

Embedded Networking and One to Many to One

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The Domain: Embedded Networking

- Networking of small devices *will* change the world
 - *vigilant observation* of what we care about
 - analysis and *action* on the results

Two Scenarios

- Auto maintenance
 - you hear a noise
 - mechanic slaps down several sensors
 - later, expert system diagnoses week's worth of readings
- Human maintenance
 - sensors in clothes monitor how far you walk, what you eat, ...
 - dynamically suggest exercise, new places to eat

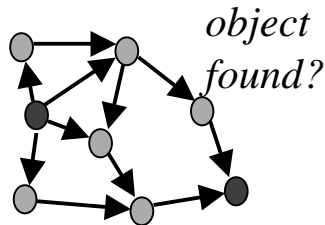
Many other scenarios: condition-based maintenance, security, collaborative spaces and classrooms, etc.

What's the problem?

- Hardware is here (Itsy, TINI, WINS, ucSimm, ...) – progress in μ CPUs, batteries, wireless protocols

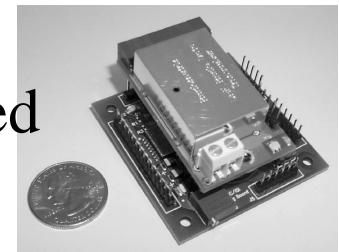
...but how do

Networks and applications



**Retrieve
interpret
respond to
data from**

**100s of
sensors:
moving,
interacting,
expiring,
being added**



Interaction of *dynamics* and *numbers*.

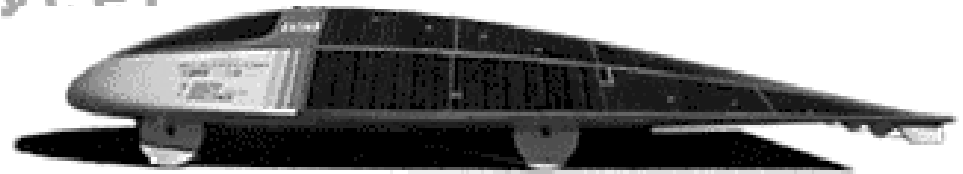
One is Easy



Ok, if not easy,
at least possible.



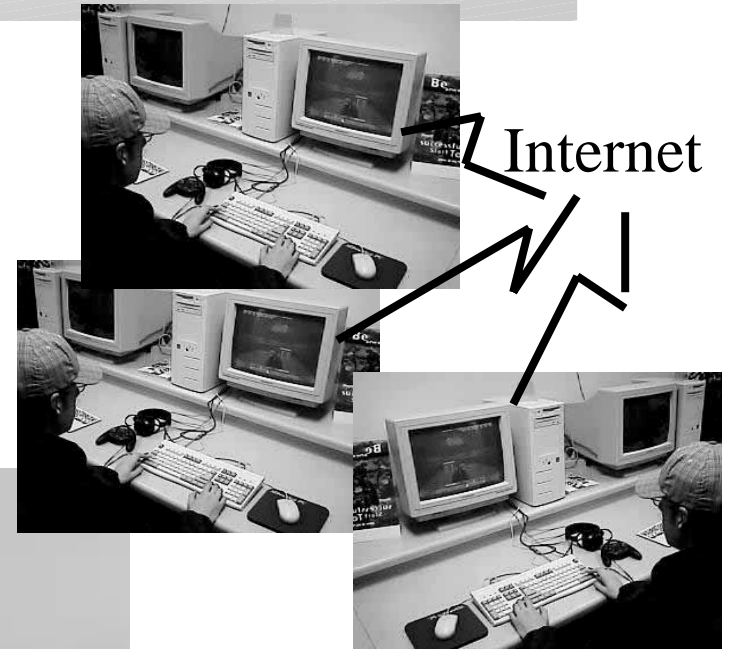
GM sunracer



Many is Hard?

Possible if

- high value
- or identical
- or lots of people



Embedded Networks: Easy or Hard?

- Many mostly identical nodes
- but non-uniform from dynamics
 - different places, sensors, users, uses
 - nodes keep changing: movement, battery exhaustion, node and sensor addition, etc.
- utility from cumulative data
 - over time or space
- can't count on attentive user per node

Interaction of *dynamics* and *numbers*.

Promising Developments: Application-specific Code

- *Application-specific* embedded networks can simplify the problem
- Useful building blocks:
 - Active networks and mobile code
 - Jini and UPNP
- But need to take approach further in energy-constrained networks

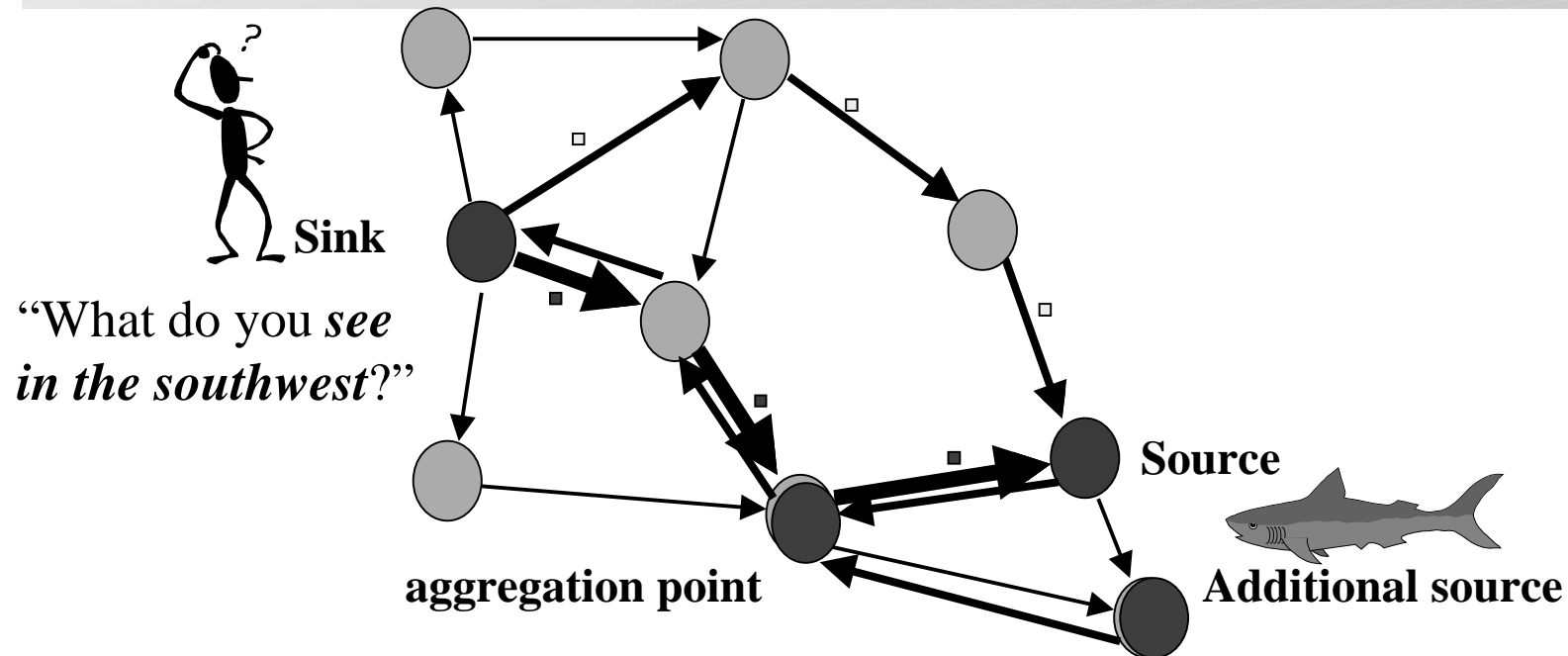
Promising developments: Using physicality

- *Physical constraints* of embedded networks can simplify the problem
- Promising examples:
 - location-based addressing
 - sensors in this room, not sensors #15, 37, 55
 - actions are often physically constrained
 - lightswitch controls lights in *this* room
- But how to determine location cheaply, everywhere?

Promising developments: localized algorithms

- “Act locally, optimize globally”
- Enabled by application-specific code and CPU-rich, energy poor networks
- Examples
 - data aggregation in network
 - data diffusion for routing
- But how to write local algs? understand limits and error conditions?

Example: Directed Diffusion



- Robust, efficient data distribution in sensor networks
 - **name data** (not nodes), use physicality
 - **diffuse requests and responses** across network
 - optimize path with **gradient-based feedback**
 - additional data causes **in-network aggregation**
- More details: <http://www.isi.edu/scadds/>

Unsolved problems

- Building the right devices and radios
 - promising devices abound, but not ubiquitous
- Security and privacy
 - how to monitor 1000s of devices?
 - firewalls just don't work in porous world of mobility
- Understanding protocols and apps
 - many parameters to data diffusion
 - monitoring and debugging testbeds
- Explore realm of *small, physical, many*

