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Wifi interworking with LTE

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Wifi interworking with LTE

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Wifi offload

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Wifi offload :

- It is one of the implementations of using small cell technologies to provide data services to cellular users.
- Smart devices today are so designed that they prompt users to log on to wifi networks for data transfer when one is in range as compared to cellular networks.

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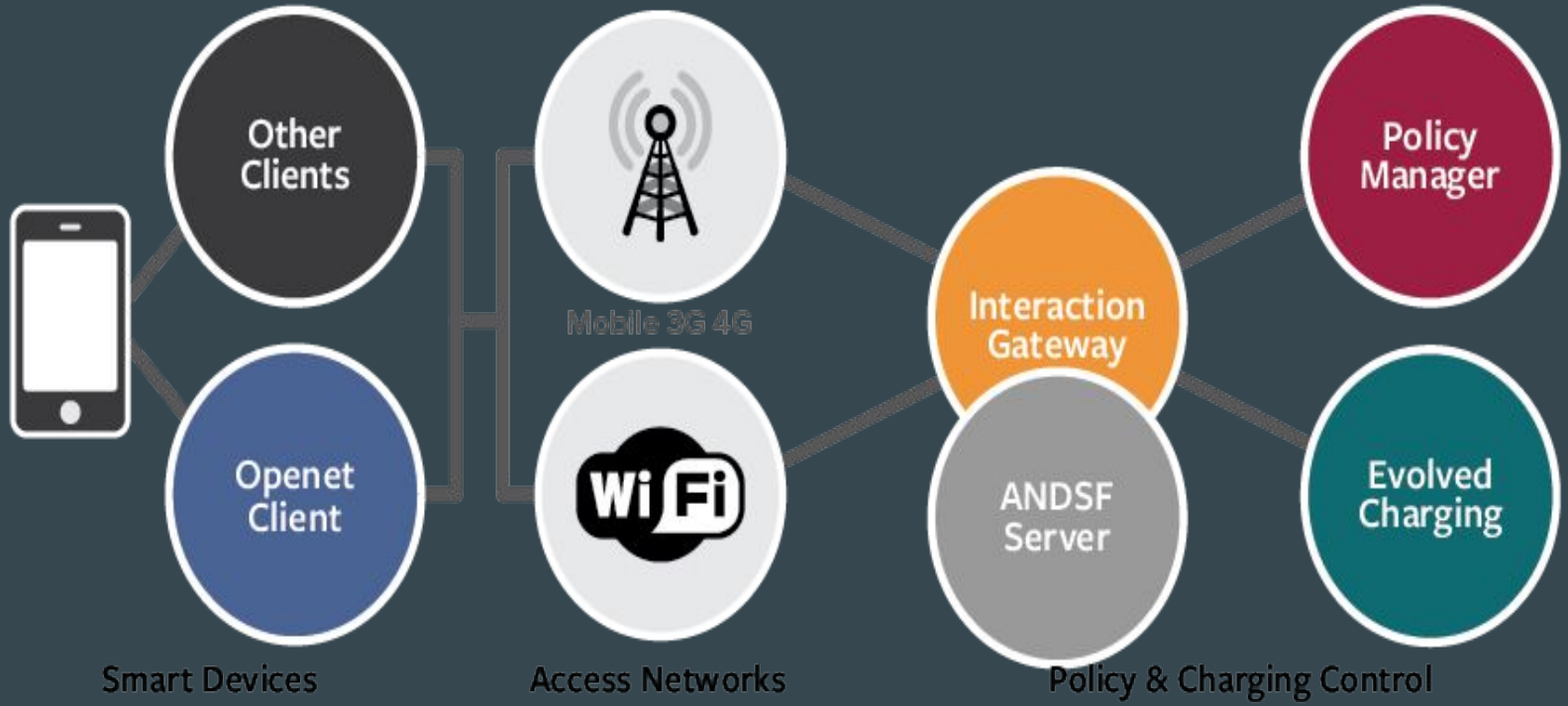
Wifi offload :



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Typical implementation of Wifi offload :

UE Location	Time of Day	Application Flows	Access Network Selection Rule	
			Priority	Access Type
Cell 1	N/A	YouTube, All HTTP traffic, All UDP traffic to server with IP address X	1	WLAN (SSID=wlan1)
			2	WLAN (SSID=wlan2)
			3	3GPP
		All other traffic	1	3GPP
Cell 2	10:00 AM to 3:00 PM	Facebook	1	WLAN (SSID=wlan1)
			2	3GPP
	All other times	Facebook	1	3GPP
			2	WLAN (SSID=wlan1)
	N/A	All other traffic	1	WLAN (SSID=wlan2)
			2	3GPP

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Wifi offload :

- It is a great fit for offloading traffic from mobile networks.
- Many network equipment manufacturers are already integrating wifi offload gateways with their 3G/4G mobile gateway network products.
- Large wifi networks are being introduced to serve locations where people do not move frequently.

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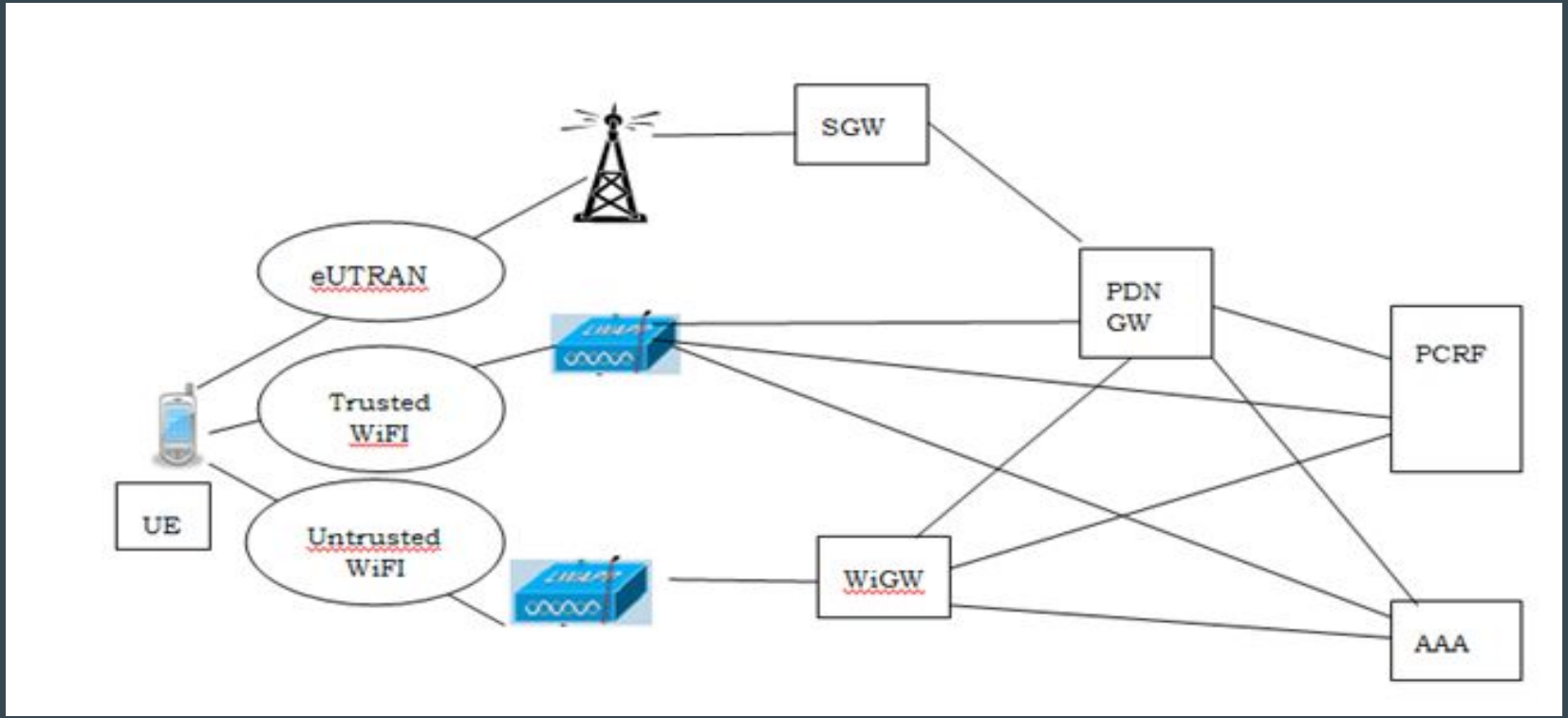
Wifi offloading with 3GPP :



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Carrier challenges

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Carrier challenges :

- Work with existing user devices that have or can add wifi capability.
- Integrate easily to existing wifi hotspots and AP's.
- Provide consistently good performance to users.
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Wifi offload testing

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Wifi offload testing :

- Performance
- Availability
- Security
- Scalability

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Test equipment for wifi offload :

- Performance
- Availability
- Security
- Scalability

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Introduction :

- LTE can assist existing wifi networks to improve the QoE of wireless communication in enterprise.
- This increase the available spectrum.
- For interworking, EDE-ANDSF is presented .

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IEEE 802.11 fundamentals :

- 802.11
- 802.11a
- 802.11b
- 802.11e
- 802.11g
- 802.11n
- 802.11ac
- 802.11ac wave 2
- 802.11ad
- 802.11ah
- 802.11r
- 802.1x

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Need for WiFi Offloading

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Need :

- Cater growing mobile data demand and smart devices usage pattern.
- Enhance the end user experience by improving serving capacity and capability.
- Viable for providing indoor services.
- Address the issue of spectrum crunch.

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Key aspects ：

- Increasing the WiFi footprint to implement offloading solutions.
- User equipment challenges and enhancements.
- User authentication and interaction with cellular core network entities for policy implementation and charging.
- Seamless inter-network mobility considerations.

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WiFi Offload for different cellular architectures

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WiFi offload ：

- WiFi offload for UMTS core network (IWLAN standard).
- WiFi offload for EPC (EPC standards for non-3GPP access) .

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Wifi offload for UMTS core network ：

- Data traffic offload in UMTS core network using wi-fi are based on the IWLAN standards.
- Standards cover the aspects of common billing and customer care, 3GPP system based access control and charging, seamless services.
- One of the main goals of IWLAN solutions was to achieve authentication without manual user intervention.

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Wifi offload for UMTS core network ：

- SIM based authentication done by WLAN networks , which are essentially IP networks, the basic 3GPP authentication protocols are modified and known as EAP-SIM, EAP-AKA.
- Another important aspect of effective implementation of offloading is mobility management.

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Wifi offload for UMTS core network ：

- The mobility function is essentially based on an IP-level mobility management protocol called DSMIPv6.
- This protocol is implemented in an entity called HA in the core network.
- The UE has a single IP address , which is called as HoA.

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WiFi offload for EPC

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Wifi offload for EPC ：

- The EPC standards for non-3GPP access aim to provide higher level of integration between the WLAN and cellular technologies ensuring tight interworking.
- In EPC, enhancements were added like PGW includes a HA functionality and the PCRF is connected to various gateway functions.

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Wifi offload for EPC :

- ANDSF functionality, which is critical for cellular wifi interworking from an operator policy point of view.
- ANDSF server stores operator policies regarding discover and selection of wifi access.

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Wifi offload for EPC :

- Interworking between 3GPP and non-3GPP networks essentially consists of mobility of IP-flows between 3GPP and non-3GPP networks.

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Wifi offload for EPC :

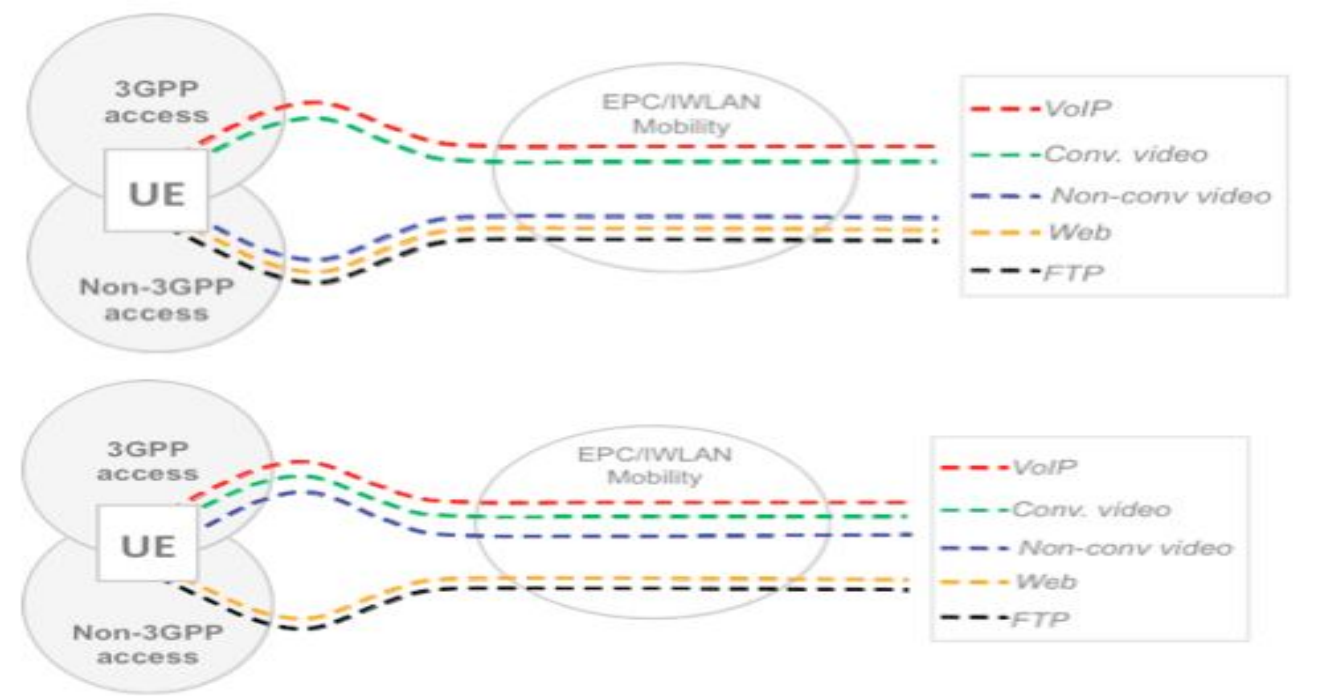

Figure 6: Dynamically Moving IP-Flows Between 3GPP and non-3GPP Radio Access Networks

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Security aspects of Mobile data offload

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Security aspects :

- User identity and device identity confidentiality.
- Entity authentication
- User data and signaling data confidentiality.
- User data and signaling data integrity
- Security in roaming scenarios

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Wifi communications issues

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Issues :

- It takes long time for UE's to establish connections to a heavily loaded access points.
- Lacking of reservation on network BW.
- Difficult to customize user's preferences.

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Integration ：

- 3GPP introduced ANDSF framework, which provides a series of policies and regulations on network accessing that are applicable in different scenarios.
- In industrial research, various implementations were developed.
- CnE by Qualcomm
- SAM by FOKUS

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Interworking system & EDE-ANDSF

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Interworking :

- The enterprise LTE network is composed with enterprise deployed LTE femto cells and E-EPC including components like ANDSF, PDN gateway, SGW and AAA server.
- All femtocells and wifi AP's are connected to PDN gateway in E-EPC.

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Interworking :

- In order to solve the network selection problem, EDE-ANDSF is proposed to replace the current ANDSF entity in the E-EPC.
- In Wifi network, one user's behaviour may have a significant impact on the others that are connecting to the same API.

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Interworking :

- Implementation of EDE-ANDSF , includes server part and client part.
- In the server end , the ANDSF database maintains information such as network coverage map, user subscription and ANDSF policies.

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Cellular traffic overloading

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Cellular traffic overloading ：

- General solution for cellular traffic offloading, which include femtocells for indoor offloading, wi-fi and peer-to-peer opportunistic offloading for outdoor and mobile environment.

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Femtocells for indoor offloading :

- This technique was initially proposed to improve indoor voice and data services of cellular networks.
- Cellular operators can reduce the traffic on their core networks when indoor users switch from macrocells to femtocells.

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Opportunistic peer-to-peer offloading :

- To improve the delivery efficiency, the system can identify the social networks of the users and deliver specific contents to a particular social group.

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Wifi for outdoor offloading :

- Wifi networks operates on the unlicensed frequency bands and cause no interference with 3G cellular networks.

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MADNet

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MADNet ：

- The MADNet architecture is built around the concept of using cellular networks to do signalling and a combination of cellular networks to deliver data.
- It is designed as a middleware between the applications and the physical connectivities.

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Modules :

- Connectivity module
- Location module
- Protocol module
- Forwarding module
- Naming module
- Data module

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MADNet general communication :

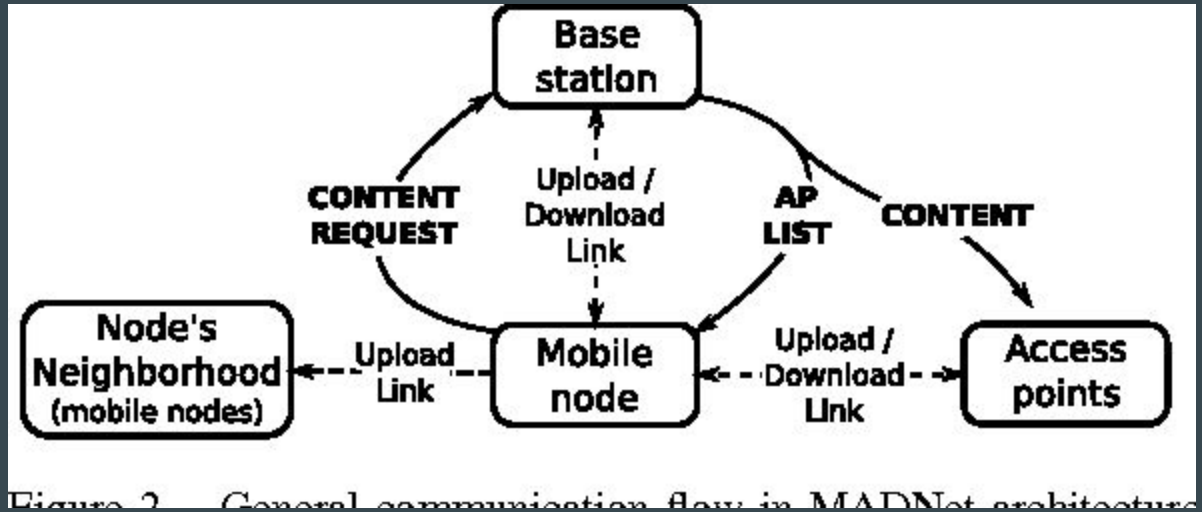

Figure 2 — General communication flow in MADNet architecture

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MADNet general communication :

- It allows components to communicate.
- The system consists of mobile devices (nodes).
- Two non-exclusive ways.

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Advanced deliveries :

- Signalling and pickup
- Peer relay
- Persistent uploading

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Practical challenges faced by operators in Wi-fi offloading

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When to introduce offloading

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Where to offload ? :

- Selection of area.
- Important to identify ideal areas.
- Backhauling challenges : use of unlicensed bands

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Challenges & recommendations :

Challenges :

- Availability & limitations of wifi planning tools.
- Backhaul
- Site availability, acquisition and deployment issues.
- Device limitations
- One way offloading
- Charging issues
- Authentication
- Wifi and DAS integration

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Mobility & multi-mode access network selection

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Introduction :

- The 3GPP EPC provides interworking functionality between 3GPP and non-3GPP access technologies according to 3GPP specifications.
- The interworking functionalities includes access network discovery , authentication of the UE , QoS consistency and seamless HO.

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Mobility :

- Offloading 3GPP network
- Supplement 3GPP access technology coverage
- EPC as a core network for FMC

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Access network discover & selection :

- The ANDSF ia a new EPC entity.
- The communication over the S14 reference point is secured either by using the Generic bootstrapping architecture and secure http solution.
- ANDSF is located in either H-ANDSF or V-ANDSF.

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ANDSF non roaming architecture :

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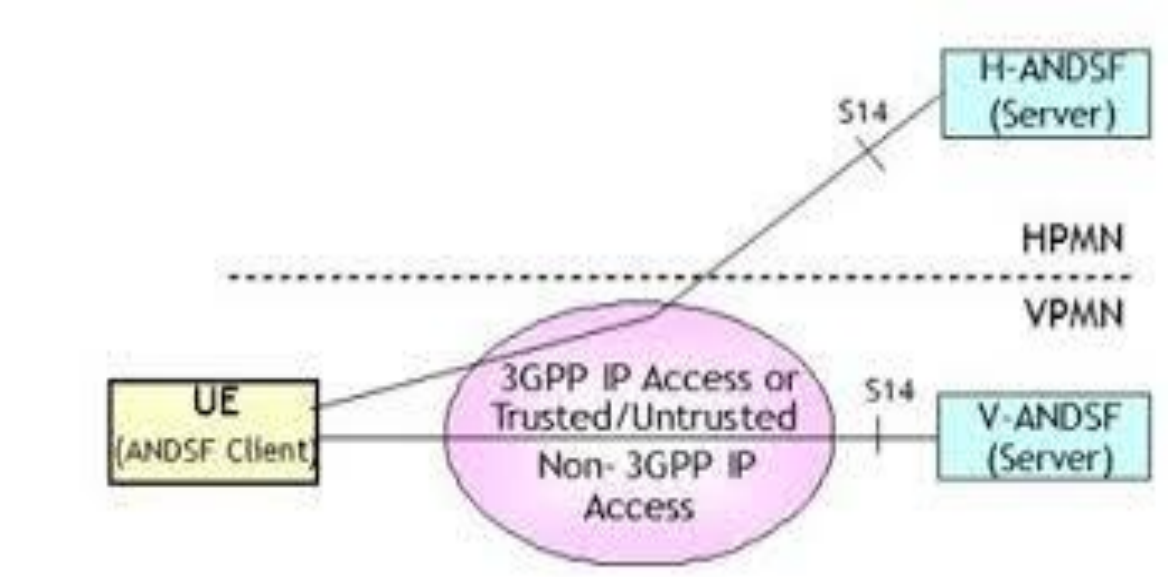
ANDSF roaming architecture :



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Functions :

- ISMP : inter - system mobility policy
- ISRP : inter - system routing policy

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Multi access network connectivity & IP flow mobility with seamless offload

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Multi-access network discovery ：

- Different heterogeneous access systems are connected to a common core EPC.

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IP flow mobility :

- It allows dynamic allocation of different IP flows to different access systems as per their requirements.
- IP flow mobility will give the opportunity of utilizing the capability of new generation mobile devices equipped with multiple interfaces, thereby ensuring optimal usage of radio resources and load balancing among available radio accesses.

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EPS Architectural requirements

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The EPS network requirements :

- Using DSMIPv6 to make seamless handovers .
- Multi access PDN connectivity and IP flow mobility should be possible for EPS and IWLAN mobility architectures.
- It should be possible for EPS/IWLAN mobility to support simultaneous access to a single PDN via different access networks.

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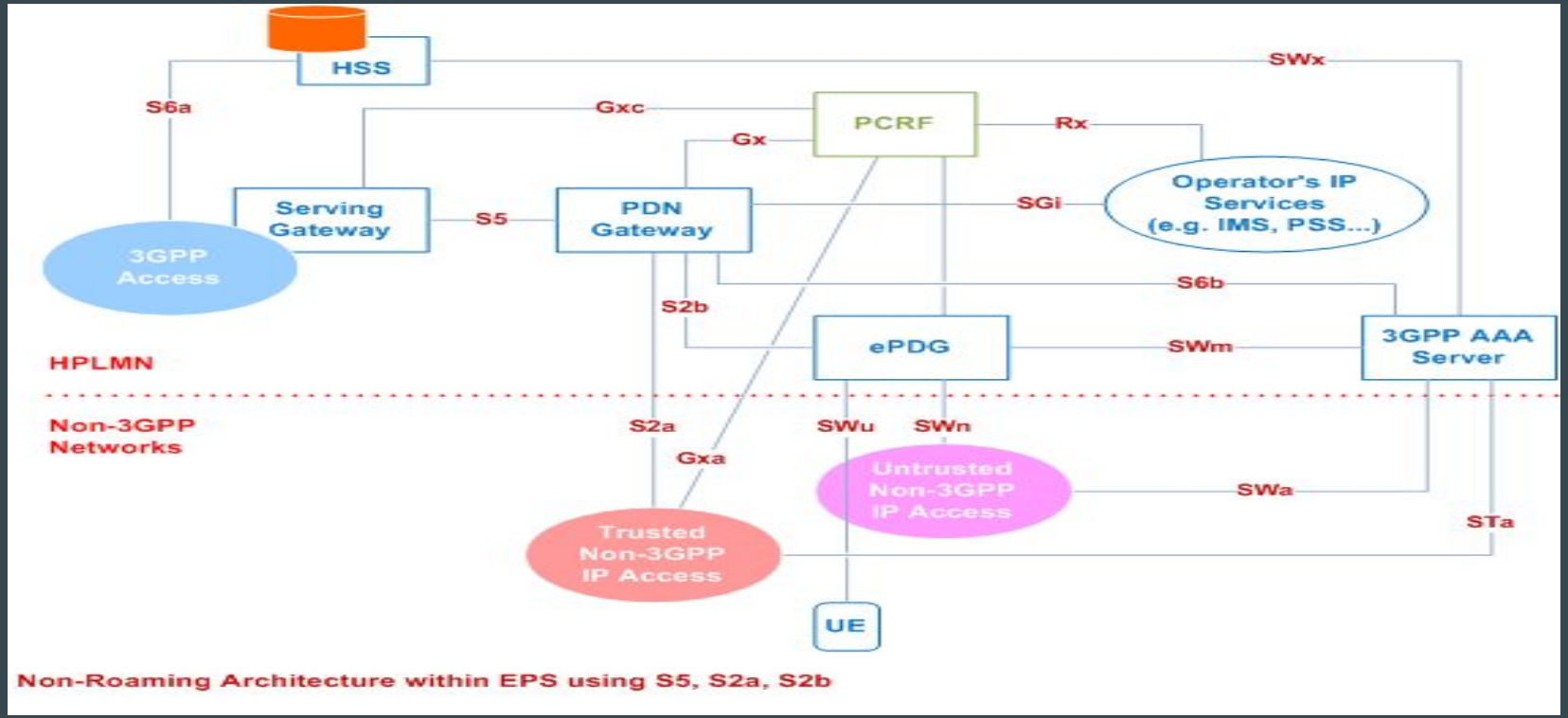
Non -roaming architecture using s2a & S2b:



Non-Roaming Architecture within EPS using S5, S2a, S2b

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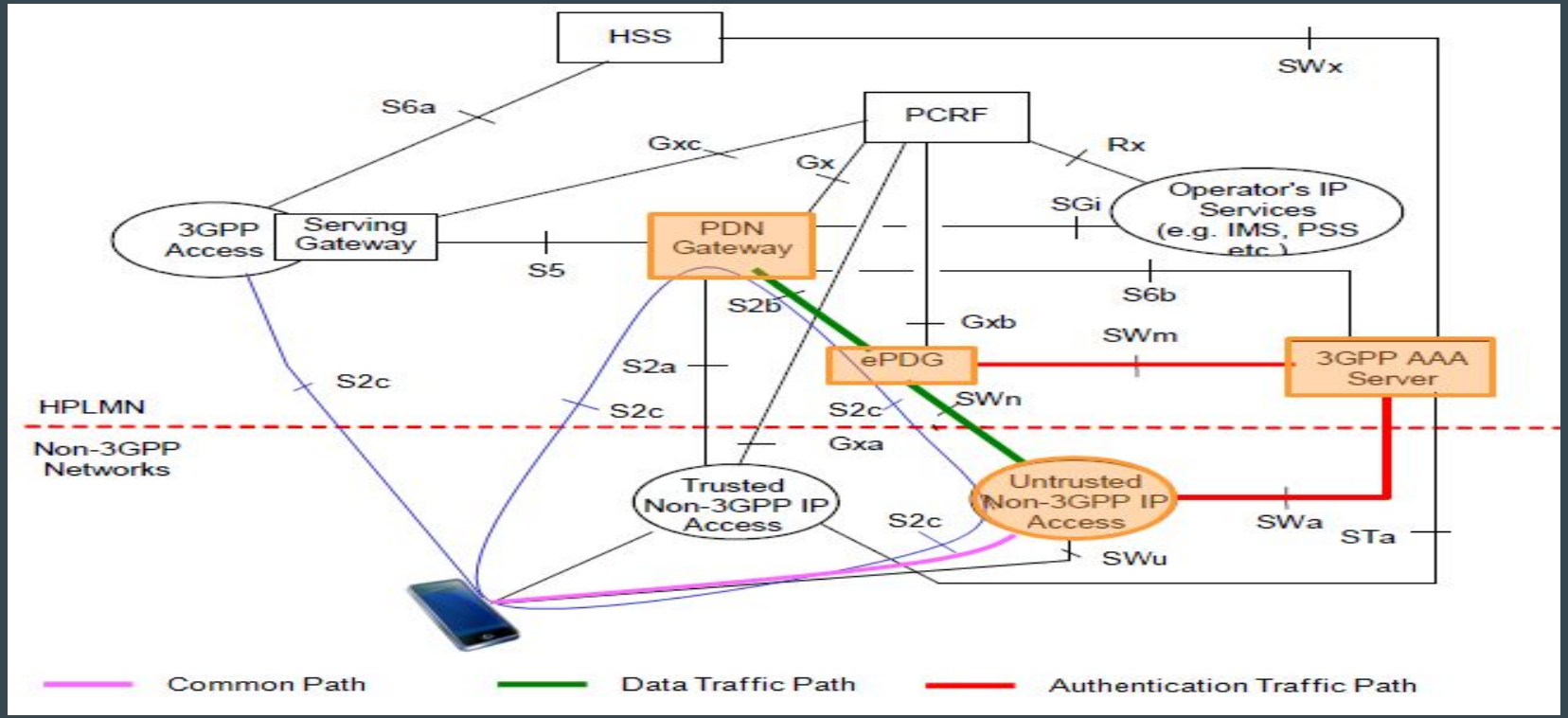
Non-roaming architecture using S5 & s2c :



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EPS network requirements :

- S2a provides user plane with related control and mobility support.
- S2b provides mobility support between ePDG & PDN-GW.
- S2c provides mobility between UE & PDN-GW based on MIPv6.

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IP Flow mobility

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IFOM :

- Supplementary DSMIPv6 extensions are introduced for MAPIM.
- Enhancements to the EPC ANDSF were also added to support mobility guidelines for IP flow mobility and seamless WLAN offloading.

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Routing filters in S2a/S2b (PMIPv6) :

- Through access specific signalling used to perform attach and PDN connectivity in 3GPP and non-3GPP access networks from the UE to the SGW.
- Through PMIPv6 signalling from the SGW and the PDN GW.
- Through protocol configuration option (PCO) in PMIPv6 signalling between SGW and PDN GW.

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Seamless WiFi offloading

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Seamless Wifi offloading :

- For mobility, two protocols are defined: PMIPv6 and DSMIPv6.

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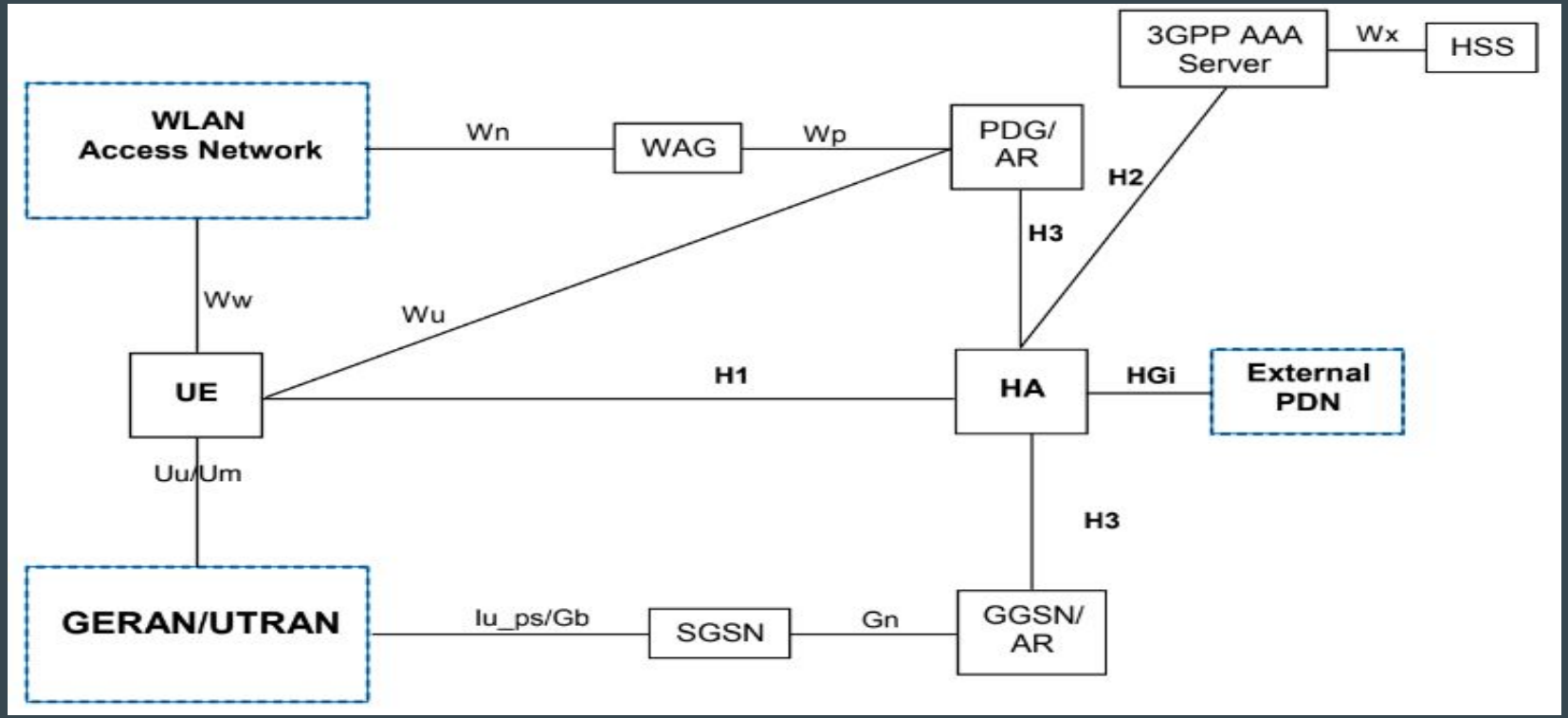
Non-roaming architecture for I-WLAN mobility :



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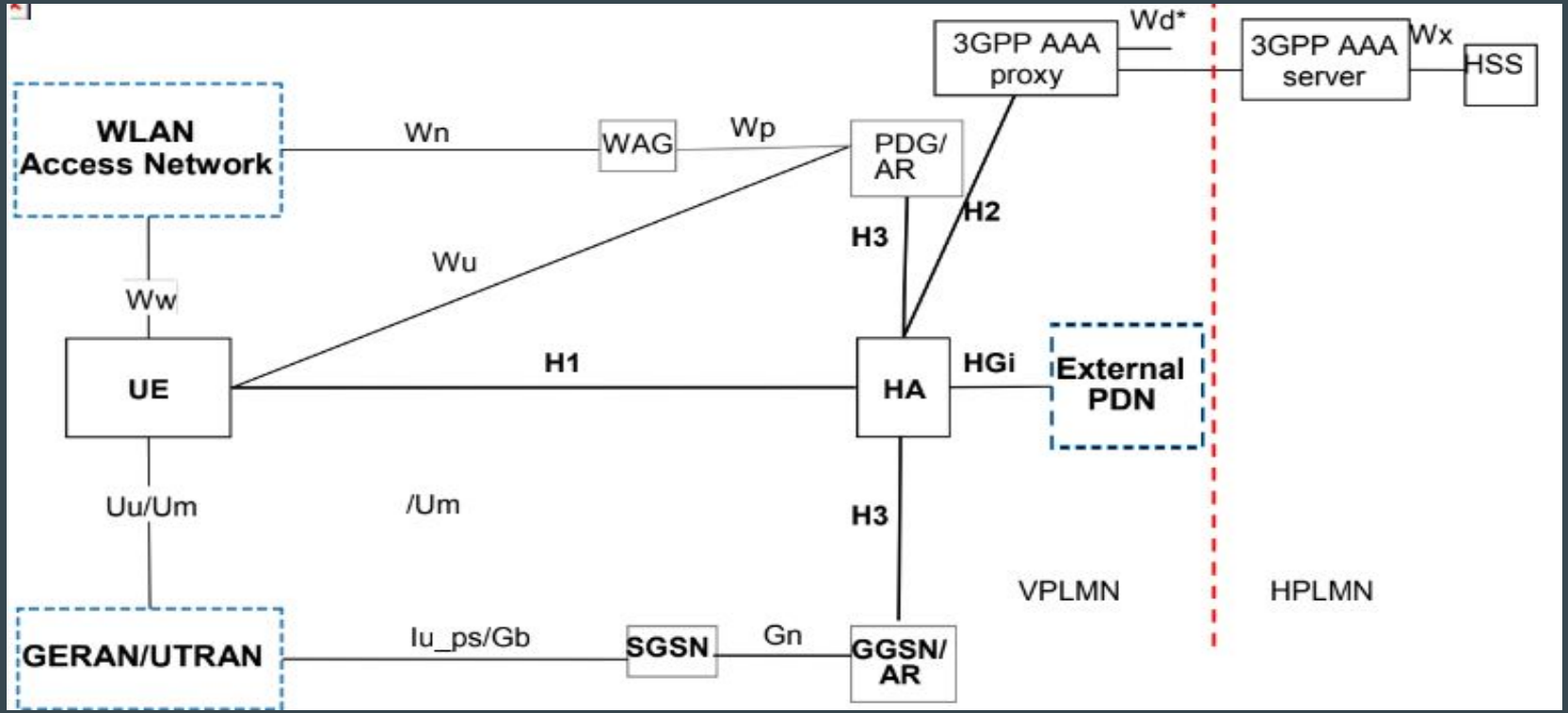
Roaming architecture for I-WLAN mobility :



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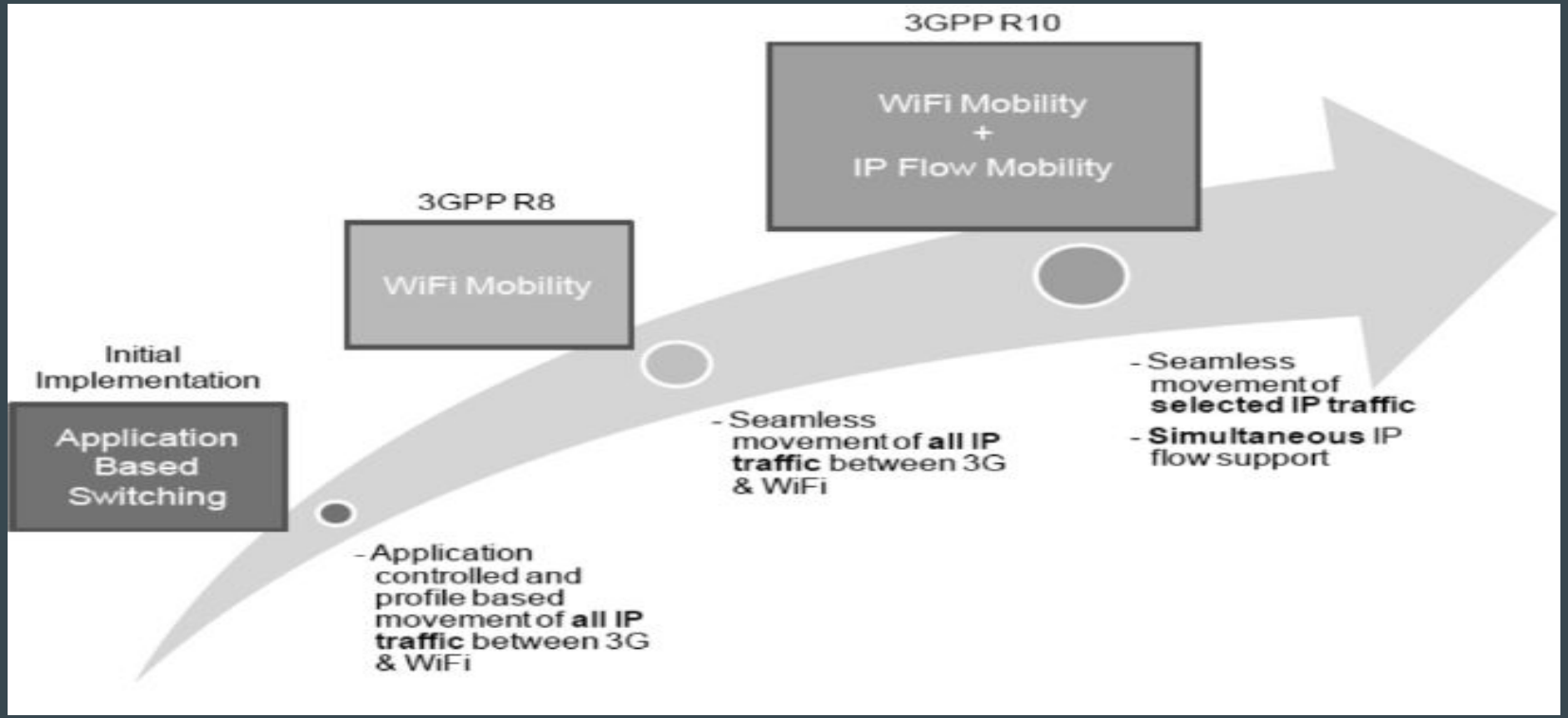
3GPP 3G/4G wifi seamless offload road :



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Application based solution :

- Changes are required only to UE and GGSN/PGW.
- The HA is the anchor that binds the permanent identifier of the node (home address) with the local address based on node's location (care of address). , the exposed IP address accessible by the application remains the same.

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LIPA

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LIPA :

- It is primarily for end users to access their local network or internet.
- LIPA is subscription based.
- It is upto the mobile operator to enable or disable LIPA for user subscriptions per CSG for each LIPA APN.

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LIPA benefits :

- Simultaneous access from mobile devices to mobile operators core networks and local IP access to local IP networks may be possible.
- Mobile devices may be billed differently for accessing the local IP network.
- The user experience may be improved by offloading the traffic away from the core network.

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SIPTO

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SIPTO :

- It allows cost-optimized handling of internet traffic and is valid for both femtocell and macrocell.
- It is upto the mobile operator to offload only selected IP traffic from s mobile device.

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SIPTO benefits :

- Simultaneous support of services via SIPTO and services via operator's core network is possible.
- Selected IP traffic offload with no user interaction may be performed.

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Impact on network architecture :

3GPP has proposed two types of breakout architectures for traffic offloading :

- Alternative 1
- Alternative 2

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Alternative 1 :

- Bypassing one of the core network nodes, thereby reducing the number of hops on the data path.
- Selecting a gateway pair close to the UE's point of attachment there by choosing the most optimal data path.

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Alternative 2 :

- Scenario 1 : both the femtocell and backhaul are provided by the same operator.
- Scenario 2 : the femtocell and backhaul are provided by different operators.
- Scenario 3 : the local breakout point is located in a private address domain (e.g behind a NAT gateway)

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Local IP access using a collocated L-GW

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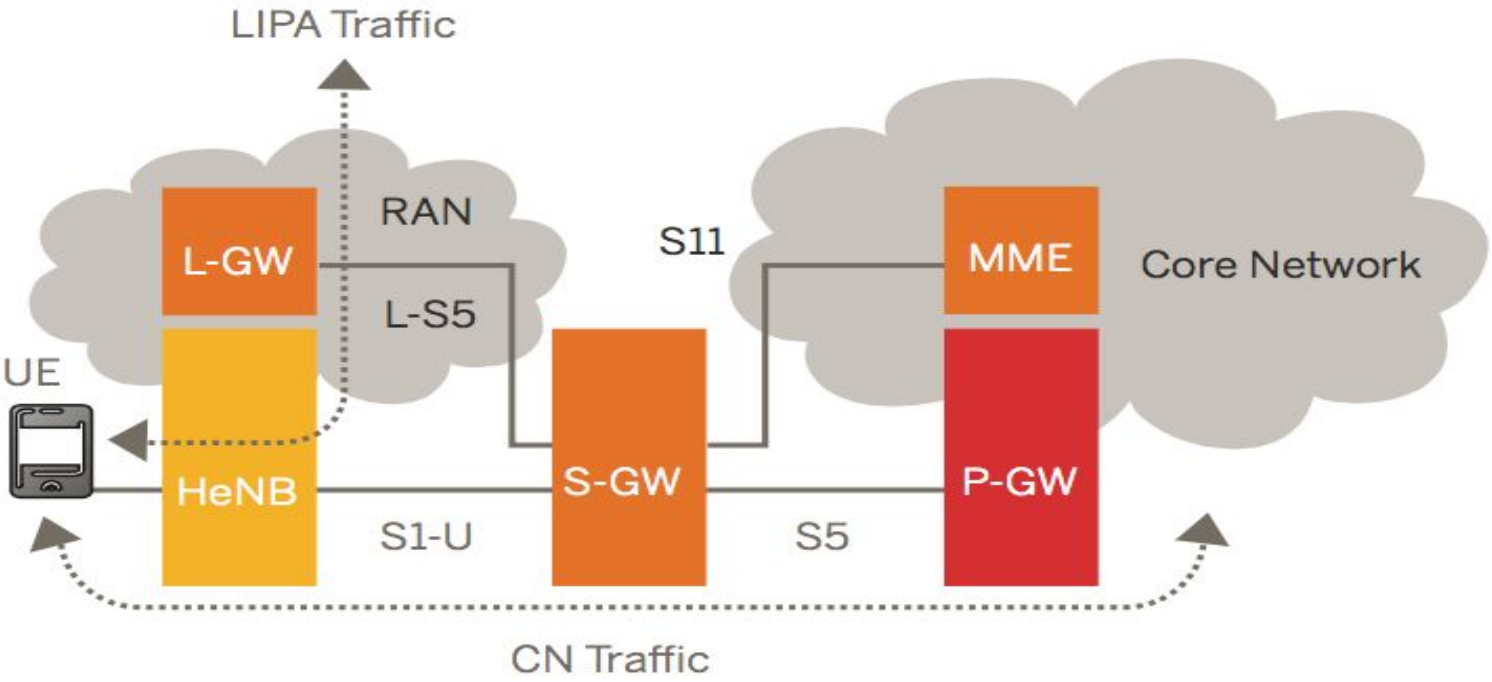
Local IP access :



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HeNB subsystem :

It supports an L-S5 interface with the S-GW and SGi interface with the local IP address.

- L-S5 : it is between L-GW and S-GW and based on GTP-C protocol.
- SGi : this reference point is between the L-GW and the external IP network.

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Additional function supported by HeNB :

- Assignment of an IP address to the L-GW and setup of the L-S5 IPSEC tunnel.
- Transfer of the IP address of the L-GW to the MME.
- Management of the internal direct user plane path between the HeNB and the L-GW for the offloaded traffic.
- Release of LIPA bearers before hnadout.

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Functions supported by colocated L-GW :

- Assignment of the UE IP Address
- SGi interface support
- L-S5 interface support
- DL and UL data transfer between HeNB and residential/ corporate IP networks.
- Enforcement of QoS.
- Lawful interception

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Architecture classification

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LIPA :

- Local IP access is the architecture that HeNB and a local GW (L-GW) are in the residential / enterprise IP network and can be achieved using a L-GW colocated with the HeNB.
- In LIPA network , connection to the local IP capable entities is established by the UEs requesting a new PDN connection to an APN for which LIPA is permitted.

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SIPTO :

- It is the architecture that H(eNB) and a L-GW are in the residential / enterprise IP network and also assumes a L-GW colocated with the H(eNB).
- The L-GW selection function uses the address proposed by (H)eNB in the S1-AP message , instead of DNS interrogation .

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SIPTO above RAN :

- The SIPTO function enables a mobile operator to offload certain types of traffic at a L-GW close to the (H)eNB that UE attaches.

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Traffic offload solution :

Traffic solution is based on SIPTO at the local network with L-GW function colocated with the eNB.

- Routing issues
- Charging issues

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:

Fff iyi

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Core network offload

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Core Network Offload :

- It is also known as internet breakout.
- In this, the operator would not have to pay to process this traffic through the mobile packet core.
- A number of core network offload options are discussed in the LIPA/SIPTO work in 3GPP rel-10.

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Packet switch core network :

- PS core offload involves deployment of internet offload gateways behind an RNC or group of RNC's to split out traffic bound for the internet from traffic bound for operator's core network . this is known as Iu-Ps offload.
- An internet offload gateway should be less expensive than a new GGSN.
- An offload gateway is optimized for data throughput , with fewer user sessions and lower transaction rate.

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Content distribution & optimization :

- Use of this architecture to push content caches and content optimization closer to the end user.
- The user will experience faster load times and benefit from having content delivered in the most appropriate format for the device and connection speed.

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Offload and traffic management :

- An unintended consequence of core network offload is by diverting traffic from core it becomes harder for the operator to meter usage , bill for traffic and apply traffic management techniques, since these all functions reside in the core.
- A proposed solution is to make the offload gateway also function as a traffic management device.

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Offload and traffic management :

- Traffic management must increasingly be RAN aware, it is logical to take advantage of the gateway's distributed location close to the RAN.

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Architectural functions

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LIPA :

- P-GW functions for the support of LIPA services.
- They are subset of the functions of the EPC PGW.
- The L-GW for LIPA shall be located in H(eNB) subsystem.

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SGW for LIPA :

- It is FFS where idle mode DL packet buffering and initiation of network triggered service request procedure should be local to the H(eNB).

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MME for LIPA :

- The SGSN/MME supports ESM functions for LIPA.
- The SGSN/MME uses the information from the H(e)node B to potentially override the normal L-GW selection algorithm.
- The granularity of LIPA control is per APN and per CSG.

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Indications to UE :

- A list of CSG IDs or cell IDs statistically configured in the UE/USIM e.g based on provisioning.
- Informing the UE via NAS.
- Including the LIPA capability in RAN layer signalling

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ANDSF

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Introduction :

- It is a key technology for enabling carriers to offload data traffic from the mobile core.
- The feature was designed to provide mobile devices with information about available alternative wireless networks and to enforce policies for selecting and using those networks.
- ANDSF can implement policies using either a pull or push model , depending upon carrier preference.

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ANDSF :

- ANDSF can implement policies using either a pull or push model , depending upon carrier preference.
- In the pull model, the mobile device contacts the ANDSF server to request policy information.
- In push model, the ANDSF server may push the entire set of offload policies to the device.

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ANDSF :

- It requires OMA-DM support on the device.
- OMA-DM is a device management protocol that was created by the open mobile alliance.

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ANDSF MO ：

- It is used to manage inter-system mobility policy, ISRP, IARP,WLANSP.
- It is also used to manage the home operator preference policy stored in a UE supporting provisioning of PSPL and S2a connectivity preference information from an ANDSF.

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ISMP & ISRP

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ISMP :

- At any point in time, there shall be at most one rule applied, the rule is referred to as the ‘active rule’.
- The rules have a number of validity conditions.
- While he rules remains ‘active’ UE shall keep considering high priority networks, than currently selected, in the prioritized network list of the rule.

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ISRP :

- Each ISRP rule contains indication on traffic distribution for UE's that are configured for IFOM, MAPCON & non-seamless WLAN offload.
- Roaming and PLMN leaves are used by the UE to determine if an ISRP rule is valid.
- An ISRP rule can contain one or more flow distribution containers.

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The HeNB subsystem

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HeNB :

- The HeNB-GW or femtocell gateway is the HeNB network access concentrator used to control capabilities necessary to manage large clusters of femtocells.
- It aggregates HeNB's or FAP's to a single network element and then connect to LTE networks.

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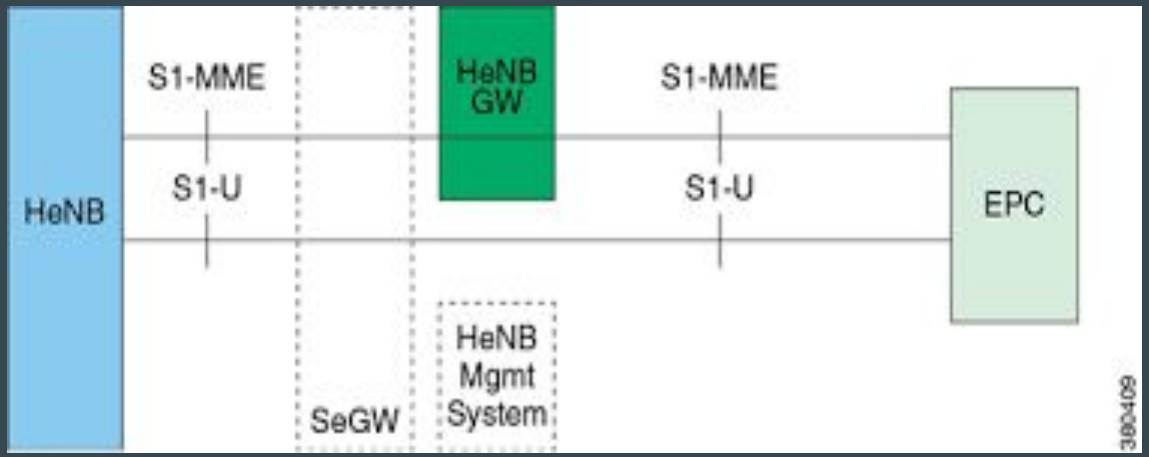
HeNB :

- Femtocell is an important technology and service offering that enables new Home and enterprise service capabilities for mobile operators and converged mobile operators.



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HeNB :

The HeNB hosts the following functions and procedures in LTE core network :

- Relaying UE- associated S1 application part messages between the MME serving the UE and the HeNB serving the UE.
- Terminating non-UE associated S1 application part procedures towards the eNB and MME.
- Optionally terminating S1-U interface with HeNB and MME.
- Supporting TAC and PLMN ID used by HeNB.

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Deployment scenarios for HeNB :

- An HeNB GW can be deployed to provide an alternate path for data traffic.
- It holds capabilities to divert the data traffic away from core and directly onto the internet thus reducing the load on the core network.

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HeNB :

It is a customer premise equipment that offers Uu interface to UE and S1 interface over IPsec tunnel to the HeNB-GW for accessing LTE core network in Femtocell access network.

- e-RAB management functions
- RRM functions
- GTP-U tunnels management
- Mobility management functions
- UE registration for HeNB

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ANDSF Mobility manager

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UMobility manager :

- The mobility manager is selective, user defined and operator assisted wi-fi offload solution that enables 4G network optimization through intelligent network access selection .
- It is a ANDSF-EPS based solution that is portable to most device environment.

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Advantages :

- Allows operators to reduce network costs.
- Improves network efficiency.
- Offers HetNet management feature to leverage client and network information to identify and connect to the most optimal function.

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Unique features :

- Wi-fi onloading/ offloading
- Data driven off-loading
- Customizable trigger allowing user to switch networks
- Qos management
- Reports detailing network analytics
- Strong and reliable connection
- Intelligent network selection

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Differences between LIPA & SIPTO

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Differences :

It requires minor changes in the UE signalling per rel-10 specifications .	It requires a rel-10 UE along with simultaneous wifi and macro network capabilities as well as DSMIPv6.
Extending LIPA for internet/intranet access will only benefit core network capacity.	Since offloading takes place above RAN , it doesn't have any impact on congestion in the RAN.
Mobility among femtocell would require sub-optimal routing of traffic back to operator core.	No impact on mobility support.
It allows direct access by passing dependency on operator core network.	UE can communicate with local network via internet-operator core network path.
It requires changes in HSS/HLR, SGSN,MME,eNB	It requires changes in HSS/HLR, SGSN,MME.

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IFOM & seamless offload

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IFOM :

- IFOM is based on DSMIPv6 , it is independent of the macro network flavour.
- It can be used for a green-field LTE deployment as well as a legacy GPRS packet core.
- IFOM provides simultaneous attachment to two alternate access networks.
- DSMIPv6 requires a dual-stack (IPv4 or IPv6) capable UE.

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IFOM :

- It requires a rel-10 UE along with simultaneous wifi and macro network capabilities as well as DSMIPv6.
- It solves the capacity problem effectively by allowing selected flows over the alternative wifi access network.
- Full mobility support at the flow level between wifi and macro network .

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IFOM :

- No direct access is possible. UE can communicate with local network via internet-operator core network path.
- It requires changes in policy control, updates in P-GW ,GGSN to implement HA capability.
- If all traffic goes over HA (integrated with P-GW or GGSN), no impact.

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IFOM :

- No dependency or changes needed in the radio access network.
- Implementing DMIPv6 on UE and HA is straight forward . Primary difficulty is to overcome concerns of mobile operators.

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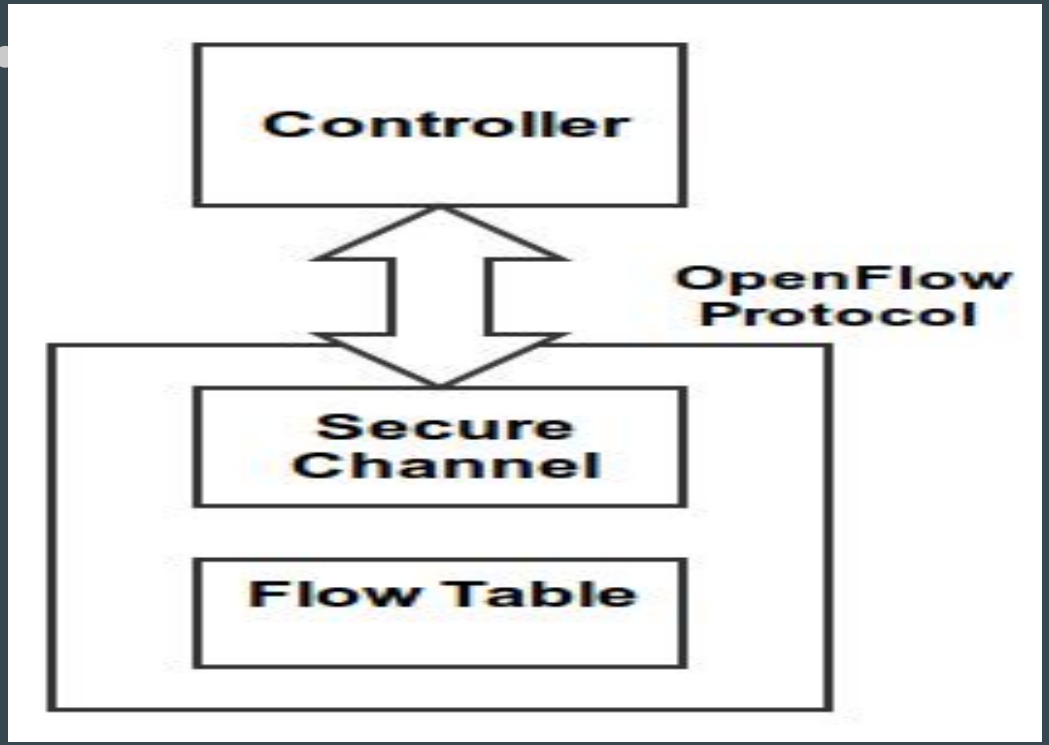
OpenFlow components :



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Flow table :

- The basic building block of openflow is flow table.
- Each packet that enters a device passes through one or more flow tables.

Header	Action	Counters

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Flow table :

Header field : each flow table header entry is made of 6 components , which defined the matching rules and basic rules for the corresponding flow.

- Match fields
- Priority
- Counters
- Instructions
- Timeouts
- Cookie

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Flow table :

Action : each flow entry is associated with zero or more actions that dictate how the device handles matching packets.

- Forward
- Drop
- Modify field

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Secure channel :

- The OF protocol describes message exchanges that take place between an OF controller and an OF device.
- It supports three types of messages :
  Controller to device
  Asynchronous
  symmetric

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SD-WAN

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SD-WAN :

- It is a specific application of SDN technology applied to WAN connections such as broadband internet, 4G, LTE or MPLS.
- It relies on four central components :
  Edge connectivity abstraction
  WAN virtualization
  Policy- driven , centralized management
  Elastic traffic management

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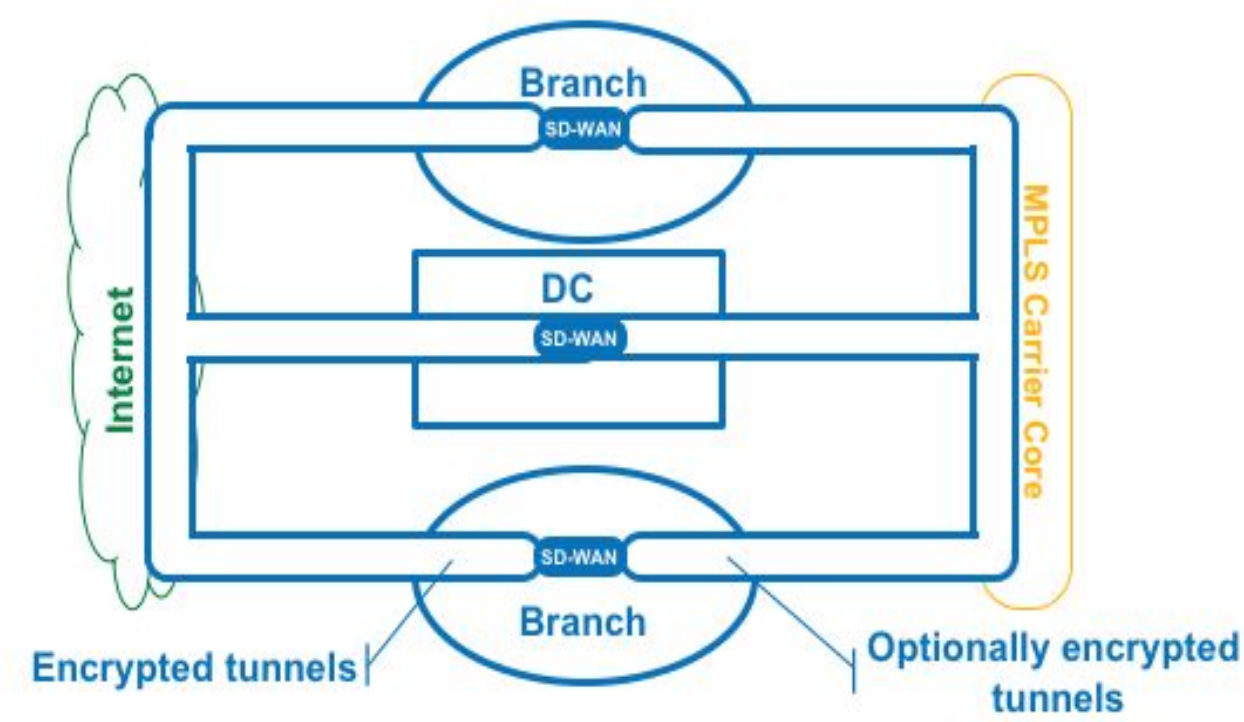
SD-WAN :



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Why SD-WAN..? :

- Security
- Centralized orchestration
- Network visibility
- Provider reliability
- Performance
- Scalability
- Connection
- Flexibility

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SD-WAN characteristics :

- SD-WAN implementation is with incorporating newer SDN, NFV and service orchestration technologies.
- These technologies provides the integration and service deployment automation that has made SD-WAN managed services so compelling.

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SD-WAN service components :

- SD-WAN Edge
- SD-WAN Controller
- Service Orchestrator
- SD-WAN gateway
- Subscriber web portal

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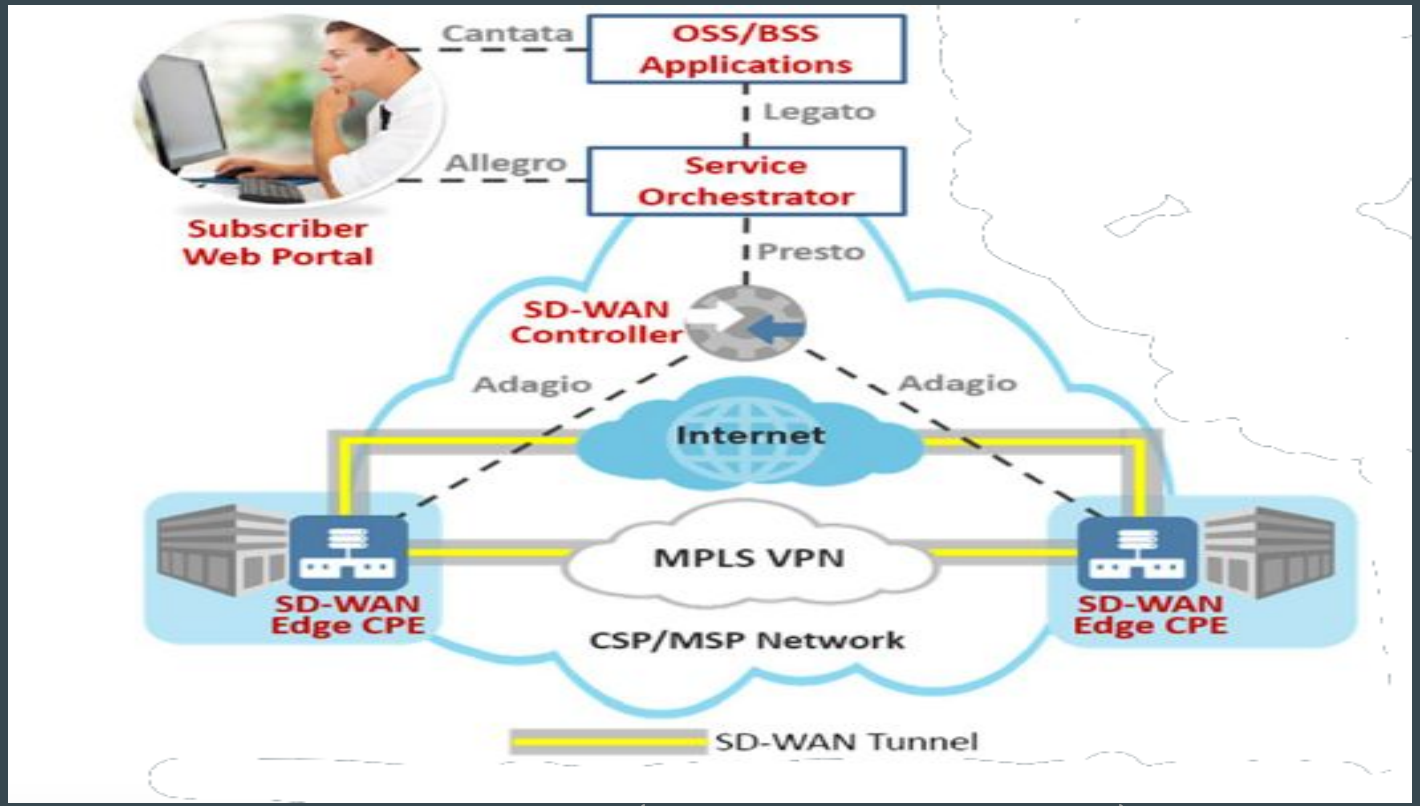
SD-WAN service components :



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vCPE

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vCPE :

- It is a way to deliver network services such as routing , firewall security and VPN connectivity to enterprises by using software rather than dedicated hardware devices.
- vCPE also known as cloud CPE, abstracts the intelligence of such devices into software based functionality that resides in a remote data center.

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vCPE :

- It is a leading application to move hardware appliance functionality to software on commercial platforms that way data centers have.
- The customer premises are natural fit for vCPE deployments.
- Multiple functions can be loaded onto a single server, simplifying management and facilitating more rapid upgrades.

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vCPE benefits :

- For service providers
- For enterprises
- Lower equipment costs
- Elimination of truck rolls
- The ability to shop for best of breed solutions
- Freedom to customize services to specific customer needs.

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SDN & NFV for mobile EPC

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SDN & NFV for mobile EPC :

- For service providers
- For enterprises
- Lower equipment costs
- Elimination of truck rolls
- The ability to shop for best of breed solutions
- Freedom to customize services to specific customer needs.

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SDN for mobile EPC :

- SDN is essentially applied to decouple the control and data planes of the EPC gateways i.e SGW and PGW.

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SDN for mobile EPC :

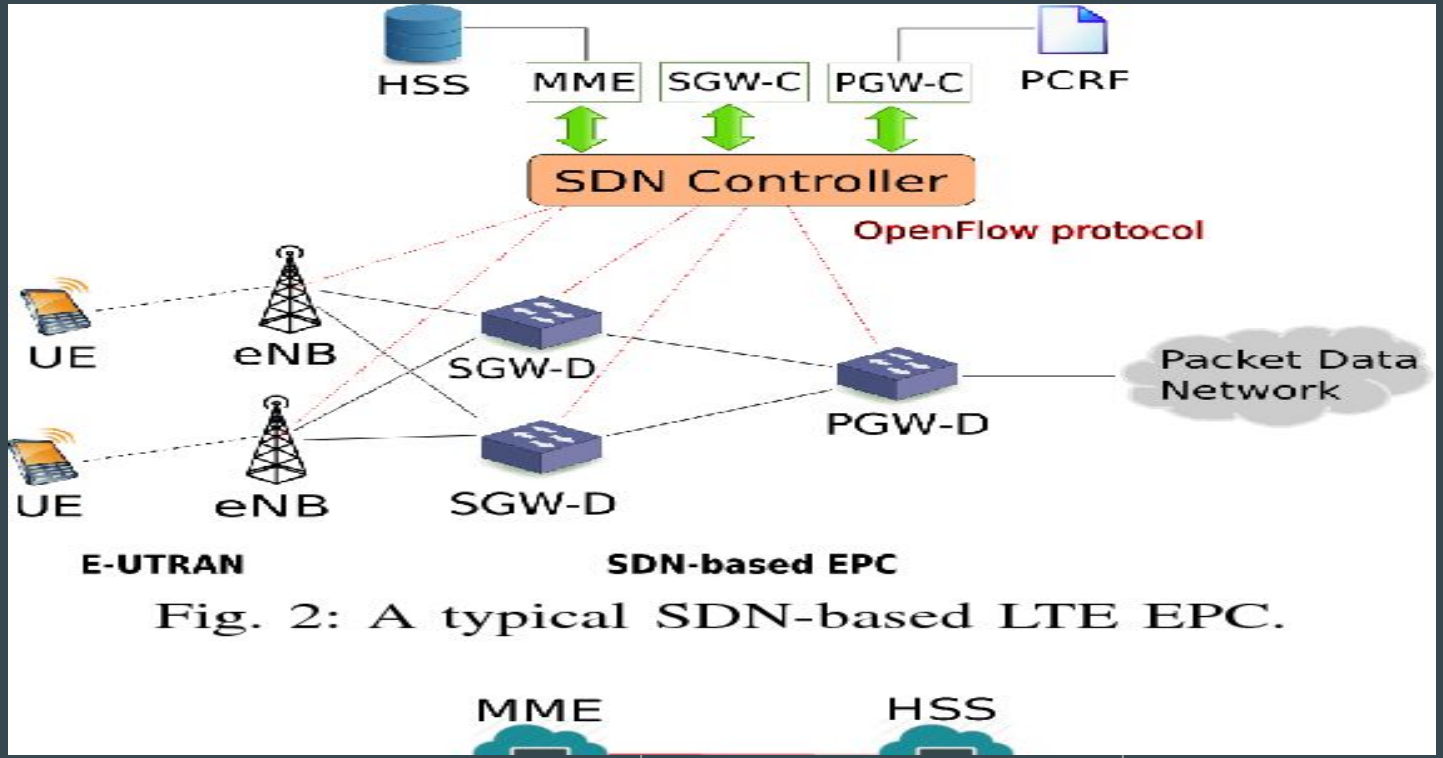

Fig. 2: A typical SDN-based LTE EPC.

MME HSS

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NFV for mobile EPC :

- NFV MANO also allows the integration with external OSS/BSS .
- NFV promises significant cost saving either in deployment or in operation for mobile operators.

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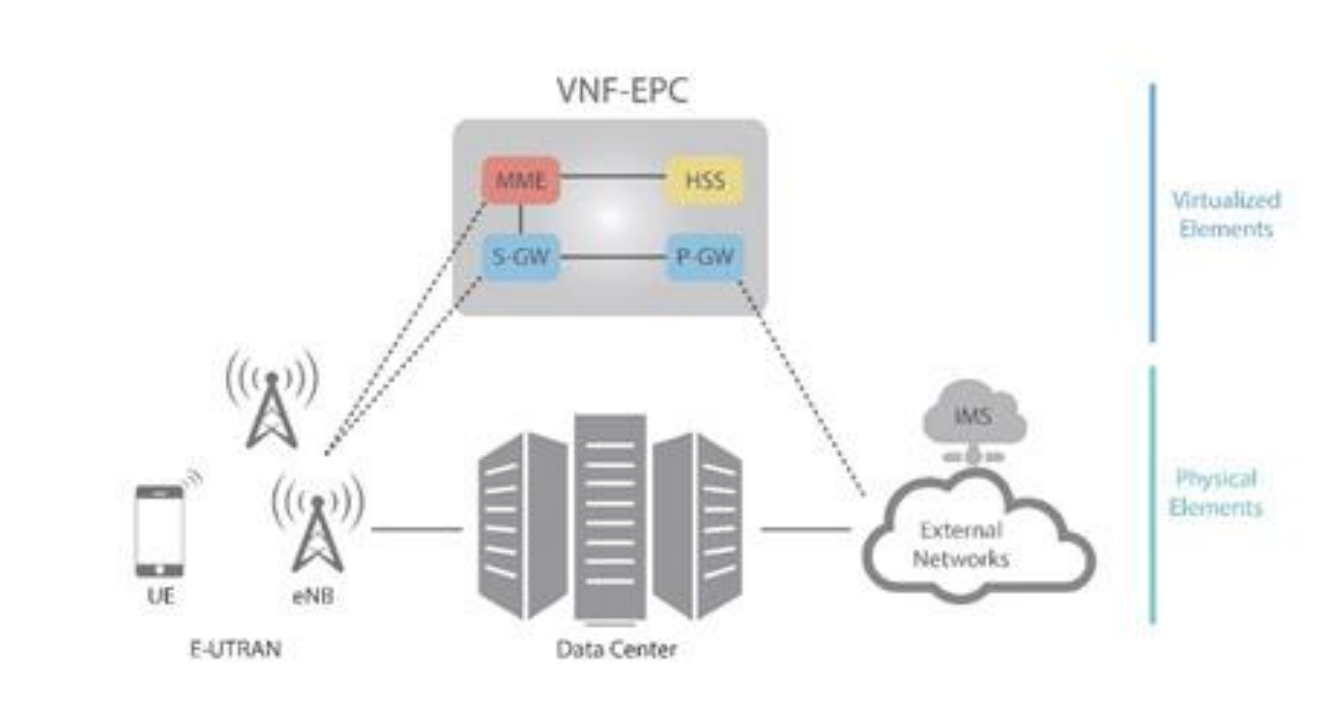
NFV for mobile EPC :



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NFV MANO

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NFV MANO :

- With NFV management and organization (MANO) , management of NFV is now addressed by the MANO stream.
- It is the ETSI-defined framework for the management and orchestration of all resources in the cloud data center.
- This includes computing, networking,storage and virtual machine resources.

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NFV MANO :

NFV MANO is broken up into three functional blocks :

- NFV orchestrator
- VNF manager
- Virtualized infrastructure manager

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NFV orchestrator :

- NFV orchestration is used to coordinate the resources and networks needed to setup cloud-based services and applications.
- This process uses a variety of virtualization software and industry standard hardware.

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SDN computing platforms

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SDN Computing platforms :

- Opendaylight
- Cisco ACI
- ONOS
- Project Floodlight
- VMWARE
- Beacon
- Juniper contrail
- vortiQa
- POX
- Nuage

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VNF

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Virtualized network functions :

- A VNF takes on the responsibility of handling specific network functions that run on one or more VM's on top of hardware networking infrastructure.
- VNFs can help increase network scalability and agility , while also enabling better use of network resources.

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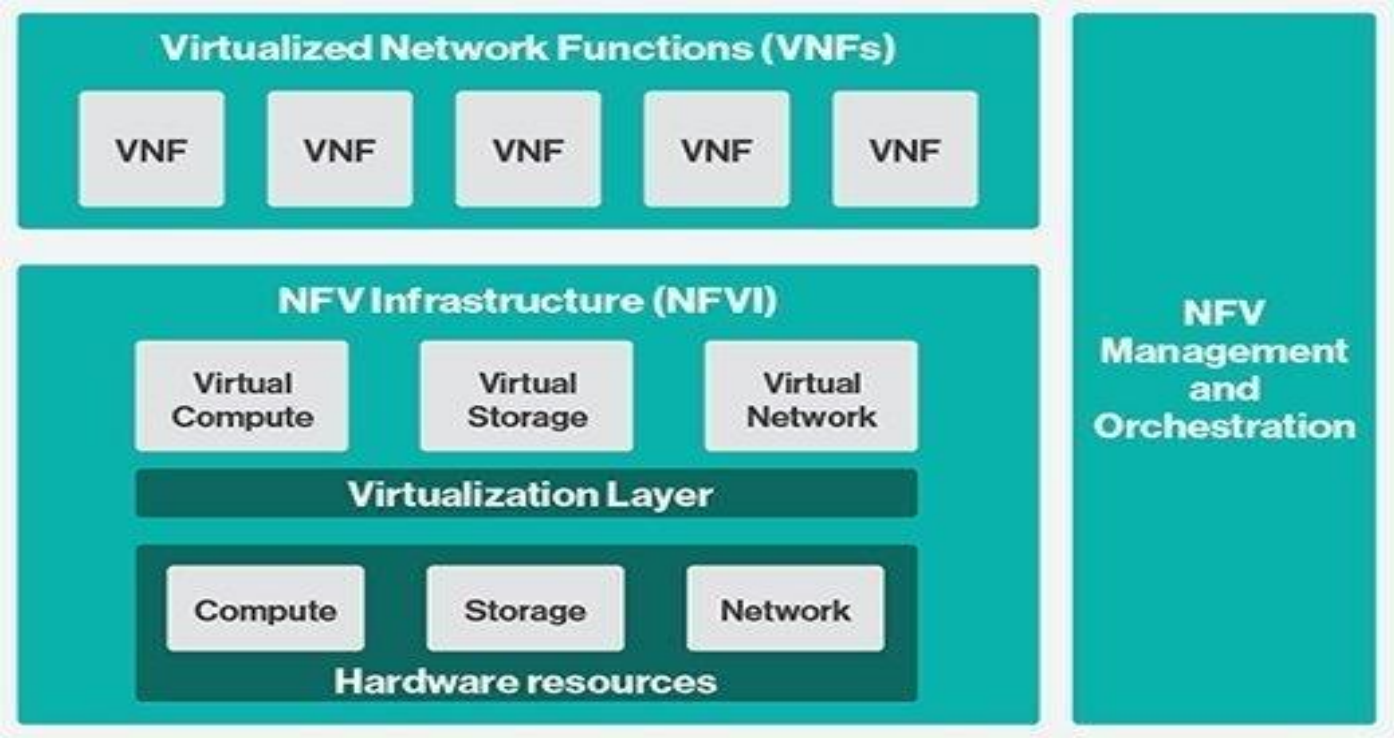
Virtualized network functions :



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Virtualized network functions :

- Software implementation of the legacy network functions .
- Network function capable of running over NFVI.
- Network function orchestrator by NFVO and VNF manager.

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VNF Architecture

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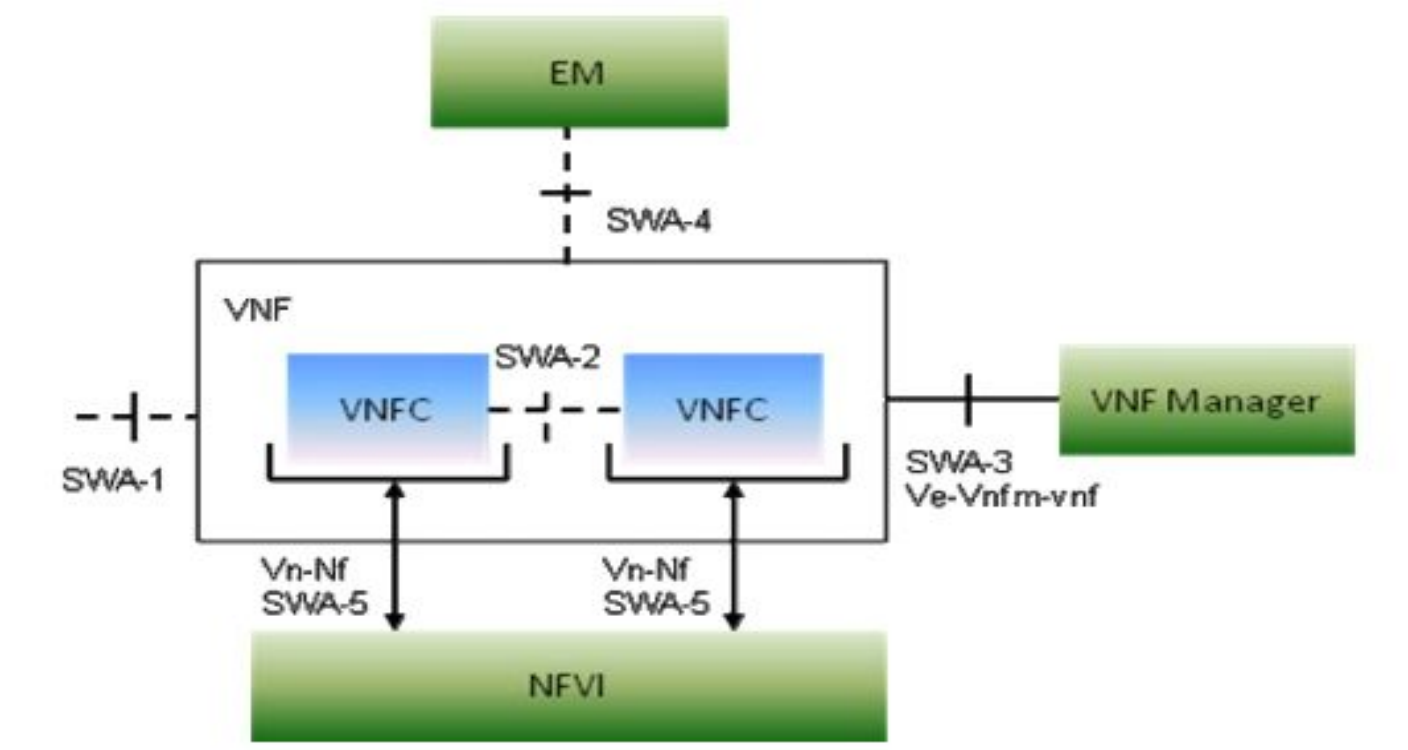
VNF Functional view :



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VNF interfaces :

- SWA-1
- SWA-2
- SWA-3
- SWA-4
- SWA-5

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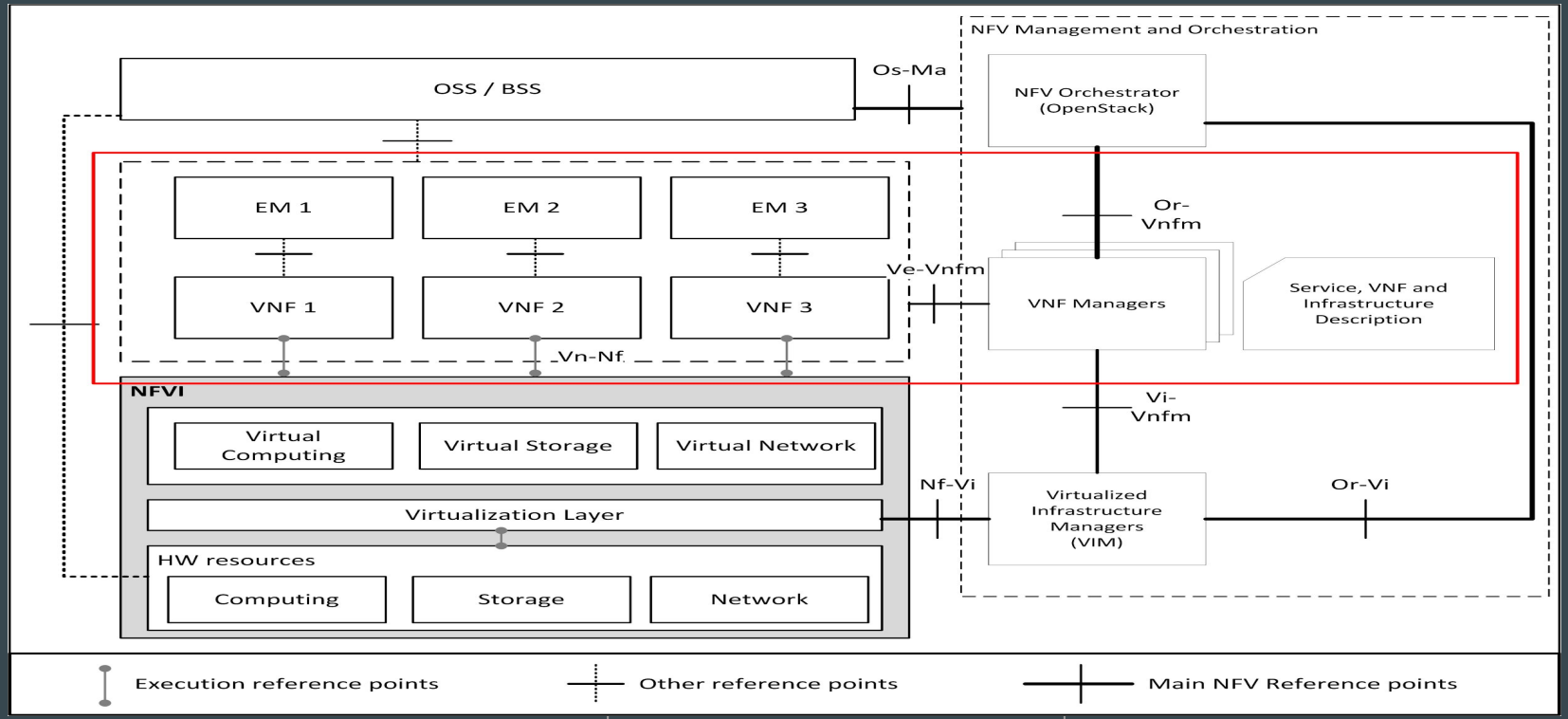
VNF interfaces :



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VNF - Design and properties :

It is divided as :

- Internal structure
- Life cycle
- VNFC states
- Load balancing

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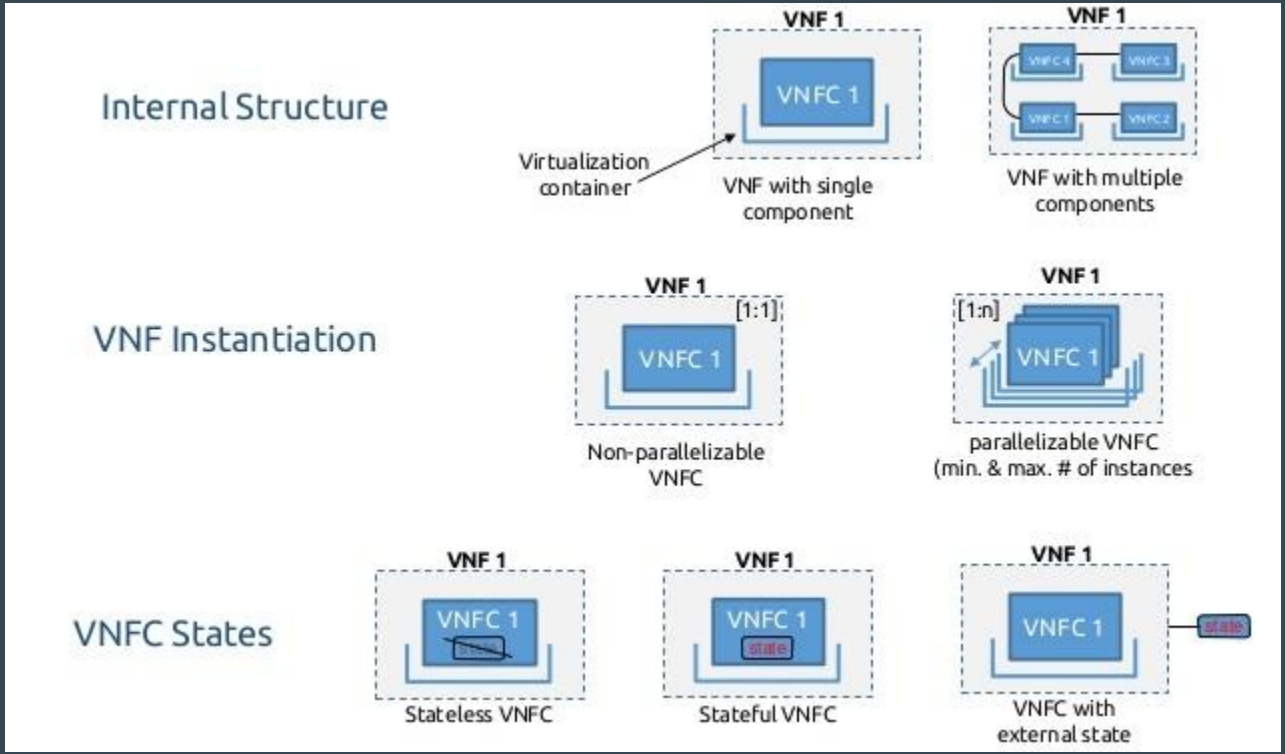
VNF - internal structure :



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VNF - Instantiation :

There are two ways to achieve this :

- Parallelizable : instantiation multiple time per VNF instance but with constraints on the number.
- Non - parallelizable : instantiation once per VNF instance.

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VNF - states :

Stateful VNFC

- VNFC that needs to handle state information of the VNF
- VNFC can be implemented stateless by sorting the state in the external repository to VNFC.

Stateless VNFC

- VNFC that does not need to handle the state information

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VNF - load balancer :

VNF - internal load balancer

- 1 VNF instance seen as 1 logical NFV by peer NF
- VNF has at least one VNFC which can be replicated
- Internal load balancer VNFC which scatters/collects information/packets/flows/sessions.

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VNF - load balancer :

VNF - external load balancer

- N VNF instances seen as 1 logical NFV by peer NF
- External load balancer which will be another VNF which scatters/collects information/packets/flows/session to/from the different VNF instances.

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VNF - load balancer :

End-to-end load balancing

- N VNF instance seen as N logical NFV by peer NF
- Peer NF itself contains load balancing functionality

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VNF - properties :

- Hardware independence
- Virtualization and container awareness
- Elasticity
- VNF policy management
- Migration operations

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VNF lifecycle management

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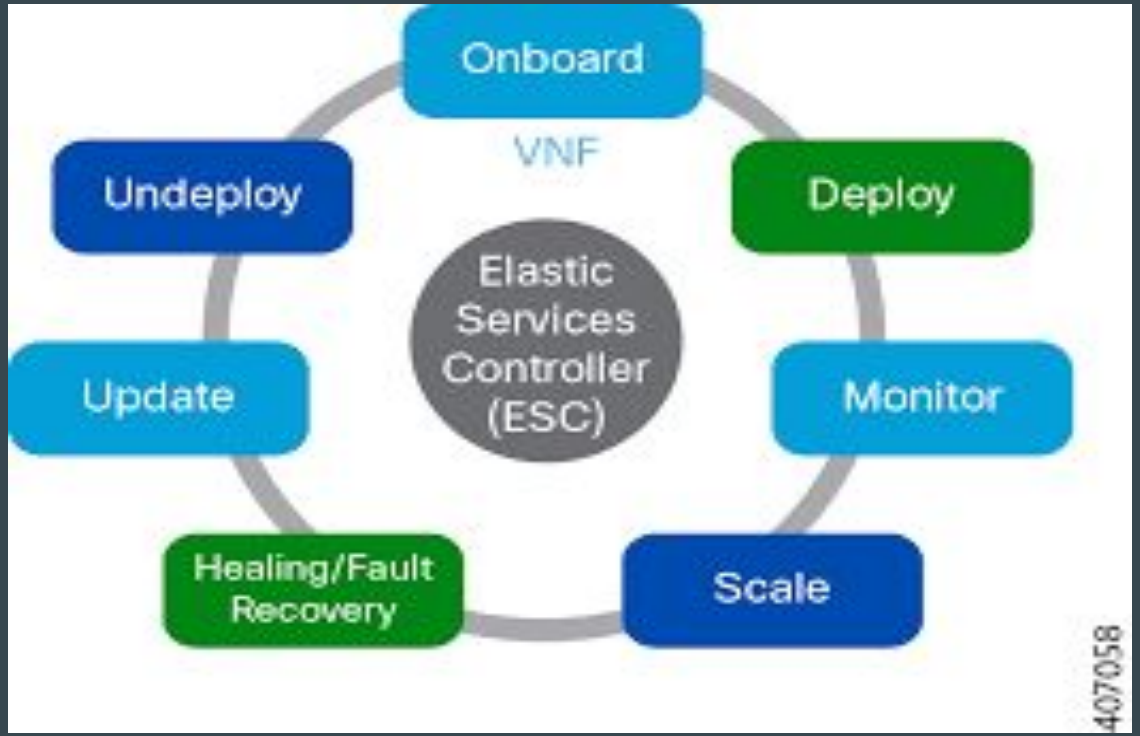
VNF lifecycle management :



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VNF lifecycle management :

- Onboarding
- Deploying
- Monitoring
- Healing
- Updating
- Undeploy

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VNF forwarding graph

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VNF forwarding graph :

- It is used to orchestrate and manage traffic through VNFs.
- The VNF-FG shows the graph of logical links connecting VNF nodes for the purpose of describing the traffic flow between these VNFs.
- VNF-FG1 : for control traffic
- VNF-FG2 : for user traffic

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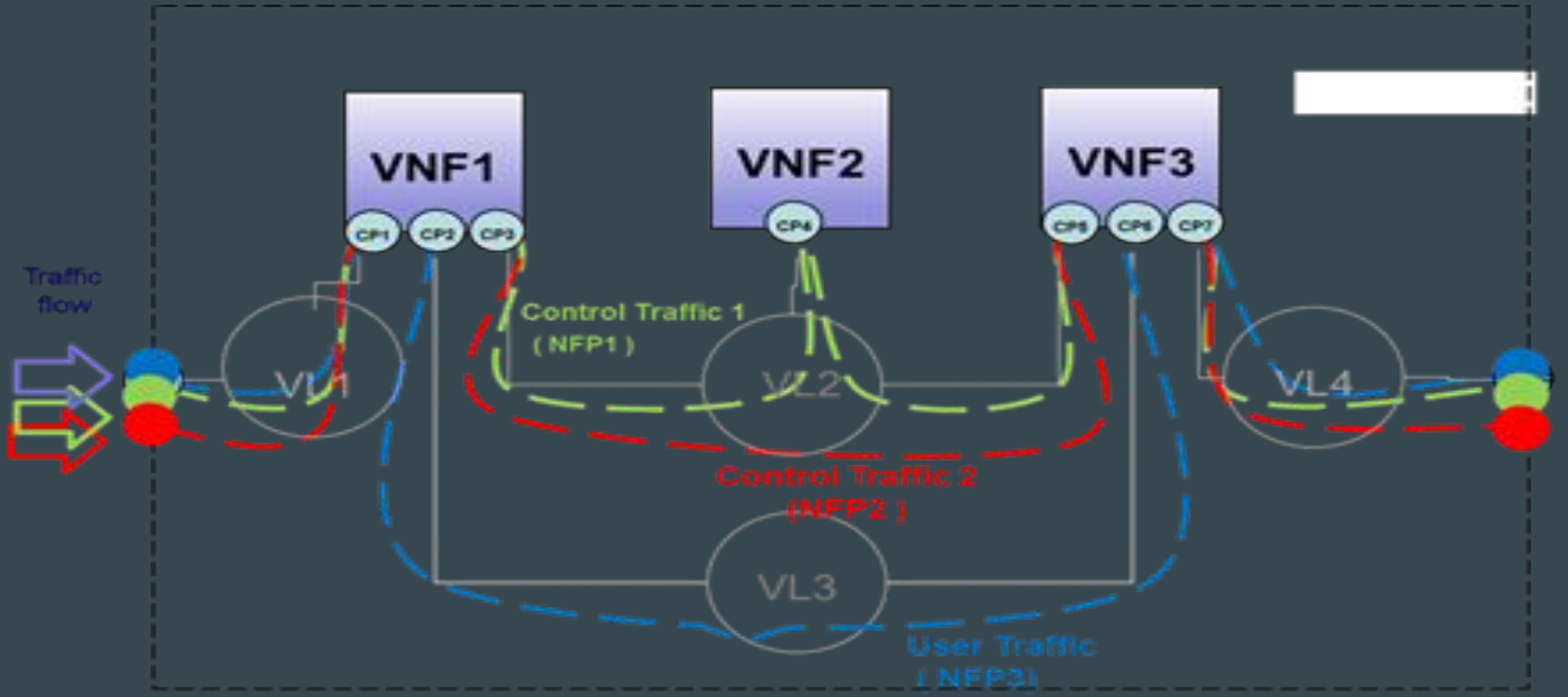
VNF forwarding graph :



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DPDK

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DPDK :

- It is a set of data plane libraries and network interface controller drivers for fast packet processing.
- DPDK enables to build applications, that we can use to process packets faster.

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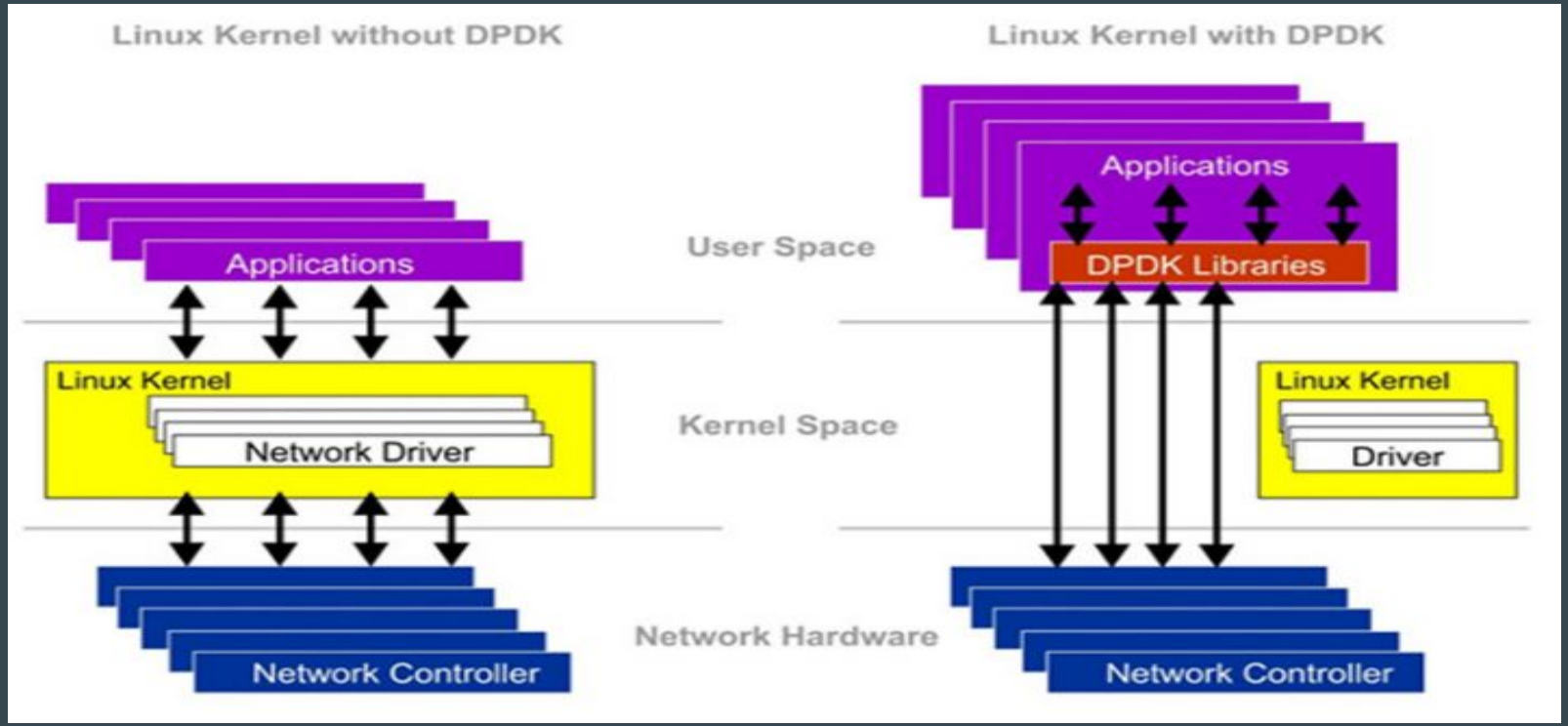
DPDK :



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DPDK components :

- EAL : Environment Abstraction Layer
- Memory manager
- Buffer manager
- Queue manager
- Packet flow classification
- Poll mode drivers

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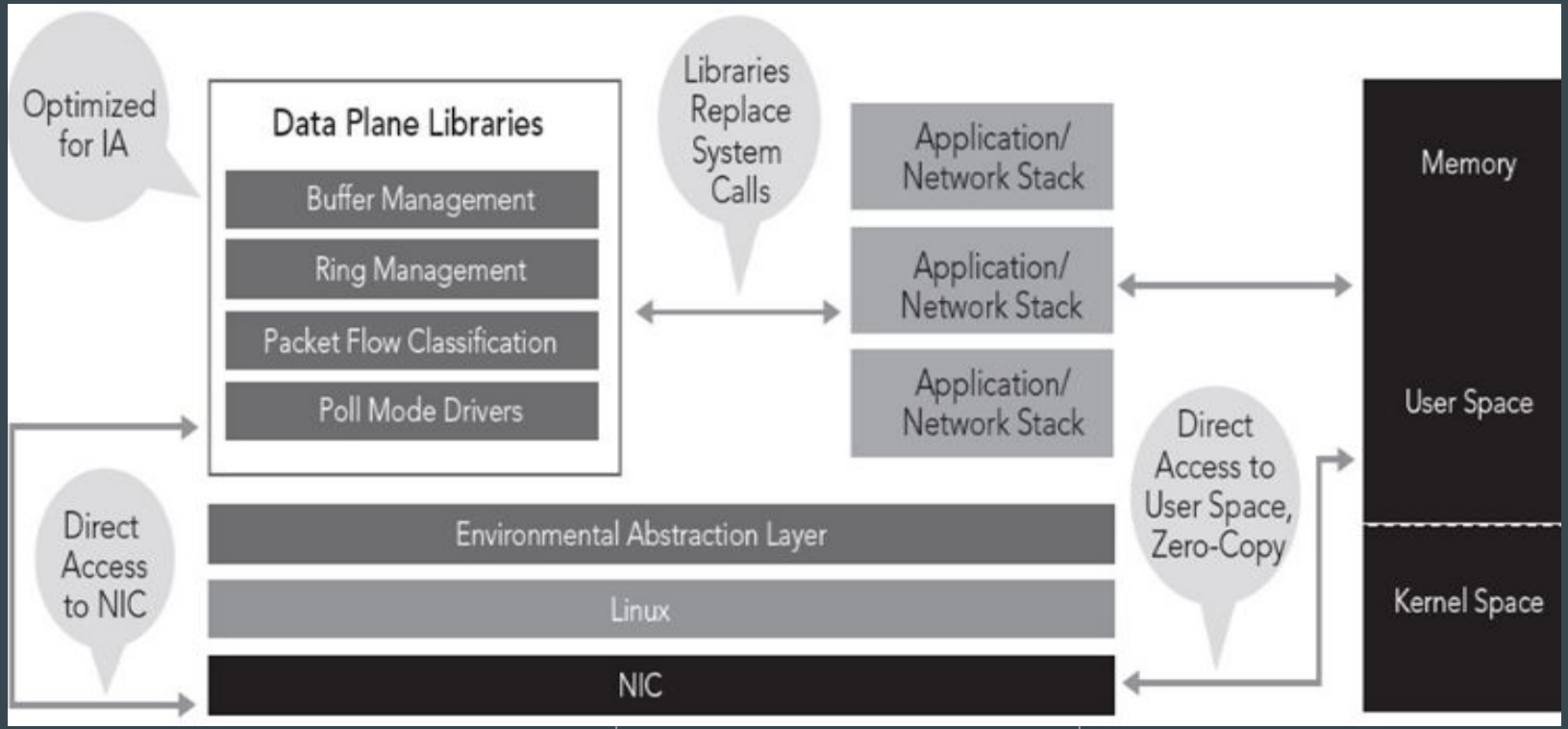
DPDK components :



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SR-IOV

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SR-IOV :

- It is a specification that allows a PCIe device to appear to be multiple separate physical PCIe devices.
- SR-IOV requires support in the BIOS as well as in the operating system instance or hypervisor that is running on the hardware.
- The SR-IOV offers different virtual functions to different virtual components (e.g network adapter) on a physical server machine.

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SR-IOV :

- It uses physical functions (PF's) and virtual functions (VF's) to manage global for the SR-IOV devices.
- PFs are full PCIe functions that include the SR-IOV extended capability which is used to configure and manage the SR-IOV functionality.
- For SR-IOV enabled PCIe devices to function, you must have the appropriate BIOS and hardware support , as well as SR-IOV support in the guest driver or hypervisor instance.

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SR-IOV :

- For SR-IOV PCIe devices to function, required to have appropriate BIOS and hardware support, as well as SR-IOV support in the guest driver or hypervisor instance.

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Juniper contrail

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Juniper Contrail :

- Juniper networks contrail is a open , standards - based software solution that delivers network virtualization and service automation for federated cloud networks.
- Using contrail, a tenant can define , manage and control the connectivity , services and security policies of the virtual network.

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Juniper Contrail :

- Once created, policies can be applied across multiple network nodes , changed, added and deleted, all from a simple browser based interface.
- A browser-based user interface enables users to define virtual network and network service policies, then configure and interconnect networks simply by attaching policies.

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Juniper Contrail :

- Contrail can be used with cloud orchestration systems such as openstack.
- It allows customers to build elastic architectures that leverage the benefits of cloud computing - agility, self-service, efficiency and flexibility.

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Juniper contrail components

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Major components :

- Contrail control nodes
- Contrail compute nodes - XMPP Agent & vRouter

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Contrail containers :

- Contrail software releases are distributed as set of packages for each of the subsystem modules of a contrail system.
- Contrail subsystems are delivered as docker containers that group together related functional components.
- Each container file includes an INI based configuration file for configuring the device within the container.

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Contrail system overview :

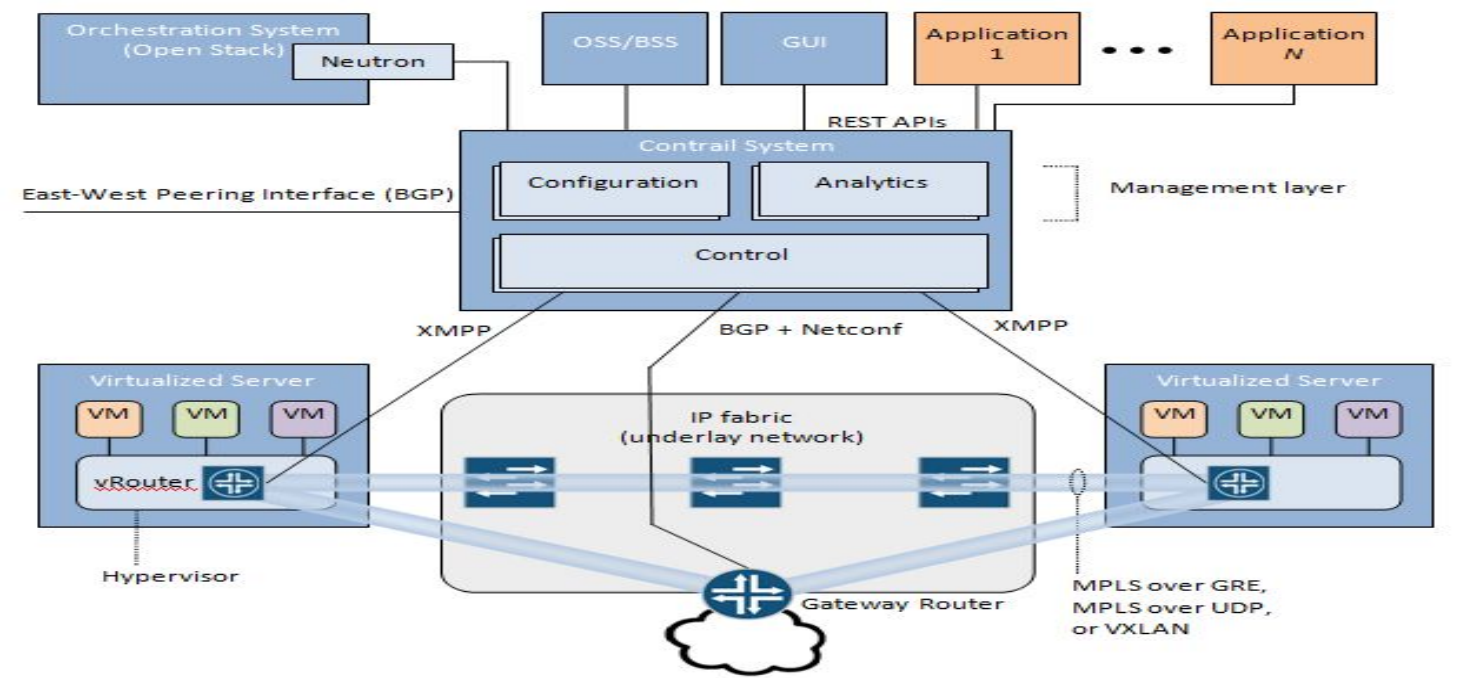

Figure 1: OpenContrail System Overview

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Juniper contrail components

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Nodes :

- Each node can be implemented as a separate physical server, or it can be implemented as a VM.
- All nodes of a given type run in an active - active configuration.

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Nodes :

- Configuration node : it keeps a persistent copy of the intended configuration state and translate the high level data model suitable for interacting with network elements.
- Control node : it implement a logically centralized control plane that is responsible for maintaining ephemeral network state.
- Analytics node : it collect, store , correlate and analyze information from network elements , virtual or physical.

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Nodes :

- Compute nodes are general purpose virtualized servers that host VMs.
- Gateway nodes are physical routers or switches that connect the virtual networks to physical networks.
- Service nodes are physical network elements providing network services such as WAN optimizers, load balancers.

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Juniper contrail components

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Contrail networking router :

- It runs on the compute node of the cloud or NFV infrastructure.
- The vRouters run in one of two high performance implementations : as a Linux kernel module or as an Intel data plane development kit (DPDK) based process.

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Key features :

- Routing and bridging
- Load balancing
- Security & multitenancy
- Elastic, resilient VPN
- Gateway services
- High availability
- Analytics services
- API services

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Key benefits :

- Simple
- Open
- High scale and performance
- United multi cloud policy
- Seamless integration

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Use cases ：

- Deploy private or public clouds
- Deploy hybrid clouds and create VPC in a service provider public cloud.
- Automate NFV through service chaining of any network and security service.

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Use cases ：

- Deploy private or public clouds
- Deploy hybrid clouds and create VPC in a service provider public cloud.
- Automate NFV through service chaining of any network and security service.

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Juniper contrail

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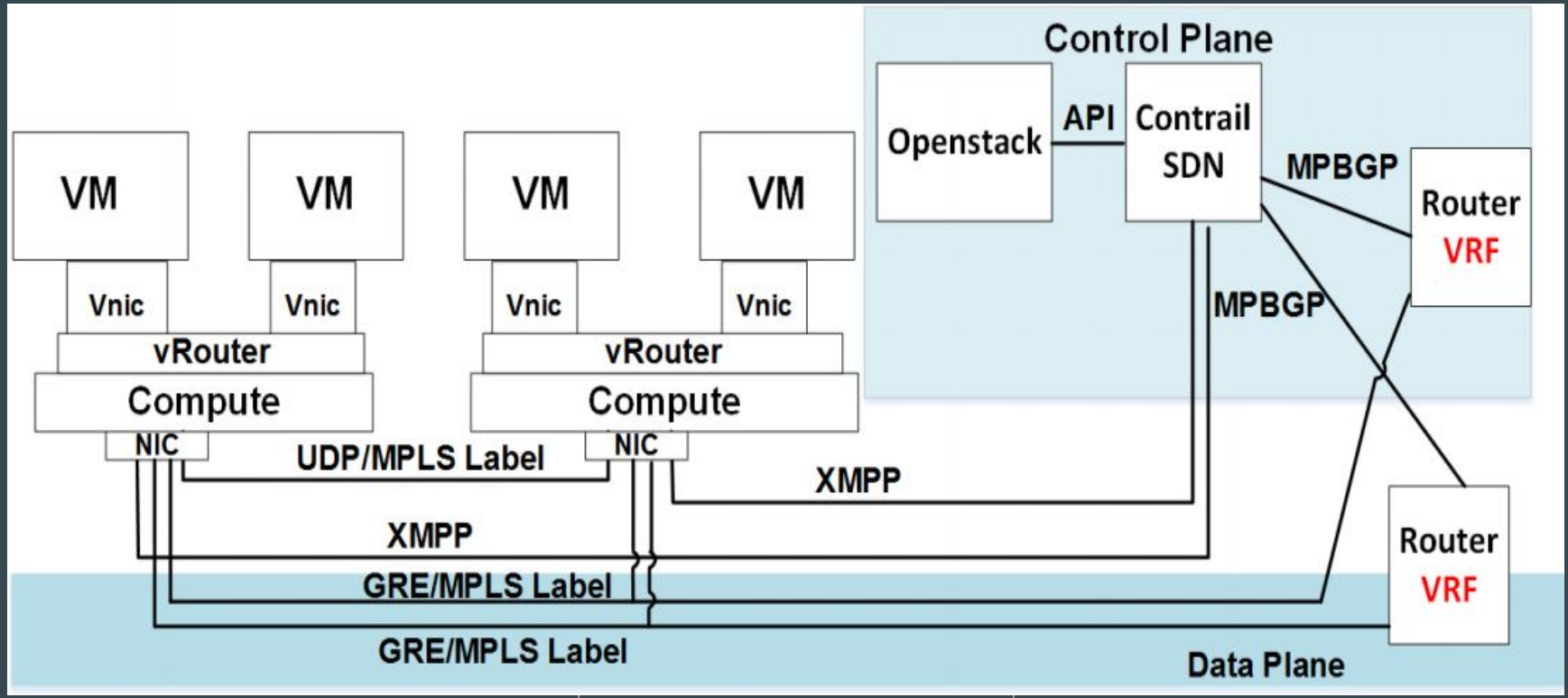
Contrail :



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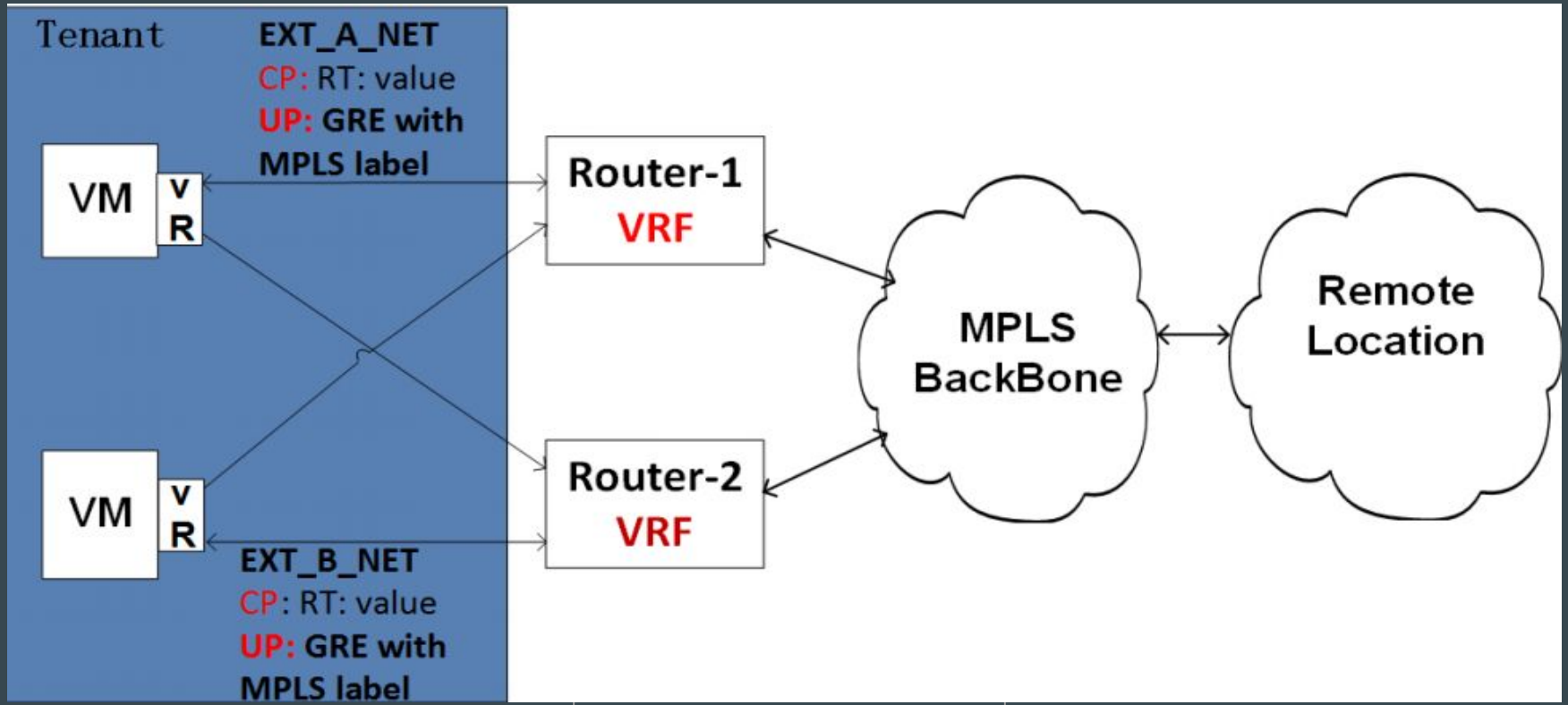
Connectivity to an external router ：



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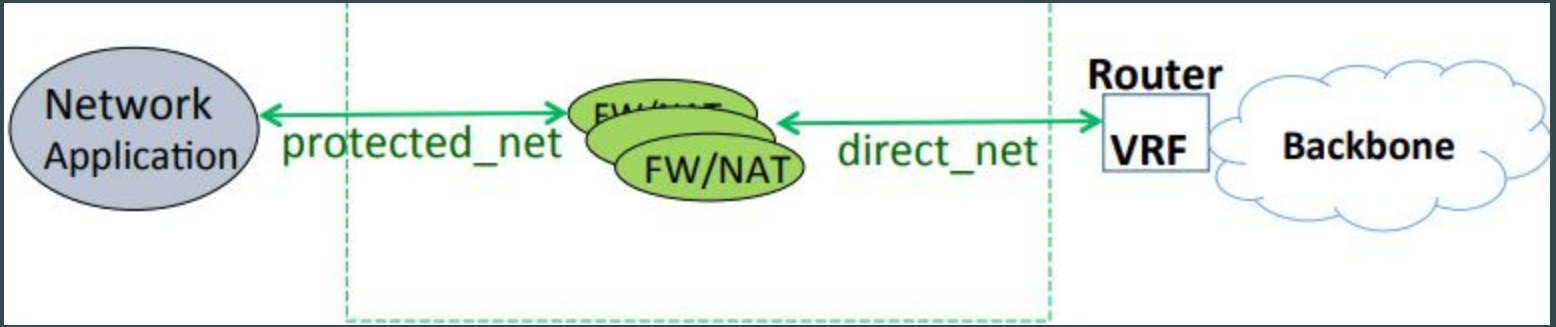
Opencontrail features :

- Policy routing or service chaining
  With policy routing you can route traffic based on predefined policy rules.



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Opencontrail features :

- Public IP addresses without NAT
- Turnking
- QoS marking and remarking
- Support of priority queues for QoS
- Jumbo frame support
- Full support of SCTP protocol
- High availability

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Contrail releases

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Opencontrail features :

- Contrail release 4.0.1 : openstack ocata, openstack Newton , Openstack Mitaka
- Contrail release 4.0 : openstack Newton , openstack Mitaka

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Server requirements

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Server Requirements :

Each server must have a minimum of :

- 64 GB memory
- 300 GB hard drive
- 4 CPU cores
- At least one ethernet port

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Downloading installation software :

All components necessary for installing the contrail controller are available as :

- An RPM file
- A debain file

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Downloading installation software :

The Contrail image includes the following software :

- All dependent software packages needed to support installation and operation of Openstack and Contrail.
- Contrail controller software - all components
- Openstack release currently in use for contrail

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Installing the operating system ：

- Install a centOS or Ubuntu minimal distribution as desired on all servers.
- Install Contrail server manager.
- Create an image .json with the ubuntu or centOS image to be used to reimage the target server.

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Configuring the control node ：

An important task after a successful installation is to configure the control node.

- The contrail controller base system image has been installed on all servers.
- The role based services have been assigned and provisioned.
- IP connectivity has been verified between all nodes of the contrail controller.
- You can access the Contrail user interface where IP address of the configuration node server that is running the service.
- Configure BGP

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Support for multiple interfaces :

- Servers and nodes with multiple interfaces should be deployed with exclusive management control and data networks .
- In case of multiple interfaces per server, the expectation is that the management connectivity to the cluster , and the control and data network carries the control plane information and the guest traffic data.

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Support for multiple interfaces :

Examples of control traffic include the following :

- XMPP traffic between the control nodes and the compute nodes.
- BGP protocol messages across the control nodes.
- Statistics, monitoring and health check data collected by analytics engine from different parts of the system.

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Contrail global controller

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Contrail Global controller :

- The global controller feature provides a seamless controller experience across multiple regions in a cloud environment by helping manage multiple Openstack installations , each having its own keystone , Neutron, Nova and so on.
- High availability is provided by using separate failure domains by regions.

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Contrail Global controller :

- To handle the resource burdens when connecting and configuring servers and virtual machines over multiple, different regions, the global controller has responsibilities as :
  Resource identifier management
  Multiple location resource provisioning

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Resource identifier management :

- The global controller uses centralized resource ID management to manage multiple types of identifiers , identifying such things as route targets , virtual networks , security groups and so on.
- The contrail global controller can interconnect virtual networks residing in different data centers using BGP VPN technology.

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Resource identifier management :

- BGP VPN recognizes VPNs by using route target identifiers.
- A virtual network ID is used to identify the same virtual networks in different data centres, to prevent looping in service chains.

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Multiple location resource provisioning :

- There are many cases in which the same resource , such as policy or services, needs to exist in multiple data centers.
- There might be security policy to apply a firewall for any traffic for an application server network that exists in multiple locations.
- Each location needs to have the same virtual network, network policy and firewalls.

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Configuring Contrail

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Configuring Contrail :

- Configuring virtual networks
- Deploying a multi-tier web application using contrail
- Configuring services
- Configuring service chaining

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Configuring virtual networks

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Configuring Contrail :

- Creating projects in openstack for configuring tenants in contrail.
- Creating a virtual network with Juniper networks contrail.
- Creating a virtual network with openstack contrail

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Service chaining

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Basics ：

- Services are offered by instantiating service virtual machines to dynamically apply single or multiple services to VM traffic.

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Contrail service chain ：

- Services are offered by instantiating service virtual machines to dynamically apply single or multiple services to VM traffic.

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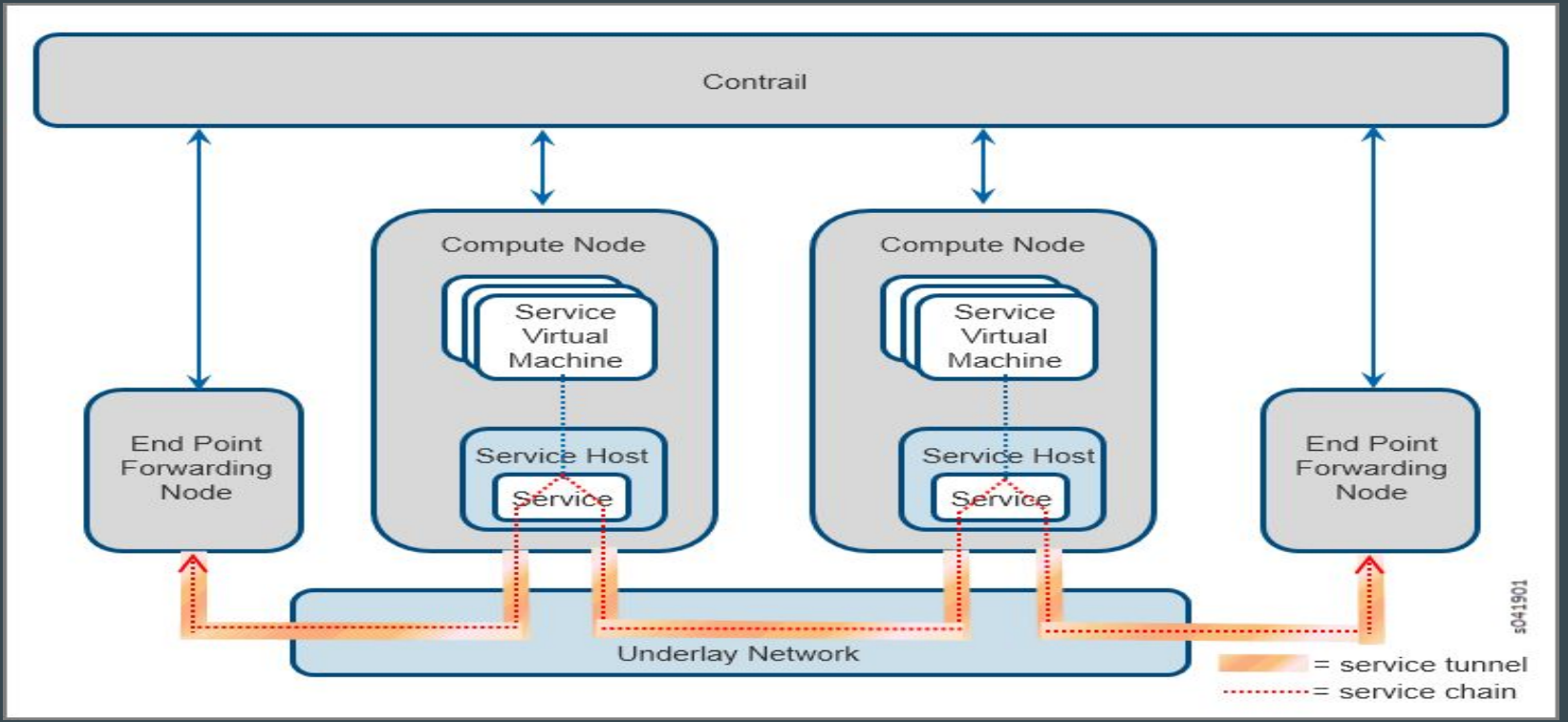
Contrail service chain ：



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Contrail service chain :

- Transparent or bridge mode
- In - network or routed mode
- In - network - nat mode

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Overview of Contrail

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Use cases

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Use cases :

- Cloud networking : it enables private clouds for enterprises and service providers, IaaS and VPC for cloud service providers.
- NFV in service provider network : this provides VAS for service provider edge networks such as business edge networks, broadband subscriber management edge networks and mobile edge networks.

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Contrail SDN controller & the vRouter :

- Contrail SDN controller : it is a logically centralized but physically distributed SDN controller that is responsible for providing the management, control and analytics functions of the virtualized network.
- Contrail vRouter : it is a forwarding plane that runs in the hypervisor of a virtualized server.

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Virtual networks :

- Virtual networks are a key concept in the contrail system .
- VNs can be connected to and extended across physical MPLS L3 VPNs and ethernet VPNs using a data center edge router.
- Virtual networks are also used to implement NFV and service chaining.

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Overlay networking :

- Virtual networks can be implemented using a variety of mechanisms. E.g each VPN can be implemented as a virtual LAN, VPN etc.
- VNs can also be implemented using two networks - a physical underlay network and a virtual overlay network.

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Contrail and open source :

- The contrail system is integrated with open-source hypervisors such as kernel-based virtual machines(KVMs) and xen.
- The contrail system is integrated with open source virtualization orchestration systems such as openstack and cloudstack.
- The contrail system is integrated with open-source physical server management systems such as chef,puppet, cobbler and ganglia.

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Graphical user interface :

- The contrail system also provides a GUI.
- This GUI is built entirely using the REST APIs .

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Contrail Architecture details :

- Contrail SDN controller provides northbound REST APIs used by applications.
- These APIs are used for integration with the cloud orchestration system - e.g for integration with openstack via a neutron plugin.
- The contrail system provides three interfaces.

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Contrail nodes

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Contrail SDN controller components :

- Configuration nodes
- Control nodes
- Analytics nodes

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Compute node :

- These are tenant VMs running customer applications such as web servers, database servers, enterprise applications or hosting virtualized services used to create service chains.
- The contrail vRouter forwarding plane sits in the linux kernel and the vRouter agent is the local control plane.

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Compute node :

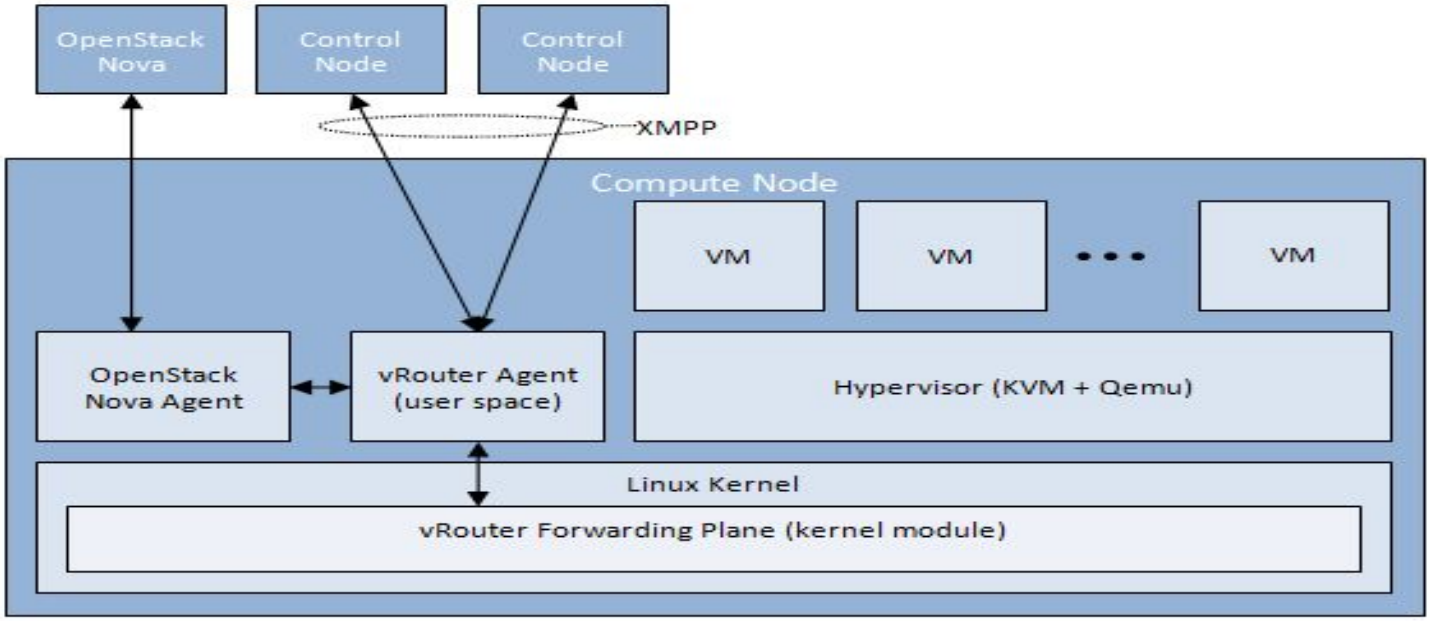

Figure 3: Internal Structure of a Compute node

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vRouter Agent :

- It is a user space process running inside Linux.
- It acts as the local, lightweight control plane and is responsible for various functions.

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Control node :

The control nodes communicate with multiple other types of nodes :

- They receive configuration state from the configuration nodes.
- They exchange routes with other control nodes using IBGP to ensure that all control nodes have the same network state.
- They exchange routes with the vRouter agents on the compute nodes using XMPP.

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Control node :

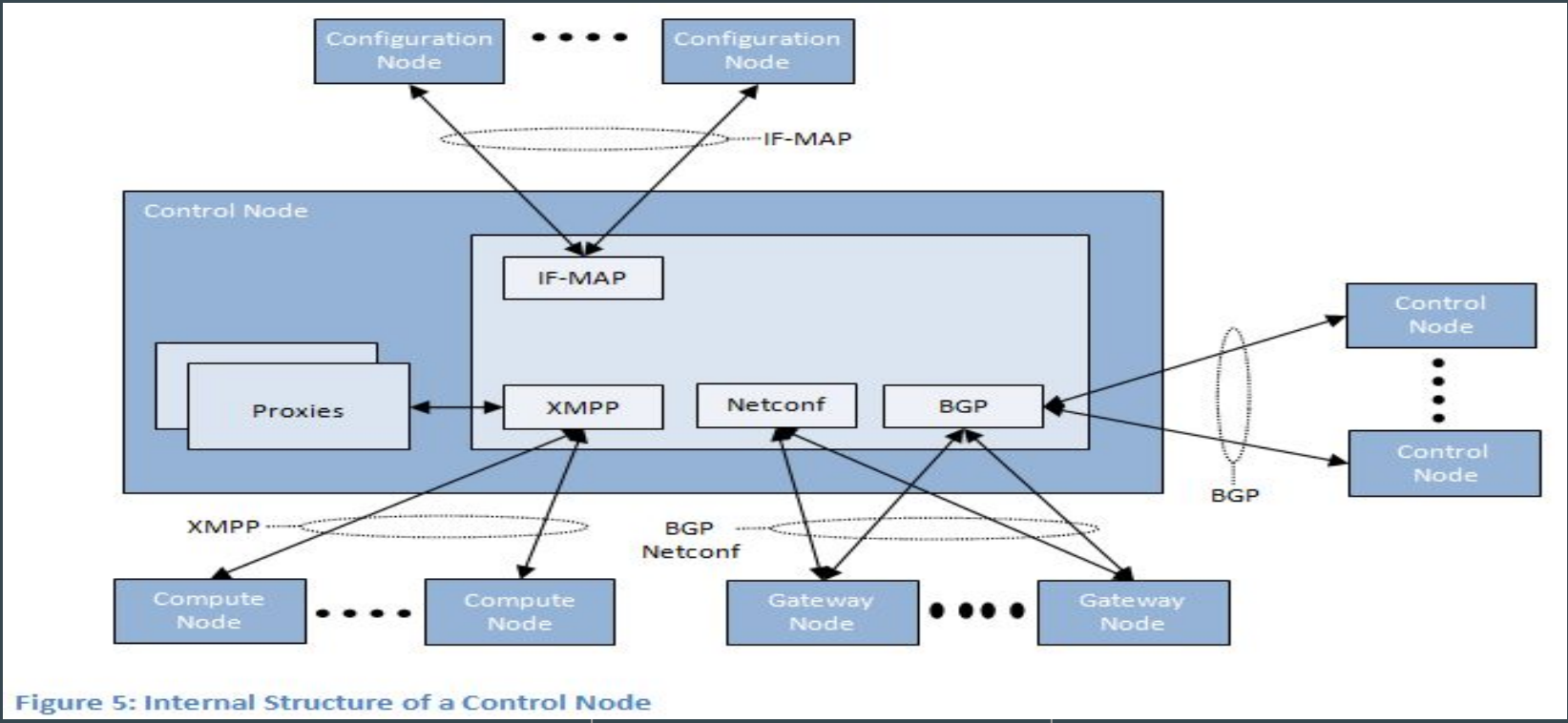

Figure 5: Internal Structure of a Control Node

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Configuration node :

- It communicates with the orchestration system via REST interface.
- It provide a discovery service that the clients can use to locate the service providers.

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Configuration node :

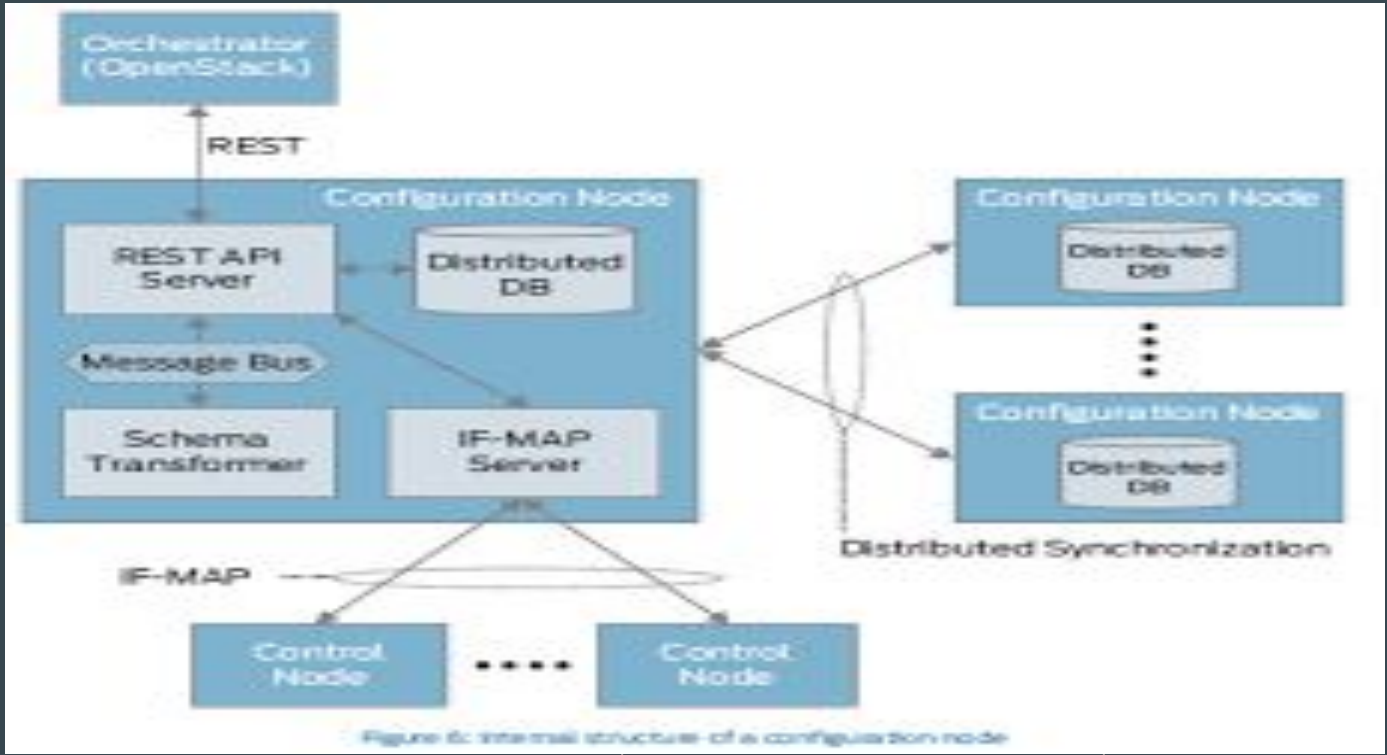

Figure 6: Internal structure of a configuration node

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Analytics node :

- An analytics node communicates with applications using a northbound REST API.
- A collector exchanges sandesh messages with components in control nodes and configuration nodes to collect analytics information.
- A NoSQL database stores this information.

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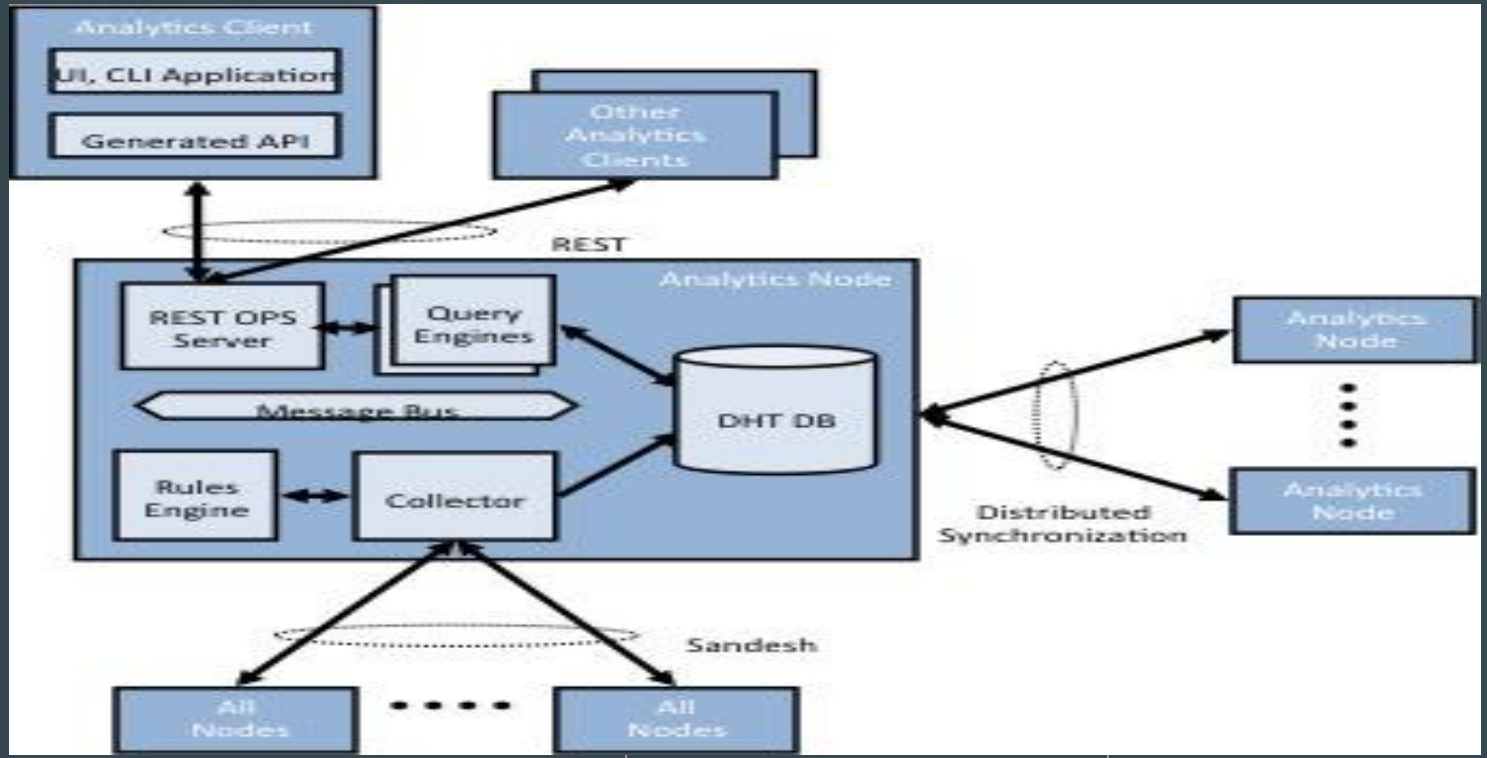
Analytics node :



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Control & management plane protocols

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IF-MAP :

- It is an open standard/server protocol developed by TCG.
- Original application of IF-MAP was to provide a common interface between MAPs , a database server acting a clearing house for info about security events and objects, and other elements of the TNC architecture.

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XMPP :

- The extensible messaging and presence protocol is a communication protocol for message oriented middleware based on XML.
- Contrail uses XMPP as a general purpose message bus between the compute nodes and the control node to exchange multiple types of information including routes, configuration, operational state, statistics , logs and events.

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BGP :

- Contrail uses BGP to exchange routing information among the control nodes.
- BGP can also also be used to exchange routing information between the control nodes and the gateway nodes.

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Sandesh :

- It is an XML based protocol for reporting analytics information.
- The structure of the XML messages is described in schemas.

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Role of orchestration in the data center

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Role of orchestration :

In the data center, the orchestrator manages many critical aspects of the data center :

- Compute
- Storage
- Network
- Applications

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Role of orchestration :

The SDN controller's role is to orchestrate the network and networking services like load balancing and security based on the application it has assigned compute and storage resources.

- Create a virtual network for a tenant within a data center or across data centers.
- Attach a VM to a tenants virtual network.
- Connect a tenant's virtual network to some external network e.g internet or VPN.

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Role of orchestration :

- Physical switches
- Physical routers
- Physical service nodes
- Virtual services

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Contrail security

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Contrail security :

- It discovers application traffic flows and drastically reduces policy proliferation across different environments.
- With contrail security, you define policies once and automatically distributes them uniformly across all deployments.
- A v Router acts as a distributed element.

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Contrail security advantages :

- Consistent, intent driven policy
- Multiple enforcement points
- Application traffic visibility & advanced analytics
- Unified operations and management

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Contrail SD-WAN

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Contrail SD-WAN :

- It delivers a simple , automated multi-cloud SD-WAN.
- Contrail SD-WAN uses contrail service orchestration to design, secure, automate and run the entire service lifecycle across service platforms, routers, gateways along with virtual firewall secure cloud endpoints.

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