Whitespace networks for vehicular communication

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***Abstract*—We outline the design of a system to exploit the TV whitespaces for dynamically gathering video feeds from public buses in a city. The system consists of the following components: (1) A FPGA based SDR board to be fixed on buses to collect the video feed from inside the bus and transmit it to the central location, (2) An open source software (GNU-radio) to configure and control the hardware and; (3) A MAC-layer design for effective communication strategy. Our novel handoff scheme has been tested on a USRP platform.**

I. Introduction

In the US, the TV band contains several frequencies in the range of 54 - 698 MHz. Inspite of its long propagation range and the large spectrum availability, detailed surveys have conveyed that this spectrum is highly underutilized. To address this issue, many cognitive radio techniques are under development which may result in efficient utilisation of unused spectrums [1].

Now-a-days, bus is a very common means of public transport. On buses, where there is no security personal on board, it is hard to maintain a tight level of security. Therefore, many buses have video surveillance cameras installed inside them. These cameras provide passengers and drivers with an added sense of security and also supply valuable evidence during criminal investigations. However, these cameras collect and store data locally in the bus, which is then transferred to the central server at the end of the day. Due to a growing need of security, there is a requirement of a system to upload the video feed data dynamically from plying buses to the station. This project aims to exploit the TV whitespaces for transmission of video feeds from buses to the central base station on the fly.

II. System Overview

The distance between the buses and the B.S. is usually very large. Keeping the cost and feasibility constrains in mind, we have decided to set up a network of towers to transfer the data in two hops viz. (1) Bus to an intermediate tower and; (2) Tower to the base station. Connection from tower to B.S. shall be wired to allow for fast communication while the link between bus and the tower has to be kept wireless. Also, a radio is required which can be tuned to any frequency in TV whitespace due to its wide spectrum availability. This need is satisfied by Software Defined Radio (SDR), whereby components that are typically implemented in hardware (e.g. mixers, filters, amplifiers, modulators/demodulators, detectors, etc.) are instead implemented via software on a personal computer or an embedded computing device. However, there is a need for a generic hardware to capture, digitize, process and transmit RF signals which is under development. We also outline a MAC-layer strategy to efficiently handle the communication.

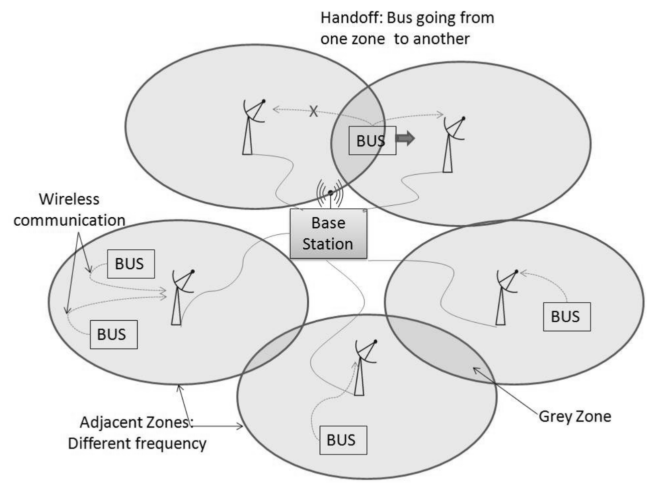

Fig. 1. Overview of the system.

III. Methodology

A. MAC Layer Design

As the unlicensed TV band is very large, we have assumed that there will be sufficient number of available frequency bands. So, neighbouring towers having overlapping regions will have different frequency assignments to prevent interference as shown in Figure 1. This dynamic allocation of bands will be done via the graph coloring problem using the database of currently available spectrum provided by the government. The fixed B.S. to tower network will be wired. The tower will use polling mechanism to wirelessly receive video from multiple buses in its range. The buses will use RSSI mechanism to measure the signal strength of the incoming signal(s). Note that although the data sent by the bus will be specific to the frequency of the tower to which it is currently connected to, the signal strength of the entire available spectrum would be measured. That way, handoff

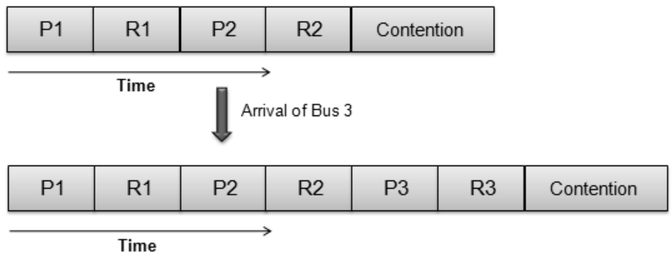

Fig. 2. Figure shows the change in frame structure of a tower induced by an incoming bus. The tower initially had two buses in its range. P1 represents the time for allocated for the RTS signal to Bus 1 while R1 is the time taken for the Bus 1 to send data to the tower. In the contention period, the arriving Bus 3 sends a request to join the tower thereby resulting in addition of the bus to the polling timeframe.

can easily take place whenever the current tower's signal strength falls below the desired value [2]. For handoff, we have considered two alternative approaches:

1) Decentralised or Bus initiated handoff: In bus initiated handoff, a contention period will be added to the tower's timeframe of polling. This time interval can be used by a nearby bus to send a connection request during handoff. After exchange of synchronisation packets, the tower will add the bus to its polling timeframe as shown in Figure 2.

2) Centralised or Tower initiated handoff: In tower initiated handoff, the central Base Station will store the route layout for all the buses. Whenever a bus leaves the vicinity of a tower, the latter will send the message to the B.S. indicating the same. The B.S. will look at the route layout of that particular bus and inform the appropriate tower to handle the incoming bus. The second tower will add the bus to its polling timeframe after the exchange of 'sync' packets.

We have successfully tested both these handoff strategies with USRP boards in the lab. Alternatively, we could use GPS in place of RSSI mechanism for effective localisation of the buses. In that case, the central B.S. will monitor the location of the buses and will control the appropriate towers in case of handoffs. Further, if needed, the buses may employ more than one radio for seamless handoffs. Fine tuning of the various polling parameters might be needed for handling obstacles during the course of the bus journey like underground routes, tall buildings etc.

B. Hardware Design

For a general purpose computer to act as a high bandwidth software radio, hardware is needed to interface it with the real world signals. The hardware serves as the radio front-end and IF processing section while a general purpose CPU acts as the baseband processing unit of the radio communication system. To meet the processing and timing requirements of modern high-speed wireless protocols, we have used USRP board as PC-coupled hardware [3] for two reasons: (1) It is an FPGA based hardware which can handle all the high-speed general purpose operations like digital up and down conversion, decimation and interpolation and; (2) It is compatible with an open source software platform, GNU Radio[4].

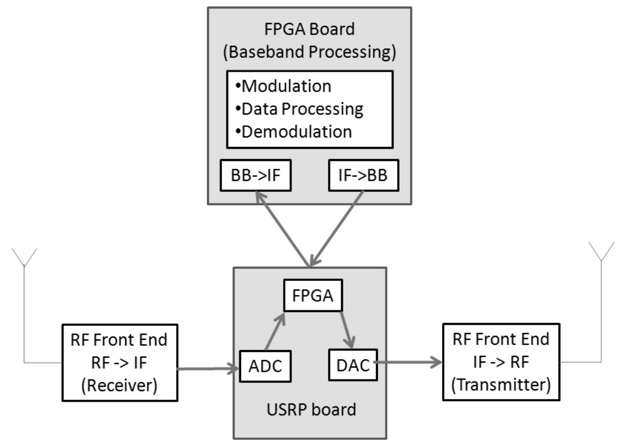

Fig. 3. Block diagram showing the design of the board [5].

C. Software Implementation

We have planned to use GNU Radio, an open source toolkit for SDR for hardware-processor interfacing. Experimentation has been done to identify the optimum values of the various parameters like transmitter and receiver gain, excess bandwidth, different modulation techniques etc. to ensure that the error in the received data is minimum. We have also tried to improve the processing time of the data by creating some application specific blocks.

IV. Conclusions and Future Work

The system offers a solution for the dynamic uplink of video data from city buses using TV whitespaces. Our work may foster design of better systems for handling real-time long range communication. Further, our work may result in design of better MAC-layer strategies for vehicular communication with high QoS and efficient obstacle-handling.

Future works include implementation of Orthogonal Frequency Division Multiplexing (OFDM) on USRP board which will increase the performance and reliability of the system. As shown in Figure 3, we also plan to replace the general purpose computer with another FPGA based board for baseband processing since the general purpose computers which have not been designed for wireless signal processing platforms can only achieve limited performance. This will reduce the cost and increase the data processing capability and portability of the entire system.

References

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