AgiTrack: Agile Cargo Tracking Using Mobile Agents

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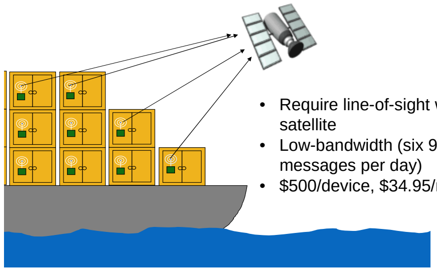
“Agilla: support for flexible deployment of adaptive software in wireless sensor networks.”

Motivation

- 7 million containers arrive annually into the US; it is impossible to check every container
- Existing container security devices are limited:



- Require line-of-sight with satellite
- Low-bandwidth (six 9-Byte messages per day)
- $500/device, $34.95/month

- Applications must be flexible: they must adapt to changes in a container’s location, local security policies, tracking technologies, and customer needs

Dynamic Context Discovery & Multi-Hop Network Formation

- Use beacons for neighbor and context discovery
- Use geographic routing for multi-hop inter-agent communication

Custom Agents for Varying Needs

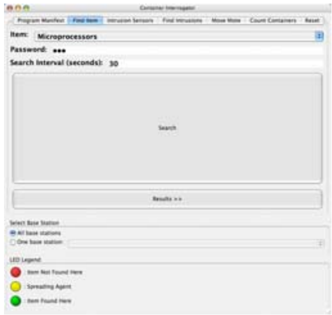
- Many mobile agents can be deployed over time in the same sensor network
- Support custom agents for each kind of user, e.g., customs officers, shippers, customers, etc.
- Allow applications to adapt to changing threat levels

Many Agents Already Supported

- Update electronic manifest list
- Search containers for a specific item
- Count and locate all containers
- Monitor accelerometer for sudden motion
- Monitor light sensor for unauthorized entry into container
- Find all recorded accelerometer and light events

Box Interrogator Application

- Discover available sensor networks
- Load electronic manifest into containers
- Inject agents to track and query cargo
- Display results graphically
- Forward results to an event correlation engine



Container Interrogator

Program Manifest | Find Item | Intrusion Sensors | Find Intrusions | Move Mote | Count Containers | Reset

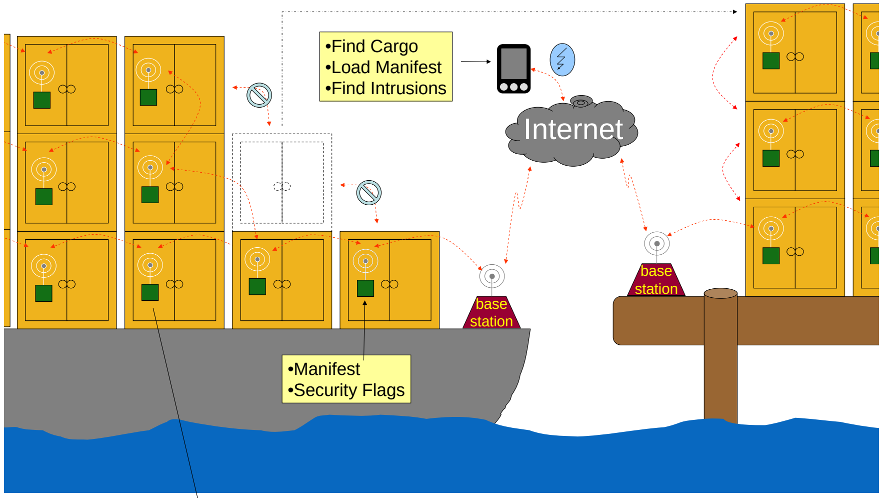
Item: Microprocessors
Password: ●●●
Search Interval (seconds): 30

Search

Results >>

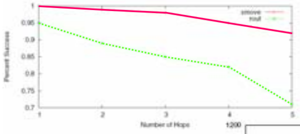
Select Base Station
● All base stations
○ One base station

LED Legend
🔴 Item Not Found Here
🟡 Spreading Agent
🟢 Item Found Here



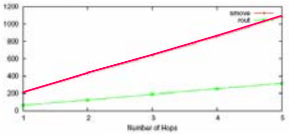
Enhance each container with a mote (i.e., a “hyperactive RFID”)

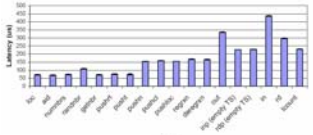
Performance Evaluation



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

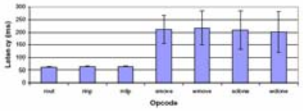
…but remote tuple space operations have less overhead



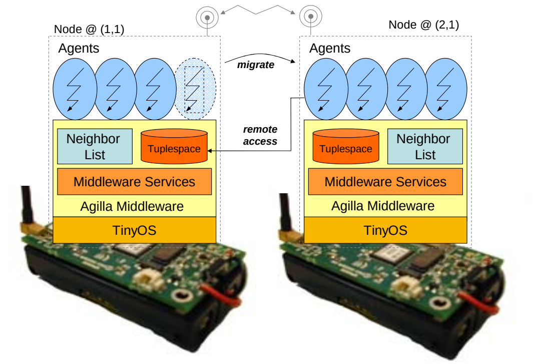


Local Operations

Remote Operations



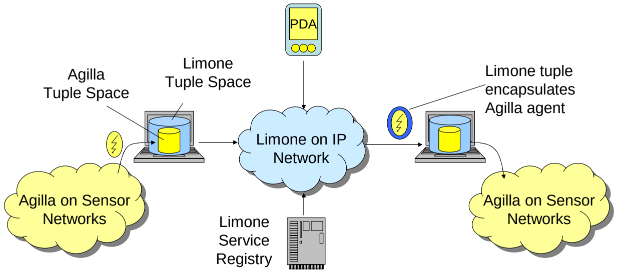
Agilla: Mobile Agent Middleware



Open-Source Software

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

Integration with IP Networks


PDA
Agilla Tuple Space
Limone Tuple Space
Limone tuple encapsulates Agilla agent
Limone on IP Network
Agilla on Sensor Networks
Limone Service Registry
Agilla on Sensor Networks

- Base stations and clients connected over an IP network
- Each base station connected to a separate Agilla network
- Clients and base stations discover each other using a central Limone service registry
- Clients place requests and Agilla agents into base stations’ Limone tuple spaces
- Base stations straddle middleware and network boundaries, converting incoming Limone tuples into Agilla operations

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

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