



NOKIA CONTRIBUTION

To the Inquiry into 5G in Australia

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1 About Nokia

We create the technology to connect the world. We develop and deliver the industry's only end-to-end portfolio of network equipment, software, services and licensing that is available globally. Our customers include communications service providers whose combined networks support 6.1 billion subscriptions, as well as enterprises in the private and public sector that use our network portfolio to increase productivity and enrich lives.

With an end-to-end portfolio that is unique in the industry, Nokia can work in partnership with operators to deliver "real 5G". Nokia's in house 5G mmWave Small Cells and AirScale BTS provide in-building and outdoor coverage, while our Microwave Anyhaul, Cloud native RAN, antennas, and 5G cloud-native core are part of approximately half of our agreements to date. Beyond our mobile networks portfolio, Nokia has excellent FP4 network processor-based IP routers and PSE- 3 chipset powered optical networking - our customers can use the Nokia Network Services Platform to make this into full-5G-strength software defined connectivity 'smart network fabric' secured by Nokia Security Orchestration, Analytics and Response (Nokia SOAR) to ensure resilient 5G.

As of June 2019, Nokia confirms its 5G leadership position with 42 commercial 5G deals in place with operators around the world, 22 with named customers such as T-Mobile, Telia Company and Softbank. Including these agreements, Nokia's 5G deals, trials and demos total over 100 5G customer engagements to date.

Through our research teams, including the world-renowned Nokia Bell Labs, we are leading the world to adopt end-to-end 5G networks that are faster, more secure and capable of revolutionizing lives, economies and societies. Nokia adheres to the highest ethical business standards as we create technology with social purpose, quality and integrity.

For more information: <https://www.nokia.com/networks/5g/>

Disclaimer: This response is based on Nokia's current understanding of the market dynamics and various standards bodies; these dynamics are changing and hence our views may update with these changes



2 5G paving the way to the Fourth industrial revolution

2.1 5G General Principles

5G is the new generation of radio systems and network architecture that will deliver extreme broadband, ultra-robust low latency connectivity, and massive networking for human beings, objects and sensors. Enabled by 5G, the programmable world will transform our individual lives, economy and society. It sounds like a bold claim but the reality is starting to take shape as 5G research pushes ahead to make rapid developments.

5G will be far more than just a new radio technology. It will combine existing Radio Access Technologies (RATs) in both licensed and unlicensed bands while adding novel RATs optimized for specific bands and deployments, scenarios, and use cases. 5G will also implement a radically new network architecture based on Network Function Virtualization (NFV) and Software Defined Networking (SDN) technologies. Programmability will be central to achieving the hyper-flexibility that operators will need to support the new communications demands coming from a wide array of users, machines, companies from different industries and other organizations such as administrations and municipalities. 5G networks will have to be programmable, software-driven, and managed holistically to enable a diverse and profitable range of services.

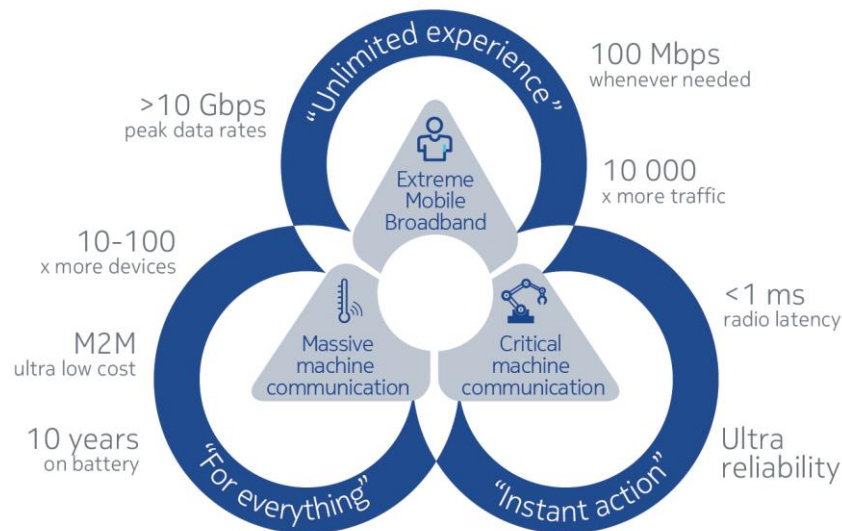
5G mobile communications will cover a wider range of use cases and related applications including video streaming, augmented reality, different ways of data sharing, and various forms of machine type applications, including vehicular safety, different sensors, and real-time control. 5G also needs the flexibility to support future applications that are not yet fully understood or even known. Starting with trials in 2016 and the deployment of first use cases in 2017, the full 5G system will be introduced in 2019/20 and will be in use well beyond 2030.

Nokia envisions 5G as a system providing scalable and flexible services with a virtually zero latency gigabit experience when and where it matters. In addition, 5G will provide at least a ten-fold improvement in the user experience over 4G, with higher peak data rates, improved “everywhere” data rates and a ten-fold reduction in latency.

The biggest difference between 5G and legacy design requirements is the diversity of use-cases that 5G networks must support compared to today’s networks that were designed primarily to deliver high speed mobile broadband. However, 5G will be about people and things that can be broadly split into three use-case categories:

- Massive broadband that delivers gigabytes of bandwidth on demand
- Critical machine-type communication (uRLLC) that demands immediate, synchronized eye-to-hand feedback to remotely control robots and deliver the tactile Internet
- Massive MTC (mMTC) that connects billions of sensors and machines,

as graphically represented in the picture below:



2.2 5G and the Internet of Things

uRLLC and mMTC use cases are seen as enablers for IoT. There are also expectations for IoT to drive the development of 5G. The relationship between 5G and IoT can be summarised succinctly as: IoT is a driver for 5G; 5G is an enabler of IoT.

The IoT is already seeing a rapid growth — well in advance of commercial 5G deployments — using networks that employ both short-range wireless technologies and proprietary low power wide area network (LPWAN) technologies in unlicensed spectrum such as Sigfox and LoRaWAN, as well as in licensed spectrum on existing 2G-4G networks employing technology standards such as LTE Cat-1, LTE Cat-M1 and NB-IoT. As such, IoT will be engulfed by 5G networks but some analysts trust that 5G mMTC will go well beyond the capabilities of NB-IoT, which is largely focused on enhanced coverage, low cost, and enhanced battery life, while 5G will be required to connect massive numbers of devices — in the order of 100,000 devices per cell. That said, mMTC might utilise a future evolution of NB-IoT in the radio access layer, making it more evolutionary than revolutionary.

Depending on the type of application, the IoT can be supported either by mMTC or uRLLC:

- 5G uRLLC use cases may target eHealth remote treatment/surgery, connected cars, including critical V2V communications and even autonomous vehicles, as well as the automation of industrial processes and mission-critical applications like drones deployed in emergency situations. While the strict latency and availability requirements are the key features of this use case, it is still expected that it will also need to support moderately high bandwidth requirements.
- 5G mMTC will support IoT applications such as monitoring in smart cities, smart homes, remote health, industrial, and agricultural processes – maximising the yield and minimising the utilisation of scarce resources.

Nokia and the wider telecommunications industry are already well along the road to 5G. Nokia has run several proofs of concept for most of the key elements that will form the future 5G standard and is already preparing 5G for commercial reality.



3 5G potential use cases and skill requirements

5G is going to change everything, every industry, every business, and every consumer experience. It will power massive broadband applications and it will create unprecedented opportunities. Nokia is leading 5G innovation. We have announced 5G commercial contracts with 42 customers and we have over 100 engagements in total with our customers. As an example, Nokia's 5G project in the Port of Hamburg received the GLOMO (GSMA Global Mobile) award at MWC2019. This Port became a testing ground for 5G applications in an industrial environment.

Here are some business cases Nokia considers for Australia:

Smart Agriculture: With the focus on reducing the resource requirements while increasing the yield for agriculture 5G (and 4G) offers a key toolkit. The density and long-battery life which mMTC (5G Massive Machine Type Communications) enables the possibility to deploy large number of sensors to, for example, detect soil moisture and acidity so that the optimal amount of water is used for irrigation.

Smart Mining: Nokia already provides high-performance networks using 4G that enable mining companies to use digital technologies to adapt to fluctuating demand, control operational costs and address growing safety and environmental concerns. This provides a starting point for bringing new levels of agility and automation to mining facilities. This enables miners to enhance and streamline operations by taking advantage of automation, robotics, digitally enhanced equipment, sensor data, predictive analytics and machine learning:

- Remove workers from the most dangerous parts of the mine
- Monitor worker health and direct them away from exclusion zones
- Optimize resource use and prevent bottlenecks at every step of the mining process
- Gain 360-degree situational awareness in remote operating environments
- Enable predictive maintenance of machines and other important equipment
- Make better decisions from the command center to the mine face

Smart Factories: More businesses are seeking to boost the productivity and flexibility of their production or provision of services while securing a safer workplace. They want to deliver more personalised offerings to better meet fast-changing consumer demands, which requires higher degrees of automation. For manufacturing-based industries, 5G can facilitate more machine-type communications (MTC), real-time control of machines, robot-human interactions and edge cloud analytics to create "smart factories".

Ports: 5G can help foster the creation of "connected ports", one where humans can interact with and share real-time information with devices and machines. For instance, with lower latency, loading and unloading operations can be made more efficient via the automated remote control of unmanned ground vehicles. Not only can this help streamline operations at ports to reduce harboring times, it can reduce the risk of human injuries and fatalities when carrying out such operations.

SMEs: Meanwhile, SMEs can benefit from 5G coupled with Machine Learning and Artificial Intelligence improving the efficiency of back-end operations by leveraging more sophisticated cloud



computing for network-related tasks. On the front-end, 5G will help staff better respond to customer queries, namely via communicating with workers through remote access software more efficiently. The 5G speed will be crucial for these small businesses to operate with higher productivity and survive and thrive in Australia's highly-competitive business environment.

Consumers: One of the most obvious consumer benefits from 5G will be much faster broadband speeds for content consumption. With the rise of online streaming services, more people are turning parts of their homes into home entertainment systems, especially since more 4K (and soon 8K) content will be made readily available by streaming services. 5G will help to ensure that the viewing experience will be smooth and lag-free.

Additionally, 5G developments have coincided with the rise of virtual reality technology. As such, 5G will make it more realistic for people to virtually participate in a live music or sports event, as the ultra-fast broadband speeds can better ensure that the consumer stays connected and engaged with the event.

Gaming is another space 5G connectivity will transform. This is where lower latency is vital to a competitor's performance, and to the fans who follow the gamers during live online streams. Outside of competitions, 5G can also raise the at-home experience of casual gamers, especially as industry leaders such as PlayStation are going the subscription-based route of Spotify and Netflix. Until now, however, not everyone has been convinced that cloud gaming would raise the experience due to latency and lag concerns - both of which 5G is well able to address.

4 Monetization considerations of 5G

With the advent of 5G, the very nature of the services being billed is changing dramatically:

- 5G services are expected to be more complex than 4G services, with more components making up each service. A greater volume of service usage is also expected across all three 5G service families. As a result, the volume of transactions to be handled by the revenue management system is expected to be orders of magnitude greater than what is currently handled by legacy systems.
- Many of the enterprise services defined thus far suggest that the service provider requirements for cost per charging transaction will be substantially lower due to the low margins on each service.
- Many 5G services will be delivered in conjunction with partners and many services will require service providers to extend beyond their normal connectivity provider role. Both of these scenarios will place significant new requirements on the revenue management system.
- Unlike previous "Gs," no single service is the driving force behind 5G. As described in the preceding section, 5G will feature a plethora of new services, each of which will place different requirements on the monetization platform.



5 Key characteristics of 5G monetization platforms

Nokia see that there are several elements to the characterization of a 5G monetization platform:

1. Rapid definition and deployment of products and pricing models: As 5G network deployments expand, service providers need to be able to create and modify new services as quickly as webscale companies do today. They will also likely need to build these services using innovative new pricing models. To support rapid service creation, the service provider product managers need a product lifecycle workbench with capabilities that include financial modeling, analytics, prototyping, A/B testing, and deployment tools.

2. Complex value chain support: Many of the anticipated 5G use cases, especially in the B2B2B segment, will be delivered in conjunction with a set of partners through a complex value chain. For example, contributors to an AR retail solution are likely to include a device manufacturer, an application provider, a connectivity provider, and a systems integrator. With a portfolio of such services, service providers will need to establish and manage an ecosystem that includes a broad range of partners that can contribute to multiple services and provide vertical industry expertise for enterprise customers. The platform capabilities required include partner onboarding, customer order management, partner provisioning, ecosystem management, analytics, and multi-partner settlements.

3. Flexible, real-time charging algorithms: Under 5G, services will increasingly move away from traditional billing parameters and instead charge based on a wide range of possible parameters. For example, services might be charged based on latency, device type (e.g. embedded in a household appliance), location (e.g. other users' usage within an area, also known surge pricing), or image quality (e.g. 8K, 4K or 1080p video). As a result, the charging component of the 5G monetization platform will need to be able to flexibly support complex charging algorithms based on service provider-customizable parameters, and do it all in real time.

4. Customizable SLA definition and enforcement: With the advent of 5G, service providers are anticipating that their ability to define and deliver on complex service-level agreements (SLAs) for their enterprise customers will allow them to differentiate from other non-telco service providers. Enterprises, especially with network slicing, are going to be expecting much more sophisticated SLAs driven by components delivered by multiple partners in the value chain. Having the ability to track, enforce, analyze, and report on these SLAs in real time will be key to the success of all stakeholders.

5. AI/ML-driven insights and predictions: The new monetization platform must provide a rich set of artificial intelligence (AI) and machine learning (ML) capabilities for a wide range of users, including:

- Internal stakeholders, who need customer demographics, segmentation and targeting, service usage, partner contributions, financial results, and SLA management
- Partners, who need service usage reporting, anonymized customer data, value chain partner settlements, and SLA commitments and results
- End customers, who need personalized offers, current and historical usage and spend, and, for enterprise customers, detailed per-user breakdowns



6. Cloud native: As service providers adopt cloud technologies and approaches in search of improved efficiency, faster time to market, and greater agility, the new 5G monetization platform must be fully cloud native. A platform that embraces a microservices-based architecture using containers will provide the required deployment flexibility and scale. Business-centric functions need to be supported in public cloud deployments to ensure a rapid rollout. It is expected that network centric functions will be deployed in the private cloud.

7. Dynamic scalability: Given the diverse range of 5G use cases, the monetization platform needs to be able to automatically respond in real time by expanding and shrinking processing capacity to ensure service continuity. The service provider can't plan these capacity adjustments in advance. It must respond in real time.

8. Telco-grade reliability: Components of the monetization platform are business critical, so they will need to deliver telco-grade, or five-nines, reliability. Achieving this reliability requires a careful design of all aspects of the components, including support for a number of redundancy models.

9. Continuous development and DevOps: Service providers have traditionally upgraded their BSSs only occasionally because of the lengthy time between software update availability, the critical nature of these systems, and the complexity of the upgrade process. A drastic change is required in a digital world. New software releases need to become available in smaller, faster deliverables. By embracing DevOps principles, software vendors and service providers will benefit from much faster and simpler upgrade processes. This approach will require vendors and service providers to change their normal internal business processes. It will also require unprecedented collaboration across company boundaries.

6 A new security approach for 5G

Cyber threats are sophisticated and constantly evolving. With 5G being an end-to-end transformation of the wireless network, attacks can make use of thousands or even millions of interconnected and vulnerable nodes.

In addition, many demanding new use cases enabled by 5G require built-in security that goes beyond 3GPP standards and encompasses automation, security orchestration, analytics and machine learning to detect and mitigate threats. The new 5G security approach integrates and automates 5G network security by treating the entire network as a sensor - data taken from existing systems is used to provide a much greater level of information.

Response to threats or security issues is then achieved through automated workflows. Essentially, this approach detects an anomaly and suggests a way to fix it based on standard or customized playbooks. The playbook provides the steps, procedures or processes that a security analyst performs - today, these would be done manually. Extensive automation frees up a security operations team to focus on priority threat investigations.

A major step in building out the new 5G security approach is a security assessment to help identify gaps between existing security capabilities and 5G security requirements. Based on the results of



the assessment, a Communications Service Provider (CSP) can decide on what investments it needs to make in security technologies and skillsets or it may decide to involve a Managed Security Service Provider (MSSP) to help it meet its 5G security challenges.

End-to-end security, from the mobile core to the edge of a network, is vital to defend against advanced persistent threats and vulnerabilities, as well as manage the transition to edge clouds. This is particularly important in 5G. Security must not only limit methods and places of attack and detect more threats when they do occur, but also dramatically cut the time between detection and mitigation.

Given the evolving and complex nature of security threats, CSPs need to constantly measure their security posture and risk levels to control, limit access to and properly secure the key operational systems and assets of their networks. Adaptability, speed, integration and automation are therefore crucial features of an efficient security and response system, especially given the new level of complexity and sophistication of 5G networks. Achieving them is done by making security operations both predictive and automated, and through using Machine-Learning, multi-dimensional analytics and threat intelligence.

This approach is the most effective way to make 5G networks secure and to therefore develop trust among CSPs' customers, which is itself a key determinant of 5G success.

7 Conclusion

The next industrial revolution promises to unlock massive economic and productivity gains and set us on course for a new era of tremendous transformation and progress.

Industry 4.0 technologies — Industrial IoT, edge computing, deep analytics based on artificial intelligence and machine learning, ubiquitous networking, augmented and virtual reality, remote control and digital twinning — are maturing and promise to bring together the physical and digital economies. As they reach a critical mass of adoption, the opportunity for realizing a much bigger productivity boom is before us.

5G offers a key underlying technology enabling massive bandwidth, lower latency and denser deployments of devices. This will benefit both the consumers directly, but also the Australian economy through growth creation.