NETWORKING TRENDS 2023:

BUILDING THE PLATFORM FOR NEXT-LEVEL DIGITALIZATION

BY: ERIK EKUDDEN, CTO

One of the most exciting aspects of my career at Ericsson is the opportunity to participate in shaping transformative innovations. Over the course of the last two decades, the tandem evolution of internet technology and mobile networks has played a pivotal role in the digitalization that has utterly transformed both business and society. A high degree of embedded openness has enabled the rapid creation of a wide variety of novel, highly innovative services, and we see that new technologies are being adopted more quickly than ever before. For example, global 5G subscriptions topped the 1 billion milestone at the end of 2022, which is two years faster than the 1 billion milestone for 4G.

The digitalization of industry and society has profoundly changed how most people and organizations consume products and services. As a next step, the mobile industry will transition toward a business platform model that enables the creation of a truly open platform for business and technology innovation. Cloud and artificial intelligence (AI) technologies, programmable networks, application programming interface (API) exposure and as-a-service business models are all instrumental in this process.
A network platform providing seamless and efficient connectivity and communication services will be essential to link consumers, enterprises and society at large.

The network platform will have the ability to handle a large variety of use cases, from best-effort mobile broadband services to guaranteed quality of service (QoS), building a global platform for anyone or anything to consume its services. At the same time, it will minimize the cost and resource usage for these differentiated services, as well helping society and industry to reach net-zero emissions and other sustainability goals.

The network platform is a cornerstone of a future world that is distance-free: a place where the physical and digital worlds coexist seamlessly and where both humans and machines can connect, collaborate and engage with each other regardless of their geographical locations. Universal, resilient and trustworthy connectivity is the keystone of this cyber-physical world.

With all of this in mind, I have chosen to focus on three key trends in this year's article:

1. Technologies that enable a cyber-physical world
2. The need for an open platform for business innovation
3. The high-performing network infrastructure

KEY TERMS

The business innovation platform is open, global and without boundaries, connecting consumers, enterprises and society at large, to enable the creation of new and innovative services that generate exponential business growth. It will be realized by the network platform.

The network platform will aggregate and abstract the network capabilities from the distributed network infrastructure into monetizable, globally available services for developers and enterprises. These services are enhanced by the integration of other value-adding functions originating from the global ecosystem. The network platform embeds interoperability and routing across the actors in the ecosystem to secure service continuity for global scale and reach.

The distributed network infrastructure is evolved with programmability and exposure of network capabilities. The programmable network infrastructure offers service differentiation and deployment flexibility. The network infrastructure capabilities are exposed to the network platform through APIs.

TREND #1
TECHNOLOGIES THAT ENABLE A CYBER-PHYSICAL WORLD

Immersive user experiences such as virtual reality (VR) and augmented reality (AR) have gained a lot of attention in industry and society in recent years. At the same time, technology giants around the world have made significant investments to speed up technology development in this area, which has led to progress in both extended reality (XR) devices and applications.

The evolution of immersive communication that ties user experience to the physical world has been a recurring theme in my CTO Technology Trends articles for several years now. This year, I want to focus on two specific capabilities that are vital for a cyber-physical world. The first, massive twinning, connects and aggregates the physical world of senses, actions and experiences, and uses that information to generate a programmable digital representation. The second, situational awareness, refers to the use of sensing technologies to monitor the surrounding environment, locate objects, and navigate for smooth and safe interaction in a cyber-physical environment.

Massive twinning – real-time digital replication

The creation of a digitalized and programmable physical world without temporal or spatial constraints will require massive twinning – that is, the creation of accurate, fully synchronized digital twins of everything that exists in the physical world, including humans, physical objects, processes and networked systems. Each digital twin knows its history, can predict its future and has full control of its real-time status. In massive twinning, all digital twins are fully synchronized. Vast amounts of data from the physical world are sent in real time to update the digital twins for use by applications. Actuators and interfaces in the real world carry out functions from the applications for action and experiences.

Massive twinning offers support to minimize resource use and fault prediction. One example of such a use case is a real-time programmable digital twin of an entire smart city that enables precise modeling, monitoring and managing of almost any public or private service, such as utilities, public transportation, public health and environmental monitoring. Another important use case for massive twinning is process optimization in a smart factory to improve productivity, flexibility, quality and sustainability. Massive twinning will also be of great use to communication service providers (CSPs) themselves by making it possible for the CSP to generate a digital representation of the entire network that can be used to simulate network rollout, optimize network operations and initiate predictive maintenance.

Ubiquitous connectivity and integrated sensing are essential components of massive twinning solutions. Massive twinning can involve hundreds of sensors and actuators per square meter, which means that the network needs to provide advanced service coverage wherever and whenever it is needed to a broad range of devices and applications. This includes the aggregation of data rates up to gigabits per second, which leads to stringent requirements on very low latency and high throughput.

In the 6G time frame, the network will provide connectivity using new and significantly more energy-efficient signaling protocols, and many of the sensors and actuators used in digital twins will be zero-energy devices that do not require any batteries or manual charging. To ensure massive twinning deployments at scale, a fully automated process to handle sensor and actuator devices in bulk will be required. High network reliability and availability, as well as stringent end-to-end data and privacy protection, will also be needed to meet the required levels of trustworthiness.

To fully unlock the potential of zero-energy devices, a holistic approach is needed. For the devices themselves, the energy-harvesting technologies – as well as the packaging and low-power integrated circuit design – will need to be advanced. In collaboration with Massachusetts Institute of Technology (MIT), Ericsson is exploring new materials and ultra-low energy designs to harvest the radio signal itself. ➔

NETWORK DIGITAL TWIN FOR OPTIMIZING 6G NETWORKS

The evolution from today's radio network simulators to network digital twins that utilize 3D gaming and computer-generated imagery technologies enables new features such as high-resolution of city and indoor environments, detailing surface materials that influence radio frequency propagation as well as the representation of dynamic scene features such as automotive traffic and user mobility. Recent technological advances have improved Ericsson's capability in several aspects such as visualization, integration, standardization of formats, collaboration and modeling accuracy. Together, these advances enable leaps in our ability to accurately simulate a radio network in a digital twin.

➔ **Situational awareness – sensing surroundings and locating objects**

Situational awareness is the ability to understand the environment and its elements in real time and derive meaningful insights in order to make informed decisions and take appropriate actions. This capability is instrumental to building a cyber-physical world and is based on massive twinning data. The digital world is created by processing the sensing and localization information provided by simultaneous location and mapping (SLAM) algorithms. The SLAM information is used for a variety of purposes including AR, 3D mapping, 3D reconstruction and real-time object tracking.

Spatial sensing capabilities will be an integral part of the future network and have been identified as an innovative feature of future 6G systems. The future network will support spatial sensing by reusing network communication signaling, utilizing the same principles as radar technologies to determine the presence, characteristics and trajectory of objects. This solution is referred to as joint communication and sensing (JCAS) and will enable services for evolving use cases such as smart cities, transportation systems and public safety applications.

The network will collect not only JCAS sensor data but also other data from non-JCAS sensors. The network platform has the capability to process the aggregated sensor data to be used for services such as SLAM, navigation and geofencing. The network platform will offer the processed sensor data through network APIs that are easily consumable for the developer ecosystem.

The main advantage of the network platform in terms of future sensing is that most of the network infrastructure is already in place, providing full-area coverage that facilitates a synchronized multi-static sensory mesh. Another useful feature of the network infrastructure is that the radio signals for sensing work in complete darkness and can even sense local weather conditions.

INTEGRATING SENSING INTO NETWORK INFRASTRUCTURES

1 THE EU HORIZON 2020 HEXA-X PROJECT

Together with our partners, Ericsson is engaged in the EU Horizon 2020 Hexa-X project on scenarios and use cases for sensing. The project also includes gap analysis to consider questions including what is needed to support the identified use cases, what can be supported with current 5G technology, and what additional functionalities are required. In the successor project, Horizon Europe Hexa-X-II, the focus will be on sensing architectures for JCAS, physical layer solutions and security aspects.

2 KOMSENS 6G

Ericsson is active in KOMSENS 6G – a research project funded by the German Federal Ministry of Education and Research – where we are working with partners on research that focuses on the integration of sensing in communication networks.

3 NXP SEMICONDUCTORS

Ericsson has teamed up with NXP Semiconductors to investigate potential new use cases for a network where communication and sensing functionalities are fully integrated into the same transmission/reception nodes. Together, we will also investigate implementation aspects of such future systems and evaluate the technical challenges and opportunities for JCAS use cases.

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TREND #2
THE NEED FOR AN OPEN PLATFORM FOR BUSINESS INNOVATION

An open platform for business innovation links consumers, enterprises and society at large across sectors and without boundaries. All producers develop and offer their own products, services or content through the platform. The platform will create connections and enable transactions between producers and consumers. Existing platform users, both producers and consumers, will receive a benefit from every new user that enters the platform. As more users join, the advantage for existing users continuously increases. In economics, this is referred to as the "network effect." An additional advantage for users is that the platform scales without any significant investments.

Inherent to the open platform for business innovation is its capability to support different use case characteristics from the simplest to the most advanced. The services are segmented based on shared requirements and needs to optimize fast deployments and minimize cost. The platform offers flexibility for the differentiation of products, services and content.

In the future, enterprises will consume network connectivity and features as a service that fit their specific needs, similar to the way cloud service works today. Depending on the use case, the service will be handled by a public network or by self-contained and independent logical network slices created in the public network that can extend into purpose-built private networks. Either way, the result is a virtual network offering that is both secure and dedicated, with a single enterprise management system for enhanced asset control and visibility, including assets connected through the macro network.

The role of the network platform

Today's network platforms provide communication-as-a-service APIs by, for example, offering SMS, video calling and voice services for developers to integrate into their application offerings. In the not-so-distant future, it will be possible to provide developers with much more advanced and programmable network capabilities tailored to application requirements on latency, reliability and throughput. These capabilities will be exposed as network APIs tailored for next-generation use cases such as immersive communication and situational awareness. Such future use cases can be further enhanced through the integration of other value-adding functions provided by the global ecosystem.

For the most efficient and scalable implementation, the network platform will aggregate and abstract exposed network APIs from the distributed network infrastructures. Further, the network platform will embed interoperability and routing across the actors in the ecosystem to secure global scale and reach.

The first step in this process will be the transformation of the existing network infrastructure architecture – including functions such as the radio-access network, the core network, operations support systems and business support systems – by strengthening the network API enablement suite in areas such as resource management and service orchestration. The second step will ensure that the network API enablement suite is equipped with state-of-the-art exposure frameworks and service definition; in other words, a network abstraction layer. As network infrastructure capabilities such as positioning, sensing and embedded compute evolve through 5G Advanced and 6G, the network API enablement suite will build new service segments and policies for service differentiation.

LIVE QoS-ON-DEMAND DEMO AT MOBILE WORLD CONGRESS 2023

Together with three CSPs and a few of our ecosystem partners, we took the opportunity at MWC 2023 to showcase how to make advanced open-network APIs easily available to the developer ecosystem. The demo exposed 5G network APIs to enable QoS-on-demand for interactive HD videoconferencing on mobile devices and lag-free mobile gaming use cases for application developers. The QoS-on-demand demo is based on the telco standardization of 3GPP network APIs and CAMARA communication APIs.

TREND #3
THE HIGH-PERFORMING NETWORK INFRASTRUCTURE

The foundation of modern network infrastructure is an open architecture with open interfaces and open APIs that enable continuous evolution in line with market expectations on business innovation and growth. Limitless connectivity, trustworthy systems and AI-powered cognitive networks will be instrumental technologies in the evolution ahead, from 5G to 5G Advanced, and on to 6G.

Limitless connectivity with greater openness

Open access interfaces, open service interfaces via network APIs, open network infrastructure layers to cloud, transport and data pipeline interfaces as well as open network applications, such as rApps, are all crucial architectural principles of the network infrastructure.

Service differentiation and deployment flexibility will be enabled with the help of end-to-end managed network slicing that dynamically optimizes the network resources within the stipulated QoS during the network slice life cycle.

Programmable networks will allow for the optimization of the overall network performance as well as the customization of device behavior targeting specific use cases. Programmable networks build on cloud technologies for faster feature development, faster bug fixing and DevOps-like operations. This will enable CSPs to adopt a software-as-a-service business model for network applications such as billing, management systems and core network functions.

Network-aware applications use knowledge of network capabilities to intelligently place application components where they will run with the greatest efficiency, performance and energy efficiency, taking into consideration factors such as where specific hardware-acceleration capabilities are available.

An architecture built on distributed network infrastructures also provides limitless connectivity – that is, connectivity that provides the required data rate and latency, and is available wherever needed. Multi-connectivity, multipoint connectivity and distributed MIMO (multiple-input, multiple-output) will be utilized to ensure robustness, performance and consistent quality, which will contribute to increased network reliability, availability and resilience (NRAR). Multipoint connectivity and distributed MIMO provide the ability to use many tightly coordinated network nodes to communicate to each specific device, which greatly enhances performance. To provide truly global coverage, the distributed network infrastructures will include non-terrestrial access components such as satellites and drone networks. As part of the longer-term radio-access evolution, spectrum utilization will extend into the sub-THz frequency bands. These very high frequencies create the possibility of highly accurate sensing for use cases such as JCAS.

Energy-efficient networks will be built by optimizing energy performance end to end. At node level, hardware accelerators and related software components such as operating systems and drivers are essential for low-energy solutions. They will provide scalable traffic processing including features like multiple sleep states and fast activation. Further, smart network and AI-based features for site energy orchestration will be embedded for network energy optimization.

In the 6G time frame, the network infrastructure will be capable of providing more than 100 times higher capacity in comparison with today's network infrastructure, with peak rates over 100Gbps, wide-area consistency latency below 5ms and centimeter-level position accuracy. The always-available, high-performance network infrastructure will offer truly global coverage in indoor, outdoor and non-terrestrial environments. This is made possible through interoperable service interfaces that interconnect all ecosystem actors on a global scale.

Embedding trustworthiness

The openness of the network infrastructure requires security assurance based on zero-trust principles – never trust and always verify – to secure all communication while constantly monitoring the trustworthiness of the communication. A secure, resilient and privacy-preserving network infrastructure is a cornerstone in supporting all society-, mission- and business-critical use cases for humans and intelligent machines in a verifiable way. This requires seamless integration of AI-based automated security controls and assurance mechanisms to make it possible to respond in real time to both known and unknown threats. This will secure trustworthy network infrastructure that performs tasks reliably, maintains data provenance, confidentiality and privacy, as well as protecting against unauthorized access or manipulation.

In a trustworthy system, secure identities are needed at all layers of the system – infrastructure, connectivity, devices and the edge – as well as in network-slicing functions. This can be enabled by means of root-of-trust mechanisms for identities. To ensure both security and privacy, the network infrastructure will use state-of-the-art protocol stacks including quantum-proof algorithms and confidential computing capabilities to protect data when it is being processed and stored. Finally, the network infrastructure will support security assurance throughout the application communication path, including devices, all network domains and the application cloud. In the long term, this will include support for bystander and spatial privacy-preserving solutions for immersive user experiences.

Artificial intelligence in programmable networks

Network infrastructure must have the flexibility to handle a large variety of use cases, which will be achieved through greater automation of network management. Programmability and distributed intelligence are the best ways to achieve this. Fully autonomous system operation is based on zero-touch deployment and operation across all stages of the life cycle, as well as on the ability to continuously optimize performance in real time. Network services will be managed by well-defined functional models and by dynamic and fine-grained allocation of heterogenous network resources.

Distribution of AI-based performance optimizations in the network requires a data-driven architecture and data-driven operations. These optimizations are continuously supervised and tuned to deliver explainable optimization results. The network will aggregate the optimization results and place them into a larger context, where they can be combined, evaluated and adjusted to reach a defined intent. A hierarchical control-loop structure is used to manage and optimize the network and end-to-end services. In an autonomous network, humans can take a supervisory role relying on trustworthy AI that is lawful, ethically adherent and technically robust.

Generative AI has reached commercial maturity and has been proven to provide efficiency gains in areas such as research and development. Further, this technology will support network analysis and optimization tasks such as predictive maintenance, fraud detection and network planning.

Conclusion

My vision for the future is a connected and sustainable physical world that is both digitalized and programmable, where humans are supported by digital intelligence and immersive experiences. Already today, we can see the emergence of real-time, programmable and collaborative digital twins for a variety of industrial use cases. As the technology evolves, we will be able to build complete smart cities and global intelligent transport systems. All the data made available by digital twins, massive sensing capabilities and spatial mapping technologies will – together with ubiquitous connectivity and network programmability – form a cornerstone of the digitalization evolution.

The unique capabilities of 5G – including global, trusted and secure access – serve as a foundation for both 5G Advanced and 6G, with the differentiating pillars of limitless connectivity, trustworthy systems and AI-enhanced cognitive networks. 5G will evolve into the network infrastructure of choice because it is the most efficient communication technology able to deliver the required openness, scale and affordability to handle the full range of differentiated services for consumers, developers, enterprises, industries and governments.

Ericsson is a leader in the effort to define 6G, working in close cooperation with ecosystem partners that include industry leaders, academia, standardization bodies and open-source forums. By delivering high-performance networks, enterprise networking and network application programming interfaces for monetization, we will help to create an open business innovation platform that connects consumers, enterprises and society in a cyber-physical world without boundaries. This new global platform is going to open up a myriad of lucrative new business opportunities across the entire ecosystem. We're keen to pursue them – we hope you are too.

ABOUT THE AUTHOR

As Group CTO, Erik Ekudden is responsible for Group Strategy and Technology. His extensive experience of working with technology leadership globally influences the company's strategic decisions and its investments in 5G, 6G, edge computing, artificial intelligence, augmented/virtual reality and the Internet of Things. Ekudden's leadership builds on his decades-long career in technology strategies and industry activities. He joined Ericsson in 1993 and has held various management positions in the company, including Head of Technology Strategy, Chief Technology Officer Americas in Santa Clara (US) and Head of Standardization and Industry. He is also a member of the Royal Swedish Academy of Engineering Sciences and the publisher of Ericsson Technology Review.

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Further reading

- **Ericsson, Follow the journey to 6G, available at:** *https://www.ericsson.com/en/6g*
- **Ericsson Technology Review Magazine 2023, Spotlight on extended reality, available at:** *https://www.ericsson.com/en/reports-and-papers/ericsson-technology-review/articles/spotlight-on-xr*
- **Ericsson blog, Five takeaways on the future of 6G XR from the 6G@UT Forum, available at:** *https://www.ericsson.com/en/blog/2023/5/five-research-insights-on-6g-xr*
- **Ericsson Technology Review, Network digital twins – outlook and opportunities, available at:** *https://www.ericsson.com/en/reports-and-papers/ericsson-technology-review/articles/network-digital-twins-outlook-and-opportunities*
- **Ericsson blog, Joint communication and sensing in 6G networks, available at:** *https://www.ericsson.com/en/blog/2021/10/joint-sensing-and-communication-6g*
- **Ericsson, Zero-energy devices, available at:** *https://www.ericsson.com/en/about-us/new-world-of-possibilities/imagine-possible-perspectives/zero-energy-devices/*
- **Ericsson, Future technologies for an intelligent society, available at:** *https://www.ericsson.com/en/future-technologies*