

# New Trends in Software Engineering

## Software Engineering for Mobility

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## Motivation



If the efforts among the organizations are not well coordinated, the actions of one of them can generate problems to others [Comfort, 2001].



# Outline



- ◆ Disasters in Urban Areas
- ◆ Problems to Solve with Technology
- ◆ Related Work
- ◆ New Collaboration Approach
- ◆ IT Restrictions for Collaboration
- ◆ Others Scenarios to be Supported
- ◆ Conclusions

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# Disasters in Urban Areas



Earthquake - Loma Prieta - 1989



Hurricane Andrew - Florida - 1992



## IFRC, 2003:

- 608 million people were affected by disasters around the world in 2002.
- 24,500 died.
- \$27 billion in economical damages to property and the environment.

It is expected the exponential increase of disaster losses to continue [Mileti, 1999, p. 66].



Tornado - Oklahoma and Kansas - 1999



Explosion - New York - 2001

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# Disasters in Urban Areas



- ◆ The cities population is growing along coastlines, fault zones, and other hazardous areas [Mileti, 1999].
- ◆ The built environments are growing in density, making the potential losses from natural forces larger [Mileti, 1999].
- ◆ The current warming of the global climate will produce more dramatic meteorological events [Mileti, 1999].
- ◆ Cities are complex and interdependent systems, extremely vulnerable to threats from both natural hazards and terrorism [Godschalk, 2003].
- ◆ The XE in urban areas have low probability but high social and economic impact [CWR, 2002].



**“Solutions to reduce the vulnerability of urban areas are expected”** [NRC, 2002].

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# Outline

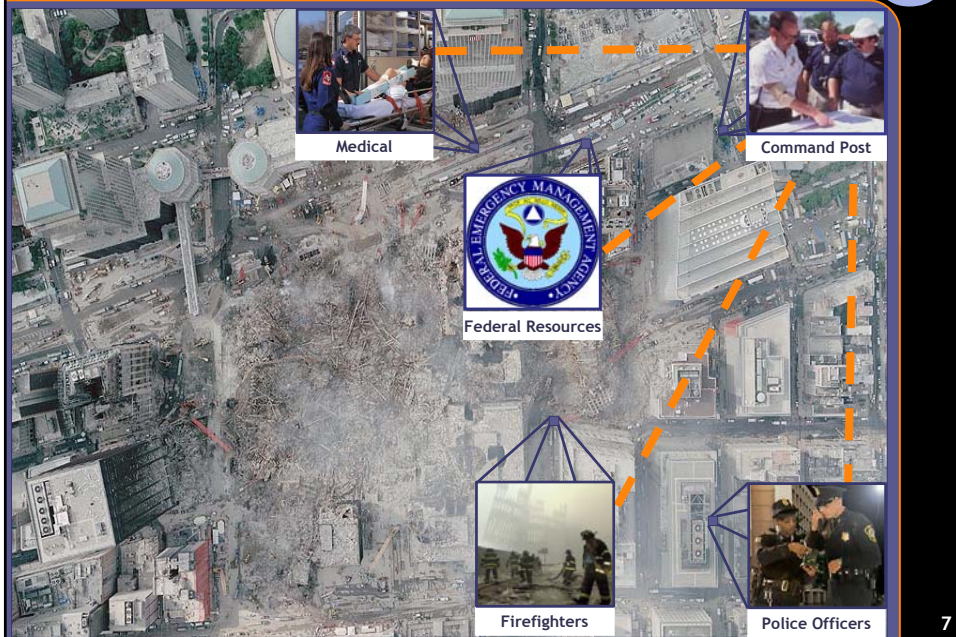


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## Problems to Solve with Technology C<sub>P2R</sub>



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## Problems to Solve with Technology C<sub>P2R</sub>

**Lack of:**

- Integral Efforts [NRC, 1999; Stewart, 2002]
- Civil Engineers by Supporting the Process [Prieto, 2002]
- Reliable and Flexible Communication Media [NRC, 2002]
- Information Availability and Trustworthiness [Prieto, 2002]
- Learning [Cohen, 1997]

Command and Control Model has shown limited effectiveness in complex disaster contexts [Prieto, 2002]

This slide features the same aerial disaster scene as slide 7, with the same inset photos for Medical, Command Post, Federal Resources (FEMA logo), Firefighters, and Police Officers, all interconnected by a network of dashed orange lines. The layout is identical to the one on slide 7, but with the addition of the text on the left.

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# Consequences



Frustration

<http://wtc911.online.fr>



Low Productivity

© Mario Tama - Getty Images - 2001



© Justin Lane - New York Times - 2001

Human Losses



© Steve McCurry - New York Times - 2001

Economic Losses

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## Related Work



- ◆ **FRP** (Federal Response Plan) [FEMA, 1999]
- ◆ **NCSA MSCMC** (Multi - Sector Crisis Management Consortium) [MSCMC, 2003]
- ◆ **NCSA GDIN** (Global Disaster Information Network) [GDIN, 2003]
- ◆ **PSWN** (Public Safety Wireless Network) [Lee, 2002]
- ◆ **TISP** (The Infrastructure Security Partnership) [TISP, 2003]
- ◆ **DHS** (Department of Homeland Security) [DHS, 2004]

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## Outline

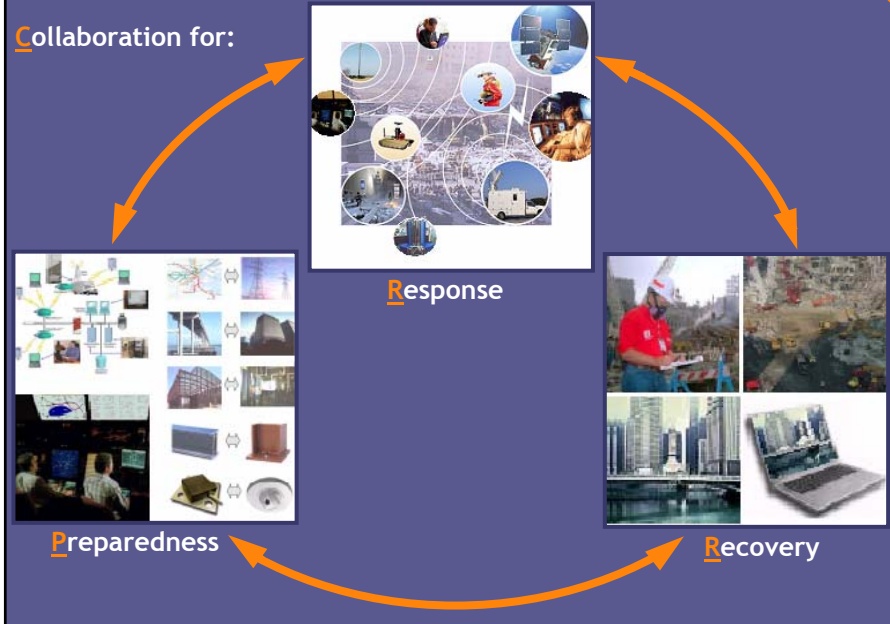


- ◆ Disasters in Urban Areas
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- ◆ **New Collaboration Approach**
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# New Collaboration Approach



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# New Collaboration Approach

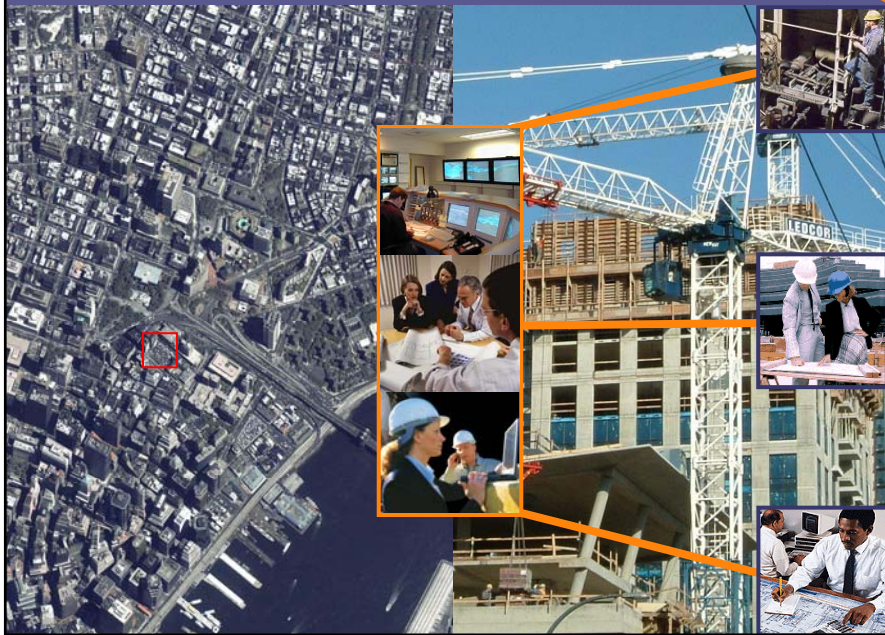


- ◆ Improve the **Collaboration Medium**
  - By Allowing the Delivering and Access On-Demand of **Digital Information**
  - By Providing a Reliable and Flexible **Communication Medium**
  - By Allowing the Implementation of Policies for **Information Trustworthiness** and **Delivering**
- ◆ Support the **Resistance & Recovery Processes**
  - By Providing **Computing Capabilities** to: Decision-Makers, Civil Engineers, First Responders, etc.
  - By Allowing the Access to **Technical Information**
  - By Allowing the Participation of **Local/Remote Experts**

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## Supporting Preparedness



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## Supporting Response



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## Supporting Recovery



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## IT Collaboration Restrictions



- ◆ Use of Standard Technology
- ◆ Interoperable Systems
- ◆ Flexible and Reliable Communication
- ◆ Usability of Devices and Information
- ◆ Limited Hardware Resources
- ◆ Deployment
- ◆ Heterogeneous Collaborators
- ◆ Context-aware Computing

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## Mobile Devices



- ◆ New powerful mobile computing devices are released every day.
- ◆ A large number of these devices are currently being used.
- ◆ Could we use them to support collaboration?



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## Mobile Devices



- ◆ New powerful mobile computing devices are released every day.
- ◆ A large number of these devices are currently being used.
- ◆ Could we use them to support collaboration?
- ◆ In which scenarios?
- ◆ For supporting what kind of tasks?



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## Advantages/Disadvantages



- ✓ Pocket-size
- ✓ Easy to deploy
- ✓ High mobility
- ✓ Price



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# Advantages/Disadvantages

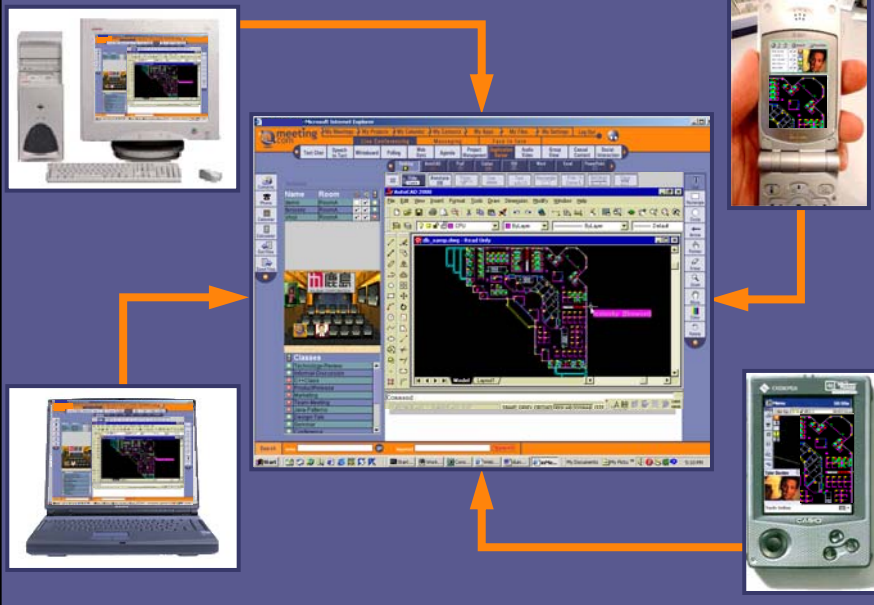


- ✓ Pocket-size
- ✓ Easy to deploy
- ✓ High mobility
- ✓ Price
- ✗ CPU, memory and storage
- ✗ Battery life
- ✗ Screen size
- ✗ Data input system



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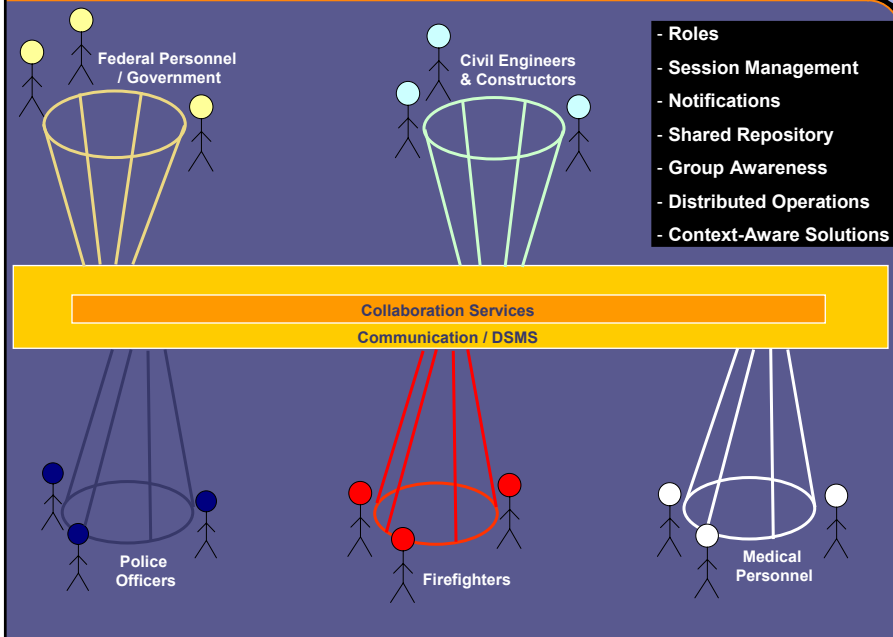
# Requirement for IT Support



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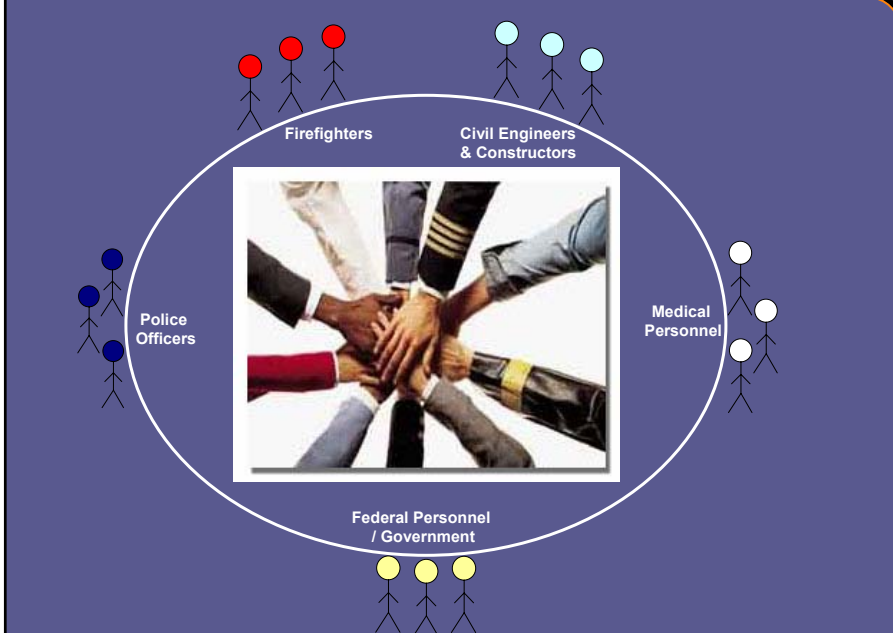


# Mobile & Interoperable Systems C<sub>P2R</sub>



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# Mobile & Interoperable Systems C<sub>P2R</sub>



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## Restrictions for the Systems



- ◆ Flexible and Reliable Communication
- ◆ Standard Technologies
- ◆ Interoperable Systems
- ◆ Limited Hardware Resources
- ◆ Usability of Devices, Applications and Information
- ◆ Easy Deployment
- ◆ Heterogeneous Collaborators

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## Futuristic Disaster Scenario



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## Outline



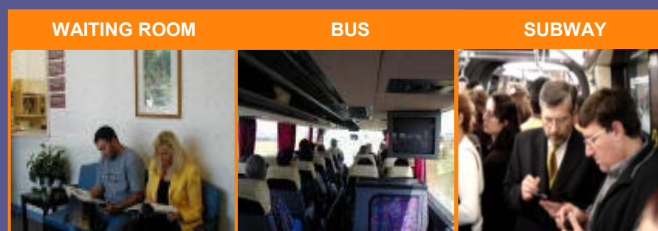
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## Others Collaboration Scenarios



- ◆ What kind of collaboration scenarios are better supported by hand-held devices?
  - ... those with little *comfort*



High	Medium-High	Medium-Low	Low
Desktop PC	Laptop	Tablet PC	Hand-held

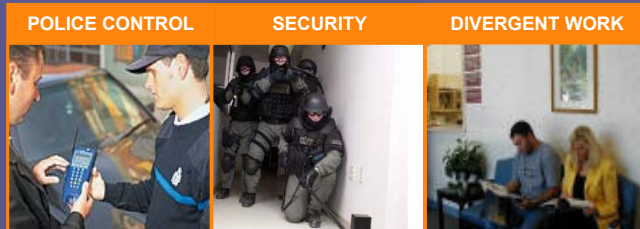
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## Others Collaboration Scenarios P<sub>2</sub>R

◆ What kind of collaboration scenarios are better supported by hand-held devices?

- ... those with little *comfort*
- ... those involving high *mobility* of people



Static

Low/Medium Mobility

High Mobility

Desktop PC

Laptop / Tablet PC

Hand-held

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## Others Collaboration Scenarios P<sub>2</sub>R

◆ What kind of collaboration scenarios are better supported by hand-held devices?

- ... those with little *comfort*
- ... those involving high *mobility* of people
- ... those involving a low rate of *data input*



High

Medium

Low

Desktop PC / Laptop

Tablet PC

Hand-held

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## Scenarios to be Supported



	HIGH	MEDIUM	LOW
COMFORT	Desktop PC	Laptop	Tablet PC
MOBILITY	PDA	Laptop / Tablet PC	Desktop PC
DATA INPUT	Desktop PC / Laptop	Tablet PC	PDA

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## New Approaches to Research



ENTOMOLOGY: Learning from natural robust societies

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## Coordination Analogy: Selecting Hive



### Collaborative Behavior:

- ◆ Scout bees leave current hive searching for a new place for the community.
- ◆ Scouts return and inform other bees of location quality by dancing.
- ◆ Bees in the hive adhere to scouts' dances related to higher quality locations.
- ◆ Eventually, all the bees will agree upon the best place and move toward it.



Communication → Social/Chemical  
Decision Making → Collaborative

Source:  
<http://www.animalbehavioronline.com/frisch.html>

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## Swarm Intelligence



NASA, Jet Propulsion Laboratory  
Communication Systems and Research Section

“Swarm Intelligence is the property of a system whereby the collective behaviors of (unsophisticated) agents interacting locally with their environment cause coherent functional global patterns to emerge” [Arabshahi, 2003].

Ant-based models successfully applied to solve optimization [Botee, 1999; Dorigo, 1996] and networking [Bonabeau, 2000] problems, among others.

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# Collaborative Self-Organization



## ◆ Example: A simple ant-based division of labor model [Bonabeau, 1997] for a Mail Company:

- Agents engaged in task T (attend a zone) if task-related stimuli (demand) > agent's threshold
  - $P(\text{task}) = S^2 / (S^2 + \theta_i)$ , probability an agent participates on a task
  - $S$  = magnitude of stimulus
  - $\theta_i$  = probability of responding to stimulus
- Learning: the more the agent performs a task the lower the threshold, and vice-versa [Theraulaz, 1991].

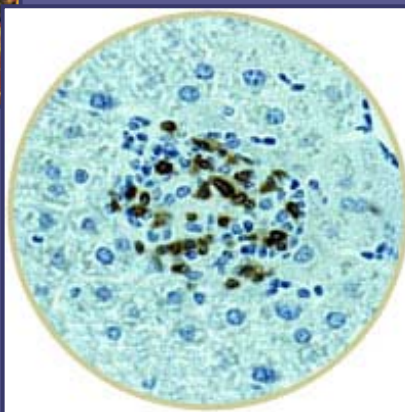
## ◆ Members of a bee colony change their role according to the environment, such as food availability in the hive [Robinson, 1998].

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# Approach to Collaboration



ENTOMOLOGY



EPIDEMIOLOGY: Effective and efficient propagation of information

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## Communication Analogy: Epidemics



### ◆ Epidemics mathematics [Bailey, 1975]\*:

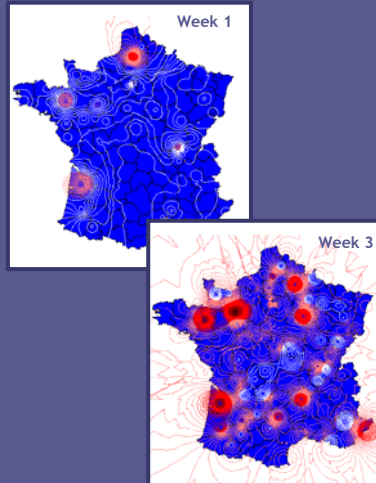
- Population of  $n+1$  members,
- At any time, each individual is either uninfected (numbering  $x$ ) or infected (numbering  $y$ )
- Then,  $x_0=n$ ,  $y_0=1$  and at all times  $x+y=n+1$
- Contact rate between any individual pair is:  

$$\beta=1-(1-(b/n))^2$$

- ◆ At each round, each node infects  $b$  neighbors based on probability  $p$ .

*Influenza in France (2000)*

[http://cg.enscm.fr/~hans/epidemiology/prou1\\_influ.html](http://cg.enscm.fr/~hans/epidemiology/prou1_influ.html)



\* One of the more useful theoretical frames in epidemics modeling [McCarty et al., 2003].

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## Communication: Epidemic Multicast



- ◆ Widely used in Computer Science to spread reliably a message from a node to a group of nodes.
- ◆ Reliability; within  $c \cdot \log(N)$  rounds, all but  $1/(N^{2cb-2})$  of nodes receive the multicast.
- ◆ Lightweight; each node transmits  $\sim c \cdot \log(N)$  gossip messages [Gupta, 2003].
- ◆ Some applications: Xerox Clearinghouse system [Xerox, 1984], Ad-Hoc Networks [Luo, 2003], Usenet newsgroups [Chandra, 2001].

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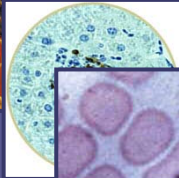
## Approaches Under Research



ENTOMOLOGY



EPIDEMIOLOGY



IMMUNOLOGY: Improving Resistance



IMPROVISATION: On-Demand Adaptation

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## Conclusions



- ◆ It is a **New Area** that Requires Exploration
- ◆ There are **Social** and **Organizational Issues** that we are not Considering
- ◆ Work on **Systems' Usability** is Required
- ◆ **Legal Issues** Need to be Addressed To Use Information about Infrastructure
- ◆ The **Work Context** is very Relevant, but does not Easy to Address

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