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TELEMATICS IN BUS TRANSIT OPERATIONS FOR MEGA CITIES IN INDIA

Bus transit is an integral part of the passenger transportation system in urban areas of India, hence it is preferred owing to the low investment cost and high accessibility compared to other modes of travel such as rail rapid transit and underground metro. A case study is made on the existing urban bus transit infrastructure with reference to the mega cities in India. This paper tries to bring out the benefits of adopting telematics technology in the bus transit operations. Given the fact that the urban bus operations have a low cost recovery index, the implementation of telematics technology with a little extra cost would help increasing the passenger shares making the bus transit attractive and would also help in becoming profitable in the long run.

TELEMATYKA W OPERACJACH TRANZYTOWYCH RUCHU AUTOBUSOWEGO W DUŻYCH MIASTACH INDII

Transport autobusowy stanowi integralną część pasażerskiego systemu transportowego w obszarach miejskich w Indiach. Jest on tu preferowany z powodu niskich kosztów i wysokiej dostępności w porównaniu z innymi metodami podróży takimi jak szybki transport kołowy i podziemne metro. Przeprowadzono studium przypadku, jakim jest istniejąca infrastruktura tranzytowej komunikacji miejskiej pięciu największych miast indyjskich. Referat stara się podkreślić zalety zastosowania technologii telematycznych w transporcie autobusowym. Niniejszy referat stara się ukazać relatywne korzyści wynikające z zastosowania technologii telematyki w działaniu linii autobusowych w tych wielkich miastach. Biorąc pod uwagę fakt, że STU tradycyjnie posiadają niski wskaźnik odzysku kosztów, wdrożenie technologii telematycznych przy poniesieniu niewielkich dodatkowych kosztów sprawi, że ruch autobusowy stanie się dla pasażerów atrakcyjny i pozwoli na szybszy zwrot kosztów operatorowi na dłuższą metę.

1. INTRODUCTION

Public transportation is one of the most effective means of commuting in cities of India or in any Third world city. Some of the characteristics of these cities are high population densities, low motorization, poverty and scarce public investment resources [1]. High densities mean short travel distances and potentially very efficient transit systems. The high investment costs of the rail based transit systems and the poor returns there after is one reason

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why the buses form an efficient alternative to the other transit systems. In India bus transit in cities is being operated by state road transport undertakings (STUs). The State Governments own most of the STUs. In some states the bus companies are operating as corporations. The overall cost recovery indices (revenue/cost) of urban operations in the STUs till 2000 were 78% [2]. The system needs to be improved in terms of enhancing the performance measures from commuter's perspective while improving the revenue generation for continuous capital investments.

Most of the STUs are facing the following difficulties:

- huge loss making entities and lack of internal resource generation hindering growth
- no autonomy of policies over the recruitment personnel
- no autonomy over fare fixation and lack of compensation for subsidies given to needy commuter groups (students, and senior citizens etc.)
- lack of professional management practices in the organisation setup
- low on technology use (information and telecommunication technology implementation)

This paper tries to address the last point in the above list. Technology related issues and their implementation involve careful planning, and implementation. It was found in many public transit companies the cost of implementation is very small compared to the capital investments [3]. The advantages of the implementation of these technologies are quite obvious. The following are some of the benefits for stakeholders in the system:

- Commuters: ticketing, and dynamic information systems
- Operator: revenue collection, and online operational control

This paper tries to bring out clearly various aspects mentioned above. Section 2 highlights basic features of telematics installed in the bus transit system. Section 3 gives an overview of the existing bus transit scenario in the mega cities of India. Section 4 gives some details of the telematics implementation in one of the mega cities in India. Summary and conclusions are presented in Section 5.

2. TELEMATICS IN PUBLIC TRANSPORTATION

Telematics unites modern information and telecommunications technologies to realise the huge potential of the Information Society. Transport Telematics Applications-also known as Intelligent Transport Systems (ITS) play particularly vital roles in ensuring mobility for all and enabling business to meet orders in increasingly competitive markets [4]. Transport telematics applications are contributing to safer, cleaner and more efficient transport by:

- helping travellers, freight distributors and transport operators to avoid delays, congestion and unnecessary trips;
- diverting traffic from overcrowded roads to alternative modes including rail, sea and inland waterways;
- reducing accidents;
- increasing productivity;
- gaining extra capacity from existing infrastructure;
- encouraging integrated transport;
- reducing energy use; and
- reducing environmental pollution

Some basic advantages in the use of telematics in public transportation are: making buses more attractive through passenger information systems and demand oriented services marginal demand areas. The various telematics technologies are listed in Table 1 [5].

Table 1

Categorization of Telematics Technologies

S No.	Category	System Technology
1	Fleet Management	Automatic Vehicle Location, Transit Operation, Software, Communication, Geographic Information, Automatic Passenger Counters, Traffic Signal Priority
2	Traveller Information	Pre-Trip and Multi modal, In –Vehicle, In Terminal/Way side
3	Electronic Fare Payment	Smart Cards, Fare Distribution, Clearing House
4	Demand Management	Dynamic Ride Sharing, Automated Service Coordination, TMC coordination
5	Intelligent Vehicle Initiative (IVI)	Lane change, Merge and Forward collision avoidance, Rear impact collision mitigation

2.1. PUBLIC TRANSPORT TELEMATICS ARCHITECTURE

There are two essential layers in the architecture of a typical telematics system: logical architecture and physical architecture. One of the most advanced telematics system installed in bus transit is in the city of Helsinki, Finland [6] launched in the year 1999. The new telematics system provides several functions such as real time passenger information, bus and tram priority at traffic signals and the schedule monitoring. The system solely runs on the wireless communication with radio modems. The architecture of the system shown in Fig.1.

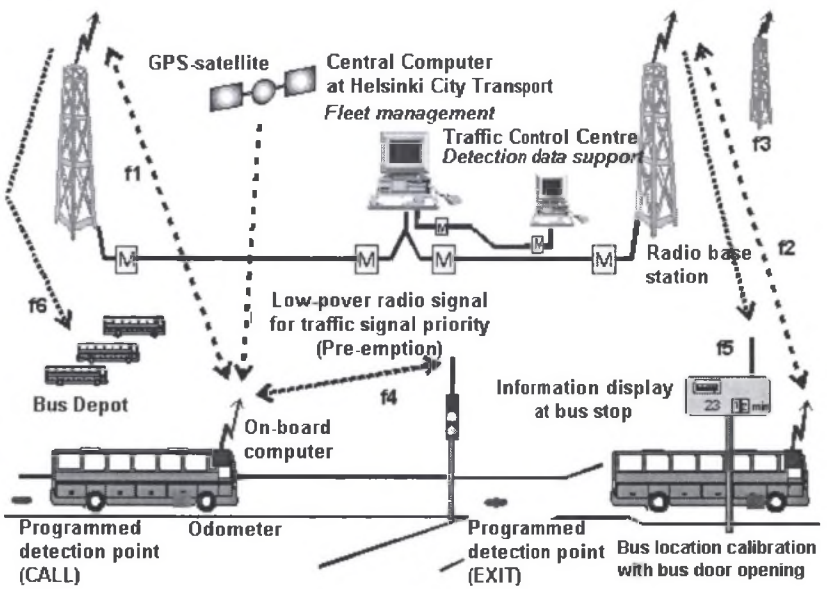

Fig.1. Bus transit telematics architecture

2.2. CHARACTERISTICS OF TELEMATICS

The corner stone of the telematics system is the location of the bus. It is determined in three steps:

- GPS-satellite navigation plots the bus roughly on the right bus stop window (a section of the route before and after the bus stop)
- Bus door opening at the bus stop locates the bus exactly on the right position along the route.
- The bus location along the route is based on the odometer counting the accurate distance of the bus from the preceding bus stop

Each bus is polled by the central equipment every tenth second. So the central computer has continuously the data of the exact position of each bus along the route.

Schedule monitoring is based on the comparison of the real location of the bus to the location calculated from the schedule. The difference indicated as seconds at the driver display is updated continuously. The same indication is sent also to the fleet management room at ten-second intervals. The fleet manager can follow the progress of all buses along the line and give some instructions to the any bus driver if some disturbances are found.

Vehicle location monitoring is based on the data of the updated position of each vehicle. Real time passenger information system provides passenger waiting at bus stops with real-time displays showing the time in minutes when the next bus arrive. Besides this the operator can send an information message to the display if some disturbs of the bus traffic are found.

The forecasts of the expected arrival time of the bus to the stop can be found also on Internet. First the user picks the right bus stop from the list and then after few seconds he or she can see, how many minutes it takes until the next bus and even the following bus arrive to the stop.

Priority at traffic signal is based on the request of the approaching bus sent via radio modem direct to the next junction. The signal priority is not given to buses, which are ahead of their timetable.

The communication of the system is based on the city-owned radio network. Three base stations are located on high chimneys in different parts of the city. Three hundred vehicles can be polled simultaneously in the network.

All buses and trams are instrumented with an on-board computer and radio modem. Visual displays at bus and tram stops and signal controller equipment are provided with radio modems. No extra cabling is needed at traffic signal junctions, either, because an unnoticeable plate antenna is located on the roof of the signal controller cabinet.

Thus all of the communication of the system relies on the radio network. This is a great advantage compared to the cable bounded systems. The system is cheaper because no civil engineering works are needed. Only the data transmission between base stations and central workstations is realized via cable network.

From the above description it is evident how the telematics system is able to help the operators and users in many ways making the bus transit operations efficient and user friendly.

3. EXISITING BUS TRANSPORTATION INFRASTRUCTURE IN INDIA

Urban population in India has grown nearly 30% in the past decade [7]. The mega cities considered as the part of the study are: Mumbai, Kolkata, Delhi, Chennai and Bangalore. These are the five largest metropolises in India, having nearly half the population of the toal 35 cities with more than a million population (Total: 108 million). In this situation there is an acute stress on the existing urban transportation infrastructure. These cities are served by bus transit system either as the sole public transportation mode (Delhi, Chennai and Bangalore) or as a feeder/complementary to rail based modes (Mumbai and Kolkata). Except in Kolkata and Delhi where the ownership of buses is with Government and Private operators, the rest of cities have buses run by corporations owned by the Government. The existing physical infrastructure with some operational data is summarised in Table 2 [8].

Table 2

Comparison of bus corporations in the mega cities of India, 1999-'00

S. No.	Parameter	BEST[1] Mumbai	DTC[2], Delhi	BMTC[3], Bangalore	MTC[4], Chennai	CSTC[5] Kolkata
1	Avg. fleet size	3460	5257	2119	2813	1204
2	Fleet utilisation	94.4	85.8	94.6	83.6	67.6
3	Vehicle utilisation (Km/bus/day)	211	221	230	250	196
4	Load factor, %	56	85	61	87	73
5	Total cost per bus/day (Rs)	6632	4 891	3 156	4 348	4 020
6	Recovery rate, %	77	69	101	84	42
7	Main travel modes	Train, Bus	Bus, train	Bus	Bus, train	Tram, Bus, train

[1]BirhanMumbai Electric Supply and Transport Undertaking
[2]Delhi Transport Corporation
[3]Bangalore Metropolitan Transport Corporation
[4]Metropolitan Transport Corporation Chennai
[5]Calcutta State Transport Corporation

From the table it is evident that out of all the transport corporations Bangalore is running profitably. Current data indicates that there is steady rise in profits since 2000-'01 [9]. In the year 2003-'04, profits rose to Rs. 27.45 crore (USD 6.1 million). This was a thirteen-fold increase from 1999-'00 levels. Thus it becomes imperative to study this particular corporation and the initiatives it has taken to improve the system.

The reforms taken BMTC are categorised as follows: internal and external [2]. In the external reforms, restructuring and autonomy, providing level playing field and fare revision were taken of. Internal reforms comprised of improvement of worker's morale and discipline, check of pilferage, commercial approach and telematics implementation. The following section gives the details of the telematics implementation and its role in the service improvement of the BMTC.

4. IMPLEMENTATION OF ELEMENTARY TELEMATICS SYSTEM

The telematics implementation in the BMTC was done in different stages. The following aspects of telematics were implemented. As a part of fleet management aspect (see Table 1) vehicle tracking system is implemented. The details of this system are discussed below.

BMTC currently operates more than 3200 buses per day, operating 3125 schedules and makes 45,000 trips per day covering more than 1200 wayside bus stops [9]. There are by 23 depots and the daily passenger traffic is 28 lakh (2.8 million) covering 6.92 lakh (0.692 million) route km. In order to monitor the operation of such a huge fleet of buses radio frequency based vehicle monitoring at bus stations and GPS systems to track the vehicle movement were put to use.

The project covering 400 buses in two depots started to implement vehicle-monitoring system [10]. In the radio frequency technology for vehicle monitoring at bus station the buses were fitted with transponders. The antenna is installed at the exit point of bus station. The departure of the buses after proper authentication by the driver is recorded through transponder attached to the antenna. This is connected to the computer in the control room. Thus there is automatic record of all the bus departures from depot.

Subsequently for vehicle tracking a GPS module is mounted on 200 buses, which record the positional values of the buses at every minute of travel [11]. The details of this system are shown in Figure 2. The data is stored in the memory module installed in the bus running on bus battery. This data in the memory is downloaded once in three days. This data is processed offline presently. The data downloaded and the coordinates are corrected to fit into the GIS map of the city. Though it is offline a number of post-journey performance analyses can be done to improve the system immensely. Some of the measures in place are the establishment of accidents, actual time taken by each schedule of the bus and many more. This is probably the first telematics initiative in the country. There are few other isolated telematics initiatives, though not at this scale [5].

The utility of these systems though implemented as pilot projects have given enormous amounts of data to work with in order to improve the system when it was implemented. It also helped in enhancing the reliability of the operations at low costs.

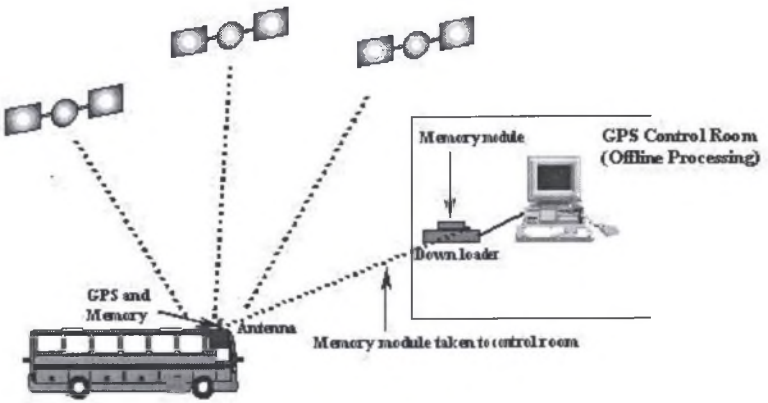

Fig.2. GPS based offline vehicle tracking at BMTC

5. SUMMARY AND CONCLUSIONS

Bus transit systems are cost effective means of public transportation in the third world cities, for which India is no exception. The most predominant mode of public transportation in urban India is bus. However, most of the urban bus transport corporations are not cost effective and inefficient in terms of service. Telematics technology can help in providing a better service and monitor the system efficiently. Real time bus arrival information and time monitoring can be easily achieved through this system. The implementation of the system is cost effective also. The technology implementation in an Indian city shows improved punctuality of buses. This experience augurs well for other STUs to adopt the technology and become efficient in the future times to come.

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