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INTELLIGENT PUBLIC TRANSPORT PREDICTION SYSTEM using WIRELESS SENSOR NETWORK

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Abstract - A suitable and systematic intelligent public transport system plays a key role in financial sector of a country. But IPTS, in most of the developing countries is not running appropriately because of financial issues for enhancing technologies and deficient in systematic planning. Wireless Sensor Network (WSN) is an emerging technology and has vast potential to be utilized in vital circumstances. WSN has important applications such as remote traffic environmental monitoring as static installation or target tracking by placing on board. It is difficult to choose an appropriate WSN for better performance in developing countries. This paper describes sensors techniques used for intelligent public transportation system (IPTS) applications and a review of influencing factors for sensor selection and case study for hypothetical cost estimation of IPTS network with different WSNs for Rajasthan state.

Keywords –Intelligent Public Transportation System (IPTS), Bus Rapid Transit (BRT), Automatic Vehicle Location (AVL), GPS, GSM, GPRS

INTRODUCTION

Wireless sensor networks are considered as a system of many small, low-cost devices - sensor nodes that are capable of performing computations, measuring various physical values, storage capabilities and communicating with each other and organizing themselves in order to cooperatively achieve a desired task. Sensor networks are related to the environment surrounding the sensor and transform them into an electric signal. Processing such a signal reveals some properties about objects located and or events happening in the sensor. A greater number of sensors can be allowed for sensing over larger geographical regions with greater accuracy [1-3].

Much of the developing countries are experiencing rapid economic growth, while transportation management practices and technologies from advanced economies might find relevance in developing countries, the developed world can likewise learn from economically less well-off places [4]. Public transport faces severe problems in almost all countries of the developing world, perhaps most important, the lack of efficient transport system resources due to high investments involves. Developing countries transport systems desperately limited necessary financial resources for investment in infrastructure, vehicles and new technologies [5-6].

In IPTS, communication costs vary widely based on the type of communication and the way the communication is charged. Significant investments in signpost technology (e.g., London Buses) are using Global Positioning System-based automatic vehicle location (AVL) method to provide the basis for their real-time systems. The cost of the underlying technology varies from $100 per vehicle to more than $7,000 per vehicle. The cost of providing the real-time information in addition to AVL technology ranges from under $100,000 for a 156- bus system to $46.5 million for a system with 5,700. Operating and maintenance (O&M) costs vary widely among systems, with the highest costs being noted for those systems that use cellular digital packet data communications technology to transmit the information [7].

98 B-Line buses are equipped with on-board GPS units, tied AVL system, as well as an onboard computer. The total cost of the central and onboard DGPS based AVL equipment and associated installation, acceptance, documentation and training costs for the transit management system was $ 4.0 million, comprising $2.8 million for the central system, $500,000 for supply and installation of vehicle-mounted hardware in the 28 buses, and approximately $600,000 for radio communications and project management. On Board Transit Management System Cost per Vehicle is $18,000 [8].

These systems are very costly for developing countries to introduce in their BRT systems. WSN plays a major role in IPTS, so selection of WSN in IPTS should be considerable.

IPTS APPLICATION CATEGORIES

Following are IPTS application categories, which are widely used in BRT, as shown in figure 1.

Traveller Information Systems –
. Traffic density information systems
. In-Terminal Transit Information Systems
. In-Vehicle Transit Information Systems

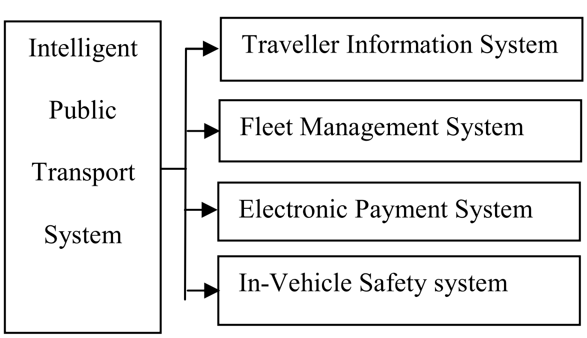

Figure 1: IPTS Application Categories

Fleet Management Systems -
. Bus Arrival Prediction systems
. Automatic Passenger Counters
. Traffic Signal Priority Systems
. Geographic Information Systems
. Bus stops Communications Systems
. Automatic Vehicle Location Systems
Electronic Payment Systems -
. Smart Cards
. Fare Distribution Systems
In-Vehicle Safety systems -
. Collision Avoidance systems
. Pile-up avoidance systems
. Vehicle Route diversion Detection systems

SENSORS TECHNIQUES IN ITPS

1. **Static Sensor Based WSN** - In these techniques, sensors are statically installed on or by the side of road from where sensors will collect various vehicles or road related information. High accuracy for vehicle detection can be achieved through these techniques, but main drawbacks are maintenance and repair costs and disruption of traffic for installation and repair.

a) **Multi Media based WSN** - Video surveillance has been projected to enable tracking and monitoring of events in the form of multimedia such as audio, video, and imaging. APTA proposed a system [9] in which closed-circuit television (CCTV) cameras, occasionally equipped with microphones which enable a central dispatch and or control centre to remotely monitor vehicles, stations and guide ways [10].

b) **Magnetic and acoustic based WSN** – Several organizations have developed magnetic guidance systems for BRT [11]. A system proposed [12], in which Vehicles are detected by measuring the change in the Earth's magnetic field caused by the presence of a vehicle near the sensor. Two sensor nodes placed a few feet apart can estimate speed. An experiment performed in 2004 [13], for traffic measurement in freeways and at intersections. These sensors deployed by the side of the road to be monitored [14-15].

c) **<u>Inductive loop based WSN</u>** - Several parameters of the road traffic are accomplished by inductive loops placed under the pavement. These inductive loops allow monitoring passed vehicle [16].

2. Mobility sensor based WSN - In these techniques, where sensors are on board with the moving vehicles. These techniques are highly reliable and accurate. Main disadvantage are high cost devices and high power consumption.
There are following types based on mobility sensing:
<u>RFID based WSN</u> - In 2010, Hatem et. al. [17-19], came up for real-time tracking and identification for bus management system using RFID, to overcome limitation of GPS and CCTV technologies.
<u>RF based WSN</u> – In 2012, a research purposed that is based on low cost and low range RF receiver and transmitter module [20]. A system introduced which comprises of a wireless sender-receiver pair across a road, based on exploiting the variation in wireless link characteristics when line of sight conditions between a wireless sender and receiver vary.

a) **<u>GPRS/GSM Based WSN</u>** - Location area update service technology based traffic information system relies on the cellular network data reported by mobile phone to position accurate location and solved the problem of mobile objects management. GPRS/GSM also used in monitoring the time of bus arrival, departing from the bus station and reporting stations name automatically.

b) **<u>GPS</u>** – In IPTS applications, GPS is very popular and efficient WSN.

INFLUENCING FACTORS FOR SENSOR SELECTION IN IPTS

<u>Cost</u> - Wireless sensor networks consist of a number of sensing nodes which are distributed in a wide area, the cost of a single node is very important to justify the overall cost of the networks. As a result, the cost of each sensor node has to be kept low. For example, In Similar functionalities system, it is unreasonable to put a \$100 GPS receiver which can be replacing by \$10 RF receiver and transmitter module for vehicle tracking system.

<u>Latency and Precision</u> - Latency decides system performance by forwarding the data in heavy load traffic in a public transportation system. Precision is defined sensing error rate with respect to an external standard. The precision might be as fine as data collection and processing in microseconds or as course as seconds.

<u>Energy Utilization</u> – Sensor selection also depends on utilization of sensor energy for performing a task with efficient coverage. Every node uses some energy for activities like sensing, processing, monitoring, storage and communication.

<u>Synchronization</u> - Some synchronization schemes require extra, energy-hungry equipment (e.g., GPS receivers) others may have practically no energy impact (e.g., in RF based WSN, listening to present packets already being transmitted for other reasons).

<u>Scalability</u>- sometime network area is dynamic, it changes depending upon the user requirements. The number of sensors in a region can be used to indicate the sensor node density. The sensor node density depends on the application in which the sensor nodes are deployed. All the sensor nodes in the network area must be scalable or able to adjust themselves to the changes in the network conditions.

CASE STUDY OF RSRTC, INDIA

This research paper discusses, case study for approximate estimation of different implementation of WSN on Rajasthan State Road Transportation Corporation, India. Following calculations made on existing RSRTC bus stands and buses for year 2011. There are three different WSN cases (GPS, GSM and RF transmitter and receiver (Tx/Rx) with GPRS. The application of ITPS to predict bus arrival time and bus stop communication system is developed.

<u>In case if GPS WSN use</u> –
RSRTC has 1350 bus stands and 4476 buses

One GPS receiver cost = 2500 INR [*33*]
All buses require GPS = 4476x2500
Total = 1,11,90,000 INR

In case if GSM WSN use –
RSRTC has 1350 bus stands and 4476 buses
One GSM modem cost = 1500 INR [*34*]
Total All stands and buses require GSM modem = (1350+4476) X 1500
Total = 87,39,000INR

Note: GSM/GPRS has monthly cost which has to be multiplied by 5826 (1350+4476). If network nodes has Combination of GPS and GSM/GPRS WSN then total expenditure will be 1,99,29,000 INR.

In case if RF Tx/Rx WSN use –
RSRTC has 1350 bus stands and 4476 buses.
One pair low range RF Tx/Rx cost = 350INR [*35*]
All buses require Tx/Rx = 4476x350 = 15,66,600INR
All stands require Tx/Rx = 1350x1500 = 20,25,000INR
(Long range RF Tx/Rx or GPRS cost is approximate same)
Total = 35,91,600 INR

Note: GPRS has monthly rental cost but in RF Tx/Rx WSN based system monthly cost is multiplied by 1350 (not 5826). It is observed from total cost estimation, that RF Tx/Rx WSN has lowest cost among other WSNs. So, for same application of IPTS RF based WSN node can be a better option for deployment.

Table 1: RSRTC data on IPTS expenditure

Year	Total investment (Technologies & engineering works) (In Lac INR)	Expenditure (On improve IPTS) From total (In Lac INR)	Percentage (%)
2011-10	141.96	36.69	25.85
2010-09	100.70	10.48	10.41

From table 1 it is seen that, in year 2010-11, RSRTC's total investment on technologies and engineering works was 141.96 Lac INR. In this amount, 25.85% expenditure means 36.69 Lac INR invested on improve IPTS for providing better services and facilities to passengers. In year 2010-11, RSRTC's total investment on technologies and engineering works was 100.70 Lac INR. In this amount, 10.41% expenditure means 10.48 Lac INR invested on improved IPTS.

Hence, Selection of WSN in IPTS plays an important role. So selection of WSNs should be in range of capital allocation for IPTS improvement.

ANALYSIS AND DISCUSSION

In this research paper, most of the performance evaluation with existing systems for wireless sensor networks that include static and mobility based WSN are presented. The first and foremost decision need to be made is whether to select WSN is making fulfillment based on requirements and constraints. From the case study of RSRTC, we justified that cost estimation vary with different WSN usages for same IPTS applications. In developing countries, where system involves low cost sensor, can simulate network with thousands of nodes and gives satisfactory results. The time, effort, maintenance and resources required should be least. Unfortunately, for GPS based solutions have not feasible in the IPTS for developing countries because:

- In a network, GPS production cost factor and large number of nodes is an important issue.
- The power consumption of GPS will reduce the effective operability duration and also reduce the battery life of the sensor of the entire IPTS network.
- Sensor nodes are essential to be small in size but the size of GPS and its antenna increases the sensor node form factor.
- In the presence of mountains routes, dense forests routes, indoor environments or other obstacles that can block the line-of-sight from GPS satellites, GPS cannot be implemented due to signal fading.

For these reasons an alternate solution of GPS is required which is cost effective, rapidly deployable and can operate in diverse environments. Some of the WSNs cannot guarantee accuracy of results due to simplified assumptions and results may not be more accurate and highly precise due to lack of realistic models for mobility based but it will near native accurate to predict IPTS behaviour and solve the intention of the deployment of the system.

CONCLUSION & FUTURE WORK

This research paper presents a survey of WSNs which are used in IPTS and selection of WSNs for developing countries. The WSNs were selected based on their cost, Latency and Precision, Energy Utilization, Synchronization and Scalability. The purpose of this study was to build necessary understanding among researchers, existing systems and WSN selection for IPTS. We believe this study will aid to pick an appropriate sensor for performance based on their IPTS requirements and constraints in developing countries. In future, we will extend our analysis and include some more WSNs or techniques for improve IPTS performance and real platforms for WSNs implementation.

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