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Set the Right Migration Path: Defining a 6G Architecture

*A Heavy Reading (now part of Omdia) white paper produced for
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Qualcomm

**AUTHOR: GABRIEL BROWN, SENIOR PRINCIPAL ANALYST,
HEAVY READING (NOW PART OF OMDIA)**

SET THE RIGHT PATH: 6G ARCHITECTURE

The mobile industry is working to standardize 6G for deployment from 2030 onward. The challenge is to design a system that will meet the demands of advanced, at-scale services in 2040, yet be economical and practical to deploy and operate.

This timeline makes 2025 a key year for both the wireless industry and 6G. It marks the start of 3GPP Release 20, which formally launches the “Study Items” that will inform development of the next generation of mobile connectivity. Decisions made in the near term will set the path for the long-term transition to 6G.

This white paper explores requirements and proposals for a new 6G architecture and core network that will allow operators to carry forward 5G investment and rapidly adopt new 6G capabilities. The context is a complex 4G to 5G transition that locked in dependencies on 4G technology and business models for longer than necessary.

At this early stage of 6G development, it is essential to consider the economics and practicalities of the transition path from 5G and the implications for the 6G system architecture. This paper argues that architecture choices made in the next two years will significantly determine the rate of adoption of 6G in the global mobile customer base.

Key messages

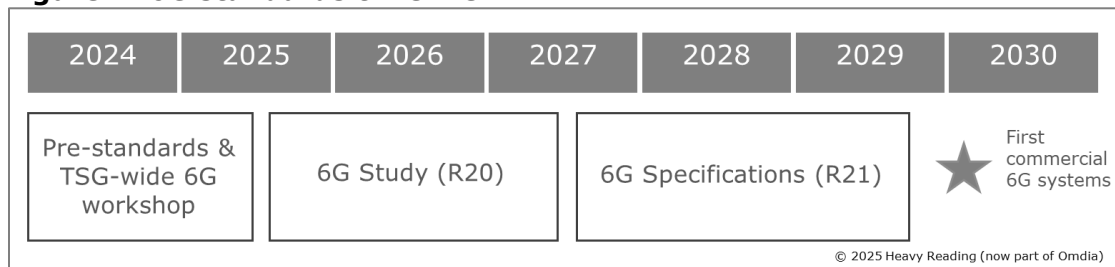
- **6G will be standalone (SA) on Day 1.** This architecture will combine shared 5G spectrum with new 6G spectrum and new 6G radios (e.g., in upper midband) connected to a 6G core. This architecture should enable rapid migration to 6G SA. Other Day 1 feature requirements include voice, emergency calling, and a scalable design for a wide range of device types, including long-lifecycle internet of things (IoT) and low latency communications (e.g., for industrial IoT).
- **The 6G core will be based on an evolved 5G core—at least in the near term.** This will be a software-centric upgrade that reuses the cloud platform, the 5G service-based architecture (SBA), and several 5G network functions (NFs). However, there will also be a need for new 6G NFs, such as a 6G AMF (access and mobility management function) and 6G SMF (session management function), to optimize non-access stratum (NAS) signaling and enable a lean control plane. AI data frameworks will bring novel capabilities to the 6G core—for example, data collection for personalization, performance optimization, or automated operations.
- **6G needs to offer a step change in system performance to merit the name.** Operators want to baseline performance to 5G Advanced Release 19. This is a high bar, which means that 6G RAN will need to support new frequency bands for new capacity, which in turn will require new radio equipment on either side of the air interface, in mobile devices, and in the RAN.
- **It is vital that 6G stays close to the state-of-the-art in the AI and cloud ecosystems.** Technology suppliers and operators should expect AI native wireless networking to influence the 6G architecture. In the 6G standards timeframe, this will likely mean defining AI in terms of frameworks rather than capturing detail in the specifications. 6G should allow operators to more rapidly adopt advances in the cloud ecosystem for networking, compute, storage, software infrastructure, security, AI models, data analytics, tooling, and operational processes.

- **Economics should be central to any 6G design philosophy.** There are many ways operator economics will influence 6G development, such as spectrum sharing, network sharing, energy efficiency, digital twins for automation, and more. The industry must be careful, however, that cost-driven development decisions do not stifle innovation and limit the creation of high value technology. A balance of prudent economics and adventure is needed.
- **Do not forget ambition: A modular design architecture will enable 6G to meet user requirements in 2035–2040.** The industry is focused on a simple, practical 6G deployment architecture that is cost efficient and leverages 5G infrastructure investment; a sensible objective seen from the vantage point of 2025. However, 6G will serve new forms of communication and enable high value applications through the 2030–40 period. The 6G architecture must be extensible after Day 1 to meet this potentially vast opportunity.

Timeline and standards

The 3GPP standards process sets the timeline for 6G development and first commercial deployments. After some years of industry discussion and scoping work, the formal standards work started in June 2025 with a study phase in Release 20 (R20). After the study phase, development of the first specifications in Release 21 (R21) will start in early 2027 with the aim to produce a single standard by March 2029, at the earliest. As shown in **Figure 1**, this timeline should enable the first commercial systems to launch from 2030.

Figure 1: 6G standards timeline



Source: Heavy Reading (now part of Omdia)

Two major R20 studies will investigate proposals for specification in R21.

Study on architecture for 6G system (Technical Report 23.801-01)

This study will investigate the requirements, assumptions, and high level principles for the 6G architecture. It has eight main work tasks, as follows:

- Define the overall 6G architecture as a collection of capabilities and functionalities
- Migration and interworking between 5G and 6G
- How to support and enable the use of AI in 6G (e.g., AI agent, frameworks, etc.)
- Integration of sensing and communication over 3GPP access
- Data framework for efficient and scalable data handling
- Computing framework for devices, core, and application servers (including exposure)
- Study 6G NTN (based on RAN decision) and service continuity aspects
- Support for cellular IoT enablers in 6G (based on RAN decision for 6G IoT)

There is no discrete task to investigate Wi-Fi access because the existing 5G/Wi-Fi interworking architecture can be reused for 6G. Several high profile contributors to the 3GPP 6G plenary reference the importance of Wi-Fi integration, and groups such as the Wireless Broadband Alliance are working to make Wi-Fi part of the 6G experience.

Study on 6G radio (3GPP document RP-251881)

The 6G radio (6GR) study aims to develop one non-backward-compatible radio access technology to meet a broad range of use cases and requirements. Below are the objectives of the study:

- Define a single RAN technology framework based on a standalone (SA) architecture
- Specify a physical layer structure for 6GR
- Radio interface protocol architecture and procedures for 6GR
- Mobility for 6GR (for all radio resource control [RRC] states)
- 6GR performance requirements
- RAN architecture, interface protocols, and procedures
- Migration from 5G NR to 6GR; interworking and mobility between 5G NR and 6GR
- AI/machine learning (AI/ML) for 6GR and RAN, leveraging 5G AI/ML framework, as appropriate
- Sensing studies based on use cases and associated requirements

More detailed technical proposals will be decided and discussed from 3Q25 onward.

VISION: BALANCE PRAGMATISM AND PROMISE

A large amount of preparatory work in ITU-R and 3GPP was done prior to the start of 6G standardization. This work is supplemented by contributions from organizations such as the operator-led Next Generation Mobile Networks Initiative (NGMN) and the Next G Alliance.

Because the mobile industry is now relatively mature, and because 4G and 5G are already very capable technologies, operator desire to constrain costs will drive an evolutionary approach to the deployment of 6G. There are, of course, major advances in technology and new application types in the pipeline, with demanding performance requirements. Broadly speaking, however, 6G is expected to build on and extend 5G, and then replace it over the long-term.

Pragmatism and real-world performance

One key requirement identified by the ecosystem ahead of standardization is the need for a simpler, more focused development process that will produce a system design that is specified for real world operation. This is reflected in submissions to the 3GPP 6G Technical Steering Group Plenary in Korea in April 2025. Two examples show this clearly, as follows.

Lean and streamlined 6G standards (3GPP document RP-250766)

One document endorsed by 21 large and well-known industry players states: “During the course of 5G and 5G-Advanced standardization, we have observed an ever-increasing trend of excessive 3GPP specifications, e.g., adopting multiple options to the same functionality.”

“An overall principle in 3GPP [should be] to create lean and streamlined standards for 6G, e.g., by dimensioning an appropriate set of functionalities, minimizing the adoption of multiple options for the same functionality, avoiding excessive configurations, etc. *Any exception* [author emphasis] to the above shall be well justified.”

This proposal was made jointly by Apple, AT&T, BT, CMCC, DT, Ericsson, Huawei, Intel, KT, MediaTek, Nokia, NTT Docomo, Qualcomm, Reliance Jio, Samsung, SKT, T-Mobile USA, Telstra, Verizon, Vodafone, and ZTE. This is a widely held view across the industry.

Realistic and usable performance targets (3GPP document RP-250293)

Another pragmatic view of 6G development comes from a group of mostly European operators concerned that the technical performance requirements (TPRs) values defined by ITU for IMT 2030 are “simply not feasible ... in real commercial cellular network deployments.” In 5G, say the operators, this led to “inflated, unrealistic expectations.”

The document states: “The cosigning operators request that 3GPP agree on a set of recommended TPRs to ITU, which are reachable with typical equipment and deployments in cellular networks, rather than overinflated theoretical research targets.”

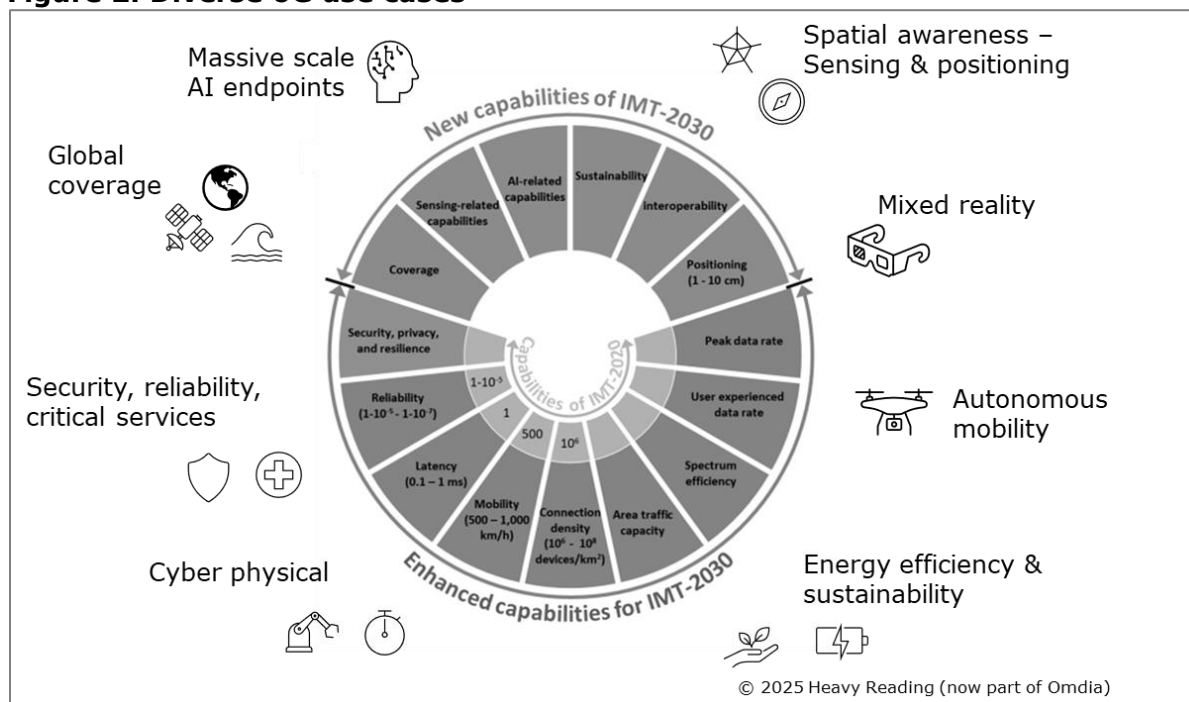
This position is endorsed by Deutsche Telekom, Telenor, Spark NZ, Oido, BT, Vodafone, Bouygues Telecom, Telia Company, Orange, and KPN.

Vision: Serve and enable the AI era

Practicality and realistic goals are sensible. Yet at the same time, the world is changing. Mobile networks are vital in enabling new forms of communication that will support high value applications in the 2030–2040 period. To meet this demand, innovation is required.

A surge in AI-enabled endpoints, connected AI services, and AI workloads at the edge looks likely in just about all the customer groups currently served by mobile operators. This includes the major use cases likely to be served by 6G, shown in **Figure 2**. Many of the proposed use cases look like 5G cases that will become more sophisticated, better defined, and more widely adopted in 6G.

Figure 2: Diverse 6G use cases



Source: Heavy Reading (now part of Omdia), IMT Framework 2030

It is essential for the industry to be ambitious and not to sleep on advanced wireless research that supports future service innovation. The 6G architecture should be sufficiently modular and agile that it can incorporate new capabilities over time. There is strong support for a scalable architecture that allows new network features to be incorporated when required and commercially justified. Broadly speaking, industry sentiment favors a continual innovation model for the evolution of 6G past Day 1.

DAY 1 STANDALONE: A SINGLE ARCHITECTURE

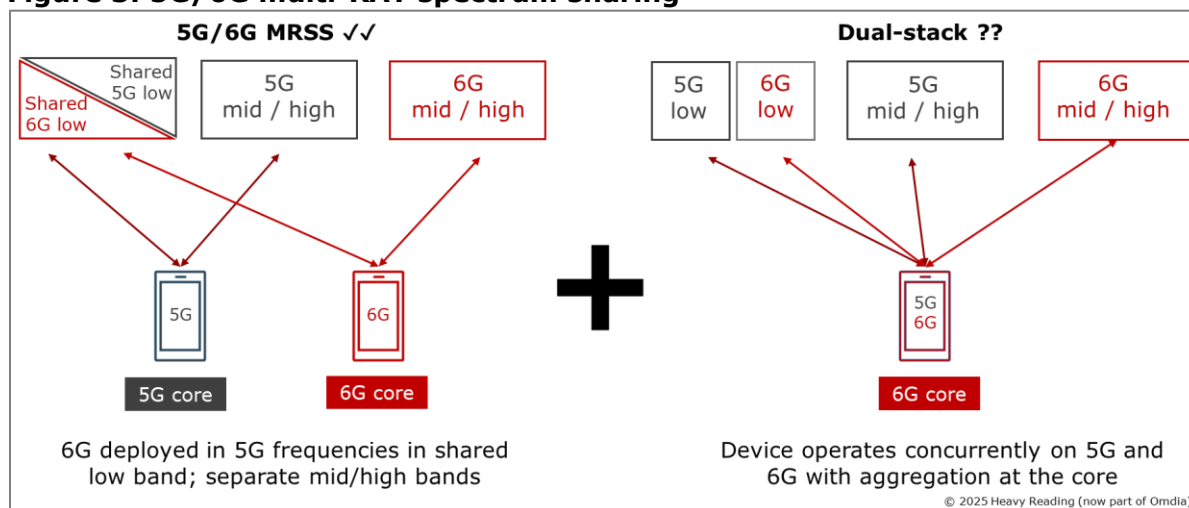
There is near-universal agreement that 6G should operate as an SA network from Day 1. 6G SA requires excellent 6G coverage, which in practice means sharing existing spectrum and radios that have been deployed for 5G using a technique called multi-RAT spectrum sharing (MRSS). MRSS takes advantage of the forward-compatible "lean carrier" 5G physical layer to deliver a low overhead 5G/6G sharing mechanism without the severe interference penalties seen in 4G/5G sharing.

MRSS with a 6G core

MRSS will play a key role in the early- and medium-term phases of 6G deployment. It is investment-friendly because it reuses existing radios and, at a minimum, requires a baseband upgrade and a core network, both of which may be software-based. Shared 5G spectrum and RAN will provide the base 6G coverage layer, in combination with new 6G spectrum and radio deployments, likely in the upper mid-bands, as shown in **Figure 3**.

There is strong support for the MRSS + 6G core deployment mode. However, the complexities and permutations of the various TDD and FDD carrier aggregation scenarios introduce some uncertainty into how MRSS will operate in practice. Carrier aggregation is classically a single-vendor implementation and therefore MRSS is likely to favor the incumbent 5G RAN supplier.

Figure 3: 5G/6G multi-RAT spectrum sharing



Source: Qualcomm, Heavy Reading (now part of Omdia)

6G RAT: Dual connectivity or dual stack?

In addition to MRSS, it is an open question whether dual connectivity or dual stack should be specified for 6G RAT. The argument for each is that where operators want to offer a higher data rate service than can be achieved with MRSS, then they might want to combine a 5G/6G MRSS low-band with a mid- or high-band 5G-only or 6G-only connection to the device to differentiate the service.

Multi-RAT dual connectivity is considered the more complex option because it introduces dependencies on the existing 5G RAN. Based on submissions to the 3GPP Plenary, there appears to be a lack of enthusiasm for this option due to the complexity of the 5G integration as well as the cost of upgrading the legacy 5G RAN.

Dual stack is generally considered easier to implement in the network, and it would allow fast deployment and adoption of high performance 6G. However, it adds complexity to the device and to the evolved 6G core, which would need to support simultaneous access to 5G and 6G, including (potentially) traffic aggregation. At this stage, this remains a topic for study. Based on the current reading of the ecosystem by Heavy Reading (now part of Omdia), dual stack appears more likely to be adopted than dual connectivity as a secondary migration option (in support of MRSS in primary).

A SCALABLE 6G ARCHITECTURE

There are diverse views on what the core architecture should be in a 6G SA network. On the most ambitious view, the mobile core architecture should be entirely redesigned to be “AI native” and decoupled from the 5G core. A full core architecture refresh may be appropriate in the future (e.g., when the majority of spectrum and users are re-farmed to 6G). However, for many operators, this vision is far ahead of their planning and investment horizon. The prevailing view is to leverage 5G core and cloud infrastructure where possible, and to introduce new functions to support 6G where necessary.

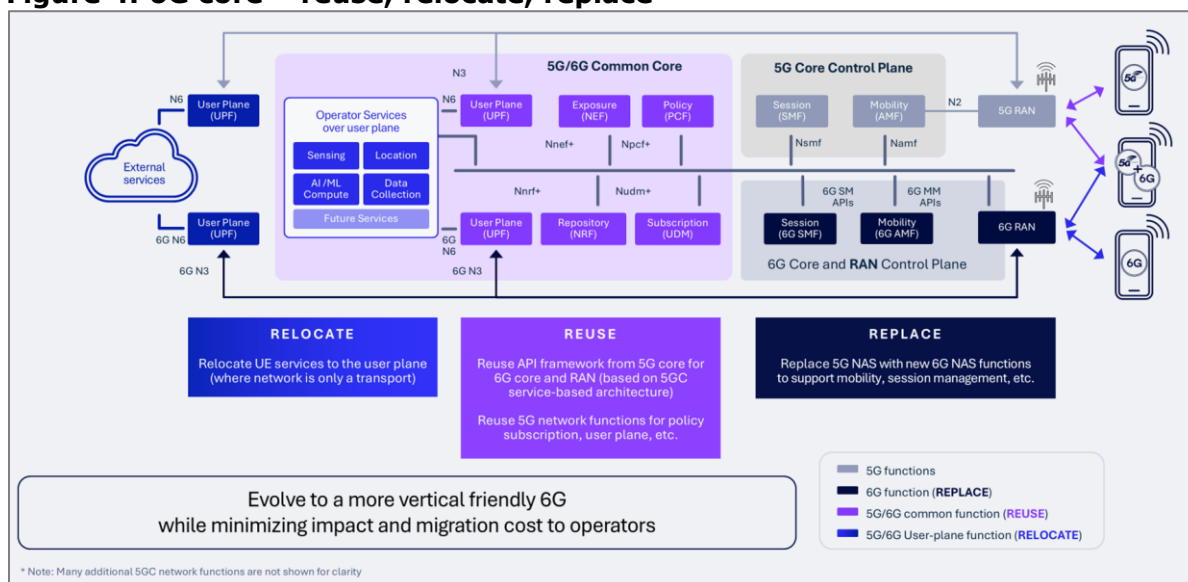
6G core architecture

There is broad industry support to reuse the 5G SBA (the API framework for connecting core NFs) for 6G, subject to the anticipated adoption of HTTP/3 or QUIC for transport and security enhancements. A proposed view on which 5G NFs to evolve or replace, and which to reuse, is shown in **Figure 4**.

The primary new 6G functions are the signaling nodes that control mobility and session management, which are known in the 5G core control plane as AMF and SMF. New 6G functions to streamline signaling may deliver, for example, better energy consumption, improved mobility, and support for new use cases and device types.

Proposed 6G AMFs and 6G SMFs will be software functions likely colocated with 5G AMFs and SMFs or possibly implemented as software upgrades to existing functions to make them dual-mode mode 5G/6G AMFs and SMFs. Either way, these new functions will be a light capex investment.

Figure 4: 6G core – reuse, relocate, replace



Source: Qualcomm

Many of the existing 5G core functions, with relevant software updates, can be reused for 6G, such as policy servers or subscriber data management. It is desirable to offer a common service portfolio across 5G and 6G, for investment protection, for deployment simplicity, and so on.

It is especially desirable to maintain and evolve external developer-facing APIs. These APIs are nascent today, and it is important to give developers consistency and the ability to target a larger market across the combined 5G/6G network platform. This does not preclude 6G-specific APIs from emerging.

Broadly speaking, the 5G core is considered to have too many discrete functions and be more complex than is necessary. There is, therefore, little appetite to specify a lot of new NFs for the 6G core unless they deliver clear, definable value.

AI native 6G system architecture

One valid critique of the incremental upgrade approach—however sensible it looks at this stage of the 5G investment cycle—is that it does not sufficiently recognize the shortcomings of the 5G core architecture, or the advances in cloud technologies since 5G specifications were created, or the huge opportunities of AI native networking paradigms.

The 5G architecture was, at least, designed to be forward-compatible, and it is proving to be adaptable in practice. For example, AI is already impacting how the 5G core is scaled as operators re-evaluate the deployment of a data collection and analysis layer in their networks to create AI native data frameworks. This re-evaluation of AI data collection in 5G may work in favor of 6G. Similarly, AI is now being applied to mobile network operations (MLOps) in meaningful ways today that will make the migration to autonomous 6G networks easier.

It is important for the mobile industry to stay close to the vanguard of the AI ecosystem and adopt informal, de facto industry standards as it creates 6G. For example, vendors and operators can take advantage of emerging protocols such as the Model Context Protocol (MCP) for inter-NF and inter-domain communications. There are already proofs-of-concept applying MCP in 5G core—for example, to enable network slicing use cases.

The AI native paradigm has even deeper long-term implications for defining network architectures. A network's ability to learn how to configure itself for the prevailing demand, the requirements of a use case, or the preferences of a customer group is a radical departure from the current mode of architecture definition and specification.

AI native wireless networking is a nascent technology, and its implications, although not yet well understood and mastered, present such a strong vision that the industry should expect these concepts to be applied to future network design. In the initial 6G standards timeframe, this will likely mean AI being defined in terms of frameworks rather than captured in detail in the specifications. Vendors will be free to create AI native implementations of 6G functions.

A lean control plane

In the mobile network control plane, the NAS and RRC protocols have increased in complexity with each 3GPP release. This has helped support critical new RAN features (such as carrier aggregation) and enabled non-IP data services related to location, data collection, and device management.

Non-IP data services that run on top of NAS require specialized knowledge compared with mainstream IP-based services, and though the control plane feature set has become richer, adoption has been limited. As a result, one proposal in 6G is to remove service functionality from the NAS control plane to the user plane.

In its place is a lean control plane that supports only the signaling needed to establish and maintain data services, such as security, mobility, and session management. This will simplify the radio network and reduce complexity in the RAN and device software stacks. Such an approach works very well with the ecosystem requirement for simpler, implementable standards unencumbered by little-used features and options.

An IP-based (i.e., user plane) approach to additional services (e.g., related to location, data collection, and device management) would benefit from the scale of the internet ecosystem. Being IP-based, these services could become “G-agnostic” and backported to previous generations or cross-ported to other access technologies such as Wi-Fi, fiber, and cable.

A challenge to a lean control plane approach is the decades of established precedents. Pruning the stack will likely meet resistance.

Mobile network user plane

How the mobile user plane function (UPF) will evolve in 6G is unclear at present. The 5G UPF is flexible, and with the correct implementation, it will meet the major 6G requirements, which means there is not a strong case to introduce a new functional equivalent in 6G.

There are some calls to investigate an SRv6 native 6G core user plane as a replacement for GTP-U in the 3GPP study phase. SRv6 is widely used in transport networks for backhaul traffic engineering; a native implementation in the 3GPP user plane could enable better end-to-end programmability and support for dynamic traffic steering based on application requirements, or to support personalized and context-aware services.

GTP tunnels (as used in 4G and 5G user planes) are, however, low overhead, well-established, and include key RAN-related information in the header field. Removing GTP functionality from the user plane would require a mobility anchor redesign and a different approach to session management, policy, and security. This is disruptive and a large amount of work.

RAN to core architecture (extend SBA to RAN)

Several influential ecosystem players have raised the idea of extending the SBA used in the core to the 6G RAN. This is based on the idea that RAN functions (especially baseband) become cloud native and programmable over time.

Re-architecting the RAN-core interface from a point-to-point model to a service-oriented model allows for direct communication between RAN and core NFs, which may be useful to support future RAN services—for example, related to location and sensing. There is reasonably broad support for extending the SBA to the RAN, and especially strong support from cloud companies. However, it will be disruptive to the current RAN operating model.

CLOUD PLATFORM SCALE

Over the past 20 years, the cloud computing sector has scaled immensely. Starting 10–15 years ago, 5G was specified to be software-defined when possible, and it is self-evident that 6G should leverage the cloud ecosystem for networking, compute, storage, software infrastructure, security, AI models, data analytics, tooling, and operational processes. Just as evident is that, because mobile networks are nationally regulated critical infrastructure, adoption of cloud technologies should be on a secure, sovereign basis.

Apply cloud industry platform scale to 6G

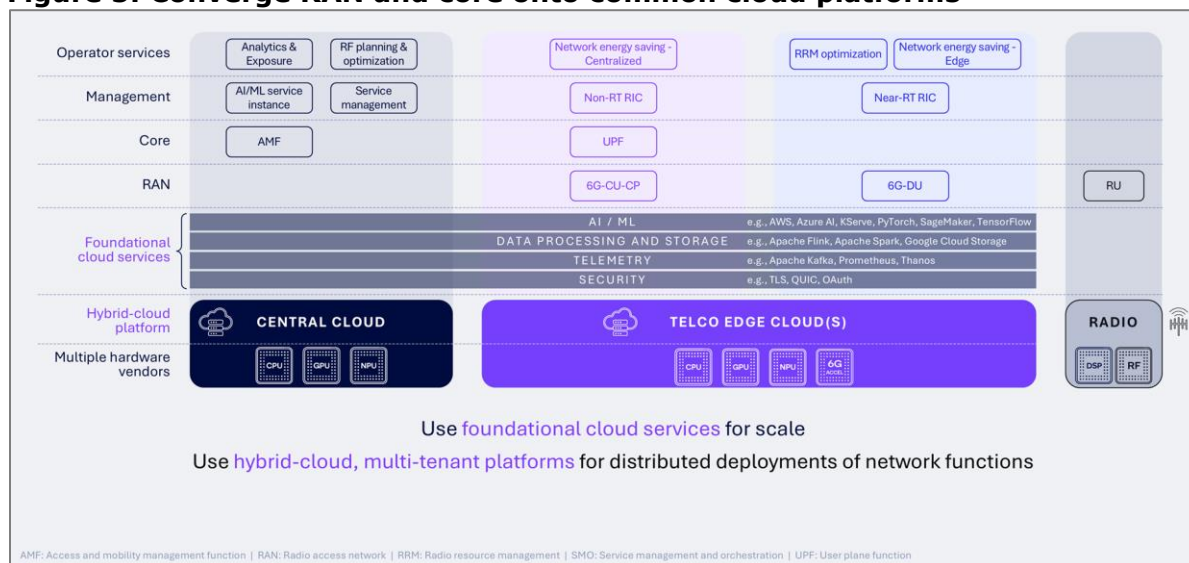
Except for antennas, radios, optics, transport, etc., many 6G functions will be software-defined and run on operator-specific cloud infrastructure platforms made of physical data centers, networking, servers, cloud software, etc. **Figure 5** shows how this telco cloud infrastructure platform will scale across core and edge locations.

Operators will source cloud platform components from the high volume commercial market, which is large scale and competitive (they may need telco-specific product versions). This infrastructure model is well on track, with leading operators considering current investment in cloud platforms to run 5G core networks as a down payment on the future cloud native, AI native 6G core. There is a strong expectation that advanced telco cloud architectures being designed and deployed today will also support 6G, even if some components and subsystems are modernized or replaced in the meantime.

Another high value contribution from the cloud ecosystem is the tooling and operational models needed to operate future mobile networks. Active developer ecosystems offer a vast array of open source and commercially supported tools that operators can use to create next-generation network management systems. Similarly, there are advanced cloud services—particularly for data storage and analytics and AI model training and inference—that already have great scale and high utility, and which the telecom industry cannot readily replicate.

The mobile industry will continue to develop mobile network-specific management systems and tools. For example, RAN management and automation will be hosted within the 6G version of the service management & orchestration (SMO) domain. These functions will use components, subsystems, and tools from the cloud ecosystem (e.g., for analytics or model training) but will be specific to the mobile industry.

Figure 5: Converge RAN and core onto common cloud platforms



Source: Qualcomm

Extend cloud infrastructure to RAN

Mobile operators are in the process of mastering cloud for 5G core. Many have ambitions to extend cloud infrastructure and operations teams to support virtual RAN (vRAN) workloads. This ambition aligns with the potential move at the 3GPP level to adopt the SBA for RAN (see above).

vRAN typically refers to baseband and ancillary functions, but a cloud operations model (CloudOps) can also extend to tools that manage more hardware-oriented radio units. Today's vRAN is the first step to potentially big changes, driven by cloud and AI, in how RAN is implemented and deployed in the 6G era.

The figure above indicates a telco edge cloud that runs RAN workloads on a continuum from a metro edge data center to a centralized RAN (C-RAN) hub. This will allow operators to balance where they deploy RAN compute, improve costs and efficiency, and run customer-facing workloads such as AI inference close to the RAN.

Cloud infrastructure itself is also undergoing an AI revolution. AI RAN will take advantage of GPUs, CPUs, and NPUs deployed in this edge infrastructure. It is vital for the 6G sector to stay closely aligned to advances in AI compute and software to capture the economies of scale and performance benefits generated by this ecosystem.

CONCLUSION

This white paper has discussed proposals for a new 6G architecture that will allow operators to carry forward 5G investment and rapidly adopt new 6G capabilities. At this early stage of 6G development, it is essential to consider the economics and practicalities of the transition from 5G and the implications for the 6G system architecture. The paper argues that 6G architecture choices made in the next two years will significantly determine the rate of 6G adoption in the global mobile customer base in the 2030s.