Article : Public Transport Bus Management : Electronics

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Abstract

Automated tracking of buses can be used to provide useful estimates of arrival times along with the crowd density

and enhance commuter convenience. Radio Frequency Identification (RFID) tags has been proposed for use in this

paper for bus tracking. The paper focuses on how RFID Technology can be used to solve problems faced by public

transport in metropolitan cities of the country. A particular case study of B.E.S.T. (A public bus transportation

system of Mumbai) is presented. There are, however, formidable obstacles in the way of widespread RFID

deployment. From a systems perspective, we highlight and explore the problem of employing RFID and

measurement of crowd density, handling of large real base data containing the bus arrival and crowd density.

Keywords: RFID, ECA, Data Management, Forecasting, Public Transportation.

1. Introduction

The Radio Frequency IDentification (RFID) is a technology which can be used for an automated identification, it

allows for non-contact reading of data, making it attractive in various applications such as manufacturing,

warehousing, retail, logistics, pharmaceuticals, health care and security. RFID systems are foreseen as a replacement

to the legacy of bar code system of identifying an item. The major advantage of RFIDs over bar codes is that it is a

non-line-of-sight technology, thus every item need not be handled manually for reading. In addition, RFID readers

can read tags even when they are hidden or moving.

The primary focus of this paper is the use of RFID technology to solve problems faced by commuters and bus

(transport) operators in many metropolitan areas. In this paper we will use Brihanmumbai Electric Supply and

Transport undertaking (popularly known as BEST) which operates in Mumbai as our case study.

The Mumbai bus system is one of the largest in the country in terms of number of buses and its fleet includes around

4500 buses and their operations. Often the buses are overcrowded; as a result commuters usually spend long hours

waiting at bus stops. The bus arrivals at a particular stop are stochastic variables in terms of crowd density as well as

arrival times thanks to traffic congestion. This unpredictability can be partly alleviated by deploying a bus tracking

and reporting system. In section 2 we briefly introduce RFID technology and its components. In section 3 we

masquerade the problems faced for measuring the crowd density. Section 4 explains the solution for the proposed

problem using RFID Technology. In section 5 we pose the challenges of handling huge number of events. Section 6

provides a framework for using the collected data in predicting arrival times for buses at different stops.

2. RFID System

RFID technology consists of the necessary three components: Tag, Reader and the Middleware.

2.1 RFID Tag: -

It consists of a microchip with data storage, limited logical functionality and an antenna which is

tuned to receive radio frequency waves emitted by a reader or transceiver for allowing wireless transmission of data

to the reader.

2.2 RFID scanner/readers: -

It consists of a radio frequency module, a control unit and a coupling element to

interrogate the tags via radio frequency communication. Readers are usually connected through middleware to a

back-end database.

2.3 RFID Middleware:

This is specialty software that plays an important role between the reader network and the

true application software to help process the significant amount of data generated by the reader network.

Middleware is responsible for conditioning the data, eliminating false reads besides performing aggregation and

filtering of data. Also, by monitoring multiple readers, middleware can detect the movement of RFID tags as they

pass from the read range of one reader to another.

3. Measurement of crowd Density

The measurement of the crowd density is always a difficult task and if the density is related to the public transport

the difficulties can be manifold. Here we propose two solutions for the same. In the first approach the sensors fixed

on the ENTER and EXIT gate can be used to detect passengers entering and leaving the bus, the difference of which

can accordingly give an estimate of the crowd. The sensors at the gate can be of an optical based or a strain-gauge

based. The proposed solution has various constraints such as the gate should be used exclusively for entrance and

exit. Only one person should be allowed to enter/exit the bus at a time. The constraints are very difficult to be

followed in places like Mumbai. The second approach seems to be the best with no constraints in which the image

processing tool can be used. We have investigated a number of techniques for crowd density estimation, movement

estimation, incident detection and their relative merits using image processing. The technique, involved background

generation and estimating the crowd density using a background as a reference images seems to be the best solution.

The technique developed involves classification of the pixels of both the images. Pixel comparisons of current image

with reference image give an estimate of the crowd density. Clearly, the reference image quality in this method

influences the accuracy of measurement. The reference is taken as an image of the bus with no passengers.

RFID SENSOR

RFID SENSOR BUS

Passenger

Passenger

Server

Bus

Figure 1: Bus tracking system

4. Proposed RFID based Solution

The crucial information such as the specific bus number, the capacity of the bus, the route number currently plying

and the termination point are stored with a tag. Each bus could have an RFID tag affixed to it while the readers are

conveniently mounted at intersections, lamp posts or bus stops initially. Tag readers continually monitors passing

buses and transfer this information in real-time to a central computer.

A commuter with access to phones could subscribe to the following service from the network provider. The

subscriber may enter his destination stop, location of the nearest bus stop on his phone. The system will inform him

of the relevant buses closest to him and expected arrival times of these buses along with the crowd density.

The above service can be provided by the network operator. The provider contacts a central computer to obtain the

set of buses traveling through the closest bus stop to the customer. This list is obtained in sorted order and could

possibly be filtered or enhanced depending on the preferences of the customer. For example, if there are several bus

stops in proximity to the commuter, information on relevant arrivals at all these bus stops can be provided. The

provider can provide customized service to each subscribing commuter for a small fee.

This service can be used for multiple purposes to locate and control bus movement in the metro city. For example, in

the event of an accident causing traffic congestion on a particular road, the buses leading to that road can be

informed. In some cases, the routes of the bus can be changed temporarily and accordingly bus driver can be

informed via wireless network. Or if it is found that a particular bus was stuck in traffic and that has led to a smaller

gap with the next bus, the bus driver of the next bus can be informed to slow down to increase the gap. Many such

applications can be thought of based on such an RFID application.

Terminus (End

Terminus (start of route)

of route)

h 5

hN - 2 hN - 1 hN

h2

hN - 4 hN - 3

SN

S1 S2 S3 S4 SN - 3 SN - 2

Bus route 225 Bus route 225

SN - 1

Stop nearer

to passenger

SN: -Stops of bus route 225; hN: -Hop delays of bus route 225; solid line shows actual hop

delays and forecasted delays are on dashed line

(Figure 2: The bus stop and hop delays)

5. Challenges of Event Handling

The radio waves' being easily distorted, detected, absorbed, or interfered and hence leads to technical challenges

associated with deployment of RFIDs. For example, there are problems with false or missing reads. There are a

number of system-level challenges such as determining the number, type and placement of readers we primarily

focus on the challenges related to data management which deals with capturing, storing and querying RFID data

The BEST consist of over 4500 buses which runs over 350 bus routes with average speed between 12 -14 Km/hr.

Many routes run for 21 hours a day. The average time between two buses on a route is about 18 minutes. But, due to

traffic congestion and peak crowds, the maximum time may exceed 30 minutes. Around 4.5 million passengers use

BEST buses every day.

[1]

[1]

The number of trips along a route will be given as

[1]

[1](21 x 60 /18), on an average. Thus,

with 70 trips per bus route and an estimated average number of bus stops per route = 18, the estimate for the number

of events that will be generated in this scenario is as below:

70 trips x 350 routes x 18 stops = 4, 41,000 events

Processing and relating so many events to derive a meaningful real-time decision is a challenging task. The above

estimates occur in the case when readers are placed at bus stops and depots and when only BEST buses are taken

into consideration. If the data is captured not only from bus stops but also from several traffic lights to get

intermediate information between two bus stops the number of events will further increase.

Managing such high volume of events and generated data poses the challenges to applications as well as back-end

databases. This data is often redundant and needs to be filtered/cleaned and consolidated in order to occupy less

space in database. In doing so, care must be taken that no useful information is lost. Researchers in the database

community have presented techniques and models for warehousing as well as cleaning/filtering RFID data. EPC-IS

and PML Core is the RFID system standardization efforts by auto-ID center.

6. Conclusion

Public Transportation is a prolific area for deployment of RFID-based systems. Tracking of buses along with crowd

density in crowded metros could greatly benefit commuters who travel to reach offices/ home using buses to avoid

long delays at bus stops. In this paper, we suggested the use of RFIDs for bus tracking using readers placed at

strategic locations, such as bus stops, and/or traffic intersections. Events such as arrival of buses can be used to

generate useful information such as earliest arrival time of a bus on a given route at a given stop. By informing a

commuter about bus arrival times the commuter can save valuable waiting time. We formulated the goal of

estimating bus arrival times as a forecasting problem which could use the many mature techniques developed for

seasonal time series as well as regression analysis. Practical RFID systems are involved in real time tracking and

monitoring of events. The system performs appropriate actions in response to events based on certain conditions. It

is natural to consider the use of the Event, Condition and Action (ECA) framework to address event management

issues. Since the number of events captured by many RFID systems is very large, clever filtering and aggregation

techniques should be employed. We are currently engaged in the development of a RFID rule based management

system using existing RFID middleware from Sun.

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