

Mobile transport evolution

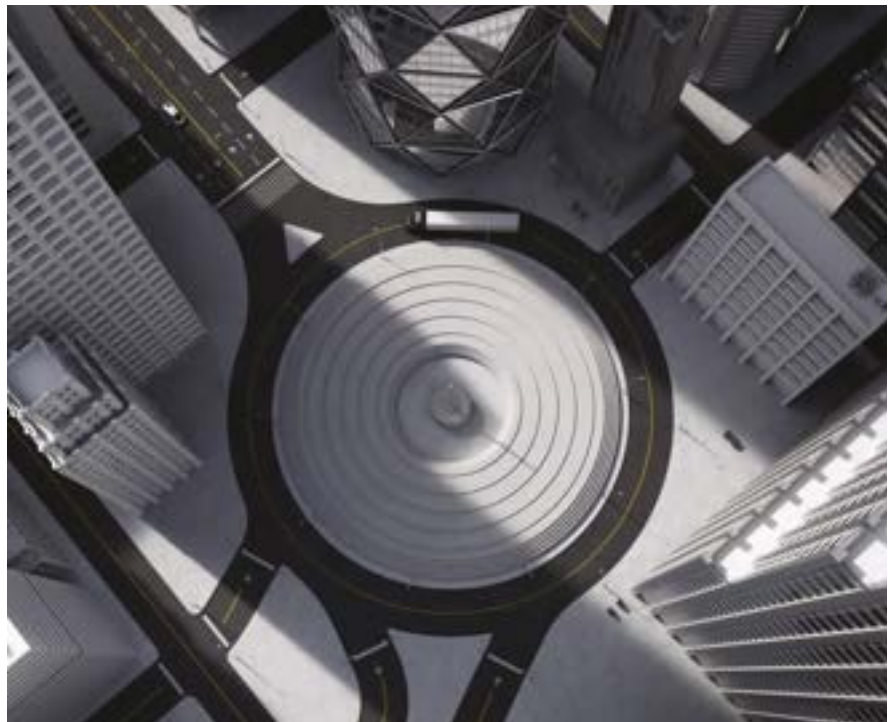
How end-to-end integration will deliver more capabilities, more intelligently, more cost-effectively



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Current network architecture needs to evolve to meet the needs of the wide variety of use cases enabled by 5G technology. As part of this, the transport network must evolve and scale efficiently to meet widely varying, but strict, requirements for performance, capacity, latency, and security. It must also support the various needs of parallel network architectures and technologies, and seamlessly support the coordination between many more cell sites, including those that will coexist with 4G technology for many years to come.



Introduction

Mobile networks are evolving to serve Gbps-plus connections, widely varying use cases, and multiple new device types, over a growing range of radio frequencies. This demands a new approach to radio access network (RAN) architecture and the underlying transport network. Traditional 2G, 3G and 4G network architectures need to evolve and the radio-near transport network needs to support this evolution. The sheer number and variety of new 5G-enabled use cases mean transport architectures must also evolve end to end, from access to core.

New 5G use cases include Gbps-plus enhanced mobile broadband, Fixed Wireless Access (FWA), and critical and massive Internet of Things (IoT), to name a few. Serving these successfully needs a transport network that can handle not only a huge increase in traffic, but also the wide variety of network characteristics for each

specific use case. For example, critical IoT uses cases will demand ultra-low latency connections, while others have more relaxed requirements on latency.

Radio network performance will depend heavily on the ability of the transport network to meet differing needs for capacity, latency and quality of service in a highly flexible, responsive, automated, integrated and cost-efficient way. Operators will need to be able to manage and orchestrate their networks end-to-end – all the way from radio access, through fronthaul and backhaul, to the aggregation and core networks.

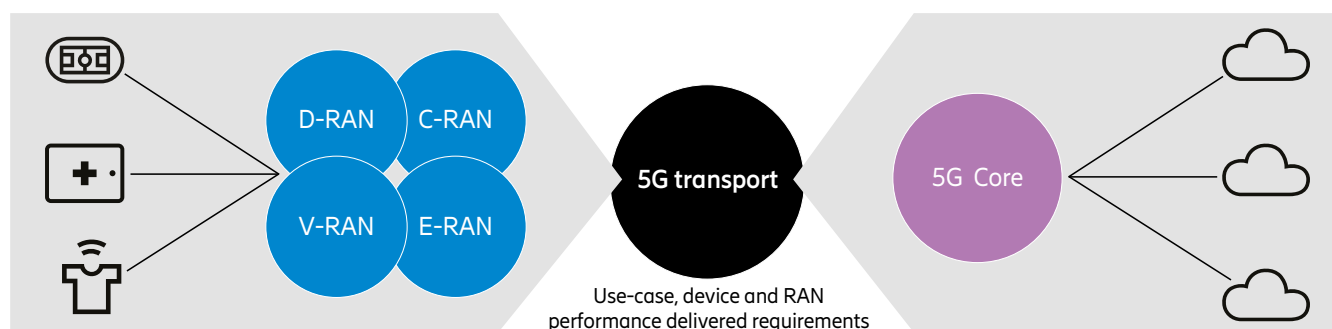
End-to-end security has never been as high on the agenda as it is in 5G. Transport networks play a key role in this: secured end-to-end transmission is crucial for many of the new services 5G will cater for.

5G networks will also have several RAN architectures running in parallel – distributed, centralized and virtualized (D-RAN, C-RAN and V-RAN) – with multiple interfaces for the transport network to handle, including connectivity back to the next-generation core.

The transport network will also need to support a range of new radio capabilities, including larger spectrum, coordination services and new radio functionality, such as Massive MIMO. Higher capacities will be required for most 5G fronthaul and backhaul networks, as well as edge and core networks, while coordination services and some radio functionality will demand improved latency.

In short, for 5G the transport network becomes the ubiquitous 'glue' that delivers high-performance IP-based connectivity, both for radio functions and for 5G services, end to end.

Figure 1: Transport infrastructure is critical to secure best 5G performance



The Challenge

5G transport challenges

The shift from classic LTE to LTE Advanced and 5G networks creates new demands on transport. Transport networks designed with a 5G vision will need to evolve in harmony with advanced LTE needs, and enable a smooth transition for network operators from 4G into 5G even as traffic levels rise.

As the part of the network that carries traffic between radio base stations and the core network and data centers, the transport network plays a crucial role in delivering the benefits of LTE Advanced and 5G radio networks:

- It must be able to handle ever-more capable user devices and the huge increase in traffic enabled by 5G.
- It must meet the needs of a growing range of services and new business models.
- It will also need to handle radio networks with many more cell sites, significantly higher capacity demands, and features such as multi-site coordination and centralized RAN architectures.

Operators need to address five key transport challenges as they roll out 5G: capacity, connectivity, capability, complexity and cost.

Capacity

Higher traffic demands from subscribers in the radio access network translate into higher traffic demand in the transport network – overall throughput increases and throughput per site increases. High backhaul demand drives the need for access to more fiber or new spectrum and more efficient techniques for microwave transmission.

As peak user connection speeds rise above gigabit-per-second levels, Ericsson predicts a global average five-fold increase in traffic volume by 2024, with even faster growth in video traffic, which will constitute 73 per cent of traffic volume by 2024. [Source: Ericsson Mobility Report 2018/11]

Transport networks need the flexibility to meet high long-term traffic growth through scalable investments. The challenge will be how to right-size the initial deployment and cost-effectively grow to meet added demand.

Connectivity

The increasing number of radio sites will drive the number of termination and access points for transport. Densification resulting from the increased bandwidth demands and the deployment of smaller cells (using higher-frequency spectrum), will mean a three- to four-fold increase in cell sites in new locations. This will, in turn, demand a high density of high-capacity interfaces.

In addition, 5G will introduce a multitude of new interfaces supporting new radio functions. Furthermore, cloud distribution in the 5G core will mean even more connection points.

The shift from LTE to 5G is a game-changer for transport: the increasing traffic volume and the significantly higher capacity demands in radio cells supporting enhanced radio functions, the growing range of services and new business models all require operators to rethink their mobile transport strategies.



The driving factors for the changes in 5G mobile transport

Traffic growth	At least eight-fold growth in global traffic by 2023	<ul style="list-style-type: none"> — Significant increase in overall transport network capacity — Need for more fiber and/or more microwave spectrum — Need for flexible solutions that scale without high up-front cost
Densification	Significantly more radio sites, for example for mmWave	<ul style="list-style-type: none"> — More transport termination points, each serving more traffic — Increased complexity
Multi-point connectivity	Devices connect to multiple transmission sites	<ul style="list-style-type: none"> — More inter-site coordination over low-latency connections
Architectural change	C-RAN, V-RAN and distributed cloud	<ul style="list-style-type: none"> — More complex traffic patterns with a shift away from single access sites and centralized core — Beamforming processing at the radio combined with eCPRI will increase use of fronthaul — Network slicing and distributed cloud computing mean more dynamic traffic patterns and more meshed connectivity — More complex planning and dimensioning
Multiple services	Shift from MBB to eMBB, FWA, and massive and critical IoT	<ul style="list-style-type: none"> — Higher demands to support different quality of service traffic — More diverse service needs on a common infrastructure — New service demands for widespread delivery with low latency

The flexibility and the dynamic nature of E-RAN and V-RAN drive the need to add or remove transport connectivity as needed. Coordinated multi-point transmission will drive the need for inter-site communication with low latency.

Since 5G is expected to support a multitude of new use cases, with varying transmission characteristics, virtualization in both the 5G core and 5G transport is key to efficient and dynamic resource utilization.

All these factors imply increased connections, scalability and flexibility in the complete 5G transport network.

Capability

New capabilities are needed in the 5G transport network to serve new use cases and radio functions such as coordination and MIMO with beamforming. These include low latency and improved synchronization, especially in the fronthaul network.

5G networks demand a new approach to security. Ever-increasing threat volumes and attack sophistication – including

zero-day attacks, advanced, persistent, targeted attacks, and adaptive malware – are driving the need for more robust mobile network security.

With the increases in connectivity, virtualization and disaggregation in 5G, there will be a greater number of connection points and a greater need to adapt to the dynamic nature of service handling. The transport network will require new capabilities that increase agility and flexibility and serve a more distributed mobile network architecture.

Complexity

The overall complexity of the transport network will be increased by the number and variety of new use cases, the increased number of connection points, and the co-existence of different radio technologies and architectures. The shift from MBB to multiple services drives the need to support different quality of service requirements. Deployment of V-RAN, network slicing

and distributed cloud will lead to more dynamic traffic patterns and more complex connectivity demands.

Cost

Complexity always comes with a cost penalty, and this needs to be resolved to make 5G business profitable.

In summary, the advances enabled by 5G technology cannot be handled cost-effectively simply by adding more capacity to the existing infrastructure. The old model of having separate layers of functionality, with physically separate equipment, connected by multiple rigid interfaces, is not sustainable in the 5G world. The transport network needs to become more integrated with the radio access and core parts, and TCO-optimized solutions are needed to manage costs.

A fundamental shift in thinking is required: one that breaks the traditional linear relationship between network performance and cost.

The Solution

Ericsson's end-to-end 5G transport platform

As they roll out 5G networks, operators will gain an advantage through deploying purpose-built, end-to-end transport systems that support simplicity, scalability and flexibility in mobile networks, whatever topology they choose to deploy.

Ericsson has thought through the transport challenges operators face as they roll out 1Gbps-plus LTE Advanced and 5G, and has developed a 5G transport portfolio that addresses these transport-specific challenges, in a way that is fully aligned with our radio portfolio.

Although transport must evolve end to end to meet the needs of new 5G use cases and efficient resource handling, the transport domain that will be most affected by the 5G challenges is the radio-near fronthaul and backhaul networks. Here, the new radio interfaces and functions, as well as increased capacities, will have the biggest impact.

New end-to-end demands, which also affect the edge and core parts of the transport network, include capacity, latency, security, scale and slicing. Network slicing, in particular, is an important technology for future 5G services and it places additional demands on the 5G transport network to enable the hundreds of anticipated 5G use cases.

To build an efficient 5G transport network, a complete transport toolbox is needed to meet new RAN requirements and handle the different deployment options in the most scalable, economical and flexible way. This will contain an extensive fiber and microwave product portfolio which enables operators to deploy the right combination of technologies to serve changing needs most cost-effectively.

To ensure flexibility, operators can deploy a combination of fiber and microwave transport technologies: fiber where multiplexing of different services offers cost-efficient and low-latency transmission for fronthaul; microwave where fast, flexible deployment is needed,

but still with 5G-ready capacity with low latency over the air.

For network slicing, the transport network needs to be able to offer end-to-end capabilities, including extensive quality of service support, segment routing, Layer 3 VPN services and security.

Building a network with best-in-class components does not necessarily deliver a best-in-class result, especially with the added demands on 5G transport. It is especially important to consider how the building blocks are managed to work together most efficiently end to end. Cross-domain orchestration is needed to deliver network slice awareness and assurance, which ultimately dictates the end-user experience and performance.

Our end-to-end 5G transport solution is built to address these challenges, supporting operators in the transformation of their transport networks.

Managing capacity growth

Transport capacity needs have grown continuously over time, and will continue to grow with the roll-out of 5G. In particular, increased spectrum needs, Massive MIMO and increased spectrum efficiency are driving the need for higher backhaul capacity.

There is a clear inflection point approaching in capacity growth beyond which current transport architecture will not be able to manage the new load, and transport modernization will become a necessity.

For example, 10 Gbps baseband interfaces and cell peak capacities beyond 1 Gbps are placing new requirements on transport equipment. New 10 Gbps interfaces are needed on cell site devices with higher switching capacities, while 100 Gbps speeds and beyond are required higher up in the backhaul and in the aggregation network.

The 5G backhaul capacity 'map' is expected to be roughly the same as today, with around one-fifth of sites needing high capacity, and the rest optimized for coverage. The high-capacity sites serve the

majority of consumers in urban and dense urban areas, meaning they will have the most urgent need for transport capacity. By 2025, the expected D-RAN backhaul capacity at these sites will be around 3–5 Gbps, while the coverage-optimized sites are expected to require around 600 Mbps. Fulfilling these requirements in the most flexible and efficient way will likely demand a combination of fiber and microwave transmission in the backhaul domain. For microwave, E-Band will become more widely used as a stand-alone solution for 10 Gbps, as will multiband solutions together with the traditional frequency bands.

Building an efficient 5G transport requires a broad set of equipment in terms of a complete toolbox: purpose-built products for 5G radio, offering flexibility in transmission technologies and a set of capabilities to support best-in-class radio performance.

In densely populated and high-traffic locations, moving from the traditional distributed (D-RAN) to centralized (C-RAN) radio architecture will help operators achieve the best balance of radio performance and coverage, service quality cost-efficiency.

Baseband centralization requires fronthauling, meaning this interface will also be affected by capacity growth in radio. Massive MIMO is driving a shift from CPRI to packet-based eCPRI, which can reduce traffic volume on fronthaul connections by as much as 75 percent, helping to manage the growth in data traffic as the number of antenna elements increases.

Capacity demands in 5G core networks will follow those in backhaul networks. In the near- or mid-term, however, such capacity demands are expected to be moderate where 5G is deployed in co-existence with established 4G networks.

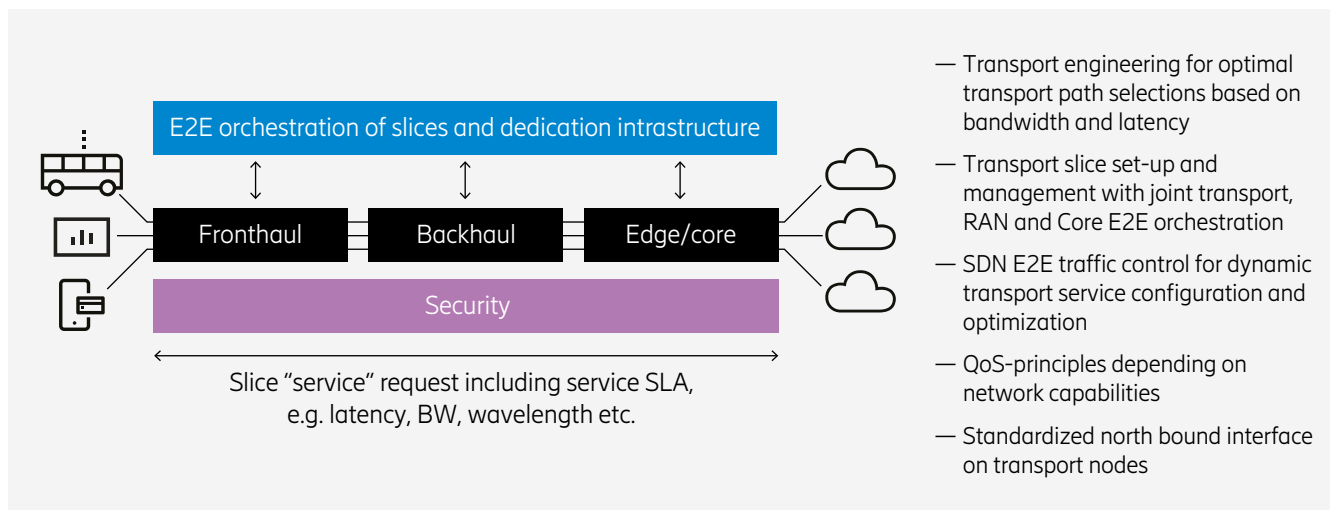


Figure 2: All components are designed to enable efficient network slicing

Handling increased connectivity

5G will be deployed in both existing and new frequency bands. With existing bands and mid-band (3.5 GHz), operators can mostly reuse their current network grids, although some additional sites, using either mmW or mid-bands, may still be required to provide full 5G coverage.

5G will nonetheless have a significantly higher need for connectivity, and the transport network needs to support this. New 5G coverage does not just mean new connections points, however. With the evolution of LTE and the introduction of 5G NR, there is a greater need for coordination between the various radio sites to support features like Carrier Aggregation or Coordinated Multipoint. This enhanced inter-site interaction and coordination will require new interfaces (such as E5) and, therefore, new backhaul connections.

Along with higher capacity, backhaul routers will also need to provide the radio network with the right port densities to serve these new connectivity needs. Similarly, for microwave, more compact but higher port density solutions will become more important.

Virtualization and cloud distribution in the 5G core require the edge and core networks to handle a greater number of connection points. Operators will need to deploy high port-density routers, with distributed cloud connection points, as well as virtualized instantiation on-premise.

New 5G transport capabilities

The radio-near backhaul transport will require additional capabilities to support the enhanced radio functions and performance needs of 5G, including synchronization and low-latency connectivity.

Backhaul routers and microwave nodes are used to distribute time, phase and frequency sync efficiently as part of the overall sync solutions for enhanced radio coordination and 5G use cases. Synchronization support in backhaul nodes is crucial to guarantee radio performance. At the same time, the distributed sync architecture must have higher fault tolerance.

Low latency is critical for coordination functions over the new radio interfaces in LTE Advanced and 5G. Transport is key to enabling enhanced radio performance. Furthermore, ultra-low latency is key to certain 5G use cases, such as critical IoT. In this context, latency needs to be considered end to end, and not just in the radio-near transport network.

The number of 5G service types will be an order of magnitude higher than today's, and transport networks will need to evolve to handle the varying requirements of these services. Transport networks will need new capabilities and enhancements to deliver the required scalability and flexibility as these services become widely deployed and used. This is connected to the inflection point discussed in relation to capacity. A toolbox of

end-to-end transport capabilities is needed to support the variety of 5G use cases:

1. Enhanced QoS, such as H-QoS with deep buffering, to handle the high number of 5G use cases.
2. Traffic engineering, supported by transport technologies such as MPLS and segment routing, in a unified way
3. Support for Software Defined Networking (SDN) and standardized interfaces across all transport nodes for enhanced traffic engineering
4. Scalable security across the whole network for secure transmission of 5G services
5. Control and user plane separation (CUPS) as accelerator in core for ultra-low latency use cases, as well as allowing them to scale the user and control planes independently and run the control plane in the cloud

Such a toolbox could be used to build efficient and scalable network slicing. By splitting the physical network into separate virtual ones, slicing enables different transport characteristics to be offered for the diverse 5G use cases, which would otherwise be impossible using a single network approach. For network slicing, SDN is key as it enables a high degree of network automation and agility, and provides dynamic configuration and control of transport resources.

In order to secure service delivery for 5G use cases per slice, operators will need to deploy high-performance and highly scalable next-generation firewall solutions to counter attacks in the backhaul and core networks and protect the network from malicious Internet traffic. In addition, next-generation firewalls will need to safely connect roaming traffic originating from other carriers.

Mobile network architecture will need to evolve to a more distributed model to support network slices transmitting low-latency use cases at high availability, and to enable scalability. For example, NG Core (EPC nodes) will be deployed using the Control and User Plane Separation (CUPS) model, with user-plane nodes hosted at distributed data centers, and control-plane nodes at more centralized locations, interconnected by the IP transport network. CUPS provides the benefits of improved latency and independent scaling between control plane and user plane functions.

Resolving complexity

The overall complexity of the transport network is driven by rising connectivity needs, the multitude of 5G use cases, virtualization, cloud distribution and the

need for network slicing. Managing this complexity will be critical to avoid a rapid increase in operational costs.

This means network operation and automation will play a key role in 5G, especially for transport networks. Management will no longer be isolated and limited to a portion of the network: in 5G the need for radio and transport to be tightly connected has never been greater; nor has the need for a holistic end-to-end view of network slicing.

Operators can build a service-based network – from access to core – that is optimized for 5G and provides an agile infrastructure with adaptive and predictive software as well as pervasive security. This network is capable of taking advantage of SDN-based automation. Examples include the need to discover the topology from different sources and provide a simplified, abstracted and consolidated view to the operator; or the possibility to monitor and measure the performances of services spanning multiple administrative and technological domains. Automation will simplify operations, enable agile service creation and delivery, and provide just-in-time service and network builds.

Automation will play a key role in 5G, where management will no longer be isolated: building a service-based network end-to-end with an agile infrastructure will enable operators to take advantage of SDN-based automation and reduce complexity while optimizing their transport network for 5G needs.

Going further down in the network layers, it must be possible to provide a traffic-engineered infrastructure which is the result of per domain tunnels stitched together and presented to the operator as a single end-to-end connection with guaranteed KPIs and SLAs.

Complexity in 5G transport networks can be reduced by introducing:

- integrated and cross-domain radio–transport–core management
- end-to-end and cross-domain orchestration with automation for 5G service provisioning and slicing
- automated end-to-end network slice assurance with traffic engineering for service differentiation and independent service scaling with slicing.



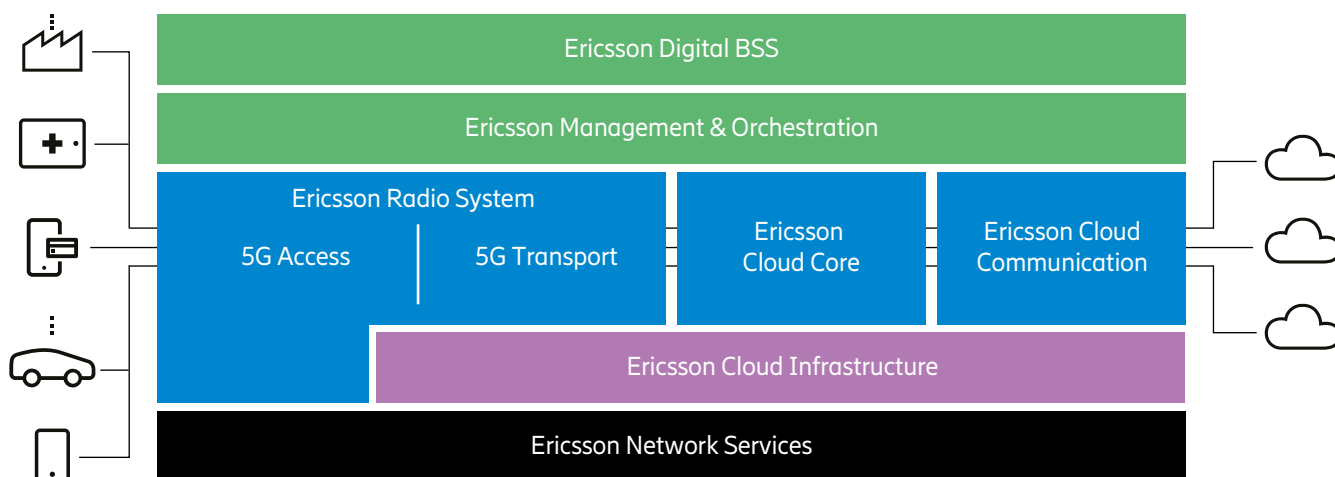


Figure 3: The Ericsson 5G Platform: taking full responsibility for the 5G promise

Cost considerations: 5G building practice

Implementing a transport network for 5G will require a fundamental shift in thinking: one that breaks the traditional linear relationship between network performance and cost.

One of the main cost drivers in 5G transport is increased complexity. However, with a proper management and orchestration layer, and simplification of the software overlay, the network will become much more dynamic, intelligent and predictive. This will deliver new 5G services at lower total cost of ownership.

Other 5G transport cost drivers that need to be considered include: how each individual product is designed; which transmission medium is selected; and how to deploy the solutions. The TCO of transport networks can be greatly reduced through the use of purpose-built products with a 'radio-in-mind' design, shared building practice, a high level of agility, and aligned implementation projects.

In fronthaul, removing framing and applying high-density service multiplexing offers a way to deliver long-distance, low-latency transmissions – resulting a simpler, more cost-efficient architecture which uses less equipment.

In the backhaul, synchronization support in routers offers a more fault-tolerant architecture and higher radio performance at a lower cost, as it also requires fewer of the otherwise high cost grand masters. Microwave offers a ubiquitous, lower-cost alternative for adding 5G connectivity where fiber is not feasible from a cost or timing perspective. The flexibility of using fiber and microwave is key to reducing 5G implementation costs.

Another key way of reducing TCO for radio-near transport is to avoid designing the total network with support for the highest capacity and lowest latency requirements. High capacity and low latency, whether driven by use cases or by radio functions, cannot be available across the entire network.

In the edge and core domains, the use of purpose-built products, based on the latest and most advanced silicon, is key to reducing TCO. 5G-tailored solutions in the core network can offer the operator industry-leading cost-savings for edge and core transport, by achieving the lowest cost per Gbps per kilometer, lower power consumption and reduced space requirements (higher port densities).

End-to-end 5G transport portfolio

As the leader in 5G radio technology and associated services, Ericsson understands the complexity and challenges of meeting the needs of 5G in the transport domain. We are unique in being able to offer an end-to-end, integrated 5G transport solution. It includes fiber- and microwave-agnostic fronthaul and backhaul, as part of our Ericsson Radio System, and best-in-class edge and core IP transport solutions, and network security solutions, from strategic partners such as Juniper Networks.

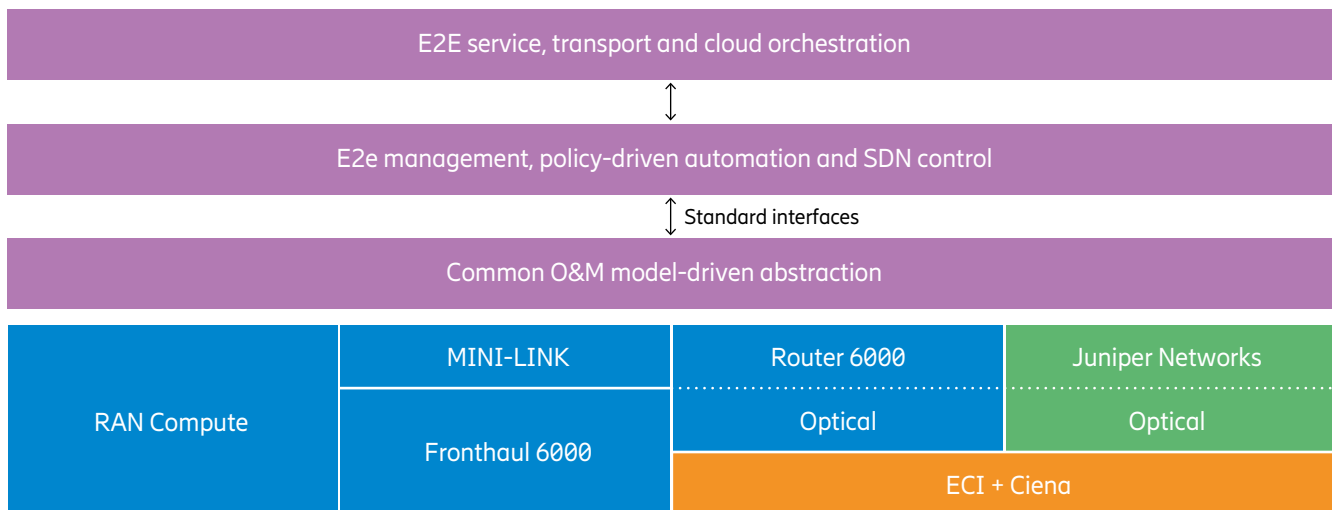


Figure 4: The complete Ericsson 5G transport offering with partners

The portfolio also offers unified management, policy-based automation and end-to-end service provisioning and orchestration for all components, including transport, cloud and services. This enables Ericsson to take full responsibility for 5G, with a complete transport portfolio that meets any 5G radio and use case requirement.

Fronthaul – Ericsson's Fronthaul 6000 is a flexible and cost-efficient fronthaul solution for CPRI and eCPRI transport, separately or together. It offers market-leading fiber density, 25G capacity and latency to achieve leading-edge 5G radio performance, even in the densest deployment areas, where RAN centralization plays the most important role.

IP backhaul – Ericsson's Router 6000 high-performance, cost-efficient 10/100G backhaul and aggregation routers are built and optimized for 5G radio performance. They are integrated as part of Ericsson Radio System and purpose-built to meet the strict requirements of high performing RANs, including eCPRI and Elastic RAN (E-RAN) through enhanced radio-supporting and IP transmission functions.

Microwave backhaul – Ericsson's MINI-LINK is the world's leading microwave solution, which supports 5G backhaul and fronthaul, with up to 10 Gbps capacity in any network scenario, superior performance and low cost of ownership – particularly where cost and time-to-market considerations make fiber unfeasible. The portfolio spans all transport technologies,

all frequency bands, and all deployment types and applications – all under a common management system.

Edge and core IP transport – Ericsson's partner Juniper offers edge and core transport routing platforms that are feature-rich, field-proven and provide industry-leading performance in throughput, scale, density and power efficiency. They provide unmatched versatility, supporting mobile and converged use cases, integrated and disaggregated 10/100 Gbps-plus optical transponder options, a universal single-chassis design, node slicing, and an open, standards-based hardware-accelerated 5G CUPS User Plane.

Optical transport – Ericsson's partnerships with ECI mean operators have access to a full-fledged underlay optical transport infrastructure to be used in combination with Ericsson and Juniper routers to serve metro and long-haul applications.

Network security – Juniper offers high-performance, highly scalable next-generation firewall platforms, which provide both Gi Firewall and security gateway solutions for end-to-end 4G/5G offerings in both physical and virtual form factors. Ericsson radio base stations have been integrated with Juniper security gateway solutions for approximately a decade and Juniper will continue to enhance its security gateway solutions to work efficiently with Ericsson's RAN solutions as they evolve to 5G.

Network management and orchestration – Ericsson provides full management and SDN capabilities both for Ericsson IP routers and Juniper's edge and core IP transport and network security solutions. Ericsson Network Manager provides 'single pane of glass' management and visibility for the entire mobile network. Implementing SDN-based management on open and standard interfaces will provide a framework for policy-driven automation and end-to-end orchestration, including transport, for efficient rollout of 5G services with network slicing.

Utilizing this policy-driven automation framework, the Ericsson Orchestrator provides both transport and cloud orchestration capabilities. It offers end-to-end Layer 2 and 3 transport services provisioning of the different transport slices to achieve guaranteed bandwidth, bounded delay and policies for each service.

Similarly, the cloud orchestration part provides Network Functions Virtualization Orchestration (NFVO) capabilities and generic Virtual Network Function Management (VNFM), which allow for lifecycle management of virtualized network functions, and both intra- and inter-datacenter connectivity.

A third component, Service Orchestrator, provides the glue between the transport and the cloud domains. It is a parser and orchestrator of service templates and is able to decompose and translate each request into provisioning queries for the transport and the cloud orchestration components.

Conclusion

The transport network is the vital link between all the pieces of current and future mobile networks. It requires significant enhancement to support the diverse set of services and deployment models expected in 5G networks.

However, simply adding 'more of the same', following the existing architectural model, is not sustainable: a new way of thinking about transport needs is required.

Intelligent, automated coordination between RAN, transport and mobile core networks will be central to any robust, sustainable 5G solution – especially when it comes to achieving the required levels of flexibility and observability.

With its end-to-end 5G offering, Ericsson is delivering a 'best of both worlds' scenario. Operators can deploy a complete end-to-end 5G solution, with pre-integrated, pre-tested, best-of-breed technologies offering all the capabilities required. At the same time, the solution offers an open, multi-vendor architecture, which addresses concerns about vendor lock-in and supports the best radio performance.



Ericsson enables communications service providers to capture the full value of connectivity. The company portfolio across Networks, Digital Services, Managed Services and Emerging Business is geared to make our customers more efficient, go digital, and find new revenue streams. Ericsson's investments in innovation have delivered the benefits of telephony and mobile broadband to billions of people around the world. The Ericsson stock is listed on Nasdaq Stockholm and on NASDAQ in New York.

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