lower, as you might have notices, than the number of representational relations added. I have constantly attempted to reduce the number of new properties, both to keep the ontology parsimonious, and to ease the task for future acquisition. So, I did add the inverse properties, which I felt were necessary, and decided there was no use to invent unnecessary ones just to have all representational-object-relations matching inverse-representational-object-relation. Overall, the ontological semantics does not impose a requirement of matching properties with inverse properties; this topic will be further addressed in section 5.3.

The next large sub-tree to be expanded was the one of representational-objects. I had to be careful, since, as a simple search has shown, the concepts of NAME, ADDRESS, WEB-ADDRESS and NETWORK-ADDRESS were already present, yet located under language-related-objects. I decided to re-formulate the definitions of these

concepts, and move them into another tree, since those useful concepts were not "mental objects that represent language, such as text, word…" as the parent node, language-related concept, had intended.

Moreover, I had concerns as to the reasoning behind representational-object being located in mental-objects tree. Obviously, representational-objects might be mental-objects (such as MATHMATICAL-OBJECTs), but they might not be, as the above-mentioned ones. Also, some real physical objects can be representational (e.g. RECEIPT, LEGAL-WILL, DOWN-PAYMENT) but there was no sub-tree outside of mental-object for those.

For all identifying information, I initially intended to allow two parent nodes: information and representational object. However, INFORMATION turned out to be an empty concept (being essentially the same as its parent, abstract-object, and lacking the theme slot of the latter), with SOFTWARE right under it, identified only by producer, software-development-corporation. Child nodes, which differ from the parent node only in the label, are not allowed in ontology. This tree in general was not, in my opinion, sufficiently elaborate, so I marked it for further development.

For user attributes in the DIM domain, we need an invariability (constancy of existence) attribute in the scalar-object-attributes (the one in scalar-event-attribute was not useful for objects; moreover, we needed an abstract one, as opposed to the available one measured in temporal units), so I added it.

To use human attributes as both identifying information AND attributes of humans, I had to expand the literal-object-attribute branch, moving some free-standing attributes into the LITERAL-HUMAN-ATTRIBUTE branch.

INDIVIDUAL-ATTRIBUTE had been, as I found out, previously used in the lexicon (with SEM ANIMAL and SEM YES), but not present in Ontology. Since such gaps do occur in the absence of real-time ontology QA software, I have considered the possible properties and the applicability of the already-mentioned, though not acquired, property. For the purposes of the domain, we needed it as a scalar, for qualifying reliability of biometrics. For these reasons, and in order not to create an additional mix-up by having the same property present as a literal and as a scalar, I created new scalar

attribute "uniqueness" for the purposes of the DIM domain, and marked INDIVIDUAL-ATTRIBUTE for review.

Among the temporal attributes, "before" and "after" were already present; I also introduced "during", as a necessary concept[4].

Information-obtain concept which I realized I needed for the DIM domain, already existed within ontology, but only as a child of both spy-on and information-security-attack. We needed it for face-recognition as a "valid and legal act". So, the only useful action to undertake at the moment was to move it out of spying and info-sec, and make it a change-event, which I accomplished.

For the domain of DIM, we had to add "user" as a social-role, under the concept of such directly. "User" was meant not as a computer-user (which is a separate concept already), but in a sense of "consumer". Incidentally, "consumer" in the lexicon was defined solely as an agent of "consumption", a financial event – not useful for describing, e.g. the user of services, etc. The existing restriction on the parent-node SOCIAL-ROLE (which includes only humans over 15 years old) was, for the purposes of the domain in question, too restrictive. For the present, I have blocked the inheritance of this property in the concepts I added. But, for example, even ACTOR, a communication-role, does not fit this categorization. So, instead of defining the age in the SOCIAL-ROLE, I would like to suggest for further consideration either to apply age restriction to the social-roles that do, in fact, legally have it, or to (possibly) restrict legal age in the TMR of a text itself, than to restrict age within a social role – it simply does not correlate with the modern reality.

Alternatively, I could also identify the lexical item "user" as an agent of "use", adding "use" to the ontology. However, under the reasoning that "user" is a universally applicable concept, which would be needed in the ontology. I have created a separate "user" concept for future applications.

For the information-obtain concept, I have com across an interesting question of the definition of the concept OWN. At the moment, it is identified as "a (continuous)

[4] I also believe that "during" is needed a cognitively-grounded concept (which is relevant, as while we are not modeling human linguistic ability in the ontology, we are trying to model the results it produces), necessary for dynamic processing of tenses. Since tenses, strictly speaking, belong to the domain of language-specific dynamic processing, I will not go into much detail here; however, I'd like to mention that script-based TMR of co-occurring events would require it.

event of owning and object." Nothing in the ontological description of it did restrict the ownership to a single entity (e.g. if one owns something, no one else owns it at the same time). Thus, I did use it for the event of "owning" information, as in:

```
(INFORMATION-OBTAIN
        (IS-A (VALUE (CHANGE-EVENT)))
        (DEFINITION (VALUE ("to obtain information about something or
somebody")))
        (AGENT (SEM (HUMAN)))
        (THEME (SEM (INFORMATION)))
        (EFFECT (SEM (AGENT (SEM (OWN (SEM (INFORMATION)))))))
        (PRECONDITION (SEM (AGENT (SEM (LACK (SEM (INFORMATION)))))))
)
```

However, strictly speaking, information is an object that can be infinitely replicated without losing its identity, so it might be useful to introduce another ownership-like concept for abstract objects. At the moment, I consider this specific question open to further deliberation.

I have also found some confusion-causing inconsistency in node naming. For example, the CIPHER-EVENT concept was part of an object tree, and did not have any double inheritance. Thus, we have a concept, the name of which suggested that it was in another third of the ontology entirely; moreover, at some point the "has-event-as-part" property was used in one of the child concepts of it. It is, again, impossible to apply an EVENT-RELATION (both RANGE and DOMAIN of the property are events, as well as it being a descendant of an EVENT-RELATION) to an object concept.

I have, without changing the name of the concept at the time, eliminated EVENT-related properties from its description, and the description of its children. Further description of the overhaul of this branch is presented in section 5.3.

5.2. Function assignment in TMR creation: aspects referred to dynamic resources.

In this section I would like to elaborate on the "division of labor" between static (lexicons, ontology) and dynamic resources of an ontological semantic natural language processing system, and to discuss the possibilities that may be explored to further refine

the performance of the system, in the view of overall changes I proposed in Chapter 3 above.

For example, as the reader would have noticed, in the lexicon acquisition, the entries are stripped of their ecological properties – e.g. the abbreviations for the level of education (Ph.D., J.D.) lack periods after them; apostrophe is also dropped in the entries that require it optionally. The reason for this is that the present work is devoted exclusively to the building of static resources; the overall system that would use them, as noted in the first chapter, would include the ecological analyzer, which would perform appropriate processing on the natural language text.

Another interesting case for discussion, brought about mainly by the differentiation I have proposed between simplex and complex events (states and processes vs. accomplishments and achievements) is the differentiation, in the TMR, between adjectives used in resultative and depictive constructions: "The virus rendered my computer unusable" or "I painted the house red," vs. "Jason left the meeting angry".

I suggest that there is no need to provide the static resources with a syntactic disambiguator for such constructions. In the course of building the TMR, the two arguments available for the adjective for modification, would be the agent and the theme of the main event. In most cases, there is only one possible semantic valency that renders an acceptable sentence: if we use the examples above, only computer (not "I", the actor) can be unusable, and only a human (not a "meeting", which is an abstract object) can have the property "angry". These valencies are specified in the static resources. On the other hand, an utterance along the lines of "Jason left me angry" is ambiguous in natural language, and should as well be in the text meaning representation rendered by a computational processing system.

Incidentally, the introduction of event structure into the semantic descriptions in the static resources warrants the need to provide the dynamics resources, responsible for TMR creation, with the module responsible for treating event structure and its ramifications. E.g. it is likely we would also need to introduce new adverbial templates, which would allow adverbs like "almost" to block telicity in accomplishments and achievements ("I almost downloaded this file" being an un-finished telic event).

The third case I would like to review came up during one of the Ontological Semantics group meetings, and it concerned the possibilities and possible need to specify the relatedness of complementary antonyms in the static resources, in order to "keep track" of the roles agents play in complementary events. One of the suggestions was to reduce complementary pairs to a single entry; another one proposed a new facet to connect such pairs both in the lexicon and in the ontology. The solution I have resorted to in the present work is simpler than complicating the syntax of the scripts with a new facet, and provides the system with more information than a singe entry. I have aimed to specify the complementary concepts as similarly as possible, with the main semantic difference expressed through one ontological connection. Here is an example of such representation in the ontology, describing the complementary antonyms "download" and "upload":

```
(DOWNLOAD (IS-A (VALUE (TRANSFER-COMPUTER-DATA)))
(DEFINITION (VALUE ("file transfer event, initiated by the receiving side")))
(DESTINATION (SEM (NETWORK-CLIENT)))
(SOURCE (SEM (NETWORK-SERVER)))
(THEME (SEM (COMPUTER-DATA)))
(BENEFICIARY (SEM (AGENT-OF (RANGE (SEM (ACQUIRE))))))
)

(UPLOAD (IS-A (VALUE (TRANSFER-COMPUTER-DATA)))
(DEFINITION (VALUE ("file transfer event, initiated by the sending side")))
(DESTINATION (SEM (NETWORK-CLIENT)))
(SOURCE (SEM (NETWORK-SERVER)))
(THEME (SEM (COMPUTER-DATA)))
(BENEFICIARY (SEM (AGENT-OF (RANGE (SEM (SEND))))))
)
```

When described in this manner, the relationship between the entries is clear (both to a human acquirer and the machine processing the scripts), and the complementarity is preserved as well.

5.3. Quantity of effort – projected and actual

The original projection was that in order to supplement the static resources for a new domain, about ~500 new ontological items and ~1,500 lexical items would be

needed. The projection proved both right and wrong: there were certainly many lexical items, which had to be acquired, however, most of them turned out not to be related to the domain of Digital Identity Management specifically. These items were "filtered out", as described in section 2.4.3, and relegated to an IOU file, which I then used as an addition to the lexicon file, so that to keep acquisition efforts to the specifics of the Digital Identity Management domain.

The domain of computer security, which was acquired shortly before the present effort began, was both a great help and a basis for expansion. For instance, after some deliberation, I have more or less completely re-done the branch of CIPHER-EVENT, expanding it to include new children and specifying it more thoroughly. Tables 5 and 6 illustrate the hierarchy of the branch before and after the changes.

Table 6. CIPHER-EVENT branch before the overhaul.

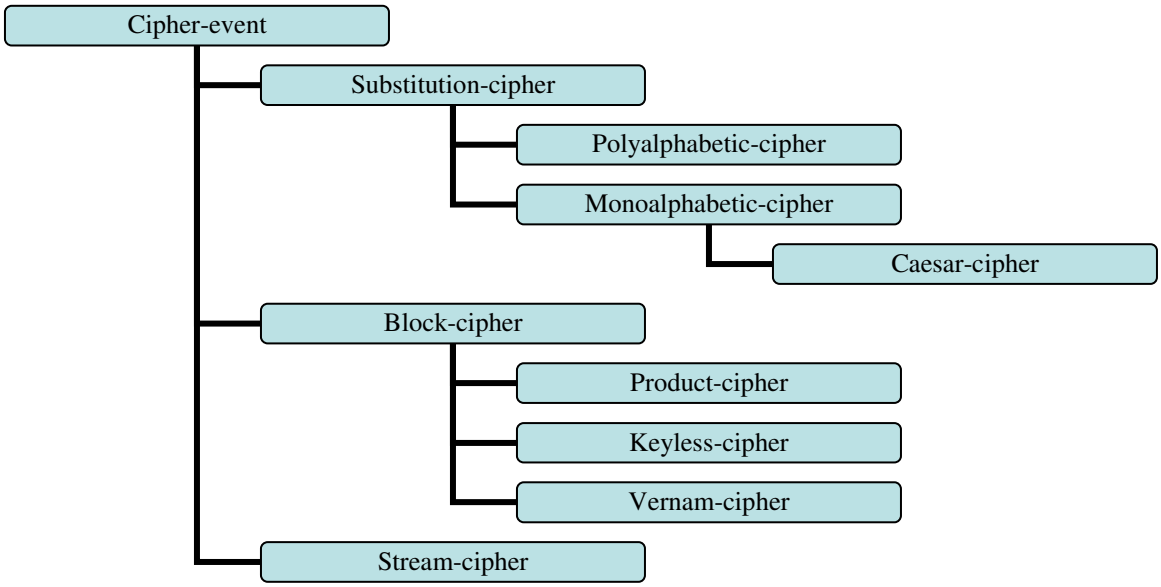
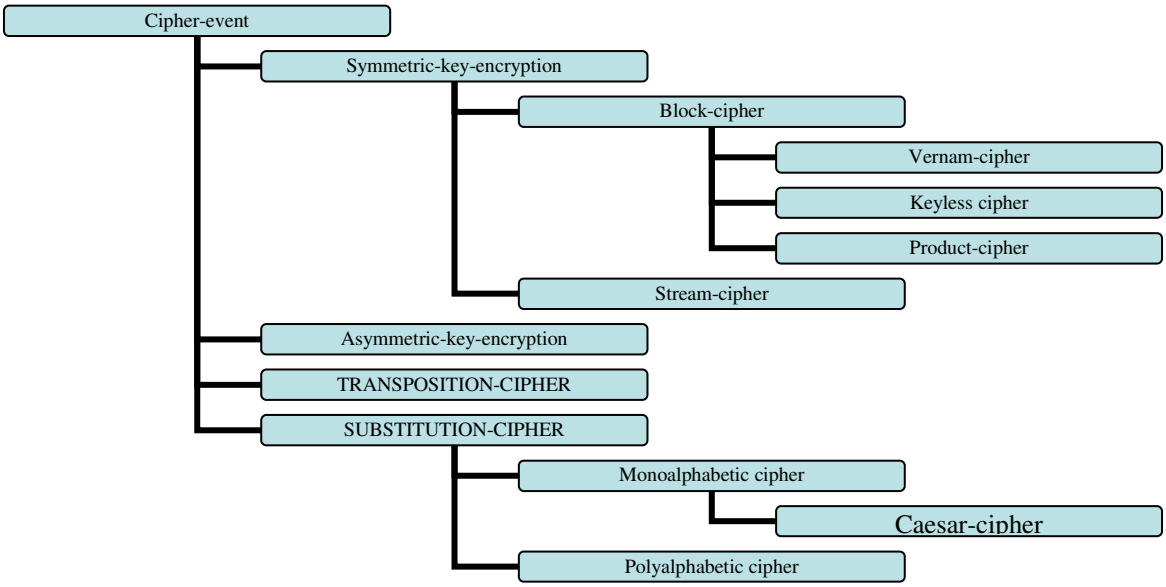


Table 7. CIPHER-EVENT branch after the overhaul.



Thus, the number of lexical entries added and expanded turned out to be lower than projected (~300 total), due to filtering of common word-stock and already-acquired items for the related domain of computer security; the number of ontological items that needed to be acquired, supplemented, or changed, however, was higher than projected in proportion to the number of lexical items. This was largely due to significant need for domain-specific additions in the PROPERTY branch, and to the need to overhaul some ontological branches, as shown above, totaling ~200.

The numbers are illustrative, however, signifying several important points:

1) Previous acquisition of overlapping domains significantly facilitates new domain acquisition;

2) New domain acquisition can require expansion of PROPERTY branch in the ontology, sometimes significantly;

3) The number of lexical and ontological items necessary for acquisition can vary depending on the criteria for domain-specificity (the number of items due for acquisition could have been significantly higher, if they included the items currently relegated to common word-stock, and if the goal of acquisition was a sweeping “leave no word behind”).

5.4. Sources used in ontological and semantic description.

I have used multiple resources for semantic and ontological description. Despite the fact that (especially at the second, bottom-up stage of acquisition) the lexical items chosen for acquisition appeared in context in the corpus, I made an effort to use as precise semantics description as possible and used several dictionaries and encyclopedias for this purpose.

Dictionary.com was specifically useful in this respect, since besides referencing entries from "The American Heritage Dictionary of the English Language" (2000), "Webster's Revised Unabridged Dictionary" (1996, 1998), and *WordNet* (version 1.6, 1997), it also had links to "The Free On-line Dictionary of Computing" (1993-2001) and "Jargon File" version 4.2.0, which were at times more useful for word sense disambiguation for the domain of Digital Identity Management, especially where it came to the lexical items, which were introduced into the mainstream vocabulary comparatively recently (e.g. "spoof", "derf").

I have also made use of Wikipedia.com, specifically for examples of usage for lexical items, as well as for semantic descriptions. Where I felt the need for the comments on how widely a specific word is used (e.g. "log off" vs. "log out") I have used www.googlefight.com to compare the frequency of word usage online.

Other examples of usage and comments come from sundry online sources; I have attempted to give preference to the texts authored by the native speakers of North American English (relying either on self-identification of the author of the web-page, or domain name extension such as .edu, .gov, .org, and .com).

5.5. Real-world specificity in ontological and semantic description

I would like to address an issue of the relation of ontological and semantic description to the real-world scientific description, as we know it. Every time I have presented the research at a conference, this question inevitably occurred to someone in the audience, in one form or another; and it does come up in both lexical and ontological acquisition.

First of all, I would like to refer again to the point addressed in section 1.7, that the differences between topology of different ontologies, and the levels of organization within one ontology are not, in fact, the most interesting ones. Since, at the present moment, the knowledge of the actual semantic organization of information in humans is minute (though introduction of fMRI methods does offer some progress in the area), and we are not attempting to model it directly, all that is necessary is that the granularity of the description fits the task in hand. Therefore, the strong linguistic relativity (Sapir-Whorf) hypothesis is not the one we entertain at any point in ontological description; on the contrary, we insist on effability and mutual translatability between languages, as they need to be represented by a single ontology.

One feature of cognitive descriptions of language, however, I did find useful in attempting to describe objects and phenomena in the digital identity management domain. Many concepts in it are, by necessity, highly metaphorical – and most of the objects in it are not the ones that humans can experience first-hand. Thus, I have made use of Lakoff's metaphorical extensions in describing, for example, the Internet as a location. Being fully aware that Internet per se is simply a system of interconnected networks, and the information available through it is physically located on one of the multiple servers connected to it, I have still used it as a metaphorical "location", as in, for instance:

```
(ONLINE-ADJ1 (CAT ADJ)
  (ANNO (DEF "an metaphorical adjective of place meaning the user is using the
Internet") (EX "I went to an online dealer to order a new computer.") (COMMENTS ""))
  (SYN-STRUC
(1  ((ROOT $VAR1) (CAT N)
  (MODS ((ROOT $VAR0) (CAT ADJ)))))
(2 ((root $var0) (cat adj)
    (subj ((root $var1) (cat n))))))
  (SEM-STRUC (^$VAR1 (LOCATION INTERNET)))
))
```

5.6. Target audience.

The goal of any ontological semantics acquisition project is to collect new data for the system (in our case, in a specific domain of knowledge), combining linguistic

theory and practice to render adequate resources for the use in natural language processing. In a sense, it is possible to say that it is not as interesting in 'what' specifically is done (though the material acquired is, of course, important and valuable in itself), as the 'how' it is done. While the entire project is primarily lexicographical in nature, the peculiarity of this particular work is that the approach is computational in nature, and can only be evaluated in terms of its applicability to natural language texts.

As such, the project has several possible audiences. The linguistic community can benefit from the evaluation of theoretical applicability of well-established and emerging theories through computational semantic approach to natural language processing. On the other hand, the computer scientists, working on the natural language processing tasks, benefit from the ready resource for a specific domain, which offers a thorough semantic representation of the domain-specific vocabulary.

5.6. Significance of the present effort and further research.

The significance of present research is in the acquisition of a highly relevant domain of Digital Identity Management, as part of Cyber-trust project, with the aims to support a broader research and education community in its effort to develop and implement a flexible identity management framework. The ontological resource is needed to:

- support and enrich representation formats for digital identities;
- apply and develop natural language processing methodologies to process policy languages;
- support the conceptual organization of the domain;
- allow for overt ontological representation of complex events and results of policy applications for various agents.
- aid in specifications of policy languages, including conditions for identity provision, revocation, profile management, identity information access, identity use etc.

Overall, the ontological support for a domain increases interoperability and coordination of efforts within it. The domain of digital identity management is

increasingly relevant in connection with the growing problem of identity theft, and expansion of online interactions and multiple-agent online collaboration in all spheres of society, including e-marketing, e-shopping, e-government, e-medicine, e-business and various applications of peer-to-peer framework.

Theoretical significance of the above research lies in the development of corpus-driven acquisition methodology, which can be used further for domain acquisition. The main methodology thus far has included paradigmatic approaches, such as rapid propagation approach (especially useful for large lexical classes), and "lexical rules" approach based on systematic relationships between classes of lexical entries. Corpus-driven methodology is more useful for "forming" domains with multiple emerging concepts and unstable use of lexical items, and presents a different sort of challenge, both in the choice of corpus for the purposes of acquisition and in the specifications of grain size of the entries.

Another point of theoretical significance of the present work lies in the application of event-structure theory to the static resources of the ontology, and the attempt to refine the grain size of lexical description and enhance the descriptive power of ontological semantics.

Further development of ontological semantics application to natural language processing, to which I am contributing, will proceed in several directions:

1) Better domain coverage and finer grain size for both lexicon and ontology. Using the emphasis on rich semantic content, it is possible to maximize the application/acquisition ratio and the use of human labor vs. machine time, which is the goal of natural language processing as a field;
2) Development of "micro-theories" used by the analytical algorithm during processing (e.g. deixis and anaphora resolution, further elaboration of event structure using syntactic and morphological filters, automatic text generation, etc.);
3) Development of applications, which could apply ontological semantics approach toward various purposes, e.g. reasoning systems, text generation, data mining, question answering, tracking behavioral scripts for self-interested agents in the text, deception detection through ontological gaps and conflicts in the text, authorship

establishment, document authentication and protection, pun generation for user-friendliness in automatic agents, and others;

4) Language-specific lexicon and processing algorithm development (at the moment, American English is the most expanded lexicon, with Spanish and Chinese following, which reflects the quantitative distribution of speakers – however, the very ontological approach, and the principle of practical effability, on which it is based, intended the use of the system for multiple languages);
5) Expansion of Fact Database and onomasticon to include the maximal number of domains, and shift toward automatic acquisition of instances for both of those static knowledge sources.

Further development of script processing for complex events with multiple self-interested agents within the ontology opens up a possibility for enhancing automated reasoning, allowing to process and plan human-computer dialog responses and goal-oriented texts. Only an approach that takes rich semantic base as its fundamental source, and also draws on syntactic and morphological resources, script-based complex event processing, and builds a “world model” ontology, thus attempting to model the output of a human language-carrying agent, can allow the framework for such diverse and multiple application.

LIST OF REFERENCES

LIST OF REFERENCES

Abelson, H., Lessig, L., Digital Identity in Cyberspace. Retrieved April 11, 2005 from http://www.swiss.ai.mit.edu/6095/student-papers/fall98-papers/identity/white-paper.html

Abernathy, W., Tien, L. Biometrics: Who's watching you? Retrieved March 28, 2005 from http://www.eff.org/Privacy/Surveillance/biometrics/

Adger, D., and Ramchand, G. 2003. Predication and Equation. Liguistic Inquiry. Volume 34, Number 3, Summer 2003. 325-359. MIT

Bacard, A., 1995. Computer Privacy Handbook. Peachpit press.

Beale, S., E. Viegas, and S. Nirenburg 1997. Breaking Down Barriers: The Mikrokosmos Generator. In: Proceedings of the Natural Language Processing Pacific Rim Symposium 1997 (NLPRS '97), Phuket, Thailand.

Bertinetto, P., 2001. On a frequent misunderstanding in the Temporal-Aspectual Domain: The 'Perfective-Telic' Confusion'. In Cecch etto, Carlo, et al (Eds.) Semantic interfaces: reference, anaphora, and aspect. Stanford: CSLI Press.

Borer, H. 2001. Exo-skeletal vs. endo-skeletal explanations: syntactic projections and the lexicon. In M. Polinsky and J. Moore (eds.) Explanation in Linguistic Theory. Stanford: CSLI.

Comrie, B., 1976. Aspect. Cambridge, UK: Cambridge University Press

Dowty, D. 1979. Word Meaning and Montague Grammar. Dordrecht, the Netherlands: D. Reidel Publishing Company.

Elliott, S. J., Kukula, E. P., & Sickler, N. C., The Challenges of the Environment and the Human / Biometric Device Interaction on Biometric System Performance, International Workshop on Biometric Technologies-Special forum on Modeling and Simulation in Biometric Technology, Calgary, Alberta, Canada. Retrieved April 11, 2005, from http://www.biotown.purdue.edu/papers/Environmental%20paper.pdf

Fillmore, Ch. 1968. The Case for Case. In E. Bach and R. Harms (eds.), Universals in linguistics theory, 1-90. New York, Holt, Rinehart & Winston.

Farwell, D., S. Helmreich, W-Y. Jin, M. Casper, J. Hargrave, H. Molina-Salgado, and F-L. Weng 1994. PANGLYZER: Spanish Language Analysis System. Proceedings of the 1st Conference of the Association for Machine Translation in the Americas, 56-64.

Filip, H. 2000. The Quantization Puzzle. In Pustejovsky, James & Tenny, Carol (eds.) Events as grammatical objects, from the combined perspectives of lexical semantics, logical semantics and syntax. Stanford: CSLI Press.

Heine, G., 1999. GSM Networks: protocols, terminology, and implementation. Artech House Publishers.

Hendry, M., 1997. Smart Card Security and Applications. Artech House Publishers.

Gattiker, U.E., 2004. The Information Security Dictionary: Defining the Terns that Define Security for E-Business, Internet, Information and Wireless technology. Kluwer Academic Publishers.

Goodman, K., and S. Nirenburg (eds.) 1991. KBMT-89: A Case Study in Knowledge-Based Machine Translation. San Mateo: Morgan Kaufmann.

Jackendoff, R. 1990. Semantic structures. Cambridge: MIT Press.

Jackendoff, R., 2002. Foundations of language: Brain, Meaning, Grammar, Evolution. Oxford University Press

Klosek, J., 2000. Data Privacy in the Information Age. Quorum books.

Ladusaw, W., and Dowty, D. 1988. Toward a nongrammatical account of thematic roles. pp. 62-73 in W. Wilkins, ed., Syntax and semantics 21: Thematic relations. New York: Academic Press.

Lakoff, G. 1977. Linguistic gestalts. CLS 13:236-87.

Levin, B. 1993. English Verb Classes and Alternations: a Preliminary Investigation. The University of Chicago Press, London.

Malaia, E. (forthcoming, 2005) Even structure and telicity in Russian: an event-based analysis for telicity puzzle in Slavic languages. Ohio State University Working Papers in Slavic Studies, Vol. 4: Ohio State University.

Meyer, I., B. Onyshkevych, and L. Carlson 1990. Lexicographic principles and design for knowledge-based machine translation. Technical Report CMU-CMT-90-118, Center for Machine Translation, Carnegie Mellon University, Pittsburgh, PA.

Monarch, I., S. Nirenburg, and T. Mitamura 1989. Ontology-Based Lexicon Acquisition for a Machine Translation System. Proceedings of the Fourth Workshop on Knowledge Acquisition for Knowledge-Based Systems, Banff, Canada. August.

Nirenburg, S. 1986. Linguistics and Artificial Intelligence. In: P. C. Bjarkman and V. Raskin (eds.), The Real-World Linguist: Linguistic Applications in the 1980s, Norwood, NJ: Ablex, 116-143.

Nirenburg, S., Raskin, V. 2004. Ontological Semantics. Cambridge, MA: MIT press.

Oflazer, K., and S. Nirenburg 1999. Practical Bootstrapping of Morphological Analyzers. Proceedings of Computational Natural Language Learning (CoNLL-99) Workshop at EACL'99, Bergen, Norway.

Parsons, T., 1990. Events in the semantics of English. Cambridge, MA: MIT Press

Pustejovsky, J. 1995. The Generative Lexicon. Cambridge, MA: MIT Press

Pustejovsky, J. 1991. The syntax of event structure. Cognition 41: 47-81.

Ramchand, J. 2003. First Phase Syntax. Ms., University of Oxford.

Ramchard, G., 1997. Aspect and predication: the Semantics of Argument Structure. Oxford: Oxford University Press.

Raskin, V., Nirenburg, S. 1995. Lexical Semantics of Adjectives: A microtheory of Adjectival Meaning. MCCS-95-288.

Rappaport Hovav, M., Levin, B. 2002. Change of state verbs: Implications for theories of argument projection. BLS 28.

Redmon, A., 2003. Reaching toward a full lexical description of the southern Baptist sermon sublanguage. Ph.D. dissertation, unpublished manuscript, Purdue University.

Shank, R., Abelson, R., 1977. Scripts, plans, goals and understanding . Hillsdale, NJ: Erlbaum

Talmy, L. 1976. Semantic causative types. pp. 43-116 in M. Shibatani, ed., Syntax and semantics 6: The grammar of causative constructions. New York: Academic Press.

Talmy, L. 1978. Figure and ground in complex sentences. pp. 625-49 in J. Greenberg, et. al., eds., Universals of human language, vol. 4: Syntax. Stanford: Stanford UP.

Talmy, L. 1985. Lexicalization patterns: Semantic Structure in Lexical Forms. Language typology and Syntactic Description III: Grammatical Categories and the lexicon, ed. by T. Shopen, 57–149, Cambridge University Press.

Talmy, L. 2001. Toward a Cognitive Semantics. Cambridge: MIT Press.

Tatevosov, S., 2000. Imperfectivity, Perfectivity, and Delimitativity. Retrieved March 28, 2005 from www.uni-leipzig.de/~gksprach/asp_ws/tatevosov.pdf

Tenny, C and Pustejovsky, 2000. Events as grammatical objects – the converging perspectives of lexical semantics and syntax. Center for the Study of Language and Information, Stanford, CA

Televnaja, J. 2004. Lexical acquisition and semantic representation of English phrasal verbs in ontological semantics. Ph.D. dissertation, unpublished manuscript, Purdue University.

Tenny, C., Pustejovsky, J. (eds.) 2000. Events as grammatical objects. CSLI Publications

Turkle, S., 1995. Life on Screen. Simon and Schuster.

Turkle, S., Who am we? Retrieved from http://wired-vig.wired.com/wired/archive/4.01/turkle_pr.html on April 12, 2005

Pfaffenberger, B., 1997. Protect Your Privacy on the Internet. Wiley Computer Publishing.

van Hout, A. 1996. Event Semantics of Verb Frame Alternations, Ph.D. dissertation, Tilburg University.

Van Hout, A., 2000. Projection Based on Event Structure. In Coopmans, Peter et al. (Eds.) Lexical Specification and Insertion, pp. 403-427. John Benjamins Dissertation Series.

Vendler, Z., 1967. Linguistics and philosophy. Ithaca: Cornell University Press

Wayman, J., The Functions of Biometric Identification Devices. Retrieved April 11, 2005, from http://www.engr.sjsu.edu/biometrics/publications_tech.html

Industry white papers:

Requirements for a Global Identity Management Service
A position paper from oneName corporation for the W3C workshop on WebServices, 11-12 April 2001, San Jose, CA. Retrieved April 11, 2005, from http://www.w3.org/2001/03/WSWS-popa/paper57

Introduction to the Liberty Alliance identity architecture, Revision 1.0 March 2003 Liberty Alliance Project. Retrieved April 11, 2005, from https://www.projectliberty.org/resources/whitepapers/LAP%20Identity%20Architecture%20Whitepaper%20Final.pdf

Security in a Web Services world: a proposed Architecture and Roadmap
A Joint White Paper from IBM Corporation and Microsoft Corporation. Retrieved April 11, 2005 from http://www-106.ibm.com/developerworks/webservices/library/ws-secmap/

Federated Identity Management: Corporate strategies from managing security, liability, scalability and the risk of fraud as identity moves toward federation. PingID White Paper. Retrieved April 11, 2005, from http://www.pingid.net/misc/Whitepaper_Identity_Federation.pdf

Discover Dialogue: Social Scientist Sherry Turkle: A Psychologist in Cyberspace, DISCOVER Vol. 24 No. 06, June 2003, retrieved from http://www.discover.com/issues/jun-03/rd/breakdialogue.html/ on April 12, 2005

VITA

VITA

□□□□□□□□□□□□□□□□□□□□□□

Education

Ph.D. **Linguistics Program** **Purdue University**	August 2005 Major: Computational Linguistics Dissertation title: "Digital Identity Management domain for Ontological Semantics: domain acquisition methodology and practice"
Graduate Certificate in Natural Language Processing	awarded in May 2004
Specialist with a Diploma in Applied Linguistics **(M.A. equivalent)** **Chuvash State Pedagogical University**	Majors: English and German Thesis "Hypertext fiction, its patterns, and link as a stylistic device" was successfully defended in Russian and English

Professional Experience

Graduate Research Assistant	CERIAS (The Center for Education and Research in Information Assurance and Security) and NLP Lab, Purdue University (2004 – present)

Worked on natural language processing and ontology support for representation formats, information organization, and language usage for Digital Identity Management as part of ITR initiative funded by NSF grant 0428554, supervised by professor Raskin. Contributed to research on phrasal verb treatment in Ontological Semantics.

Media/Legal Intern EFF, San-Francisco, CA, (summer 2002)

Wrote web content and articles on the development of international and US copyright law (copyright term extension, piracy, legislation and technology (CBDTPA, DMCA), open audio license, private performance rights). Attended brainstorming meetings of the legal team and technology team, worked closely with attorneys and technology coordinator to research issues pertaining to interaction of law and technology. Played Diablo online as part of the Blizzard vs. BnetD legal team effort to establish the extent of interoperability and possible copyright infringement under DMCA.

International Business Assistant Scientific-production enterprise "Dynamics", Cheboksary, Russia (1996-2001, part-time)

Interpreted at international meetings, translated technical documentation for relay protection software and hardware. Worked under tight deadlines, managed multiple projects.

Academic Teaching Experience

Graduate Teaching Assistant Linguistics Program Purdue University. Lafayette, IN (fall 2002 – spring 2004)

Assisting in teaching a basic lecture course (90 students) *Introduction to Linguistics* (three semesters). Responsible for grading students' writing assignments, designing exams and quizzes, generating out-of-class discussions, creating and managing course's website, conducting special seminars, and lecturing on several topics (including semantics and pragmatics).

Team Leader Accelerated Learning program SuperCamp, Colorado Springs, CO (summer 2004).

Facilitated an accelerated learning program based on neuro-linguistic programming techniques, including speed reading, creative writing and language learning, for high school students from around the world.

Teaching Assistant Pre-departure orientation for FSA-FLEX program participants 1999-2000, Nizhny Novgorod, Russia.

Created and conducted interactive trainings in intercultural communication, personal development and vision building to a group of 20 students chosen to spend a year in the United States high schools on FSA scholarship.

Awards and Honors

Best Credentials E-portfolio University-wide e-portfolio competition, Purdue University, 2005.

Graduate Teaching Certificate	Awarded by the Office for Instructional Excellence, Purdue University, to Teaching Assistants, who taught a minimum of two semester-long classes, participated in a PU campus teaching orientation and micro-teaching with consultative feedback, participated in a minimum of six hours of continuous improvement sessions focused on teaching, were observed while teaching followed by consultative feedback and written self-analyses; utilized Informal Early Feedback and end-of semester student evaluations for two semesters, including written self-analysis, and created a pilot portfolio by documenting teaching and professional development activities. (2004)
Honorable Mention	International Essay Contest for Young People; awarded by GOI Peace Foundation, Japan (November 2002)
Kneale Literary Award	2nd place in Short Prose section; awarded by Purdue University (April 2002)
1st place in Parliamentary Debates and Best Speaker	Western-NIS British Parliamentary Debate Tournament, Moscow, Russia (July 2001)
1st place in Republican web-design competition Cheboksary, Russia, 2001	"Best educational Web-site by young designers",
1st category diploma of Russian National Conference-festival "Youth of Big Volga"	for research in linguistics (March 1999).

Professional university and community services

Purdue Graduate Student Government	senator from Linguistics Program. (2003-2004)
Travel Grant Committee PGSG	reviewer for the university-wide travel grant competition.
Invited speaker	invited to attend a closed pre-departure orientation for Young Leadership Fellows of IEX in Moscow. Presented a

	lecture on graduate learning in US universities and success strategies for international students. (August 2002)
Guest lecturer	*Copyright in Digital World.* National Russian conference of computer specialists "Spryg-2002). Covered topics of current trends in legal approaches to copyright in the United States and international perspectives on intellectual property law.
Chair, Student Scientific Society	Chuvash State Pedagogical University, Linguistics Department (1999-2001).

Grants, Fellowships and Scholarships

PGSG Travel Grant	A competitive university-wide grant for presentations of student work at conferences; received in order to present in Denmark, fall 2003.
Russian-US Young Leaders for Public Service Fellowship	awarded by the US Department of State, $25,000 2001/2002
US-Russian Student Leaders Fellow	A fellowship to attend Russian-US Student Leaders Conference at Stanford, CA (2000)
Student fellowship by Government of Russian Federation	Provided by the government of Russian Federation to the best 100 students in Russia. (1998/1999 academic year)
FSA-FLEX Scholarship	Awarded by the US Department of State, $12,000, 1995-96

Publications

Malaia, E. (forthcoming). *Event structure and telicity in Russian: an event-based analysis for telicity puzzle in Slavonic languages.* Ohio State University Working Papers in Slavic Studies, Vol. 4: Ohio State University.

Raskin, V., Triezenberg, K., Malaia, E. (2005). *Domain acquisition for ontological semantics*. Proceedings of Midwest Computational Linguistics Colloquium.

Spartz, J., E. Malaia, and C. Falk (2005). *Methodology and Tools for Ontological Semantic Acquisition.* Proceedings of Midwest Computational Linguistics Colloquium.

Raskin, V., Triezenberg, K., Malaia, E., Hempelmann, C., Mohamed, D., (2004). *The Purdue Ontological Semantic Project*. Proceedings of Midwest Computational Linguistics Colloquium.

Malaia, E. (2003). Online affiliation formation. Proceedings of the 1st Nordic Symposium on Multimodal Communication: Copenhagen, Denmark.

Presentations and papers

Malaia, E. (2005, March). *Digital Identity Management – domain implementation in Ontological Semantics*. Poster presented at CERIAS 6th annual Information Security Symposium, Purdue University.

Malaia, E. (2004, April). *Indiana Dialect Survey – an online implementation*. Working prototype presented at conference Teaching and Learning with Technology: Engaging Students in a Virtual World, Purdue University.

Malaia, E., Kaganovich, N. (2004, April). *Using Internet and WebCT Connection in Teaching Introductory Linguistic Courses.* Poster presented at conference Teaching and Learning with Technology: Engaging Students in a Virtual World, Purdue University.

Malaia, E. (2004, January). *Case for OT case assignment.* West Lafayette: Purdue University. Manuscript, Rutgers Optimality Archive.

Malaia, E. (2003, November) *Event structure and telicity in Russian: an event-based analysis for telicity puzzle in Slavonic languages.* Paper presented at Midwest Graduate Colloquium on Slavic Linguistics, Ohio University.

Malaia, E. (2003, May). *Online affiliation formation.* Paper presented at the Nordic Symposium for Multimodal Human-computer interaction, Copenhagen, Denmark.

Membership in Professional Organizations

Linguistic Society of America
Society for Slavic Linguistics

Other certifications and skills

CITI Course in the Protection of Human Research Subjects, Fall 2004
Programming in Java; web-design.
ERP lab experience.

Languages

- English
- Russian – native
- German – working knowledge,
- Chuvash (Altaic language family) – linguistic familiarity