IMPACT OF 5G NETWORK PERFORMANCE ON USERS LOYALTY

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ABSTRACT

Every year people consume more and more data. This review contains a description of promising areas of 5G application and user loyalty in this area. Existing spectrum bands become congested, leading to service disruptions, especially when many people try to access network services at the same time. 5G is much better at handling thousands of syn-chronously connected devices. In smart cities, ultra-low latency in 5G networks critical for smart grids and connected infrastructure. Revolutionary areas for which 5G offers great promise include robotic surgery. The development of 5G help bring virtual and augmented reality to the masses, making technologies accessible to a wide range of users. Fast speeds and low latency will allow to fully immerse in VR/AR. Virtual reality is successfully used also in education, medicine, industry, military and aviation training. Issues of the consumer market evolution are always relevant, and the development of 5G networks will be no exception. In article we look at this topic from different points of view and also use data from Ericsson ConsumerLab, an exclusive research series tracking 5G consumer market evolution. The significance of 5G is not limited to technical specifications. This technology promises to be a driving force in the new industrial revolution, providing the basis for the digital renewal of industry and business, changes in the way big data is processed and the creation of new, innovative services and applications.

KEYWORDS: *5G, consumer loyalty, innovative services, mobile communications, connected devices*

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1 Introduction

Fifth generation wireless mobile communications (5G) is a set of cellular network specifications. Currently, the agreed standards for 5G are as follows:

- Peak data transfer rates are at least 20 Gbit/s downlink (i.e. from operator to subscriber) and 10 Gbit/s uplink to the mobile base station. Overall, this means a 20x speed increase over 4G LTE.
- 5G connection density is at least 1 million connected devices per square kilometer.
- Mobility – 5G will allow the subscriber to move at speeds of up to 500 km/h (4G-120 km/h).
- Energy efficiency – “sleep” mode of base stations and reduction of cell range in dense networks will significantly reduce energy consumption.
- The increase in spectral efficiency will be 30 bps/Hz on the downlink and 15 bps/Hz on the uplink.
- Latency under ideal 5G network conditions is up to 1ms (compared to 20ms for LTE).

Every year people consume more and more data. Existing spectrum bands become congested, leading to service disruptions, especially when many people try to access network services at the same time. 5G is much better at handling thousands of synchronously connected devices.

Power plants require constant maintenance; their proper functioning and safety depend on this. Fast and reliable 5G communications will allow you to continuously monitor systems using sensors (pipeline leak detectors, etc.). This will significantly reduce the need for human intervention and improve the security of power systems.

In smart cities, ultra-low latency in 5G networks will be critical for smart grids and connected infrastructure. This will not only improve the quality of government and public services, but also improve public safety. Already, Barcelona, Spain, Columbus, Ohio, and Singapore are using smart street lights and sensors that monitor things like air quality, parking availability, and waste collection [2, 26].

Columbus, supported by a U.S. Department of Transportation grant, is already deploying and testing apps that help ease traffic jams, automatically notify road repairs, and enable communications between self-driving cars.

The use of autonomous vehicles reveals one of the most critical needs of modern wireless infrastructure: on the road, any second of delay can lead to tragedy. The ability of cars to instantly respond and communicate with their peers using 5G will take autonomous vehicles to the next level and ensure road safety [29-31].

With an eye to the future, 5G technology can increase the availability of medical services for the population and generally increase human life expectancy.

If currently fitness trackers have already become the norm, then with the full implementation of 5G, wearable devices (not only bracelets, but also smart clothes and shoes) will be able to take advantage of high data transfer rates and allow doctors to remotely control and analyze patient parameters and even monitor, whether he took the medicine on time [19, 32].

Revolutionary areas for which 5G offers great promise include robotic surgery.

Smart farming is more than just a technical innovation: it is necessary to feed the world's ever-growing population [4].

The development of 5G, as experts predict, will help bring virtual and augmented reality to the masses, making technologies accessible to a wide range of users. Fast speeds and low latency will allow you to fully immerse yourself in VR/AR. In addition, we should not forget that virtual reality is successfully used not only in the entertainment sector, but also in education, medicine, industry, military and aviation training.

Issues of the consumer market evolution are always relevant, and the development of 5G networks will be no exception. Let's look at this topic from different points of view. Let us pay attention to Ericsson ConsumerLab, which prepared a report on the results of 2023 on this topic.

They have conducted an exclusive research series tracking 5G consumer market evolution, making it the most extensive global consumer study on 5G thus far. Conducted between May and June 2023, online interviews engaged with 37,000 con-sumers across 28 markets, including 10,000 active 5G users [1].

The respondents are a representation of the online population aged between 15 and 69 within the surveyed markets, providing a statistical reflection of the opinions of a total of 1.5 billion consumers and 650 million 5G users. Research explores whether exceptional network quality can act as the primary driver for 5Gadoption and customer loyalty. This understanding creates fresh opportunities for communications service providers to leverage the potential of 5G.

New 5G users value 5G outdoor coverage and speed, but, in markets where 5G population coverage exceeds 80 percent, long-time users prioritize video quality and upload speeds for the apps they use, reflecting evolving expectations.

5G is reshaping video streaming and AR usage. Emerging formats such as 4K, 360-degree experiences, and multi-view videos are increasingly driving usage and 5G data consumption as service providers bundle such rich media content into their 5G plans. On average, 5G users have reported a 47 percent increase in time spent on these enhanced video formats over the past 2 years and the share of daily users of augmented reality (AR) apps has doubled compared to the end of 2020.

5G performance at key locations influences consumer loyalty. A total of 17 percent of consumers across 28 markets have switched their service providers since the launch of 5G, driven primarily by issues with 5G network performance. A significant influence in the decision to switch is the 5G experience in critical locations, such as arenas and airports [21, 22]. Smartphone users encountering issues at these locations are three times more likely to churn [3].

5G consumers are willing to pay a premium for differentiated connectivity. While 37 percent of smartphone users value increased data allowances in their 5G plans, a significant 20 percent expect differentiated 5G connectivity, seeking elevated and con-sistent network performance linked to demanding apps or key locations. These individ-uals value premium connectivity and are willing to pay a premium of up to 11 percent for a 5G plan that ensures elevated network performance.

2 Mobile communication services in 5G networks

5G is not just a mobile communication standard; the introduction of 5th generation networks transforms our perception of the world and leads to a social transformation of society. The economics of networks are changing. 5G technology will account for 15% of the global mobile telephony sector by 2025 (GSMA forecast, www.gsma.com); for Europe and China this figure will be 30%, and for the USA 50%.

Some 5G metrics, such as peak data speeds and battery life, are simply incompatible and even mutually exclusive. But all of these indicators should not be performed by one device at a time or, in principle, supported by the entire list. The idea is to distinguish between different types of scenarios for the provision of mobile radio services depending on the degree of importance (high, medium, low) of a particular indicator. In Network Slicing, the 5G physical architecture will be divided into multiple virtual networks or layers, each dedicated to a different use case. Each of the scenarios will satisfy one or another set of previously specified indicators and, accordingly, will be aimed at its own market segment.

The specification defines only three scenarios: eMBB (enhanced Mobile Broadband); URLLC (Ultra-Reliable Low Latency Communication); mMTC (Massive Machine-Type Communications).

mMTC is a machine-to-machine interaction scenario where human participation is minimal and all processes are automated. mMTC devices include: water, gas, electricity meters; street lighting controllers; parking space sensors; GPS/GLONASS bookmarks; various smoke/fire sensors; burglary sensors; “smart” trash cans and other IoT devices [27, 33]. As you can see, high speed and ultra-low latency are not at all important here, but autonomy and a huge number of connections in the network are very important. We are talking about the so-called. LPWA (Low Power Wide Area) devices are about mass-produced, simple and cheap devices with ultra-low consumption, capable of operating on a single battery for up to 10 years.

Standards and specifications for LPWA networks were laid down in releases 13 (Cat.NB1 and Cat.M1) and 14 (Cat.NB2 and Cat.M2) of 3GPP and NB-IoT networks (aka LTE Cat.NB1/NB2) and eMTC (LTE Cat.M1/M2) have already been launched into commercial operation. Networks for such devices are characterized by low transmission speeds (up to 150 kbit/s in LTE Cat.NB2 and up to 1 Mbit/s in LTE Cat.M1), wide and “deep” coverage. The advantage of NB-IoT and eMTC is that the deployment of networks by cellular operators does not require huge investments and the allocation of separate frequency bands – these LPWA networks can operate in existing frequency bands and on existing network equipment, while one base station can serve more than wide area compared to 2G, 3G or LTE networks [6-8].

The URRLC (included in 3GPP Release 16) and eMBB (defined in 3GPP Release 15) scenarios are the responsibility of 5G. URRLC script, from its name, stands for ultra-reliable low latency communications. And eMBB is ultra-wideband, which means high-speed communication.

Streaming video

Market participants predict a shift in such a classic application as “video streaming” towards increasing data transfer rates without special requirements for delays. The main driver for this will be the need for high-quality 8K video.

With the advent of 5G, 4K and even 8K videos have become the norm for all residents of the city and suburbs, and in the field of film/photo production, even more attention has been paid to quality such as detail.

Consumption of video content on a widescreen TV sets download bandwidth requirements. However, 5G opens up higher upload speeds as well. This will open the door to the introduction of urban video surveillance systems with intelligent facial recognition on all continents. In such systems, the entire computing part with artificial intelligence is located on the network; all that is required of video surveillance cameras is to be able to transmit video of the proper resolution to the server. There are examples of the implementation of such systems in the world.

The government of Shanghai (China) has been using such a system since 2015. More than 170 million “smart” video cameras are connected to it. For example, this system helped detect a criminal in a crowd of 50 thousand on the way from a concert of a popular singer. He came to the concert with his wife and, according to the detainee, he expected to get lost in the crowd. In practice, such systems bring the city not only savings on security and operational investigative activities, but also generate a positive socio-economic effect - citizens and tourists are not afraid to buy expensive things, visit public places at any time of the day, and businesses do not fear for their safety. the safety of clients and property is now the city's task.

With the advent of 5G, this system has only become more efficient and less expensive to deploy and maintain, and therefore more accessible.

Sky Office

In the early stage of commercial 5G deployment, excluding smartphones, the key 5G product is expected to be the Sky Office-connected laptop. Sky Office is the concept of transferring the computing power of a laptop to the cloud by equipping the laptop with a built-in 5G modem. Thus, the cloud can host not only user files (Cloud Drive), but also software, such as MS Office 365 (Cloud Office) or gaming software products (Cloud

Games). In this concept, a laptop becomes, simply put, a screen with a keyboard and a camera.

If cellular networks provide sub-millisecond latency and provide a dedicated, reliable communication channel on an unlimited basis (Network Slice), then working with Sky Office could become a popular way to use a laptop in the future. At the same time, the consumer will receive a number of interesting consumer qualities that are unattainable with conventional laptops:

- low consumption at the level of tablets with a battery life of 14 hours or more;
- "always ready", the laptop does not waste time downloading software, it is already running – in the cloud;
- "ready everywhere", the loss of a laptop no longer means the loss of data and licenses;
- thin and light body, the composition and structure of the laptop are simplified, and this leads to a reduction in size and weight;
- passive cooling, the laptop no longer performs energy-consuming calculations and heats up slightly;
- the connection is safer than Wi-Fi, because... 5G is almost impossible to hack; the communication channel is protected by the latest encryption algorithms.

Bringing the Sky Office concept into reality requires building an entire ecosystem with the participation of players from several industries, such as: operating system and software manufacturers, laptop manufacturers, cellular operators, cloud service providers, chipset manufacturers, eSIM and 5G module manufacturers. But despite the complexity of implementation, Sky Office is expected to have rapid growth in China and many other countries in the near future.

Virtual and augmented reality

The entertainment industry has always been a driving force in the development of consumer electronics. The highest performance demands come from game console consumers. The most advanced, but also less common technologies in the world of games are virtual reality (VR) and augmented reality (AR).

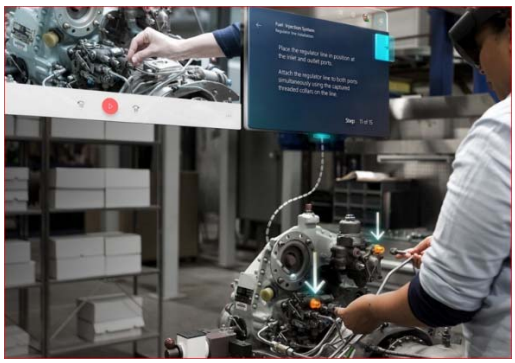
Gradually, VR and AR have gone beyond the gaming industry and are being introduced into education, medicine, and industry – the potential is difficult to overestimate [19, 20]. The next step in this industry is the combination of AR and VR with 5G.

It is clear that with 5G online games will only gain popularity. With the transfer of computing power to the cloud (Cloud Gaming), gaming consoles are less loaded, which makes the video smoother, more detailed and dynamic. Having overcome the technological barrier with 5G, the AR/VR games market has become more in demand. Virtual travel to other cities, diving to the bottom of the ocean and even flights into space are opening up. It is a well-known fact that a person's perception of the world greatly depends on what he sees; with XR+5G, the horizons of the average person are significantly expanded, changing society's approaches to studying the world and creative activity in all areas.

Study the structure of microorganisms

MRI results analysis

Engineering equipment setup



Engine assembly at the factory

Tactile Internet

Continuing the topic of XR and artificial intelligence, it is necessary to say separately about a derivative direction, such as the tactile Internet. Tactile Internet is the transmission of tactile sensations and touches over any distance with a minimal, almost imperceptible delay. The name of the technology was proposed at the Dresden Technical University, where work began in 2012 on the creation of robotic systems capable of remotely transmitting sensations [5, 11].

Scientists are now working to create artificial touch by introducing sensors into soft robotic structures and the most sensitive touch sensors. Now sensors are already able to reproduce the force and nature of touch, distinguish between different materials: metal, wood, textiles, etc.

The tactile Internet puts forward requirements that 5G networks will be able to handle:

- delays less than 1 ms;
- reliability - for performing critical tasks (for example, remote operation), network losses, equipment failure, etc. are unacceptable;
- high data transfer speed – more than 10 Gbit/s;
- high network density – support for connecting more than 100 devices per 1 sq. km.

To reproduce sensations, it is assumed that there are some devices in contact with the recipient, for example, clothing (T-shirts, jumpers, trousers), accessories (gloves), shoes, hats, exoskeletons or special devices that are tactile displays with tiny drives, which drive moving elements (needles, pins).

With the help of the tactile Internet, you can teach how to draw, play musical instruments, perform remote surgical operations, i.e., everything that requires “fine motor” skills. In e-commerce, you can use this technology to touch or try on a product before purchasing it. You can touch museum exhibits and even feel the weight of ancient artifacts in your hand. Multiplayer online shooters with XR+TI will become more realistic, you will be able to feel pain, shocks, impacts, heat and cold.

The first practical examples of the use of tactile Internet in surgery already exist today. In the USA, tests are being carried out to introduce the so-called. “telesurgery”, when a surgeon performs a surgical operation remotely via a 5G network. Telesurgery is very different from classical telemedicine – we are not talking about a simple video broadcast in conference mode, but about the “presence” of the surgeon during the operation. His movements, precision, personal skills, instant reaction to events - everything will be transmitted through 5G networks without physical presence and without degrading the quality of the operation. The services of rare specialists will become more accessible, and patients will be able to choose a surgeon regardless of their country of residence.

UAV (drones)

Telesurgery places high demands on latency and reliability of communication, but there is another area that requires, in addition to everything else, massive connectivity – UAVs (Unmanned Aerial Vehicles or “drones”). Today you won’t surprise anyone with light unmanned drones for a variety of purposes – from entertainment to specialized military drones. With their help, they shoot spectacular videos, conduct terrain reconnaissance, save people, transport goods, etc. But almost all of them are controlled directly by a person who has direct wireless reliable contact on an unlicensed frequency [23-25].

In the context of the implementation of 5G, in progressive countries, regulatory authorities have already paid serious attention to this topic, and therefore work is being carried out to standardize and ensure security in this area. For example, in Europe there is a special expert group 5G PPP (5G Infrastructure Public Private Partnership, www.5g-ppp.eu/5gdrones) based on the European Commission and representatives of the information and communication technology industry (operators, providers, institutions, small and medium-sized businesses) from Britain, France, Switzerland, Austria, Finland, Greece, Poland and Estonia. The 5G PPP public-private partnership will provide solutions, architectures, technologies and standards for UAVs. Through this state initiative, the European Union sees one of the ways to strengthen its technological leadership on the world stage [28].

With standards governing the mass circulation of drones, artificial intelligence systems, reliable, constant and fast 5G wireless communication for an entire hive of drones, new markets and services can be opened up in a variety of areas. Imagine: drone couriers delivering food from stores or important medicines to hard-to-reach places; rescue drones searching for people lost in the forest or sea both day and night; firefighting drones extinguishing fires at an early stage; agrocopters spraying grain crops – and all on a global scale, and not in individual cases.

C-V2X infrastructure

From UAVs we will move on to unmanned vehicles. Many have seen Tesla's video presentation (www.tesla.com), where an electric car controlled by artificial intelligence moves through the city with minimal driver interaction. Or another example is the Waymo service (www.waymo.com), which allows you to call a taxi using a mobile application and take it to the selected point without a driver at the wheel.

Both services are built on different operating principles, controlled by powerful artificial intelligence built into the car. The car makes situational decisions based on visual information and data from lidar (Waymo). A “smart” car is surrounded by “not smart”, unpredictable cars under human control.

There is an infrastructure approach to autonomous driving, enshrined in the 14th release of 3GPP – C-V2X. The acronym C-V2X stands for Cellular Vehicle-to-Everything, which is the concept of transmitting information from a vehicle to any object that can affect the vehicle and vice versa.

Tesla autopilot in motion with a driver behind the wheel

Waymo on the move without a driver behind the wheel

This approach allows the vehicle to “communicate” with other cars (V2V), infrastructure (V2I), LTE network (V2N), power grid (V2G), pedestrians (V2P) and even houses (V2H). The 15th release of 3GPP also introduced the ability for cars to communicate with the 5G network, which made C-V2X more attractive thanks to the URLLC service.

Thus, vehicles connected to the C-V2X system will be able to “see” the whole picture of the road situation, “know” about the relative position, obstacles, dangerous areas, and artificial intelligence located in the network will not just form a trajectory for them individually, but will do this taking into account the mutual influence on the transport system. Such systems will solve the transportation problem better and safer than any driver, reduce travel time for each traffic participant, and make traffic predictable, safe and energy efficient [9, 10].

The international consulting company PricewaterhouseCoopers (PwC) predicts that by 2040 all transport in megacities around the world will become unmanned. However, at first such transport will require attention from the driver in certain situations along the way. During this period, legal issues related to unmanned and electric vehicles will also be resolved. In particular, legal and insurance aspects. A certain amount of time will be spent creating a network of charging stations for electric cars.

State of 5G networks in the world

As stated, current 4G networks cannot cope with the demands posed by new application scenarios. In addition to connection density, radio bandwidth, etc., delays in 4G networks are quite high. Delays consist of delays in the radio part and in the infrastructure part, and today they amount to tens of milliseconds. For full-fledged 5G networks, including support for Network Slicing and URLLC, both a new NGCN (Next Generation Converged Network) network infrastructure and an upgrade of the radio access network will be required. It is clear that it is impossible to complete such a volume of work at once.

The 3GPP consortium initially took into account the complexity of deploying new networks and adopted scenarios for the transition from the standard configuration of LTE networks (#1) to 5G. It is proposed to first implement 5G on top of the existing LTE EPC infrastructure in NSA (Non-Standalone, #3) mode, as cellular operators did throughout 2019. In this configuration, delays on the radio part will be reduced, but due to the limitations of the LTE EPC core, the overall latency will be far from URLLC requirements. The main point of this configuration is different – in the radio part we will receive a significant increase in throughput sufficient for most existing eMBB applications, as well as connection stability with a large number of connected subscribers per base station.

According to the forecast of experts from SNS Telecom (www.snstelecom.com), by 2030, 345 million subscribers will be connected through the FWA service via 5G, and over 90 million units of CPE subscriber devices will be sold.

3 User expectations and satisfaction trends

As 5G technology continues its global rollout, it is vital to understand user expectations and satisfaction trends, especially in advanced markets with extensive 5G coverage and high market penetration.

Overall satisfaction among users with 5G has shown growth, with a notable 10 percent year-on-year increase across the 28 markets surveyed. This positive trend underscores that 5G is indeed meeting user expectations. Over half of all 5G users in early markets – US, Mainland China, UAE, Qatar and the Kingdom of Saudia Arabia (KSA) – report very high satisfaction with 5G. However, in South Korea, Japan, Taiwan and Singapore, on average just 20 percent of 5G users report being highly satisfied, despite having great 5G network performance. This indicates heightened expectations, especially among those who have been on 5G for some time. Once consumers have been using 5G for over a year, the share of satisfied users decline. This decline is particularly pronounced in markets where 5G has reached 80 percent population coverage and 40 percent market penetration. These include the United States, Qatar, UAE, South Korea, Mainland China and Taiwan. One way to understand of the reasons behind this is by examining how expectations around 5G performance are evolving with tenure on the network.

For 5G newcomers, who can be characterized as more mainstream users who have used 5G for less than 6 months, key factors influencing their overall 5G network satisfaction include mobile data upload speeds, the extent of 5G outdoor coverage and voice experience. Since 5G coverage is already built out in these markets, and improving, most users seem satisfied with these aspects. In contrast, experienced 5G users, those who have been using 5G for over a year, have different priorities driving their satisfaction. These include mobile upload and download speeds, app experience KPIs like video streaming quality, mobile gaming and video calling experience, together with the consistency of 5G speed. Notably, for experienced 5G users, the importance of video streaming experience is 20 percent higher than for 5G newcomers.

Significantly, experienced 5G users currently express lower levels of satisfaction with mobile upload speeds, consistency of 5G speeds and app experience indicators like mobile gaming and video calling quality. Service providers must prioritize and demonstrate tangible im-provements in key application experience KPIs such as video streaming, gaming, and video calling quality. They should actively explore and promote novel use cases and apps that can best highlight the unique advantages and potential of 5G technology.

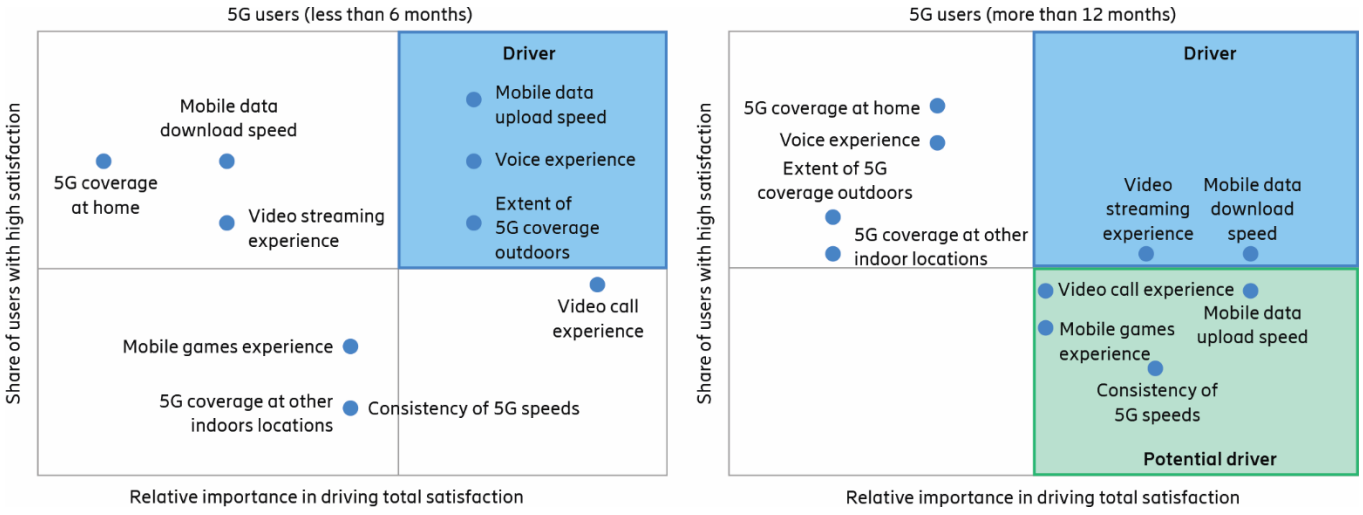


Figure 1: Share of satisfied users and the importance of KPIs in driving total satisfaction

Note: G users in markets where 5G penetration is more than 40 percent and 5G population coverage is more than 80 percent (US, Qatar, UAE, South Korea, Mainland China, Taiwan)

Source: *Ericsson ConsumerLab, 5G value, 2023 [1]*

Over the last three years, there has been a significant upsurge in mobile data consumption among 5G users globally, with subscribers, on average consuming two to three times more data than 4G subscribers, which begs the question: What's driving mobile data traffic over 5G networks?

Surge in 5G user engagement: enhanced video and AR. One recurring question pertains to the driving factor behind the surge in data traffic on 5G networks. The shift to more advanced video formats is the main driver of the higher consumption of 5G users. Examples include 360-degree videos and multi-view streaming, which allow users to pick and choose multiple camera feeds, control the angle on any stream, and zoom in and out at any time during the stream. On average, 25 percent of daily users are now engaging with these formats, signifying their rising popularity. Notably, the number of daily users of AR apps has doubled compared to the end of 2020 [1].

Enhanced video formats such as multi-view streaming with interactive features could drive as much as five times more data usage when compared to regular video streaming. The availability of innovative service bundles plays a pivotal role in incentivizing a substantial transition toward exploring and adopting more advanced apps.

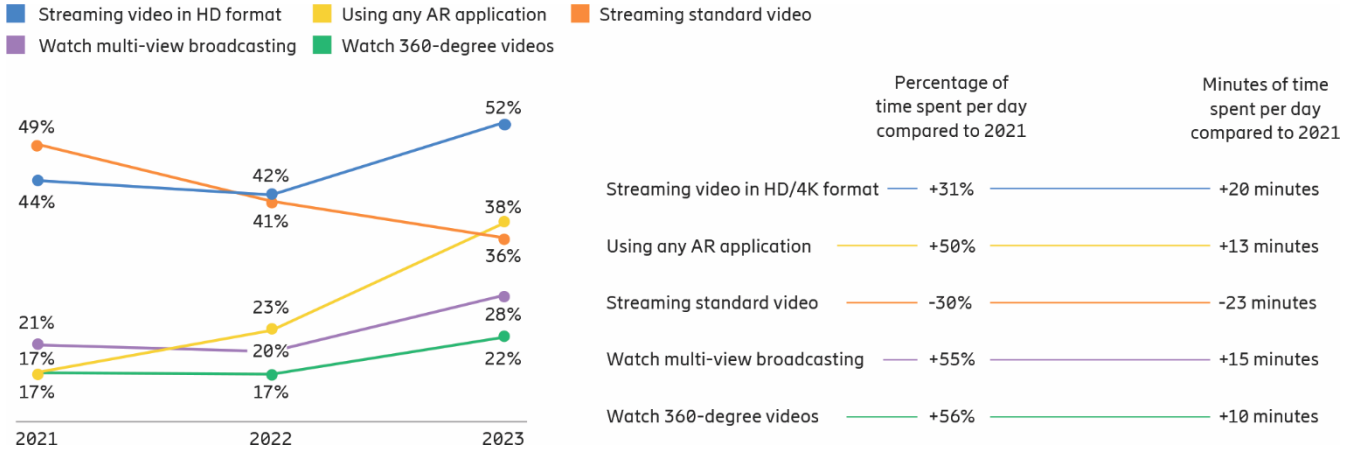


Figure 2. Daily share of services by 5G users: 2020/2021-2023

Note: Smartphone users in Australia, Canada, Mainland China, Germany, Ireland, Italy, KSA, Qatar, Singapore, South Korea, Sweden, Taiwan, Thailand, UAE, UK and US

Source: *Ericsson ConsumerLab, 5G value, 2023 [1]*

he perception of 5G availability is a crucial measure of consumer sentiment con-cerning network coverage, and significantly influences upgrade intentions and overall network satisfaction. This metric remains crucial for service providers to monitor. Fur-thermore, of increasing concern are scenarios where optimal performance was assured.

Since the global launch of 5G across all 28 markets that we have studied, 17 percent of 5G users have switched providers. The main reasons behind these switches are predominantly network-related rather than pricing considerations. Roughly one in two users made the switch in order to obtain an improved 5G network experience, high-lighting how 5G performance is becoming a pivotal factor in terms of influencing con-sumer decisions to switch providers.

Despite the current 5G population coverage being 1.5 times that of 2021, the perception of 5G availability has only increased by 7 percent. An essential determinant of switching decisions is 5G performance in critical usage locations. Frequent network connectivity issues in places like arenas, concert venues and airports have a significant negative impact on consumers' perceptions and memories.

As 5G matures, attention should shift from providing wide area 5G coverage toward ensuring strong performance and indoor coverage in these vital locations, aligning with the initial promise of enhanced performance and high capacity.

4 5G performance at key locations influences consumer loyalty

In analysis has examined various monetization models that are either being implemented today or could be explored in the future by service providers. These include different benefits such as increased data allowances or unlimited data, plans tiered by specific speeds, bundled content-rich apps, and the possibility of network elevation or on-demand performance enhancement, known as quality of service (QoS) offerings. These QoS offerings can be generic, applied to any type of data usage, or linked to specific apps, such as gaming, video calling or live streaming.

The introduction of 5G naturally leads to an increase in data consumption. Globally, 37 percent of users still consider getting more data to be a justifiable reason to pay a premium, which is particularly significant in markets where 5G pricing is centered around data bucket plans such as the Philippines, Mexico and South Africa.

Figure 3 illustrates the diversity in monetization approaches, with user preferences for 5G plan features and their willingness to pay extra for 5G premium offerings. On the vertical axis, the premium level is represented, while the horizontal axis quantifies the percentage of users who want this to justify paying a premium for 5G. This chart underscores the existence of consumer potential beyond the provision of data buckets alone. It reveals that not only do QoS offerings hold a higher consumer potential in driving 5G premium, but other paths to monetization also present significant mobile revenue opportunities.

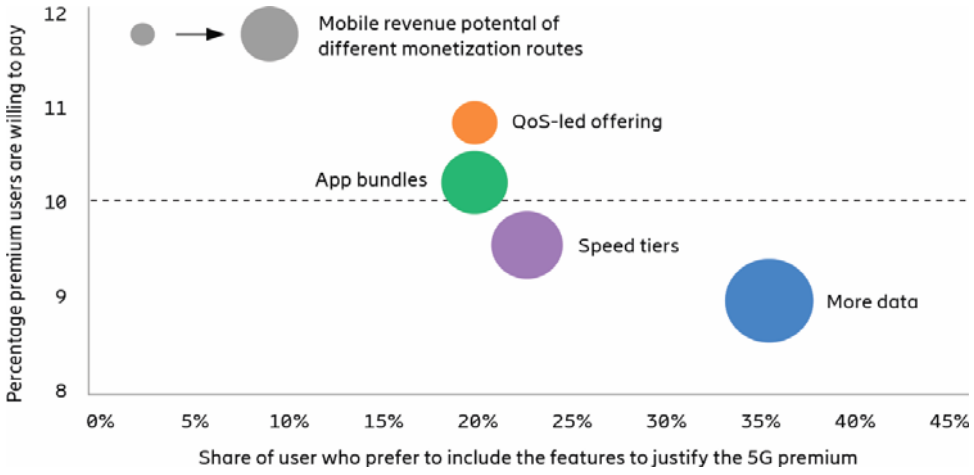


Figure 3. User preference for 5G plan features and willingness to pay extra for 5G premium

Note: Smartphone users aged 15-69

Source: *Ericsson ConsumerLab, 5G value, 2023 [1]*

Service providers can employ multiple strategies for delivering QoS-based offerings, including techniques like network slicing or providing quality-on-demand APIs to developers such as the recent example of Deutsche Telekom commercial launch of network APIs. Note the complexity of this area, particularly due to net neutrality regulations. While some countries can roll out strategies like app prioritization with more flexibility, others have a more stringent regulatory landscape, making the introduction of QoS-related offerings a complex endeavor. This often necessitates discussions around the country's net neutrality stance and the regulator's views.

Distinct strategies must be pursued based on market needs and conditions. Service providers have the flexibility to choose their path to evolve their monetization strategy, moving from data centric to speed tiers, content bundling, and eventually QoS-based pricing. Each combination of different tiering approaches, could bring an incremental result.

5 Conclusion

The significance of 5G is not limited to technical specifications. This technology promises to be a driving force in the new industrial revolution, providing the basis for the digital renewal of industry and business, changes in the way big data is processed and the creation of new, innovative services and applications.

Infrastructure Challenges

• High Development Costs: The introduction of 5G requires significant investment in new infrastructure, including the installation of a large number of small base stations to provide dense coverage.

• Technical Limitations: 5G high-frequency bands have shorter range and poorer penetration through obstacles, requiring a denser network of transmitters, especially in urban environments.

• Integration with Existing Networks: The need to integrate new technology with existing 4G networks and infrastructure.

Security Issues

• Data Protection: Increasing volumes of transmitted data and its centralization require stronger measures to protect against cyber attacks and data leaks.

• Network Vulnerability: More devices and access points increase potential cybersecurity risks, requiring the development of new security protocols.

• Dependence on Technology: Increased dependence on digital infrastructure makes society more vulnerable to disruptions or attacks.

Accessibility and Equality of Access

• Digital Divide: There is a danger that 5G will increase the digital divide as high-speed connectivity may not be available in remote or poor areas.

• Affordability for Consumers and Businesses: The cost of implementing and using 5G can be high, making its affordability questionable for small businesses and some segments of the population.

• International Inequality: Different countries may roll out 5G at different rates, leading to global inequality in access to advanced technologies.

While the promise of 5G appears promising, it comes with a number of complex challenges and issues that must be addressed to successfully and safely implement the technology. From infrastructure and technical issues to social and security issues, each aspect requires careful planning and cooperation between government agencies, private companies and international organizations.

Forecasts about the Development and Spread of 5G

• Global Adoption: Over the next 5-10 years, 5G is expected to become the dominant mobile technology in many countries, with widespread adoption in both developed and developing economies.

• Development in Different Regions: Countries with developed technological infrastructure, such as the US, South Korea, China and European countries, are likely to lead the adoption and development of 5G. In developing countries, the process may take longer due to infrastructural and economic constraints.

• Collaboration and Standardization: International collaboration and standards development will be key to ensuring interoperability and efficiency of 5G networks globally.

5G promises to be one of the key drivers of technological advancement in the near future, revolutionizing the way we work, communicate and live. This technology will open new horizons for innovation in many industries, driving economic growth and improving the quality of life around the world.

5G technology is coming into our lives, bringing the promise of a new era of connectivity and technological innovation. This is not just an acceleration of the mobile Internet, it is a catalyst for a number of breakthrough changes affecting all aspects of our existence – from ever day life to global industrial processes [12-17].

5G paves the way for smarter and more connected societies, supporting the development of smart cities, revolutionizing industries and providing the foundation for new technological advances such as autonomous vehicles and the expanded use of the Internet of Things. However, with the potential comes significant challenges, especially with regard to security, infrastructure and equal access to technology.

We are on the cusp of big changes, and 5G will certainly play a key role in them. The opportunities it opens up could shape the world of the future – one that is more connected, efficient and innovative.

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