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# An Overview of High Speed Streaming in 5G

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***Abstract*—The fifth generation of mobile communications (5G) provides advanced features which were not witnessed ever before. Its data rates, end to end latency, and several other performance parameters are absolutely exemplary. Extremely high data rates and low latency are very much suitable for applications related to multimedia communication. In fact, multimedia streaming is a priority area for 5G. The main requirements of multimedia streaming are fulfilled by 5G technologies. In this article, we analyze 5G features for highspeed streaming. Real-time streaming was not a popular application over mobile platforms in the previous mobile generations. However, these streaming related issues will be resolved in 5G. We go through the modern day streaming requirements and their infrastructure. The high bandwidths required in the core network of the 5G will be provided by the fast networking facilities of optical networks. In the access part MIMO and large constellation for modulation will serve the high speed streaming requirements. In this article, we logically correlate the advanced 5G features with high-speed streaming requirements.**

***Keywords—5G, streaming, streaming in 5G, high speed streaming, real-time streaming***

## I. INTRODUCTION

The fifth generation of mobile communications (5G) is a complete paradigm shift in the wireless communication arena. It brings many advanced features in the wireless domain which were not witnessed ever before [1]. The main focus of 5G is to provide large data rates with very small end to end latency between devices which can do many miracles in the practical world [1]. 5G is going to be the main tool for the future data deluge for the next decade. It is anticipated by Cisco that by 2021 the count of mobile devices will reach 11.6 billion, which will increase the data traffic by more than 1 zettabyte [2]. The video traffic is directly linked with the growth of mobile users is the main reason for the resource consumption in 5G networks. The video data traffic has three main aspects such as: more number of videos in the streaming, longer viewing time, and an evolution to higher resolutions and complex formats. Rapid evolution in telecommunication technologies from 2G to 3G, then 3G to the 4G, and in the last few years from 4G to 4.5G has increased the demand of bandwidth [3]. However, high bandwidth alone is not sufficient for effective and meaningful streaming. High speed streaming needs very low latency and even lower jitter. There are several initiatives in LTE, LTE-Advanced (4G), and LTE- Advanced Pro (4.5G) for efficient streaming over the wireless cellular networks which offer reduced delay and enhanced network capacity. However, the ubiquitous availability of wireless access to the high definition streams is not very flexible over these platforms. Though the peak user end data rates have been increased from 64 kbps to 100Mbps in 3G to 4.5G respectively, the streaming requirements are still not been fulfilled. Therefore in the 5G initiatives, these streaming related aspects are being seriously considered [4]. The new initiatives in 5G in this regard include: the cloud based storage, device to device communications, and softwarization of 5G networks [5]. It will make them more flexible to meet all the requirements for high speed streaming. In addition to the above, it is also expected that 5G will provide better connectivity, scalability, and energy efficiency to the network [1],[6].

Streaming is the term used to describe high volume, high frequency and low latency data processing for driving some end devices. It is expected that in the future “networked society” distant controlled operation of gadgets and machines over a reliable 5G network will be feasible with zero delay [6],[7]. The Internet of things (IoT) is one of the examples of real-time remote and proximity task execution using sensors and other controllable devices. In these types of networks, latency has a significant effect. End to end latency can be estimated by considering the processing speeds of all the intermediate nodes when data streams pass through them. Along with the throughput which is the actual data transfer, other parameters such as the inter-channel interference, jitter, scalability, connectivity, energy efficiency, and compatibility with existing networks, are also the main contributing elements while analyzing high speed streaming in 5G. It is further emphasized that it will be challenging for service providers to provide high quality of experience (QoE) to the end users [10]. Software defined networking schemes such as network slicing and segregation of traffic are essential for high speed streaming. 5G will have a software defined traffic management and network slicing will be used for different types of traffic [20].

The demand for multimedia devices has increased beyond the existing infrastructural facilities available in last few years. Optical fiber communication provides multi-gigabit-per-second data rates in the access networks. Thus, optical fibers are the right choice for the 5G backhaul, front haul and even the connections between the gNBs (the 5G base stations) and the small cells. It is noteworthy that deployment of optical fiber cable is a costly deal. Therefore, the fiber connections till the small cells can be provided in the urban areas where the revenue generation potentials are very high. For the rural areas, wireless links provide a cost- effective fiber alternative to connect the zones beyond the reach of the fiber network [8]. Unequal geographical and temporal imbalance of spectrum usage for bandwidth- hungry mobile applications, such as ultra-high definition video, video streaming with high definition television have motivated millimeter waves (mm waves) communications as a favorable technology to soothe the pressure of scarce spectrum resources for fifth generation (5G) mobile broadband [10]. These mm-wave frequencies can be used to enlarge the currently saturated 700 MHz to 2.6 GHz radio spectrum bands for wireless communications [11]. This will also allow fiber replacement with mm-wave mobile backhauls. Mm-waves frequencies around the 27GHz and the 71 GHz bands have much larger bandwidths which can beused for 5G communication purposes. Apart from that, the hardware technologies have also been developed which work well in the mm-wave frequency bands. High gain steerable antennas at the mobile and base station, improves the performance of mm-wave wireless communications [13], [14]. Since mm wave allows larger bandwidth allocations, it provides higher data transfer rates which is key requirement for high streaming. In this scenario the latency for digital traffic is greatly decreased, which provides much better internet-based access and applications that require minimal latency. Mobile video streaming in mm-wave 5G networks faces basic challenges due to high user mobility and mm-wave antenna directivity. Since mm wave support small diameter cells, users typically have short connection durations and frequent handoffs, which causes video streaming suffer from connection latency and long handoff delays[13].

Mm-wave frequencies require new spatial processing techniques, such as massive MIMO and adaptive beamforming due to the much smaller wavelength [10], [13]. This significant jump in bandwidth and new capabilities offered by mm-waves would be able to support future video streaming with high performance support for D2D communications in 5G networks where UE can send/receive data to/from a BS with the help of another UE even when it is not within the coverage of the BS. Despite the many studies in D2D video communications [14],[15],these aspects required to provide the requesters with high performance video streaming that simultaneously satisfy high quality of experience (QoE). High speed streaming requires following features: 1) on time arrival of received video segments, 2) to get high quality playback

high peak signal-to-noise rate (PSNR), 3) real-time storage facilities, and 4) low quality fluctuation in received segments to ensure trouble free playback [10], [11]. Maintaining the quality of service (QoS) while fulfilling all the required parameters for high speed streaming is one of the challenging tasks. In fact, it has been observed from the streaming experiences that the QoE is more important than the QoS provisioning. While QoS deals with the exact data recovery, QoE provides the practical data perception aspects at the end devices. Therefore, the user experience and perception is directly associated with the QoE. If the QoE is improved without significant changes in the QoS, the end users normally get better services. However, it is noteworthy that in 5G both the QoS and QoE improvement schemes have been proposed for overall quality assurance [17].

Software defined networking (SDN) is one of the advanced features of 5G which is normally implemented through network function virtualization. It will facilitate the network slicing (NS) in the 5G channels. NS is essential for high speed streaming. It allocated prioritized higher bandwidths for streaming in the network’s core and access areas. In [14], the basic SDN framework for optical networks has been presented. These techniques are useful for the 5G core networks. In [15], SDN techniques for 5G have been presented. It shows the resource allocation, management and sharing required in the 5G environment. In addition to these, SDN provides the logical segregation of the network functions into three vertical planes: data plane, control plane, and management plane. This segregation is essential for the control and management of the network.

In this article, we present the main issues of high speed streaming. We show how 5G provides a better platform for multipurpose multimedia streaming. We show the main features of 5G for high speed streaming.

The reminder of this article is organized as follows. In Section II, we present the basic features of 5G which are pivotal for high speed streaming. In Section III, we present the basic principles of high speed streaming. In Section IV, we present the 5G streaming environment. In Section V, we conclude the article with the main points.

## II. BASICS OF5G

5G is an ultra-advanced fifth generation cellular mobile technology which is going to change the social fabrics and the business landscapes to a large extent. 5G will have many advanced features compared to 4G and 4.5G [3]. In fact, 5G technologies will have access to several new resources such as the mm waves. Thus 5G will operate at extremely high carrier frequencies and its antennas will have several new features. The target of 5G is also to achieve very high data rates with average data rate of 3 Gb/s which is very much suitable for streaming. Right now, the main attention in 5G researches are to reduce the costs in its deployment, latency, power consumption, and complexities involved in the design of 5G wireless networks and components. Some of the recent trends in the wireless communications such as the proliferation of IoT, its associated technologies, and device to device communication are going to be the parts of 5G [1]. 5G in the access part is basically involved with the use of mm wave antenna arrays or massive MIMO antennas. Design and deployment of mm wave antennas for 5G is very challenging. It will be supported by appropriate beam forming technologies which use sophisticated signal processing techniques. As the fading of the mm waves is very fast, small cells are the right choice for the access areas. Due to small sized cells, 5G offers huge densities of devices and sensors around every gNBs. In 5G, existing spectrum can be redistributed and the new spectrum can be added to accommodate the huge traffic [2]. 5G networks are going to be denser and more heterogeneous to get the benefit from the improvement of spatial reuse. The spectral efficiency of 5G can be enhanced by using advanced modulation techniques and the massive MIMO systems.

### *A. Main features of 5G*

As described in this section, 5G will have several new features for the very first time. Some of the main specifications and features of 5G are presented in Table II. Here, we explain these features briefly.

#### *1) Very high data rates*

In 5G, a peak data rate of 20 Gb/s is set for line of sight conditions. Average speed of 3Gb/s is set for static conditions [4]. A lower limit of 100 Mbps is set for high speed mobile applications.

#### *2) Latency*

A round trip latency is expected to be less than 1 ms. This is required to support different applications of 5G such as high speed real time streaming, virtual reality, fast IoT, and mission critical applications.

#### *3) Number of interconnected devices*

The device densities are going to be very high in 5G. The device to device communication would further increase this number by at least 10 times.

#### *4) Longevity of battery*

Battery life can be significantly increased by intelligent selection of waveforms and switching techniques. A minimum of 100 times reduction in power consumption is required to support 5G low power applications.

#### *5) Spectral efficiency*

The ratio of the bit rate (in bits/s) to the used bandwidth (i.e., frequency in Hz) is known as spectral efficiency. It is the number of bits/s carried by a single Hz. 5G is going to have increased spectral efficiency up to 4.5. This is a very big achievement in the wireless domain.

### *B. Optical Wireless hybrid nature of 5G*

The huge bandwidth advantages of optical fibres along with high energy efficiency. These two attributes are comparable with the 5G applications. The existing passive optical network (PON) can be used for setting up 5G fronthaul network of cellular mobile communication. This adds cost advantage as the existing PON comes at low cost. This method supports software defined network (SDN) for a dynamic architecture. In dynamic architecture the data plane and the control plane are decoupled to add flexibility in control and maintenance.

### *C. Utilities of massive MIMO*

Wavelength Division Multiplexing (WDM) in the optical networks has attracted the use of optical networks with 5G. With this hybrid nature of 5G it is possible to implement massive MIMO in dense cellular traffic. Low tendency feature of optical networks for end-to-end communication is one of the very important requirements for 5G front haul networks [15]. Massive MIMO systems in 5G require huge number of optical transceivers. This is a strong need for cost effective, low power consuming optical transceivers. These optical receivers can be implemented using DSP techniques and optical fibers.

## III. PRINCIPLES OF STREAMING

These days, streaming is a basic requirement for all the Internet and mobile users. The contents over different electronic platforms are delivered using the principles of digital streaming. Now, it is very popular and the streaming economy has a significant share in the digital economy. Streaming of digital contents is generally the provisioning or sending of the stored contents to the remote users when demanded. Streaming media became popular due to the advances in the digital technologies. After the arrival of the Internet, streaming became the main technique for delivering the video, audio, multimedia, and other entertainment related digital contents.

### *A. Streaming and Downloading*

It is worth an explanation that streaming is not the general digital delivery of digital contents. It is the continuous flow of digital contents along with its final execution at the receiving end without a significant delay. Meaning, you request a remote fine through your electronic/ computing interface and the contents are executed as they arrive at your interface. However, if the contents are transferred to your system and get stored in the storing facilities in your device, then it is not streaming. It is normally known as download. Therefore, the data files such as books, eBooks, journals, documents, and several other types of non-multimedia contents are downloaded not streamed. Download is a process of transferring a file from a remote location of the user's specified location. That is why the multimedia contents can be either downloaded or streamed. If you want to watch it when you request it from the remote location, then streaming is the right option. However, if you want to store it in your system and want to reuse it time and again without requesting the remote host to resend it, then downloading is the right option.

### *B. Basic Requirements for Streaming*

Streaming has its own requirements. It is not possible over all the electronic platforms. First of all, the host and client must be connected directly through some digital medium/ media. It can be wired or wireless depending on the situation. For every type of digital content, there is a minimum bandwidth requirement to provide the digital streaming uninterruptedly. The end to end latency between the client and the host has to be within a specific limit. The caching facilities at the client end have to be really good to accommodate the incoming digital streams without much processing delay. The file readability at the client end is a mandatory requirement. Meaning the incoming streams must be readable on the client devices/ interfaces. These days, all the commonly used digital platforms provide all these basic facilities for digital streaming. We address these issues in the following subsection.

### *C. Basic Infrastructure for Streaming*

The basic infrastructural requirements of streaming are: a minimum bandwidth between the host and the client; appropriate infrastructure for a very small end to end latency; high performance server at the host end; compatible digital platform which includes appropriate hardware, software and middleware; and finally the power supply at both the host and client ends to carry on the digital streaming. In general, the basic problems in the streaming process arise mainly from two fronts: limited bandwidth and higher latency. The bandwidth become very limited during the peak traffic hours and thus it is not possible to provide enough bandwidth to each end user as they demand. Low bandwidth scenarios are very common over the wireless connections. That becomes even worse in the wireless mobile conditions. Similarly, latency can be higher in the areas where the infrastructure is poor and underdeveloped.

During the high traffic conditions, congestion increases and overall end to end delay is increased significantly.

### *D. Streaming in the Internet Era*

Streaming has become a normal daily activity for the people these days. People use it for both real time streaming (also known as live streaming) and multimedia transfer which is normally non-real time. The real time streaming is used in the important activities such as video conferencing and telemedicine applications. People also use the services such as Skype, Viber and several other video messaging services. These services may not be real-time but still the qualities of these services are very much acceptable. Digital streaming has created a special place for itself in the digital economy. Several premium services are available these days such as Netflix and Amazon Video. Free services such as YouTube, Daily Motion and Mixer are very popular across the world. The premium Internet Protocol television (IPTV) services are completely streaming solutions. It is expected that in the next decade almost all the television services will be streaming based whether it is live or delayed broadcasting.

## IV. STREAMING IN 5G

In 5G cellular communication several new trends have been proposed. Its main specifications have been presented in section II. The proposed average data rate in 5G is much higher than the 4.5G (i.e., LTE advanced pro). The spectrum for 5G is different from its legacy systems. Right now, there are two main options for 5G spectrum. One is the sub 6 GHz bands, and the other is the mm wave bands starting from 27 GHz up to 75 GHz. The bandwidth available in the latter option is really high. However, the mm wave bands would be deployed in small cells. The larger coverage per 5G base station (gNB) is possible in the sub 6 GHz bands. The spectral efficiency is also proposed to be 4.5 bits/Hz. This is really high from the wireless communication perspectives. The end to end latency will be very close to 1ms. This is really exemplary from the cellular communication points of views. These three improvements in 5G in bandwidth, spectral efficiency and latency are crucial for the future streaming. In fact, the Internet access over the mobile phones or the mobile Internet is growing very fast. Almost all the smart phone users use some kind of streaming. Therefore, mobile Internet is going to be the main platform for streaming.

### *A. High Bandwidth for Streaming*

Digital streaming demands high bandwidths. Therefore, optical networks are perfect for high speed streaming which provide very high bandwidths in both the core and passive optical networks (PONs). In 5G, the whole core network is optical, and it will use the fast switching technologies. In case of the urban deployment of small cells, optical fibers can be stretched all the way till the small cells. High bandwidths coupled with the high spectral efficiency would utilize each Hz very efficiently. Therefore, 5G is very much tailor made for high speed streaming as the bandwidth constraints will no more be the limitations for busty traffic of digital streams.

### *B. Lower Latency*

Latency is the main difficulty for real-time streaming. The streaming traffic is normally very busty and the traditional networks get congested when they handle the busty traffic. This is one of the main reasons behind the high latency for streaming traffic. However, the significant reduction in latency in 5G is very much promising for the real-time digital streams. The end to end latency will be reduced to 1 ms. This is very much encouraging for the high speed busty streams. Real-time streams are very much reliable with such a small latency.

### *C. Massive MIMO and Beamforming*

MIMO is an essential part of modern wireless communications. It provides several advantages such as the spatial diversity, noise reduction, interference cancelation, increased spectral efficiency, and higher channel capacity. All these benefits of MIMO are harnessed through appropriate signal processing techniques. These efficient techniques are collectively known as beamforming. 5G will have massive MIMO, meaning the number of antennas at the transmitters and the receivers will be much higher than the normal MIMO. For instance, 4G uses 2×2 MIMO in its transceivers. However, in massive MIMO of 5G there will be 64×64 or even higher order antenna configurations. These facilities would do wonders for all the benefits offered by MIMO. Beamforming techniques are also improved to track the targeted receivers. This is really magical for the high speed streaming applications.

### *D. Advanced Caching Techniques*

Streaming needs advanced caching techniques. The traditional caching techniques are not suitable for the high speed digital streams as it takes a very long time for its processing and execution. For high speed digital streams, equally fast matching caching techniques are essential. In 5G several advanced caching initiatives have been proposed. One of them is the content centric caching which is provided over the content centric networking facilities [18]. This is found to be very promising for the high speed streaming.

Even the real-time streaming can be provided quite easily in this framework.

### E. Multiple Cloud Storage

Cloud is now an essential part of every data network. Clod provides storage, retrieval and processing facilities which are essential for the hosts and clients. In 5G, multiple distributed cloud facilities have been proposed. This is very much essential for high speed streaming [17]. In fact, in the cloud RAN initiatives, every radio access network will be provided with a cloud which can handle the local streaming demands. These local distributed clouds reduce the load from the central servers. They store the high demand contents in their local facilities and provide them to the clients whenever it is asked for.

### F. Software Defined Networking

Software defined networking provides better network management and flexibility of resource allocations [21]. In 5G network slicing will be an integral part of bandwidth management [20]. It will segregate different traffic classes using segregation techniques. Network slicing will put all the streaming traffic in one slice of the band at the main switching points. This will be quite flexible for streaming traffic management.

## V. Conclusions

Multimedia streaming in 5G will be a game changer. Mainly, for the high resolution videos providing real time transmission 5G is the perfect choice. Two of the main expectations from 5G networks are delivery of good quality of experience (QoE) and ultra-high-definition (UHD) video streaming. In order to achieve the high speed streaming, data targets the network and application functions should be placed into the network edge. This will reduce the overall latency of the system. The low latency applications should also be able to manage the state between the application instances in different edge nodes.5G low latency network slice that offers 5G low latency services from the closest network edge node is one of the ways to achieve the target. Change in mobility management system can also help in achieving the goal by reducing the latency. This new method may include a gateway selection algorithm which should be topology aware, handover procedures that are able to switch the user plane as fast as possible and a seamless gateway relocation method. Further the improved efficiency will reduce operating expenses (OPEX) for mobile users, especially to deploy large scale video streaming services.

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