Low Cost Communication Link for Intelligent Public Transport System with Dynamic Protocol

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Abstract—This paper is about research to provide the solution for optimization of use of public transport, better services to users and various options to management to improve transport system with cost effective. Many existing models for bus arrival prediction system, based on vehicle motion tracking with high cost equipments. Bus arrival Prediction Technology (BAPT) is the key technology of designing and implementation with low cost communication link and specialized protocol. With the help of GPRS based communication, the central station can connect the each bus station, and receiving all information about the current status of the every vehicle. Based on analysis of traffic density at central stand, it will update all bus stands with updated predicted time within stations. Specialized protocol designs in such a way that it communicate among buses, bus stands and central stand. It helps in bus failure detection system which improves transport management.

Keywords- Bus Stand Module (BSM), Central Stand Module (CSM), Global Position System (GPS), Bus arrival Prediction Technology (BAPT).

I. INTRODUCTION

Intelligent Transportation Systems is an application of current information and communications technologies to the transportation area. 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 lacking the necessary financial resources for investment in infrastructure, vehicles and new technologies [1]. There are several studies and researches in this field. Most of the existing system use advances communication system in technologies like wireless communication, Global Positioning System (GPS). Automatic Vehicle Location (AVL) systems and Automatic Passenger Counters (APC) based on global positioning systems (GPS) have been adopted by many transit systems to monitor the movements of buses on real time basis. The geographic information system (GIS) or GPS tools used in a transit system for monitoring the movement of buses can also be used to create a digital route map [2-5]. Most of the GPS based intelligent public transport system not feasible in developing countries due to high cost GPS system. In fact, we need not to be bothered about the movement process of buses, but focus on the buses arrival time or the departure time at bus stations. In 2009, a RFID based system purposed for Bus Management System. This system can monitor bus traffic inside spacious bus stations, and can inform administrators whether the bus is arriving on time, early or late. This information is then displayed on the different wireless displays inside and outside the bus station [6]. This real-time schedule tracker system developed only for schedule bus timing within bus stand. In 2011, a GSM based system purposed, in which GSM Machine fitted on buses, is used to transmit a 32-bit binary code, which is received by the receiver which encodes it. People density value and other data, is collectively transmitted to the computer connected to server via SMS system [7]. This system is expensive due to using GSM machine on all buses and SMS service used for data transmission.

II. SYSTEM ARCHITECTURE

In the research, develop a cost-effective model to predict the bus arrival time at stops using historical and analytical bus travel time information which receives from all bus stands. For fulfilling this aim, implemented a wireless communication network, based on low cost and low range RF receiver and transmitter module.

A. Software Implementation

The main contribution in this paper is to design the communication protocol and software which helps to communicate among all BAPT modules. The objective of this software is to interface between stand to bus, bus to bus, stand to stand, stand to GPRS device and display.

1) Protocol implementation – In proposed system, one dynamic communication protocol implemented as shown in figure 1. This protocol is able to communicate all BAPT modules which is based on type of communication, to make the system more reliable. According to type of communication and command field, system will respond. Protocol field descriptions are following:

- *SF (Start Flag)*: It is used in all data packet at the beginning, to indicate the start of some data to be sent. Based on communication between different modules, the start of frame can be of either type with unique address as listed table 1:
- *Source/Destination Address*: Based on the communication the source/address can either \be a bus or stand. There will be specific addresses fixed for bus and the stand. This is necessary for the packets to reach the exact address, and the destination should know from whom it's receiving the data packet.

- *Command Field*: The command in the data

Action taken in module	Address
Bus Stand ← → Bus Stand	0x2A
Bus → Stand	0x2B
Stand → Bus	0x2C
Bus → Bus	0x2D
Stand → CSM	0x2E
Reserved for Future	0x2F

Table 1: Start Flag field

packet of BAPT determines the type of information being sent to either stand or bus. The command information being sent from source to destination can be of types table 2:

Command Description	Code
Acknowledgement(ACK)	0x30
NACK / ARQ Auto Resend request	0x31
Sync Command	0x32
Bus Info Command	0x33
Bus Failure Command	0x34

Table 2: Command field description

- *Bytes Field and Check Sum Field*: Byte 1, byte 2 and byte 3, which can be used if necessary in future enhancement of BAPT. It is XOR of Command and its data bytes (If Command has

SF	Dest. Add	Source Add	Cmd	Byte1	Byte2	Byte3	Check Sum	EF

Figure 1: BAPT Protocol

no data then checksum is not required).

- *EF (End of Frame):* This frame is used in the data packet of BAPT to indicate the end of information being sent from any source and destination. If the EF frame is not received by the destination within the specified time then the data packet will be sent again by the source.

2) *Packet information*: In the system following messages are using for communication:

i. *Info Message*:
   a) Bus to Stand: Contains polling stand ID Bus ID and seats vacant
   b) Stand to Stand: Contains Destination stand ID Bus ID and seats vacant

ii. *Fail Message*:
   a) Bus to Bus: Contains failed Bus-ID and problem ID
   b) Bus to Stand: Contains polling stand ID, failed Bus-ID and problem ID
   c) Stand to Stand: Contains Destination stand ID, failed Bus-ID, Nearest Stand ID and problem ID

iii. *Maintenance/service message*:
   a) Stand to Stand: Contains new time predicted estimation value
   b) Bus to Stand: Add/remove any Bus/Stand ID

B. Hardware Implementation

The systems have three major parts: Bus module, Bus Stand Module and Central station module. All modules contain one 89V51RD2 microcontroller. Bus module have switches panel with specific problem ID, low cost 433.92/315 MHz RF transmitter and receiver with 3^{18} series of encoders and decoders, tactical sensors switches for count number of seated persons in a bus. In the bus stand module, SIM300 GPRS module use for stand to stand communication, LCD for display, 433.92/315 MHz RF transmitter and receiver with 3^{18} series of encoders. In Central Bus station, apart from bus station requirements, only RTC, EEPROM and server connectivity RS232 are used.

1) *Bus Module:* This module is mounted at each bus of the transportation system with unique ID. Bus driver is provided with switch panel, if any predefine problem (like tyre puncture, fuel empty and engine failure etc) occurs in the bus then driver can press the corresponding switch for help. In the failure case, failure bus blinks alert signal and it starts broadcasting the id and problem for help, once any bus that has same module, comes near its range it will receive the fail message and provide acknowledge message immediately.

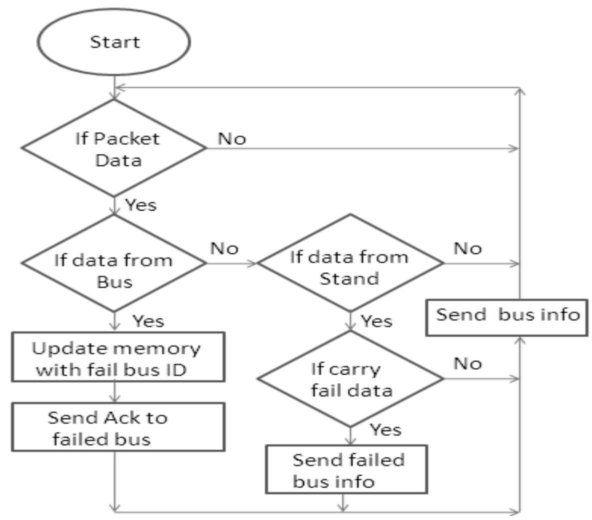

Figure 2: Bus Module Flow Diagram

After receiving the acknowledge message the fail bus will stop blinking alert signal and move to the non-working state. Now passing bus will store the fail message in its memory and when any bus stand polls for buses, bus will send it is own information and fail message also. Bus will wait for acknowledge from the stand if acknowledge comes it will delete the message from the memory else during next polling cycle it will send again as shown in figure 2. Bus module receiver is used to receive polling packets from stand and fail messages from bus. If polling packet is received bus module, software reads the vacant seats information, own id and sends both to the polling stand.

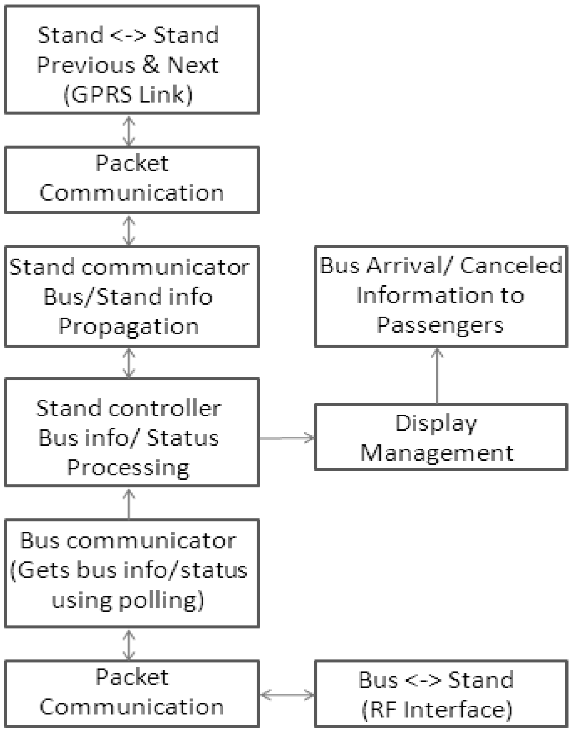

Figure 3: Bus Stand Module Flow Diagram

2) *Bus Stand Module:* Bus Stand Module consists of two parts: Main Stand Module (MSM) and Bus Communication Controller (BCC). MSM is main module which controls all the communications in the network. It has direct interface with buses, adjacent bus stands and users. It is equipped with display which use for showing user the information of buses arrival time, stops away, seats vacant, cancelled, delayed. It has separate GPRS device to communicate with previous and next stand and for getting information of buses near stand or arrived at stand it uses specialized communication controller using UART link, it is called bus communication controller (BCC) it scans all buses near stand communicate with them get information from them and sends all this information in a queue one by one to MSM. Serially receiving bus arrival of failed bus info from the BCC, updating bus status for display and pass info packet to next stand using GPRS device as shown in figure 3. The principle is it sends a polling/interrogation packet with a low range (150-200meters) transmitter, and then waits for reply from the buses. If any bus is in the range then it will send reply with bus-id and other information like vacant seats. This reply is buffered in the internal queue as multiple buses may send reply. Once buses have replied, it starts transmitting the bus information serially to MSM, which further processes the information, does display management and pass info to next stand with its exclusive GPRS packet switching Tx-Rx interface with next stand for updating current bus information.

3) *Central Station Module*: This module is placed at central station where most of the buses start and end. And here all the messages from the various routes, various stands, and buses are collected and stored in the server, this server will run special software which will do statists analysis to find out the traffic pattern and will update bus stands accordingly. For this task, it is equipped with RF interface to receive messages from stands, and RTC to keep track of time, max232 to interface to RS232 port of the server and microcontroller for reading incoming packets from the stands and then process it.

III OPERATION OF SYSTEM

In the system, bus arrival time estimation using traffic density modelling in CCM server, which can estimated times from one stop to next stop are automatically updated using wireless communication in all the bus stands as shown in figure 4. All bus stands are connected to each other using GPRS wireless communication network and all data including number of passengers information of bus arrival at particular stop will finally stored in central station for future statistical analysis like change of route to avoid traffic congestions, adding of buses if arrival frequency is too low, deletion of route if it is very slow moving route. Based on this statistical data, central bus stand unit can take decision on certain time line basis. Information of seats vacant, filling, and getting emptied will be send to central station and based on this data transport management can take an action and buses will be order from bus depot if buses are running full or extra buses can be remove from route if buses running empty.

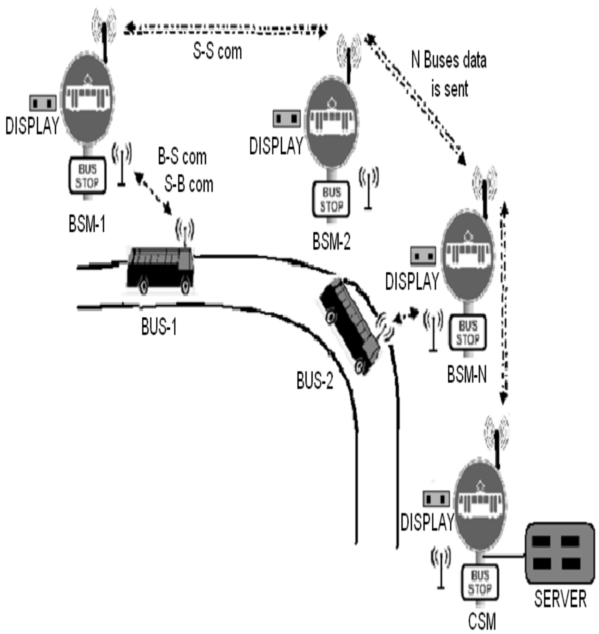

Figure 4: Bus Arrival Prediction Technology

Stand-Stand	Mean Travel Time in minutes
S1 - S2	50
S2 - S3	80
S3 - S4	60
S4 - S5	70
S5 - S6	40
S6 - S7	100
S7 - S8	90

Table 3: Bus Lookup Table

Bus Arrival Prediction system:- When BCC gets the information of the Bus arrival and after updating bus status in their memory, MSM propagate the bus information from current stop to next stand MSM and this will go on and finally the bus info will reach to central station's CSM where it will be stored in server database. As seen example of the system in table 3, bus takes 50 minutes to travel from stand1 to stand2 and so on. If packet is reaching Stand6, contains the information that Bus1 is at stand2 then Stand6 will add up all times from its location to bus stoppage location.

Let suppose 40+70+60+80 = 250 minutes, and it will display the Bus1 is four stops away and arriving in 250 mins (4hour 10mins). This lookup table is prefixed and stored prior to the installation or at first boot up time. This traffic density model is a statistical model which will be based on bus information data stored at central station. This data will contain bus arrival time at all stands in the given route so management can be found out how much actual time bus is taking to travel using multiple bus data on same route and refine the model at the end of every day once the difference between mean travel time between the stands and newly calculated travel times between the stand will be greater than some threshold value then it will recommended to update lookup table at all the stands of the given route. As it is already known that Bus travel time between the stands, is mainly dependent on the many traffic conditions.

Bus failure detection system- If bus fails in some route that time driver will have provision to intimate to next bus stop with failure reason. Failure bus will broadcast a help/information packet with failure information and any ongoing bus will listen it and convey to next bus stop for avoiding delay in help and alert for passengers. Whenever bus will fail with some reason then bus driver will press specific reason button and fault message packet with specific reason ID will broadcast. Any ongoing bus which will having same Tx & Rx module, will receive fault message packet and this bus will update it to next bus stop with faulty reason, bus number and bus stop ID where last time it detected. Bus stand will connect to display of predicted bus arrival time for user notification.

Display management - After Bus stand get information from Bus about its ID and seats it declares to the users via display that respective bus has arrived and vacant seats info is provided. And bus stand also passes this bus information to next bus stand which on receiving this info inform users that bus is one stop away and coming is some x1 minutes which is predefined. Now this bus stand send info of same bus to next bus stand on getting this info the bus stand displays bus is two stop away and coming in x2 minutes in both the bus stand timers are there and countdown goes on which keeps in decrementing arrival times once it reaches zero in first stop bus status is changed to arriving soon instead of coming in x minutes. But in subsequent stops if countdown reaches to zero then bus info is changed to bus is delayed as it has not reached to next stop itself target stop is at least one stop after that, from previous stops info is going to come once bus reaches to those stops. And if bus fail message is reached to stand, bus stand will display bus is cancelled.

IV. SYSTEM EVALUTION AND RESULTS

The designed system is first verified via sending communication protocol packets among all modules as communication example shown in table 4.

All modules received messages successfully within time line. Bus stand to adjacent bus stand communication verification done with AT command request and response in GPRS module at both the end. In the test bench (shown in figure 5) performed the first testing and verification procedure. Bus failure detection system, bus cancelled, delayed, arrival soon, bus number and seat vacant in arrival bus information displayed successfully according to current scenarios. Bus failure detected and informed via passing bus to near bus station also successful.

Communication	Information	Packet Description
Bus stand to Bus stand	2A 43 33 61 41 15 21	stand-id 42 to stand id43 bus info: busid-61 @stand-id 41 15 vacant seats
Bus to Bus	2D 63 91 21	It is bus-id 63, It has problem id-91 (for example Tyre Puncture)
	2D 30 21	Acknowledge from passing bus
Stand to Bus	2C 43 21	Stand-id 43 is polling for all the busses near stand
	2C 30 21	Acknowledge for fail packet if bus is sending some other bus fail message
Bus to Stand	2B 43 33 61 09 21	Polling reply to stand-id 43, It is bus-id 63 vacant seats 09
	2B 43 34 64 91 21	Polling reply to stand-id 43 Failed bus message: Bus-id 64 has failed with problem id-91
Bus stand to Central Station Module CSM	2E 45 33 61 41 15 21	To stand-id 45 i.e. CSM, bus info: busid-62 @stand-id 42 15 vacant seats

Table 4: Protocol communication example

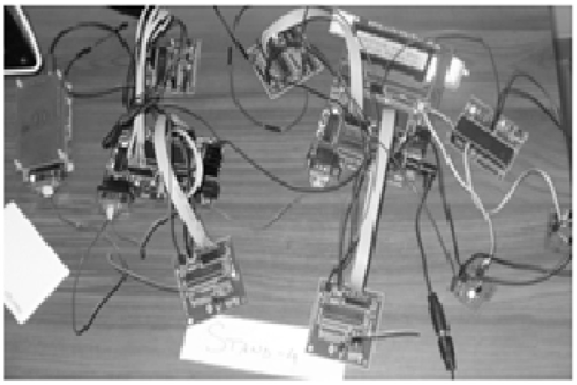

Figure 5: System Test Bench

V. CONCLUSION

In this project, the result of the designed system with log cost RF link and specialized protocol, has accomplished the target. The proposed system provides the fleet an ability to take decisions according to real-time information, in addition to historical data. It ensures that the tracking process is within an accurate and acceptable range, failure bus detection happened with failure reason.

VI. REFERENCES

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