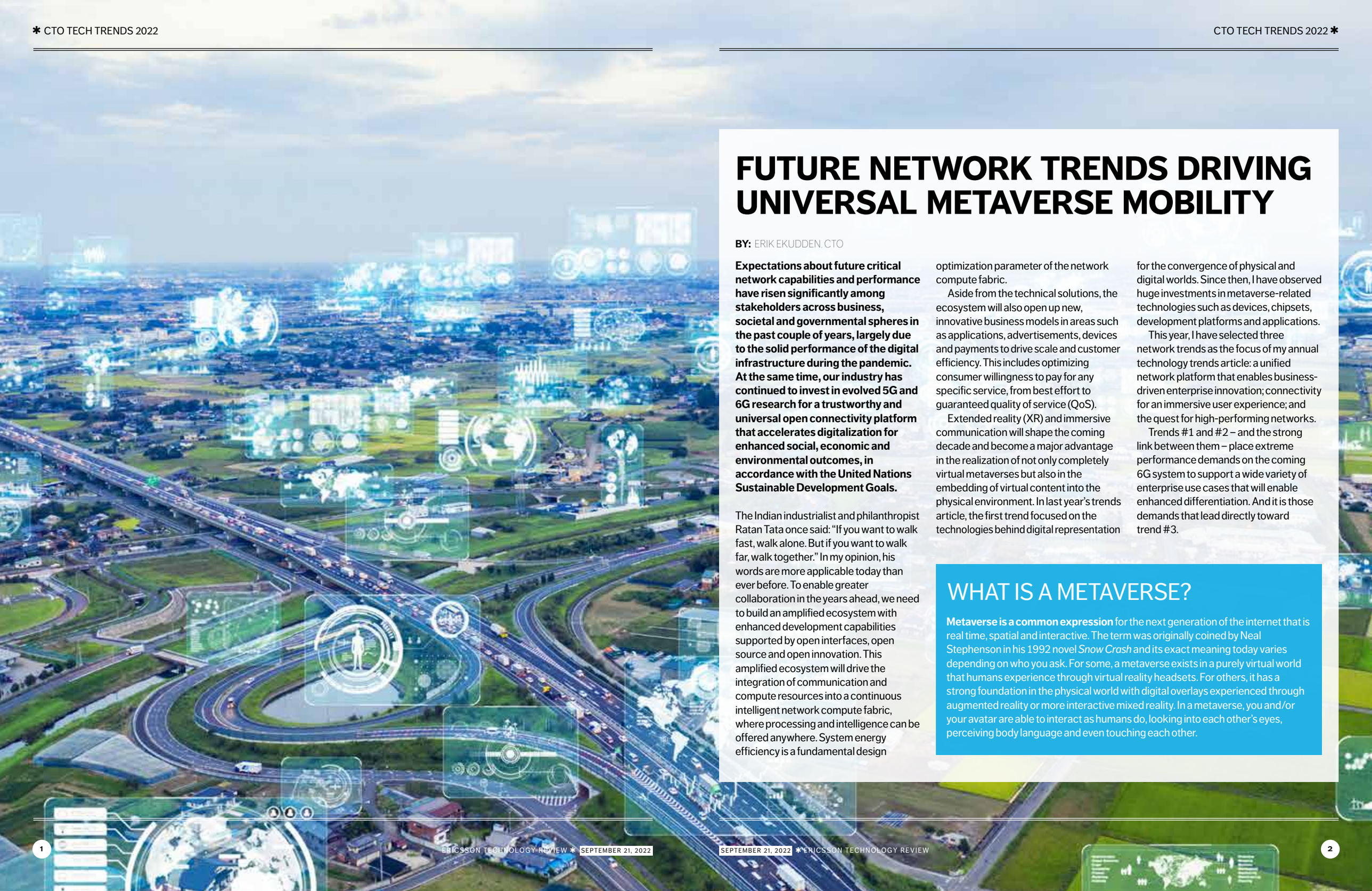


FUTURE NETWORK TRENDS DRIVING UNIVERSAL METAVERSE MOBILITY

BY: ERIK EKUDDEN, CTO

Expectations about future critical network capabilities and performance have risen significantly among stakeholders across business, societal and governmental spheres in the past couple of years, largely due to the solid performance of the digital infrastructure during the pandemic. At the same time, our industry has continued to invest in evolved 5G and 6G research for a trustworthy and universal open connectivity platform that accelerates digitalization for enhanced social, economic and environmental outcomes, in accordance with the United Nations Sustainable Development Goals.

The Indian industrialist and philanthropist Ratan Tata once said: "If you want to walk fast, walk alone. But if you want to walk far, walk together." In my opinion, his words are more applicable today than ever before. To enable greater collaboration in the years ahead, we need to build an amplified ecosystem with enhanced development capabilities supported by open interfaces, open source and open innovation. This amplified ecosystem will drive the integration of communication and compute resources into a continuous intelligent network compute fabric, where processing and intelligence can be offered anywhere. System energy efficiency is a fundamental design optimization parameter of the network compute fabric.

Aside from the technical solutions, the ecosystem will also open up new, innovative business models in areas such as applications, advertisements, devices and payments to drive scale and customer efficiency. This includes optimizing consumer willingness to pay for any specific service, from best effort to guaranteed quality of service (QoS).

Extended reality (XR) and immersive communication will shape the coming decade and become a major advantage in the realization of not only completely virtual metaverses but also in the embedding of virtual content into the physical environment. In last year's trends article, the first trend focused on the technologies behind digital representation for the convergence of physical and digital worlds. Since then, I have observed huge investments in metaverse-related technologies such as devices, chipsets, development platforms and applications.

This year, I have selected three network trends as the focus of my annual technology trends article: a unified network platform that enables business-driven enterprise innovation; connectivity for an immersive user experience; and the quest for high-performing networks.

Trends #1 and #2 – and the strong link between them – place extreme performance demands on the coming 6G system to support a wide variety of enterprise use cases that will enable enhanced differentiation. And it is those demands that lead directly toward trend #3.

WHAT IS A METAVERSE?

Metaverse is a common expression for the next generation of the internet that is real time, spatial and interactive. The term was originally coined by Neal Stephenson in his 1992 novel *Snow Crash* and its exact meaning today varies depending on who you ask. For some, a metaverse exists in a purely virtual world that humans experience through virtual reality headsets. For others, it has a strong foundation in the physical world with digital overlays experienced through augmented reality or more interactive mixed reality. In a metaverse, you and/or your avatar are able to interact as humans do, looking into each other's eyes, perceiving body language and even touching each other.

TREND #1
A UNIFIED NETWORK PLATFORM FOR BUSINESS-DRIVEN ENTERPRISE INNOVATION

A unified network platform will both support and drive the development of a wide variety of new, innovative enterprise use cases. Many of them will involve the delivery of easy-to-use immersive experiences by and between humans as well as autonomous communication and operation between intelligent machines or between humans and machines. As such, the unified network platform will act as an open innovation platform connecting different ecosystems, facilitating collaboration and business growth.

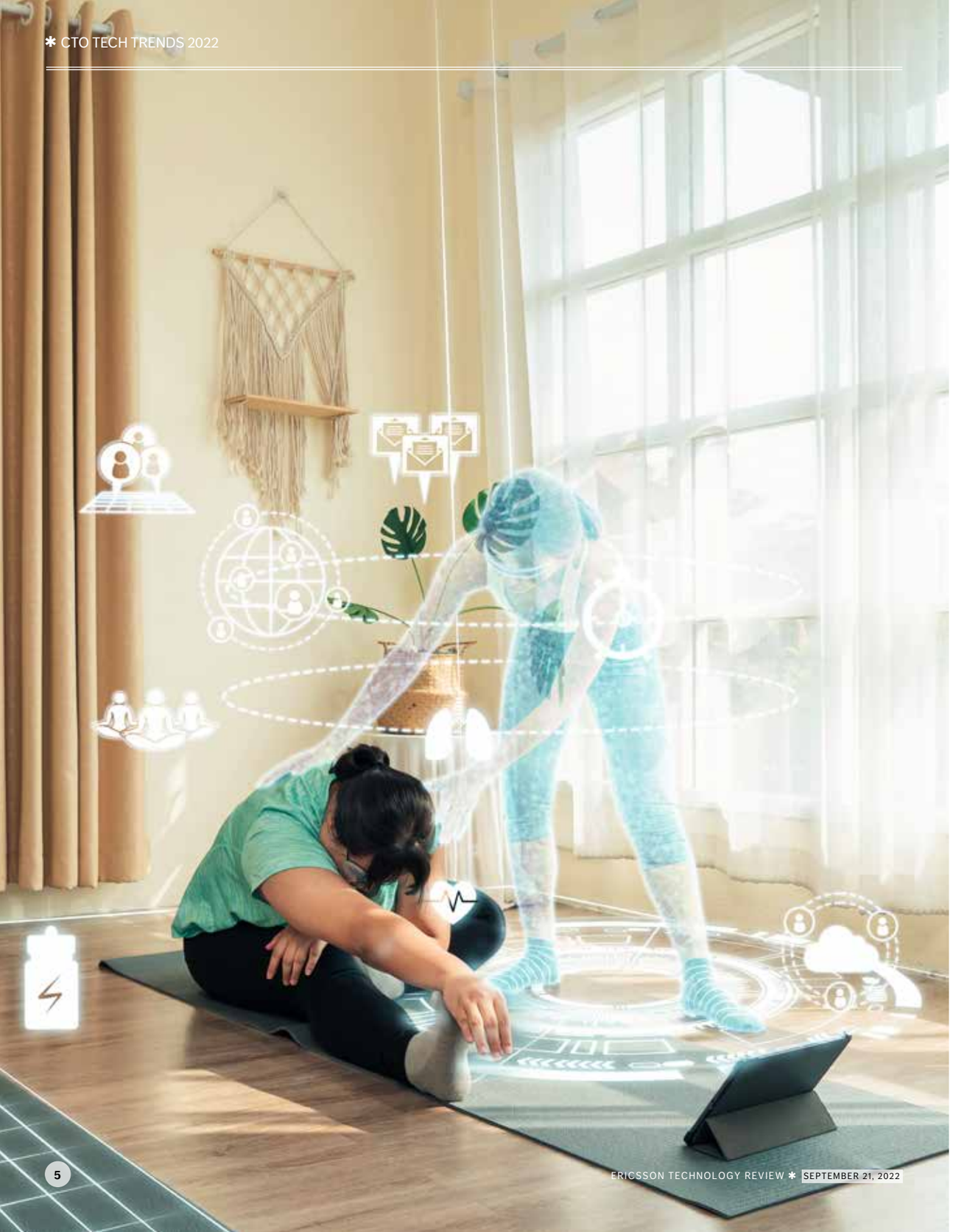
One of the keys to enhanced application innovation is the evolution of network user/developer interfaces through exposed, easy-to-use functions. This includes, for instance, functions that enable productivity, communication, collaboration, gaming and enhanced video. The unified network platform will offer aggregation capabilities that enable interoperability across the actors in the ecosystem to secure unified and global reach. These exposed network capabilities will optimize both application performance and user experience. The developer will have the freedom to select the level of differentiation depending on the application/consumer needs such as quality of experience (QoE), performance, security and privacy.

Architecture

One fundament of the unified network platform is the possibility to aggregate and enhance service exposure from different networks. Examples of exposed functions through open application programming interfaces (APIs) include QoS prediction, spatial information, user identity, service authorization, instantaneous radio coverage and user-density maps. To manage the different service provider network interfaces, the unified network platform will secure aggregation and routing of the exposed network functions. These network functions will be enhanced by integration of other value-adding functions originating from the global ecosystem. This can involve mediation and interoperability functions for spatial rights management, for example.

The network features and services exposed by the unified network platform will enable the developer ecosystem to build and monetize new applications. Exposed services will range from basic aggregated 5G network features, unified communication services, to more advanced services such as guaranteed QoS, real-time gaming, XR conversations and dedicated industry services. Advanced and highly differentiated services that leverage network slicing will be delivered according to service-level agreements (SLAs). The unified network platform will provide a unified software development environment that will lead to a surge in service and application innovation.

The unified network platform will benefit from industry alignment that ensures cost efficiency, faster innovation and industry adoption. In particular, it is important for the industry to align on exposed network capabilities through open APIs for ease of use in the innovative enterprise business development process.



TREND #2
CONNECTIVITY FOR AN IMMERSIVE USER EXPERIENCE

Many network capabilities will need to grow exponentially during the decade ahead in order to unleash the full potential of technologies such as XR, artificial intelligence (AI), the Internet of Things (IoT) and the Internet of Senses. After successfully handling the exponential growth of each previous technology generation, our industry is now investing in evolved 5G and 6G research to meet future requirements.

Industry leadership will require QoE differentiation from the best-effort services that have traditionally dominated the IT industry. Guaranteed QoE requires solutions that span the end-to-end (E2E) ecosystem of device, network, distributed and central compute, and application actors. This calls for collaboration among the different actors in the ecosystem to establish open standards that enable global scale, innovation, interoperability and performance.

Opening the door for extended reality

Starting from more basic functions, XR applications will develop as devices and network capabilities advance. Important application clusters for this evolution involve gaming, entertainment, social communication, retail, shopping and virtual work, for example.

Existing XR applications primarily focus on a single user who is physically present in a predefined static environment with immersive content that is semi-static in the sense that it only partially adapts to the environment, such as attaching to the floor or another flat surface. This will evolve to dynamic environments that contain moving objects and people, which means that applications need to start adapting to such dynamics.

As XR continues to mature, it will eventually be possible for multiple users to be physically present in dynamic environments with content that dynamically adapts to the surroundings. Real-time occlusion of the rendered content will enable a fully spatialized digital experience.

To render the immersive content, the physical environment needs to be replicated in a digital format known as a spatial map. Spatial maps are built on static physical environmental data, such as real estate and roads, overlaid by real-time physical environmental data such as moving cars and pedestrians.

To master the rendering, the spatial map information also needs to include the location and orientation of the application user, including their head movement and foveal area – that is, the area covered by the part of the human eye that is responsible for high-acuity vision.

Network evolution

XR applications will demand new system design optimization across the E2E system of device, connectivity, edge and cloud. For instance, spatial-map compute and rendering distribution will have a strong influence on device energy consumption, weight and size. Spatial mapping and rendering processing will need to be offloaded in order to design iconic devices with eyeglass-style, slim form factor and long battery life. Our research at Ericsson indicates that processing offload of XR applications to the edge reduces device energy consumption by threefold to sevenfold depending on the level of device processing offload.

The move from traditional 2D media to advanced immersive media services increases the informational load, due to the multiplicity of media streams and the increased media quality requirements. It puts high pressure on processing and transmission bitrates across the whole communication chain asymmetrically depending on how the XR use case is implemented – that is, it can impact the uplink, the downlink or a combination of both. For instance, device spatial-mapping compute offload (to edge/cloud) will result in a more symmetric traffic load in the downlink and uplink compared with mobile broadband (MBB) traffic, which is mainly heavy downlink traffic.

To guarantee QoE for XR applications, stringent bounded latency requirements are needed when device compute is offloaded to the edge and the cloud. To reduce the bounded latency requirements smart on-device processing techniques will be implemented, such as asynchronous time warp that transforms network-rendered content to compensate for pose changes between time of rendering and display.

To optimize QoE for all network users, the traffic for XR applications can be separated from other MBB traffic with the help of intent-based network slicing. Further, to ensure that latency requirements are met, time-critical communication features such as radio-access network (RAN) assisted rate adaptation (using low-latency, low-loss, scalable throughput technology) and latency-optimized scheduling will be introduced.

There is a strong relationship between wide-area cellular network coverage, capacity and latency demands. The key parameters for improving wide-area cellular network coverage are allocation spectrum efficiency and inter-site distance. For 2030, Ericsson Mobility Report forecasts a traffic increase that is higher than the expected spectrum gains. As this will not be sufficient to support the forecasted traffic increase, network densification will grow in importance to ensure capacity and increased uplink coverage for limitless connectivity.

The growing differentiation of XR services and the variety of new device types require more intelligent interaction with the network. In a cognitive network, the orchestration of these interactions involves tasks such as device onboarding, connectivity management and QoS policy selection. The network must have the ability to distribute actions among devices, the RAN, core, edge and application to dynamically secure the QoE with minimal E2E resource utilization. A first step in this direction is the Dynamic End-user Boost developed by Ericsson, a smartphone app that enables the user to dynamically optimize QoE.

TREND #3
THE QUEST FOR HIGH-PERFORMING NETWORKS

As the digitalization process continues to advance, many human experiences are going to become much more immersive. For example, the work-from-anywhere experience will connect colleagues from separate locations as if they are physically present in the same environment. The digitalization of industries will leverage a digital representation of the complete physical operations – known as a digital twin – to improve operational technology applications. The evolution toward fully autonomous vehicles is another excellent example of the ongoing transformation that is happening all around us. Network deployments that deliver dynamic, adaptable and distributed connectivity services are essential to support all of these advancements.

Moving beyond best-effort connectivity

A key element of future connectivity services is global and pervasive coverage, both indoors to outdoors, that can meet the requirements of society-critical MBB, as well as mission-critical and business-critical applications for enterprises and industries with extreme radio access performance at selected locations. This connectivity also includes seamless service delivery between, for example, private and public networks or terrestrial and non-terrestrial networks.

The connectivity requirements will vary in terms of performance, with some use cases requiring close to zero consecutive packet losses and connectivity that is always on. Such time-critical and bounded latency applications require several times more radio resources than typical MBB served by public networks today. The combination of a high-performing network with reliable and deterministic processing in the edge (or the cloud) will make it possible to offer E2E guarantees to critical applications.

Such high-performing networks also imply network solutions with downtime that is near to zero. It is critical to consider all network nodes and segments to identify and address weak points to improve the characteristics for E2E services. E2E availability and resilience management will be provided through an application-aware network that dynamically orchestrates the provisioning according to the agreed QoS.

Trustworthy networks

By the end of this decade, billions of IoT assets, products and machines will be connected all around the world. Ensuring efficient, secure and low-cost deployment and operation throughout their 10-20 year lifetimes requires a fully automated process that can handle devices in bulk. The use of cellular credentials such as eSIM and iSIM as a single root of trust will be key to ensure global reach.

As resources and applications become more distributed, requirements on security are increasing. The need for E2E solutions to meet customer and regulatory security demands is growing quickly. To address this, all identities must be authenticated and authorized in the distributed E2E link of cloud-network-device-application-user. The best way to facilitate this requirement is by implementing a zero-trust architecture and control based on the principle of "never trust, always verify." Zero-trust solutions heavily rely on intent-based automation built on AI techniques such as machine learning and machine reasoning.

PROOF OF CONCEPT FOR 5G-ENABLED INDUSTRIAL ROBOTICS

Within the Ericsson 5G-SMART project, leading global technology company ABB and Ericsson have demonstrated how large parts of the control of industrial robots can be offloaded to a digital representation of the robot and its surroundings in an edge compute environment that is connected to the (mobile) robot via a high-performing 5G network. Key robotic tasks such as action planning, localization, mapping, motion planning and navigation are executed in the edge. A machine vision system on the shop floor can be connected to the control of a mobile robot in the edge cloud to enable precise robotic actions with sub-centimeter precision to support actions such as docking a mobile robot at a target station and performing pick-and-place operations.

Conclusion

Digitalization offers unlimited opportunities to individuals, enterprises and society by enabling powerful new solutions that provide mission-critical services, immersive communication and the omnipresent Internet of Things. The successful rollout of these use cases – each with its own unique benefits – will have a direct correlation to the performance of the digital infrastructure that they use. Performance is a major competitive differentiator and, as such, represents a first-mover advantage for communication service providers.

Limitless connectivity, trustworthy systems and cognitive networks are the main differentiation pillars of evolved 5G and 6G. Going beyond connectivity, evolved 5G and 6G will become the trusted platform for intelligence, compute and spatial data, encouraging open innovation and serving as the information backbone of society, industry and enterprises.

A unified network platform is the most efficient system to deliver the performance, quality and scale required to enable universal metaverse mobility, as well as being the most affordable communication solution for humans and machines in any reality. Another major advantage is that the digital infrastructure is already an integral part of the digital economy today, providing a broad range of services and business logic to the ecosystem.

At Ericsson, it is our firm belief that the best way to build a trustworthy and scalable digital infrastructure is through business-driven investments and long-term collaborations between ecosystem actors. With this in mind, we are committed to substantially investing in research and development in evolved 5G and 6G, as well as engaging in deep and long-term collaborations with customers, vendors, enterprises, industries and society at large. Together we will make the unimaginable possible, and create a world where limitless connectivity improves lives, redefines business and pioneers a sustainable future.

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.

Further reading

- **Ericsson Technology Review, Five network trends towards the 6G era, available at:** *https://www.ericsson.com/en/reports-and-papers/ericsson-technology-review/articles/technology-trends-2021*
- **Ericsson Technology Review, Holographic communication in 5G networks, available at:** *https://www.ericsson.com/en/reports-and-papers/ericsson-technology-review/articles/holographic-communication-in-5g-networks*
- **Ericsson Technology Review, Service exposure and automated life-cycle management: The key enablers for 5G services, available at:** *https://www.ericsson.com/en/reports-and-papers/ericsson-technology-review/articles/5g-service-automatation-key-enablers*
- **Ericsson Technology Review, End-to-end network slicing orchestration – a key enabler for industry-vertical use cases, available at:** *https://www.ericsson.com/en/reports-and-papers/ericsson-technology-review/articles/end-to-end-network-slicing-orchestration*
- **Ericsson Technology Review, XR and 5G: Extended reality at scale with time-critical communication, available at:** *https://www.ericsson.com/en/reports-and-papers/ericsson-technology-review/articles/xr-and-5g-extended-reality-at-scale-with-time-critical-communication*
- **Ericsson, 5G-SMART – a research collaboration for 5G in manufacturing, available at:** *https://www.ericsson.com/en/cases/2021/5g-smart*