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Audio streaming over low data rate wireless system

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Abstract— Audio applications over wireless networks have recently emerged as a promising research field. However, the limits in terms of communication bandwidth and transmission power have withstood the design of low-power embedded nodes for audio communication. In this work we describe the implementation details of an embedded system for the wireless broadcasting of audio signals over the low data rate wireless system. Here the audio data transferred through a wireless network instead of alarms. That is it tells how to go and where the disaster occurs. This is a challenging task because the effective data rate available in mesh network is low. Most of the bandwidth is consumed by alarm/data communication and audio steering is a real time application. Because of this low data rate we use Huffman compression and decompression algorithms to compress and decompress the audio data.

Keywords- Compression; Decompression; Huffman algorithm; Radios; frequency hopping.

I. INTRODUCTION

Over the last decade there has been abundant interest in life safety systems like fire networks to help evacuation in buildings i.e mass movement of persons from a dangerous place due to a disaster. Many papers have been published in various fields of scientific and engineering disciplines, where a wide range of wired networks have been studied and proposed. Total installation expenses of today's wired fire systems are higher than the cost of the fire system components. On average, cost of laying conduits and wiring one sensor/output device is approximately 4 times the cost of the sensor/output device itself. In wired fire systems, wires serve two purposes – communication and power distribution. The total install cost of the system can be greatly reduced by eliminating wiring completely. This is possible by using wireless for communication and batteries for powering the devices.

This paper aims at developing such a complete wireless fire system, which will offer same functional efficiency and reliability of the wired fire system at a small incremental cost. It will save installation time and cost.

The paper is organized as, after reviewing the fire system architecture in Section-II, Section-III discusses how data process in the network. Section-IV discusses about the Frequency hopping algorithm, section-V discusses about Time synchronization, section-VI discusses about Huffman algorithm, section-VII discusses about results and discussion and Conclusions are presented in Section-VIII.

MSP430 microcontroller datasheet referred from the reference [1] and reference [3]. SX1231 transceiver datasheet referred from the reference [2].

II. FIRE SYSTEM ARCHITECTURE

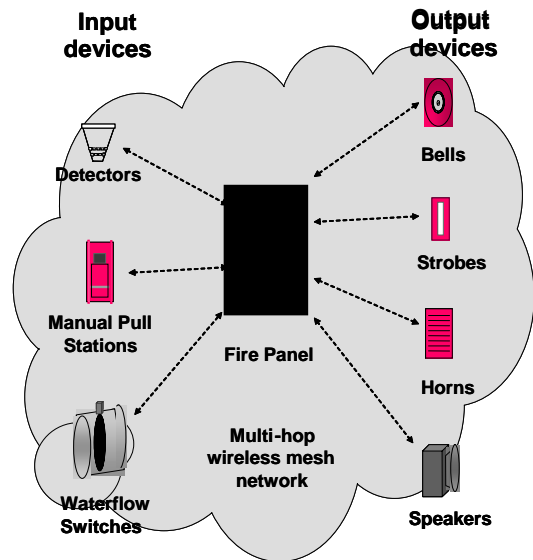


Figure1: Architecture of Fire system

The Architecture of Fire system as shown in Figure 1. Mainly it consists of Fire panel, Fire detectors, Speakers and Audio Devices. All components of the fire system will comprise of two units – sensor /fire panel unit and radio unit. The sensor unit comprises of smoke sensor and heat sensor etc. The radio unit comprises of a microprocessor and transceiver section. The transceiver section includes a power amplifier to boost the Tx power to meet the range requirement.

The RF range of radios is largely a function of frequency of RF transmission, transmit power of radio and nature of obstructions. To ensure long RF range in presence of obstructions, the lower ISM band – 902 to 928 MHz is selected for operation of the wireless fire system.

The maximum transmit power of the radios is restricted by regulatory requirements. The transmit power also impacts the power consumption of the radio. It's beneficial to keep the Tx power low to get good battery life. With a transmit power limited by these two factors, it's not possible to guarantee direct RF communication between all fire

system components in all types & size of buildings. A wireless mesh network is devised to provide indirect connectivity between fire system components. All devices of the fire system participate in the mesh network. The mesh network offers coverage of large building structures through multi-hop communication via the nodes of the system.

Each node of the mesh network plays role of a router (alternately referred as a **parent** or parent node) for next level nodes (alternately referred as **child** nodes). If a parent node doesn't know when the child nodes are going to transmit, it needs to remain alert all the time to be able to receive child node's messages. As the fire system components are battery powered, they need to sleep and conserve the power. To allow the nodes to sleep for maximum time while playing router's role, each node in the system is allotted a time slot for transmission. The parent nodes know the child nodes' Tx slots and remain awake only during these slots for reception.

The wireless fire system is based on a specially designed Time Division Multiple Access multi-hop wireless mesh network formed by battery operated nodes.

Wireless network Design

A. Robust communication

Wireless communication is unreliable due to the very nature of the channel characteristics and due to dynamic or mobile obstructions/reflectors. The communication between the nodes of the fire network is made robust in presence of channel issues by adopting the following techniques.

a) *Selection of transceiver chip & Tx power levels:* The transceiver chip with a very good sensitivity is selected for use in wireless fire system components. This offers a very good link margin and noise immunity. Low noise amplifier (LNA) is also used to further improve the sensitivity. To increase the link margin further, the transmit power is boosted by using a power amplifier (PA). Regulatory requirements don't permit transmission of higher power signal in single channel. Frequency Hopping Spread Spectrum (FHSS) communication mechanisms meeting regulatory guidelines is used to meet the Tx power regulations. The radio unit offers a very robust RF link which overcomes most of the channel issues.

B. Interference Immunity

The lower ISM band is used for wireless communication in industrial, scientific and medical applications. The dominant users (interferers) in this band are cordless phones, walkie-talkies, amateur radios, medical data acquisition systems, wireless data loggers, RFIDs, etc.

a) *Message retransmissions:* Re-transmissions improve the probability of message reaching the destination in presence of the interference.

b) *Frequency hopping communication:* The network also adopts frequency hopping communication technique. The network hops to a new channel in such a way that every transmission attempt from a device happens at a different (widely separated) channel. If original transmission of a

message fails due to interference, its retransmission may succeed because a different channel is used for every time.

C. Low power consumption

The TDMA protocol enables the node to sleep for most of the time as it has to wake up only in predefined slots either to receive messages from its child nodes or to transmit its own messages.

D. Secure communication

Multi-hop communication in the wireless fire system uses data aggregation at each node. This necessitates a security scheme based on a group key. Payload is authenticated using security algorithm & shared key. This makes it possible to identify and filter unauthenticated packets coming from intruder devices.

a) *Security key distribution:* One of the major tasks in implementing security is to distribute security keys to devices. The wireless fire system uses a pre-install mode in which keys is distributed to all devices using wireless communication by PC based Tool.

E. Multiple separate systems operating in overlapping RF space

In densely populated buildings or shared buildings as apartments, it is possible that multiple wireless fire systems may have overlapping RF ranges. It's necessary that these systems should co-exist without disturbing each other. To logically separate the fire systems, each fire system is assigned a unique Network ID. The Network ID is transmitted in each packet and is used to discard packets accidentally received from a neighboring network. In case of a fire system comprising of multiple GW, a network ID is used to separate its network from other system.

III. DATA PROCESSING

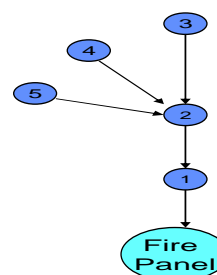


Figure2: Example Fire Network

The fire network is shown in Figure 2. Here 1,2,3.....are the input and output devices. All input and output devices are connected to Fire panel. Fire panel acts as a parent to all nodes. From nodes to Fire panel and Fire panel to nodes the data processed by packets form. According to reference[8], here we used TDMA so the data processed slot by slot.

The frames and slots in TDMA as shown in Figure 3. Here the data streams are divided into frames and each frame divided into time slots. Each time slot contains the actual data.

Each node consists of one parent. Always child send the data to the parent like this all input devices send data to the Fire panel and Fire panel send that data to the output devices. Here all nodes communicate wirelessly. To communicate wirelessly we used radios and antennae.

Each node consists of one micro controller, one radio, sensors and antenna. Whenever sensor detects fire it sends command to the controller, controller sends command to the sounders. Then sounders make alarms. Here we used the Texas instruments micro controller. To communicate all nodes wirelessly we used SX1231 radio because of this capability to the licence free ISM bands.

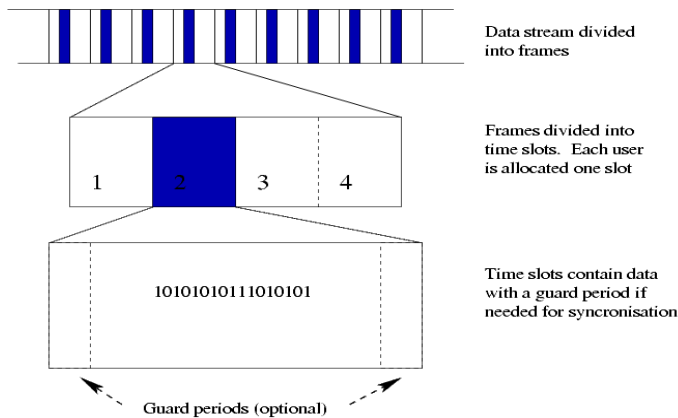


Figure3: TDMA frames and slots

The SX1231 is a highly integrated RF transceiver capable of operation over a wide frequency range, including the 433,868 and 915 MHz license-free ISM (Industry Scientific and Medical) frequency bands. Its highly integrated architecture allows for a minimum of external components maintaining maximum design flexibility. All major RF communication parameters are programmable and most of them can be dynamically set. The SX1231 offers the unique advantage of programmable narrow-band and wide-band communication modes without the need to modify external components. The SX1231 is optimized for low power consumption while offering high RF output power and channelized operation. The data rate for SX1231 is 150kbps. Based on reference [5], to transfer Audio through the network here we used GFSK modulation because it recommended for best bandwidth efficiency at low data rates. Here each node consists of one SX1231 transceiver. Because of low data rate of the SX1231, to send audio data through the wireless network is difficult. Most of the bandwidth is consumed by alarm/data communication and audio transmission is a real time application, this is referred

in reference [6] reference [8] and reference [10]. According to reference [4] and [9], to send audio data through the network we used Huffman compression and decompression algorithm.

According to reference[7], an Audio data is first partitioned into small audio clips. Each clip consists of a certain no of audio frames and each frame is encoded using the Huffman coding. After encoding , these frames are packetized and then transmitted . Once Receiver received the data then its Depacketized and then decoded using Huffman coding after that it play. This is shown in Figure4.

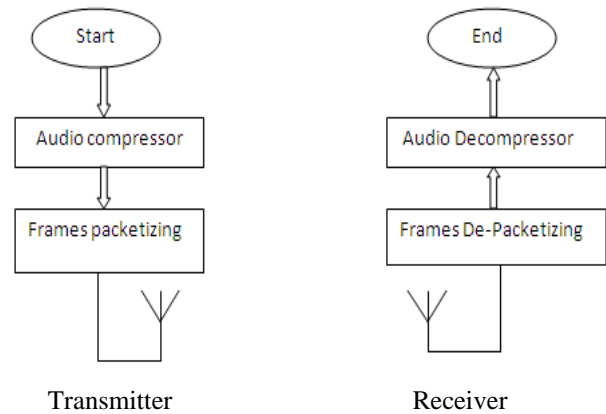


Figure4: Audio data transmission

To reduce interference among all channels in ISM band we used Frequency hopping algorithm and to made reliable communication we maintained Time synchronization between all nodes and panel.

IV. FREQUENCY HOPPING ALGORITHM

The 900MHz ISM band is a license free band and there are several RF equipments which use this band. To avoid interference from other systems and equipments, the wireless fire system uses frequency hopping communication.

The frequency hopping algorithm is designed in such a way that every transmission from a node happens at a different frequency.

As per FCC rules, the frequency hopping system should not use one channel for more than 400ms. FCC also restricts that hopping pattern to be random.

To meet these requirements all the nodes of wireless fire system hop to a new random channel to provide more robust redundant communication.

A. FH pattern & phase

A pseudo-random frequency hopping pattern is derived using a random sequence generation algorithm (reused from One Wireless). All nodes in the system are

programmed to use the same algorithm so that they hop to the same frequency in a given phase. All nodes switch to a new channel at beginning of every request phase and every response phase .

The phase of FH sequence is important to derive the next channel to hop to. The phase is incremented every time after hopping to a new channel.

V. TIME SYNCHRONIZATION

A. Health messages & ACKs

Health messages are used for node failure detection & time synchronization.

Each device transmits Health message to its parents. The parents acknowledge the Health message in its response phase. The Health messages terminate at the parent nodes, they are not forwarded to the panel.

The Health messages are also used for time synchronizing the nodes. Health message and its ACK carry the timing & FH phase information necessary for synchronizing the child node.

The child node transmits its time and FH information in the Health message. The parent nodes transmit their time and FH information in the Health ACK packet. The child node finds the difference between its clock and parent's clock and corrects its clock to synchronize with that of the parent. The nodes can be synchronized to 1-tick accuracy using this method.

Time sync field

8-bit	8-bits	8-bit	16-bit	8-bit
Super-frame number	Phase	Slot number	Clock ticks	FH phase

The Fire panel hosts the master clock of the system. All nodes synchronize with the Fire panel through their parent nodes.

Here the time and FH transmission in child node's Health message is not of any value for synchronization of child node itself. But it's included in the packet to help the discovering nodes to time and frequency-synchronize with the network.

VI. HUFFMAN ALGORITHM

Compression is the art of representing the information in a compact form rather than its original or uncompressed form. Various lossless data compression algorithms have been proposed and used. Some of the main techniques in use are the Huffman Coding, Run Length Encoding, Arithmetic Encoding and Dictionary Based Encoding.

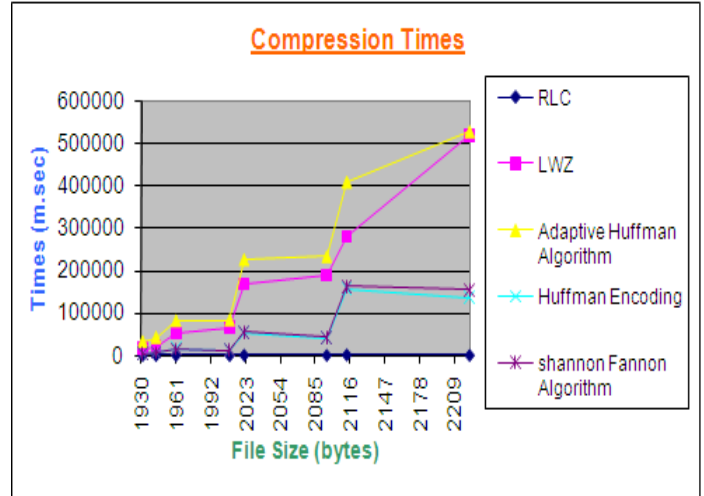


Figure5: Compression times

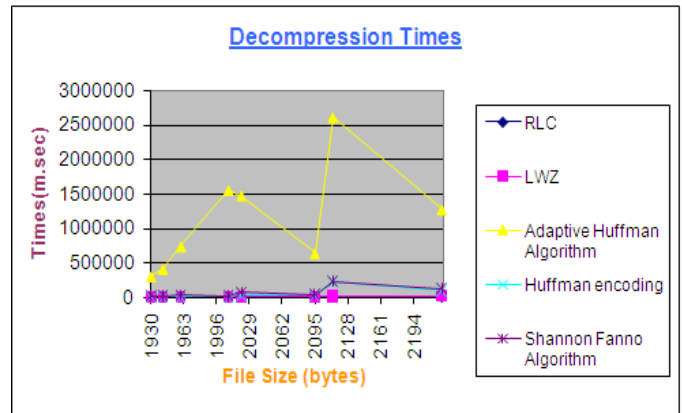


Figure6: Decompression times

By considering the compression times, decompression times in figure5 and figure6 and saving percentages of all the algorithms, the Huffman algorithm can be considered as the most efficient algorithm among the selected ones.

The simplest construction algorithm uses a priority queue where the node with lowest probability is given highest priority:

1. Create a leaf node for each symbol and add it to the priority queue.
2. While there is more than one node in the queue:
 1. Remove the two nodes of highest priority (lowest probability) from the queue.
 2. Create a new internal node with these two nodes as children and with probability equal to the sum of the two nodes' probabilities.
 3. Add the new node to the queue.

- The remaining node is the root node and the tree is complete.

B. Decompression

The process of decompression is simply a matter of translating the stream of prefix codes to individual byte values, usually by traversing the Huffman tree node by node as each bit is read from the input stream (reaching a leaf node necessarily terminates the search for that particular byte value). Before this can take place, however, the Huffman tree must be somehow reconstructed. In the simplest case, where character frequencies are fairly predictable, the tree can be preconstructed (and even statistically adjusted on each compression cycle) and thus reused every time, at the expense of at least some measure of compression efficiency.

VII. RESULTS AND DISCUSSION

Here we used one PC based Tool to see how the network formed and how many nodes are connected to the Panel.

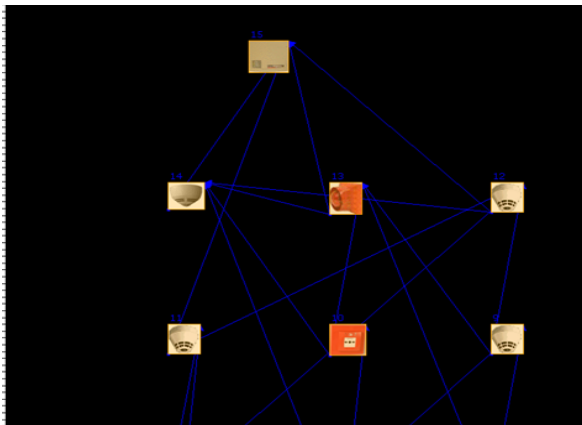


Figure7: Wireless Fire Network

Figure 7 shows the Fire network in the PC based tool. This Network consists of Panel, Detectors, Sounders and Audio devices. Whenever the Fire detectors detect the fire and send commands to the Fire panel, it sends commands to the Sounders and Audio Devices, then Sounders make sound and Audio Devices play where exactly the fire detected.

VIII. CONCLUSIONS

In this paper we presented the wireless fire network consists of a fire panel, Detectors, Sounders and audio devices. The devices in this network communicate wirelessly by using SX1231 transceiver and antennae. Whenever fire attacks, the detectors detect and send commands to the Panel. Then Panel gives commands to the Sounders and audio devices. If we use only sounders in the network the people inside the building may not be able to identify where exactly the fire attacked. To overcome this problem audio devices have been used apart from sounders.

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REFERENCES

- [1] *MSP430 controller Texas Instruments Family Data sheet SLAU208E–November 2009* - <http://www.ti.com>.
- [2] *SX1231 Transceiver SEMTECH Family Data sheet APRIL-2010* - <http://www.semtech.com>.
- [3] *SLAS612A–DECEMBER 9 2008–REVISED JANUARY 2009 Data sheet* - <http://www.ti.com>.
- [4] *S.R.Kodituwaku et.al. / Indian journal of Computer Science and Engineering Voll No 4 416-425* - <http://www.ijcse.com/docs/IJCSE10-01-04-23.pdf>.
- [5] *Masahiko Shimizu, Nobuhisa Aoki, Kazuo Shirakawa, IEEE transactions on communications vol no 45,no-4, April-1997.*
- [6] *Toh C, Tsai W.K Scott A.D, Guichai G, Personal indoor and mobile Radio communications, PIMRC2003 IEEE.*
- [7] *Khalifeh A, Yousefizadeh H, Optimal Audio Transmission over Error - prone Wireless links, IEEE Transactions, 2010.*
- [8] *Rahul Mangharam, Anthony Rowe, Raj rajkumar, IEEE international Realtime systems December-2008* <http://doi.ieeecomputersociety.org/10.1109/RTSS.2006.511>.
- [9] *Marcelloni F, Vecchio M, A simple Algorithm for Data Compression in Wireless Sensor Networks, 2008 LCOMM IEEE, Available at* <http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=04542766>.
- [10] *Zhu ji, Qian Zhang, Wenwu zhu, Jianping zhou, Power-efficient distortion-minimized rate allocation for audio broadcasting over Wireless networks 2002 IEEE.*