TECHNOLOGY TRENDS DRIVING INNOVATION

– *five to watch*

Our industry has an increasingly important role to play in creating the foundation for new business in a broad range of industry sectors in countries all around the world. As Ericsson's new Chief Technology Officer, it's my job to keep track of technological advancements on the horizon and leverage them to create new value streams for society, consumers and industries. The challenge is timing, and to see new things in the context of the present without losing sight of history.

I have selected the five trends presented here based on my understanding of the ongoing transformation of the industry, including rapid digitalization, mobilization and continuous technology evolution, and how they affect the future development of network platforms – one of the essential components of the emergent digital economy. At Ericsson, our role is to keep these top trends in sight to guide our innovation, test our limits and ultimately create a thriving market for the next generation of technology. →

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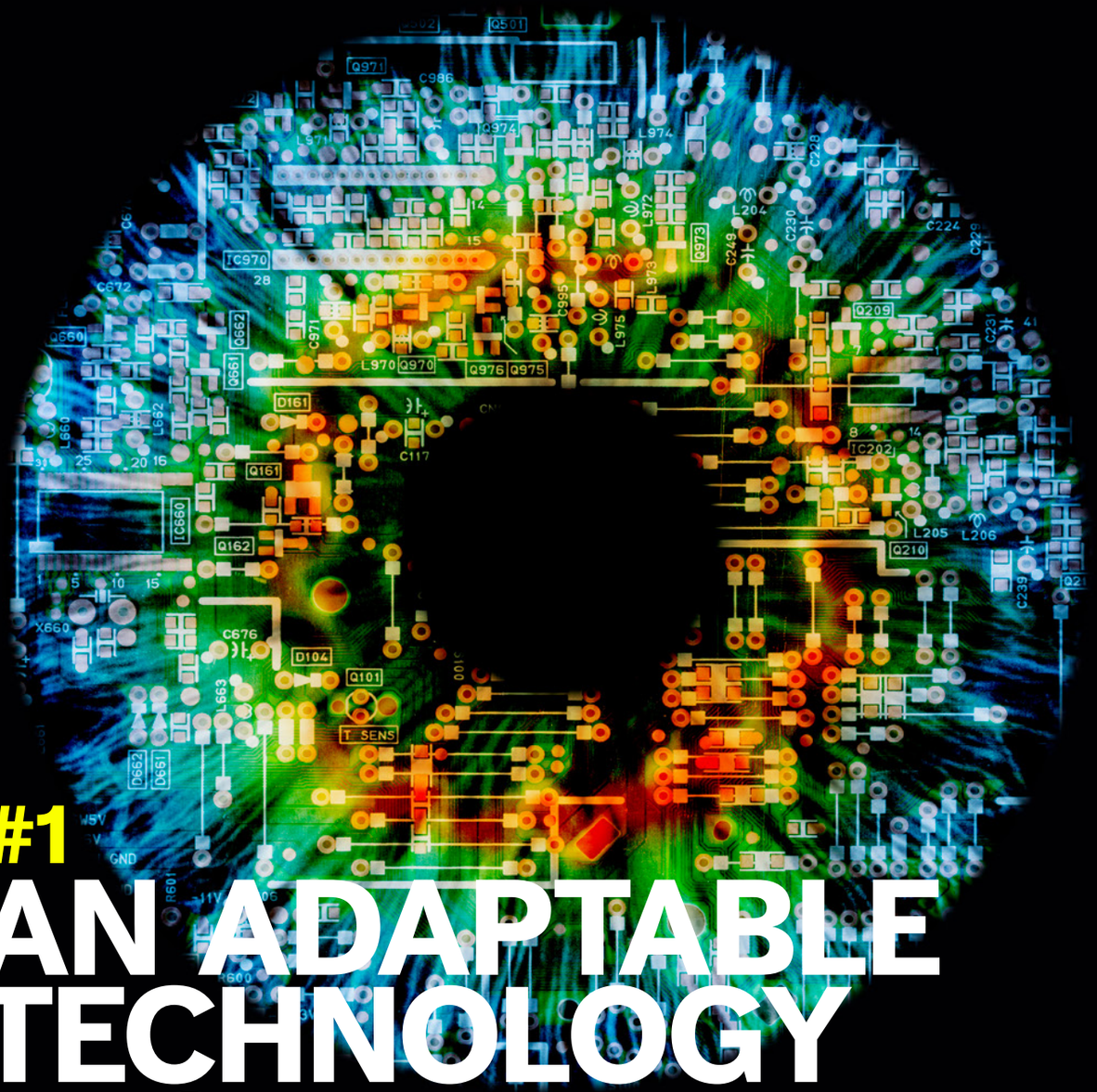

#1 AN ADAPTABLE TECHNOLOGY BASE

TO RELEASE the full potential of the digital economy, the underlying technology components will rely on a symbiotic evolution in the software and hardware dimension. It is in the lowest layers of the technology stack – at the intersection between software and hardware – where more powerful and flexible solutions will become available, enabled by virtualization technologies and horizontal architectures.

ARCHITECTURAL ADJUSTMENTS AHEAD

Geometrical scaling has long been the main path for the transistor technology evolution but extensive research is currently underway to find alternative methods to increase transistor performance. Significant efforts are being put into building more advanced architectural structures, such as various types of non-monolithic integration technologies, to increase integration and thereby maintain the performance evolution track.

In the computing domain, the dominating CPU architecture trend is massive multicore to meet parallel processing demands. With more processors on a chip, memory architectures and data transfer will become key technologies in hardware. Non-volatile memory and integrated silicon photonics will reach maturity and change the entire memory/storage hierarchy. The new technologies are expected to have significantly higher performance as well as lower latency and energy consumption.

To further enhance computational power and performance in data centers, specialized resources such as smart network interface controllers, general purpose graphics processors and field programmable gate arrays will be made available for virtual applications through abstractions. A similar co-processing architectural approach can be expected for quantum computing.

The rapid advances of base components will mean that the first exascale systems with computing power at double the capacity of today's top 500 computers combined can be expected within five years.

In combination with specific types of algorithms and applications, these technology shifts could prove to be disruptive.

SPURRING INNOVATION THROUGH ALGORITHM EVOLUTION

Massive data collection from, for example, IoT sensors will drive the need for new predictive software algorithms that also take advantage of the increasingly parallel computational power. Algorithm development will play an even more significant role in software design. One example is deep learning, a branch of machine learning that uses a layered algorithm structure to learn hierarchical concepts.

The amount of code needed to reach a higher level of complexity is very small, a reduction by a factor of 10 or more, compared with traditional software system approaches. This type of system learns from examples: it utilizes a generic algorithm that uses the examples to set parameters in the algorithm to fit the particular task at hand.

Reinforcement learning is a technology to develop self-learning software agents, which can learn and optimize on an observed state of the environment and a reward system. This enables development of self-learning systems that require neither human intervention nor hand-engineered, threshold-based policies.

ENABLING THE FUTURE COMMUNICATION SYSTEM

From a connectivity perspective, one interesting area is beamforming in future 5G networks, where symbiosis of software and hardware plays an important role. At mm-wave frequencies, hundreds of antennas and transceiver chains work together with advanced control algorithms to generate, form and steer radio waves in real time to accomplish multiuser MIMO (multiple-input, multiple-output). Each device is accessed by a single user dedicated beam to optimize network and user capacity, efficiency and quality.

At Ericsson, we are currently investing in a variety of collaborative efforts with academia and the technology industry to foster an open environment in which to share ideas and visions that will enable the most successful future network from both a societal and individual human perspective. ✪

#2 THE DAWN OF TRUE MACHINE INTELLIGENCE

ARTIFICIAL INTELLIGENCE (AI) first emerged in the early 1950s when symbolic logic and rule-based systems were used to generate logical conclusions. Another important step included artificial neural networks, capable of performing pattern recognition by learning from data through iterative optimization. The advancements in these computational-intense algorithms have progressed in performance and cost through the evolution of computing power, data availability and connectivity.

Machine intelligence (MI) combines machine learning and AI methods to create data-driven intelligent, non-fragile systems for automation, augmentation and amplifications. MI is about the ability to augment human intelligence. Humans will be empowered by an ecosystem of sharing data and insights, with support from digital assistants guiding and augmenting human awareness. MI will create a new type of autonomous coaching environment where humans and machines can train and mentor each other. This situation is comparable to a teacher in a classroom guiding, mentoring, discussing with and learning from the students.

MI will help us understand and accomplish things we never would have discovered by ourselves. It establishes a whole new foundation and potential for innovation, with the ability to be much more influential than industrialization.

Human-machine communication will further evolve toward a multifaceted communication platform that includes capabilities such as situation and social awareness. A deeper dialogue between humans and machines will emerge, moving beyond cognitive intelligence toward augmented human intelligence.

SIMPLICITY THROUGH ANALYTICS AND AUTOMATION

Among the many tools in the MI toolbox is analytics – covering everything from straightforward analytics over multiple nodes and petabytes of data, to complex multidimensional analytics on parallel processor systems. Today, analytics is often a human-involved process that requires the consideration of several aspects, including how to handle data volumes, data speed and the multitude of data types.

An example of complex event process handling with a massive amount of real-time data is electronic trading. This type of tool is capable of handling, analyzing and drawing conclusions based upon millions of messages per second. From a network perspective, we will see these types of use cases further substantiated by the evolution of the IoT. Connected cars and other types of connected devices will come online, providing more use cases that require real-time messaging from a variety of decentralized data sources.

Jettison and metadata are essential to handle the huge variety in data structuring. Automating these tasks is of great importance to any enterprise with digital aspirations because human-intense interventions are not scalable.

Automation is best described as a closed-loop system. The automation closed loop refines system intervention depending on recorded impact, with minimal latency. The intervention is updated based on feedback on the system performance. The closed loop introduces the necessary changes without human intervention, based on performance goals defined by humans.

We are entering the era of early enablement of sentient MI that can be used to create digital attention, agile memory and goal management.

NETWORK EVOLUTION BRINGS MUCH MORE THAN RAW DATA

Over the next decade, industry and society will establish a foundation of insight-driven systems leveraging MI technologies. New service engagements will emerge, driven by predictive modelling and automated operations. Furthermore, a variety of deployment models serving different use cases will emerge, such as pure cloud-native applications, on-premises data center operations, and distributed deployments across multiple sites. All of this will be beneficial to many digital businesses and industries.

Analytics, MI and automation capabilities will be an integral part of future networks, substantiating innovation from network operation to new business opportunities within the IoT, for instance. ✪

#3 END-TO-END SECURITY AND IDENTITY FOR THE IOT

WHILE THE IoT is undoubtedly full of promise, there are still concerns about the proper handling of security and privacy, especially within mission-critical industries. Cybersecurity threats are emerging rapidly at the same time as the volume of the connected devices and software is increasing. It is more essential than ever to take a comprehensive approach to security and privacy that ranges from devices and gateways with connectivity to the cloud, IoT platforms and applications; chips to services; and development to operations. The need for industry-wide and cross-industry collaboration must also be taken into account.

This comprehensive approach includes end-to-end management of security and privacy that provides predictive security insights and, in many cases, automated adjustments based on policies. Security and privacy are not things that can be added on; they must be fully integrated into domains and components, processes, storage and communication.

A SYSTEM BUILT AND ENABLED BY TRUST COMPONENTS

The comprehensive approach to security and privacy will be based on an industry-wide agreement on how to secure trust in development, deployment and operations. It will include security and privacy enabling development tools, along with tools for automated and secure deployment. It will also include operations that provide direct feedback to development, continuous compliance monitoring, and in many cases, automated, policy-based security and privacy orchestration that considers the constantly changing threat, vulnerability and trust landscapes.

In the coming years, identity management technologies will continue to be in the spotlight – along with technologies that enable trust in business-critical data and privacy-related personal data. Blockchain is an emerging technology that has potential in this regard. Security analytics and machine learning technologies will provide security insights about threats, vulnerabilities and security status. System integrity will be based on root-of-trust technologies that enable trustworthy hardware and software components.

The trust-enabling security and privacy technologies implemented in devices should be cost-effective and highly scalable. Mission-critical industries in particular will require high trust in security and privacy, as well as the ability to meet tight time constraints.

A COLLABORATIVE INDUSTRY EFFORT

As a part of the comprehensive security and privacy approach, collaboration in threat, vulnerability and trust exchange will increase. Different industry players can contribute to the collaboration within their area of expertise.

Greater transparency will boost trust, which will in turn boost IoT adoption and accelerate digitization in mission-critical industries. The comprehensive approach to security and privacy together with industry-wide collaboration, joint trusted development and standardization will be essential trust enablers. Since network service providers are ranked among the most trusted industry players (according to sources such as the 2015 Accenture Digital Consumer Survey), Ericsson is committed to helping them play this key, trust-building role across multiple industries.

#4
AN EXTENDED DISTRIBUTED IOT PLATFORM

THE TECHNOLOGY shifts that the IoT brings will transform the technology industry in unprecedented ways. Networks will facilitate transactions, operations, logistics and the like, and simultaneously collect and analyze data, enabled by a cloud-based network infrastructure that connects machines, vehicles and devices. The race is on to develop and expand the capabilities of an industry-wide IoT platform. New business opportunities will be born through cross industry-society engagements.

An industry-wide IoT platform will be made up of decentralized devices ranging from simple passives to autonomous devices that are connected and communicating through a distributed cloud with a horizontal application and management platform. It is a distributed system, where insights are aggregated from the edge toward the center and regulated by policy and security settings that are specific for each application and use case. This is a multi-cloud based infrastructure, where a combination of public and on-premise solutions connect and serve any type of IoT-related service from near-product to software-as-a-service.

The Industrial IoT (IIoT), a branch of the IoT that is optimized for industry-specific use cases with enterprise connectivity, is also emerging. Production flexibility is enabled by system functionalities that have both specific nomadic and mobility capabilities. Everything centers around different aspects of logistics – not only from a physical perspective but also around information flow and data streams. By setting policy roles, network slices are created, defining what is allowed for each specific use case. Secure handling of information is essential, so that data can neither leak in or out of the system.

SEMANTIC INTEROPERABILITY TO SECURE FUNCTIONALITY GROWTH

Devices come with different monitoring, management and security functions. Robots in warehouses, for instance, require position tracking and coordination and delivery functions. Simple home automation solutions use cloud-based applications that are centrally connected to other information flows, such as weather forecasts, traffic cameras and so on. A connected vehicle cloud includes functions such as infotainment, over the air upgrades, telematics, remote control, vehicle safety and security, fleet management and emergency services.

Pre-provisioned devices are one of the building blocks that enable an IoT platform that can grow in functionality as new device types connect to the network. The first time these devices "wake up" and connect, they inform the system who they are, what they can be used for and what they are capable of. The system is further enhanced by zero touch provisioning, including fully automated device cycle management.

Devices become an integral part of the future network and incorporate connectivity among clusters of devices through a combination of wireless and wired access technologies. The wireless connections are based on both wide area and short range technologies.

SEMANTIC APPLICATIONS AND SERVICE SOLUTIONS

The extended distributed IoT platform brings major opportunities to the business landscape when enabling a wide range of new digital services. It's also a model that moves from traditional heavy capital investments toward an operational-expenses-centric model. This is manifested through an adoption and evolution of various types of "as a service" models.

A full palette of new flexibility is brought into the market as pay-as-you-go/use/grow enables SMEs to offer far better services than they do today. These services include proactive and predictive maintenance, where the service improves over time as a result of the ability to learn from data.

Ericsson's IoT-related engagements range end to end. For example, we are examining how access technologies can be optimized for various types of IoT use cases such as NB-IoT (NarrowBand IoT) to reduce power consumption and cost. Ericsson is also investing heavily in the evolution of LTE and the enablement of 5G networks to extend the range of addressable IoT use cases and applications. Additionally, we are working to create cross-industry engagements such as 5GAA to connect the automotive and telecom industries (including devices) to develop end-to-end solutions for future mobility and transport services. It is vital for a healthy, evolving market to have industry-wide standards that reduce fragmentation, which would otherwise hamper IoT market adoption.

#5
OVERLAYING REALITY WITH KNOWLEDGE

IN THE LAST couple of years, many devices capable of rendering immersive experiences have reached the consumer market. The virtual reality (VR) market has mainly been driven by the gaming industry but the technology has now been picked up by studios and other content creators. Augmented reality (AR), which offers a user experience that connects to the physical location, is also becoming popular. Real-time information is overlaid on whatever the user looks at, which enables the user to understand reality in greater depth.

AUGMENTED KNOWLEDGE VIRTUALLY EVERYWHERE

One example of AR is a task-based digital assistant that simplifies complex tasks with real-time guidance. This type of system is able to provide feedback as soon as a mistake is made by an operator or field service engineer. The feedback helps the practitioner become more knowledgeable and take immediate action to fix the mistake.

Another promising use case combines VR and AR services. In this scenario, a user is assisted by a remote technician to solve a difficult problem. The user shares a real-time video of the surroundings with the remote technician. The technician analyzes the video and instructs the user on how to solve the problem by sending audio and overlaid graphics to the user's AR glasses.

Within the area of AR, a wide range of use cases emerge besides remote mentoring. Many practical applications are also recognized in digital industrial workplaces, which are sensor-rich environments with networked machine and computational power available for analytics of sensor and machine data. Objects that are currently offline can easily be connected and augmented through computer vision technologies. This is an extension of immersive applications in a typical IIoT scenario that provides increased productivity through improved uptime, quality and safety. Additional support tools within IIoT include visualization of data, document navigation and employee training.

PUSHING TOWARD REALITY PARITY

The technology evolution for immersive solutions requires a wide range of tools and infrastructure. These tools include display technology, real-time eye tracking, volumetric capture, perceptual computing for locations and surrounding positions, body movement and more. High-resolution cameras, microphones, GPS, gyros, connectivity, battery, voice and gesture control are also examples of components included in the concept. Compared with today's smartphones, the obvious difference is within the man-machine interaction.

Over the next decade, computer vision will get better through 3D mapping, improved field of view, full-color depth and holographic technologies. With improved compute capabilities comes reduced disturbances from latency and rendering. VR is expected to reach parity with reality and thereby enable true 3D communication.

VR and AR are compelling use cases for 5G because they require high data rates and low latency. Change of viewport when turning the head requires low latency or the user will suffer vertigo. Motion to photon delay should be less than 20ms. End-to-end delay and latency requirements are key to providing a pleasant user experience. Bandwidth may become high (for the uplink video) depending on the use case.

Unfortunately, the current VR/AR market is fragmented with many verticals for different cameras, workflows and headsets. To address this issue, Ericsson became a founding member of the VR Industry Forum, which creates guidelines and interoperability along the entire end-to-end chain. The scope is to further the widespread availability of high-quality audiovisual VR and AR experiences for the benefit of consumers.