Cisco Ultra 5G Packet Core Solution

Introduction

5G is the next generation of 3GPP technology, after 4G/LTE, being defined for wireless mobile data communication. Starting 3GPP Release 15 onwards 3GPP has started defining standards for 5G. As part of 3GPP Rel 15 New 5G Radio and Packet Core evolution is being defined to cater to the needs of 5G networks. [1] and [2] provide more details on 3GPP standards for 5G architecture.

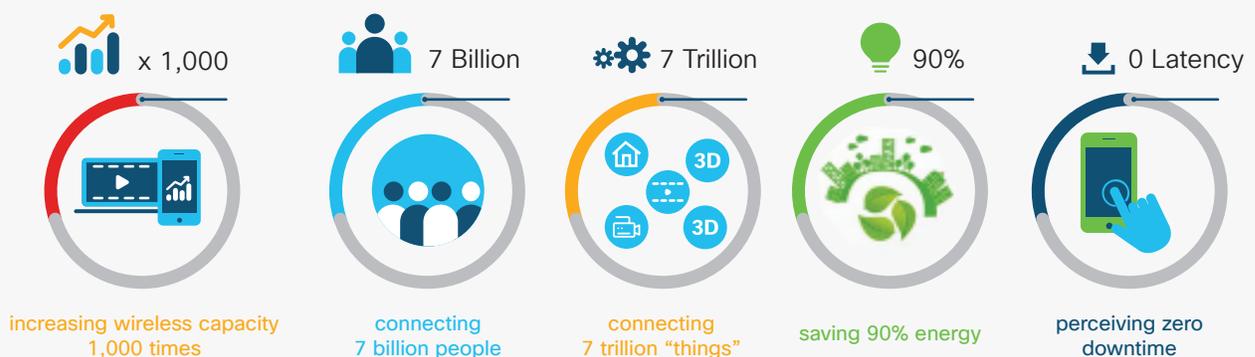Below listed are the some of the key end goals of 5G:

- Very high throughput (1-20 Gbps)
- Ultra low latency (<1ms)

- 1000x bandwidth per unit area
- Massive connectivity
- High availability
- Dense coverage
- Low energy consumption and
- Up to a 10-year battery life for machine type communications

Below are some of the projections set by 5G PP (A Joint initiative between EU Commission and European ICT):

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

5G PPP will drive the future networked society

x 1,000
increasing wireless capacity 1,000 times

7 Billion
connecting 7 billion people

7 Trillion
connecting 7 trillion "things"

90%
saving 90% energy

0 Latency
perceiving zero downtime

[1]   3GPP TS 23.501: System Architecture for the 5G System; Stage 2.

[2]   3GPP TS 23.502: Procedures for 5G Systems; Stage 2.

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Cisco's 5G vision

As per Cisco, 5G is an enabler for new set of possibilities and capabilities. Every new generation of 3GPP wireless mobile data communication technology has set the stage for 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 which led to proliferation of applications like video, ecommerce, social networks, games and several other applications on mobile devices. Focus in 3G/4G was more on mobile broadband for consumers/enterprises.
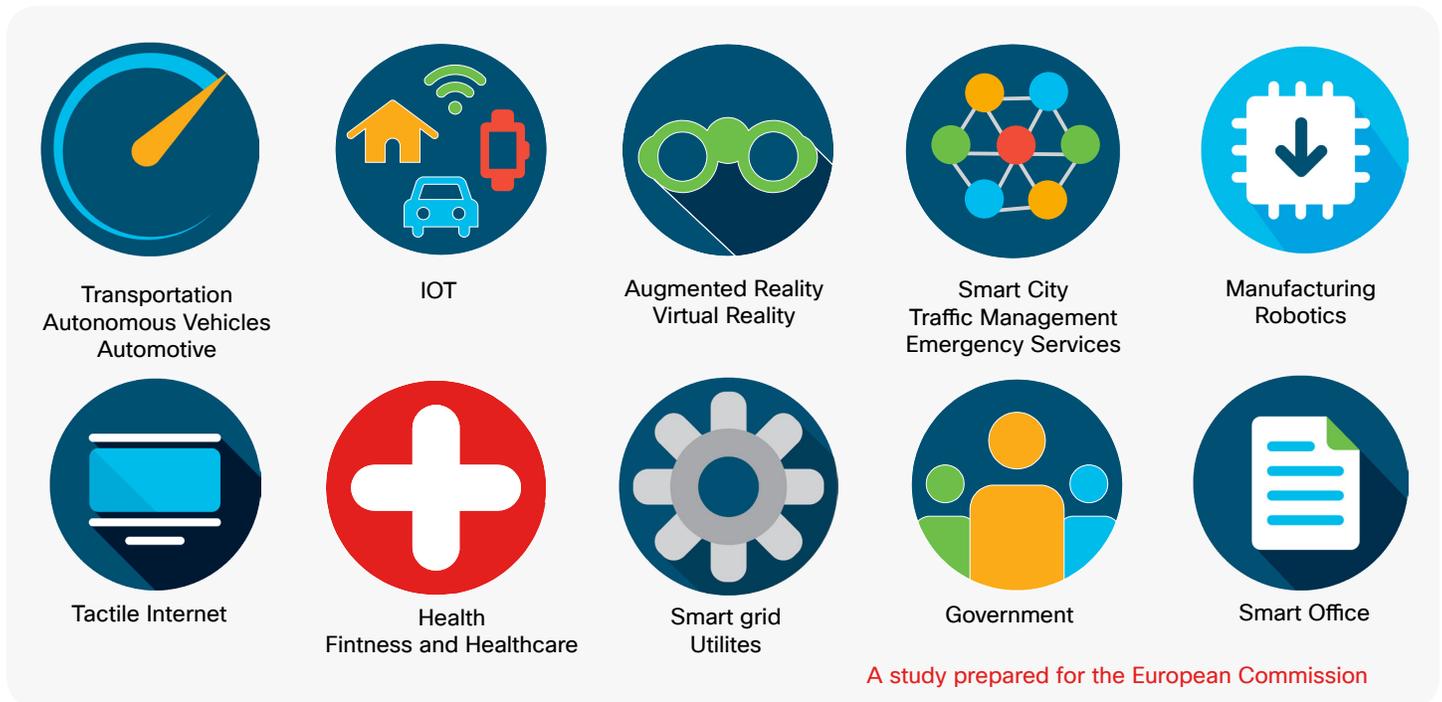
Currently below are some trends and new opportunities that Operators witness and need to gear upto:
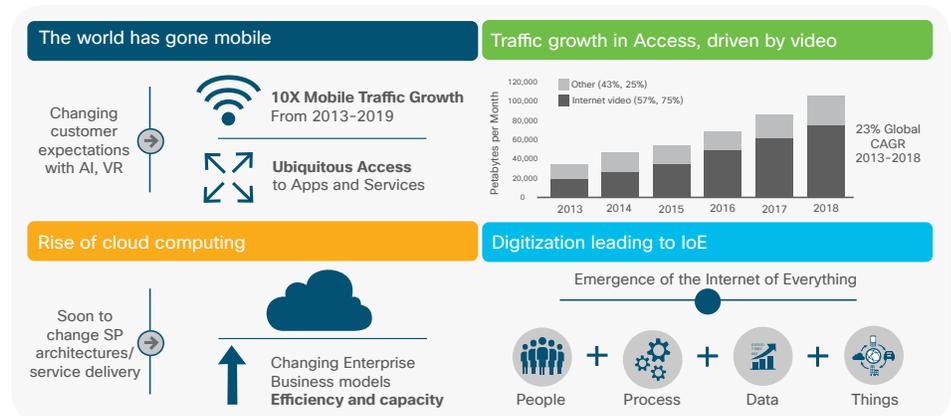
At the same time new set of Use cases are being introduced that is going to throw up new set of challenges and complexities. Thus, new 5G network has to help Operators manage current needs as well as gear up for new needs of the upcoming new use cases. 5G is not just going to be about high-speed data 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/enterprise subscribers with high throughput connectivity. 5G will enable new revenue avenues and opportunities for Operators by being able 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 views 5G core as an opportunity 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 are being defined for the mobile core that facilitate new opportunities such as personalized networks through slicing and more granular functions. 5G provides a framework to take advantage of the massive throughput and low latency that new radio provides.

Below listed are some of the use cases that 5G will cater to:

| Transportation Autonomous Vehicles Automotive | IOT | Augmented Reality Virtual Reality | Smart City Traffic Management Emergency Services | Manufacturing Robotics |

| Tactile Internet | Health Fintness and Healthcare | Smart grid Utilites | Government | Smart Office |

A study prepared for the European Commission

Below is the chart that illustrates the broad categories of use cases (source: ITU) that 5G will cater to:

5G Usage scenarios

Source: ITU
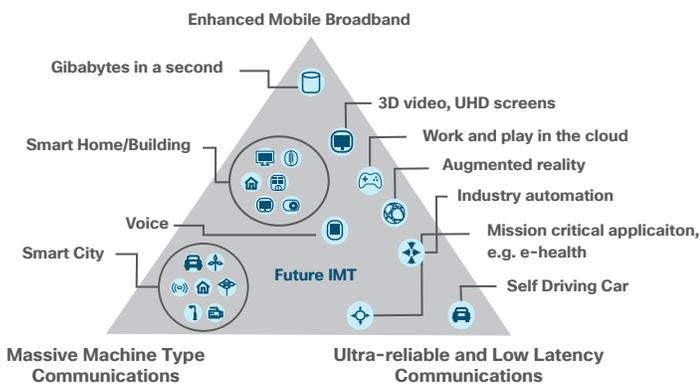
Below listed are the 3 different Use case categories that will cover all the use cases.

- **Enhanced Mobile broadband (eMBB):** 5G Enhanced Mobile Broadband (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, Factory Automation):** Ultra-Reliable Low Latency Communications (URLLC) 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 then end user in a Control and User plane Separation (CUPS) architecture to achieve the latency requirements.

- **Massive 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 which require a similar service to 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. Below are characteristics of these use cases:

- Efficient low cost communication with deep coverage.

- Light weight device initialization and configuration.

- Efficient support of infrequent small data for mobile originated data only communication scenarios.
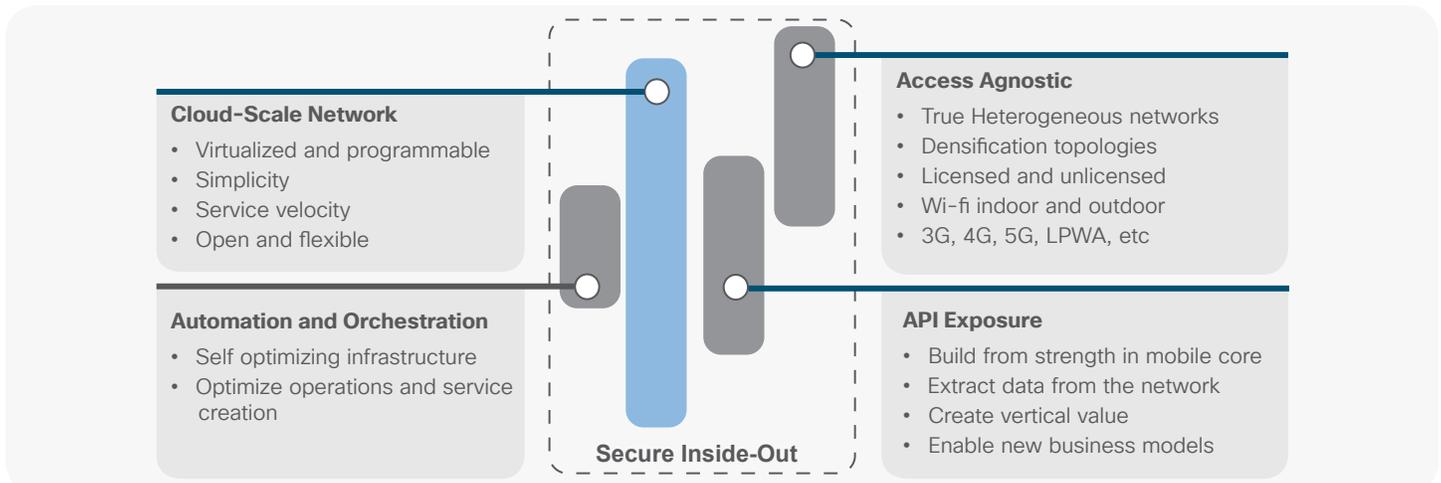
Cisco Ultra 5G Packet Core Solution

Given the several different use cases, each with different needs and requirements, it is going increase the network complexity and increase costs for Operators. Thus, in order for Operators to be able to cater to these different use cases and stay ahead of the competitors, Cisco believes Operators will need following capabilities:
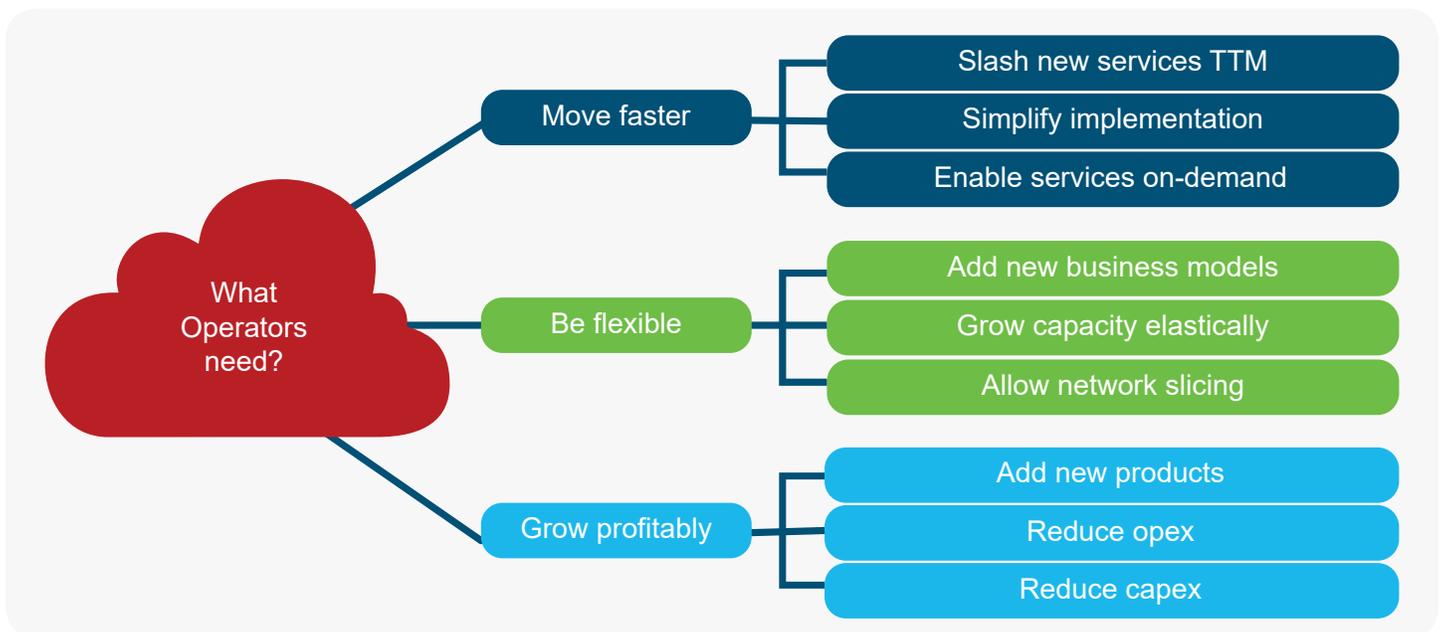
Cisco is developing its 5G solution keeping above Operator needs in mind. Cisco's strategy is to transition its customers to Cloud centric world to be able to get the benefits of Cloud Native solution and thus equip them to be able to meet the needs listed above. Cisco believes 5G is not just about new Radio, but it is the total end-to-end network including both RAN and Packet Core need to evolve to cater to these needs of Operators.

Below listed are key tenets of the Cisco 5G Solution Architecture:

Cloud-Scale Network
- Virtualized and programmable
- Simplicity
- Service velocity
- Open and flexible

Access Agnostic
- True Heterogeneous networks
- Densification topologies
- Licensed and unlicensed
- Wi-fi indoor and outdoor
- 3G, 4G, 5G, LPWA, etc

Automation and Orchestration
- Self optimizing infrastructure
- Optimize operations and service creation

API Exposure
- Build from strength in mobile core
- Extract data from the network
- Create vertical value
- Enable new business models

Secure Inside-Out

Cisco is a leading Packet Core vendor for decades and has been influencing 3GPP standards given its expertise it has built over several years. Cisco has witnessed transitions earlier too, firstly from 2G to 3G and then 3G to 4G and is currently best placed vendor to define and lead the solution for the important and crucial transition from 4G to 5G.
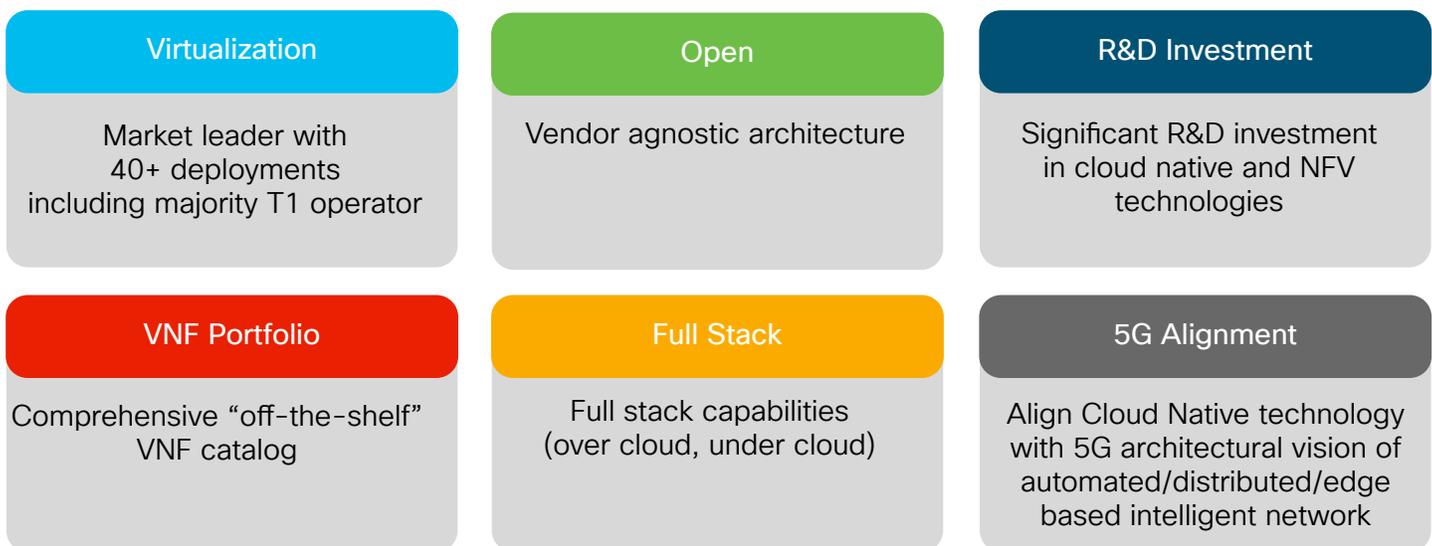
Cisco's 5G Solution will be based on Cloud Native Ultra Service Platform based solution. Ultra Services Platform is one of the industry leading virtualized platform for mobile core services. Cisco's Ultra Service

Platform based VPC solution is deployed in 40+ networks globally making Cisco one of the leading Virtual Packet Core Vendor.

Cisco has been working on several Packet Core concepts even before they could get standardized in 3GPP. For instance, Cisco was one of the vendor to demonstrate CUPS in MWC in 2016 and 2017 even before 3GPP could standardize it. Continuing the similar trend Cisco is aggressively working in introducing a pre- standards version of the 5G solution and thus evaluate needs the needs of the NextGen 5G network and take them to 3GPP and influence the standards accordingly.

Below listed are some of the reasons for Operators to choose Cisco 5G solution:

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

Virtualization	Open	R&D Investment
Market leader with 40+ deployments including majority T1 operator	Vendor agnostic architecture	Significant R&D investment in cloud native and NFV technologies

VNF Portfolio	Full Stack	5G Alignment
Comprehensive "off-the-shelf" VNF catalog	Full stack capabilities (over cloud, under cloud)	Align Cloud Native technology with 5G architectural vision of automated/distributed/edge based intelligent network

5G Non-Standalone Solution (NSA): In 5G NSA Operators will leverage their existing EPC Packet Core to anchor the 5G NR using 3GPP Release 12 Dual Connectivity feature. This will help Operators with aggressive 5G launch needs to launch 5G in shorter time and with lesser cost. 5G NSA solution might suffice for some initial Use cases. But 5G NSA has some limitations with regards to getting a much cleaner truly 5G Native solution and thus all the Operators will eventually expected to migrate to 5G Standalone solution.
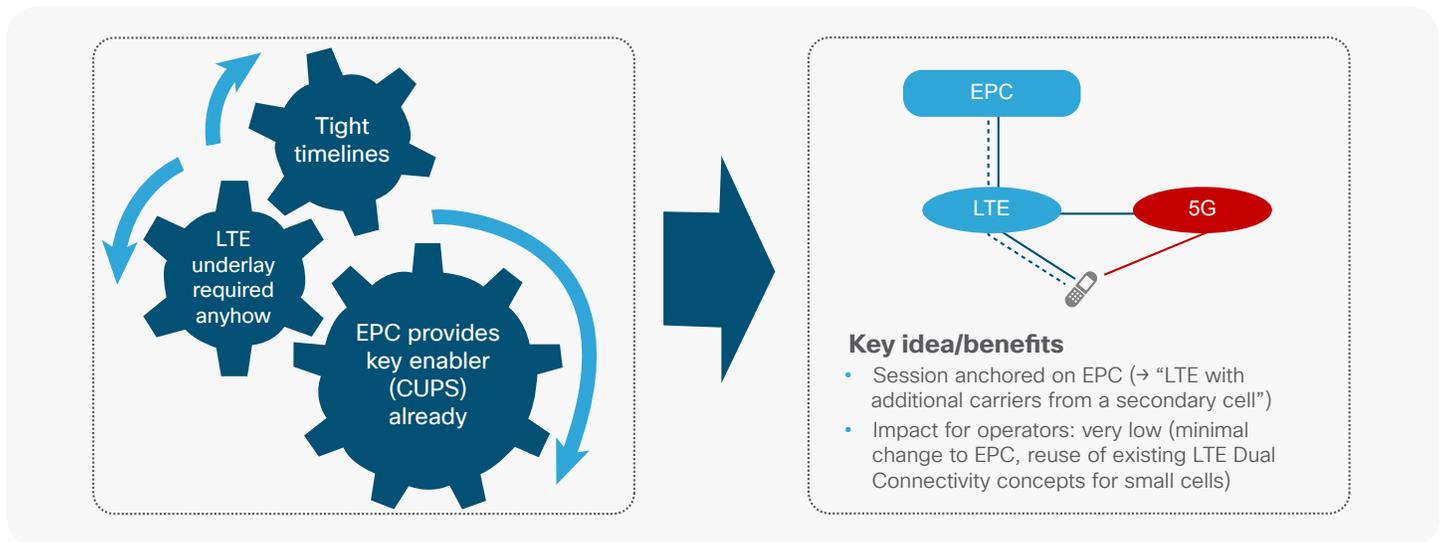
5G Standalone (SA) Solution: In 5G SA an all new 5G Packet Core is being introduced. It is a much cleaner with several new capabilities built inherently into it. Network Slicing, CUPS, Virtualization, Automation, Multi-Gbps support, Ultra Low latency and other such aspects are natively built into 5G SA Packet Core architecture.

Cisco will have in its portfolio Packet Core solution for both 5G Non-Standalone (NSA) and 5G Standalone(SA) network. Cisco's goal is to come up with 5G Packet Core solution that 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 vendor and has several Customers world over who have deployed Cisco Packet Core solution for EPC. Cisco will enhance its EPC Packet Core solution to support 5G NSA Packet Core capabilities. Cisco will support 5G NSA features in its existing EPC Packet Core network functions so that Operators, with Cisco EPC Packet Core solution, can just do Software upgrade and buy 5G NSA licenses to turn on the 5G NSA capabilities.

Key idea/benefits
- Session anchored on EPC (→ "LTE with additional carriers from a secondary cell")
- Impact for operators: very low (minimal change to EPC, reuse of existing LTE Dual Connectivity concepts for small cells)

Cisco has introduced 4G CUPS solution. Cisco 4G CUPS solution will provide flexibility and benefits of Control and User plane separation and support for 5G Peak Data rates on per session basis. Refer to [12] for more details on Cisco CUPS solution.

Cisco 5G NSA Packet Core solution will enable Operators with Cisco EPC packet Core to launch 5G service in shorter time, leverage existing investment and infrastructure for some time for 5G. Thus it will provide seamless option to launch 5G with very less disruption in the network.

Cisco 5G NSA solution will support all three Option 3 (3, 3a, and 3x) with its 5G NSA Packet Core solution. It will be 3GPP compliant solution thus it can interoperate with any RAN and Network functions that at 3GPP standards compliant.

Cisco 5G NSA Packet Core Solution will support feature parity for both 4G and 5G sessions, thus Operators can have all the value add features available for 4G sessions to be available for 5G sessions too.

Cisco is already involved in multiple 5G NSA trials with multiple Operators globally and expect to soon go live in some Operators networks by Q1 or Q2 CY2018.

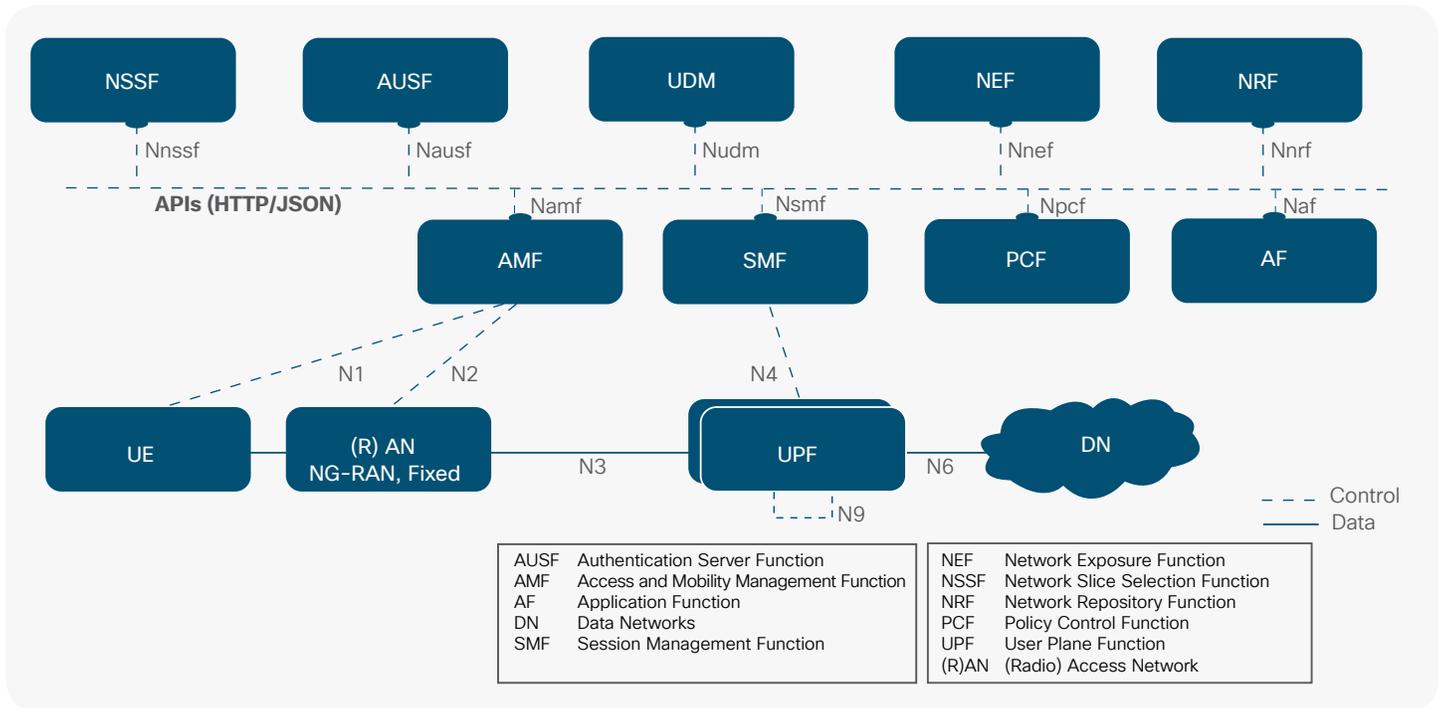# Cisco Ultra 5G SA Packet Core Solution

5G SA Packet Core is equipped several new capabilities inherently built into to so that operators have flexibility and capability to face new challenges thrown open by the new set of requirements for varying new use cases. The network functions in new 5G Core are broken down into smaller entities such as the 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 like the NRF which borrow their capabilities from cloud native technologies.
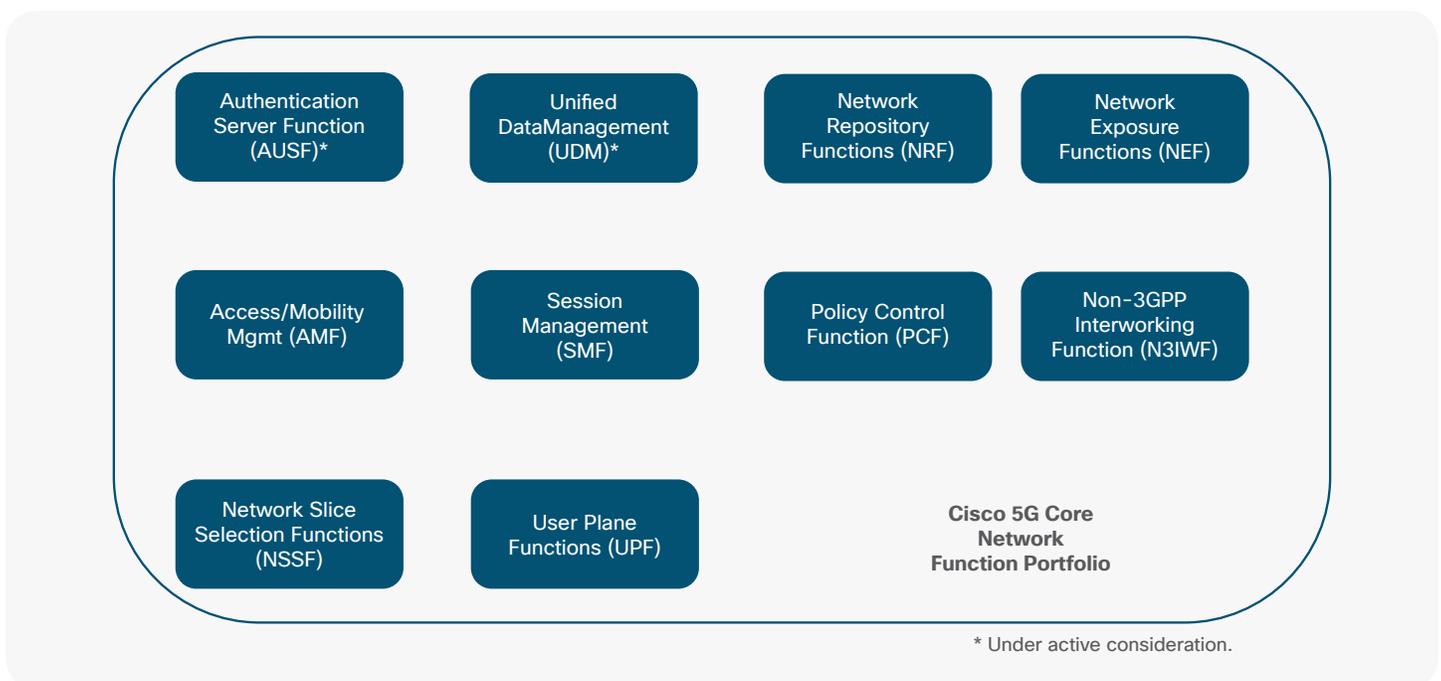
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[12]   Whitepaper on Cisco Ultra Packet Core CUPS.

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 the users connect to applications, corporate networks and each other.

Given below is the new 5G SA architecture as defined by 3GPP in [1]:

AUSF	Authentication Server Function	
AMF	Access and Mobility Management Function	
AF	Application Function	
DN	Data Networks	
SMF	Session Management Function	

NEF	Network Exposure Function	
NSSF	Network Slice Selection Function	
NRF	Network Repository Function	
PCF	Policy Control Function	
UPF	User Plane Function	
(R)AN	(Radio) Access Network	

Cisco eventually aims to have almost the network functions that are needed in 5G SA Packet Core. Cisco 5G SA Packet Core Solution will have following network functions in its portfolio:

Authentication Server Function (AUSF)*

Unified DataManagement (UDM)*

Network Repository Functions (NRF)

Network Exposure Functions (NEF)

Access/Mobility Mgmt (AMF)

Session Management (SMF)

Policy Control Function (PCF)

Non-3GPP Interworking Function (N3IWF)

Network Slice Selection Functions (NSSF)

User Plane Functions (UPF)

Cisco 5G Core Network Function Portfolio

* Under active consideration.

[1]   3GPP TS 23.501: System Architecture for the 5G System; Stage 2.

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 WLAN. AMF also receives mobility related policies from PCF (e.g.

mobility restrictions) and forwards them to the UE. AMF fully supports 4G interoperability with the interface to 4G MME node.

SMF – Session Management Function

Cisco SMF builds upon the evolutions of the Cisco's industry leading SAE-GW solution in the 4G space and its evolution in the 4G architecture to evolve to CUPS to support a decomposed 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 towards CUPS and laid the groundwork for the SMF evolution ahead of the 3GPP standards and besides 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 UEs, 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.

UPF – User Plane Function

Cisco User Plane Function (UPF) is designed as a separate 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 functionality that the monolithic StarOS offers currently (such as SPI/DPI, traffic optimization and inline services NAT/Firewall/DNS snooping etc.).

Cisco User Plane Function product evolution for 5G continues to build upon its core principles of delivering industry leading performance, while integrating intelligence in the data path to deliver differentiated services in truly distributed network architectures. The User Plane product strategy encompasses a broad range of user planes that can run on existing physical

assets (investment protection), on prem Telco Cloud and Virtualized environments as well as truly Cloud Native User Planes that can support a mix of Public, 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 User Plane product strategy is based on incorporating intelligent inline services as well as a Traffic steering framework to support service chains which can include external 3rd Party applications as well. The key product capabilities of Cisco UPF are Integrated DPI Based Services, Cisco Ultra Services Proxy (CUSP), Cisco Ultra Traffic Optimization (CUTO) and others.
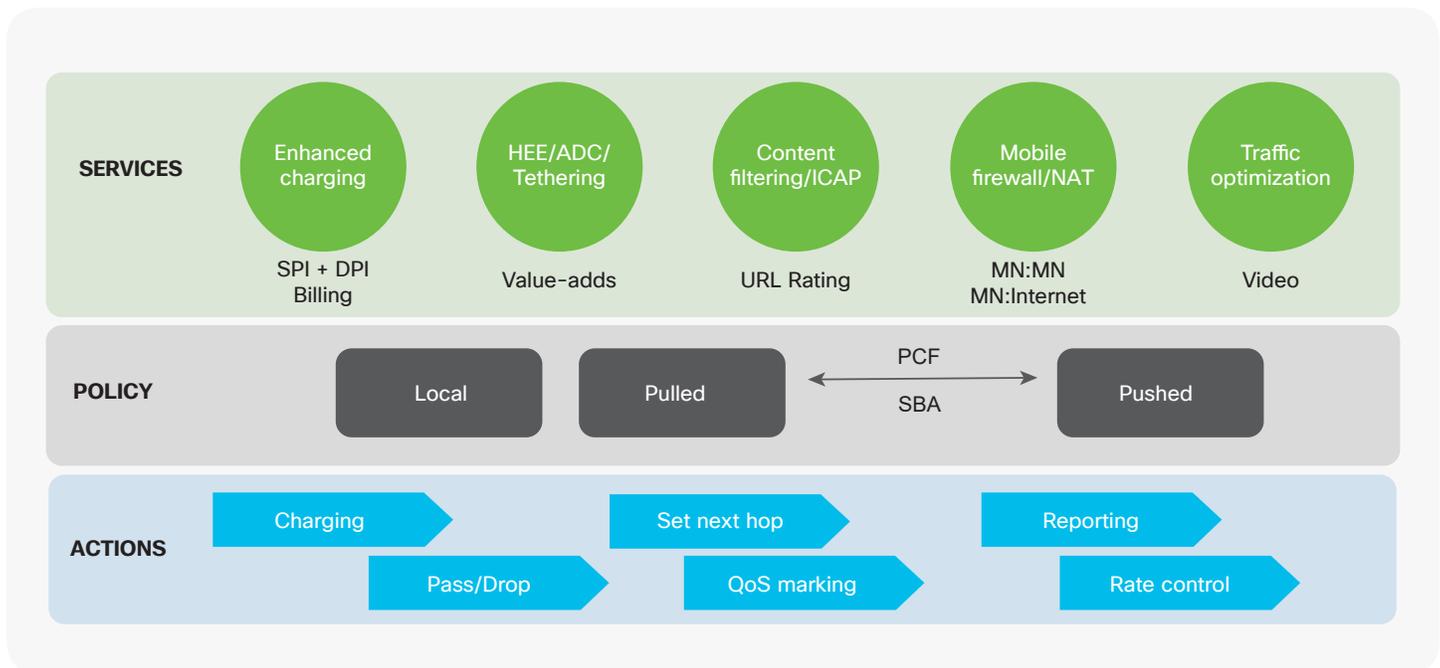
Cisco DPI and Inline Services

• ADC (Application Detection and Control)

Cisco's ADC solution allows operators to dynamically detect applications run by subscribers and derive business intelligence on 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/Facebook) and realize use cases more accurately.

• Integrated subscriber FW/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 functionality. Inline services facilitate easier management

and and helps with reducing overall latency. The NAT implementation is carrier grade, endpoint-independent and subscriber-aware and supports NAT44 and NAT64 functionality. The Firewall service An in-line 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

An in-line service available in StarOS to extract and categorize URLs contained in HTTP requests from mobile subscribers based. The URLs are pre-categorized into classes by an external database. HTTP requests from UEs are checked for URL categorization and policies are applied based on subscriber profile. Various actions are taken based upon URL category and subscriber profile such as to permit, block, redirect etc. The content filtering solution is optimally applied at the EPC 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 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 extensive RAN CAPEX investments are required by operators to keep up with mobile traffic growth. Operators are supporting the volume demand by increasing the number of cell sites in the RAN as otherwise the subscriber QoE will suffer. Cisco's CUTO is a software solution on the 4G PGW or 5G UPF that allows the use of existing RAN a lot more efficiently thereby delaying or reducing RAN investments. CUTO enables up to 40% more traffic to be transmitted over a given band of spectrum and via existing cell sites and improves QoE for all subscribers and data flows.

PCF – Policy Control Function

Cisco PCF is a direct evolution of the Cisco PCRF on the existing CPS Cloud Native Docker container based platform. The new PCF will have support for all the existing features of the legacy 3G/4G CPS PCRF in addition to new 5G QoS policy and charging control functions and the related 5G signaling interfaces defined for the 5G PCF by the 3GPP standards (eg. 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 keeping legacy CPS PCRF functionality intact, and enabling hybrid 4G/5G PCRF/PCF solution where necessary for customer operations.

Cisco NRF

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 leverages and extends key 4G product assets in area of 4G node selection and 4G diameter signaling control.

Cisco NSSF and NEF

The Cisco NSSF and NEF solutions is also being delivered in line with evolving 3GPP standards, and delivers respectively, advanced network slicing authorization and validation, and open API network exposure capabilities. Cisco's NEF leverages cloud-ready, commercially deployed Cisco 4G API Gateway called Mobile orchestration gateway.

Summary

As per Cisco, 5G is an enabler for new set of possibilities and capabilities. 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/enterprise subscribers with high throughput connectivity. 5G will enable new revenue avenues and opportunities for Operators by being able 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.

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