WIPER: The Integrated Wireless Phone Based Emergency Response System

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Overview

- **Motivation**
- **Using Cell Phones as Sensors**
- **The WIPER/DDDAS System**
  - **Design Considerations**
  - **Detailed description of proposed system**
- **Discussion**
- **Summary**

Problem Domain

- Disasters, crises, emergencies, civil disorders, humanitarian relief efforts, transportation disruptions, … events involving large numbers of people.
  - Natural origins: hurricanes, tornados, earthquakes, tsunami, snow storms, floods, volcanoes, epidemics, …
  - Human origins: terrorists attacks, political unrest, civil unrest/disorder, industrial accidents, transportation accidents, …

Emergency Response Management

- **Problems**
  - Communication
  - Co-ordination
  - Situation Awareness (SA)
  - Sharing SA
- **Information Needs**
  - Alerts - Has something happened?
  - Location - Where, extent?
  - Numbers - How many people?
  - Movement - Stationary, moving?
 - What is nature of the event?
  - How should we respond?

Cell Phones: An In-Place Mobile Sensor Network

- Increasing ubiquity in urban areas
- Approaching 100% in some regions
- Often more popular than wired systems, especially in developing economies
- Cell tower and handset continually exchange "signal strength" info
- Location data
  - Closest cell-tower cells, distance estimates possible
  - Ability to triangulate
  - Growing availability of GPS data
- Collective knowledge of the location, numbers, and movement of a large sample of population in a region is potentially available

WIPER

- Wireless Integrated Phone-Based Emergency Response System
- Ties into the existing cellular phone infrastructure to detect, monitor, predict anomalies
  - Fact: people make cell phone calls during a disaster
  - Family, friends, E911
  - New calling patterns
  - Increased numbers of calls placed
- Streaming data
  - Calls placed per cell tower
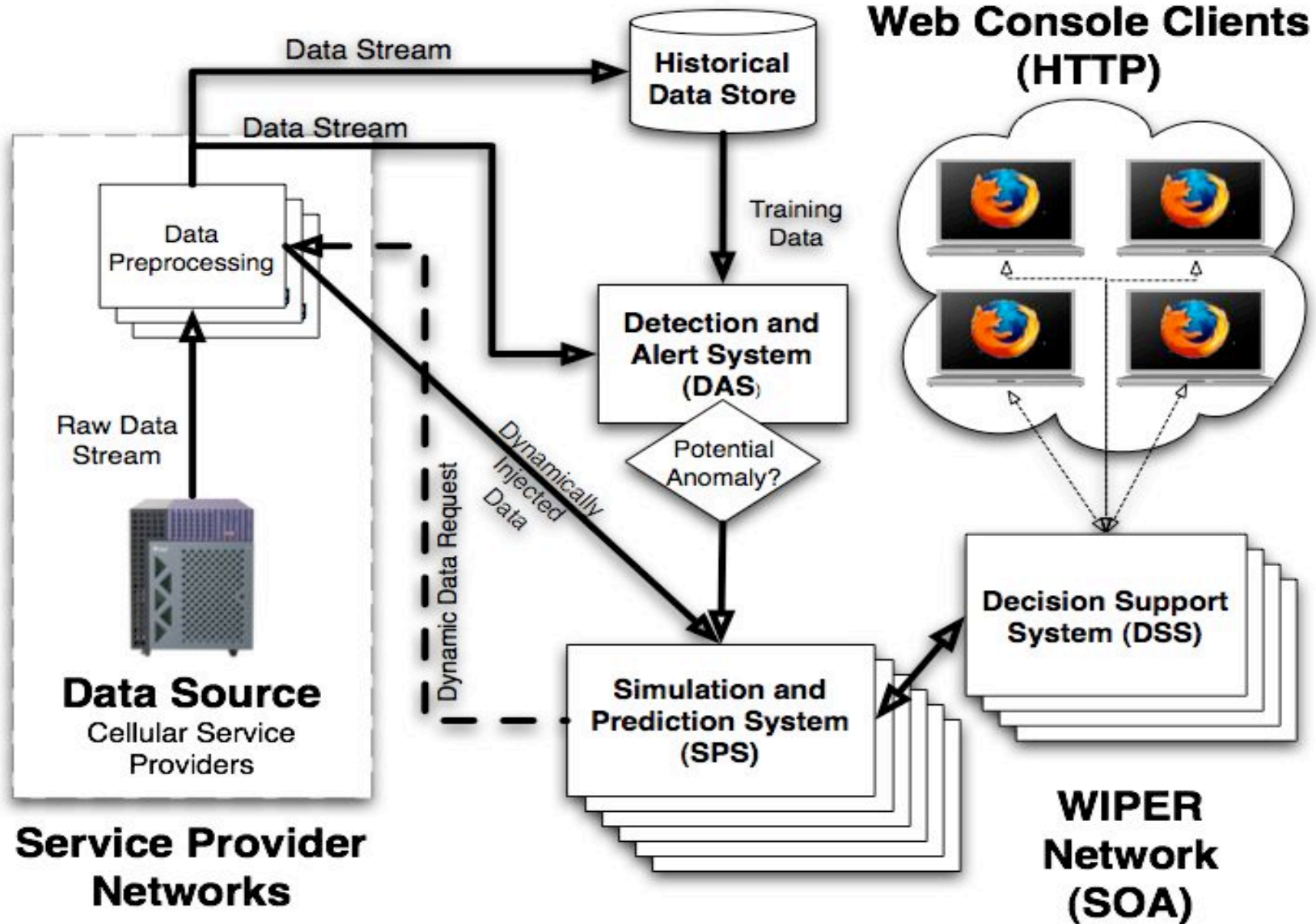 - Calling patterns
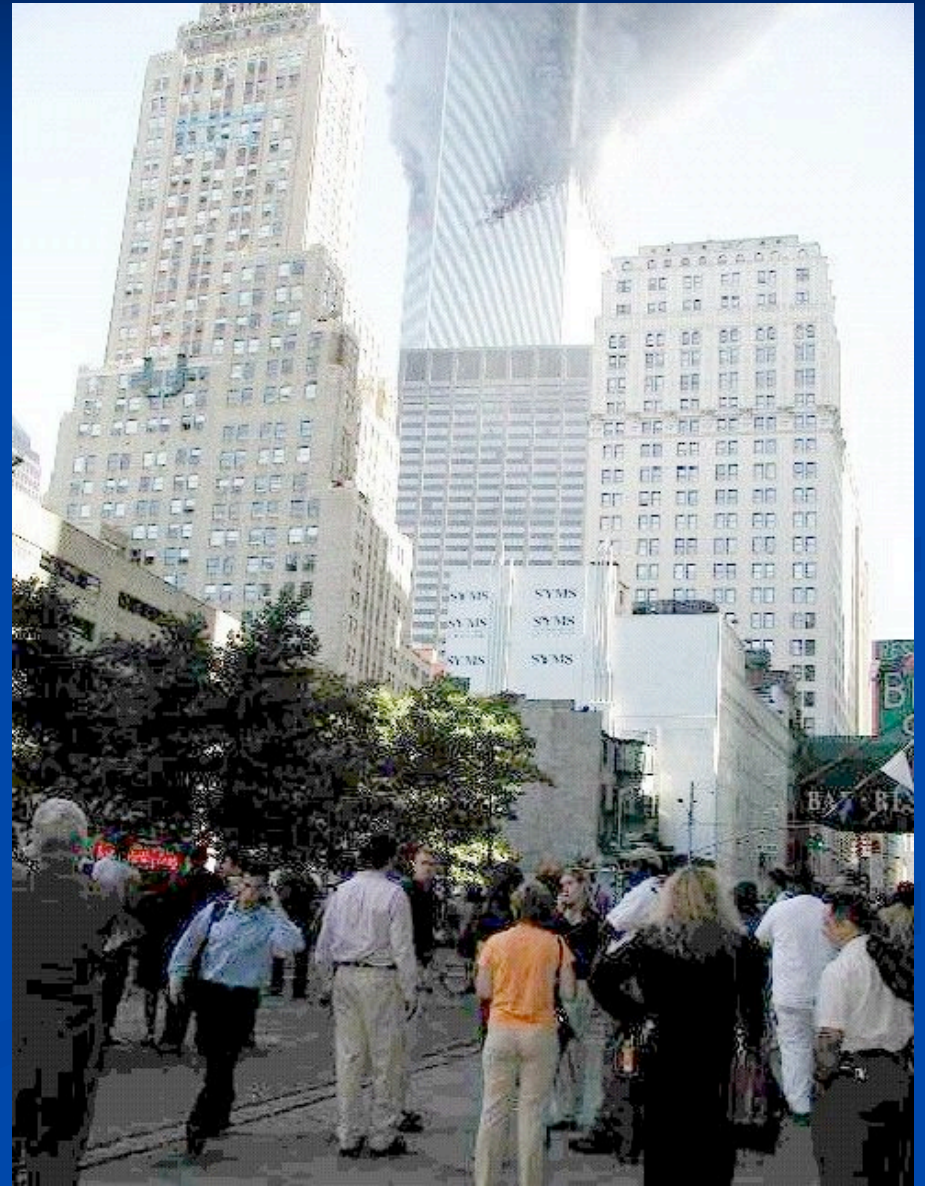
WIPER/DDDAS - System Structure

- Four components:
  - Data Source
    - Historic data from cellular service provider
    - Eventually will use live data streams
  - DAS - Detection and Alert System
  - SPS - Simulation and Prediction System
  - DSS - Decision Support System
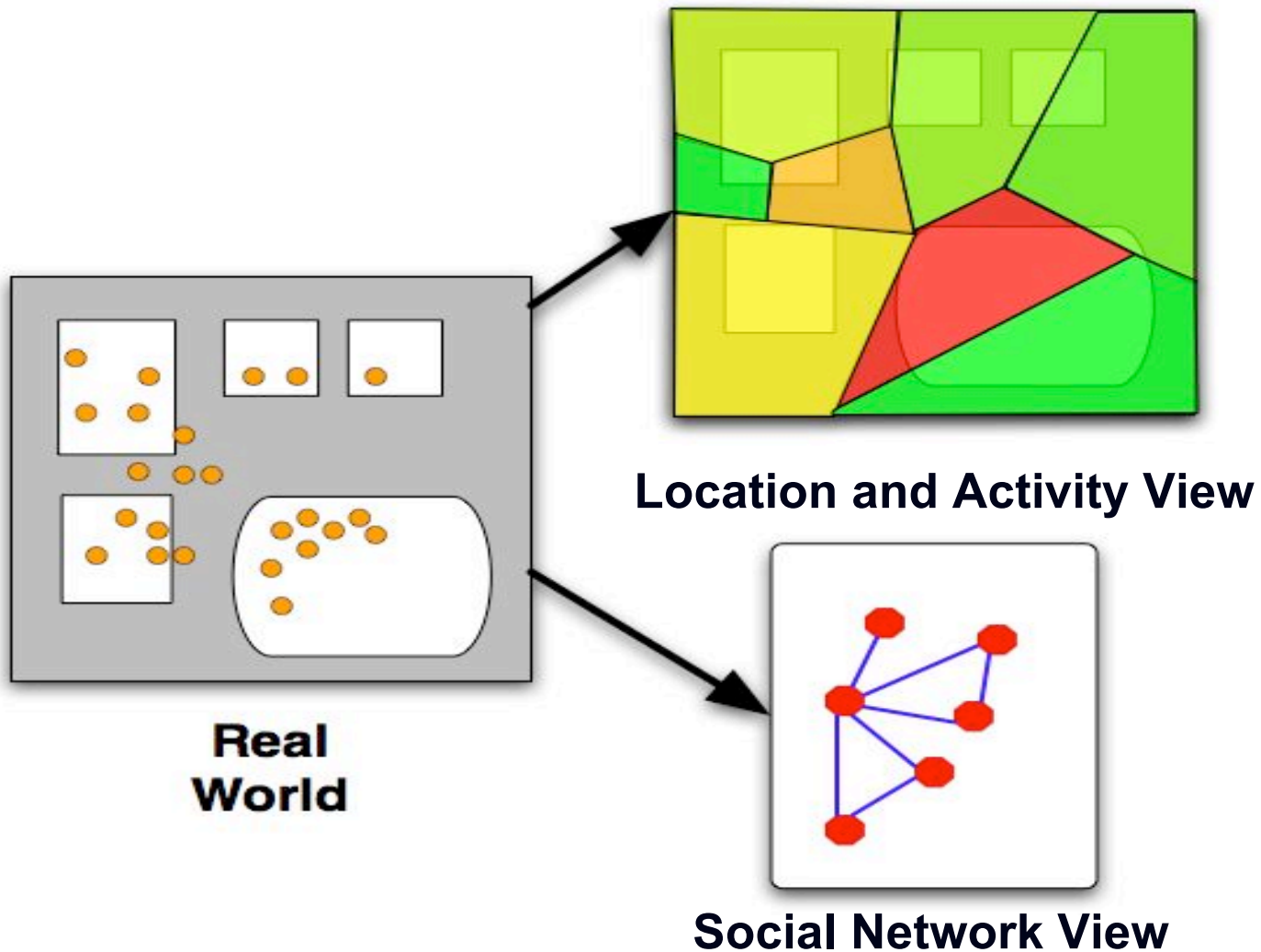
WIPER/DDDAS Overview

WIPER - Data Source

- Data collection occurs at the cellular service provider
- WIPER receives anonymized, pre-processed, encrypted data
- No personally identifiable information leaves the service provider's network

WIPER - Detection and Alert

Location and Activity View

Real World

Social Network View

Detection and Alert System

- Will use data stream mining to detect crisis events
- Monitors call activity, location, social network for anomalies
- When an anomaly is detected, alert is raised, state is passed on to SPS

Detection and Alert System

- Detection system trained on historic data
- Currently we are analyzing historic data to understand periodic normal events
- Working with experts in Sociology, Social Network Analysis to develop models that reflect current understanding of social systems
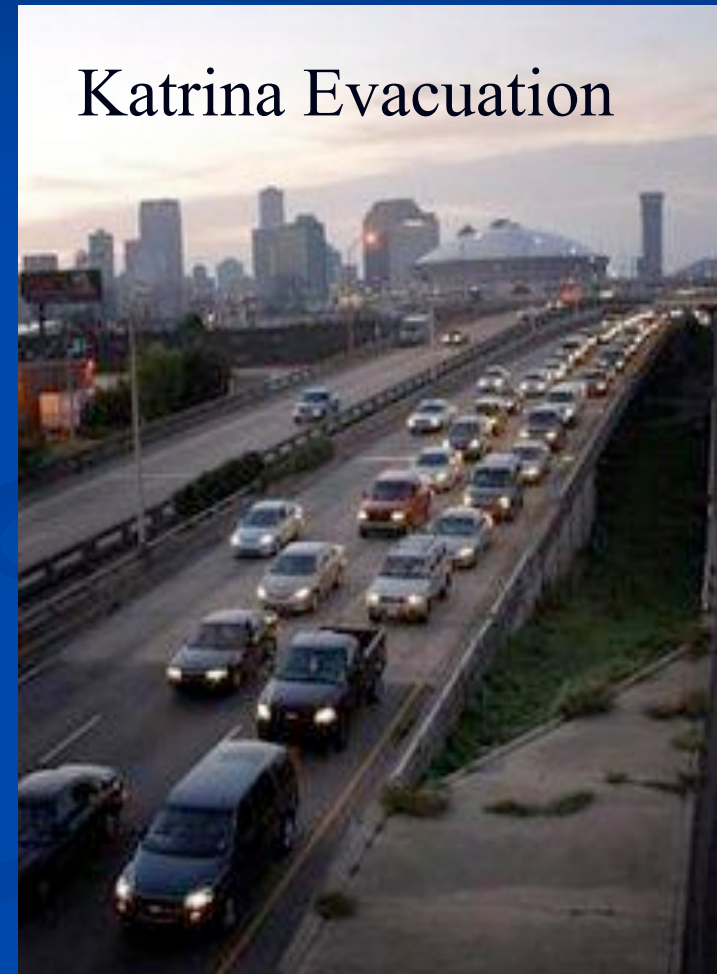
Simulation Prediction System

- For all alerts, from DAS or the DSS, WIPER generates an ensemble of Agent-Based Simulations

- Simulations used to determine nature of anomaly, predict evolution of event

- Simulations use direct stream of information to monitor real world and dynamically validate simulations

Simulation Prediction System

- WIPER uses DDDAS concepts
- Dynamic, Data-Driven Application Systems:
  - Couple simulations with sensors
  - Use streaming data to refine simulations
 - Allow simulations to steer sensors, adapt data collection

Katrina Evacuation

Simulation Prediction System

- Agent-Based/GIS-Based Simulations used to test hypotheses about real-world phenomena
- Geo-spatial constraints embodied in the simulations
    - Rivers, roads, coast-lines
    - Accurate cell-tower coordinates
    - Overlaid on maps to support emergency response managers
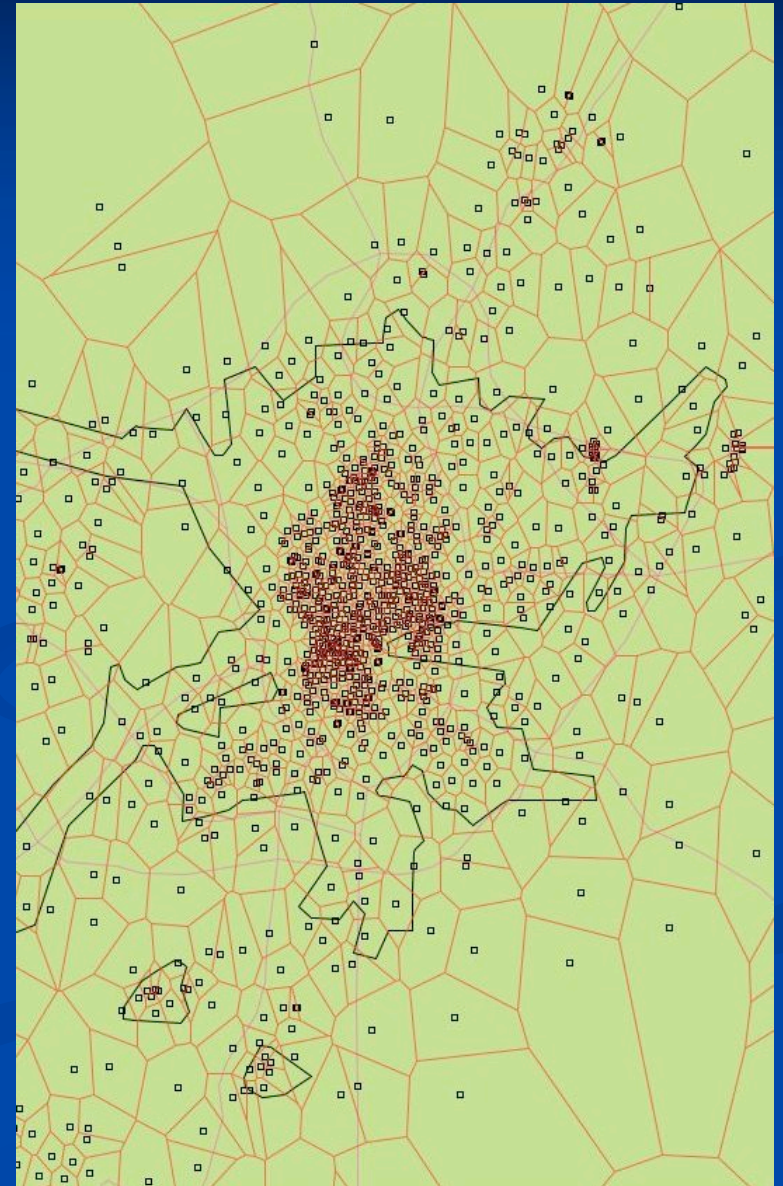
Decision Support System

Activity View
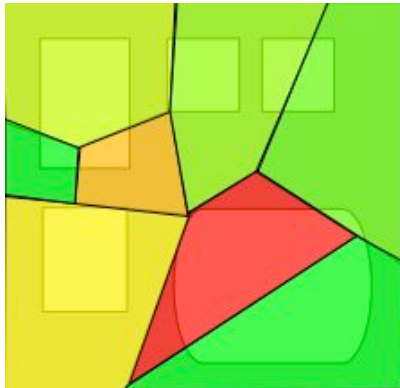
Simulation Output

Simulations Dispatched

Evaluating Potential Anomaly….

Possible Match Found: Benign Pedestrian Event

Validation:

   KS Test Value

   Chi-Square Value

Continuing to Track Anomaly…

System Log

Potential Anomaly Detected

Time – 2006-04-15

Location – Lat XX.XXX Long YY.YYY

Console User

Decision Support System

- Web-based console that provides access to real-world info, results from simulations
- Emergency responders can compare the real-world information with the simulation predictions, decide course of action
- If desired, console can be shared with responders in the field over encrypted web connection
- Alerts could be sent from DSS directly to cell phones in affected area

- Geo-spatial data - maps of crises area
- Temporal data - timelines, events
- Numerical data - graphs, charts, tables
- Predictions - animations

Discussion

- WIPER System provides complimentary tools for monitoring and predicting crisis events - improved Situation Awareness

- Connection to cellular service provider allows multi-modal monitoring of real time events without need for new sensor infrastructure

- Architecture protects privacy while providing access to information, but potential for privacy concerns

- Open standards/software - Service Oriented Architecture and AJAX

- Computational challenges: real-time detection, faster-than real-time agent-based GIS-based simulations

- Limitations of cell phones during prolonged power outage

Summary

- WIPER is a demonstration project using existing cell phone system a a mobile sensor network
- Employs DDDAS principles
    - Simulation prediction system
    - Large amounts of streaming data
    - Simulation system adapts to new data
    - Simulation system requests higher fidelity data for dynamic validation of simulations

Hurricane Rita I45N Freeway Gridlock

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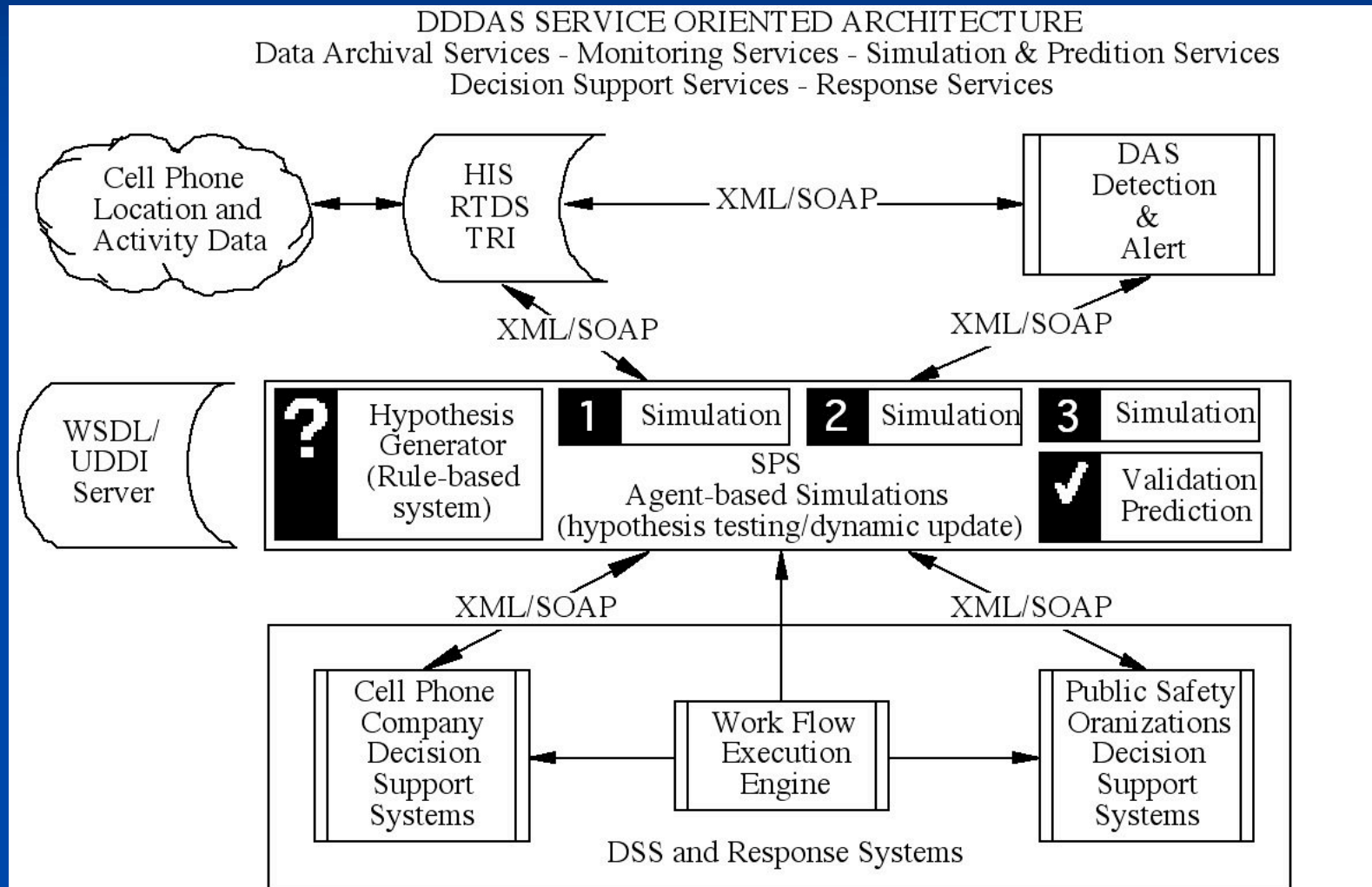Nick Ransom, Computer Science & Engineering

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Thank You

Questions?

WIPER - Service Oriented Architecture

DDDAS SERVICE ORIENTED ARCHITECTURE
Data Archival Services - Monitoring Services - Simulation & Predition Services
Decision Support Services - Response Services

Cell Tower Locations