(IJIEEE) 2017, Vol. No. 3, Jan-Dec **e-ISSN: 2454-9592; p-ISSN: 2454-8081**

DEVELOPING A DATA FORWARDING SCHEME FOR THE EFFICACIOUS USE IN THE WI-FI NETWORKS

Amardeep Chahal

ABSTRACT

Today IT innovation patterns are gone up against another mechanical marvel. It is the crossing point of innovation and human sciences. That is an IT union. Despite the fact that the intermingling patterns will prop up, later on, there is the Internet of Things, which is another preparing to quicken these patterns. A large number of IoT gadgets will transmit different data through the Internet, and the principle channel of data streams will be a Wi-Fi system. In any case, current Wi-Fi innovation isn't set up to suit this information yet. In this manner, we propose the Efficient Data Forwarding Scheme (EDFS) to take care of these issues. The proposed EDFS allocates an appropriate transmission opportunity (TXOP) to the IoT gadgets for supporting productive information transmission. In the EDFA, Wi-Fi AP (Access Point) gives a determined or pre-characterized TXOP, which is appropriate for the information transmission properties of IoT gadgets. Because of the way that the information transmission highlight of IoT gadgets isn't the constant traffic in most cases. In light of the EDFA, a Wi-Fi AP cannot just allocate an effective TXOP to a gadget, yet in addition, bolster different IoT gadget prerequisites inside the Wi-Fi hotspot. We contrasted it and inheritance Wi-Fi transmission plan to demonstrate the beating results by utilizing the OPNet test system

1. INTRODUCTION

Nowadays, IT infrastructure environments have beendramatically changed, and this trend will be accelerated.It has been mainly caused by various types of multimediadata, deepened fluctuation of daily traffic, rapid deploymentof cloud computing, huge size data center, spreadingIT-based business, and so on. These changes do require not only a simple and flexible infrastructure scheme butalso needed super high speed and bandwidth networksas a necessity. Therefore, the telecommunication serviceproviders are competitively adapted to gigabit technologiessuch as gigabit Ethernet, IEEE 802.11ac, etc. from allover the world. In addition, the Internet of Things (IoT) willbe an inevitable and essential technology in the middleof this trend. Actually, the IoT technology isn’t droppedfrom skies. It has constantly been evolving from RFID(Radio Frequency Identification) technology in the pastfew years. It just had gotten into the limelight as a next-generation business in recent days. That is, the IoT has beenthe eye of a typhoon in the nowadays converged trends.Although it seems to be evolving with the trends, respectively, these trends are tightly coupled to eachother. Due to the fact that the present ICT infrastructures,which are used to IoT, Wi-Fi, and etc., will pursueto be changed from hardware-based technology to theefficient and flexible software-based technology. That is, the programmability of topology and behavior, IaaS (Infrastructure as a Service), virtual infrastructure, integrated smart infrastructure, interworking to other network techniques, and so on, will be the main functionalities in the near future [1,2.]

Actually, Wi-Fi technology could have died out the technology in the past few years ago, if there were no various hand-held devices and the smartphone. However, it has been continuously spotlighted technology, since the tremendously increasing wireless data are needed in the smartphone and hand-held device. These tendencies can't be an out-of-hand thing by only mobile networks such as LTE (Long Term Evolution), Mobile WiMAX (Worldwide Interoperability for Microwave Access), and etc. This is why the current limelight of Wi-Fi technology is still continuing. In addition, there is one other important reason. It is the IoT technology because it is not only causing the explosive effects in the data usages but also using the Wi-Fi technology as a fundamental transmission scheme3,4.

In spite of this technical background, the existing Wi-Fi standards and technologies didn't consider the data transmission of IoT devices yet. That is, the IoT devices are handled at a normal station within the Wi-Fi hotspot. It can be one of the reasons which cause the inefficient Wi-Fi network throughput because most of the IoT devices' traffic attribute isn't a real-time feature. To solve this problem, we propose an efficient data forwarding scheme, which is very appropriate for the traffic attribute of IoT devices. The proposed EDFS can assign the proper TXOP, which does not only consider a traffic attribute of IoT device but also calculated or pre-defined with a time interval, to the IoT devices within the Wi-Fi hotspot.

2. RELATED WORKS

2.1 Wi-Fi Technology

Recently, there are many Wi-Fi technologies such as Gigabit Wi-Fi, Super Wi-Fi, Wi-Fi Direct, and so on. Although there are many Wi-Fi standards, technologies, and applications, the current Wi-Fi evolutions are focused on bandwidth expansion, as shown in Table 1.

The evolution of Wi-Fi technology has mainly led to some PHY techniques. It means that MAC techniques didn't almost change up to now than PHY techniques relatively. However, there are introducing various MAC techniques in recent years. Especially, these MAC techniques, which are related to reduce the control frame overhead and to adjust the back-off time, are focused on improving Wi-Fi network efficiency and providing user QoS/QoE.

Legacy IEEE 802.11 Distributed Coordinating Function (DCF) has some lacks in these functionalities. These limitations are as followings in detail. First, all stations (STAs)' services have equal priority when they access the media. Second, the media access control of each STA is impossible. Third, an Access Point (AP) and STA have the same priority so that it makes a beacon frame transmission delay. In the IEEE 802.11e standard, the enhanced Distributed Channel Access (EDCA) uses four access categories (ACs) to solve the above problems, as shown in Figure 1. In addition, the OFDMA (Orthogonal Frequency Division Multiple Access) based techniques, which are currently being discussed in the IEEE 802 TG (Technical Group), are as shown in Figure 25–9.

2.2 IoT Technology

Generally, wireless sensor network technology is a kind of surveillance/control/communications technology, which can support self-networking configuration & organization, and to collect information from some sensor nodes. Nowadays, the ultimate goal of wireless sensor network technology is evolving to the Internet of Things (IoT) and M2M (Machine to Machine). To achieve this goal, there are some important elemental technologies, which are sensing, information processing and exchanging, intellectual network configuration, wireless sensor routing technology, and so on.

On the one hand, wireless sensor networks are based on non-IP communications, the common devices, whereas, are based on IP communications, which are connected to the Internet. In the non-IP communications, the devices can use various technologies for their communications, such as Bluetooth, ZigBee, RFID, Z-Wave and etc. These typical non-IP based sensor nodes can exchange the information to connect the Internet through a sink node due to the fact that the sensor nodes should adopt some technologies to establish an Internet connection. For example, sensor nodes can be applied.

Table 1. Wi-Fi technology

Name	Features
IEEE 802.11ac	• Enhanced technology from IEEE 802.11n • Bandwidth: 20MHz ~ 160MHz • Maximum Throughput: 6.9Gbps (Theoretically) • Using 8 spatial stream • 256 QAM • Multi-user MIMO • Beamforming • Etc.
IEEE 802.11ad	• IEEE 802.11ad is a discrete technology • Throughput: 6.8Gbps (Single Antenna, 64QAM without channel bonding) • Maximum Throughput: 30Gbps (Theoretically) • Frequency Band: 60GHz • LOS (Line-Of-Sight) indispensability • Etc.
IEEE 802.11af	• IEEE 802.11af is a Wi-Fi technology which is used in TV white space band • Extended Hot Spot (broad service coverage) • There are many applicable services • It is one of the next generation Wi-Fi technology • Etc.
IEEE 802.11p	• Established standard in 2010 for supporting the next generation ITS • Bandwidth: 10MHz • Throughput: 6 ~ 27Mbps • Frequency Band: 5.850 ~ 5.925GHz • Etc.

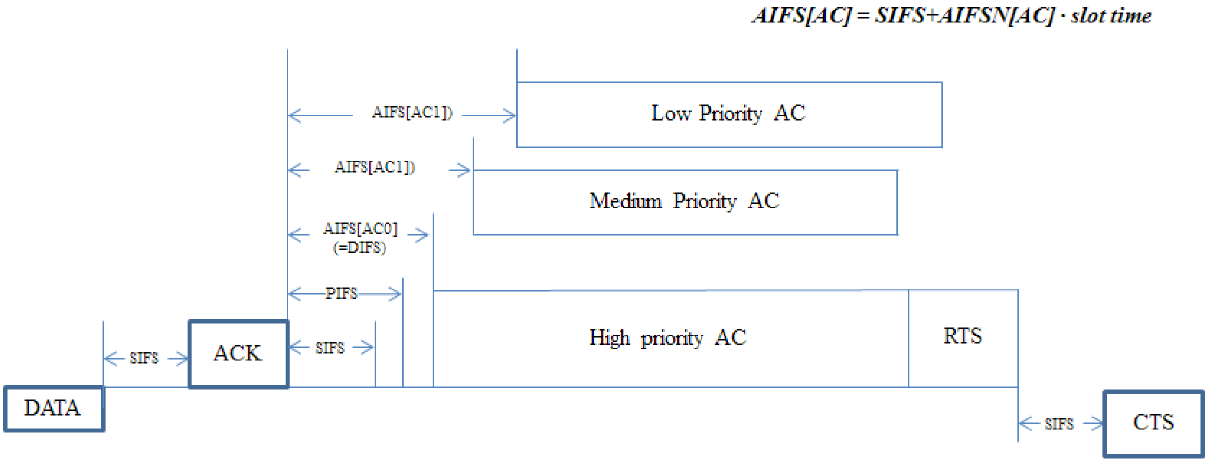

Figure 1. Priority-based backoff algorithm in IEEE 802.11e.

3. EFFICIENT DATA FORWARDING SCHEME

Basically, IoT devices have the same priority as other STA when they should access the medium. Although the IoT devices or sink node of the IoT devices have few transmission data, and they don't need high bandwidth, the devices should contend for gaining a TXOP in the current Wi-Fi networks. It is a very inefficient situation in the Wi-Fi networks because most of the IoT devices have to save their battery, and they usually need to make a periodic connection. Nonetheless, the current Wi-Fi standards haven't any considerations about that [11–13].

To solve these problems, we propose an efficient data forwarding scheme for IoT devices. Basically, the proposed scheme assigns the differentiated access privilege to

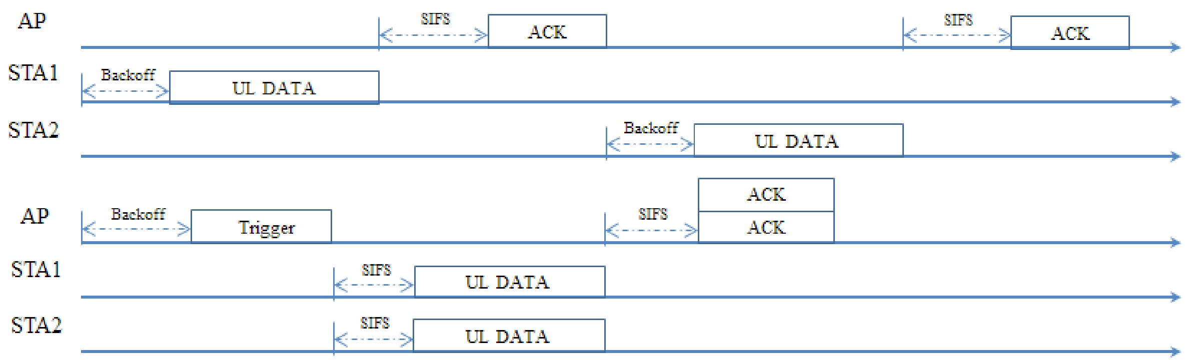

Figure 2. UL Transmission scheme and OFDMA based UL transmission scheme

Table 2. Non-IP communication technology

Name	Features
ZigBee	• Wireless network technology for low transmission speed and short distance communication • Low power consumption and low cost • Various and broad applicable scopes for intelligent home network, factory automation, distribution, HCI, telematics, environment monitoring, etc. • Consist of physical layer, MAC layer, network layer, and application layer • IEEE 802.15.4 standard • Supporting the routing and addressing scheme for tree topology and mesh topology • Profile: ZigBee Home Automation Public Profile, ZigBee Smart Energy Profile • RF4CE: Enhanced ZigBee specification (including remote control solution and network stack) • Supporting AES-128 in RF4CE
Z-Wave	• Home automation wireless transmission technology, which is established by Z-Wave Alliance • Supporting the reliable communication between one or more nodes and control units • Consist of physical layer, MAC layer, transport layer, routing layer and application layer • Frequency Band: 869MHz/908MHz(Europe/America) and 2.4GHz • Maximum Throughput: 9.6kbps, 40kbps, 200kbps (Theoretically) • There are 2 types (Controller and Slave) • Supporting the source routing base routing in the routing layer
6Lo WPAN	• It is a technology to connect to the legacy IP networks with IPv6 in low power WPAN • Based on IEEE 802.15.4 PHY/MAC • It is possible to connect to a IP base network without gateway or intermediate device

Guarantee a TXOP of IoT device. It can be a kind of application of the IEEE 802.11e standard.

The back-off process is determined by various parameters such as CW_{min} (minimum congestion window), CW_{max} (maximum congestion window), AIFS (arbitration inter-frame space), and TXOPlimit, as shown as Figure 1. The $CW_{min}$is the most important factor to affect all of the stations in the Wi-Fi networks because the Wi-Fi network, which is based on the IEEE 802.11 standards, frequently encounters congestions, which are caused by contention. However, if the IoT device has the same parameter value as other normal stations (N-STA), the IoT device can't achieve their efficient data forwarding. That is, the device can't save their battery lifetime, because the device has to keep the status as awake when it has to transmit their data. Therefore, the proposed EDFS assign the parameters of IoT device (i-DEV) and N-STA, including Access Point (AP) to avoid the situations as follows:

$$\begin{aligned} i &= DEV\{(CW_{\downarrow}\min^{\uparrow}(\text{i}-\text{DEV}) \\ &= CW_{\downarrow}\min^{\uparrow}\ default\ RP2 \\ &\quad (\text{w}_{\downarrow}\max/\ w_{\downarrow}(i-DEV))@CW_{\downarrow}\max^{\uparrow}(i-DEV \\ &= CW_{\downarrow}\max^{\uparrow}\ default\ RP2(\text{w}_{\downarrow}\max/\ w_{\downarrow} \\ &\quad (i-DEV)),\text{and}\ @\ \text{AIFS}_{\downarrow}(i-DEV) \end{aligned} \quad (1)$$

$$\begin{aligned} & N-STA\{(CW_{\downarrow}\min^{\uparrow}(N-STA) \\ & = CW_{\downarrow}\min^{\uparrow}\ default\ 2^{\uparrow}i\ @CW_{\downarrow}\max^{\uparrow} \\ & (N-STA) = \text{CW}_{\downarrow}\max^{\uparrow}\ default\ 2^{\uparrow}i, and \\ & @\ AIFS_{\downarrow}(N-STA) = DIFS)-1 \end{aligned} \quad (2)$$

$$RP2(k)\begin{cases} 2[\log_2(k)], & k-_2[\log_2(\text{k}) \leq_2 [\log_2(\text{k})]-\text{k} \\ & _2[\log_2(\text{k}), \text{otherwise} \end{cases} \quad (3)$$

where wmax represents the highest weight in the Wi-Fi network, wi-DEV is a weight for the i-DEV and AP, and RP2(k) is the integer power of 2 closest to k.

The proposed EDFS assigns a higher weight tothe i-DEV than the N-STA, as shown in equations (1), (2), and (3). Based on these equations, AP and i-DEV can be acquired high priority than N-STA. It means that the i-DEV has a shorter back-off time, and then the device can keep high medium access privileges than N-STA based on the short back-off time. Therefore, the i-DEV can retain much more TXOP than N-STA based on the scheme in the proposed EDFS, because the i-DEV has more media access privileges with short back-off times. However, it isn't enough to save the battery and to guarantee the IoT devices' data transmissions, because the IoT device doesn't need high bandwidth than N-STA. Although the EDFS assigns the high priority to an IoT device when the device wants to transmit their data, it doesn't need to keep the status all the time because the IoT data transmission will have periodically occurred. So, we adjust admission control functions to solve this problem in the EDFS. The admission control part in the EDFS handles the admission of i-DEV and N-STA to improve the entire Wi-Fi network throughput and the efficient data transmission of IoT devices. The admission control part of EDFS manages admission processes by using each station's local variables, which are admitted_time and used_time. It is almost similar to the IEEE 802.11 EDCA contention-based admission control usages. However, the IoT devices will send a specific traffic specification (TSPEC) to AP, when they have to send the TSPEC. Basically, all stations send a QoS request frame to AP when they negotiate the traffic stream (TS). In the QoS request frame, there are many values such as the TSPEC of mean data rate, delay bound, minimum PHY rate, and so on. On the other hand, it is added the periodic value of the IoT device in the EDFS. Based on the periodic value, the EDFS control the admission processes of IoT device. As a result, the EDFS can keep a high weight status for a while.

Since the AP receives the QoS request frame of IoT device, it distinguishes the QoS request frame is the corresponding TS of IoT device or not. And then, the AP determines that the request will be accepted or not. The AP calculates a medium time if it is accepted. The calculated medium_time is as follows, and then the value will send to each station, where, $w_{i\text{-}DEV}$ means the weight of the IoT device, and the medium_time$_{i\text{-}DEV}$ value is 0 <medium_time$_{i\text{-}DEV}$> requested time of the IoT device. The later process is the same as the IEEE 802.11 EDCA admission control part.

$$medium_{time} \begin{cases} medium_{time\,i-DEV} = medium_{time\,i} \times w_{i-DEV} \\ medium_{time\,N-STA} = medium_{time_i} \end{cases} \quad (4)$$

We have implemented a network topology by using the NS-2 to verify the EDFS performance. There are four stations; one is a sink node of IoT devices; the other is normal stations in the simulation networks. The normal stations are configured to generate streaming traffic for 1 hour, the sink node of IoT devices is configured to generate the data transmission periodically in every 5 minutes. On the one hand, we set the weight (wi-DEV) of sink node data transmission to 5.

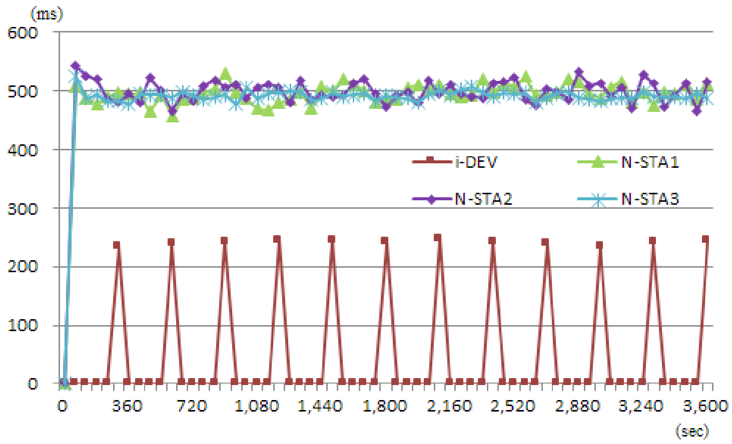

Figure 3. Delay comparison of i-DEV and N-STAs.

Figure 3 shows the delay comparison results of the i-DEV and N-STAs. The average delay of i-DEV is 241.38ms, and the N-STAs' average delay is 496ms, 501ms, and 492ms, respectively. Based on these results, we are proof that the proposed EDFS can provide an acceptable delay to the IoT devices. The bandwidth of IoT devices isn't an important matter because the IoT device doesn't need high bandwidth. Therefore, the proposed EDFS could be improved the overall Wi-Fi network throughput, including the IoT devices and sink nodes.

4. CONCLUSION

The proposed EDFS can be a kind of QoS scheme because it could assign various weights or priorities to each station in the Wi-Fi networks. In addition, the EDFS has a consideration of the IoT device and the sink node. However, normal stations and IoT devices have different traffic attributes, such as bandwidth, delay, jitter, and so on. So, we propose the EDFS to solve these problems. The EDFS assign the various weight to the IoT device so that the traffic attributes of devices are applied to the transmissions when they need to transmit their data. Nevertheless, the EDFS can't assign dynamic weights to each station yet. It can be a very important thing because the IoT technology and device will be certainly deployed in the near future, and there are various types of devices. So, it will be one of our future researches.