Fluid Software Infrastructure for Wireless Sensor Networks

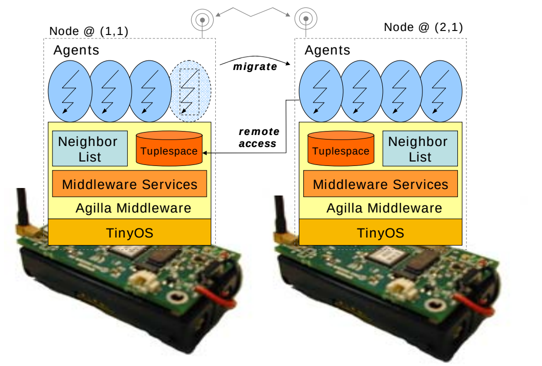
Washington University in St. Louis
School of Engineering & Applied Science

Gruia-Catalin Roman (PI) and Chenyang Lu (Co-PI)

Mobile Computing Laboratory

"An agent-based organization of software applications executing over wireless sensor networks can simplify the development process and achieve a level of flexibility that is not available today."

Agilla: Mobile Agent Middleware



http://mobilab.wustl.edu/projects/agilla/index.html

Research Implications

Transit Behavior

- *What is the agent's lifecycle?*
- Agent is injected into the network, collects data, and leaves
- Location-based addressing
- Approximate content-based migration destination

Exploratory Behavior

- *How does an agent explore a network?*
- Content-based remotely accessible shared memory
- Remote communication vs. agent migration
- Agent sleep schedule

Malleable Behavior

- *How does an agent adapt to a changing context?*
- Agent instruction morphing
- Dynamic instruction set
- Agent reflection – so an agent can determine what code it has and what it needs

Clique Behavior

- *What type of emergent behaviors arise from groups of agents?*
- Individual agent frailty requires groups of coordinating agents
- Malleable agent →Agent specialization
- Autonomous talent-balancing – agent drops some of its functionality because too many other agents can do it
- Application survivability – what is the minimum number of agents required to ensure the clique survives?

Coordinated Behavior

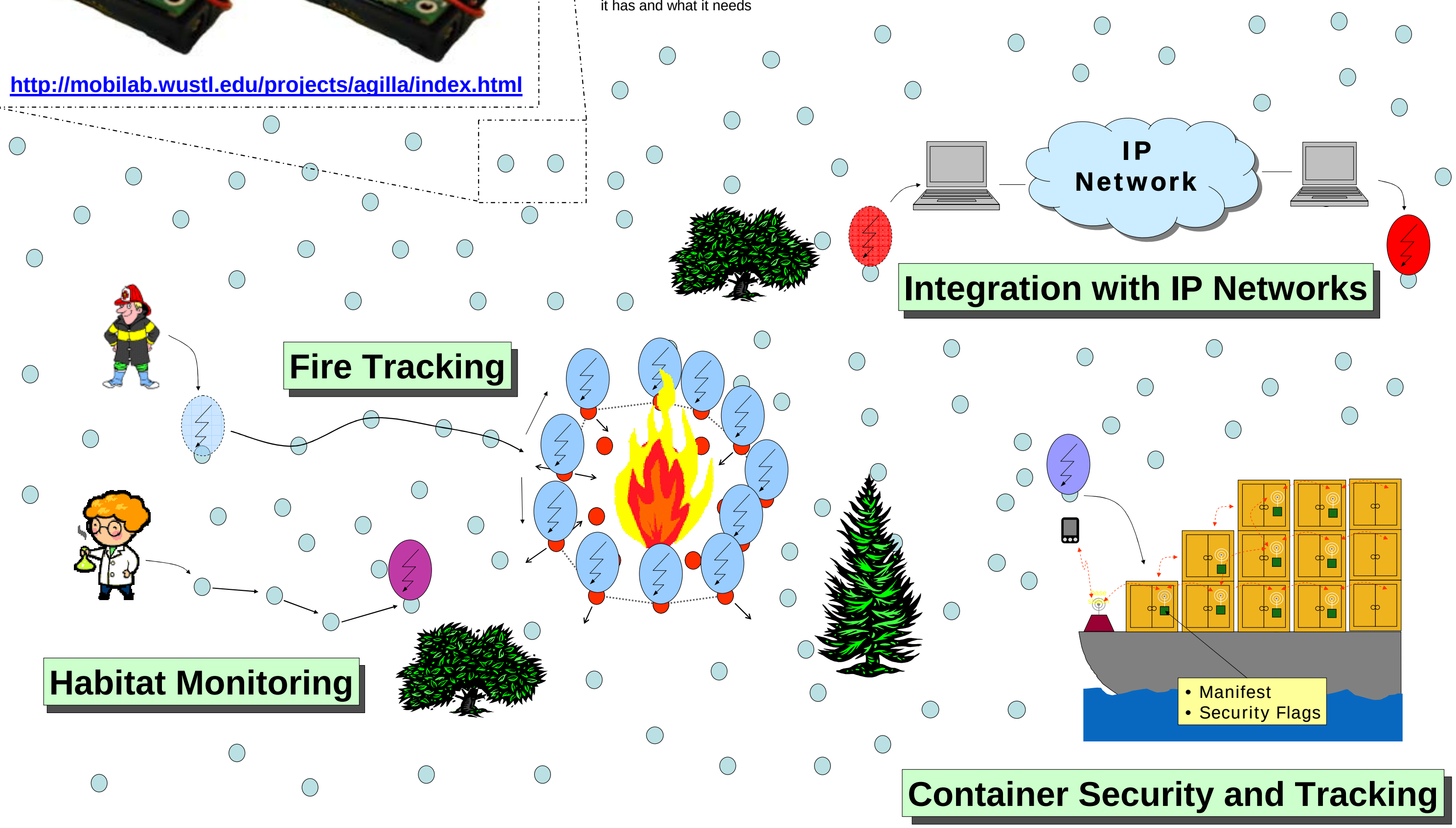
- *How do agents coordinate?*
- Primitive abstractions supporting high-level decoupled interactions
- E.g., shared tuple spaces
- The choice of a coordination model for sensor networks is an open question

Spatiotemporal Behavior

- *What type of spatiotemporal behaviors do applications exhibit?*
- Agents must be present at a certain time & place to perform
- Applications tentatively categorized into 3 spatial structures:
  1. Sparse - Agents coordinate over large distances
  2. Compact - Agents are all located in the same general area
  3. Geometric - Agents must maintain a geometric shape, e.g., a circle around an intruder

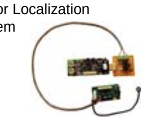
Security

- *How do we deal with malicious agents and privacy?*
- Lightweight mechanisms required
- Virtual machine "sand box"
- Coordinated message scattering and collection

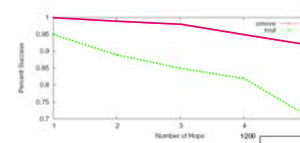


Experimental Test Bed

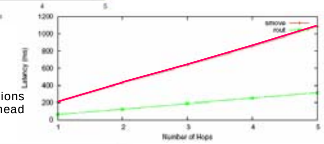
- Implemented on Mica2, ported to MicaZ, and NMRC Dsys25 motes
- TinyOS 1.1.14, NesC 1.2
  - 4 Agents/mote
  - 100 byte tuple space
  - 46K ROM, 3.3K RAM
- Integrated with the Cricket Indoor Localization System



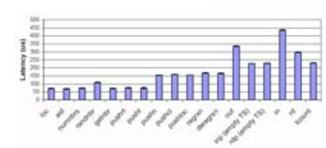
Performance Evaluation



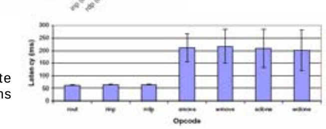
Migration instructions are more reliable because of hop-by-hop acknowledgements…



…but remote tuplespace operations have less overhead



Local Operations



Remote Operations

This research is supported by the NSF under NOSS contract CNS-0520220