

Vehicle Parking Mobile Network

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Abstract—Universal Software Defined Radio Peripheral (USRP) and Banana pi board can be used to configure a vehicle parking mobile network. The base station is created in the center of the parking area. The base station can issue useful information to the drivers. The number of the vehicles in the parking area, amount of free space, and directions to the free space could be provided to the driver through the USRP base station. The base station sends text messages to the driver. The base station can provide the essential information to the driver through GSM network. Each driver has a GSM mobile device. The device will be connected to the vehicle parking mobile network. International Mobile Equipment Identification (IMEI) number is used to configure the network, between base station and the mobile devices. The mobile devices can be used by the drivers to get the essential details regarding the parking area. The information includes the necessary features of the parking area. The information would be provided to the driver from time to time. Multiple text messages will be provided to the driver. The text message contains all the necessary details about the parking area.

Keywords—USRP, GSM, Banana PI, base station, communication network, OpenBTS, and mobile device

I. INTRODUCTION

A vehicle parking mobile network can be designed using USRP N210 and banana pi board. The system could provide essential details to the drivers. The capacity, free space, directions to the free space, and number of vehicles inside the parking area, are provided via text messages. The text messages are forwarded to the mobile phones of the driver. The driver receive messages with the interval of ten minutes.

Drivers can use their own mobile phones. The mobile phones will be connected with the vehicle parking base station network. The RF front end of the antenna of the base station can cover up to 30m range. If we use the proper RF antenna with amplifier, then we can increase the range of the base station. The mobile device will be connected to the network, as soon as a vehicle enters to the vehicle parking mobile network. The mobile will be disconnected from the network, as soon as the vehicle leaves from the communication network. The network can provide sufficient details about the vehicle parking mobile network to the each drivers. The drivers can use the details in the text message to park their own vehicles in the parking area.

The base station contains a USRP front end and a Banana Pi board. The base station is connected with the Banana pi board with gigabit Ethernet cable. The banana pi board contains Ubuntu operation system. The operating system support the applications of the base station. The Open BTS is a standalone application and which can be used to configure the base station in a banana pi board. Open BTS supports Ubuntu operating system. The data bases of the system is connected to the Open BTS application. The data bases are installed in the system. Open BTS supports SQLite 3 data base. The SQLite 3 data base contains the tables which are used to configure the Open BTS as a mobile base station. The data base contains configuration parameters of the base station and the client details of the vehicle parking mobile network.

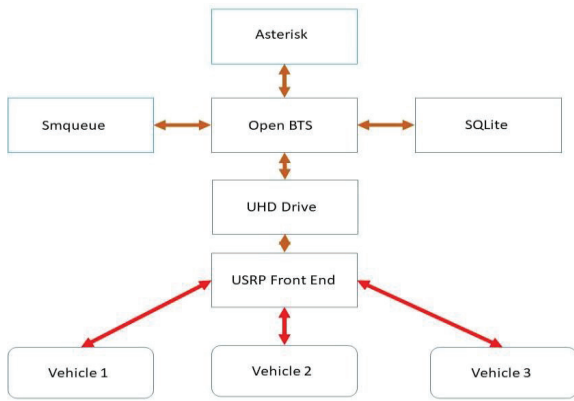


Fig. 1. Block diagram of the Vehicle Parking Mobile Network.

Fig 1 indicates the block diagram of the Vehicle Parking Mobile Network. The arrows in the Fig 1 shows the connections between the sub systems. The mobile devices are connected with the Vehicle parking mobile network through the USRP radio front end. The mobile devices of the drivers are connected with the base station through USRP front end. GSM communication protocol is used for this purpose.

The USRP N210 could be used as the radio front end and which is connected with the Open BTS application. The smqueue, asterisk, SQLite3 applications are connected with the Open BTS application. Open BTS can get the necessary configuration parameters and subscriber details from SQLite3 data base. The smqueue application is used to create, send, and receive short messages. It also uses GSM protocol to send and receive the messages. A USRP device is shown in Fig. 2. It has two antennas and a mother board. A GSM daughter board is attached in the USRP device.

The database stores configuration details, system details, connection details and subscriber details.



Fig. 2. USRP N210 device

The USRP device is connected with the Ubuntu system using gigabit Ethernet cable. The Ubuntu Operating system is installed in Banana pi board. The Ubuntu operating system contains certain applications, which are Open BTS, Smqueue, Asterisk, SQLite 3, GNU Radio, and UHD drive.

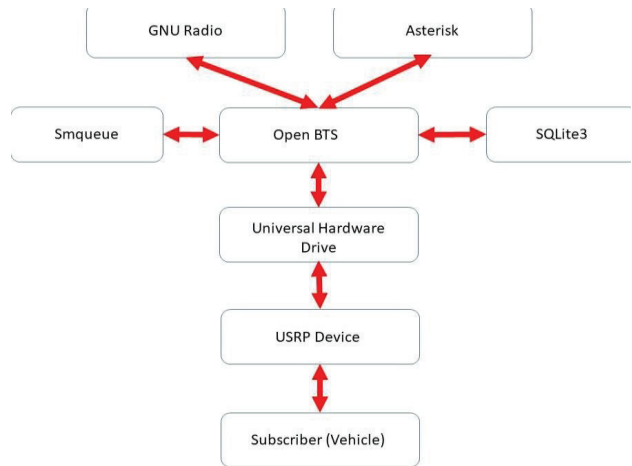


Fig. 3. The block diagram of the system

The Fig. 3 shows the block diagram of the system. The arrows in the Fig 3 shows the connections between the sub systems. It shows the communication between different applications of the system. The interconnection between the applications are clearly stated in the block diagram.

The research gap is establishing an efficient communication network using open source software to help the drivers to park their vehicles in shopping malls or cinemas. Also the communication network is established with high accuracy, efficiency, and precision. The parking system should be automated to provide efficient and errorless service to the clients.

II. RELATED WORKS

D. Thomas et al [6] have explained about a smart parking system in shopping malls. Shopping malls are crowded with vehicles in weekends. The system provides an algorithm to efficiently manage the parking system in shopping malls. The system includes IOT communication. The system is developed as a smart parking system. The smart parking system can be used by smart

city applications. The smart parking system is proposed for a shopping malls. The insufficient capacity of the present parking system causes the people to park in the road side near to the shopping malls. This causes congestion of traffic in the roads near to shopping malls. The proposed solution includes an android application for the drivers. The drivers can use android application to book the parking area in advance. The application asks the drivers to input the parking duration. When the duration exceeds, the application will send an alert message to the drivers of the vehicle.

T. HSU et al [7] have presented their work in automated vehicle parking system. The research work uses an algorithm which contains sensors, fusion, path and tracking. It uses an ultra-sonic sensor to measure the parking space. A user interface is given to drivers. The drivers can use the user interface to select the parking space. The simulation of the automated parking system shows a good result to find the parking space in the parking area. It also includes reverse parking and parallel parking methods. It also consider safety features to park the vehicle in the automated parking system and provide comfort and safety features to the drivers to park their vehicle in the parking area. It includes the coordinated control of the steering angle to calculate the parking space in the parking area. Path planning and tracking are used in the automated parking system. It also uses sensors and electric power steering to find the space for automated parking. The algorithm provide efficient space calculation for the drivers to park their vehicle.

Kumar et al [8] have used internet of things and wireless sensors to establish a vehicle parking system. The system provides parking facilities to shopping malls, tourist attractions and other public places. Identifying proper place for parking causes lot of issues. This research suggest an intelligent vehicle parking system for the places, where parking causes serious issues. Sensor technology is included in the intelligent vehicle parking system. Wireless sensor network with tiny sensors are used in the vehicle parking system. Also this network includes base station and sink nodes. Base station has large computation capacity and large memory size. Sink nodes act as an interface between wireless sensor network and

network administrator. Also wireless sensor network can be used in industries to protect any dangerous environments in the industry. Wireless sensor network contains countless, vitality compelled, self-designed with self-aware nodes.

A. Kianpisheh et al [9] have presented their work in smart parking system. This system assists drivers to find correct space for parking. The system provide the response within a short time duration. The system uses ultrasonic sensors to find a vacant place or improper parking situations. It contains vacant parking, space detection, and detection of improper parking. This parking system provide a suitable solution for shopping complexes. It also provide solutions for banks, post offices, restaurants, cinema, and children's play. It includes the difficulties in finding vacant spaces, improper parking, and parking fee payment. It uses both vision based method and sensor based method to find proper location for parking. Vision based method uses CCTV camera to find the vacant spaces. Usually one camera is used for multiple vacant spaces in the parking area. Image processing software tool is used to detect the parking spaces in the parking area. Another method uses sensors to detect parking spaces in the parking area. Sensors are placed in the parking area to calculate vacant space, improper parking and reverse parking.

Z. Zusheng et al [10] have presented their research on street parking system. The cities have much severe issues in parking. The research work present a solution on wireless sensor network. It uses a magnetic sensor in the parking space to calculate the vacant space in the road. It uses vehicle detection algorithm to detect the vehicles in the road. An adaptive sampling mechanism is utilized to narrow down the energy consumption of the sensor nodes. It uses nearly 82 sensors to detect the vacant space in the road. 98 % of accuracy is obtained in the street parking system algorithm. The sensor uses Li ion battery and the life time of the sensor node is more than 5 years. This algorithm propose the solution to parking problems in city centers. The parking problems cause traffic jams in the city roads. The increment in the automobiles causes traffic issues in the city centers. People needs to drive around the city center to search a proper parking place. This

algorithm works a lot to obtain suitable vacant spaces in the city centers.

Z. Mahmood et al [11] have presented their research work in fully automated car parking system. They use face detection and recognition technology for billing system in the automated car parking system. The ticket loss and car theft issues can be eliminated by this system. A camera is placed in the entrance and exit of the car parking system. Camera frames are received by the parking system. The camera captures the face of the driver and then register the face in the data base. It includes image capturing, face and vehicle detection, and feature removal. It proposes an algorithm for automated car parking system. It uses automated object detection technology to automate the car parking system. It reduce the utilization of power sensors and manual work. Cost will be reduced in the system by using optical sensors in the automated car parking system. Due to the increment in the number of vehicle owners, the vehicle safety issue became as a serious issue at present days. Vehicle safety is considered in the design of automated car parking system.

III. OBJECTIVES

The research work contains the following major objectives. Most of the objectives are obtained in the research work.

1. Configure the USRP and banana pi board as the Vehicle parking Mobile Network.
2. Connect and disconnect the mobile subscribers to the Vehicle Parking Mobile Network.
3. Provide necessary parking details to the mobile subscribers through the smqueue application.
4. Add the user details in the system.
5. Calculate parking details and provide the details to the subscriber.

IV. BACK GROUND

A. UNIVERSAL SOFTWARE DEFINED RADIO PERIPHERAL (USRP)

USRP is a device, which can be used as the front end communication device of the mobile

network. It generates uplink and down link communication with the mobile subscriber. It has two RF antennas. The uplink and down link communication uses the two antennas. 1800 MHz GSM band is used in the uplink and down link RF communication. The GSM link will be established between mobile subscriber and the USRP device. The RF antenna can serve 30m range of communication. If we need to increase the range, then we can use RF amplifiers and repeaters to increase the gain of the antenna.

The USRP device has a gigabit Ethernet port. The USRP can communicate with the Ubuntu operating system through the gigabit Ethernet port. The Ubuntu operating system contains the Open BTS application. The USRP device has a mother board and a daughter board. The daughter boards are designed to support specific kind of communication protocols. 2G, 3G, and 4G communications can be implemented by different type of daughter boards. The daughter boards can be purchased in online market places.

B. Open BTS

Open BTS is an application which can be used to establish a communication network. Open BTS needs Ubuntu operating system to run the functionalities of the OpenBTS application. The Ubuntu operating system is installed in the Banana pi board. The source code of the Open BTS application can be down loaded from the web site [1].

Open BTS can be used to establish a GSM network. The mobile subscriber of the vehicles can be connected and disconnected with the network. Open BTS helps to configure a software base station for the GSM network. Open BTS can be used to establish a Vehicle Parking Mobile Network. When a vehicle enters to the network, it will be automatically connected to the network. When a vehicle leaves from the network, it will be automatically disconnected from the network.

C. Smqueue

Smqueue is an application, which is available in [1]. Smqueue is available with the Open BTS. Smqueue is used to handle text message communication within the network. Smqueue can be used to create, send and receive the text messages within the network. The mobile subscribers can receive text messages using the smqueue application. The details about the parking place will be sent to the mobile subscribers

(drivers of the vehicle) using smqueue application. Smqueue needs Open BTS to run the application. The details about the subscribers can be received from the SQLite 3 database. SQLite 3 data base contains the imei number of the mobile subscribers. Smqueue application is installed in the Ubuntu operating system. A banana pi board is used to install Ubuntu Operating system.

D. Asterisk

Asterisk is a software, which is used to switch calls between different mobile subscribers. A port is used to connect Asterisk switch with the Open BTS application. Asterisk switch directs the calls to the correct destinations. Asterisk switch can forward the calls based on the extension number. Asterisk is a software switch which can be used to exchange the calls. Asterisk function as a private branch exchange (PBX). The source code of the Asterisk switch can be downloaded from web site [2]. Asterisk has its own command line interface (CLI). Also Asterisk has its own commands. The command line interface of the Asterisk can be used to control all the functionalities of the Asterisk switch. Asterisk switch could be installed in the Ubuntu Operating system. A banana pi board is used to install the Ubuntu operating system.

E. *SQLITE 3Date base*

SQLite3 data base is used to store the configuration parameters of the system. The Configuration parameters of Open BTS, Asterisk, and Smqueue are stored in the SQLite3 data base. When the system is started, the applications automatically receive the configuration values from the SQLite3 data base. Also the details of the mobile subscribers are stored in the SQLite3 data base. The source code of the SQLite 3 database can be downloaded from a web site. The link [3] shows the web site location of the SQLite3 data base. The SQLite3 database can be installed in the Ubuntu Operating System. A banana pi board is used to install the Ubuntu operating system. A command line interface (CLI) is available with SQLite3 data base. The command line interface can be used to configure the data base of the system. Sqlite3 database has certain functionalities, which are, create database, create tables, insert values, modify values, and delete values.

F. *Universal Hardware Driver*

Universal Hardware driver is used between Open BTS and USRP device. A full duplex communication will be established between universal hardware driver and USRP device. Also a full duplex communication is established between universal hardware driver and Open BTS. Open BTS uses the universal hardware drive to access the USRP device. The source code of the universal hardware driver can be downloaded from a web site. The link [4] shows the web site of the universal hardware driver. The universal hardware driver can be installed in Ubuntu operating system. A banana pi board is used to install Ubuntu operating system. Universal Hardware driver provide an interface between Open BTS and USRP device.

G. *GNU Radio*

GNU Radio is an application which is used by Open BTS for mathematic calculation. Open BTS access GNU Radio to calculate and observe values of the network. Necessary mathematical functions are available in GNU radio. Open BTS can easily calculate the values from GNU Radio. The GNU radio has certain sub modules, which are, audio signals, Boolean operators, byte operators, channel models, control port, debug Tools, and equalizers.

GNU Radio can be downloaded from GNU Radio web site [5]. The link [5] shows the web site of the GNU Radio software. GNU Radio can be installed in Ubuntu operating system. A banana pi board is used to install Ubuntu operating system. GNU radio modules can be used by the Open BTS application

V. METHODOLOGY

The base station is configured using USRP and Banana pi board. The system diagram is shown in Fig 4.

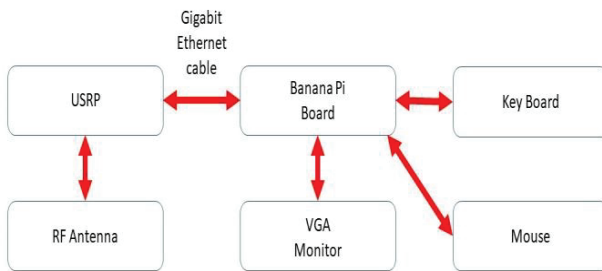


Fig. 4. The system diagram of base station

The base station contains RF antenna, USRP, Banana pi, LCD Monitor, key board and mouse. The Open BTS, Smqueue, UHD drive, Asterisk, SQLite 3 and GNU Radio are installed in the Banana pi board. A gigabit Ethernet cable is used to connect USRP and Banana pi board. The monitor is connected with Banana pi board with HDMI port. A HDMI to VGA converter is used to connect the monitor with Banana pi board. The key board and mouse are connected with the Banana pi board through USB ports of the Banana pi board. Fig 5 shows the banana pi board which is used to configure the base station.

The SQLite3 is used to create system and user databases in the Ubuntu system. System database store the essential details of the configurations and the user database stores the essential details of the subscribers of the system. SQLite 3 command line interface is used to create and configure the data bases. SQLite3 command line interface provide wide range of commands to create and configure databases.



Fig. 5. The banana pi board of the base station [12].

The USRP is connected with two RF antennas and which can be used to establish 1800 MHZ GSM communication link with the subscribers. The drivers are given a mobile phone and which can be connected to the GSM network. When the

drivers enter to the network, they will be automatically connected to the communication network. A welcome message will be provided to the drivers, as soon as they enter to the communication network. The imei number of the mobile phones will be registered in the user data base of the system. A unique extension number will be provided to the each mobile subscriber (driver). The extension number will be used to route the calls and messages within the network. After the welcome message, the system will send necessary details to park the vehicle in the parking area. The details are sent via text messages. This messages are called as parking guide text messages. Drivers can use the text message to find the current position of the vehicle. They can use the details to park the vehicle. The parking space will be calculated by the system and forwarded to the drivers.

When the mobile phone enters to the parking network, it will be automatically registered in the parking network. When the mobile phone leaves the parking network, the mobile phone will be automatically disconnected from the network. The directions to the vacant space will be properly given by the text message communication to the drivers.

The RF antennas can serve 30 m range of the vehicle traffic. If we use a proper RF amplifiers and signal repeaters, then we can increase the range of the communication network. The gain of the antenna can be increased by using the proper RF antennas. The RF antennas can establish GSM communication network.

Ultrasonic sensors are used to find the vacant spaces in the parking area. Another banana pi board is used to find the coordinates of the vacant spaces in the parking area. The banana pi board calculate the vacant spaces in the parking area and inform the coordinates of the vacant spaces to the base station. The ultrasonic sensors are connected with the GPIO pins of the banana pi board. The sensing system contains a banana pi board and multiple ultrasonic sensors. Fig. 6 shows the details of the sensing system. The space calculation unit will communicate with the main system using USB communication peripheral. Ultrasonic sensors send sound pulses to the cars in the parking area. The reflected sound waves will

be captured by the microphone in the ultrasonic sensors. The propagation time of the sound waves will be measured to calculate the distance of the objects in the parking area. If the car is available in the parking area, then the distance value will be low. If the car is not available in the parking area, then the distance value will be high. Based on the distance values of the ultrasonic sensors, the vacant space of the parking area will be calculated and the vacant space values will be uploaded in the database by the board. There is a minimum distance threshold value to detect the vacant space in the parking area. If the distance value is higher than the distance threshold value, then the sensor will detect a vacant space. The vacant or occupied values will be updated in the SQLite3 database. The power of the sensor node will be supplied by a rechargeable battery.

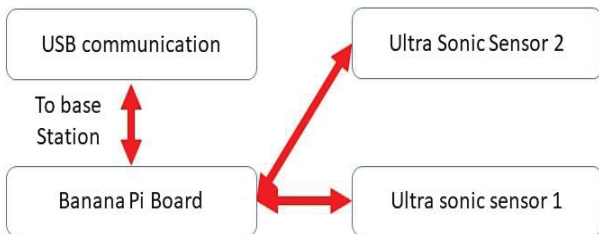


Fig. 6. The block diagram of the sensing system.

The coordinates of the vacant spaces will be forwarded to the base stations and stored in a database. This data base is called as space data base. The coordinates will be used to provide the vacant spaces to the drivers. The coordinates of the space data base is updated in every 5 minutes. The updated space details of the space data base will be shared to the driver. The space details will be shared to the drivers. Fig. 7 shows the block diagram of the data base in the base station. The base station will use the data base to start and configure the system. SQLite3 is used to create and configure the data bases.

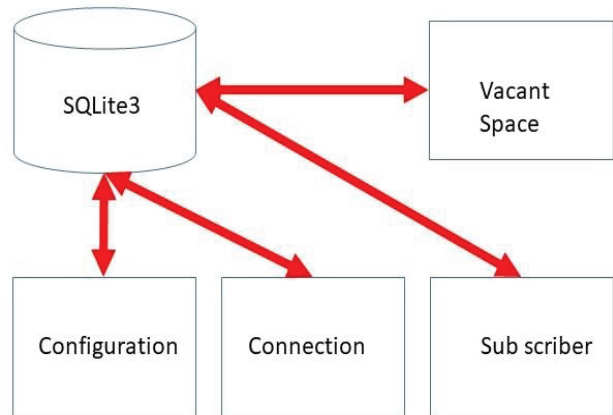


Fig. 7. The block diagram of data base system.

The SQLite3 data base is used to store multiple values. Configuration, connection, subscribers, and space details are stored in the data base. The space details will be stored in the data base. The data bases are used by the vehicle parking communication network. The sensors will send the space values to the Banana Pi board. Banana Pi board stores the values in the SQLite3 data base. SQLite3 data base contains tables to store the data of the sensors.

VI. RESULTS AND DISCUSSION

Fig 8 shows the screen shot about the OpenBTS command line interface (CLI).

```

sklnny show device List Sklnny device information
sklnny show lines [verbose] List defined sklnny lines per device
sklnny show line List sklnny line information
sklnny show settings List global sklnny settings
sqlite show status Show status information about the SQLite 2 driver
sqlite show tables Cached table information about the SQLite 2 driver
stun set debug {on|off} Enable/Disable STUN debugging
tuning test Run a tuning test
udptl set debug {on|off|ip} Enable/Disable UDPTL debugging
ulimit Set or show process resource limits
unistm reload Reload UNISTIM configuration
unistm send packet Send packet (for reverse engineering)
unistm set debug {on|off} Toggle UNISTIM debugging
unistm show info Show UNISTIM info
voicencall reload Reload voicencall configuration
voicencall show users List defined voicencall boxes
voicencall show zones List zone message formats

~/p-desktop*CLI> sip show users
Username      Secret      Accountcode  Def.Context  ACL  ForcerPort
MSIS20050302890100      Secret      3078923984   default      No   Yes
colper        3078923984   sip-local    No            Yes
serverB
MSIS20050302890096      sip-external No            Yes
MSIS20050302890097      sip-external No            Yes
MSIS20050302890098      default      No            Yes
MSIS20050302890099      sip-local    No            Yes
MSI413011230218418      sip-local    No            Yes
    
```

Fig. 8. The command line interface of the OpenBTS system.

In the CLI of the OpenBTS system, we can find the subscriber details of the communication network with relevant imei numbers. The imei numbers are used to establish a mobile communication parking network. Session

Initialization Protocol (SIP) is used to establish the mobile communication in the communication network. The communication network sends essential details of the vacant space to the drivers. A unique extension number is provided to each subscriber of the parking network.

The ultrasonic sensors will find the vacant spaces in the vehicle parking network and sends the details to the database. The database is installed in the banana pi board. The vacant details will be calculated from the sensor values and the information can be sent to the drivers via USRP device. The USRP device runs OpenBTS application which is used to send the vacant space details to the drivers in the communication network. The unique extension numbers will be used to identify the drivers in the communication network. The unique extension numbers are connected with the imei number of the mobile phone. The driver will receive the vacant space details via sms in the communication network.

The sqlite3 database contains configuration, connection, subscribers and space details of the communication network. The details will be used by the system to identify the vacant space. The vacant space details of the communication network will be used by the communication network to identify the locations of the free space. Fig. 9 shows the command line interface of the sqlite3 database of the network.

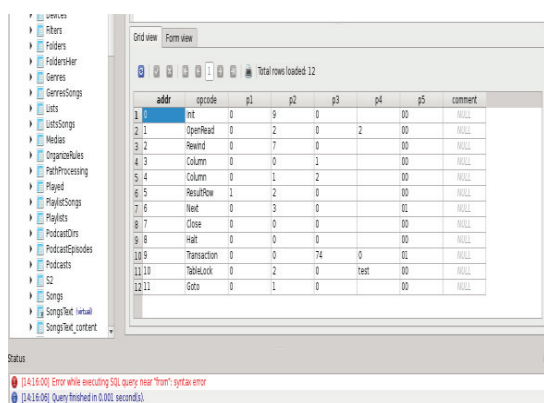


Fig. 9. The command line interface of the database system.

Problems are encountered in fine tuning the ultra sonic sensors and noise reduction. We need to configure the sensor parameters to remove the environmental noise in the ultrasonic sensors. Also the problems are faced in increasing the range of the base station. Also we faced problems

to find the sensor values in the irregular parking of the vehicles.

VII. CONCLUSION

The USRP, OpenBTS, Asterisk, Smqueue, and Banana Pi board can be used to establish a communication network. The communication network can be used to identify the vacant spaces in the parking area. The communication sends text messages regarding the parking details to the mobile phones of the driver. IMEI numbers can be used to connect the mobile phones with the communication network. The communication network can provide the service to 30m range of the communication. The range can be increased with the signal amplifiers and the repeaters in the communication network. Drivers can get useful details to park their vehicles in the parking area via USRP communication.

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