Evaluate and Analysis Multimedia Traffic with QoS-Based Multiple Access Protocol for Wireless Communication

Hong Yu and Elijah Perron

Abstract — In the past decade, billions of devices and smartphones as terminals have been connected and managed by the wireless networks. Multimedia traffics in high performance wireless network utilities work on QoS-base multiple access protocols, specifically in 5G wireless networks or Industry 4.0. These protocols can enhance utility and effectiveness by increasing throughput, reducing delay, and lessening the loss ratio while the terminals communicate with other terminals in the wireless networks. In this paper, we will present a novel multiple-access protocol in the wireless network and evaluate and analyze the performances of multimedia traffic on the wireless network. Furthermore, administrators or IT regulators can use the protocol as an opportunity to create healthier network environments, which will definitely encourage continuing investment in wireless network and next-generation technology.

Keywords — Loss Ratio, Multimedia Traffic, Multiple Access, QoS Delay, Terminals, Throughput, Wireless Network.

I. INTRODUCTION

During the 1980s, the standardization of the second generation (2G) system known as the global system of mobile (GSM) communications was the first digital international mobile system. It rapidly spread across the globe in communication network. In the past decade, multiple access (MAC) technologies aimed at the division in time, frequency and code domains such as frequency-division multiple access (FDMA) in the first generation (1G), time-division multiple access (TDMA) in the second generation (2G) systems, code-division multiple access (CDMA) in the third generation (3G) systems, and orthogonal frequency division multiple access (OFDMA) in 4G systems [1].

Recently, technologies that are more intelligent have been used to interconnect the entire world through the networks and the terminal devices, especially with 5G technologies and smartphones. These technologies are designed to provide incredible and remarkable data capabilities, unhindered call volumes, multiple accesses and immeasurable multimedia broadcasting within the latest mobile operating system. Wireless network or 5G wireless network with text, voice, imagine and multimedia data focus on high carrier frequencies with massive bandwidths, extreme base station and device densities and unprecedented numbers of antennas as well. For example, unhuman driving acquires real-time traffic information with minimum delay with GPS systems on the 5G wireless network [2], [3].

Fig. 1 shows the multiple accesses in the terminal of wireless network. $S_1, S_2, (\ldots), S_{N-1}, S_N$ stands for the multiple sources such as text, imagine voice and broadcasted multimedia. These terminal applications of wireless network adapter open the transport protocol as the specific streams and distribute to the upper network layer and lower network after applying the multiple access modulation such as massive throughput advanced QoS-based user-centric aggregation (MassiveAQUA). The quality-of-service (QoS) services all data sequentially in priority traffic for wireless multiple access layers. The modulation signals will be transmitted to the servers of the wireless networks by the physical hardware with Radio Access Technologies (RATs) which can communicate with the physical interfaces.

For the next generation of wireless networks or 5G wireless networks, it requires huge capacity, high-speed data rates and extra numbers of users to interconnect servers. Meanwhile, all data exchanged in wireless networks requires more efficient use of the frequency spectrum. Currently, orthogonal division multiple access (OFDM) is a significant performance method in 4G technology [4]. However, the existing 4G technology has many limitations to adapt to 5G wireless network specifications such as speed, latency, OFDM encoding, bandwidth, and reliability.

Fig. 1. The system model of wireless network terminals.
An essential concern in 5G wireless networks is the accessibility, such as massive multiple input, multiple output (MIMO). For example, there are more ad-hoc devices to interconnect wireless network called internet of things (IoT) under industry 4.0. Therefore, the researchers focus on innovative modulation for multiple accesses such as Filter Bank Multi-Carrier with Quadrature Amplitude Modulation (FBMC/QAM) and Filter Bank Multi-Carrier with Offset Quadrature Amplitude Modulation (FBMC/OQAM).

In this paper, we will illustrate a protocol for the terminals of the wireless network and implement it on a testbed with the servers and terminals. The rest of this paper is organized as follows: Section II is on surveying the latest multiple accesses in wireless networks. Section III illustrates a developed protocol with a wireless network testbed. Section VI is the protocol algorithm evaluation and analysis, and conclusions are given in Section V.

II. SURVEYING THE MULTIPLE ACCESS IN WIRELESS NETWORK

In the previous brief of wireless network terminal architecture, each source S(t) will be processed by transport protocol and network lay processing (NLP) in the upper network layer and the network layer before the queue, Q(t), accesses the entire wireless network architecture, specifically the 5G wireless network. A survey of the latest multiple access technologies with QoS-based sources illustrates the following.

A. MassiveAQUA Algorithm

Massive Throughput Advanced QoS-based User-centric Aggregation (MassiveAQUA) is used to adapt QoS modules with advanced QoS user-centric network aggregation algorithms. It is defined as an independent algorithm to the wireless network and mobile terminal technologies. It works with Lyapunov drift plus-penalty optimization for packet optimal scheduling in a wireless network with the multiple Radio Access Technology (RAT) interfaces [2]. It is supposed to achieve queue stability and simultaneously minimize queue delays, consequently having minimal overall end-to-end delay. When the queue vector that is reached using (1),

$$S(t) = [Q(t), Z(t), U(t)]$$ (1)

is applied to Lyapunov function, we get (2).

$$L(S(t)) = \frac{1}{2} \sum_{i=1}^{M} [Q_i^2(t) + Z_i^2(t) + U_i^2(t)]$$ (2)

where,

$Z_i(t)$ --- the virtual queues to the upper layer network

$U_i(t)$ --- the virtual queues to the lower layer network

$Q_i(t)$ --- the actual queues to the access interface

Lyapunov drift is defined as (3).

$$\Delta(S(t)) = E[L(S(t + 1)) - L(S(t))|S(t)]$$ (3)

Lyapunov drift-plus-penalty expression is defined as (4).

$$\Delta(S(t)) + V_1 \cdot E[u(x(t), \alpha_{NL}(t), t)|S(t)] + V_2 \cdot E[g(p(t), d(t), \alpha_{NL}(t), t)|S(t)]$$ (4)

where,

$V_1, V_2$ --- fixed positive penalty control parameters.

Therefore, the MassiveAQUA algorithm is supposed to optimize some problems such as less or equal to the time average of the maximal output servicing rate, stable rate, control policy action and maximal throughput.

B. OMA vs NOMA

Orthogonal Multiple Access (OMA) technology allocates multiple users in time-domain, frequency-domain and code-domain. 1G technology (FDMA), 2G technology (TDMA), 3G technology (CDMA) and 4G technology (OFDMA) have been categorized for OMA access technology in wireless network communication systems. However, the available orthogonal resources with OMA technology applications limit the accessibility users.

Non-orthogonal Multiple Access (NOMA) technology in 5G wireless network is to increase NOMA resources allocation among the users at the receiver complexity solutions [3], [5]. The access development is shown in the following Fig. 2.

Currently, NOMA techniques can be primarily classified into power-domain NOMA and code-domain NOMA. The power-domain NOMA ensures the users can be served in given time slot/frequency resource block (RB) in the wireless network or 5G wireless network. When the power-domain NOMA technique applies to multiple access in wireless networks, the superposition coding (SC) technique assists to the transmitter and the successive interference cancellation (SIC) technique assists the receiver at the same time. It is fundamentally different from the classic OMA techniques of FDMA, TDMA, CDMA and OFDMA [3], [5].

Fig. 2 the multiple access development tracking map.

According to the perspective of information theory, the capacity of multiple access channels in additive white Gaussian noise (AWGN) and fading scenarios, the uplink of an AWGN stream is (5).

$$\Sigma_{i=1}^{K} R_i \leq W \log(1 + \gamma \frac{P_i}{N_0 W})$$ (5)
where,
K --- the multiple users
W --- the bandwidth
Pi --- the transmitted power
\( N_0 \) --- the power spectral density of Gaussian noise.

The downlink of an AWGT stream is (6).

\[
R_k = W \log \left( 1 + \frac{P_k |h_k|^2}{N_0 W + (\sum_{k+1}^K P_l |h_l|^2)} \right) 
\]  

(6)

This is valid for all possible splits \( \sum_{k=1}^K P(k) \) of the total power at base station (BS), \( h \) denotes the channel gain between the BS and the \( i_k \) user and \( p_i \) is the power-scaling coefficient.

In fading channels, the channel state information (CSI) is only measured at the receiver since each user has the same average power \( P_{ave} \) at the transmitter. (7) shows the total cost measurement at the receiver.

\[
C_{sum} = E \left\{ \log \left( 1 + \frac{\sum_k P_k |h_k|^2 P_{ave}}{N_0} \right) \right\} 
\]  

(7)

For code-domain NOMA techniques, single carrier NOMA (SC-NOMA) and multiple carriers NOMA (MC-NOMA) in wireless communication have required massive bandwidth and data multiplexing in the domain. IDMA, LPMA and LDS-CDMA technologies of SC-NOMA focus on increasing channel diversity, latticing consolidation codes and creating a codebook. On the other hand, LDS-OFDM, SCMA, PDMA and BOMA technologies of MC-NOMA aim at the diversified-carrier environment, connectivity rate, the maintaining array of clients, and efficiency [6].

C. NOMA with Beamforming and NOMA with Spatial Multiplexing

In principle, the next-generation wireless system is expected to server the number of emerging use cases categorized into the different functions for increasing spectral efficiency, transferring data with low latency and high reliability, specifically catering to large number of low-data, low-cost devices in combination of NOMA and multiple-input multiple-output (MIMO) technologies [7].

In practice, base-stations (BS) and receivers are equipped with multiple antennas. NOMA with beamforming (NOMA-BF) exploits the power domain for transmission to increase signal-to-noise (SNR) ratio or for spatial multiplexing to increase the throughput [8]. The two-stage beamforming approach is proposed by using the notion of multicast beamforming in Fig. 3.

On the other hand, NOMA with spatial multiplexing (NOMA-SM) is to increase the spatial multiplexing gain by using multiple antennas as well. Fig. 4 shows the block sources/time slot usable rate of OMA with TDMA and NOMA with spatial multiplexing [8].

These surveys have described the fundamental concept and potential benefits of NOMA protocol. MIMO-NOMA wireless networks have exceptional potential of supporting massive connectivity and the low latency that is essential to the upcoming the next generation network. Furthermore, it highlights the NOMA-related issues along with some potential future research directions [9].

III. THE ARCHITECTURE OF A PROTOCOL

A. A Wireless Network Testbed with the Protocol

Wireless networks or 5G technology have to face many security challenges since wireless networks will encompass connected devices, sensors and self-driving cars beyond our current experience of tablet and smartphone connectivity with multimedia services. The security of wireless networks mainly involves authentication, confidentiality, integrity and authorization for access to network connectivity in massive input massive output [10]. Massive traffic with authorization for access to the network will create congestion that will result in a collapse of the wireless network. Currently, many TCP versions for the protocol utilized in high-speed wireless environments with the congestion control mechanism create or redesign such as TCP Ohrid or HSTCP protocol [11]. There is a need of an ultra-fast protocol to assure data transfers more efficiently than the traditional protocols and evaluate the performance by the well-known characteristics such as throughput with QoS, respectively offered by cloud-based services.

In this paper, a protocol will be developed. The basic idea is to use a standard cell for network level functions, while adding a specific protocol sublayer for multiple access wireless networks due to the inherent nature of radio communication. The protocol will deploy to a wireless network testbed with some base servers and mobiles. After simulating the wireless network with the protocol in the different channel state information (CSI), it will be evaluated by the time delay, the throughput and the loss ratio. Fig. 5 shows a diagram of the wireless network testbed with various data sources.
B. The Source Service Categories

When terminals or clients generate data or multimedia sources and communicate with other terminals or servers, the operation of wireless networks can be divided into a number of functions. Therefore, all sources will be classified by their different characteristics. In this paper, Voice is sorted by constant bit rate (CBR). Data is sorted by available bit rate (ABR), and Ftp is sorted by the non-real time available bit rate (nrt-VBR). Video is sorted by real time available bit rate (rt-VBR). Email is sorted by unspecified bit rate (UBR). Meanwhile, it is expected to support Quality of Service (QoS) based on service for fixed and mobile wireless users.

C. The Weighted Fair Queuing

Since mobile phones have short buffer space, some of the traffic may be lost due to buffer overflow in high-speed networks. Weighted Fair Queuing may help. Fig. 6 shows the processing queuing model of a cell. The queuing will be weighted in fair queuing.

There are various QoS requirements due to the data or multimedia properties in wireless networks. These QoS requirements involve the specifications of the data and QoS mechanisms that realize desired QoS behavior. QoS refers to the capability of network traffic over multiple access technologies. The classified QoS requirements can help alleviate most congestion or high-traffic problems.

D. The Algorithm of the Multiple Access Protocol for Mobile

Wireless communication is to transfer the information expressed in a variety of media such as Voice, Video conference, Ftp, Data and Email. Any QoS generated by the stations of mobiles force strict time-to-live performance requirements in the source type server priority. Fig. 7 shows a multiple access protocol for handling full complement multiple media signals. Fig. 8 shows the traffic packet process function of the protocol in mobile.

In the flow charts, a number of nodes with the different type of traffic time-to-live (TTL), priority and weighted fair queuing have been assumed in the wireless network. When the classified sources access the buffers of the stations, the mechanism switches and routes the source data and adapts it to the MAC queuing stream for QoS requirement.
F. Channel State Information (CSI) for QoS Requirement

The objectives of the flow of bit streams or queuing streams are to maximize throughput for a source-destination pair, and to minimize congestion on the network. The throughput from the sources to the destinations will be affected by the channel utilization factor and the channel state information (CSI). The channel utilization factor ($\rho$) is defined as the link capacity usage. And the flow bit error ratio stands for the CSI status in scale. When the flow bit error ratio (BER) is different, the throughput will be changed if the source nodes and destination nodes are the same. Moreover, the protocol will increase the throughput and reduce the most congestion or high traffic in wireless networks. The throughput is the fraction of the channel capacity used for data transmission. If the average message size is $P$ bits, the average time to transfer a single packet is $T$ secs, and $C$ bit/s is the capacity of the channel, then the throughput $\eta$ is given by $\eta = \frac{P}{TC}$.

IV. EVALUATION AND ANALYSIS

In this paper, OPNET network simulator simulates a testbed, which consists of a base station, several mobiles and source generation stations. The performances are evaluated by the specified QoS requirements in various operational conditions. The channel state information (CSI) includes the channel utilization factor ($\rho$) and flow bit error ratio (BER). For the project, the channel utilization factor has been set as a constant ($\rho=0.259$). The flow bit error ratio (BER) has been set at BER=1E-06 and BER=1E-12. The throughput, namely metric, will be obtained and compared with the different priority, TTL and CSI. Fig. 9 shows the throughput with the CSI status ($\rho=0.259$ & BER=1E-06). Fig. 10 shows the throughput with the CSI status ($\rho=0.259$ & BER=1E-12).

In Fig. 9, it illustrates the throughputs of the stations in different cases with specific CSI ($\rho=0.259$ & BER=1E-06). Trace 1: it indicates the throughput in the same priority and same time-to-live (TTL). Trace 2: it indicates the throughput in the different priority and same TTL. Trace 3: it indicates the throughput in the same priority and different TTL. Trace 4: it indicates the different priority and different TTL.

![Diagram](Image)

**Fig. 7.** The protocol at the mobiles for handling request to transmit from different types of sources.

**Fig. 8.** The traffic packet process function at the mobiles.

E. The Cell Transfer Latency QoS Requirement

The latency is defined in the network environment such as propagation, queue routing times and so on. It is defined as the average time spent by a packet in the MAC queue from the instant it is received until its transmission is complete. It is a function of protocol and traffic characteristics. Therefore, when comparing protocols, it is necessary to compare them based on the same traffic parameters. Typically, the queue is an approximation for the behavior of individual links for networks involving Poisson arrivals at entry points, a densely connected network and Moderate-to-heavy traffic loads. In particular, the technology mapping end-to-end QoS requirement directly into link rate is presented.

![Diagram](Image)

**Fig. 9.** The throughput with $\rho=0.259$ & BER=1E-06.
However, it may deal with the various type sources on a dynamic basis with queues. The data loaded in the buffer increases the throughputs and security.

The congestion of wireless network or 5G wireless network such as MIMO, or packet forum for each service and requirements certain probability distribution and priority and TTL. Trace 3: it indicates the different throughputs of different cases with specific CSI ($\rho=0.259$ & BER=$1E^{-4}$).

In Fig. 10, it illustrates the throughputs of the stations in different cases with specific CSI ($\rho=0.259$ & BER=$1E^{-12}$). Trace 1: it indicates the throughputs of the stations in the same priority and same TTL. Trace 2: it indicates the different priority and same TTL. Trace 3: it indicates the different priority and TTL.

According to the comparison of the throughputs of Fig. 9 and Fig. 10, the throughput increases in wireless networks.

V. CONCLUSION AND FUTURE WORKS

In wireless network, the sources are active or inactive with certain probability distribution according to the QoS requirements. And QoS requirements need to be guaranteed for each service and transmit the various type sources in cells or packet forum. The protocol, which has been designed for MIMO, is able to reduce and dynamically manage the congestion of wireless network or 5G wireless network such as increasing the throughputs and security. The input load traffic to the stations may change dynamically because the data loaded in the buffer of the station is overflowing. To ensure the optimal utilization of data traffic need to allocate the various type sources on a dynamic basis with queues. Meanwhile, the various type sources should be sorted in priority for efficient process in wireless network.

As a future work, the best protected data transmission is encryption with authentication over wireless networks. However, it may delay the data transmission and lose some data with the authorities. The continued research and analysis will focus on the latency and loss data ratio on the protocol.

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Hong Yu received the Bachelor degree in Electrical Engineering in 1989, M.S. degree in Electrical Engineering from the Catholic University of America in 2000 and his Ph.D. degree in Electrical Engineering from the Catholic University of America in 2008. Currently, he is an assistant professor of Engineering Technology Department at Fitchburg State University. His teaching and research areas of interest include wireless network communication protocol, VLSI design and simulation, optical switching application, EEG discrete wavelet classification at minimum free energy operated, Smartphones, UAVs for Earthquake newscast, and renewable energy development. He is an IEEE senior member.

Elijah Perron is a senior student. He is majoring in Electronic Engineering Technology in the department of Engineering Technology at Fitchburg State University, USA. He is an IEEE student member.