Dissertation Progress Report

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Overview

1. Research Goals
2. Completed Work
3. Status of Completed and Proposed Goals
4. Publications

Original Research Goals

- Network Understanding / Anomaly Detection System
- Creation of Simulations from Streaming Data
- Updating Simulations from Streaming Data
- Online Validation Against Streaming Data
- Sensor Steering

Original Research Goals

- ~~Network Understanding / Anomaly Detection System~~ Removed
- Creation of Simulations from Streaming Data
- Updating Simulations from Streaming Data
- Online Validation Against Streaming Data
- ~~Sensor Steering~~ Removed

Revised Research Goals

Research goals have been revised to reflect the priority of the WIPER project

- GIS for Data Analysis, Visualization and Simulation
- Data Curation
- WIPER: Simulation Prediction System
- Design and Implementation of WIPER Simulation
- Movement and Activity Models

Revised Research Goals

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- GIS for Data Analysis, Visualization and Simulation
- Data Curation
- WIPER: Simulation Prediction System System description, published in [1, 2, 3]
- Design and Implementation of WIPER Simulation
- Movement and Activity Models

Original Research Goal Status

- Creation of Simulations from Streaming Data - Mostly Complete
- Updating of Simulations from Streaming Data - In Progress
- Online Validation Against Streaming Data - Offline Implementation. Working Towards Online Implementation

Revised Research Goal Status

- GIS for Visualization and Simulation - Complete
- Data Curation - Complete
- Design and Implementation of WIPER Simulation Prediction System - Mostly complete
- Design and Implementation of WIPER Simulation - Mostly Complete
- Movement and Activity Models - Taxonomy and Implementation of several movement models complete.

Creation of Simulations from Streaming Data

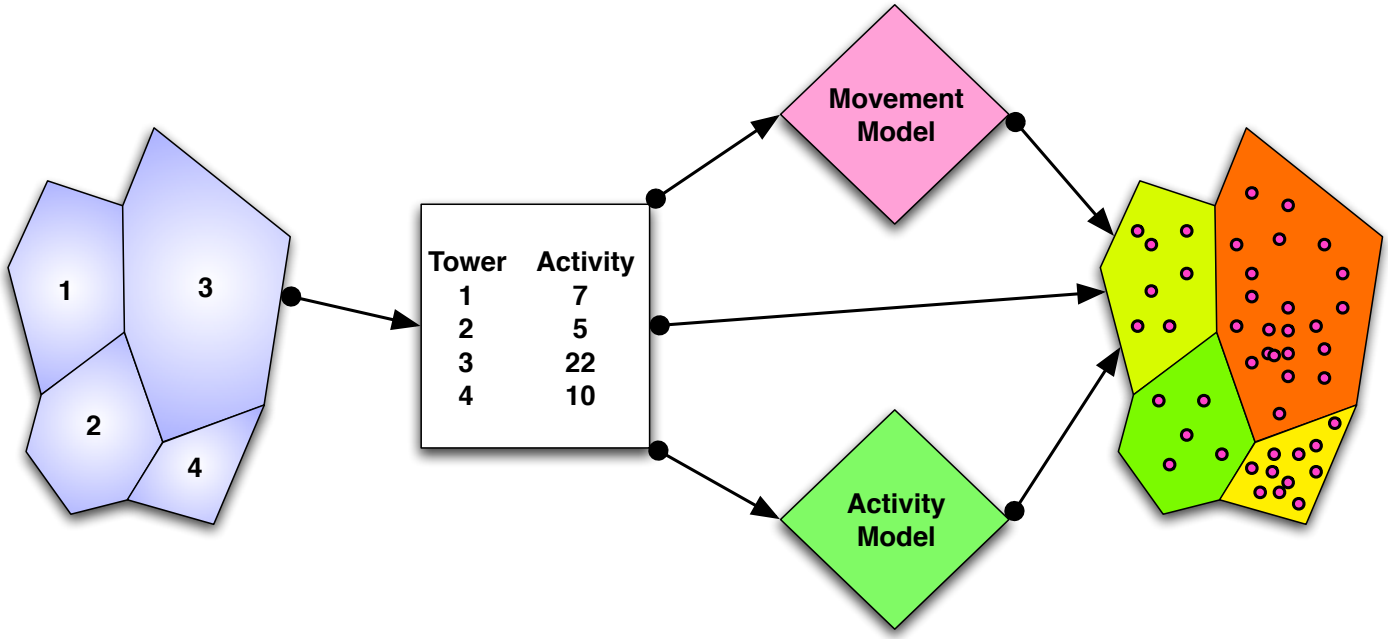

Figure: Graphical Explanation of Process for Generating Simulations from Streaming Data

Creation of Simulations from Streaming Data

Procedure

- Offline: Develop Movement and Activity Models
- Offline: Build GIS files describing area
- Online: Receive "snapshot" of activity in tower cell and region from DAS
- Online: Apply Movement and Activity Models to generate distribution of agents over cell

Validation of Simulations

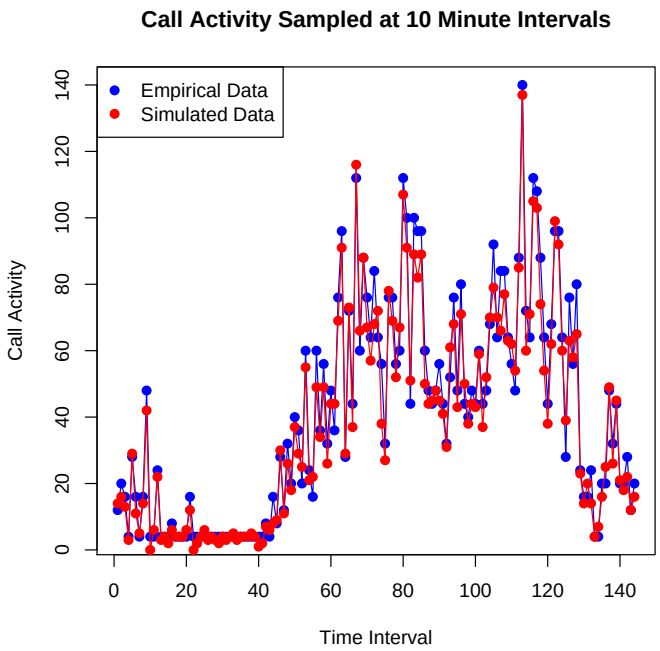

Figure: Plot of actual and simulated activity data.

Call Activity Data Validation

- Activity Model uses Empirical Data to Generate Activity
- Passes Kolmogorov-Smirnov test, D $= 0.0903$, p=0.6003, two-sided test at $\alpha = 0.05$

Validation of Simulations

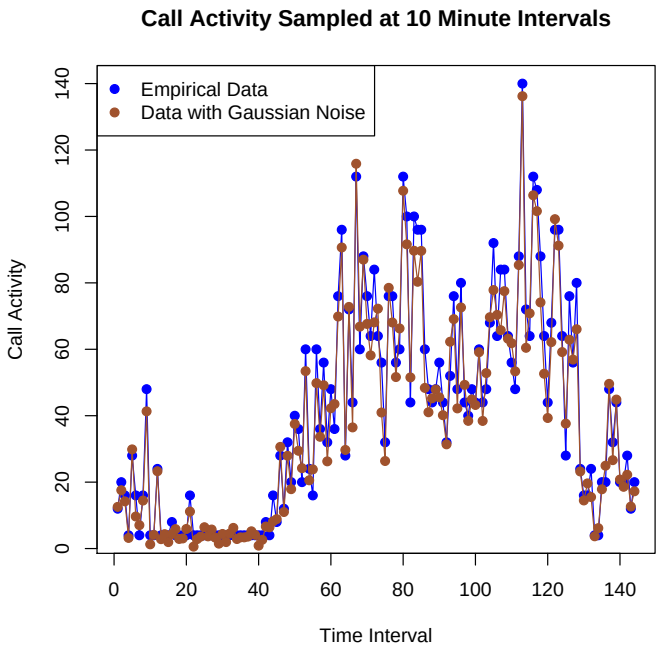

Figure: Empirical Data Plotted against data normally distributed around the points.

Call Activity Data Validation

- Data generated by normally distributing points around empirical data
- Generated with mean = empirical data, sd = 1
- Fails Kolmogorov-Smirnov test, D = 0.1389, p = 0.1243, two-sided test at $\alpha = 0.05$

Validation of Simulations

Several issues remain when validating simulations online vs streaming data

- Valid against empirical data? Distribution? Model? Currently using KS test against empirical data, with poor results
- KS test unable to distinguish normally distributed data generated from empirical distribution
- Idea: Utilize the prior probability of anomaly from MMPP model for validation.
- Implement in a per cell fashion, need to be cautious with time intervals

GIS for Visualization and Simulation

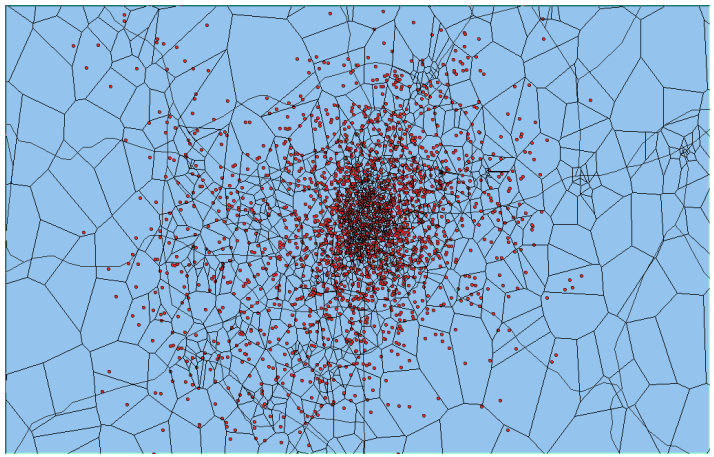

Figure: GIS Image from a WIPER Simulation

GIS Uses:

- Visualizing tower locations, relationship to urban areas, etc
- Simulations: agent and tower locations can be initialized from data, agents can interact with real world geography

GIS

Figure: Cell phone activity overlaid on a satellite image.

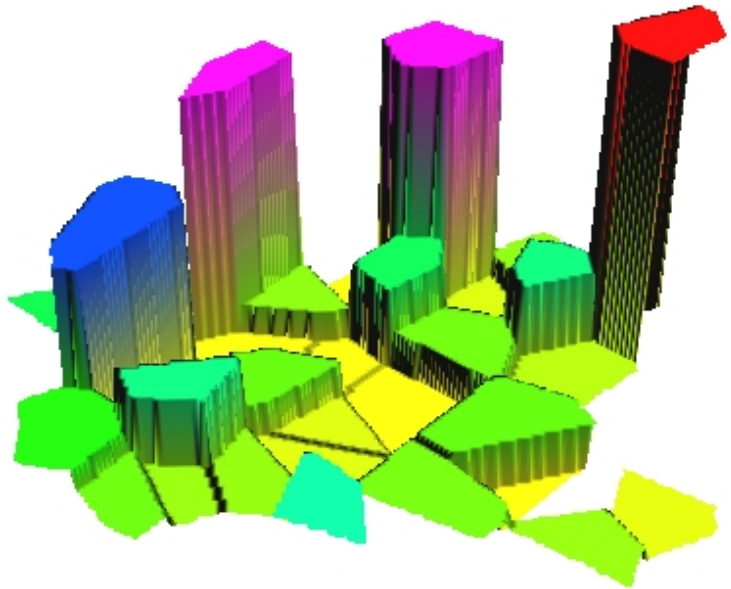

Figure: 3D View of Tower Activity

Data Curation

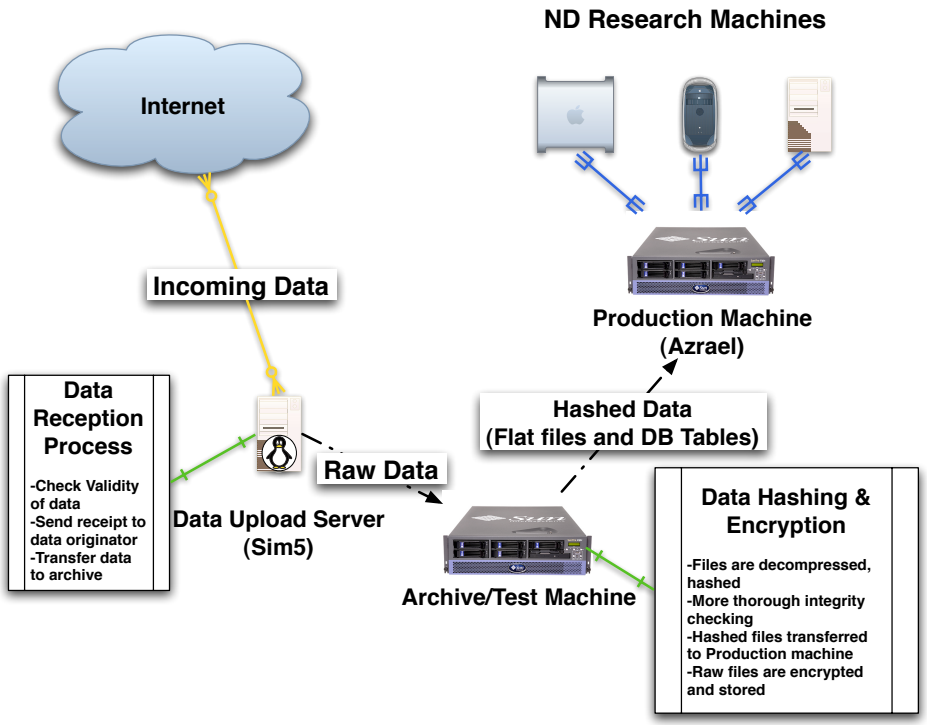

Figure: The Data Curation Workflow

Overview of the Data Curation Workflow

- Created workflow to curate privacy-sensitive data
- Manage tradeoff between access to data and protection of cell customer privacy
- Implemented cryptographic hashing scheme to protect customer privacy

The WIPER Scenario

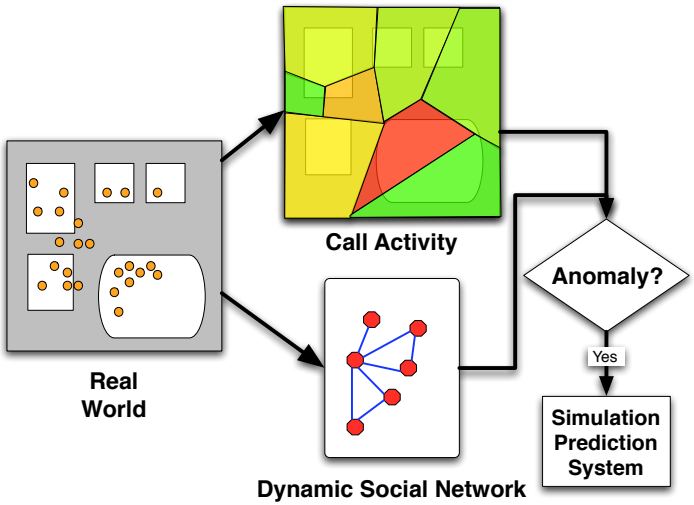

Figure: The WIPER Scenario

WIPER Scenario

- Detect Anomalies from streaming data
- Run simulations to understand crisis events
- Output results to web console

Overview of the WIPER System

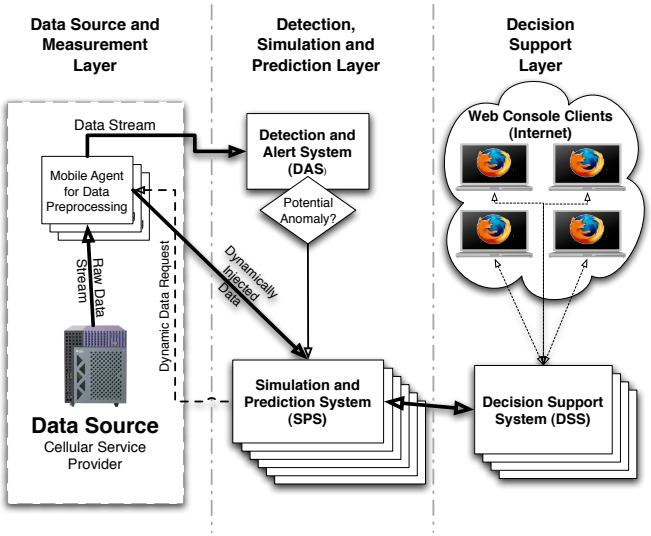

Figure: The WIPER system

The WIPER System Components

- Real Time Data Source
- Detection and Alert System
- Simulation Prediction System
- Decision Support System

Design and Implementation of WIPER Simulation

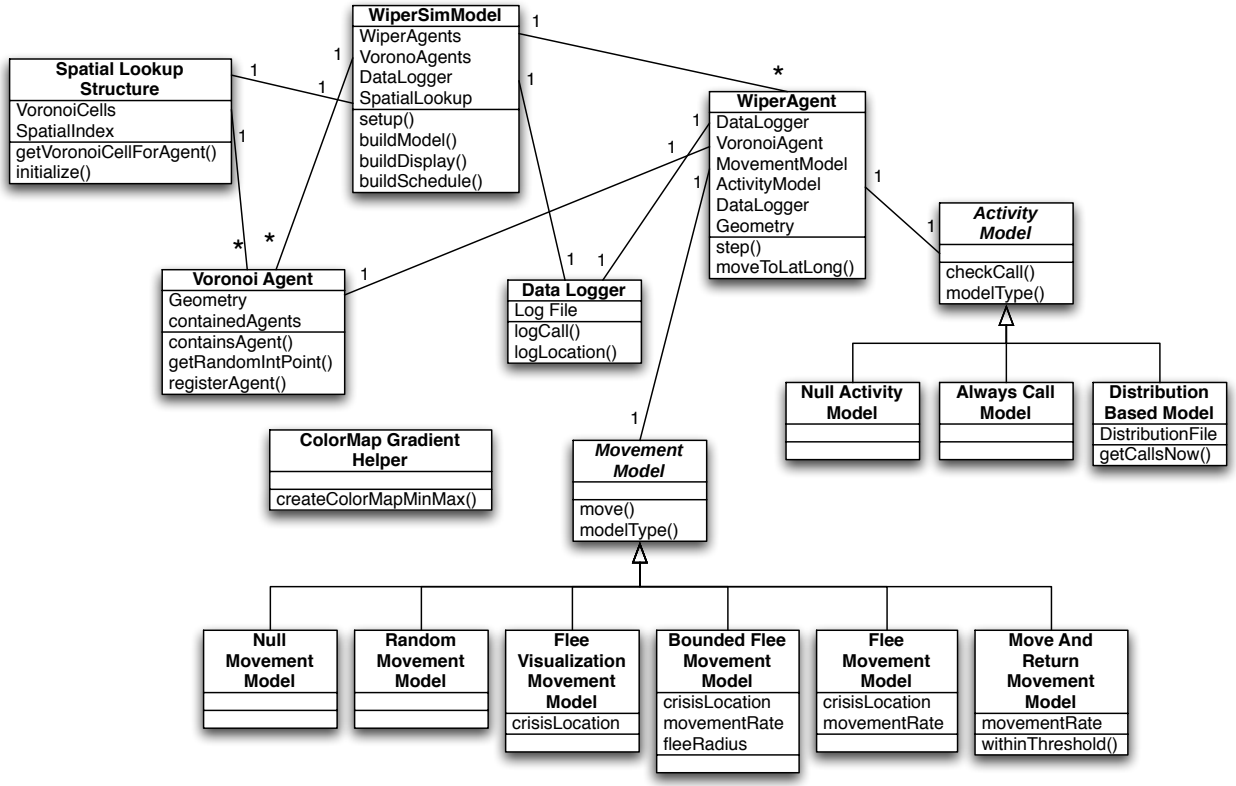

Figure: The WIPER Simulation

Crisis Behavior Taxonomy

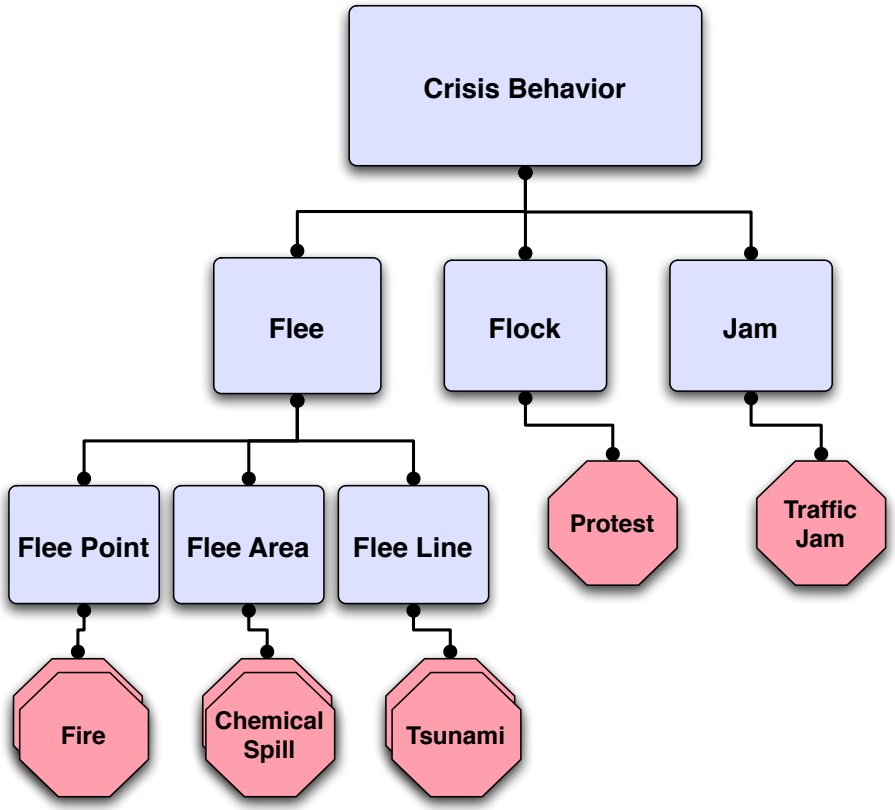

Figure: A Taxonomy of Crisis Scenarios.

Movement and Activity Models

- As shown in the previous figure, movement models for crisis scenarios can be arranged in a taxonomy. This taxonomy allows rapid development of models due to shared components.
- The class hierarchy mirrors the crisis taxonomy and uses code re-use to reduce development time and increase model validity.

Movement Models

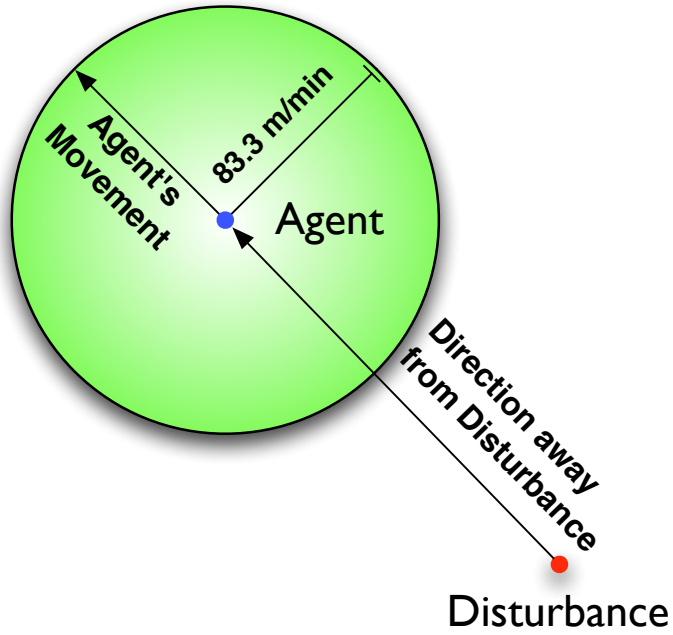

Figure: Basic Flee Action

Movement Model Explanation

- Agent calculates new location based on direction to disturbance
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Activity Models

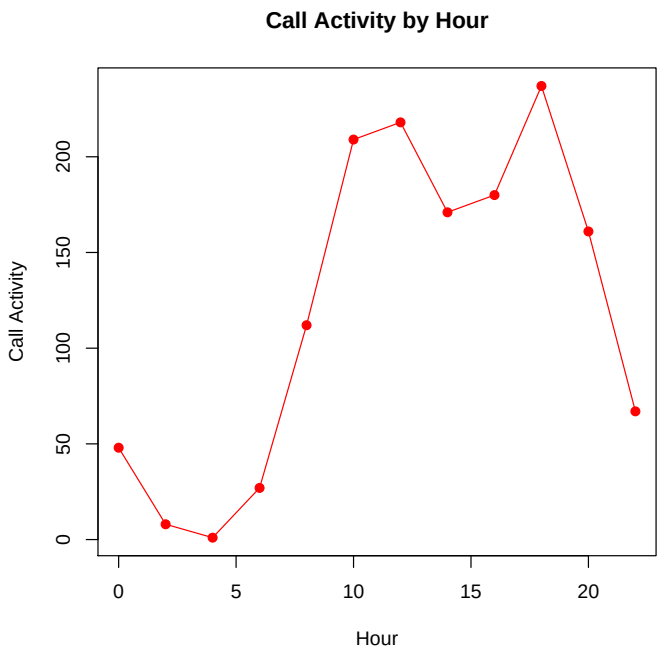

Figure: Empirical Distribution of Call Activity

Activity Model Explanation

- Simulation Reads in Empirical Distribution of Call Activity for the Day of Week
- Simulation schedules an appropriate number of calls for the time period based on the empirical distribution

Publications

[1] T. Schoenharl, G. Madey, G. Szabó, and A.-L. Barabási, "WIPER: A multi-agent system for emergency response," in Proceedings of the Third International ISCRAM Conference, May 2006.

[2] T. Schoenharl, R. Bravo, and G. Madey, "WIPER: Leveraging the cell phone network for emergency response," International Journal of Intelligent Control and Systems, vol. TBA, 2007.

[3] G. R. Madey, A.-L. Barabási, N. V. Chawla, M. Gonzalez, D. Hachen, B. Lantz, A. Pawling, T. Schoenharl, G. Szabó, P. Wang, and P. Yan, "Enhanced situational awareness: Application of DDDAS concepts to emergency and disaster management," in Proceedings of the International Conference on Computational Science (P. Sloot and J. Dongarra, eds.), May 2007.