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Energy-Efficient Provenance Transmission in Large-Scale Wireless Sensor Networks

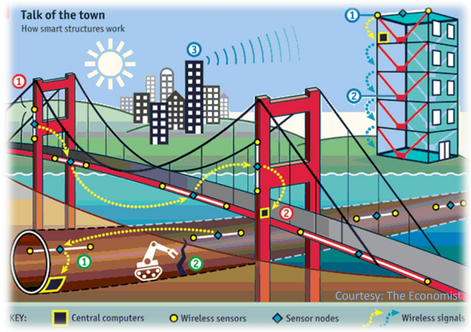
S. M. Iftekharul Alam
Electrical and Computer Engineering , Purdue University

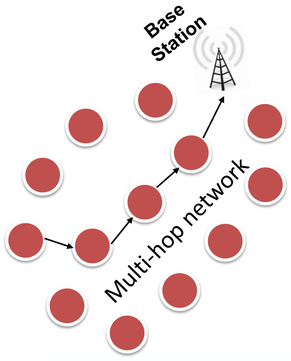
Sonia Fahmy
Computer Science, Purdue University

PURDUE UNIVERSITY

Emergence of Large Scale Sensor Networks

- Global Sensor Network to fight climate change.
- Sensor based *decision support systems* to monitor power grid and critical infrastructures:
  - Smart Grid
  - Smart Building
  - Smart Bridge
  - Smart Tunnel



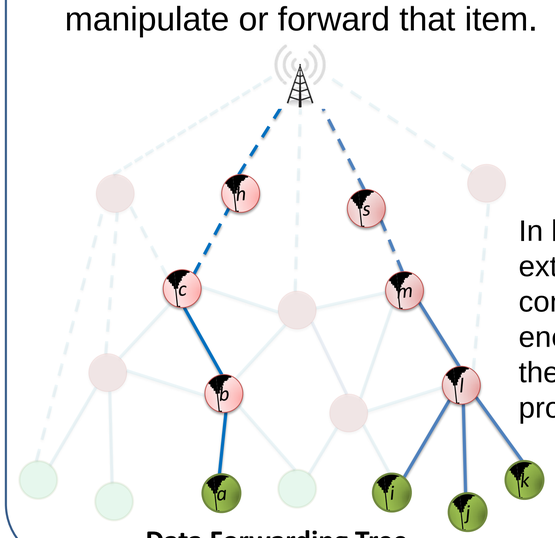


- Data item is collected from sensors at the base station and made available to decision makers for further analysis.

Trustworthiness of data affects the quality of decision making

Provenance and Trust Framework

- Trust models assess trustworthiness of data based on provenance similarity and value similarity.
- Provenance of a data item is a tree of nodes that manipulate or forward that item.



Data Forwarding Tree

In large scale networks, extended period of radio communication and energy dissipation due to the increasing height of provenance tree.

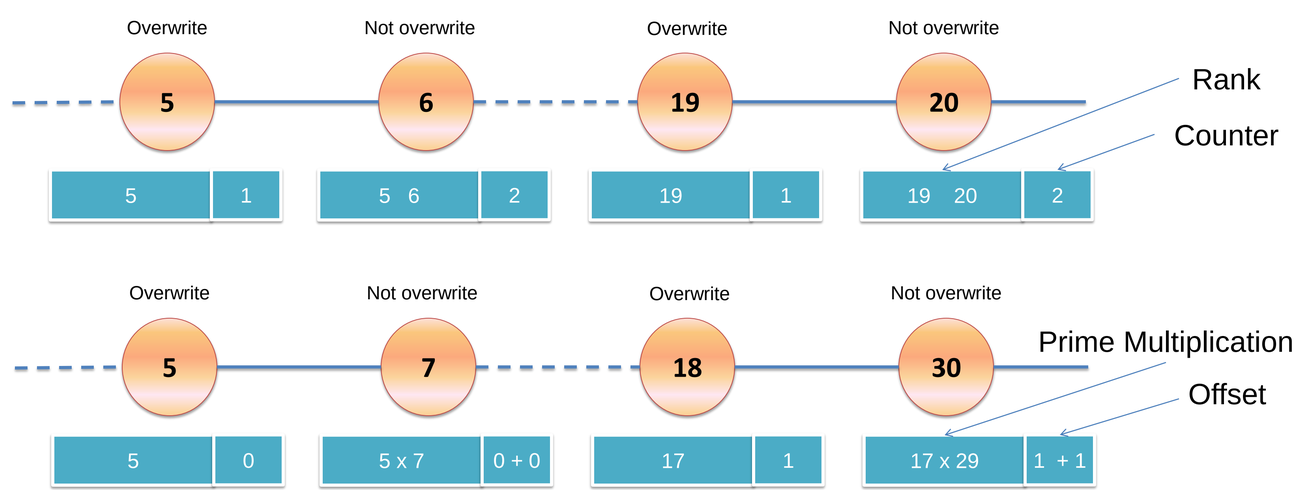
Probabilistic Provenance Flow (PPF)

Adaptation of probabilistic packet marking (PPM) of IP traceback

Embedding a connected sub-graph of full provenance into a single packet	Two complementary encoding schemes : (a) **Juxtaposition of ranks** and (b) **Prime multiplication**	Faster decoding and construction of provenance

Provenance Encoding

- *prime(n)* = The greatest prime number less than or equal to *n.*
- *offset(n) = n – prime(n).*
- Difference between node ID and *prime(ID)* is less than or equal to 7.
- *rank(ID)* = Position of *ID* in an increasing sequence of IDs of all member nodes.



Provenance Decoding and Construction

Rank method: Use the counter to extract partial provenance.

*Use **Prime Factorization*** to extract data from prime multiplication field.

Use solution to ***Subset Sum*** problem to extract data from offset field.

Exploit ordering information extracted by *rank* method.

Full provenance: at least one ID for every node is received.

Goals and Challenges

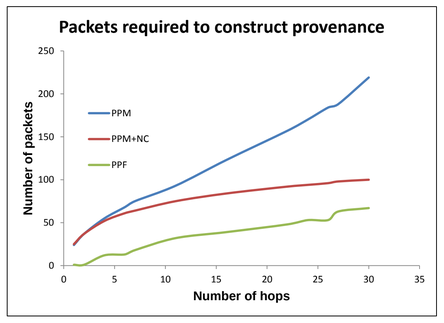
Probabilistic incorporation of node ID to reduce the expected length of the provenance.

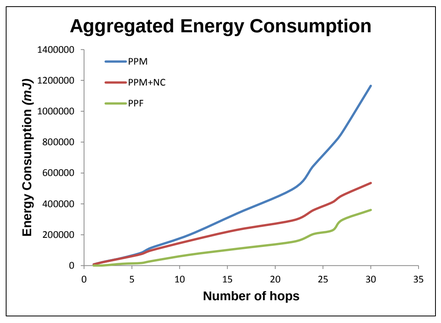
Number of bits required to represent provenance should be fixed.

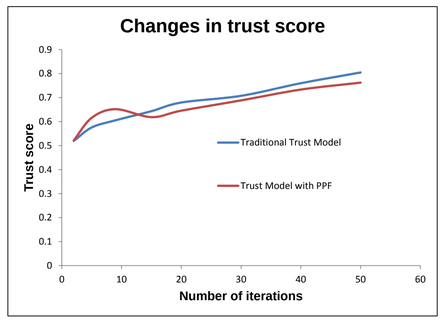
Fast convergence of provenance construction is critical.

Topological changes should be rapidly reflected in provenance.

TOSSIM Simulation







- PPF requires 33% fewer packets than PPM based approaches of IP traceback.
- PPF consumes 30% less energy than PPM with network coding.
- Trust model integrated with PPF provides high level of accuracy for trust score calculation.

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