White Paper

Cisco Ultra 5G Packet Core Solution

Abstract

This white paper provides a brief overview of the 5G capabilities in the Cisco® Ultra Packet Core. It is assumed that reader is aware of the Third-Generation Partnership Program (3GPP) Embedded Packet Capture (EPC) architecture and Cisco Ultra Services Platform solution.

Scope

This paper can be shared with engineering, the Prime License Manager (PLM), the Accounts team, and customers.

Disclaimer

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Introduction

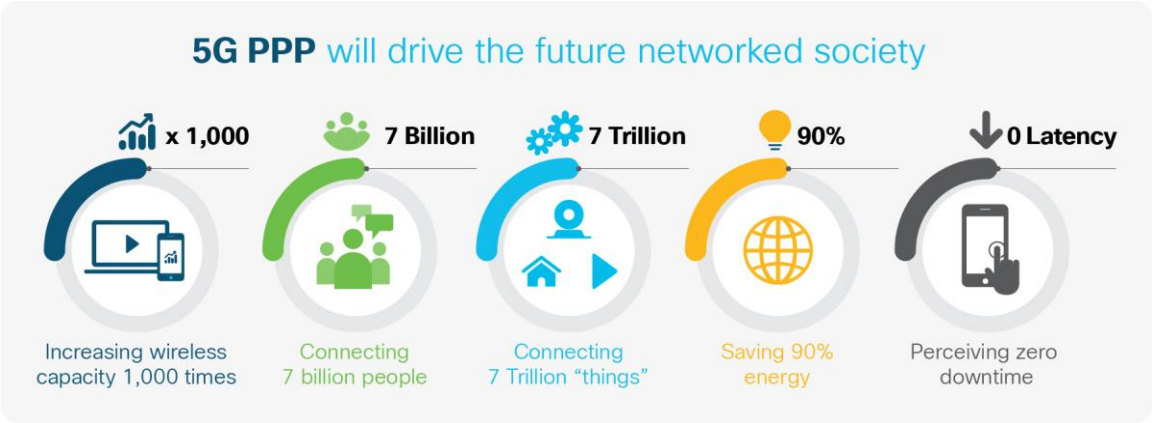
5G is the next generation of Third-Generation Partnership Program (3GPP) technology, after 4G/LTE, being defined for wireless mobile data communication. Starting with 3GPP Release 15 onward, this technology defines standards for 5G. As part of 3GPP Release 15, new 5G Radio and Packet Core evolution is being defined to cater to the needs of 5G networks. References 1 and 2 provide more details on 3GPP standards for 5G architecture.

Following are the some of the key goals of 5G:

- Very high throughput (1–20 Gbps)
- Ultra low latency (<1 ms)
- 1000x bandwidth per unit area
- Massive connectivity
- High availability
- Dense coverage
- Low energy consumption
- Up to a 10-year battery life for machine-type communications

Figure 1 shows some of the projections set by 5GPP (a joint initiative between the European Union Commission and European Information and Communication Technology [ICT]):

Figure 1. 5GPPP will drive the future networked society



Source: 5G PPP

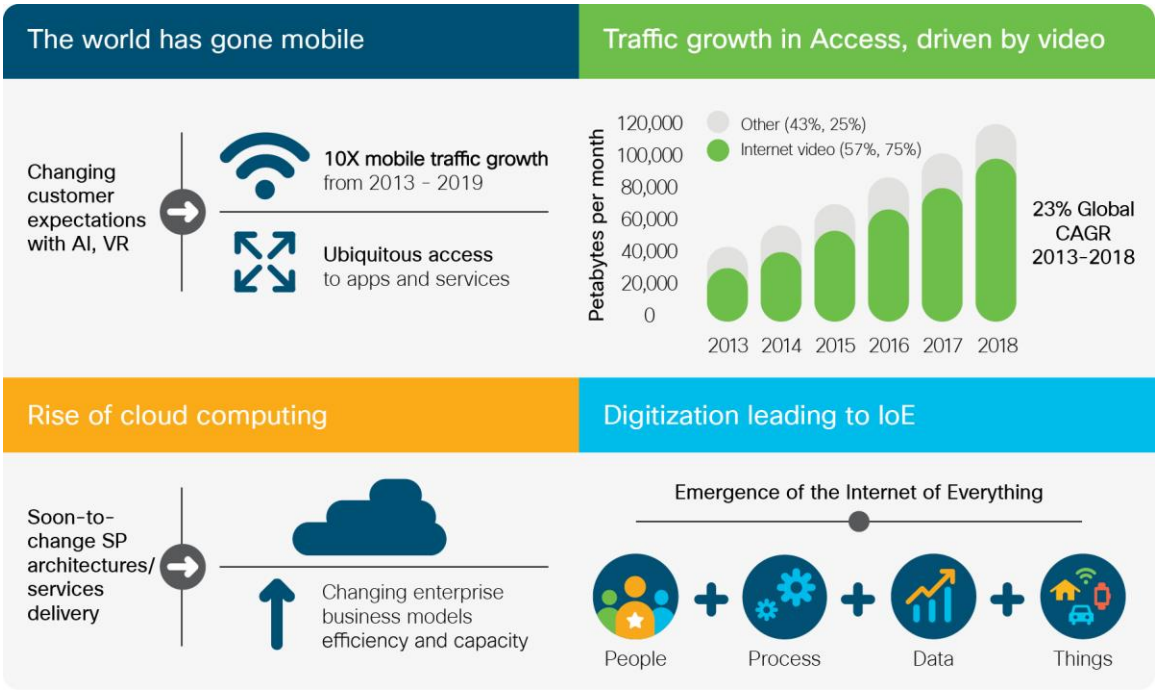
5G will bridge wireless and wireline networks, forcing a major network architectural change from radio access to core.

Cisco's 5G Vision

Cisco views 5G as an enabler for a new set of possibilities and capabilities. Every new generation of 3GPP wireless mobile data communication technology has set the stage for a new set of use cases and capabilities. 3G was the first truly wireless mobile data communication technology that catered to data communication. Whereas 4G was the first truly all-IP wireless data communication technology, both 3G and 4G have been instrumental and foundational to the data communication over mobile devices. This situation led to proliferation of applications such as video, ecommerce, social networks, games, and several other applications on mobile devices. Focus in 3G and 4G was more on mobile broadband for consumers and enterprises.

Figure 2 shows some trends and new opportunities that operators should address.

Figure 2. Opportunities



A new set of use cases is being introduced that is going to have its own set of challenges and complexities. Thus, the new 5G network has to help operators manage current needs as well as support new needs of new use cases, some that have yet to be imagined. 5G is not just going to be about high-speed data connections for enhanced mobile broadband, but will enable several new capabilities that can cater to several new enterprise use cases. 5G will not just be about serving consumer and enterprise subscribers with high throughput connectivity. 5G will enable new revenue avenues and opportunities for operators with its ability to cater to requirements for several new enterprise use cases. To this end, Cisco envisions 5G to equip operators with more capabilities to cater to enterprise customers' needs to support their current and future use cases.

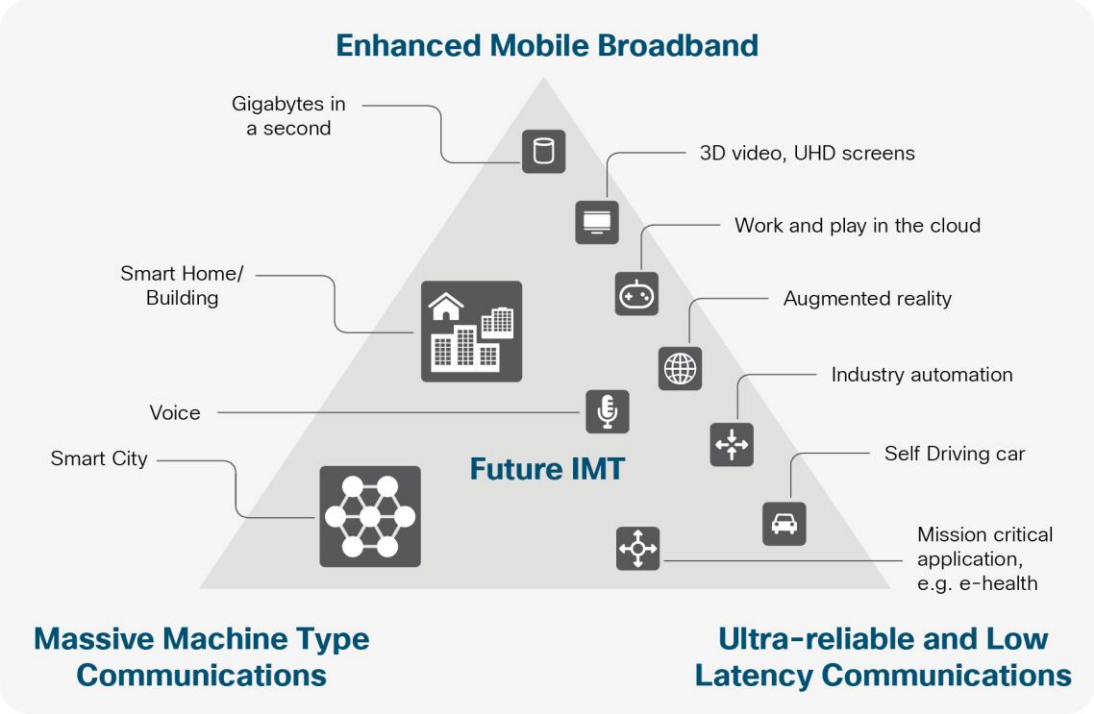
Cisco understands that the 5G core needs to be the enabling platform for service providers to take advantage of the major changes taking place in the data center, networking, and the economics of mobility in a standardized multivendor environment. Very significant changes for the mobile core that facilitate new opportunities such as personalized networks through slicing and more granular functions are being defined. 5G provides a framework to take advantage of the massive throughput and low latency that new radio provides.

Figure 3 shows some of the use cases that 5G will cater to.

Figure 3. 5G use cases

Figure 4 illustrates the broad categories of use cases that 5G will cater to.

Figure 4. 5G usage scenarios (source: ITU)



Source: ITU

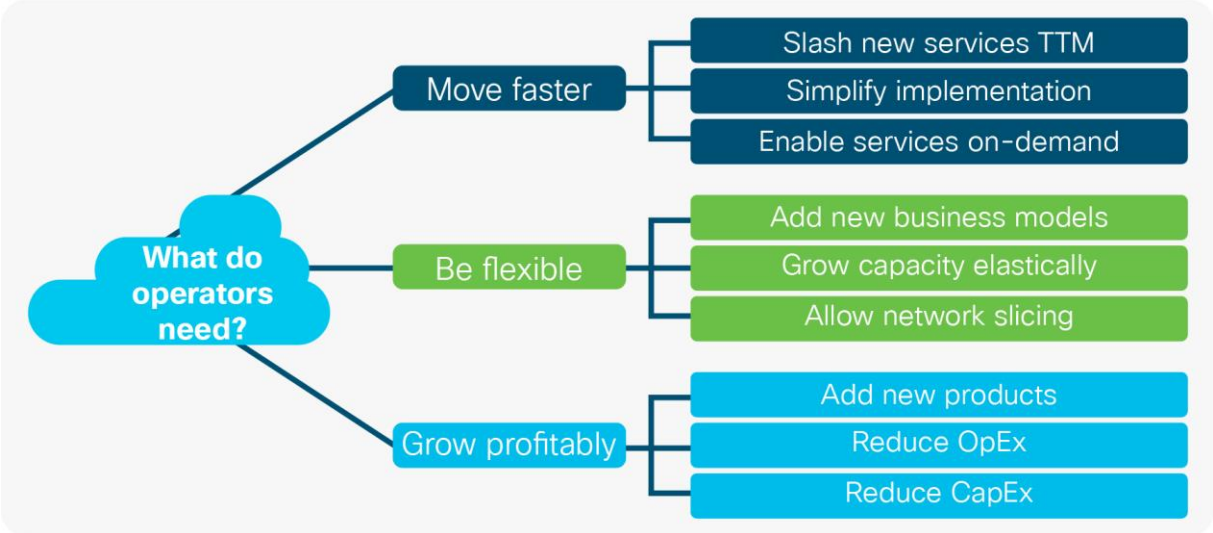
These three requirements enable all the use cases.

- **Enhanced Mobile Broadband (eMBB):** 5G eMBB brings the promise of high speed and dense broadband to the subscriber. With gigabit speeds, 5G provides an alternative to traditional fixed line services. Fixed wireless access based on mmWave radio technologies enables the density to support high-bandwidth services such as video over a 5G wireless connection. To support eMBB use cases, the mobile core must support the performance density and scalability required.
- **Ultra-Reliable Low-Latency Communications (robotics and factory automation) (URLLC):** Ultra-reliable low-latency communications focuses on mission-critical services such as augment and virtual reality, tele-surgery and healthcare, intelligent transportation, and industry automation. Traditionally over a wired connection, 5G offers a wireless equivalent to these extremely sensitive use cases. URLLC often requires the mobile core User Plane Function (UPF) to be located geographically closer to the then end user in a Control and User Plane Separation (CUPS) architecture to achieve the latency requirements.
- **Massive Internet of Things (IoT):** Massive IoT in 5G addresses the need to support billions of connections with a range of different services. IoT services range from devices sensors requiring relatively low bandwidth to connected cars that require a service similar to that of a mobile handset. Network slicing provides a way for service providers to enable Network as a Service (NaaS) to enterprises, giving them the flexibility to manage their own devices and services on the 5G network. Following are characteristics of these use cases:
  - Efficient low-cost communication with deep coverage
  - Lightweight device initialization and configuration
  - Efficient support of infrequent small data for mobile originated data-only communication scenarios

Cisco Ultra 5G Packet Core Solution

Although 5G promises greater flexibility and new opportunities for the operator, it also offers a greater potential for added complexities and cost. Cisco believes that the capabilities shown in Figure 5 are required to reduce complexity and cost and enable you to stay ahead of your competition.

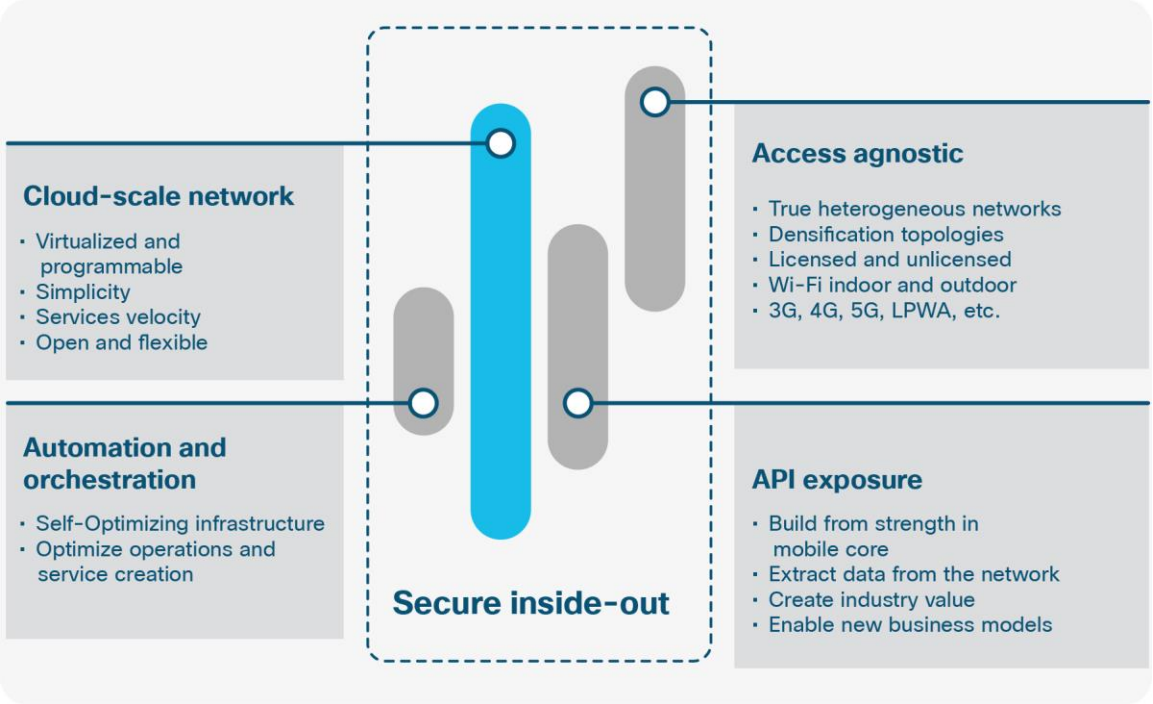
Figure 5. Capabilities required to reduce complexity and cost



Cisco's 5G strategy is about delivering what the operator needs to succeed in this new environment, including the agility, flexibility and security to address their customer's requirements for a better connected experience. This strategy includes maintaining investment protect for existing infrastructure, including the repurposing of their Cisco ASR 5500 Series Evolved Packet Cores (EPCs) while they evolve to a more virtualized architecture. We are also highly focused on protecting the operators investment in their new 5G solutions. We understand that 5G is far more than just a new radio; 5G is about delivering connected experiences from the multicloud to the client across a multivendor architecture.

Figure 6 shows the Cisco 5G solution architecture tenets.

Figure 6. Cisco 5G solution architecture



Cisco is a leading packet core vendor for decades and has been influencing 3GPP standards given the expertise have built over several years. Cisco has witnessed transitions earlier too, first from 2G to 3G and then 3G to 4G, and we are currently best-placed vendor to define and lead the solution for the important and crucial transition from 4G to 5G.

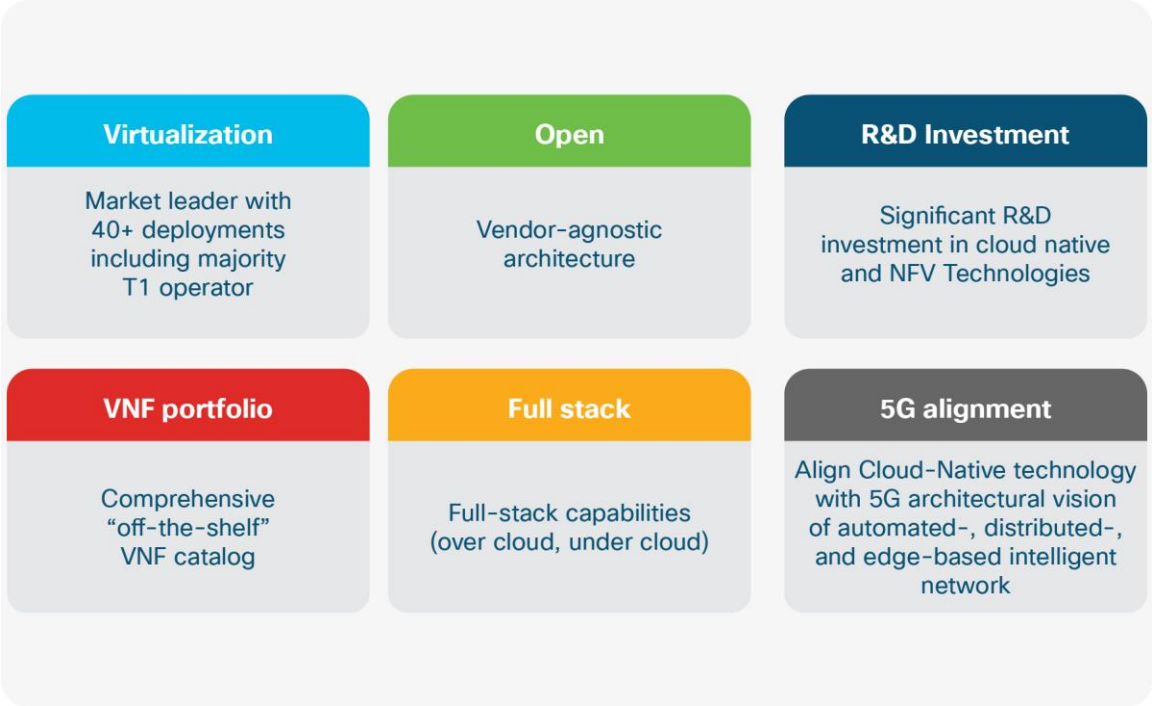
Cisco's 5G packet core solution product strategy is to provide a synergistic and coherent set of 5G Standalone (SA) packet core for 5G Network Functions (NFs) compliant to 5G SA 3GPP standards, using the Cisco Cloud Native Ultra Services Platform. This platform helps Cisco enable best-in-class "cloud" operational benefits across the full Cisco 5G SA NF portfolio. These cloud operational benefits include dynamic network-function scale-in/out, faster network-function upgrades, in-service network-function upgrades, and support for NETCONF/YANG, streaming telemetry.

Cisco Ultra Services Platform is one of the industry-leading virtualized platforms for mobile core services. The Cisco Ultra Service Platform-based Virtual PortChannel (VPC) solution is deployed in more than 40 networks globally, making Cisco one of the leading virtual packet core vendors.

Cisco had been working on several packet core concepts even before they could get standardized in 3GPP. For instance, Cisco was one of the vendors to demonstrate CUPS at the Mobile World Congress (MWC) in 2016 and 2017, before 3GPP standardized that technology. Continuing the similar trend, Cisco is aggressively working to introduce a pre-standards version of the 5G solution in order to evaluate the needs of the next-generation 5G network. It plans to introduce the version to 3GPP to influence the standards.

Figure 7 lists some of the reasons for operators to choose a Cisco 5G solution.

Figure 7. Reasons to Choose Cisco for 5G solution



3GPP has defined two different solutions for 5G networks: 5G Non-Standalone (NSA) and 5G standalone.

5G Non-Standalone Solution (NSA): In 5G NSA operators will use their existing EPC to anchor the 5G new radio using the 3GPP Release 12 Dual Connectivity feature. This feature will help operators with aggressive 5G launch needs to launch 5G in a shorter time and at lesser cost. The 5G NSA solution might suffice for some initial use cases, but 5G NSA has some limitations with regard to getting a much cleaner, truly 5G native solution and thus all the operators will eventually be expected to migrate to the 5G Standalone solution.

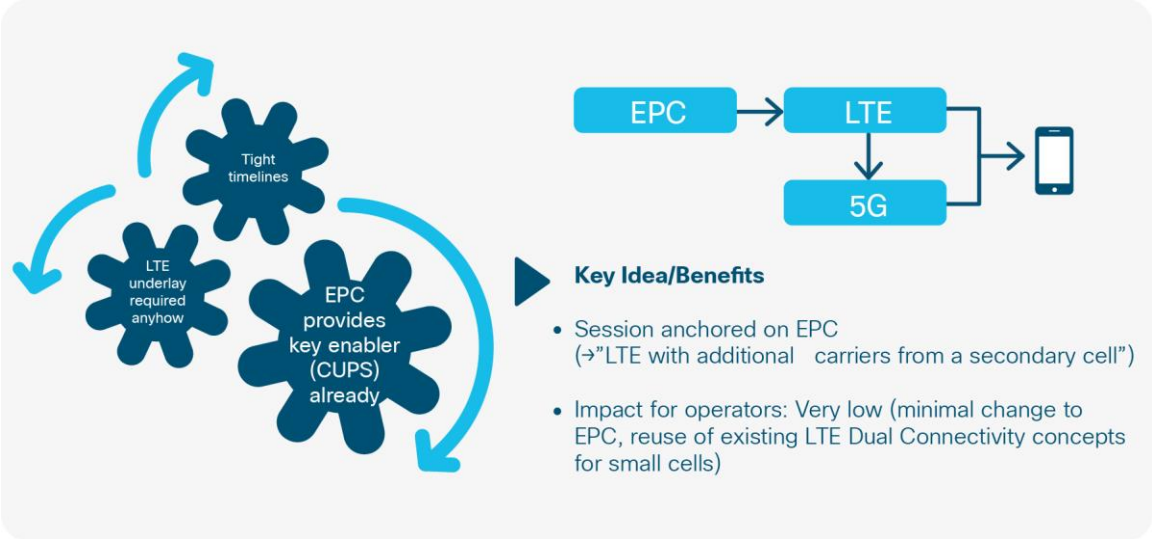
5G standalone solution: In 5G standalone a new 5G packet core is being introduced. It is much cleaner, with several new capabilities built inherently into it. Network slicing, CUPS, virtualization, automation, multi-Gbps throughput support, ultra-low latency, and other such aspects are natively built into the 5G standalone Packet Core architecture.

Cisco has in its portfolio packet core solutions for both 5G non-standalone and 5G standalone networks. Our 5G packet core solution allows operators to make transition from 4G to 5G in a graceful step-by-step manner.

Cisco Ultra 5G NSA Packet Core Solution

Cisco is one of the leading packet core vendors and has several customers worldwide who have deployed the Cisco Packet Core solution for EPC. Cisco enhanced its EPC packet core solution to support 5G non-standalone packet core capabilities. Cisco will support 5G non-standalone features in its existing EPC packet core network functions so that operators, with Cisco EPC Packet Core solution, can just do a software upgrade and buy 5G non-standalone licenses to turn on the 5G non-standalone capabilities (refer to Figure 8).

Figure 8. Simplify 5G packet core evolution



The Cisco 4G CUPS solution will provide flexibility and benefits of control- and user-plane separation and support for 5G peak data rates on a per-session basis. Refer to reference 12 for more details about the Cisco CUPS solution.

The Cisco 5G NSA Packet Core solution enables operators with Cisco EPC Packet Core to launch 5G service in a shorter time, using existing investment and infrastructure for some time for 5G. Thus it will provide an option to launch 5G with very little disruption in the network.

The Cisco 5G NSA solution supports all three option 3s (3, 3a, and 3x) with its 5G NSA packet core solution. It will be a 3GPP-compliant solution, so it can interoperate with any Radio Access Network (RAN) and network functions that are 3GPP-standards-compliant. Cisco Mobility Management Entity (MME), Cisco Serving GPRS Support Node (SGSN), Cisco Serving Gateway (SGW), Cisco Packet Data Network Gateway (PGW), and Policy and Charging Rules Function (PCRF) will support the 5G NSA features.

The Cisco 5G NSA Packet Core solution supports feature parity for both 4G and 5G sessions, so operators can have all the value-add features available for 4G sessions to be available for 5G sessions too. Cisco EPC Packet Core network functions are available on the Cisco Ultra Services Platform and are already deployed on several customers' networks worldwide. EPC network functions will eventually be available on the new Cisco Cloud Native Ultra Services Platform including all 5G functions as well.

Cisco is already involved in multiple 5G trials with multiple operators globally and expects to soon go live.

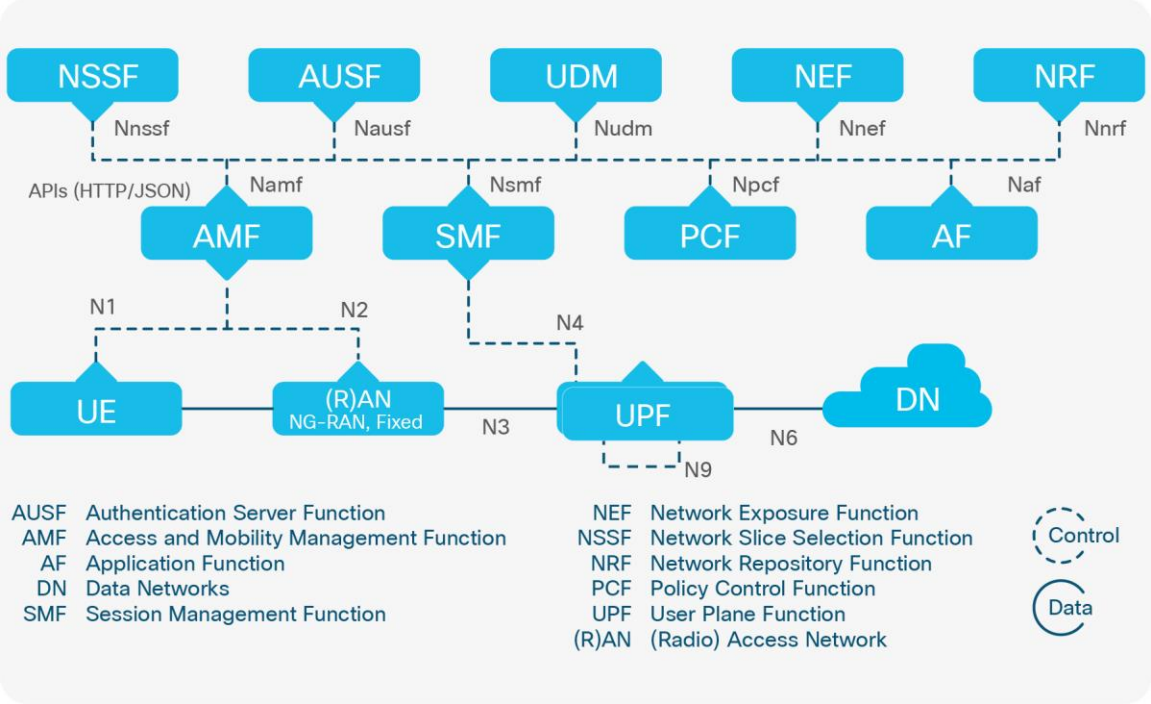
Cisco Ultra 5G SA Packet Core solution

The 5G standalone packet core is equipped with several new capabilities inherently built in so that operators have flexibility and capability to face new challenges with the new set of requirements for varying new use cases. The network functions in the new 5G core are broken down into smaller entities such as the Single-Mode Fiber (SMF) and UPF, which can be used on a per-service basis. Gone are the days of huge network boxes; welcome to services that automatically register and configure themselves over the service-based architecture, which is built with the new functions such as the Network Repository Function (NRF), which borrow their capabilities from cloud native technologies. For more details about cloud native evolution, please refer to reference 11.

Separation of the user plane has freed it from the shackles of the control plane state and permits deployments at the edge with very little integration overhead. Multi-access edge computing that spans both wireless and wireline technologies will significantly redefine how users connect to applications, corporate networks, and each other.

Figure 9 shows the new 5G standalone architecture as defined by 3GPP in reference 1.

Figure 9. New 5G standalone architecture

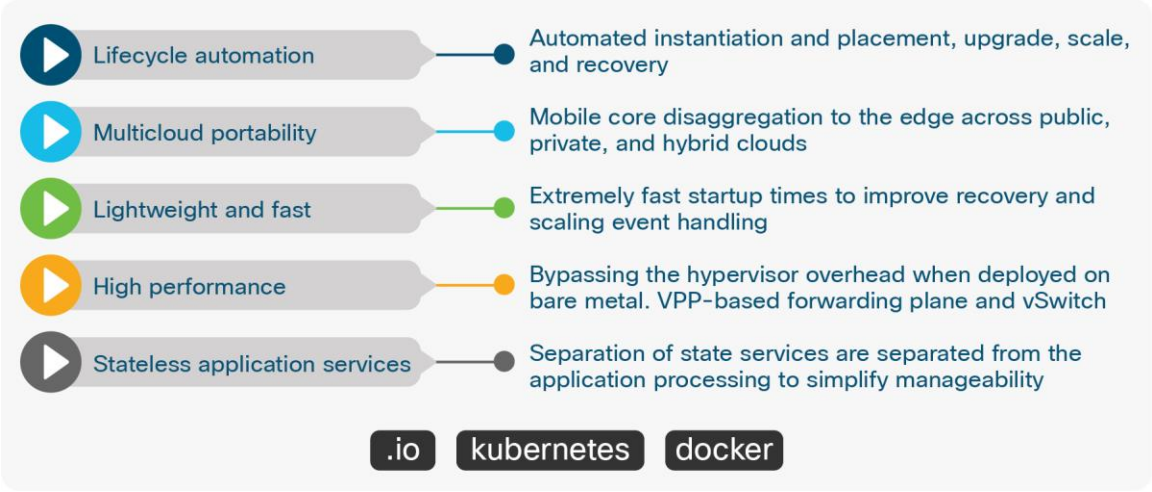


Cisco Cloud native Ultra Services Platform

The Cisco Ultra Services Platform has evolved into a cloud-native platform. With this evolved cloud-native platform, the Cisco 5G Stand-Alone (SA) solution provides a synergistic and coherent set of 5G SA network functions compliant to 5G SA 3GPP standards. These functions help Cisco enable best-in-class “cloud” operational benefits across the full Cisco 5G network-function portfolio. These cloud operational benefits include dynamic network-function scale-in/-out, faster network-function upgrades, in-service network-function upgrades, and support for NETCONF/YANG and streaming telemetry. Cisco’s goal is to provide a modular network-function implementation that enables carrier-specific adaptations to implement differentiated services. Cisco’s 5G Packet Core portfolio strategy is that all our 5G network-functions will use these common base software platform characteristics. This scenario enables our 5G core solution so customers can enjoy the related cloud operations benefits across the range of relevant Cisco network functions, consolidating and streamlining the network-function management and operational processes, and reducing carrier Operating Expenses (OpEx).

Cisco’s Cloud Native Ultra Services Platform delivers common configuration tools, common telemetry, logging, a unified control plane, common HTTP2/Stream Control Transmission Protocol (SCTP), Smart Business Architecture (SBA)/Representational State Transfer (REST)/JavaScript Object Notation (JSON), common database technologies, high-availability and Geographical Redundancy (GR) services, and common orchestration across all our 5G standalone network functions. This Cisco Cloud Native Ultra Services Platform uses open-source software services and tasks (for example, IP Communicator [IPC]; data synchronization; Service Bus; and configuration), life-cycle management [for example, kubernetes, load balancer, service mesh, and continuous integration and continuous delivery support enabling improved time to market and improved service velocity (refer to Figure 10).

Figure 10. Cisco’s Cloud Native Ultra Services Platform Features



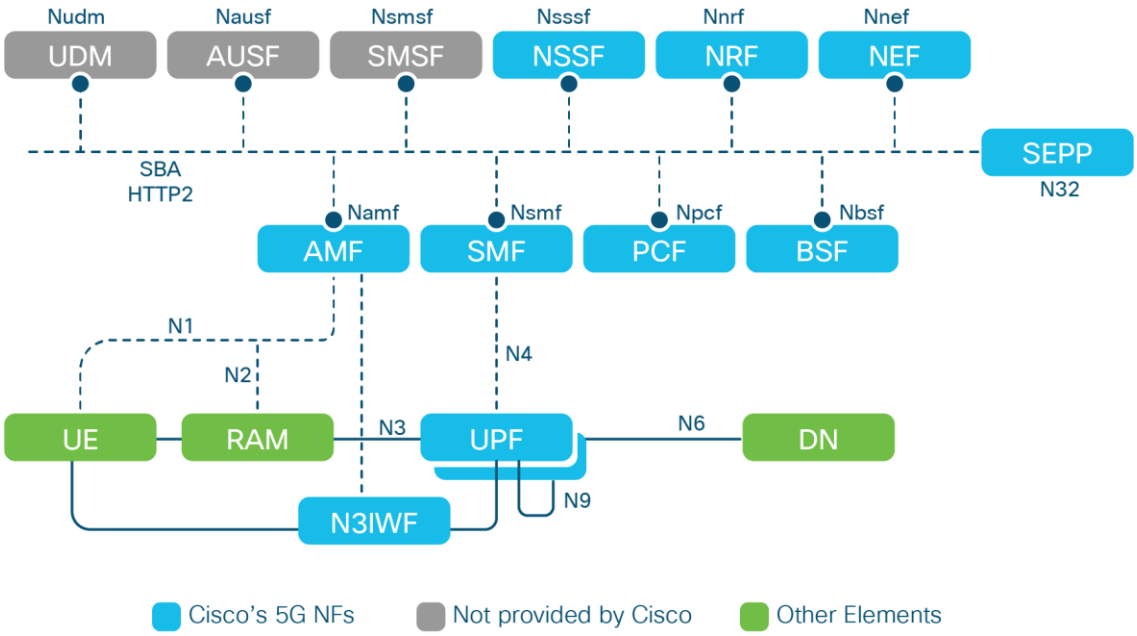
Cisco 5G SA Network Function Portfolio

In addition to delivering 3GPP Release 15-compliant 5G network functions, Cisco’s 5G solution strategy is to deliver an operationally efficient, unified, and high-performance 5G service-based architecture across these 5G network functions, with value-added Cisco capabilities beyond 3GPP.

Finally, Cisco’s 5G solution strategy is also to use our significant 4G software features across our 4G EPC products to provide maximum 4G and 5G feature compatibility where possible in our 5G network functions, and to enable feature-rich 4G and 5G network interworking capabilities in these network functions.

Cisco's 5G SA portfolio is composed of all key mobile core network functions: Access and Mobility management Function (AMF), [[define]] SMF, UPF, PCF, Network Repository Function (NRF), Network Slice Selection Function (NSSF), Network Exposure Function (NEF), Binding Support Function (BSF), Non-3GPP Interworking Function (N3IWF), and Security Edge Protection Proxy (SEPP) (refer to Figure 11).

Figure 11. Cisco 5G SA packet Core architecture



Cisco believes some of key drivers for the new 5G SA architecture are as follows:

- Truly converged multi-access core
- Service-based architecture
- Improved and enhanced network slicing capabilities
- Cloud-native friendly architecture
- Better integration between application and network layer
- New value-added capabilities
- Simplified Quality-of-Service (QoS) framework
- Interoperability with 4G EPC
- Different deployment options to suit different operator needs

AMF - Access and Mobility Management Function

AMF supports registration management, access control, and mobility management function for all 3GPP accesses as well as non-3GPP accesses such as Wireless LAN (WLAN). AMF also receives mobility-related policies from the PCF (for example, mobility restrictions) and forwards them to the user equipment. AMF fully supports 4G interoperability with the interface to 4G MME node.

SMF - Session Management Function

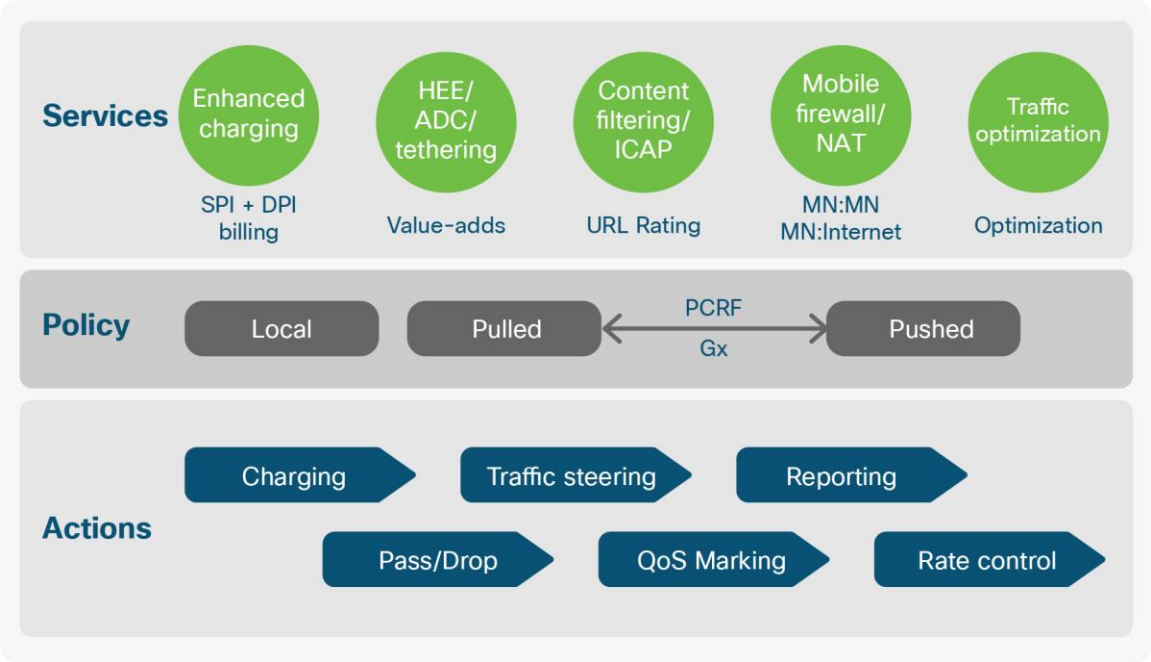
Cisco SMF builds upon the evolutions of the industry-leading Cisco System Architecture Evolution Gateway (SAE-GW) solution in the 4G space and its evolution in the 4G architecture to evolve to CUPS to support a decomposed SAEGW control plane (SAEGW-C)as the central control-plane entity that communicates over an Sx interface to the distributed and hybrid user-plane functions. Cisco started on the journey toward CUPS and laid the groundwork for the SMF evolution ahead of the 3GPP standards. In addition to supporting the standards-based SAEGW-C and its evolution to SMF, the rich history and experience of delivering integrated inline services and how that can be enabled in various operator networks for the various use cases is the key differentiation of the Cisco SMF product strategy. In the 5G architecture, SMF is responsible for session management with individual functions being supported on a per-session basis. SMF allocates IP addresses to user equipment, and selects and controls the UPF for data transfer. SMF also acts as the external point for all communication related to the various services offered and enabled in the user plane and how the policy and charging treatment for these services is applied and controlled.

User Plane Function

The Cisco User Plane Function (UPF) is designed as a separate network functions virtualization (VNF) that provides a high-performance forwarding engine for user traffic. The UPF uses Cisco Vector Packet Processing (VPP) technology for ultra-fast packet forwarding and retains compatibility with all the user-plane functions that the monolithic StarOS offers currently (such as Source/Dest Policy Incomplete [SPI/DPI] traffic optimization; and inline services Network Address Translation (NAT), firewall, Domain Name System (DNS) snooping etc.).

Cisco UPF product evolution for 5G continues to build upon our core principles of delivering industry-leading performance while integrating intelligence in the data path to deliver differentiated services in truly distributed network architectures. The UPF product strategy encompasses a broad range of user planes that can run on existing physical assets (investment protection), on-premises Telco Cloud, and virtualized environments as well as truly cloud-native user planes that can support a mix of public and private cloud offerings. Supporting distributed architectures with user planes moving closer to the edge and supporting Mobility Edge Compute (MEC) use cases to support the data-path services, delivered closer to the edge and with really low latency, is an integral part of the 5G evolution. Cisco UPF product strategy is based on incorporating intelligent inline services as well as a traffic steering framework to support service chains that can include external third-party applications as well. The key product capabilities of Cisco UPF are Integrated DPI-based services, Cisco Ultra Services Proxy, Cisco Ultra Traffic Optimization (UTO), and others (refer to Figure 12).

Figure 12. User Plane Functions



Cisco DPI and Inline Services

Cisco DPI and inline services include:

- **Application Detection and Control (ADC):** Cisco ADC allows operators to dynamically detect applications run by subscribers and derive business intelligence about the traffic and apply packaged promotions such as zero rating of music, video, or social media applications. ADC employs heuristic, statistical, and deterministic analysis-based detection of applications and content. Cisco exploits co-development opportunities where possible with content providers and the operators to better identify applications (such as Google, Amazon, and Facebook) and realize use cases more accurately.
- **Integrated subscriber firmware and NAT:** StarOS supports firewall and NAT inline services as part of the DPI function, thereby eliminating the need for an operator to deploy an external box that provides such functions. Inline services facilitate easier management and help reduce overall latency. The NAT implementation is carrier-grade endpoint-independent, and subscriber-aware and supports NAT44 and NAT64 functions. The firewall is an inline service that inspects subscriber traffic and performs IP session-based access control of individual subscriber sessions to protect the subscribers from malicious security attacks.
- **Integrated content-filtering solution:** This inline service to extract and categorize Universal Resource Locators (URLs) contained in HTTP requests from mobile subscribers is available. The URLs are pre-categorized into classes by an external database. HTTP requests from user equipment are checked for URL categorization and policies are applied based on subscriber profile. Various actions are taken based on URL category and subscriber profile such as to permit, block, redirect, etc. The content-filtering solution is optimally applied at the SMF/UPF before unnecessary traffic propagates further into the network.

Cisco Ultra Services Proxy

Cisco is also integrating an inline services proxy for supporting optimization for end-user flows based on an integrated TCP/HTTP proxy that can be used to adapt to changing characteristics of a mobile connection and adjust the overall flow based on the service being offered. This proxy is based on integrating an industry-leading solution from a partner as an integrated offering and greatly simplifies the conventional way of offering such services, which incurred heavy overheads on how the traffic was steered and moved around in order to apply such services.

Cisco Ultra Traffic Optimization

Mobile video tsunami is a reality now, and operators must make extensive RAN Capital Expenditures (CapEx) investments to keep up with mobile traffic growth. Operators are supporting the volume demand by increasing the number of cell sites in the RAN; otherwise the subscriber Quality of Experience (QoE) will suffer. The Cisco Ultra Traffic Optimization (UTO) is a software solution on the 4G PGW or 5G UPF that allows the use of existing RAN much more efficiently, thereby delaying or reducing RAN investments. Cisco UTO enables up to 40-percent more traffic transmission over a given band of spectrum and through existing cell sites and improves QoE for all subscribers and data flows.

Policy Control function

Cisco PCF is a direct evolution of the Cisco PCRF on the existing Cisco Policy Suite Cloud Native Docker container-based platform. The new PCF supports all the existing features of the traditional 3G and 4G Cisco Policy Suite PCRF in addition to the new 5G QoS policy and charging control functions and the related 5G signaling interfaces defined for the 5G PCF by the 3GPP standards (for example, N7, N15, N5, Rx, ..). Through various configuration options, operators will have the flexibility to enable or disable various features, protocols, or interfaces. The PCF evolution is planned in an incremental manner to keep older Cisco Policy Suite PCRF functions intact, and enable a hybrid 4G and 5G PCRF and PCF solution where necessary for customer operations.

Network Repository function

Cisco NRF is being delivered in line with 3GPP requirements in support of intelligent NFV core network node selection. Cisco’s NRF product further delivers value-added intelligence in the areas of stateful node selection, serving node discovery, topology hiding, signaling proxying as a basis for advance 5G network automation, and superior 5G core overall flexibility and simplicity of operations. Cisco’s 5G NRF product uses and extends key 4G product assets in the area of 4G node selection and 4G diameter signaling control.

Network exposure function

Cisco’s NEF uses the Cisco 4G Application Programming Interface (API) gateway called mobile orchestration gateway, which is commercially deployed in cloud-native networks today. The Cisco 4G API Gateway currently enables subscriber session QoS control services and sponsored data charging services between the core network and over-the-top applications, and as such lays the essential foundation for our 5G standalone NEF function in the 5G standalone core.

Network slice selection function

Network slicing enables the network to be segmented and managed for a specific use case or business scenario. A slice comprises the 5G network functions needed to compose a complete Public Land Mobile Network [[define]] (PLMN). The operability of a slice can be exposed to a slice owner such as an enterprise delivering an Internet of Things (IoT) service. Examples of slices include fixed mobile wireless, connected car, as well as traditional consumer services. The network operator generally defines the granularity of a slice to best meet the business requirements.

Network slicing requires the ability to orchestrate and manage the 5G network functions as a common unit. This orchestration requires coordination across individual network functions to ensure services are properly configured and dimensioned to support the required use case.

NSSF provides a network slice instance selection function for user equipment. It is possible to determine whether to allow the network slice requested by the user equipment. It also is possible to select an appropriate AMF or candidate AMF set for the user equipment. Based on operator configuration, the NSSF can determine the NRF(s) to be used to select network functions and services within the selected network slice instance(s).

Cisco had worked on the pre-standards NSSF function for even 4G EPC. and has a solution for doing slicing for 4G EPC too. This pre-standards NSSF solution is evolved now for 5G standalone packet core.

Binding Support Function

The 3GPP Binding Support Function (BSF) is a distinct 5G SAnetwork function used for binding an application-function request to one of many PCF instances, as described in TS 23.503. The 3GPP BSF addresses a “PCF binding” problem (that is, getting an application function and NEFs to talk to the same PCF as the SMF Protocol Data Unit [PDU] session) in 5G SA (independent of diameter), and it also fulfills a Diameter Routing Agent-like (DRA) binding function for 5G SA scenarios where the traditional IP Multimedia Subsystem (IMS) interacts with the 5G SA core through the Rx protocol. For the IMS use case, the BSF is defined to terminate (and convert) or proxy the Rx directly to the relevant PCF using binding-based routing at the BSF.

Also per 3GPP, the BSF can be co-located with other network functions such as SMF, PCF, NRF, etc., but most suitably co-located with the NEF.

As a 5G SAnetwork-function type, the BSF per se does not apply to option 3x for which the EPC core applies, including traditional virtual DRA (vDRA) nodes that perform Rx and Gx binding-based routing in 4G. Being an extension of Cisco vDRA in 4G, the Cisco BSF can, however, operate in the option 3x core, but in this case the Cisco BSF would, of course, be configured as a DRA node.

Security Edge Protection Proxy

Security Edge Protection Proxy (SEPP) is a nontransparent proxy that supports message filtering and policing on inter-PLMN control-plane interfaces and also topology hiding for the PLMN network. A SEPP function should perform the firewall role for transactions between domains. Given that the SEPP is the point where integrity protection and encryption are applied, the SEPP has visibility into each aspect of a transaction.

The SEPP function applies permit/deny Access Control Lists (ACLs) based on configured rules. This approach is effective for known threat exposures.

Furthermore, the SEPP function generates flow-related information that will be provided to an off-board threat visibility analysis function such as Cisco Stealthwatch® security. This capability supports the creation of a baseline behavior profile, which allows the operator to validate the policies driving the ACL creation against observed behavior and correct as necessary. It also allows the operator to detect anomalous behaviors in real time and instigate manual remediation. For example, rogue nodes attempting to use SEPP services would be highlighted.

These flow records can also be used to assist resolving disputes between roaming partners, using Internetwork Packet Exchange (IPX)-like functions or directly connected.

Additionally, the SEPP firewall functions allows the presentation of optional security honeypot-like functions. Suspect flows, based on rogue node identification, would be processed by the function in such a way that potential attackers perceive no detectable change in behavior.

Non-3GPP interworking function

The non-3GPP interworking function (N3IWF) is used for integrating non-3GPP access types into the 5G SA core to make it a truly converged core. It is used mainly for non-3GPP access types such as Wi-Fi and fixed-line integration into the 5G SA core. The N3IWF terminates the Internet Key Exchange Version 2 (IKEv2) and IP Security (IPsec) protocols with the user equipment over [[define]] NWu and relays over the N2 interface the information needed to authenticate the user equipment and authorize its access to the 5G core network. It also mainly supports termination of N2 and N3 interfaces to the 5G core network for the control and user planes, respectively.

Migration path from 4G to 5G

Cisco believes migration from 4G to 5G has to be graceful and should happen in a step-by-step manner. 4G is going to co-exist with 5G for a long time to come, even if 5G is introduced. Given this reality as well as the fact operators need to have a network that can cater to a wide variety of devices, they need to have a network that supports these different types of devices at the same time.

The Cisco 5G solution is geared to help operators easily perform the step-by-step migration from 4G to 5G.

Figure 13 shows the step-by-step migration path that Cisco recommends to operators to migrate from their current 4G EPC network to a 5G network.

Figure 13. Migration from 4G EPC to 5G network

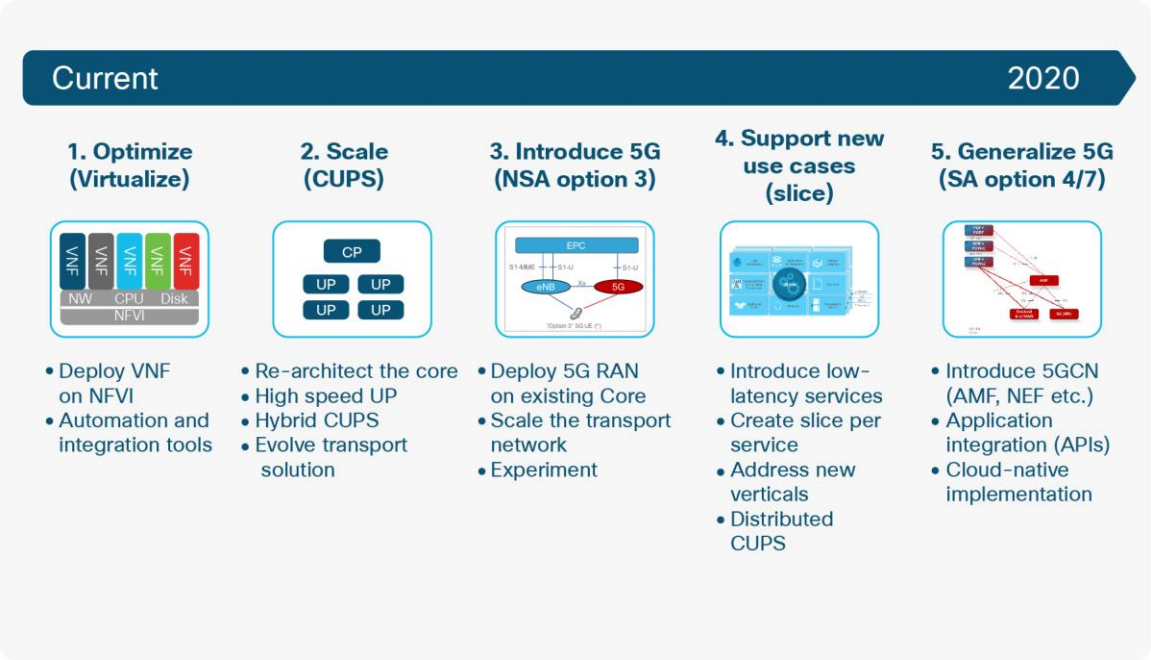
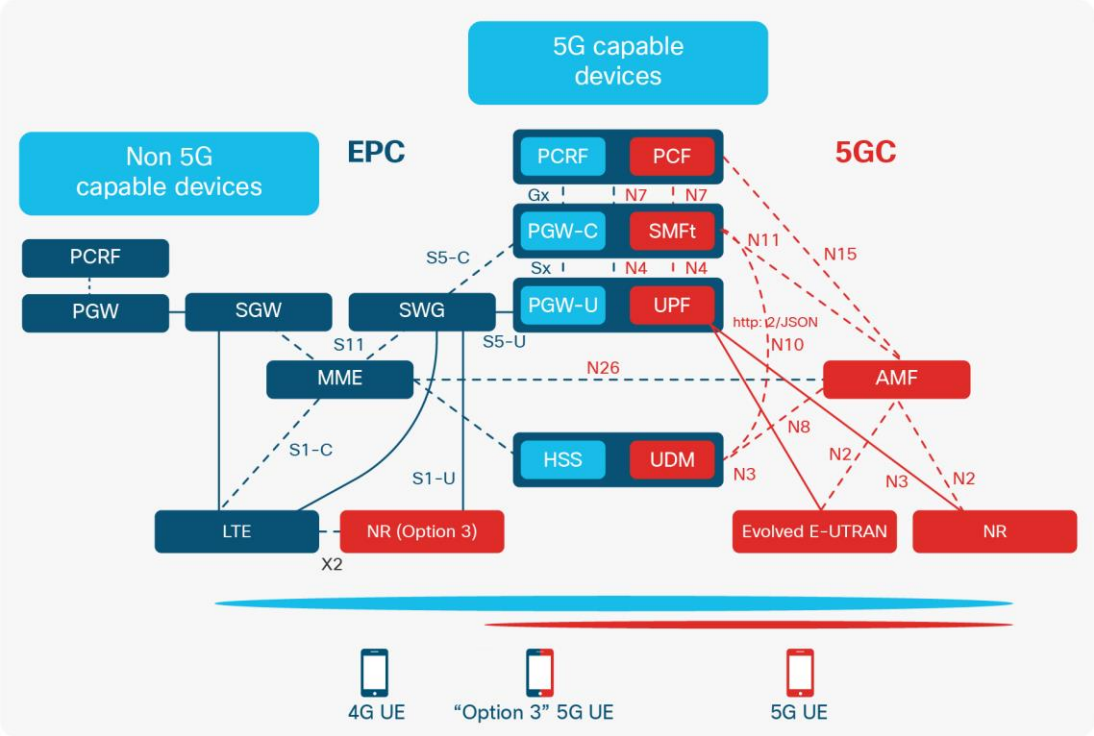


Figure 14 shows how the interoperable network will look like eventually. The network will support different types of older as well as truly native 5G SA devices at the same time. As the industry transitioned from 2G and 3G to a 4G network, this evolution is expected to follow a similar path from 4G to 5G networks.

Figure 14. Interoperable network



Summary

5G enables a new set of possibilities and capabilities. 5G is not just going to be about high-speed data connections for enhanced mobile broadband, but also will enable several new capabilities that can cater to several new enterprise use cases. 5G will not just be about serving consumer and enterprise subscribers with high-throughput connectivity; 5G will enable new revenue avenues and opportunities for operators by its ability to cater to requirements for several new enterprise use cases. Thus, Cisco envisions 5G to equip operators with more capabilities to cater to enterprise customer needs to support their current as well as new use cases.

Cisco is a leading packet core vendor for decades. Cisco has witnessed several 3GPP technology transitions earlier too, first from 2G to 3G and then from 3G to 4G, and is currently the best-placed vendor to define and lead the solution for the important and crucial transition from 4G to 5G.

We are developing our 5G solution with operator needs in mind. Ours strategy is to transition our customers to a cloud-centric world to get the benefits of our cloud-native solution and thus equip them to be able to meet their needs. We believe 5G is not just about new radio, but about the total end-to-end network, including the need for both RAN and packet core evolve to cater to these operators' needs.

The Cisco 5G Packet Core solution product strategy is to provide a synergistic and coherent set of 5G standalone network functions compliant to 5G standalone 3GPP standards, over the Cisco Cloud Native Ultra Services Platform. This platform is the cloud-native evolution of the Cisco Ultra Services Platform. The Cisco Cloud Native Ultra Services Platform helps Cisco enable best-in-class "cloud" operational benefits across the full Cisco 5G SA NF portfolio. These cloud operational benefits include dynamic network-function scale-in/-out, faster network-function upgrades, in-service network-function upgrades, and support for NETCONF/YANG and streaming telemetry.

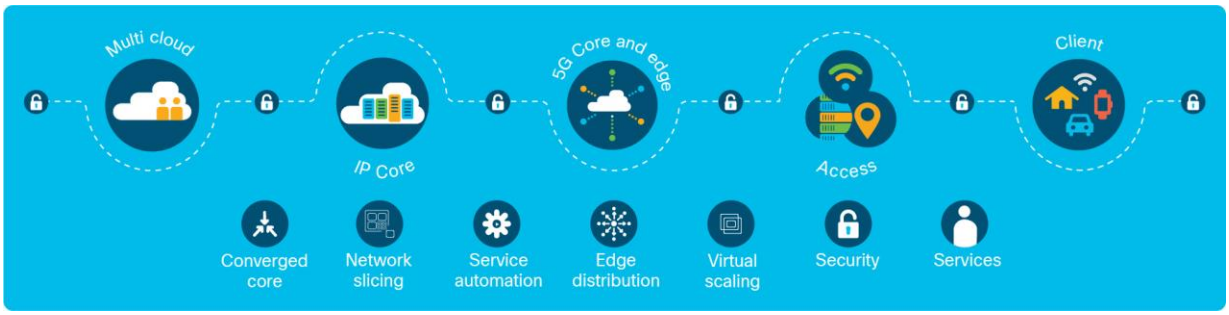
Cisco will have in its portfolio a packet core solution for both 5G Non-Standalone (NSA) and 5G standalone networks. Cisco's goal is to develop a 5G packet core solution that allows operators to make the transition easily from 4G to 5G.

Conclusion

The Cisco Ultra Services Platform is an important piece of the entire Cisco 5G value chain. Cisco is taking a multicloud-to-client approach, unifying multivendor solutions into a single, secure, standards-based architecture. And emphasizing that with the proper secure network so customers can start delivering 5G services today in a cloud-scale mobile Internet for business, consumer, and IoT— bringing in "new 5G money" with a compelling value chain. 5G is where the breadth of Cisco matters, because we do service enablement, the services themselves, the 5G core, the IP transport, the cloud, etc. We can truly optimize and secure across the entire service layer.

The Cisco Ultra Services Platform is a fully virtualized architecture supporting control- and user-plane separation and a distributed architecture. This platform includes software components for packet core, policy suite, and automation. The new cloud-native evolution of the platform expands its potential and flexibility to deliver your 5G and digital transformation success (refer to Figure 15).

Figure 15. Cisco 5G: Redefining your network



For more information about the Cisco Ultra Services Platform, please visit:

- https://www.cisco.com/go/5g
- https://www.cisco.com/c/en/us/solutions/service-provider/ultra-services-platform/index.html

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