Certain Investication of Long Range IoT Communication Using Emergency Vechicle

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ABSTRACT

In the present world, with the growing number of vehicles, traffic has increased to a very greater extent. This mainly has a major impact on the vehicles dealing with an emergency situation .The system employs assistance to such emergency vehicles without any human effort. Conventional technologies use the manual or semi manual systems. Manual system uses the manpower. The semi manual methods use the fixed interval traffic light and image processing which do not distinguish between the emergency and other vehicles. In this Project IOT based Android Application will display the current Railway cross status, Traffic signal Status, Heavy Traffic status and Alternative Path selection. By using our IOT based Android Application in smart phone the drive can reach the target in time. The goal of this Project is to develop a IOT based Android Application for the Emergency Vehicle to reach the target in time. As an emerging technology, IoT enables a machine-to-machine connectivity without a network infrastructure. Therefore, IoT is strongly considered a technology for communications in emergency environments. Especially, a WiFi protocol is under standardization as IEEE802.11ah for IoT-based long-range communications. However, the service range is not enough to cover a communication area in emergency situations. This paper addresses a consumer transceiver for long range communications of IoT in emergency environments. The transceiver is based on IEEE802.11ah WiFi protocol which is under standardization for low-cost and low-power service.

Index Terms —Consumer transceiver, WiFi, IoT communications

I. INTRODUCTION

In order to effectively save human lives and assets in severe disaster situations, advanced technologies have been utilized in emergency alert systems [1]. The technologies mainly rely on cellular networks or mobile broadcasting networks. Cell broadcast service (CBS) broadcasts emergency messages to the users in a specific cell area via cellular networks [2], [3]. Automatic emergency alert service (AEAS) [4] broadcasts emergency messages via mobile broadcasting networks such as terrestrial digital multimedia broadcasting (T-DMB) [5], [6]. However, the technologies are available only when network infrastructures including repeaters can still sustain in the emergency situations. infrastructures undergo a serious damage due to natural or social disasters. However, the research trends of IoT mainly emphasize low-cost and low-power operations rather than direct long-range communications [10].

In this paper, a novel transceiver is proposed for long-range IoT communications. The IoT transceiver can afford to support the service coverage of network in the case of network outage. The transceiver is based on IEEE802.11ah WiFi protocol [11]. The IEEE802.11ah protocol guarantees low-cost and low-power operations [12]-[16]. The WiFi protocol also supports a mild-range service for low data-rate M2M communications [12]. Therefore, the proposed IoT transceiver can rely on the IEEE802.11ah protocol in order to transmit an emergency message via M2M connectivity in emergency situations such as network outages. However, the broadcast coverage for emergency messages is usually larger than the IEEE802.11ah coverage. Therefore, a novel architecture is required in the transceiver in order to enlarge the service coverage of the IEEE802.11ah protocol.

As an emerging WLAN technology, the IEEE802.11ah standard specifies a WLAN system operating at sub 1 GHz license-exempt bands [11]-[16]. In the standard [11], the sub 1 GHz license- exempt bands imply the carrier frequencies lower than 1 GHz. Especially, 900 MHz is one of the most popular carrier frequencies for the IEEE802.11ah [11], [12]. Since the IEEE802.11ah operates at the carrier frequency lower than 1 GHz, it provides much longer communication range than the conventional WLAN standards operating at 2.4 GHz [12]. The IEEE802.11ah protocol relies on orthogonal frequency division multiplexing (OFDM) technology for robust transmission under frequency-selective channels. In the standard, the number of subcarriers for OFDM is 64 at 2 MHz bandwidth [11]. However, only 58 subcarriers are used for data transfer in the IEEE802.11ah. On the other hand, the proposed architecture fully exploits the 64 subcarriers for the transmission of emergency messages at 2 MHz bandwidth, which guarantees higher data rate than the minimum data rate of IEEE802.11ah. Due to the slight modification of the standard, frequency-domain (FD) channel estimation [17] is unavailable on the preamble since it just contains pilot data for 58 subcarriers. Therefore, time-domain (TD) least-square method (LS) [18] is utilized on the preamble for channel estimation, which estimates the channel parameters for 64 subcarriers. Furthermore, TD-LS method effectively exploits the preamble structure for channel estimation, which leads to better estimation performance than FD channel estimation. In addition, the presented transceiver utilizes a concatenated ce communication range, which especially satisfies the service coverage of repeaters for mobile broadcasting networks. The concatenated coder consists of inner coder and outer coder. As an inner coder, the transceiver utilizes the proposed quasi-orthogonal (QO) coder, which is similar to the QO spreader in 2.4GHz WPAN systems [19]. As the outer coder, the transceiver utilizes the binary convolutional coder (BCC) as specified in the 802.11ah standard [11]. The proposed inner coder significantly contributes to lengthen the service range at the expense of data rate, which can be compensated by entire usage of 64 subcarriers.

Experimental results exhibit that the proposed transceiver gives better channel-estimation performance, better receiver performance, and longer communication range. They also show that the presented approach is very suitable for IoT communications of emergency messages in emergency environments.

The rest of the paper is organized as follows: Section II describes the IoT services based on IEEE802.11ah as related works. Section III describes the IEEE802.11ah protocol under standardization. Section IV details the proposed transceiver architecture for IoT communications of emergency messages. The experimental evaluation in section V addresses the excellent performance for the presented transceiver. Section VI concludes the paper.

II. Related Works: IoT Services Based On IEEE802.11ah

The IEEE802.11ah task group (TG) adopted several use cases as application examples for IEEE802.11ah WiFi [12]. Among the use cases, the IoT-related services include smart grid scenario based on IEEE802.11ah and backhaul network based on IEEE802.11ah.

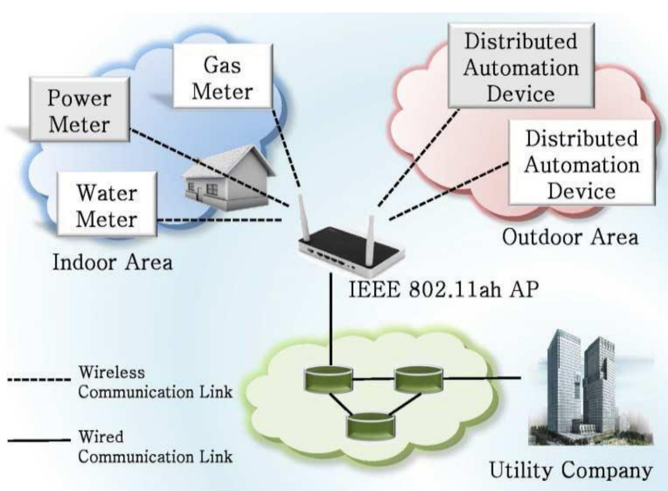


Fig. 1. The smart grid scenario based on IEEE802.11ah.

Fig. 1 illustrates the smart grid scenario based on IEEE802.11ah. Smart grid systems have been devised in order to support significant improvements in the efficiency, reliability, economics, and sustainability of electricity services [20], [21]. Therefore, smart grid requires a reliable and pervasive communication framework for two-way flow of information [20]. As shown in Fig. 1, smart meters measure home utility data such as electric power, gas, and water. Then, the smart meters transmit the measured data to the IEEE802.11ah access point (AP) via IEEEE802.11ah WiFi protocol. After collecting the measured data, the AP retransmits the collected data to distributed automation device and utility company. Based on the measured data, the utility company and the distributed automation device make a decision for optimal usage of utility data, and transmit the decision command to the home smart meter via IEEEE802.11ah WiFi protocol. In the scenario of Fig. 1, the maximum service coverage of IEEE802.11ah AP is 1 km.

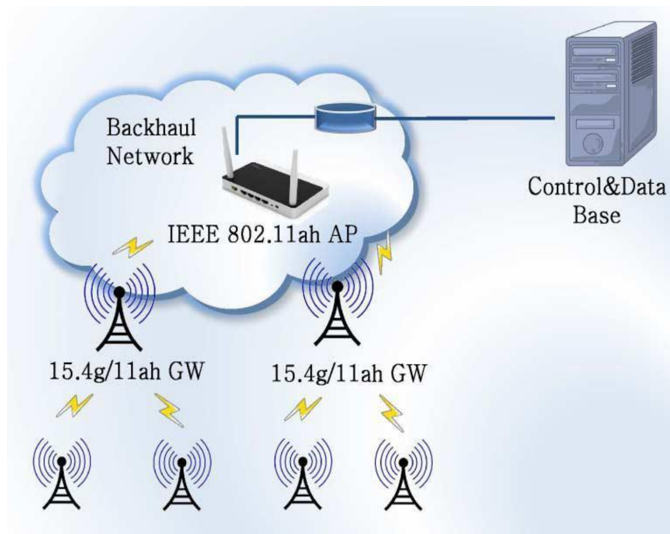


Fig. 2. The backhaul network based on IEEE802.11ah.

Fig. 2 illustrates the backhaul network based on IEEE802.11ah. In Fig. 2, IEEE802.15.4g belongs to WPAN systems and is called the wireless smart metering utility network (Wi-SUN) [22]. The Wi-SUN is attached to home smart meters, and manages and controls home utility data. Therefore, the smart meters transmit the measured utility data to the 15.4g/11ah gateway (GW) via the IEEE802.15.4g protocol. Since the IEEE802.15.4g is a kind of WPAN, it supports short-range communications. Therefore, the distance between the smart meter and the 15.4g/11ah GW is relatively short. The 15.4g/11ah GW converts the received 15.4g data format into the 11ah data format. Then, the GW retransmits the converted data to the IEEE802.11ah AP via IEEEE802.11ah WiFi protocol. Since the IEEE802.11ah protocol is used, the distance between the AP and the GW is much longer than the distance between the GW and the home smart meter. Finally, the IEEE802.11ah AP transmits the received utility data to the control and data base via the backhaul network. Based on the utility data, the control and data base determines a decision for optimal usage of utility data, and transmit the decision command to the home smart meter via the backhaul network and the IEEEE802.11ah/IEEE802.15.4g protocols.

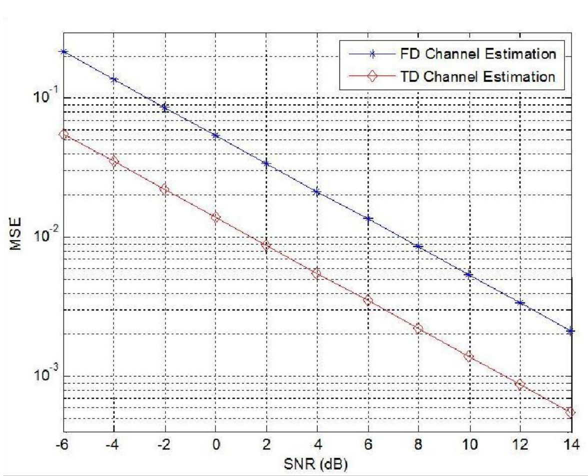
In Figs. 1 and 2, the IEEE802.11ah supports a mild-range communications. However, the distance is not enough to support the broadcast coverage (such as the service coverage of repeaters for mobile broadcasting networks) for emergency messages in the cases of emergency. Therefore, a revision to IEEE802.11ah is required in order to increase the service range. The proposed consumer transceiver includes the revision to IEEE802.11ah.

III. EXPERIMENTAL EVALUATION

Experimental evaluation exhibits the effectiveness of the proposed transceiver for long-range IoT communications. Table III summarizes the experimental parameters. The proposed transceiver operates at the carrier frequency of 900 MHz. As an outdoor channel environment for the transceiver, the evaluation uses the spatial channel model (SCM) [24], [25] whose length (L) is set to 6 at 900 MHz as depicted in Table IV. In the proposed transceiver, each packet consists of 156 OFDM symbols, which include emergency alert messages for mobile broadcasting networks [23]. For the TD LS-based channel estimation, the numbers of set elements (J) and samples in each set element (Q) are set to 6 and 10, respectively in this simulation as shown in Table IV.

TABLE III
EXPERIMENTAL PARAMETERS

Parameter	Value/Method
Carrier frequency	900 MHz
Channel	Spatial channel model
Channel length (L)	6
Time-length of OFM symbol	40 μs
No. of OFDM symbols in packet	156
Inner coder	QO encoder / QO decoder
Outer coder	BCC / Viterbi decoder
No. of set elements (J)	6
No. of samples in each set element (Q)	10
Modulation	QPSK
Channel estimation	Time-domain LS



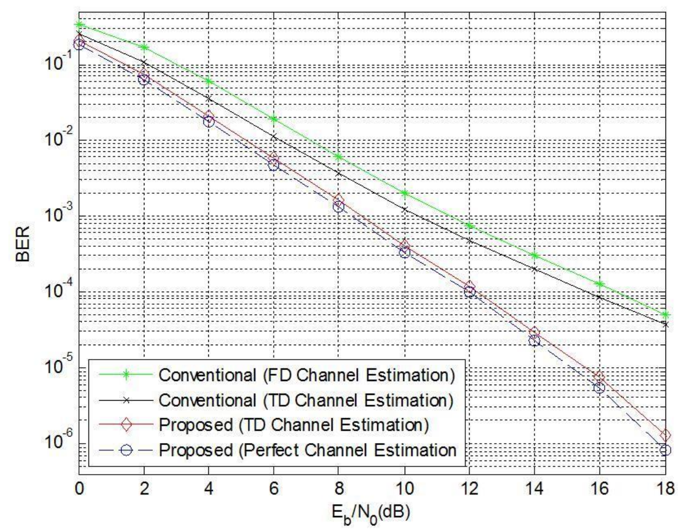


Fig. 11. The BER performance for the proposed transceiver and the conventional IEEE802.11ah.

IV.BER performance for the proposed transceiver

Fig. 11 shows a comparison of the BER performance for the proposed transceiver and the conventional IEEE802.11ah. The conventional IEEE802.11ah and the proposed transceiver follow the architectures of Fig. 2 and Fig, 7, respectively. In addition, the conventional IEEE802.11ah and the proposed transceiver employ the FD/TD channel estimation and the TD channel estimation, respectively. As shown in Fig. 11, the proposed transceiver achieves the E_b/N_0 gain of about 4.5 dB at the BER of 10^{-4}. In other words, the QO coder and the TD channel estimation significantly enhances the receiver performance for the proposed transceiver. As a benchmark, Fig. 11 also exhibits the BER performance for the transceiver with perfect channel estimation. As shown in the figure, the BER performance for the proposed transceiver is very close to that for the transceiver with perfect channel estimation. This also indicates that the QO coder and the TD LS-based approach are very suitable for enhancement of receiver performance as well as full utilization of 64 subcarriers.

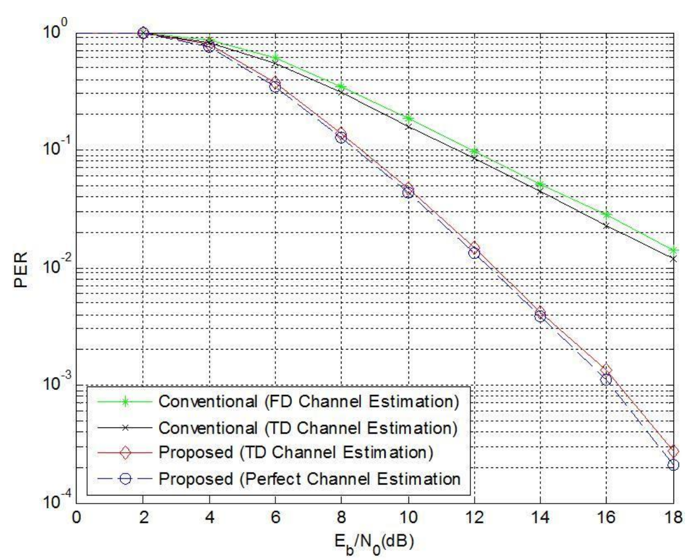


Fig. 12. The PER performance for the proposed transceiver and the conventional IEEE802.11ah.

Fig. 12 exhibits a comparison of the packet error rate (PER) performance for the proposed transceiver and the conventional IEEE802.11ah. Like the BER performance of Fig. 11, the PER performance for the proposed transceiver with TD channel estimation is also very close to that for the proposed transceiver with perfect channel estimation in Fig. 12. The proposed transceiver achieves the E_b/N_0 gain of about 3.7 dB at the PER value (PER of 10%) of the minimum sensitivity input-level [11] as shown in Fig. 12.

At the PER value of the minimum sensitivity input-level, the E_b/N_0 gain confirms the long-range IoT service of the proposed transceiver for retransmission of emergency messages. Especially, the relations between SNR and E_b/N_0 for the proposed transceiver and the conventional IEEE802.11ah are given in (13) and (14), respectively as follows [26]:

$$SNR_{proposed} = \left(\frac{E_b}{N_0}\right)_{proposed} \rho R_{c,in} R_{c,out} .$$

$$SNR_{general} = \left(\frac{E_b}{N_0}\right)_{general} \rho R_{c,in} .$$

In (13) and (14), ρ and $R_{c,in}$ are the spectral efficiency and the code rate of inner coder (BCC coder), respectively. Therefore, ρ is set to 2 for QPSK modulation [26] and $R_{c,in}$ is set to 1/2 in Table 1. In (13), $R_{c,out}$ is the code rate of outer coder (QO coder). $R_{c,out}$ is set to 1/8 in (13) since the QO encoder of Fig. 7(a) converts 4-bit information into 32 real codes (16 complex values) as shown in Table III. From (13) and (14), the SNR gain for proposed transceiver can be found as follows:

$$SNR_{gain}\ (dB) = 10\log_{10}\frac{SNR_{general}}{SNR_{proposed}} = \left(\frac{E_b}{N_0}\right)_{gain} - 10\log_{10} R_{c,out} , \quad (15)$$

where $\left(\frac{E_b}{N_0}\right)_{gain}$ is expressed as

$$\left(\frac{E_b}{N_0}\right)_{gain} = 10\log_{10}\frac{\left(\frac{E_b}{N_0}\right)_{General}}{\left(\frac{E_b}{N_0}\right)_{proposed}} . \quad (16)$$

Since $\left(\frac{E_b}{N_0}\right)_{gain} = 3.7$ dB at the PER of 10% in Fig. 12, and $R_{c,out} = 1/8$, SNR_{gain} (dB) = 12.731 dB at the PER value (10%) of the minimum sensitivity input-level in (15). The path loss for IEEE802.11ah is expressed as follows [24], [27]:

$$PL\ (dB) = 8 + 37.6\log_{10}(d) , \quad (17)$$

where d denotes the distance (for service coverage) in meters. In the conventional IEEE802.11ah, the distance for MCS 1 is about 550 m for the minimum sensitivity input-level [12]. The distance is not enough for the service coverage of the repeaters since their typical coverage is higher than 1 km in mobile broadcasting networks. Using (17), the path loss is 111.04 dB at 550 m in the conventional IEEE802.11ah. For the proposed transceiver, the expression of (17) is slightly modified as follows:

$$PL + SNR_{gain}\ (dB) = 8 + 37.6\log_{10}(d) . \quad (18)$$

With the same path loss (111.04 dB) and the SNR_{gain} (dB) of 12.731 dB, the distance for the proposed transceiver is about 1.3 km. Therefore, the proposed transceiver (or the MCS 11 of Table II) entirely supports the typical service coverage of the can afford the long-range IoT service in mobile broadcasting networks.

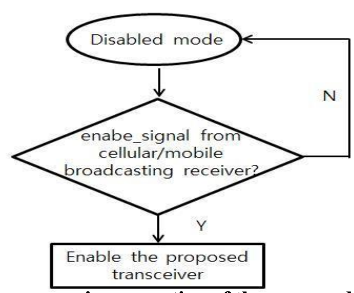


Fig. 13. The power-saving operation of the proposed transceiver for consumer application.

Fig. 13 illustrates the power-saving operation of the proposed transceiver for consumer application. The transceiver is in the disabled mode for power saving under normal conditions. Only in the case of repeater outage, the cellular/mobile broadcasting receiver of Fig. 9 generates the enabling signal (enable_signal), which enables the IoT operations of the proposed transceiver. Therefore, additional power consumption is not expected in normal conditions.

VI. Conclusion

This paper describes a consumer transceiver for long-range IoT communications. The transceiver is based on IEEE802.11ah, which is under standardization. The IEEE802.11ah supports low-cost and low-power services for IoT communications including M2M connectivity. However, the coverage of the IEEE802.11ah is not large enough to support the typical service coverage of the repeaters. In this paper, a transceiver is proposed in order to support the service coverage of the repeaters. The transceiver exploits an inner coder called QO coder in addition to the architecture of IEEE802.11ah-MCS 1 at 2 MHz bandwidth. In this paper, the MCS mode for the transceiver is defined as MCS 11, which fully utilizes 64 subcarriers within one OFDM symbol for data

transmission. Since the current preamble contains the pilot values for only 52 subcarriers, a channel-estimation approach is presented in this paper in order to achieve the channel parameters corresponding to the 64 subcarriers. The channel estimation method is based on TD LS technique. Since the TD channel estimation averages the noise term 6 times, it exhibits better estimation performance.

The experimental evaluation shows that the TD channel estimation is superior to the conventional FD channel estimation in terms of MSE. The evaluation also confirms that the proposed transceiver outperforms the conventional IEEE802.11ah-MCS 1 at 2 MHz bandwidth in terms of BER and PER. From the comparison of the PER performance, it is revealed that the service range of the proposed transceiver (MCS 11) is much larger than that of MCS 1. Finally, the experimental evaluation confirms that the proposed transceiver can support the typical range of repeaters for mobile broadcasting service. In addition, it is concluded that the proposed transceiver is very suitable for long-range IoT communications especially in emergency situations including repeater outage.

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