

Opportunistic Networks for Emergency Preparedness and Response

Leszek Lilien^{1,2} and Ajay Gupta¹

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

² Affiliated with Regenstrief Center for Healthcare Engineering and Center for Education and Research in Information Assurance and Security, Purdue University, West Lafayette, Indiana

1. Opportunistic Networks – The Missing Link?

- ❖ Communication network forms a backbone of any organization or service
 - Including **Emergency Preparedness and Response (EPR)** systems
 - Communications breakdowns blamed for delays, even chaos, in emergency responses
 - Also blamed for lack of other resources
- ❖ We have invented an entirely new category of computer networks: **Opportunistic Networks, or Oppnets** – well suited for helping in emergencies
- ❖ Basic idea: Diverse systems join an oppnet dynamically in order to perform certain tasks they have been invited (or ordered) to participate in

2. Objective: Leveraging Resources

- ❖ Oppnets leverage resources by (among others):
 - Bridging diverse *communication media*
 - Offloading *computations* to additional platforms
 - Integrating independent *sensing* systems to enhance their sensing capabilities

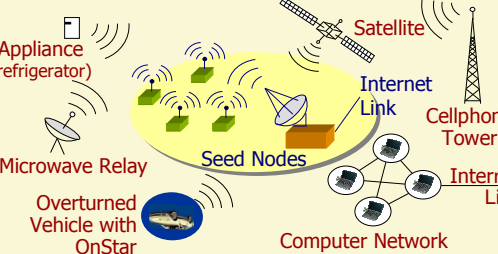


Figure 3. Expanded Oppnet Example.

4. Oppnet Emergency Preparedness

- ❖ For **unpredictable emergencies** (e.g., unexpected terrorist attacks, earthquakes), seed deployed after a disaster —without any preparations
- ❖ For **predictable emergencies** (e.g., expected terrorist attacks, hurricanes), seed deployed and even grows into expanded oppnet before a disaster
 - Oppnet will suffer losses during the disaster
 - By having expanded *before* the disaster, oppnet able to grow more quickly *after* the disaster
- ❖ Facilitating oppnet growth by preparing **Oppnet Reserves** (like Army Reserves) ahead of crises
 - Not required but helpful
 - Volunteer helpers sign up for Oppnet Reserves well ahead of any emergency
 - Maybe for some incentives (moral, monetary, etc.)
 - „Trained” for active duty by installing facilities that make them easier to contact by oppnets
 - E.g., install standard oppnet protocols
 - Ready for active oppnet duty whenever needed



Figure 1. Seed Oppnet Example.

3. Seed Oppnet and Expanded Oppnet

- ❖ First, a pre-designed **seed oppnet** or a **seed** is deployed (Fig.1)
- ❖ A seed grows (cf. the GROWTH block in Fig. 2)
 - Detects **candidate helpers**
 - Evaluates candidates
 - Invites and admits selected candidates
 - Candidate that joins oppnet becomes a **helper**
 - Integrates helpers' resources
- ❖ **Expanded oppnet** is the result of growth (Fig. 3)
- ❖ Oppnet uses helpers for collaborative processing
 - Determines useful helper functionalities
 - Offloads tasks to helpers / Manages tasks
 - Releases a helper when no longer needed

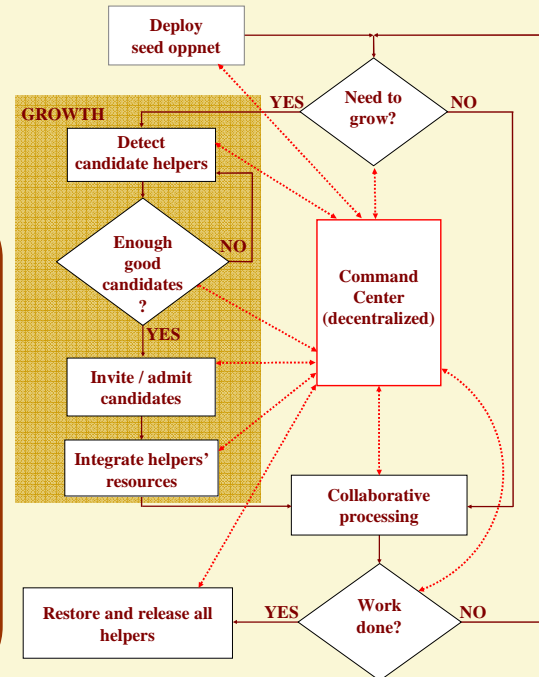


Figure 2. Basic Oppnet Operations. [Z. Huma Kamal]

5. Oppnet Emergency Response

- ❖ **Example 1: Oppnet's Emergency Response After a Disaster**— A deployed seed orders (this is an emergency!) the following helpers to join (Fig. 3):
 - Satellite system – ordered via a direct link
 - Cellphone infrastructure – via Bluetooth-enabled cellphone
 - Computer network –via wired Internet link
 - Body area networks (BANs) on or within bodies of occupants in an overturned car – via OnStar™
 - Microwave data network – via a microwave relay
 - Home area networks (HANs) – via, e.g., an embedded processor in a refrigerator
- ❖ By **ordering** helpers to join in **life-or-death emergencies**, an oppnet leverages resources (communication, computation, sensing, storage, etc.) available in its environment
 - Oppnet must **ask** for help **when no emergency**
- ❖ **Example 1 cont.**— Use of diverse oppnet helpers
 - Helper 1 —supervising visual surveillance cameras— detects an overturned car (cf. Fig. 3)
 - Helper 2 asked to recognize its license plate
 - Helper 3 finds that the car has OnStar link
 - Helper 4 contacts BANs (Body Area Network) on or within bodies of car occupants via OnStar infrastructure
 - Helper 5 evaluates obtained info
 - Helper 6 dispatches rescuers for car occupants

Oppnet Emergency Response—cont.

- ❖ **Example 2: Use „Hidden” Helper Capabilities**
 - After a disaster oppnet contacts 2 independent sensornets (SNs):
 - Water infrastructure control SN
 - Public space surveillance SN
 - SNs ordered to abandon normal functions, and help in rescue & recovery operations
 - Water infrastructure SN (with multisensor capabilities, under road surfaces) — ordered to sense vehicular movement and traffic jams
 - Public space surveillance SN — ordered to search for images of human victims

6. Major Research Challenges

- ❖ **Interoperability** challenges
 - Bridge diverse networking technologies
 - Detect / contact candidate helpers
- ❖ Challenges in providing **basic primitives**
 - For operations identified by blocks in Fig.2
- ❖ **Privacy** Challenges
 - Privacy is the „make it or break it” issue for oppnets (as for any pervasive computing)
 - Mutual privacy protection from each other among: Oppnet / Helpers / Environment
- ❖ **Security** Challenges
 - Mutual security protection from each other among: Oppnet / Helpers / Environment
 - Develop lightweight cryptographic primitives
 - Develop specialized Intrusion Detection