Sensor News Network

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Motivation

• **Build a sensor news network (CNN without reporters!)**
  – E.g., equipment news network, physical space network,

• **Problem of gathering, managing, and presenting, rapidly changing information about physical space:**
  – Large scale micro-sensors networks
    • Billions of sensors (many of them mobile)
  – Fixed to mobile interaction
  – Thousands of datasets (mostly unstructured)

• **What is the information architecture?**

• **Web: example self organizing system**
  – E.g. Latest indexers find semantic information based on structure of the web as a graph

• **Can we automatically construct useful “indexes” --- maps --- for data distributed in mobile sensor networks?**
Current Wireless networks

- Too much focus is on access
  - Fixed world protocols ➔ wireless links
  - Access to the net from portable devices
- Wider-area broadband wireless networks: Data over voice
  - Cost per bit too high
- Ubiquitous coverage
  - Good for voice but not necessarily data
- Wireless is not part of Information Technology (yet)
What’s coming?

- Universal radio’s
- Programmable/ single chip radios
- Incredible miniaturization (MIPS/Joule)
- Silicon cockroaches
  - What do with them? Can’t eat them
- Millions/billions of physical objects interconnected and data about them made available on-line
  - These elements will not only be the end units but also serve as network elements
- Moore’s law will get you there!!
Scenario

What’s around me?

- Where is the TA for 352?
- What’s around me?
- Are roads icy?

- Don’t call 911
  Accident already reported

- Mines around??
Approach

• Build an infrastructure that will be able to provide an enhanced view of the surrounding physical space
  – As users navigate physical space, they will be sprinkled with information (illuminated with information)

• Idea: Closely tie location, communication (network), and information

• Main elements of webdust

• Dataspaces
  – Scalable query /propagation methods by using network primitives (broadcast, multicast, anycast, geocast, gathercast)

• Digital sprinklers
  – Collect, aggregate and distribute data based on spatial relevancy
  – Resolution inversely proportional to distance from epicenter

• Spatial web/landscape database
  – Automatic indexing of spatial information
  – Crawl “physical space” to infer properties
Digital Sprinklers

• Sprinkle/Sniff information based on spatial “relevancy”
• Disseminators/aggregators of information collected from dataspaces/sensors
  – Users who pass by will be sprinkled with information
  – Users can also park information on digital sprinklers – graffiti
  – Assist in answering aggregate queries
• Aggregate query on physical space → contact surrounding digital sprinklers
• Conveying exceptional news or breaking news
  – Use local and global prediction models to convey exceptional news
• Challenges
  – Distribution of updates, query execution, resolving proximity (5 mph vs 60 mph), resolving resolution, caching, distribution of updates
Information dissemination

Disseminated data

Local                     partial                               remote

Locally gathered data
Data/query possibilities

- Locally gathered data
  - When did the last bus leave?

- Locally disseminated data
  - What is the schedule for busses leaving this stop

- Local + remote gathered data
  - Has the last bus that left this stop reached the next stop

- Remote gathered data + remote disseminated data
  - How late are busses arriving at the next stop

- Locally disseminated data + remote disseminated data
  - What is the scheduled travel time between this stop and next stop

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Spatial Web

• **Motivation**
  – Query the physical space

• **Inspiration**
  – Web is an ad-hoc structure on conceptual space
  – Millions and Millions of “producers”
    • My pages point to DCS Rutgers, UMASS, Berkeley, MIT who point to…
  – Rich theoretic structure based on social network research

• **Can we build a massive, ad-hoc representation of physical space?**
  – Anyone can add to the structure
  – How to automatically build useful representations?
  – Can we make meaningful queries against the spatial structure?
Physical Space as a graph

Spatial Web

[Diagram of a Spatial Web with nodes and connections]
Spatial web

- Establish a spatial link structure on surrounding dataspaces
- Self-organizing web of links that correspond to the physical space
  - Physical space represented by a graph
  - Answer queries about surroundings by crawling local space
- Link information based on spatial proximity
- Answer queries by crawling
- Crawl using these links to obtain a semantic structure of the physical space
- Trade-off accuracy for time-to-crawl
- Challenges
  - Crawling while on the move, on-line crawling vs offline crawling, prefetching, predicting trajectories, transforming web structure to spatial web structure and vice versa
Spatial Web

• All Spatial web pages have a limited physical "DataScope"
• Links between the Spatial Web pages mirror the relevant structure in the physical space

• The DataScope is represented by a SPOT (SPatial ObjecT)
  – Abstract Data Type of a spatial database viz. polygons, convex hull, etc.
• SPOTs are mapped on to Spatial Tags :
  – simple human readable strings
  – allow for the construction of a spatial database over all spatial web documents
Physical space as a graph

• Nodes or pages have embedded location tags
• Badri=in <scope=Room 345>
• Pages have spatial links <sref, URL (location tag)>
• Badri=in <scope =<Room 345> <sref, Room346> <sref = Core>

• Spatial link exists between SPOTS that are “adjacent”

• Adjacent may imply overlapping, containment, intersection, nearby
Spatial Web

- Tag Resolver: mechanism to map tag names to actual SPOTs they denote
- Web Presence for entities in the real world like places, sensors, things & people
  - Eg. web page will comprise of the XML encoded SPOT, and “spatial” hyperlinks to nearby entities
- Capability to build a spatial crawler over such an infrastructure to answer “whats around me?” type of queries dynamically
- Current Prototype: Tags for barcodes, Resolvers, Compaq iPAQ for the PDA.
Motion through space

Stationary units define a stable graph

Mobile units change link structure by crawling or "reassess surroundings"
Motion through space

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Information

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