WiSe (Wireless Sensornet) Laboratory

WESTERN MICHIGAN UNIVERSITY

Opportunistic Networks and Their Privacy and Security Challenges

Leszek Lilien,[1,2] Zille Huma Kamal,[1] Vijay Bhuse[1] and Ajay Gupta[1]

[1] WiSe Lab, Department of Computer Science, Western Michigan University, Kalamazoo, Michigan

[2] Affiliated with the Center for Education and Research in Information Assurance and Security (CERIAS), Purdue University, West Lafayette, Indiana

1. Opportunistic Networks – The Missing Link?

- ❖ Communication network forms the backbone of any organization or service
  - ➢ Including emergency response systems
    - ▪ Delays, even chaos, in responses most often blamed on communications breakdown
    - ▪ Also blamed on lack of other resources
- ❖ We have invented an entirely new category of computer networks: **Opportunistic Networks**, or **Oppnets** – can help in such problems
  - ➢ In oppnets, diverse systems—not deployed originally as oppnet nodes—join an oppnet dynamically in order to perform certain tasks they have been invited (or ordered) to participate in

2. Objectives

- ❖ Oppnets are envisioned to provide, among others:
  - ➢ Bridges between disjoint communication media
  - ➢ Additional platforms for offloading tasks
  - ➢ Additional sensing modalities by integrating existing independent sensory systems

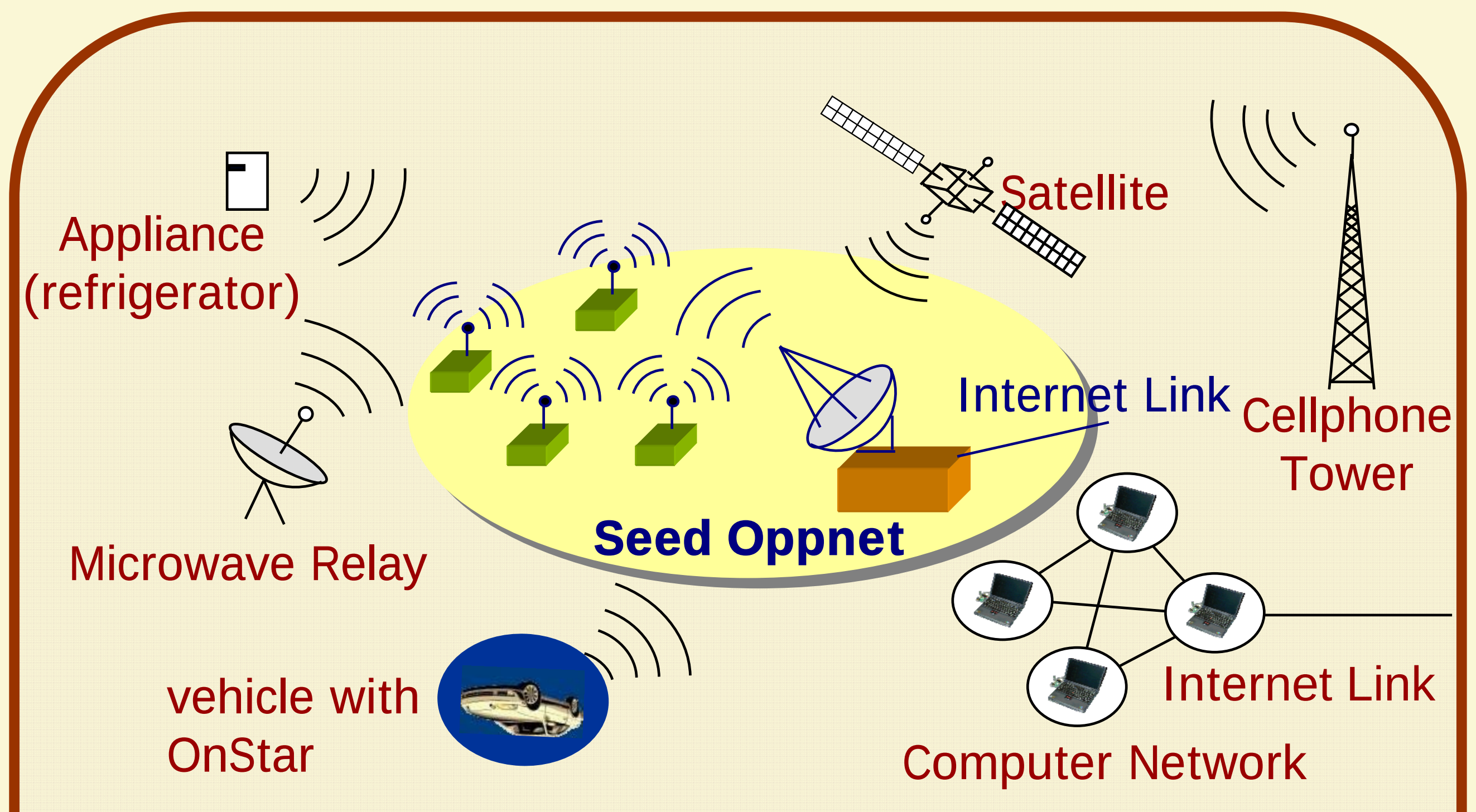
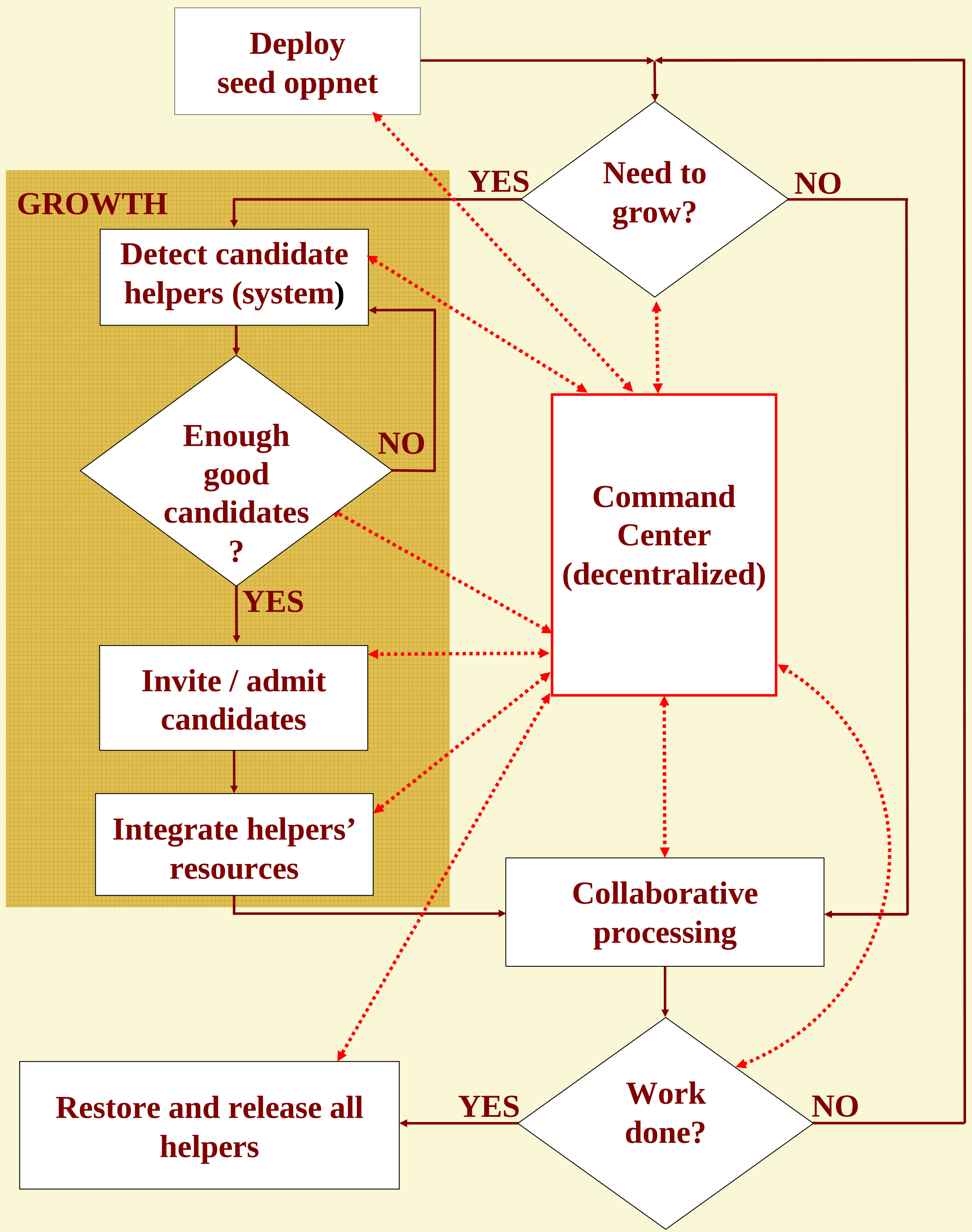


Figure 3. Expanded Oppnet

4. Example Emergency Application

- ❖ Seed oppnet is deployed after a man-made or natural disaster
- ❖ Seed orders (in emergency!) many helpers to join:
  - ➢ computer network – ordered via wired Internet link
  - ➢ cellphone tower – via Bluetooth-enabled cell-phone
  - ➢ satellite – via a direct satellite link
  - ➢ home area network – via embedded processors in a refrigerator
  - ➢ microwave data network – via a microwave relay
  - ➢ BANs (body area networks) on or within bodies of occupants in an overturned car – via OnStar™
- ❖ Example shows how an oppnet can leverage resources—such as communication, computation, sensing, storage, etc.—available in its environment



Deploy seed oppnet

Need to grow?

YES

NO

GROWTH

Detect candidate helpers (system)

Enough good candidates ?

NO

YES

Invite / admit candidates

Integrate helpers' resources

Command Center (decentralized)

Collaborative processing

Work done?

YES

NO

Restore and release all helpers

Figure 1. Basic Oppnet Operations

5. Privacy Challenges

- ❖ Privacy is the „make it or break it" issue for oppnets
  - ➢As for any pervasive computing technology
- ❖ Protecting oppnet from helpers and helpers from oppnet
- ❖ Assuring privacy
  - ➢ Privacy of data storage and processing
  - ➢ Privacy of communication based on its patterns
    - • E.g., broadcast/multicast from/to the base station
- ❖ Using trust and increasing it
  - ➢ Routing through more trusted systems
  - ➢ Using shared secrets with b-cast authentication
  - ➢ Using digital signatures

6. Security Challenges

- ❖ Prevent malicious helpers from joining
- ❖ Prevent common attacks
  - ➢ MITM (man-in-the-middle)
  - ➢ Packet dropping
  - ➢ DoS attacks on weak devices
  - ➢ ID spoofing
- ❖ Develop „good" lightweight cryptographic primitives
- ❖ Use Intrusion Detection (ID) – when prevention fails
  - ➢ Heterogeneous – real-time ID and response
  - ➢ Secure distribution of information amongst nodes about malicious entities

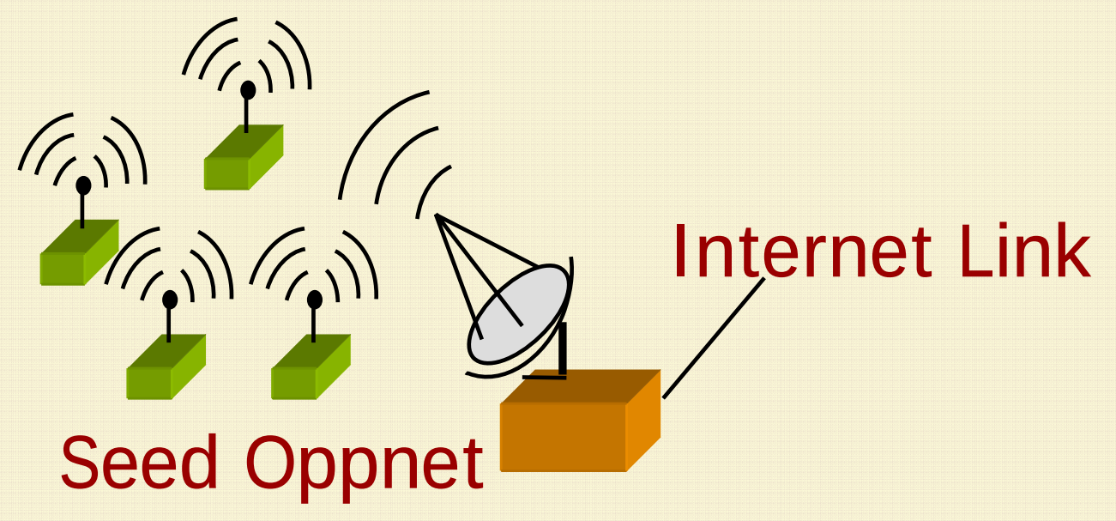


Figure 2. Seed Oppnet

3. Seed Oppnet and Expanded Oppnet

- ❖ First, a pre-designed **seed oppnet** is deployed (Fig.2)
- ❖ Seed oppnet growth (cf. GROWTH block in Fig. 1)
  - ➢ Detect candidate helpers
  - ➢ Evaluate candidates
  - ➢ Invite and admit selected candidates
    - ▪ Candidate that joins oppnet becomes a **helper**
  - ➢ Integrate helpers' resources
- ❖ Seed oppnet grows into **expanded oppnet** (Fig. 3)
- ❖ Collaborative processing
  - ➢ Oppnet determines useful helper functionalities
  - ➢ Oppnet offloads tasks to helpers
  - ➢ Oppnet manages offloaded tasks

7. Other Research Challenges (cf. Fig. 1)

- ❖ Detecting candidate helpers in diverse communication media
  - ➢ Integrate disparate technologies
    - ▪ Possible solution: virtualize at the network layer to seamlessly enable communication between devices in different medium
      - - Similar to virtual machines in grid computing
  - ➢ Distinguish between devices found in the same communication medium
    - ▪ Differentiate between devices by services rendered
  - ➢ Classify and evaluate candidate's usefulness and reliability
    - ▪ Categorize as computation, communication, sensory, storage, etc., resource
    - ▪ Usefulness depends on oppnet's goals
- ❖ Inviting candidates and admitting the ones that accept invitation
  - ➢ Candidates are helpers not slaves
  - ➢ But in emergencies, mandatory „call to arms"
- ❖ Integrating helpers' resources
  - ➢ Managing network dynamics, offloading tasks to helpers that are best suited for given jobs, coordinating tasks
- ❖ Collaborative processing
  - ➢ Data integration, information fusion
- ❖ Restoring and releasing helpers
  - ➢ To minimize oppnet's intrusiveness w.r.t. helpers