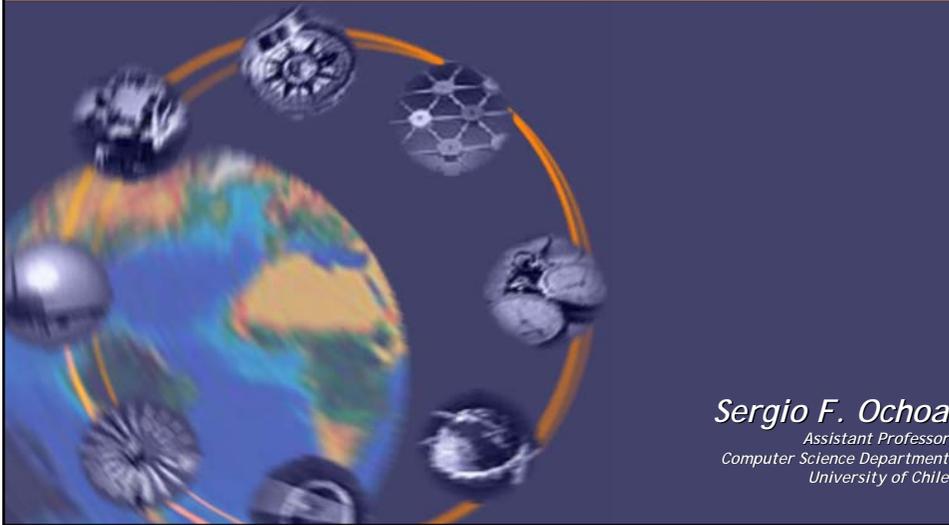


# New Trends in Software Engineering

## Software Engineering for Mobility

April, 2005



*Sergio F. Ochoa*  
Assistant Professor  
Computer Science Department  
University of Chile

# Motivation



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

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# 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>



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

An aerial photograph of a disaster-stricken urban area, identical to the one above. It includes the same callout boxes for 'Medical', 'Command Post', 'Federal Resources', 'Firefighters', and 'Police Officers'. On the left side, there is a list of items under the heading 'Lack of:'. A small number '8' is in the bottom right corner.

**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]

# 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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# Outline



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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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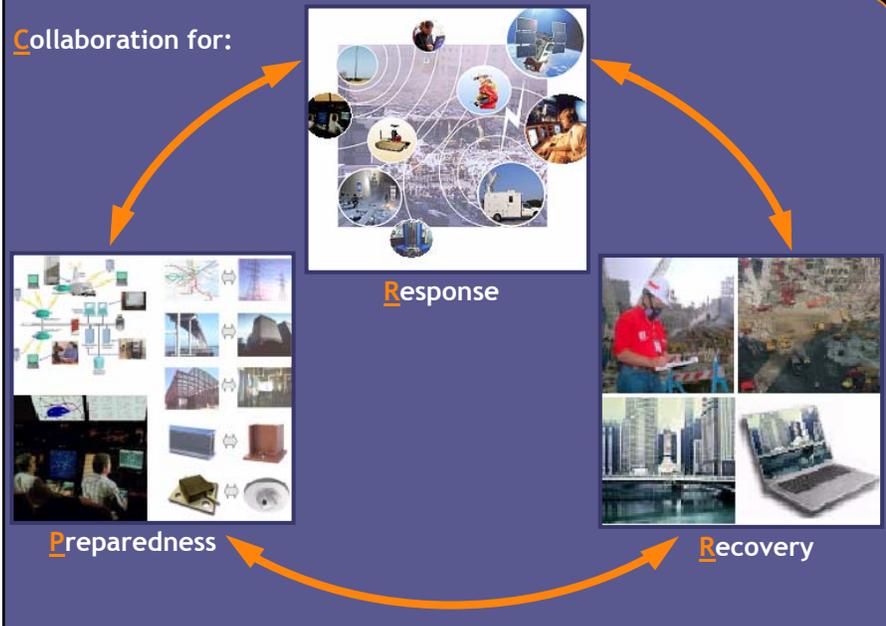
## Outline



- ◆ Disasters in Urban Areas
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# New Collaboration Approach



# 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**

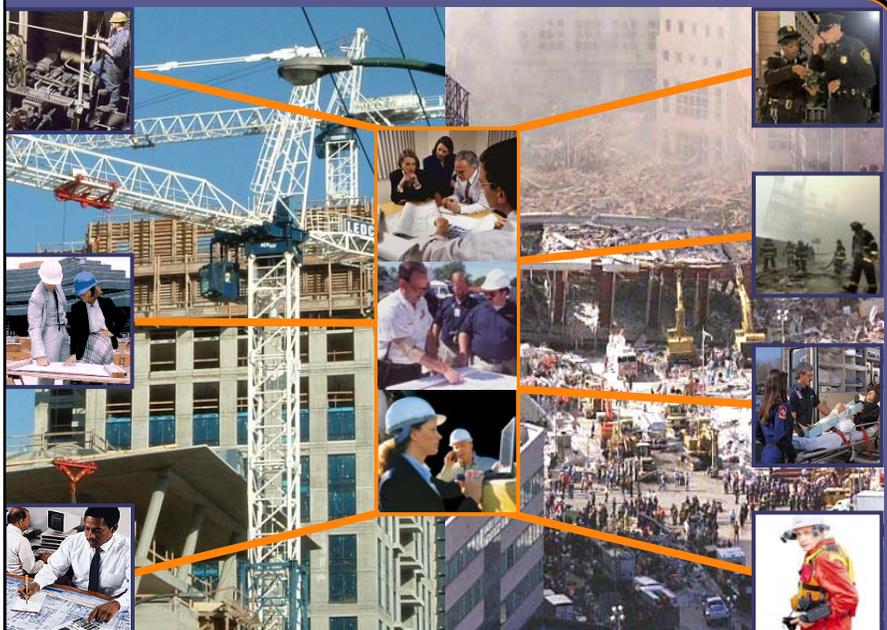
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# Supporting Preparedness



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# Supporting Response



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## 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

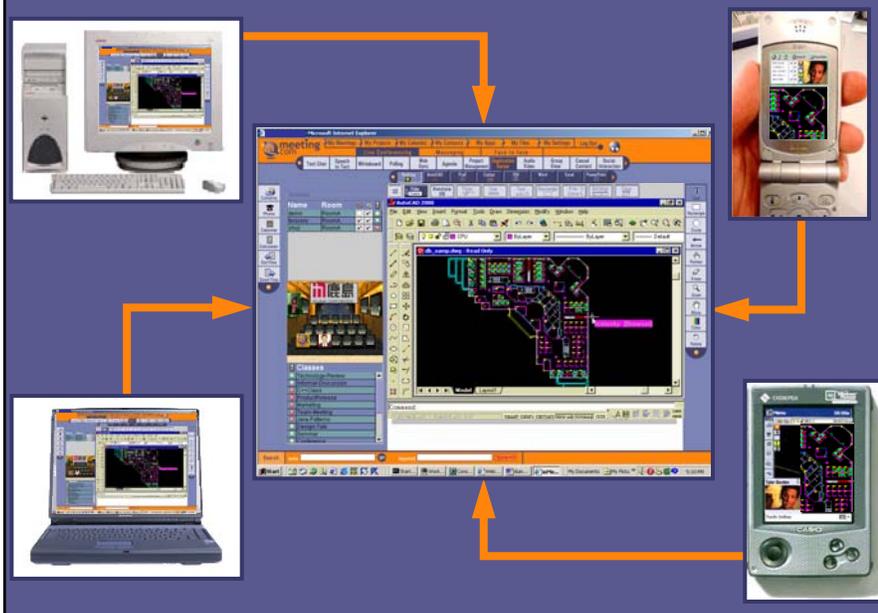


- ✓ Pocket-size
- ✓ Easy to deploy
- ✓ High mobility
- ✓ Price
- ✗ CPU, memory and storage
- ✗ Battery life
- ✗ Screen size
- ✗ Data input system



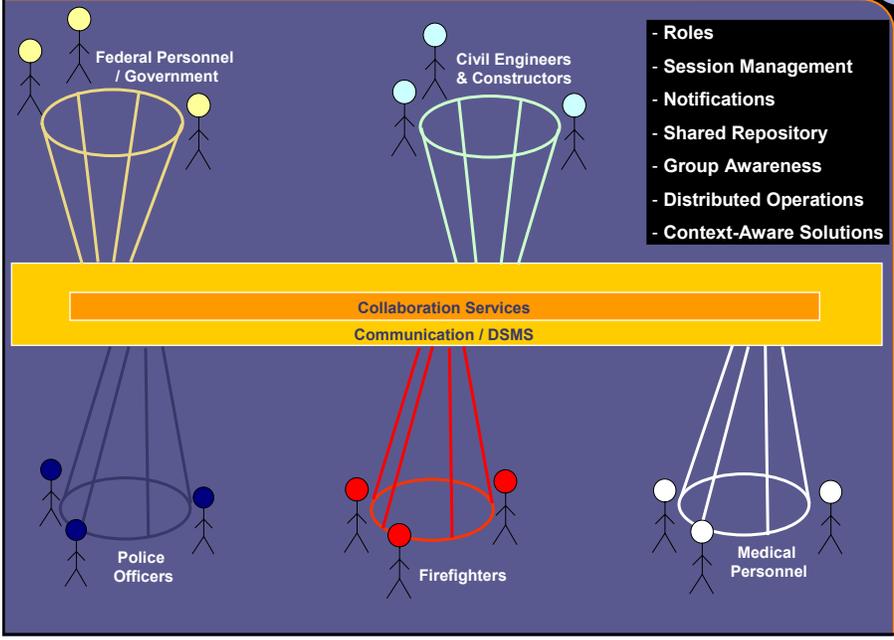
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# Requirement for IT Support

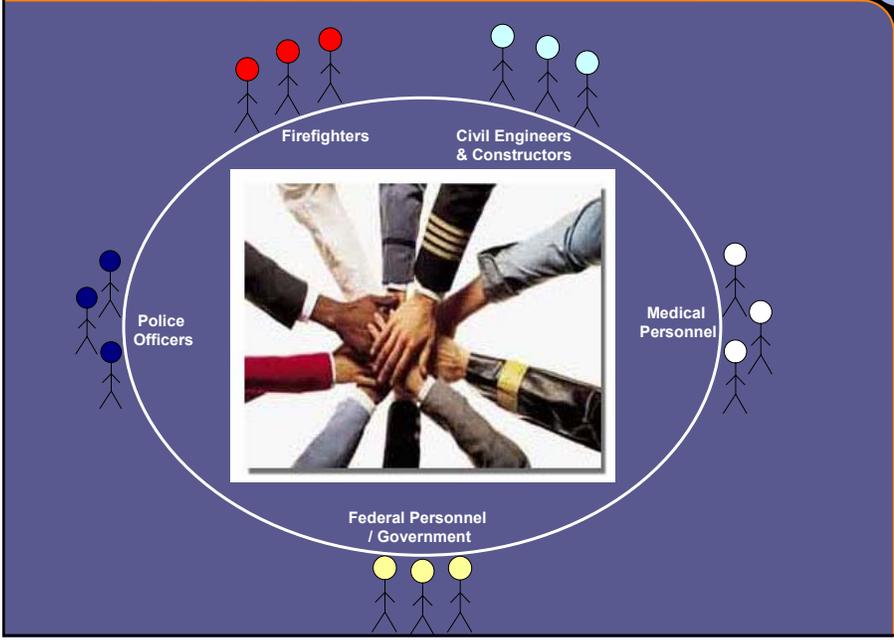


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# Mobile & Interoperable Systems C<sub>P2R</sub>



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



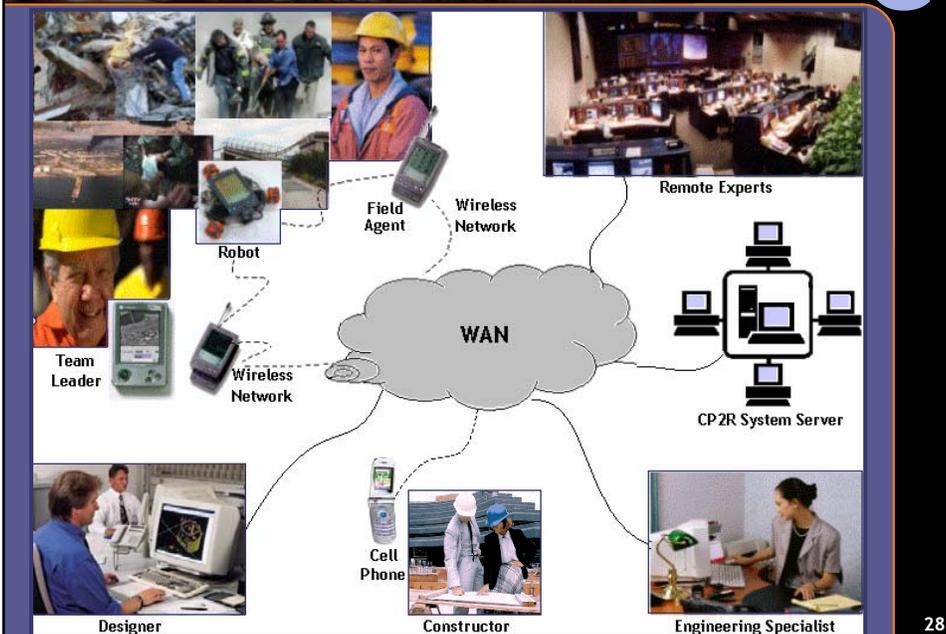
## Restrictions for the Systems



- ◆ 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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- ◆ Conclusions

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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

POLICE CONTROL	SECURITY	DIVERGENT WORK
		
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*

SHORT ANNOTATIONS	PREDEFINED ACTIONS	NAVIGATION
		
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.

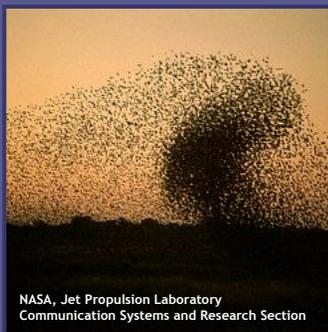


Communication → Social/Chemical  
Decision Making → Collaborative

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

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## Swarm Intelligence



“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].

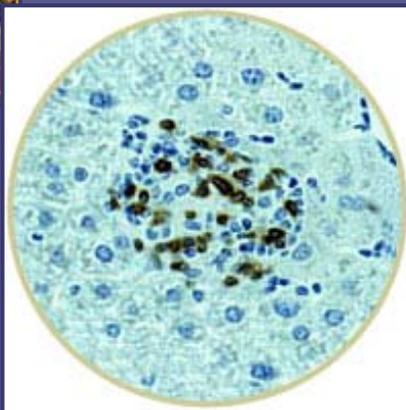
◆ Members of a bee colony change their role according to the environment, such as food availability in the hive [Robinson, 1998].

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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]\*:

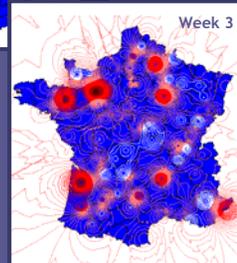
- Population of  $n+1$  members,
- At any time, each individual is either uninfected (numbering  $x$ ) or infected (numbering  $y$ )
- Then,  $x_0=n$ ,  $y_0=1$  and at all times  $x + y = n + 1$
- Contact rate between any individual pair is:  

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

## ◆ 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].

# 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].

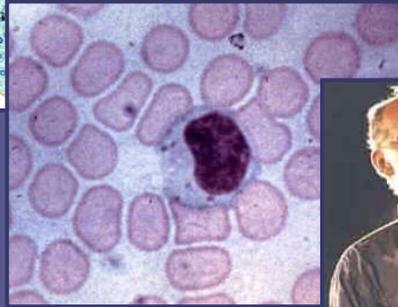
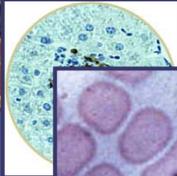
# Approaches Under Research



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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## References



- ◆ [Cohen, 1997] Cohen, J. "Emergency Engineering: Structures Specialist Contribute Expertise to Search and Rescue Operations After Collapse". *Claim Magazine*, June 1997.
- ◆ [Comfort, 2001] Comfort, L. "Coordination in Complex Systems: Increasing Efficiency in Disaster Mitigation and Response," *Annual Meeting of the American Political Science Association*, San Francisco, August-September, 2001.
- ◆ [DHS, 2004] Department of Homeland Security. Research and Technology. Feb. 2004. [http://www.dhs.gov/dhspublic/theme\\_home5.jsp](http://www.dhs.gov/dhspublic/theme_home5.jsp)
- ◆ [Fema, 1999] Federal Emergency Management Agency (FEMA). "Federal Response Plan". 9130.1-PL. April, 1999.
- ◆ [GDIN, 2003] Global Disaster Information Network. [www.gdin.org](http://www.gdin.org), 2003
- ◆ [Godschalk, 2003] Godschalk, D. "Urban Hazard Mitigation: Creating Resilient Cities", *Natural Hazards Review*. ASCE. Aug. 2003. pp. 136-146
- ◆ [IFRC, 2003] International Federation of Red Cross and Red Crescent Societies, IFRC. *World Disasters Report 2003: Focus on Ethics in Aid*. 2003
- ◆ [Lee, 2002] Lee, R. & Murphy, J. "PSWN Program Continues to Provide Direct Assistance to States Working to Improve Public Safety Communications". *Homeland Defense Journal*. Vol. 1, Num. 22. Dec., 2002
- ◆ [Mileti, 1999] Mileti, D. *Disasters by Design: A Reassessment of Natural Hazards in United States*. Joseph Henry Press. Washington D.C. 1999.

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# References



- ◆ [Murphy, 1999] Murphy, R. "Rescue Robots at the World Trade Center", *Journal of the Japan Society of Mechanical Engineers, special issue on Disaster Response Robotics*, to appear in vol. 102, no. 1019.
- ◆ [MSCMC, 2003] NCSA Multi-Sector Crisis Management Consortium. (<http://www.msccm.org/index.html>), 2003.
- ◆ [NRC, 1999] National Research Council: Board on Natural Disasters. "Reducing Disaster Losses Through Better Information". *National Academic Press*. Washington, D.C. 1999.
- ◆ [NRC, 2002] National Research Council. Making the Nation Safer: The Role of Science and Technology in Countering Terrorism. National Academic Press, Washington, D.C. Sep. 18, 2002.
- ◆ [Prieto, 2002] Prieto R. "The 3Rs: Lessons Learned from September 11<sup>th</sup>". *Royal Academy of Engineering*. Chairman Emeritus of Parsons Brinckerhoff. Co-chair, New York City Partnership Infrastructure Task Force. October, 2002.
- ◆ [Stewart, 2002] Stewart T. and Bostrom A. "Extreme Event Decision Making Workshop Report", *Center for Policy Research. Rockefeller College of Public Affairs and Policy*. University of Albany, and Decision Risk and Management Science Program NSF. June, 2002.
- ◆ [Tisp, 2003] The Infrastructure Security Partnership. "The Partnership Working to Protect American's Infrastructure". 2003. <http://www.tisp.org>