5G in MENA

An overview by FTTH Council MENA
of current and upcoming developments and requirements.

September 2017

Introduction

5th generation mobile networks with their new New Radio (NR) technology are drawing near with initial rollout anticipated by 2020. Trials are taking place all around the world, even though the standardization of 5G technology is still to be finalized.

This paper discusses 5G, its applications and benefits, not only in general, but also specifically for the MENA region. The associated network architecture is described, as well as different ways of realizing this and considerations that help ensure 5G can be used to its fullest potential.

Importantly, we will also explain the relationship between next-generation wireless technologies and why there can be no successful rollout, and why 5G can't reach its full potential, without a fibre-optic backbone. This document will raise the following points:

1. **Why 5G?**
2. **Synergies between Fibre and 5G**
3. **The cost of 5G deployment vs. FTTH deployment**
4. **5G trends and investments in MENA region**

Contributors:
Christine Beylouni, Director General FTTH Council MENA
Gamal Hegazi, T&T Committee Chair
Patrick Faraj (Corning), T&T Committee Member

Enabling a fully connected interactive world: Faster speeds, new user cases and new business models

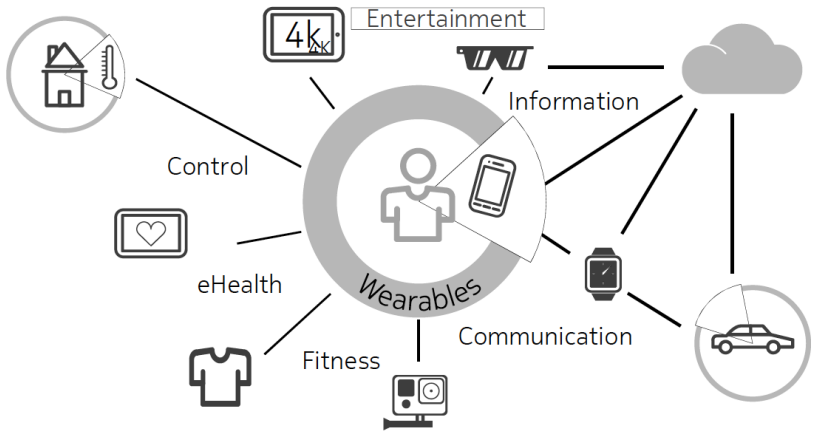
Workable 5G standards are expected by 2018-2020. Industry studies state that 5G will help a broad range of industries to produce up to $12.3 trillion worth of goods and services by 2035. By 2020, the 5G network is expected to support 50 billion connected devices and 212 billion connected sensors as well as enable access to 44 petabytes (ZB) of data. Tomorrow's hyper-connected world will not be possible without scalable infrastructures and 5G to process vast and ever-increasing data flows. 5G offers smart, fast networks with very low latency, connected devices and back-end services. Applications include advanced digital services, enhanced mobile broadband, machine-to-machine (M2M) communications and artificial intelligence.

Unlike 'traditional' point-to-point networks, 5G is an end-to-end system that moves communications to a computing platform. It can derive insights from data generated by devices. Packets containing data from billions of devices are seamlessly moved to select other devices over the appropriate processing platform. Digital hubs will handle 5G traffic flow and data packets are sent by the most logical route according to, for example, the type of information and infrastructure involved, location or time.

Although the name may suggest otherwise, 5G isn't simply an extension of 3G and 4G. It is a transformative ecosystem that integrates wireless access technologies such as 4G, Wi-Fi and millimetre wave. It combines cloud infrastructure, a virtualized network core, intelligent edge services and distributed computing.

5G increases data rates, reduces end-to-end and improves coverage. These properties are particularly important for tomorrow's mobile coverage and Internet of Things and machine-to-machine communication applications.

Increasing download speeds from today's 10 to 20 Mb/s average to 100 Mb/s to 1 Gigabit makes innovations such as HD 4K video and Virtual Reality accessible on a large scale. These speeds will be essential for deploying new technologies including autonomous vehicles and smart energy grid and water systems.



Source: Nokia

5G standard requirements according to Next Generation Mobile Networks Alliance

- Data rates: tens of Mb/s for tens of thousands of users
- Data rates: 100 Mb/s per second for metropolitan areas
- 1 Gb/s simultaneously to many workers on the same office floor
- Several hundreds of thousands of simultaneous connections for wireless sensors
- Spectral efficiency significantly enhanced compared to 4G
- Coverage improved
- Signalling efficiency enhanced
- Latency reduced significantly compared to LTE

5G according to the International Telecommunications Union.

- 20Gb/s peak download rate
- 10Gb/s peak upload rate
- 30b/s/Hz peak spectral efficiency downlink
- 15b/s/Hz peak spectral efficiency uplink
- 100Mb/s user experienced download rate
- 50Mb/s user experienced upload rate

1. Why 5G?

Increased network speeds: driving consumer bandwidth needs

Users will continue to expect new services such as augmented reality applications and HD mobile streaming or autonomous vehicle support. Enterprises and financial institutions will do more and more business and develop new services using mission critical networks. In these environments, as well as in the fast-moving world of healthcare, downtime is simply unthinkable and low-latency, high-speed communication and bandwidth are essential.

Revenues for providers won't only come from Gb connectivity, but also from revenue sharing models developed with next-generation service providers.

5G networking improves mobile device connections, making IoT applications and remote devices more effective. 5G's data transfer, storage and analytics capabilities can help users derive more value from communication services. Below, we'll take a closer look at the various roles and the capacities of 5G.

1.1 Internet of Things

The Internet of things (IoT) is connects devices, systems, buildings and other items that include embedded electronics, electronics, software, sensors, actuators and allowing them to collect and exchange data and provide new services and solutions. Going forward, more and more networked sensors will link the internet to power grids, security systems, household appliances and so on. To autonomous vehicles or mobile games, high bandwidth and minimal latency are essential.

Besides advanced applications such as remote surgery and 'Smart City'-type lighting and traffic management, IoT offers people the opportunity to harness the power of the internet for a wide range of tasks, from optimizing energy management, remotely regulating lighting, home security or thermostats, and using Artificial Intelligence and Virtual / Augmented reality on a daily basis. Within the next few years, there will be tens or even hundreds of billions of connected devices.

1.2 Mobile Devices

We are used to having high-speed access on all of our devices and are using increasingly demanding applications and platforms. Mobile operators need to keep up. Offices, schools, homes and public areas require a great deal of wireless capability. When it comes to mobile networks, 4G will suffice for the time being. But in five to ten years, 4G will no longer meet the requirements of new applications. 5G can fix many of the problems inherent to 4G and existing wireless technologies. More users and devices can be supported simultaneously at higher speeds than 4G.

5G networks make use of significantly higher frequencies than current networks. These networks will operate in high-frequency bands (between 30 GHz and 300 GHz) in the millimetre wave spectrum. Uninterrupted high-quality video and audio streaming on Smartphones and tablets will become more widespread. What's more, more and more devices are no longer capable of no way of connecting to wired networks and are equipped exclusively with wireless interfaces.

High-frequency millimetre wave bands can be used, offering more than five times the space of the lower bands used in 4G LTE. However, high-frequency signals are weaker and have difficulty moving through solid objects. Small cell networks with smaller cell sites remedy this.

1.3 Telemedicine

Smart Healthcare based on 5G improves telemedicine and remote care with faster connections, low latency and higher bandwidths. Devices capture and analyse vast volumes of data and have greater context for interpreting information. What's more, rural areas or underserved urban populations can have greater access to medical expertise. Data analysis allows physicians to aggregate and analyse information in new, smarter ways. This information can be used to learn and determine which treatments are likely to be most effective. Collecting and analysing anonymous data on a vast scale allows the healthcare sector to spot patterns and take preventive or curative.

Digital medicine opens up the possibility to ask for expert opinions or instantly share information such as X-rays or CT scans enables across geographic areas of any size. This helps the health care system to overcome geography, or barriers thrown up by patient income or status. Developments in diagnostics allow new applications to expand the use of monitoring devices and wearable medical equipment. For patients suffering from serious or chronic health issues (cancer, diabetes, cardiovascular disease…) remote monitoring devices can track vital signs and glucose levels and electronically transmit this information to health care providers. Alerts inform patients and physicians when vital signs run outside acceptable ranges.

An increasing number of medical measurement devices are now becoming available in wearable form, such as ECG monitors, blood pressure monitors, glucose monitors and pulse dosimeters. By analysing data and providing recommendations, these wearables can be beneficial to individual users and healthcare professionals.

5G also supports precision medicine, which relies on personalized information about a patient's genes or environment to optimise treatment. Remote surgery will also become widespread once latency levels are minimized throughout healthcare networks.

1.4 M2M

Machine-to-Machine (M2M) technology is changing everything from operational efficiency and customer relationships to quality control, decision-making and business models. The current 4th industrial revolution is driven by new technologies that allow seamless connectivity between IoT devices and M2M communications.

Support for dynamic resource allocation and application prioritization allows 5G to support a wide variety of M2M devices. 5G can support the growing volume of M2M nodes and sensors with mobile connectivity.

1.5 Connected cities

As Smart Cities evolve, the next generation of connectivity will enhance quality of life and unlock job growth and economic gains. 5G will play a huge role in enabling the required Internet of Things, connected transit and other technologies. Smart-city energy grids, enhanced safety, autonomous driving, transportation networks and water systems depend on the presence of low-latency, ultra-fast, and secure cloud services.

5G offers excellent coverage and performance outdoors and in buildings and underground (subways, public transport, urban areas, stadiums and convention centres). It also leads to greater reliability, improving the user experience.

1.6 Business

5G will shake up a broad range of professional service and ICT industries, bringing new business and revenue models. Optimised asset and building usage and energy monitoring help reduce costs and promote sustainability, for example.

Increasingly globalisation means there are more virtual and remote teams than ever, collaborating through a wide range of enterprise communications tools. 5G brings uninterrupted ultra-high definition video telepresence, enhanced telephony and information-sharing services and more, encouraging interactions between teams, members and end-users. 5G will support everything from improved retail experiences to smart city applications.

Current developments in the area of financial services, which have taken flight in recent years, show how rapidly new services become the new standard for an entire industry. This development is expected to continue and even accelerate.

LOOKING AHEAD

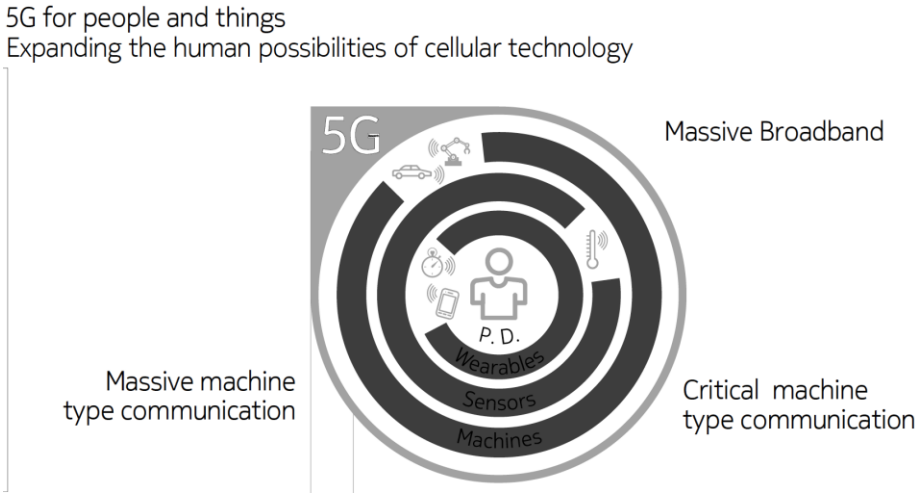
In 2035, 5G will enable $12.3 trillion of global economic output. That is nearly equivalent to US consumer spending in 2016 and more than the combined spending by consumers in China, Japan, Germany, the United Kingdom and France in 2016

The global 5G value chain will generate $3.5 trillion in output and support 22 million jobs in 2035. This figure is larger than the value of today's entire mobile value chain

The 5G value chain will invest an average of $200 billion annually to continually expand and strengthen the 5G technology base within networks and business application infrastructure

5G deployments will fuel sustainable long-term growth to global real GDP. From 2020 to 2035, the total contribution of 5G to real global GDP will be equivalent to an economy the size of India – currently the seventh largest economy in the world

Source: **IHS Markit**



Source: Nokia

2. Synergies between Fibre and 5G

2.1 Fibre: a prerequisite for 5G

Digital and mobile technologies have had a significant impact on our economies, societies, jobs and daily lives. However, not everyone is aware of the fact that these technologies and services are based on reliable broadband connectivity. Any interruption to the service can have serious consequences.

Market analysts predict that by 2030 more than half the population in developed countries will need capacity of 100-plus Mb/s. Optical fibre is the only currently available technology capable of meeting today's bandwidth needs, whilst also providing future-proof broadband networks that support a large number of services that we can't even imagine yet. In fact, introduction of 5G would make little sense without a ubiquitous fibre backbone.

A high-performance fixed infrastructure improves the capabilities of a mobile network. For high-frequency 5G to support high connection density and high-speed mobility, mobile service providers need to deploy vast numbers of cellular towers and base stations closer to users and devices. These towers and base stations must be interconnected through high-speed optical fibre networks.

Critical component

The effectiveness and potential of 5G networks will be severely limited in the absence of fibre. The performance goals associated with 5G, such as low latency, high capacity and extreme reliability depend on having ample fibre. A well-specified wired backbone, scaled to suit wireless connection speeds, is a must for successful rollout and further development of 5G. If this isn't factored in from the outset, bandwidth is diluted to the point of becoming unusable when shared between large numbers of users or systems. Operators are investing in fibre backbone to support 5G. In the US, for example Verizon is buying 37 million miles of fibre to improve its wireless network. The fibre will be used to improve 4G LTE coverage, accelerate 5G deployment and deliver high-speed broadband to homes and businesses.

It is a widely accepted fact that denser networks will be needed to support the expected rise in mobile data, a dramatically broader array of connected devices, and increased machine-to-machine transactions, all at materially lower latency and at higher quality of service levels. Thus, fibre will be a critical component of next gen access network infrastructures." To understand why this density is essential, and how 5G will affect the way in which fibre networks are designed, rolled out, expanded or services, we need to examine current and future network architecture approaches. According to one study, deploying 5G wireless speeds 10 to 100 times faster than 4G in the USA will cost $130 to $150 billion in fibre cabling over the next 5-7 years. Failing fibber deployment will impede the deployment of 5G, whilst also potentially enlarging the 'digital divide' between groups of people that have access to education, information, business, government and entertainment services, and those who don't.

2.2 A closer look at fronthaul and backhaul

In traditional Radio Access Networks (RAN), a BaseBand Unit (BBU) is connected to Remote Radio Units (RRUs). The BBU processes user control and data and RRUs generate radio signals, which are transmitted through antennas. BBU and RRU antennas are traditionally co-located at a cell site. In this *distributed* architecture, the BBU at the cell site connects to the Mobile Telephone Switching Offices (MTSOs) through a **backhaul** link. In a *centralised* RAN architecture, BBUs from adjacent cells are relocated to a single MTSO. This is the most basic form of centralised RAN. In the most evolved version (called Cloud-RAN) the BBUs are virtualised, instead of hardware units. The link connecting the BBU and the RRU that was initially at the cell site and now has extended to backhaul-like distances, is called **fronthaul.**

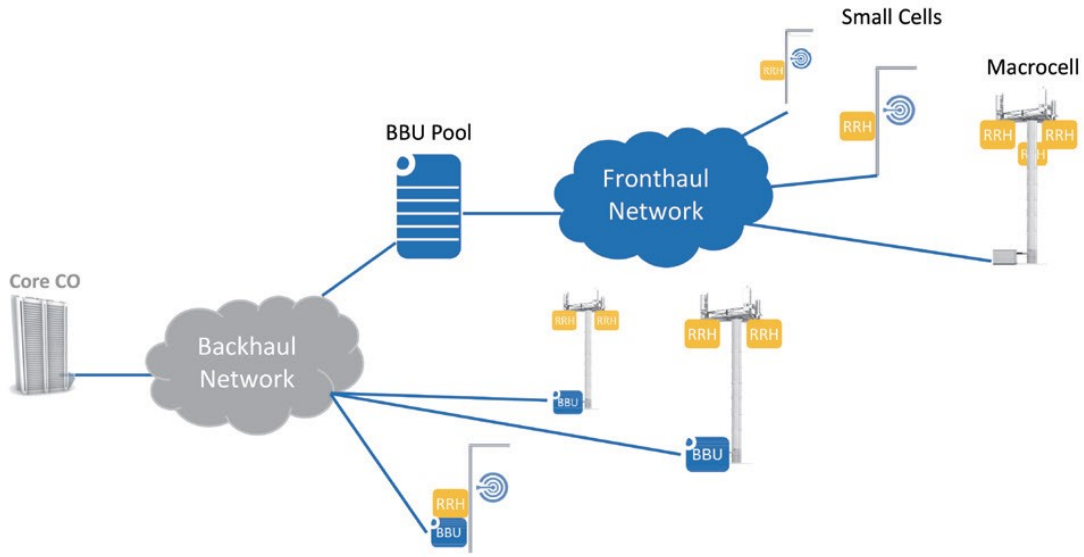
The value of centralized RAN architectures

Aggregating BBUs makes possible to dynamically allocate BBU resources to RRUs, balancing mobile traffic loads and allows a much tighter coordination between cells for a more efficient use of the frequency spectrum that can now be reutilised. Centralised architectures also bring other CAPEX and OPEX benefits: at the cell site, since the equipment left is now lighter and simpler is now easier to install and maintain; while all the BBUs collocated can be operated and maintained all together saving 40 – 50% of energy on support equipment such as air conditioning.

Bandwidth and latency requirements of C-RAN architectures

In centralised RAN architectures, BBU and RRU communicate through the fronthaul segment using digital baseband interfaces. The most used type is the Common Public Radio Interface (CPRI), which offers relatively high rates when compared to the 1Gbps handled by backhaul links. This is because CPRI is essentially Digital Radio over Fibre (D-RoF) - the optical signal is modulated by a radio signal then transmitted over the fibre. Radio signals are optically distributed to cell sites at carrier frequencies and converted from the optical to electrical domain at the cell site before being amplified and radiated by an antenna.

This implementation is simpler and cost-effective at the cell sites as no frequency up/down conversion is required but it means that the bandwidth transmitted through the fronthaul link is higher (a 4G sector, for example, typically needs 10Gbps in CPRI). This high bandwidth combined with very low latency requirements of fronthaul links in centralised RAN architectures (typically between 200 - 400µm) are the reason why fronthaul links need optical fiber.



Source for illustration and content section 2.2: Corning

In short: legacy 2G and 3G mobile network architectures based on copper and Time Division multiplexing (TDM) circuits to connect cell sites to a nearby Mobile Switching Center over the Mobile Backhaul network is beginning to show its age. Adoption of 4G mobile network technologies has resulted in widespread fibre upgrades of backhaul links and the trend will continue with the introduction of fronthaul links needed by centralized architectures to support 5G.

2.3 Why is a home fibre connection necessary for 5G?

Wired Homes will have the fastest connection to mobile. Standards suggest wireless networks can reach speeds identical to those of structured cabling. However, these speeds are difficult to achieve in the real world, not every component in the network will be of the highest possible specification, and one weak link can severely lower the connection speed. Long distances and wide ranges will also affect speed. As distance to Wireless Access Points increases, performance decreases quickly. Wireless is sensitive to electromagnetic disturbances caused by everything from weather, power lines, poorly insulated equipment and motor vehicles. Fibre connections are essentially immune to interference of any kind. What's more, fibre is more secure as it is virtually impossible to tap without being detected.

To realise the full potential of advanced 5G services in and around the home, FTTH is essential. Fibre infrastructure will always be better than wireless when it comes to network efficiency. Mobile services simply provide local access linked to fibre optic infrastructure and the closer you can get fibre to the end users, the better the quality and user experience. In addition, fibre close to the wireless point improves latency and adds redundancy. Gigabit capacity and millisecond latency are useless without a fibre network.

5G may act as a catalyst for FTTH development. Together with IDATE, the FTTH Council Europe carried out a study that demonstrated how LTE and wireless activities are drivers for fibre. High population density

means every building needs to be connected with fibre to provide enough mobile coverage. Furthermore, studies show that (Gb) broadband access improves the market value of properties and boost regional economies.

Although some parties claim otherwise, it's not a question of adopting either 5G OR FTTH: the two are not mutually exclusive. Instead, the approaches are complementary and can result in exponential growth of options available. To improve coverage, capacity, and end user experience network operators are introducing (fibre-based) small cells, closer to the user. In this capacity, fibre is a proven technology that is scalable, secure and generally cost-effective. 5G is all about making experience more immediate and responsive, but this requires significant network power. Edge data centres and edge computing will place content and processing in the cloud, but close to the end user and multi-Gb throughputs at each mobile site are required to deliver Gb speeds to each portable device. The only technology that can deliver such backhaul throughput over distances of more than a few hundred meters, whilst offering a decent degree of future-proofing, is fibre.

5G will require an outstretched, highly granular fibre network. This allows IP-based backhaul that is more capable of handling traffic than traditional circuit-switched backhaul. This offers operators and service providers a long-term upgrade path and the freedom to create new products and services. Besides gaining access to or laying fibre, operators need to increase base station density and capacity. This can be achieved by simply rolling out more base stations of the current type, or rolling out wireless small cells in frequently visited areas such as shopping malls and conference centres, or in densely populated spots. Instead of 'daisy chaining' base stations, it is advisable to have fibre running to a third or more.

2.4 Fibre solutions

In facilitating 5G, operators will - understandably - try to reuse existing assets to the highest degree possible. But where today's typical residential, business, and mobile networks are generally expanded by overbuilding, 5G requires up to 100 times more cell sites than are currently available, making network convergence an attractive option.

Several approaches are being taken to connecting the rapidly increasing number of cell sites that will be required to support 5G. One approach is leveraging existing **Passive optical networks** (**PONs**). These provide fibber to domestic and business users. These PON technologies generally share the same outside plant architecture and have developed from 155 Mbps APON in 2000 to more recent 100 Gbps PON.

PONs are based on point-to-multipoint architecture, with unpowered optic splitters allowing a single fibre to serve multiple end-points. By consolidating services into a single fibre network, users can increase bandwidth while reducing cost and infrastructure. 5G feeders may be added to existing networks and 5G traffic can be carried over fibre together with other kinds of traffic.

Compared to 4G, the data rates 5G requires for fronthaul or mid-haul are up to 10 times higher. There are several PON variants that can offer this: GEPON (1Gbps symmetrical), WDM PON, XGS PON (10 Gbps symmetrical) and NGPON2 (40 Gbps symmetrical, which may be expanded to 80 Gbps in the future).

GEPON (Gigabit Ethernet Passive Optical Network) relies on a single Layer 2 IP network to carry data, voice, and video, and generally delivers 1 Gbps symmetrical bandwidth. Although the cost can be just 10% of that of GPON equipment, it can impose some limitations with regard to bandwidth and latency. GEPON is not to be confused with GPON, which stands for Gigabit Passive Optical Networks.

Wavelength Division Multiplexed (WDM) PON infrastructure converges wireless and wired services for distribution. However, there may be limitations to the reuse of existing FTTH infrastructure and potential issues with customer migration to fibre. These need to be carefully examined before opting for WDM PON.

XGS-PON should be able to deliver symmetrical broadband speeds of up to 10 Gbps, four-times the speed provided by current XG-PON1 technology, making it relatively easy to grow existing fibre networks according to demand.

The NG-PON2 standard is a hybrid of time- and wavelength-division multiplexing approaches. NG-PON2 and GPON can share the same optical distribution network (ODN), which is a benefit for vendors and operators who can combine business and residential services over the same and easily move with future requirements.

3. The cost of 5G deployment vs. FTTH deployment

Operators and other stakeholders don't need to choose between wireless and wire line investments. Instead, these budgets will merge. Making smart strategic decisions regarding which technology to use in specific sections of a network, or upgrading capacity in a planned way, are essential.

3.1 Rollout approaches

To meet the demands of digitalization and data and position themselves for success by 2030, operators need to shift their investment focus from mobile to fixed. By 2030, the winners will be the operators with the largest installed base of fibre. This will allow them to serve retail customers (fixed-line and business), connect mobile base stations serving their own mobile operators, and offer backhaul to third parties. Having the largest installed base of fibber for the consumer segment (with the highest FTTH/B deployment density) and for the business segment (with the highest density of fibre access points) is key to success. Rolling out a high-density small cell network in urban requires high capex investments, and adds to existing opex. Many operators will be taking a step-by-step approach to 5G rollout, which will impact service availability. However, 5G is not an evolution of 4G and its predecessors, but a new platform altogether. In many situations and especially greenfield projects it is advisable to make large investments and 'go full 5G' from the outset. Regulators need to promote a supportive climate that removes bottlenecks and incentivises investment. Low and high-frequency band spectrum is required to ensure timely rollout of 5G networks and maximise network investment. This, in turn requires technical and policy rules regarding unlicensed spectrum, spectrum sharing and other areas.
Operators capable of fulfilling customers' bandwidth demand in the most adaptive way at the lowest deployment cost will be able to maintain market share and develop new revenue streams. What's more, they will be able to offers new services and platforms first, with the best possible user experience, making the most of their capacity and accessing additional revenue streams. Increased density of the fibre footprint allows integrated operators to deliver a superior customer experience and gain market share in B2B and B2C fixed-network market segments.

Recent technology breakthroughs have been successful in driving down product, installation and civil work costs, widely regarded as the biggest challenges in fibre deployments.

3.2 5G increasing revenues for optical products

Corning has recently forecast that optical sales could be up more than 10% on a year-over-year basis in the third quarter. CEO and chairman of Corning Wendell Weeks has told investors that the fibre-based wireless backhaul needs of wireless operators migrating to 5G could be a significant demand driver for cabling. "If truly 5G as it is defined by the industry becomes the standard way to do wireless connectivity, then we are looking at a very significant secular driver for our product, perhaps one of the more significant that we have seen in our long and storied history in this business." CFO Tony Trapani stated that company expects further boosts in the optical communications segment. Of course, whether 5G will be successful not only depends on connectivity, but also on the presence and adoption of next-generation applications and a developer ecosystem. Operators should already start looking for potentially successful business models and possible partnerships with application and service providers.

4. 5G trends and investments in MENA

In September 2016, the MENA region (Middle East & North America) had over 29,2 million fixed broadband subscribers and 162 million Mobile broadband subscribers. FTTH/B subscribers represented around 9% of total fixed broadband subscribers. Although ADSL access technology is still leading Fixed Broadband is growing rapidly in some countries. Several countries are deploying or will deploy fibre networks based on a national Broadband Plan. Significant programs have been launched in Qatar, Oman, Lebanon and Kuwait.

Mobile Broadband is the leading choice for many end users in the Middle East / North Africa region. Kuwait, for example, has an extremely high smartphone penetration rate and is reaching the limits of 4G.

Staying in the lead

Operators in the Gulf region were amongst the earliest to deploy LTE and aim to maintain their leadership with 5G technologies. UAE is expected to lead 4G/5G take-up rates over the next 5 years

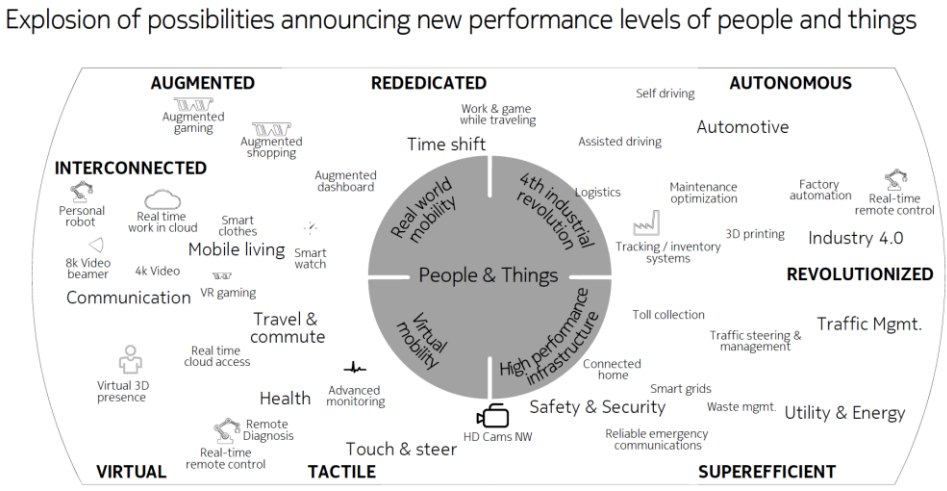
Smart cities and smart technology adoption are a significant driver for the fast uptake of 5G and the ambitions of Middle Eastern countries such as Dubai in this area are sure to accelerate this.

Etisalat (UAE) completed the Mena region's first 5G mobile technology live trial during Gitex 2016 reaching a peak speed of 36 Gb/s. The company plans to invest over Dh3 billion ($817mln) to develop infrastructure and expand mobile and fibre optic networks across UAE and launch5G service by the time of the Dubai Expo 2020. Ooredoo and Vodafone in Qatar are planning a 5G launch ahead of the FIFA World Cup 2020.

The rapid uptake of LTE deployments across the region is paving the way for 5G, with 20 million 5G subscriptions expected by 2022.

Significant FTTH/B projects in MENA

- *In **UAE** and **Qatar**: FTTH coverage over total households near to be reached*
- *In Qatar: Ooredoo and QNBN program => QNBN is focusing now on Public Sites and is lightly used by Vodafone and Ooredoo.*
- *In **Lebanon**: It can be observed that there is a plan to increase the number of FTTH Homes Passed to 1.300 by the end of 2016 and a plan to cover 600.000 at the end of 2017.*
- ***Kuwait**: There is a national plan (MOC) that will increase the FTTH Homes Passed to 67.000 by 2017 and a third phase will be implemented in 2018 to increase to 100.000 homes passed.*



Source: Nokia

The MENA 5G mini panorama

Together with Idate, FTTH Council MENA conducted a 'mini 5G panorama' in 2017 across the full geographical scope of 17 selected MENA countries. The study highlights the countries considering 5G (UAE, Bahrain, KSA…). It describes current and future involvements in 5G including any possible spectrum issues. This document also details trials and future investments regarding 5G along with first cost element related to building a 5G Network such as Small Cells for high frequencies. The findings and related report can be provided as an annex to this paper on demand.