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Content Delivery Scheme Based on Network Selection for Power Saving

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ABSTRACT
In this study, we present content delivery scheme based on network selection for power saving. There are two main communication technologies such as Wi-Fi and mobile telecommunication (4G, 5G) in smartphones. Power consumption is one of the important factors in smartphones. Wi-Fi network consumes low power compared to mobile telecommunication in multimedia streaming. The proposed scheme transmits the multimedia content data first when the Wi-Fi signal is strong. In this manner, it can reduce the energy consumption of a smartphone. Therefore, the proposed content delivery scheme is expected to be useful for providing multimedia streaming services with low-power consumption.

Key words : Multimedia Streaming, Power Consumption, Content delivery network (CDN), content distribution, WiFi, LTE (Long term evolution)

1. INTRODUCTION

With the rapid spread of smartphones, the number of mobile users is rapidly increasing. Mobile users enjoy the Internet by accessing Wi-Fi (WiFi) or mobile telecommunication (4G, 5G). In addition, the user trend of mobile users has changed from using text and image content in the past to using video content. According to a Cisco report, the total number of mobile subscribers worldwide will grow from 5.1 billion (66% of the population) in 2018 to 5.7 billion (71% of the population) by 2023[1-3].

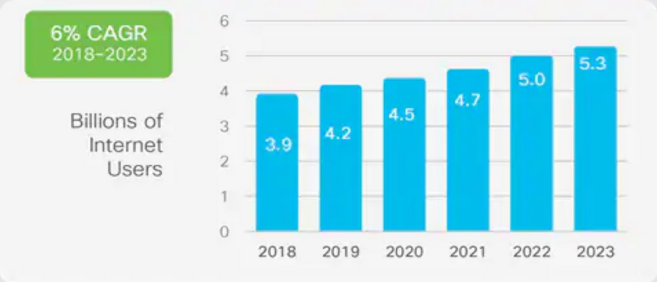

Figure 1: Global Internet user growth

Figure 1 shows the global Internet user growth. Globally, the total number of Internet users is projected to grow from 3.9 billion in 2018 to 5.3 billion by 2023 at a CAGR (compound annual growth rate) of 6 percent. In terms of population, this represents 51 percent of the global population in 2018 and 66 percent of global population penetration by 2023[3].

With the popularity of YouTube, Netflix, and Disney Plus, traffic through large-capacity video content is also rapidly increasing. And with the increase of video users, the problem of smartphone battery discharge has occurred. In today's smartphones, battery usage has become an important factor, and thus power consumption has also become an important factor[4-9].

In this paper, a technique to reduce battery consumption during multimedia streaming such as video was studied. Mobile data traffic and battery consumption have increased during multimedia streaming. There are two main communication technologies such as Wi-Fi and mobile telecommunication in mobile devices. Wi-Fi network consumes low power compared to mobile telecommunication [10,11]. Therefore, power consumption can be reduced by using Wi-Fi communication rather than mobile telecommunication in multimedia streaming.

The proposed scheme transmits video content data in the Wi-Fi network first when the Wi-Fi signal is strong. In this manner, it can reduce the energy consumption of smartphones. Therefore, the proposed content delivery scheme is expected to be useful for providing multimedia streaming services with low-power consumption.

This study is organized as follows. Chapter 2 briefly explains the backgrounds. The proposed content delivery scheme based on network selection is described in chapter 3. Lastly, chapter 4 presents the conclusion.

2. BACKGROUNDS

2.1 W-iFi

Wi-Fi is a family of wireless network protocols, based on the IEEE 802.11 family of standards, which are commonly used for local area networking of devices and Internet access, allowing nearby digital devices to exchange data by radio waves. These are the most widely used computer networks in the world, used globally in home and small office networks to link desktop and laptop computers, tablet computers, smartphones, smart TVs, printers, and smart speakers together and to a wireless router to connect them to the Internet, and in wireless access points in public places like coffee shops, hotels, libraries and airports to provide the public Internet access for mobile devices[11].

2.2 Mobile telecommunication

Mobile telecommunication is a communication network where the link to and from end nodes is wireless. Currently, 5G mobile communication has been developed.

In telecommunications, 4G Long-Term Evolution (LTE) is a standard for wireless broadband communication for mobile devices and data terminals, based on the GSM/EDGE and UMTS/HSPA standards. LTE is the fourth generation of mobile communication. It improves on those standards' capacity and speed by using a different radio interface and core network improvements. LTE is the upgrade path for carriers with both GSM/UMTS networks and CDMA2000 networks. Because LTE frequencies and bands differ from country to country, only multi-band phones can use LTE in all countries where it is supported[12].

In telecommunications, 5G is the fifth-generation technology standard for broadband cellular networks, which cellular phone companies began deploying worldwide in 2019, and is the planned successor to the 4G networks which provide connectivity to most current smartphones[13].

2.3 Power Consumption

Smartphones have a limited battery. Therefore, power consumption has become an important factor in smartphones. When data is transmitted from mobile, power consumption is less in WiFi network than in mobile **telecommunication** network.

Figure 2 shows the energy consumption comparison of WiFi and LTE during multimedia streaming. In general, LTE exhibits higher energy consumption than WiFi. In Figure 2, QL1, QL2, and QL3 represent quality levels in video encoding. Table 1 shows the quality levels in the video encoding used in the experiment[10].

Equation (1) shows the energy calculation formula. Energy E in joules (J) is equal to power P in watts (W) multiplied by time t (in seconds)[10].

$$E(J) = P(W) \times t(s) \quad (1)$$

where E is energy in joules, P is power, and t is time.

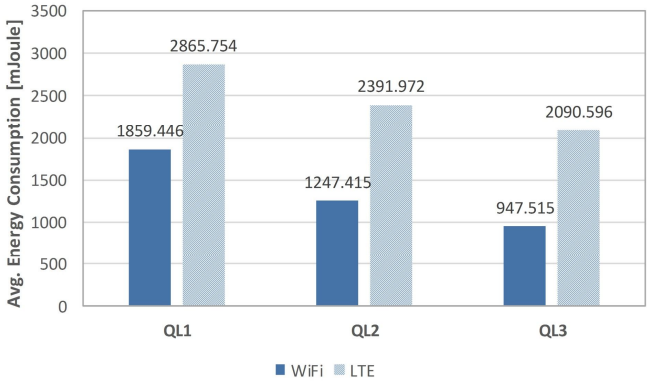

Figure 2: Energy consumption comparison

Table 1: Video encoding

Quality Levels	Video Codec	Overall bitrate [kbps]	Resolution	fps
QL1	MPEG-4 /H.264	2032	960 x 544	30
QL2	MPEG-4 /H.264	1090	592 x 366	25
QL3	MPEG-4 /H.264	615	368 x 208	20

3. PROPOSED CONTENT DELIVERY SCHEME BASED ON NETWORK SELECTION FOR POWER SAVING

This chapter describes the content delivery scheme based on network selection for the proposed power saving. A mobile telecommunication or cellular network is a communication network where the last link is wireless. And Wi-Fi is a technology for wireless local area networking with devices based on the IEEE 802.11 standards. Normally, Wi-Fi network consumes low power compared to mobile telecommunication network.

Video content streaming services such as YouTube is very popular today. When we watch video content, it consumes a lot of power. Therefore, efficient techniques are needed to reduce power consumption in smartphones[10].

Figure 3 shows Wi-Fi information (Storing RSSI) in a smartphone. In telecommunications, received signal strength indicator (RSSI) is a measurement of the power present in a received radio signal[14]. If the received signal strength is strong, more data can be transmitted stably during the same time period. In Figure 3, the RSSI is as strong as -34dBm, so that a lot of data is transmitted at once with 256-QAM modulation. 256-QAM is a variation on the quadrature amplitude modulation (QAM) signal modulation scheme[15]. 256-QAM yields 256 possible signal combinations, with each symbol representing eight bits (2^8 = 256). Accordingly, the link speed is 702Mbps, indicating a high maximum transmission rate.

Figure 3: Wi-Fi information in smartphones (Strong RSSI)

If the received signal strength is weak, less data can be sent in the same amount of time. In Figure 4, the RSSI is weak at -74dBm, so that less data is transmitted at a time with QPSK modulation. Quadrature Phase Shift Keying (QPSK) is a form of Phase Shift Keying in which two bits are modulated at once, selecting one of four possible carrier phase shifts (0, 90, 180, or 270 degrees)[16]. QPSK allows the signal to carry twice as much information as ordinary PSK using the same bandwidth. Accordingly, the link speed is 13Mbps, indicating a high maximum transmission rate.

Therefore, if the received signal strength of Wi-Fi is weak, energy consumption increases because data needs to be transmitted over a longer period of time. If the received signal strength of Wi-Fi is weak, it may be advantageous to receive data through mobile telecommunication such as LTE.

In this study, if the Wi-Fi signal is higher than the threshold, multimedia content is downloaded through the Wi-Fi network. If the Wi-Fi signal is lower than the threshold, the multimedia content is downloaded through the mobile telecommunication (4G, 5G) network.

Figure 4: Wi-Fi information in smartphones (Weak RSSI)

Figure 5 shows the flowchart of the proposed content delivery scheme based on network selection. If the smartphone is not connected to Wi-Fi, multimedia content is downloaded through the mobile telecommunication network. When the smartphone is connected to Wi-Fi and the RSSI is above the threshold, multimedia content is downloaded through Wi-Fi. These techniques can reduce energy consumption in smartphones.

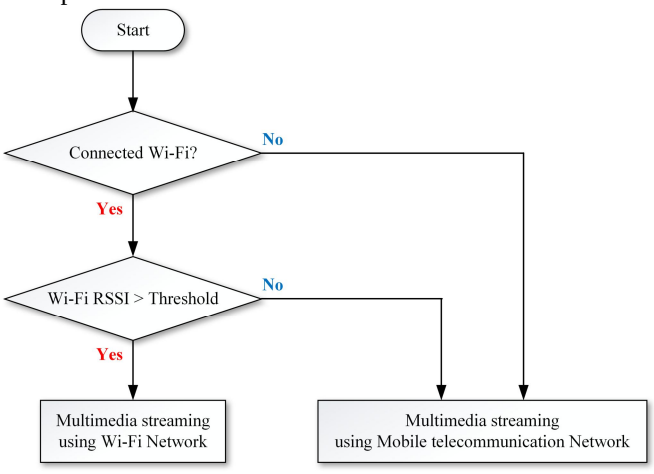

Figure 5: Flowchart of the proposed content delivery scheme based on network selection

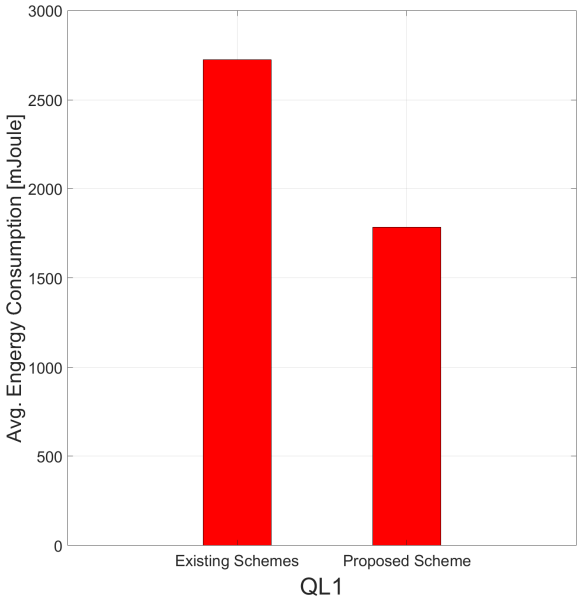

Figure 6: Average energy consumption in QL1 (Existing Scheme vs. Proposed Scheme)

Figure 6 shows the average energy consumption at quality level 1 (QL1). Quality level 1 is energy consumption in MPEG-4/H.264 video codec, multimedia streaming at 2,032 kbps, 960 x 544 resolution, 30 fps as shown in Table 1. The average energy consumption of the proposed scheme was 1,783 mJ and that of the existing scheme was 2,727 mJ. Therefore, it was confirmed that the proposed scheme was excellent by consuming less energy.

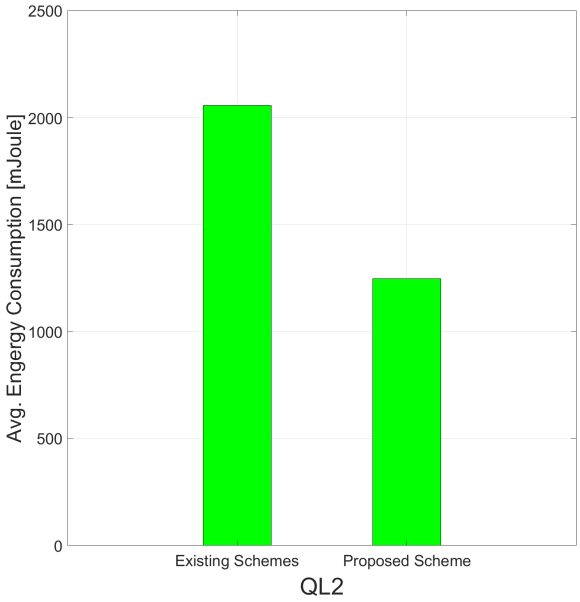

Figure 7: Average energy consumption in QL2 (Existing Scheme vs. Proposed Scheme)

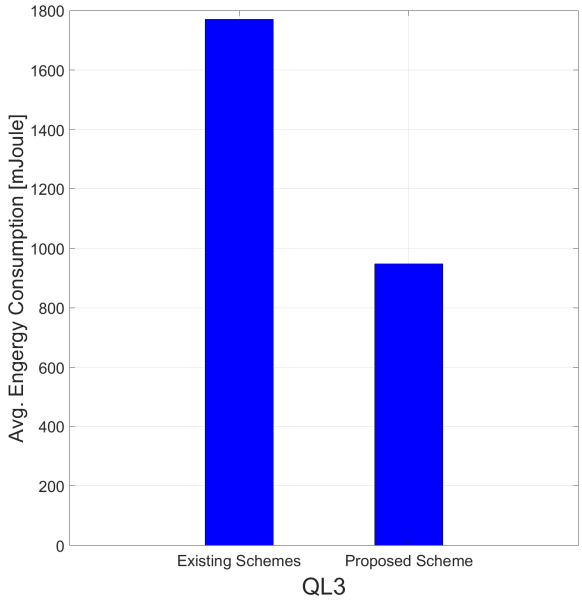

Figure 8: Average energy consumption in QL3 (Existing Scheme vs. Proposed Scheme)

Figure 7 shows the average energy consumption at quality level 2 (QL2). Quality level 2 is energy consumption in MPEG-4/H.264 video codec, multimedia streaming at 1,090 kbps, 592 x 366 resolution, 25 fps as shown in Table 1. The average energy consumption of the proposed scheme was 1,247 mJ and that of the existing scheme was 2,058 mJ. Therefore, it was confirmed that the proposed scheme was favorable by consuming less energy.

Figure 8 shows the average energy consumption at quality level 3 (QL3). Quality level 3 is energy consumption in MPEG-4/H.264 video codec, multimedia streaming at 615 kbps, 368 x 208 resolution, 20 fps as shown in Table 1. The average energy consumption of the proposed scheme was 948 mJ and that of the existing scheme was 1,771 mJ. Therefore, it was confirmed that the proposed scheme was more satisfactory by consuming less energy.

5. CONCLUSION

This study proposes content delivery scheme based on network selection for power saving. Power consumption is one of the important factors in mobile devices. However, Wi-Fi network consumes low power compared to mobile telecommunication network in general. The proposed scheme transmits the content data first when the Wi-Fi signal is strong. In this way, it can reduce the energy consumption of smartphone. Therefore, the proposed content delivery scheme is expected to be useful for providing content delivery services with low-power consumption.

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