SUMMARY:

This paper shows a very interesting DDDAS implementation by using the devices that have are so common today, the cell phones. Earlier the emergency response managers had to rely on the various kinds of data that are very contradicting, inaccurate and incomplete. Moreover to use that information effectively, they had to combine the data from various sources, which is very challenging job. But now cell phones can be used for the same task. To make any call or to receive a call, a cell phone user have to register its spacio-temporal position periodically with the nearby cell tower. So, these mobile phone providers can provide the real time data about the location, call volume and call patterns of the cell phones of their subscribers. And this data can be very useful to drive this DDDAS. The motivation behind this project are the recent events like Katrina and Rita. Other disasters like earthquakes, floods, terrorist attacks, industrial accidents, and civil disorders also suggest applications for this system.

DDDAS have four research area: (1) dynamic, data driven application technologies, (2) algorithms used to inject and steer the real time data, (3) the software systems to support these applications in dynamic environment, and (4) measurement system, because the dynamic steering of data require improved measurement and observation. WIPER system focuses on all the four research areas of DDDAS ie dynamically responding to the streaming real time data, using algorithms for detecting anomaly, rules and agent based system for assimilating the new data. It employees the open-standard, open-source SOS to integrate multiple distributed modules. The data used in this system is both actual data about the call and location and the synthetic data to simulate emergency. This data is stored in the database and is anonymized to protect the privacy as the data is aggregate in nature so can't track individual cell phone by actual user ID, and does not include the content of phone calls.

Design of the data consists of three layers. First layer is the Data Source and Measurement Layer. It contains the real-time historic data and the synthetic data. There are three sources of data: Real Time Data Source (RTDS) which contains full activity data, spacial data which is automatically collected by mobile phone company, including 30 sec Call Detail Record, identity of the closest tower and the activity data such as caller and receiver, duration of call and nature of service used. Historical Data is generated from the RTDS, stores the aggregate information and is used to train and calibrate system that detect the anomalies. Third is Triangulation Application (TRI) which provides the high precision location (triangular) data on selected phones but activated only when required It is steered by either SPS or DSS module. These data sources are designed as such that the real time data streams from the cell carriers can replace the archived data sources used during development.

The second layer is Detection, Simulation, and Prediction Layer. It consists of two parts. The first one DAS (Detection and Alert System), processes the data
streaming from RTDS, compares it with the data in HIS, and if it discovers any anomaly, it reports it to SPS(Simulation and Prediction System), the second part. This part then accesses the detailed data available to RTDS and then select the relevant information in vicinity of anomaly. Its rule-based system generates the hypothesis about the nature of the anomaly and then launch the agent-based simulation for that anomaly, which acts as a test for this hypothesis. Now the history of each simulation is stored and as the new data is injected each simulation's prediction data is validated dynamically against the new data. The simulations that are close to reality are recalibrated and rerun from that point of time and others are terminated. More hypothesis and simulations are generated if needed. Here validated simulations are used to predict the evolution of anomaly and these are shared with the modules in the DSS (Decision Support System) Layer. If in case the spacial resolution is not sufficient then the detailed data is requested from RTDS and TRI. Multiple instances of SPS can be invoked for multiple alerts. The important part of this system is the Agent Based Simulation. Here the agents are the cell phones which have unique properties and behavior, based on hypothesis. This agent based paradigm uses bottom-up approach ie the simple agents interact with themselves and the simulated environment. The implementation is object-oriented where the agents act as the objects of the cell phone data type. An agent based simulation tool, RePast is used to build the simulation. The special features of this tool are that it can be used on JAVA/J2EE or .NET platform providing maximum portability and can work on both ESRI ArcMap and OpenMap GIS which can be used to accurately represent the mobile phone and to constraint the agent movement in simulation.

DSS (Decision Support System) Layer is the third layer of this system. It is a user interface to WIPER and provides view on status of emergency and predicted evolution of emergency. It activates the response applications on request of emergency managers and autonomous systems.

**ANALYSIS:**

This is a prototype of the proposed DDDAS. As we know that DDDAS should be dynamic and data driven, WIPER is data driven because it is periodically obtaining the wireless data from the local cellular network and maintaining different data sources so that they can be used differently with different requirements. It is dynamic in the sense that it is showing the artificial intelligence behavior in many ways throughout this project like the data sources are designed as such that the real time data streams from the cell carriers can replace the archived data sources used during development, call data is updates periodically to update the caller's location. Above all the whole process going inside WIPER is dynamic ie when the call data summary streams through the system it has an ability to detect the abnormal activity in terms of call pattern or population movement and then to trigger its simulation and prediction system dynamically, which have got the, so called, artificial brain to set up an hypothesis for this abnormal behavior by using its rule-based system and this hypothesis initiate the agent based simulation. Also, the automated dynamic validation of simulation is done against the streaming data as a test for the hypothesis and to predict the evolution of anomaly.
But there are some challenges in the design and deployment of this system. WIPER will deal with different tasks and multiple distributed heterogeneous applications, but despite of that it must be able to exchange data and control information in both real world and in prototype. The data collection and response system should be able to respond to requests for detailed data, and simulations should be able to adapt to new streaming data. And since these applications and data sources will work on various different platforms and environment the open standard based SOA (Service Oriented Architecture) has been planned to use. This will permit more easy reuse and ability to integrate and extend the softwares.

In addition to these there are some problems with this project. Few are addressed by the paper itself. WIPER system uses wireless cellphone to collect data about the populations during emergencies, and extreme large scale disasters, but these kind of emergencies can disable the key components of the cell phone system, thus reducing its data collection ability in effected areas like disabling the cell tower and on individual basis the battery standby of cell phones. Other is the privacy issue, but this point seems to be very contradicting and is not clarified in this paper. On one its mentioned that privacy have to be maintained by filtering the caller ID and call contents from the other data but on the other side its saying that WIPER uses aggregate data, ie user cant be traced by using that data and even call contents cant be retrieved. But if thats the case then how can this system be used for the emergencies due to individuals like terrorist attack where caller ID and the call contents both are important.