5G and Education

Document Revision History

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Introduction

Next generation of mobile technology, 5G, is envisaged to bring a "Networked Society", providing an unlimited access to information and data at anytime, anywhere by anyone and anything. 5G is expected to provide an order of magnitude improvement in the areas of latency, energy efficiency, accuracy of terminal location, reliability and availability, flexibility to accommodate future unseen applications, and creating an impression of "infinite" capacity. As a key enabler for Internet of Things (IoT), 5G will allow the connection of many more devices simultaneously and improve the terminal battery life. Lastly, capability of 5G in transferring human tactile communication over Internet, will be a key enabler for moving from today's content-based wireless communication towards steering and control communication, allowing us to have tactile communication through network. And of course, security and privacy will be cornerstones for 5G, helping its users manage their data, tune their exposure over the Internet and protect their privacy.

5G will be the catalyst for the transformation of the economy and connected society. Our future society and economy will strongly rely on its infrastructure which will cover the network needs and contribute to the digitalization of vertical markets such as education, automotive, banking, city management, utilities, finance, food and agriculture, media, government, healthcare, insurance, manufacturing, real estate, transportation and retail. Future network infrastructure, 5G, will become 'the' infrastructure, one that can be used for all sorts of different services. As the use cases for future 5G are so diverse, each one with different set of requirements and parameters in the network, each use case/business model could occupy its own network slice. The intention of a network slice is to provide only the traffic treatment that is necessary for the use case, and avoid all other unnecessary functionalities. This makes it possible to adopt the technology for each market more rapidly and efficiently. In order to have a clear view about each vertical market and reflect its needs and requirements into 5G specification and architecture, 5G has involved other vertical markets in its requirement gathering. However, it seems one of the most important ones, education, hasn't yet been included. The intention of this document is to highlight the role of 5G in enhancing education, extending our experience of learning and teaching far beyond what we have had over last decades.

Recent developments in mobile access technologies have provided the possibility of having higher availability of the rich digital resources beyond the physical confines of the classroom and in the hands of learners. However, unlimited access to information is only the steppingstone for ubiquitous learning and effective teaching and learning is still required. Advances in mobile technology, IoT and Tactile Internet, can open a new chapter in education. The future learning model will be an international, immediate, virtual, and interactive environment which enables learners to learn and interact in much different ways that we do today. The new model will be learner-centric, skill-centric, on-demand and personalised. It will improve student development in the areas of critical-thinking and collaborative learning. In order to reach this model embracing mobile technology seems indispensable. Applications such as Virtual Reality (VR) and Augmented Reality (AR) will play a big role in quality education and understanding-based learning. By combining Tactile Internet with VR and AR the learning experience will go far beyond today's one, bringing new definition to Tele-teaching, Tele-mentoring, virtual university, virtual classroom, virtual team-working, etc. New mobile technology and connected devices will give students the opportunity to learn with minimal intervention from teachers and mostly through exploration, discovery and peer coaching.

Potential education use cases

Some of possible use cases related to Connected Education can be listed as follows:

- **Tactile Internet & Skillset communication:** Having a network capable of transferring our tactile communication through Internet will help us to move from today's content and information delivery Internet to a manual skillset delivery Internet. This will create new ways of Tele-teaching and Tele-mentoring especially for manual training and skill development. The use of Tactile Internet in education can bring new definition and experience for distance learning and distance team-working. In order to have a natural haptic interaction of our limbs with video and audio feedback the response time of service should be very low, i.e., the round trip time of few milliseconds which can be only envisaged by 5G.
- **Virtual Reality & education:** While the initial use case for VR was the entertainment industry, it also has relevance in education and training, and will have a big role in providing quality education and improving understanding-based learning among students. By tailoring these services to education, (e.g. by, having virtual tours of the human body with the possibility of interacting with models and moving the different layers of the body), the learning process can be more fun and much more interesting. This also can bring new experiences for distance learning, enabling the virtual presence of students (e.g., located in suburban area) in the classroom. This type of service needs very high bandwidth (bi-directional) and very low latency (i.e., 2-4ms).
- **Augmented Reality & education:** Similar to the VR, AR has already started to show its relevance and usefulness in education. Providing the necessary information can make contextualised learning ubiquitous and pervasive. AR can be an efficient way of providing the right amount of information at the right time to the right audience. Also, immersive AR can enable new ways of learning and team working in education through services such as mobile cloud classroom and Virtual Presence. Enhancing the learning experience is not the only possible use case for AR. It can also help teachers to get necessary information about each student and be aware of their particular needs and capabilities. The requirements for implementing such services, including optimised routing, seamless wide-area coverage, virtual presence, low delay speech & video coding, need to be considered.
- **Walled-off classroom:** By combining Tactile Internet and VR, the future experience in teaching and learning could go far beyond today's experience. This can remove the physical location constraint for experimental practices, and facilitate and enable the sharing of resources between larger numbers of students irrespective of their current location. The impact would be more significant in hands-on-experience with expensive equipment and facilities.
- **Personalised learning:** Individual access to a mobile device holds the promise to connect each learner into intelligent personalised systems that can suggest learning pathways, enable aggregated analysis and through better data capture of learner experiences enable much better decision making about all aspects of a students' education. Categorising students in different groups and suggesting different multi-media contents can increase the load on the network. However, in-network caching technologies such as Content Centric Networks (CCN) and Information Centric Networks (ICN) can be used to improve efficiency by reducing the service response time and bandwidth consumption.
- **Student wireless backpack:** Today's cloud-based storage services have made it possible to access files irrespective of device of use. Due to the centralised architecture of cloud providers there is a notable delay in access to the content even with a relatively fast internet connection. Future mobile technology will

enable single device content access anywhere by using distributed cloud and mobile edge computing. All the user needs is a device to access any of his personal content and stored files. Using this feature students can resume their work at a convenient time and place through different devices with an impression of immediate response time.

- **Student with especial needs:** Advances in mobile technology and robotics can open new opportunities to assist students with especial needs, making learning easier for them. Cloud-based robots can be considered as a full-time assistant for disabled students, helping them to interact with the education environment and their peers. Rather than having to call a teacher over for help (which can cost both the student and the teacher time they could be using more productively) the students can take care of the issue with the help of their robot.
- **IoT & Smart Classroom/Smart Campus:** IoT applications are affecting all aspect of our life, from smart building to smart healthcare. However, one of the fast growing area of these applications is in education which can improve our today's teaching, learning and campus operating experience. IoT applications can also help us change the role of teachers in the classroom, reducing the burden of administrative load on them and allowing them to concentrate more on individuals. Being automatically logged into the classroom as soon as entering to the class, being distracted by a signal as soon as losing concentration during lecture, real-time feedback to a lecturer about areas that students still have problem based on the real-time analyses of their notes, all are just few examples of how IoT and connected classroom can enhance learning and teaching experience.

Technical Requirements for 5G

- **Backhaul Network:** One of the main requirements of 5G is a core network that can relay traffic with the required QoS for a particular service. Internet service for the U.K. education sector is usually provided directly or indirectly through a National Research and Education Network (NREN). NREN is a specialised internet service provider dedicated to supporting the needs of the research and education communities within a country and usually has peering with other mobile operators and service providers. It is usually distinguished by support for a high-speed backbone network, often offering dedicated channels for individual research projects. Different NRENs across Europe are interconnected with each other via GÉANT1. Together, GÉANT connects over 50 million users at 10,000 institutions across Europe. Operating at speeds of up to 500Gbps, and offering unrivalled geographical coverage, GÉANT is remaining the most advanced research network in the world. Apart from connectivity, GEANT Associations opens a door for a Pan-European deployment of successful services through other NRENs, enabling collaboration on projects ranging from biological science to earth observation and arts & culture over dedicated infrastructure. The use of Network Slicing in 5G can help to meet the need of different project/services through having totally independent and isolated virtual networks within or between an

1 http://www.geant.org/

individual physical infrastructure, making it possible to provide different level of latency, reliability, availability and security for each use case. The work being conducted in 3GPP SA2 and ETSI ISG NFV can be used to meet this requirement. Also, techniques like Information Centric Networks (ICN) and Content Centric Networks (CCN) based Content Retrieval can be used to improve the efficiency of the core network helping them to meet the demand of high bandwidth and low latency requirements of future services.

- **Non-3GPP Access Network:** Most NRENs provide their community with a federation-based Wi-Fi service called **edu**cation **roam**ing service (eduroam[2]). eduroam is a hugely popular worldwide network access service which is implemented on a federated basis. Participating organisations, using their existing infrastructures, connect to national NREN-operated RADIUS systems and overlay eduroam network services, which adhere to comprehensive technical standards. That makes it possible for eduroam-enabled organisations worldwide to provide *seamless* Internet connectivity to their local, as well as roaming users from participant organisations without any need to issue guest-access account. Having started in Europe, eduroam has gained momentum throughout the research and education community and is now available in 76 countries and expanding its coverage not only in education communities but also in public places such as city centres, public transport, etc. Based on the requirements outlined in the 3GPP technical documents, the next generation system architecture must support new RAT(s), the evolved LTE, and non-3GPP access types. As part of non 3GPP access types, WLAN access and Fixed access shall be supported. The consideration of eduroam specification in further discussions in SA2 and NGMN regarding the provision of consistent user experience over 3GPP and non-3GPP access networks is recommended.
- **Cellular coverage in education premises:** Cellular coverage is key for education organisations, because smartphones and tablets tend to be the students platforms of choice, and students working habits are increasingly based on an "anytime, anywhere" approach to connectivity. Unfortunately, the quality of that coverage is not good in most of premises and has until now been outside of the organisation's control, determined by the operators commercial priorities and roadmap. This leaves many educational organisations poorly served by cellular voice and/or data, either through rural location or through signal strengths that while acceptable in outside spaces are insufficient within the buildings of a campus. Due to the diversity of operators offering services to the students, any solution to this problem should cover at least the top players in the mobile operators market, without degrading the quality of service of any, since there is no mechanism for an educational organisation to enforce uniformity in its students' choice of platform. The nature of NRENs (having dedicated backhaul and providing high-quality and high-data rate connectivity to the education sector), makes them a good candidate for piloting multi-operator based solutions such as Multi-operator core network (MOCN), i.e., sharing/pooling frequency and using common PLMN-ID and aggregated gateway.
- **Throughput:** Students are mostly categorised as heavy users among service providers. Considering the fact that Audiovisual communications have a huge impact on learning, it is expected that the throughput requirement of most education use cases would be considerably high. 5G promises to offer 20Gbps peak data rate in special scenarios such as indoors and dense areas, as well as several 100Mbps everywhere, as

2 https://www.eduroam.org/

being specified in the SA1 work. However, how that translates to actual implementations will always be down to actual demand.

- **Latency:** Real-time interaction with the environment is crucial for education services. However, it is by its definition subjective and the required response time for each application depends on the context of the service. Due to the diversity of use cases in education, the target latency requirement varies significantly between them. While for applications needing tactile interaction through the Internet a latency of 1ms is required, other use cases can leverage their delay-tolerant nature and ease off the 1ms delay requirement significantly. The crucial and challenging part is meeting a round trip time (RTT) of few milliseconds and the discussion about having necessary changes in access and core networks is already underway in 3GPP SA1 and 3GPP RAN.
- **Heterogeneity:** The wired and wireless systems in the education sector are increasingly diverse and experience continuous change with additional mobile devices entering and leaving a single wireless collision domain. There is the need for wireless technologies that can adapt to these changing, heterogeneous environments, making it possible to have an optimised use of all resources without jeopardizing any of the services.

- **Zero-touch configuration:** The education sector, especially schools, often lack enough technical experts. Therefore plug-and-play and self-organising/optimising devices that can sense and learn from their environment and autonomously tune their transmission strategies and achieve the optimal performance can help. This also applies to any service students/teachers would like to use outside the education premises.
- **Asset Management:** With the increase in the number of connected devices on a campus helping to improve operating, learning and teaching experience there is a need for efficient asset tracking and handling with accurate location.

About Jisc:

Jisc offers digital services to UK education and research in pursuit of its vision for the UK to be the most digitally advanced education and research nation in the world. Working together across the Higher Education (HE), Further Education (FE), skills sectors and Research Council Establishments, Jisc provides trusted advice and support, and reduces sector costs across shared network, digital content, IT services and procurement negotiations, ensuring the sector stays ahead of the game with research and development for the future. Nationally, Jisc also provides services to many Local Authority education networks, via Regional Broadband Consortia and otherwise, in support of ICT provision in schools and community development learning. Jisc is unique in the perspective and expertise it has within the sector and has earned a reputation as a trusted partner for its community for the way in which it makes commercially pragmatic decisions and provides the practical assistance and know-how that help our customers to evolve and embrace new and better ways of working.