Simulation of WSN Based Vehicle Monitoring for BRTS Corridors Using Ptolemy II

Harshal Arolkar*, Kashyap Dhamecha** and Darshan Patel**

*** GLSICT, Ahmedabad, Gujarat, India, harshal@glsict.org*

*** M.Tech Students, Department of Computer Science, Gujarat University, Ahmedabad, Gujarat, India*

kd.dhamecha@gmail.com, patel.darshan.2709@gmail.com

ABSTRACT

Wireless sensor network (WSN) have become most interesting area of research since last decade. The nodes in wireless sensor networks are capable of monitoring the conditions and co-operatively communicate to the network. Each node in the network has critical impact on the system behaviour, so it is important to simulate the functioning of the nodes before its deployment in real world. In this paper we have simulated a vehicle monitoring system using WSN for Bus Rapid Transit System (BRTS).

This paper is divided into five sections. Introduction of BRTS and wireless sensor network is given in section I, overview of proposed architecture and its solution is discussed in section II, information of the tool used for simulation is given in section III. Simulation work of proposed architecture is shown in section IV. Finally conclusion is given in section V.

Keywords: **BRTS, Ptolemy II, VisualSense, WSN**

I. INTRODUCTION

BRTS, in Ahmedabad was launched on 14th October 2009. Separate dedicated corridor is build for proper and smooth functioning of BRTS. Currently there are 75 bus stations available between RTO and Piranha area. The approximate distance between two stations is around 500m. In the first phase 45 km length of the BRTS route has been completed. In next phase the route is further to be extended by 20 km. For this project total 730 buses are approved for Ahmedabad BRTS, out of them around 200 buses are currently running on road [8].

There is an increase in chances of accident due to trespassing by other vehicles, persons, animals or fallen objects on the BRTS corridors. Table 1 shows the result of survey done by the team of JANMARG in 2009-2010 [2]. As of now only 200 buses are running on corridors; but if it increases to 730 buses, there are chances of increase in number of accidents also. At present there is no automatic system available for monitoring as well as avoiding possibility of accidents on BRTS corridor; we have already proposed a solution for the same using wireless sensor network in [5].

A Wireless Sensor Network consists of spatially distributed autonomous sensors to monitor physical or environmental conditions such as temperature, sound, vibration, pressure, motion, pollution etc. The sensors cooperatively pass their data to other nodes at different location [3]. Based on the requirement, sensors can be organized in best suitable topology viz. star, mesh, hybrid [1].

II. PROPOSED ARCHITECTURE AND SOLUTION

The proposed architecture as described in [5], consists of wireless sensor network, database and mobile services. Sensor node will be deployed on the BRTS corridors to sense trespassing. In case there is any kind of trespassing within the corridor, the sensor will then send this information to the control centre. The control centre will then generate an appropriate

Accidents involving BRTS Vehicles From 15th Oct '09 to 14th June '10								
Month / Accidents	1st	2nd	3rd	4th	5th	6th	7th	8th
Total number	2	1	2	6	6	4	4	5
Fatalities	0	0	0	0	1	0	0	0
Serious injury	0	1	0	0	0	0	0	0
Minor injury	0	0	0	2	1	0	0	0

Table 1: Status of Accidents involving BRTS vehicles

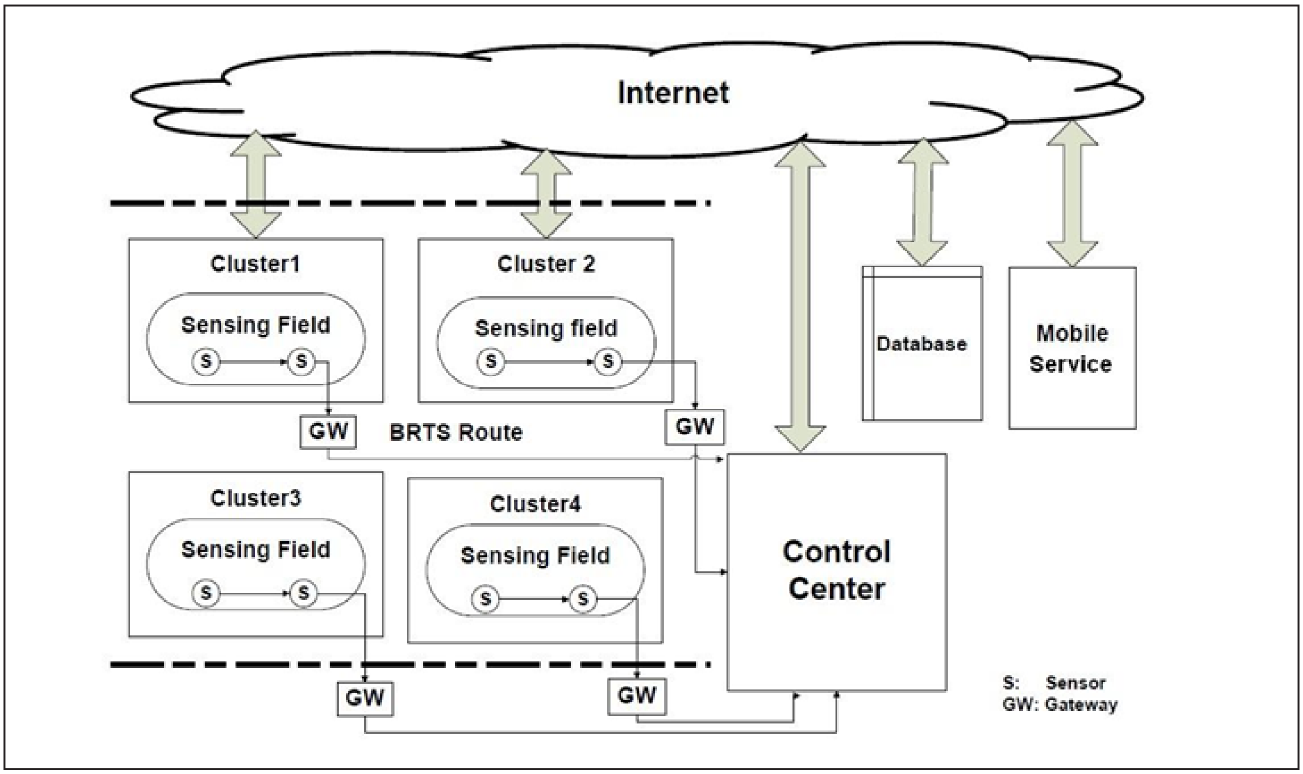

Figure 1: Architecture for monitoring BRTS corridors using WSN

message and send it to the concerned entity like, bus driver or security guards.

In the proposed architecture, shown in Figure 1, at the lowest level, sensor nodes are deployed to sense different types of obstacle from the BRTS route. The BRTS route is divided into number of wireless sensor clusters. Individual sensor nodes within the clusters will communicate and coordinate to create a cluster.

Once the cluster is formed, sensor nodes within the cluster will transmit data using multi-hop mechanism to cluster head which acts as the gateway. The gateway serves to communicate between source sensor node and control centre which may be at far distance from the place of object. Based on the data received the control centre looks into the database and creates a message for appropriate person (security guard or bus driver) and sends message through mobile service. Bus driver who receive this message will understand about the present obstacle and can take appropriate action to avoid the accident. In same way a security guard who receives the message, can go to the place of trespassing and take appropriate action.

III. SIMULATION TOOL

Modelling of wireless sensor networks requires sophisticated representation and analysis of communication channels, sensors, ad-hoc network protocols, localization strategies, energy consumption in sensor nodes, etc [4]. We have chosen Ptolemy II as a simulation tool.

Ptolemy II has been under development since 1996, it is a successor to Ptolemy Classic, which was developed since 1990. The core of Ptolemy II is a collection of Java classes and packages. Ptolemy II is an open source software framework supporting actor oriented design. Actors build in java, are components that execute concurrently and communicate through messages using communication ports. In Ptolemy II computation of the model is take care by component called director. Because of DE (Discrete Event) domain of Ptolemy II, components can interact with each other via events with time stamp. DE domain supports dynamical changes in topology and multi threading. In multi thread, one thread can execute the simulation and other thread can change structure of model [6]. Because of its flexibility to simulate in different abstract level model for a same platform and capability of combining models with behavior defined in different domain, it is the best suitable simulation framework [7].

In Ptolemy II various specialized tool has been created from this framework, viz, HYvisual, Kepler, VisualSense. HYvisual is for hybrid system modeling, Kepler is for scientific workflow and VisualSense is for modeling and simulation of wireless network and sensor networks.

IV. SIMULATION OF VEHICLE MONITORING

A simulator Ptolemy II is actor oriented; hence it requires creating a composite actor according to requirement. Simulation of the architecture is described in this section. We have tried to map a real life scenario into our simulation.

It contains three different routes that include two cross roads. Accordingly five areas have been defined for the BRTS route and at the each intersection there is one security guard manning the intersection. Random trespassing of vehicles other than the BRTS buses has been done. Figure 2 shows the above mentioned scenario. To complete our simulation, composite actors like sensor node, gateway node, control centre and mobile service centre also had to be created. The description of the same is mentioned herewith.

Sensor Node

A sensor node that emulates a motion detector has been created in VisualSense. Motion detectors can be either active or passive. Active sensors use ultrasonic or microwave pulse to detect motion while passive detectors use body heat to detect motion. We have created active motion detectors, these detectors send microwave or ultrasonic pulse in its range and according to the reflection it receives; it then identifies the obstacle.

32 such homogeneous sensor nodes have been created for the simulation. A sample sensor node is shown in Figure 3. The sensor is capable of detecting any activity of trespassing within the range of 200m radius. Each sensor node has been tagged with identification like sensor1, sensor2 and so on. A radio channel has been used to transmit the signal within its range.

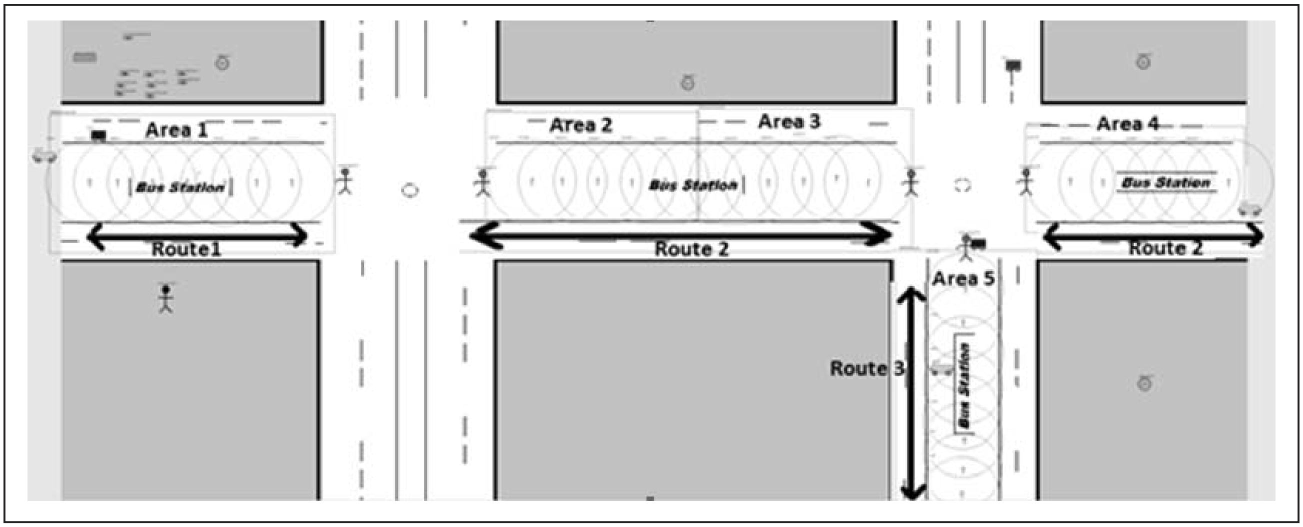

Figure 2: Simulation of BRTS Corridor

Whenever an object arrives in the range of the sensor, a signal will be reflected back to sensor using same channel and the node will identify it as an obstacle. A hop by hop mechanism has been implemented such that the message reaches the gateway node. The gateway node also works as an aggregator. Delay Channel is used for multi hoping. Route 1 is covered with 7 sensor nodes, route 2 with 17 and route 3 with 8 nodes.

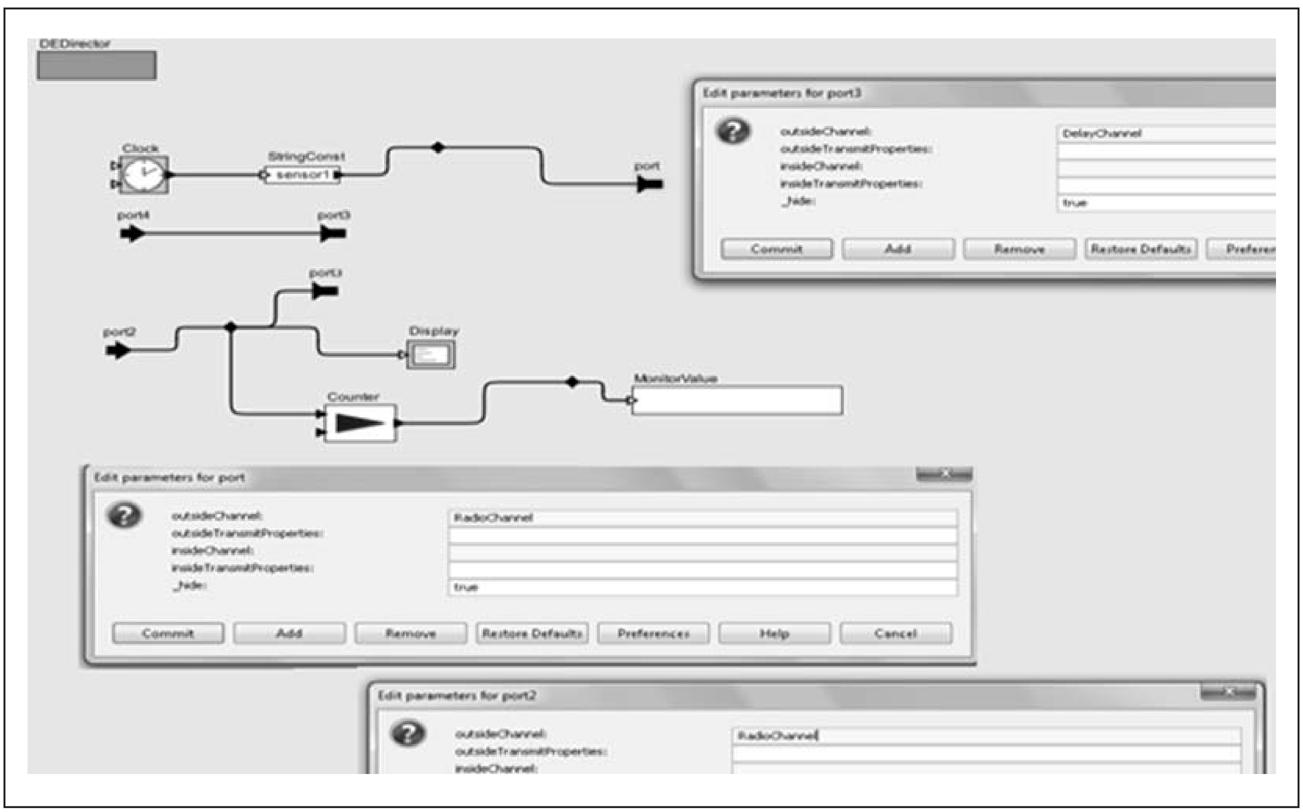

Figure 3: Simulation of Sensor Node

Gateway Node

As mentioned in the architecture, the gateway node will receive information about the obstacle from all the sensors through multi hop message passing. Once the information is available with gateway, it is then to be transferred to the control centre. Before transferring the information, the gateway node will map the location of the sensor node that sent the data. The control centre thus will directly come to know about the location of the obstacle. If required this information may be aggregated and only single message may be sent. Figure 4 shows the gateway node. All gateway nodes will broadcast the information to control centre through erasure channel.

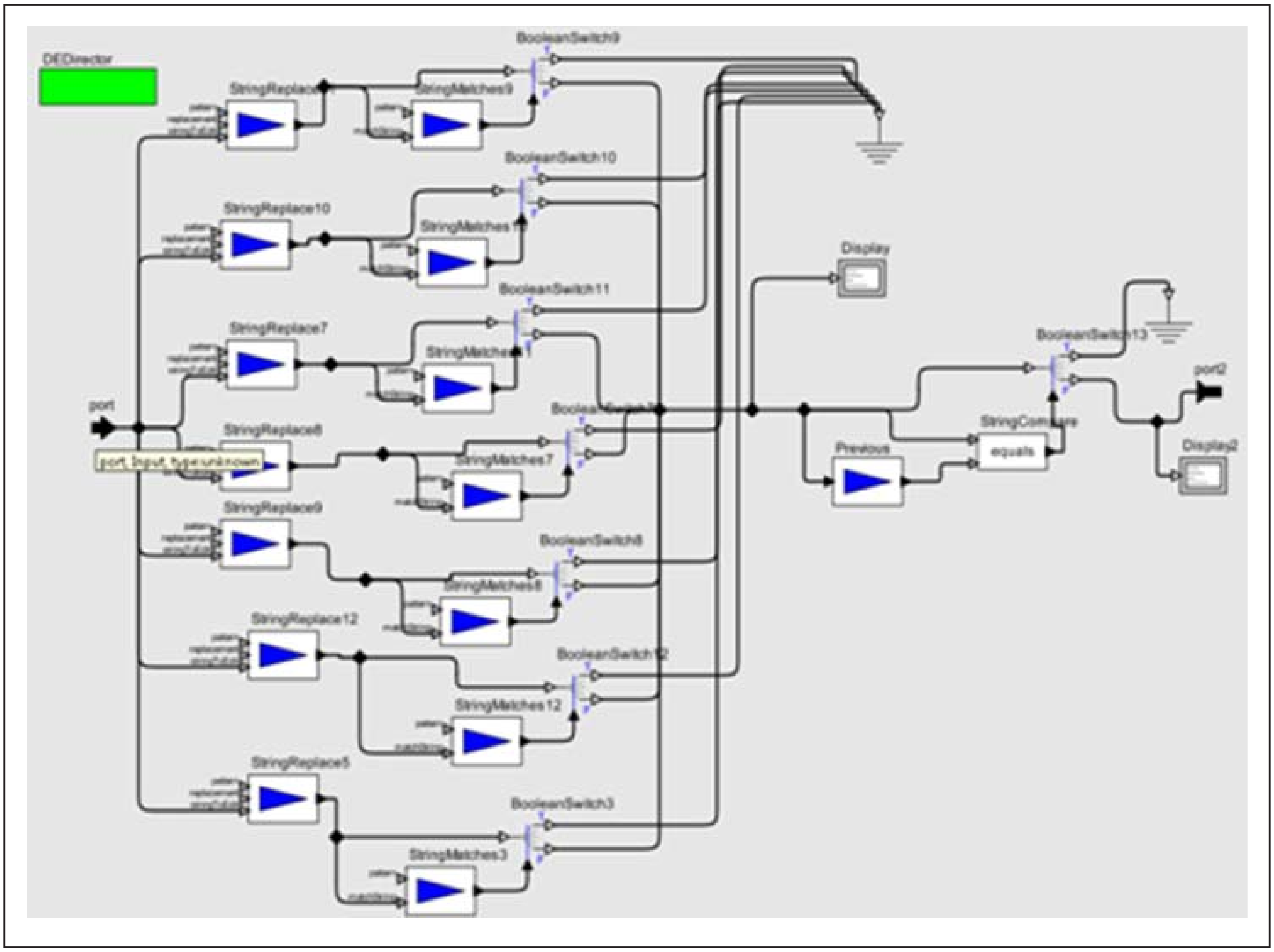

Figure 4: Simulation of Gateway Node

Control Centre

This is a centralized node, which will receive the information from all clusters through erasure channel. After receiving the area in which obstacle or trespassing is detected, control centre will try to look for the security guards and BRTS buses available within that area. For identifying available BRTS bus in particular area, control centre will broadcast the query to each cluster. The query contains the name of area from which available buses are needed to be identified. Particular cluster will then send the list of available buses to control centre. After acquiring the list of buses and security guard to whom messages can be send database lookup will be done to extract information (mobile number) of these people.

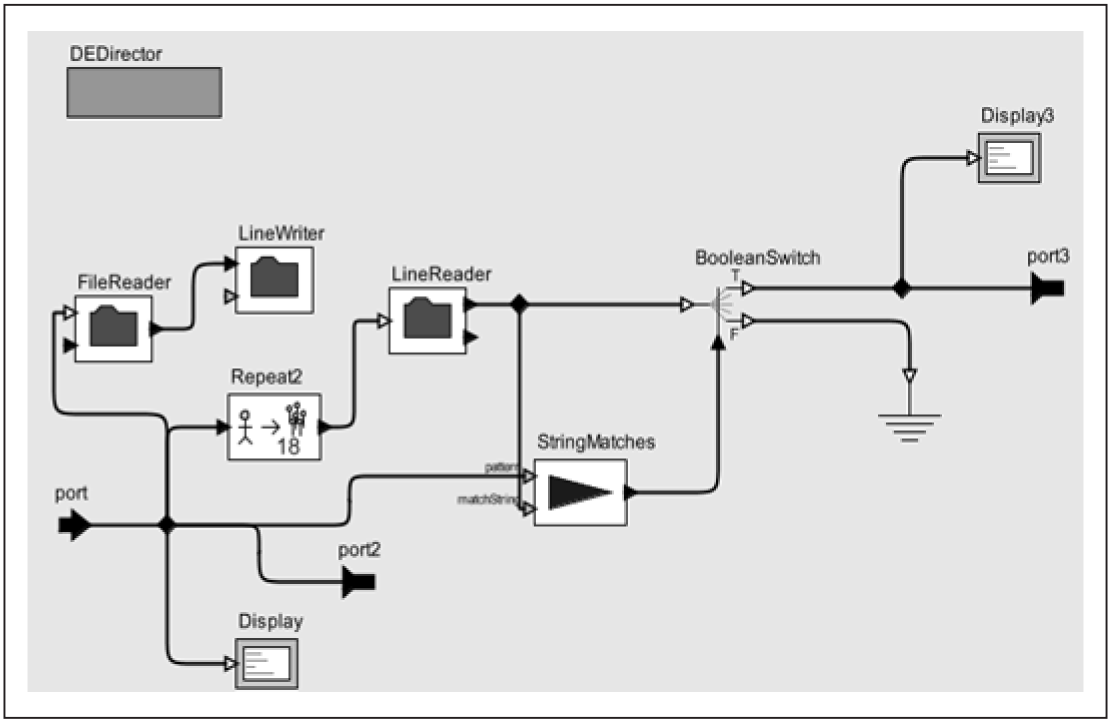

Figure 5: Simulation of Control Centre

The list of entities to which messages are to be sent will finally be sent to mobile service centre. Figure 5 shows composite actor for the control centre while Figure 6 shows mobile service centre.

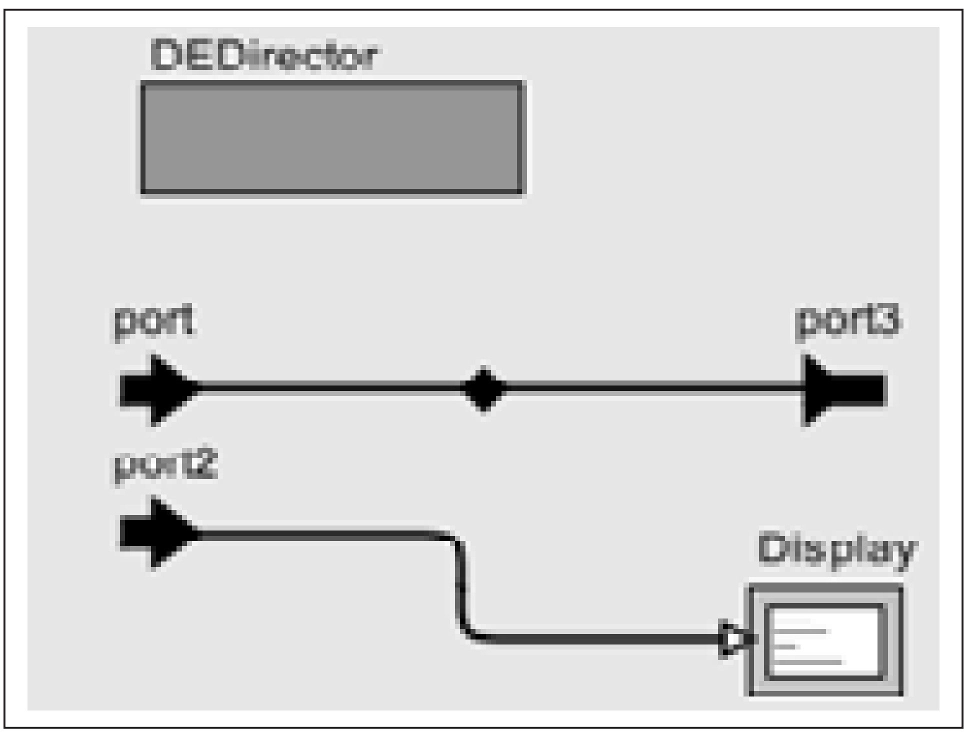

Figure 6: Simulation of Mobile Service

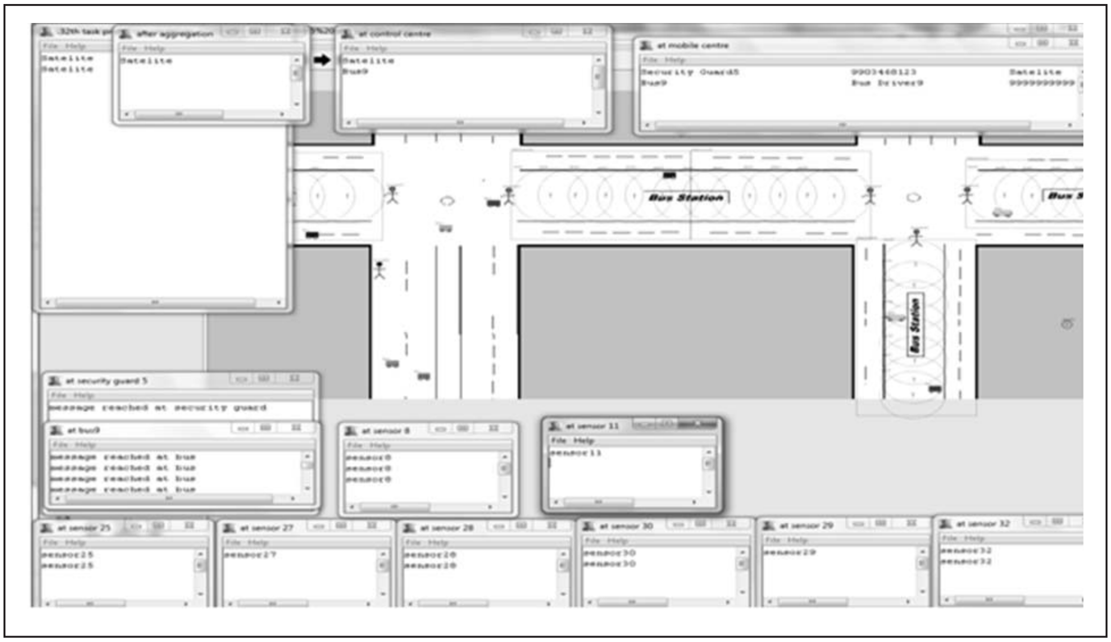

Figure 7: Final Output

Figure 7 shows the output of this simulation. It shows information of each sensor node that has sensed the obstacle in their range. It also displays aggregated as well as un-aggregated information at gateway node and the list of the person to whom message will be sent, extracted by control centre as well as mobile service centre. Finally it displays the messages to be sent to a particular security guard and/or bus drivers.

In case any sensor node goes down that is it becomes inactive, the system will not be affected, but instead there will be additional delay in response time for sending messages. Figure 8 shows such a scenario where sensors with id 26 and 31 go down, in such a case other sensor nodes in that area will sense the obstacle and inform the control centre.

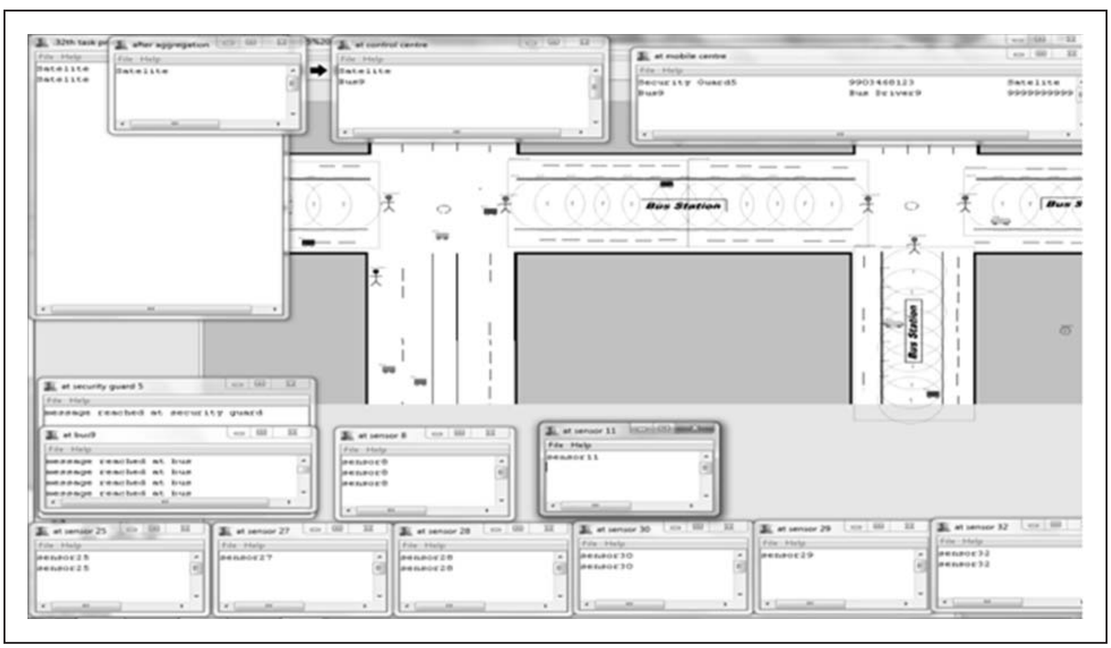

Figure 8: Output with two sensor nodes inactive

The delay in the response time will vary, depending on location of the sensor nodes that have failed. Table 2 shows output of different scenarios related to the simulation. Table 2 shows that each sensor node detects same obstacle number of times; so total number of detection as can be seen in column 5 of table 2 are more. But because of aggregation happening at gateway node, control centre will receive this message only once.

V. CONCLUSION

This paper addresses the system for monitoring the movement of buses on the route of BRTS. The main aim of the system is to reduce accidents and improve the quality of transport system. The simulation results are encouraging and show that proper monitoring may reduce the accidents to large extents. Different failure scenarios proved that even if 80% sensor nodes fail, still the system will work properly though with some delay. The delay as such is not going to cause a major impact on the systems behaviour. To increase the lifetime of the sensor node aggregation mechanism has been incorporated. The physical implementation of the said system thus guarantees reduced accidents and better quality of transport system.

VI. REFERENCES

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Table 2: Simulation Results

Number of sensors failing out of 32	Number of obstacle(s) detected	Route in which obstacle is detected	Number of sensors that detect obstacle	Total number of detection	Area number	Average response time including delay for area in second
0	1	Route 1	7	20	Area 1	0.16
	1	Route 2	17	41	Area 2	0.16
	1	Route 3	8	13	Area 3	0.16
	2	Route 1,2	24	65	Area 4	0.16
	2	Route 1,3	15	39	Area 5	0.16
	2	Route 2,3	25	52		
	3	Route 1,2,3	32	76		
10	1	Route 1			Area 1	0.16
	1	Route 2	10	22	Area 2	15.1
	1	Route 3	7	11	Area 3	6.05
	2	Route 1,2			Area 4	6.07
	2	Route 1,3	12	31	Area 5	5.12
	2	Route 2,3	17	37		
	3	Route 1,2,3	22	50		
15	1	Route 1	4	14	Area 1	0.15
	1	Route 2	9	20	Area 2	15.1
	1	Route 3	5	9	Area 3	6.05
	2	Route 1,2	13	35	Area 4	6.06
	2	Route 1,3	9	19	Area 5	6.16
	2	Route 2,3	14	31		
	3	Route 1,2,3	18	42		
20	1	Route 1	3	11	Area 1	0.16
	1	Route 2	6	9	Area 2	15.02
	1	Route 3	3	4	Area 3	6.04
	2	Route 1,2	9	24	Area 4	6.06
	2	Route 1,3	6	12	Area 5	7.03
	2	Route 2,3	9	19		
	3	Route 1,2,3	12	20		