

Impacts on 3GPP architecture when enabling IPv6 service

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for tomorrow's challenges

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Impacts on 3GPP architecture when enabling IPv6 service
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Outline

- Quick background and history
- Basic concepts in 3GPP end user IPv6 services
- End user IPv6 service impact to 3GPP core network
- Transition complexity – long tail of legacy
- And what then?
- Summary

PS: this presentation has a network & vendor bias and does not contain IPv6 usage graphs & numbers..

Some history and the basics..

Quick background and history

- IPv6 has been part of 3GPP (or ETSI) specifications from the beginning:
 - The presenter used IPv6 in a live network with commercial mobiles already in early 2005.
- The IP connectivity was modeled after PPP-based dial-up:
 - Which is still visible in the 3GPP architecture and the link (or rather pipe) assumptions.
- At the time 3GPP adopted IP, wireless IP networking was not ‘the main service’:
 - Circuit Switched was brought until Rel-8; telco mentality shows.. and often at the expense of better IP service.
 - The radio resource is a scarce resource, which sometimes is “conserved” at the expense of better IP service.
 - Since Rel-8 the architecture has been ‘IP only’.
- 3GPP still promotes dual-stack as the official IPv6 transition mechanism:
 - TR23.975 has a lot of transition scenarios and discussion but no binding conclusions.

Release	Description
1997 (~year 1997)	The first release of GPRS; PDP Type IPv6 already included.
1998	
1999	The first release of UMTS (3G).
Rel-4	
Rel-5	IMS and HSDPA introduced. IMS was supposed to be IPv6-only...
Rel-6	HSUPA introduced. 3GPP I-WLAN..
Rel-7	HSPA+ introduced.
Rel-8 (~year 2007)	The first release of EPS (LTE); PDN Type IPv4v6 (dual-stack); DSMIPv6, PMIPv6, 3GPP IPv6 transition TR..
Rel-9	PDP Type IPv4v6 for GPRS!!
Rel-10	DPCPv6 Prefix Delegation.
Rel-11 (~year 2012)	WLAN access to EPC..
Rel-12	...

Basic concepts in 3GPP end user IPv6 services

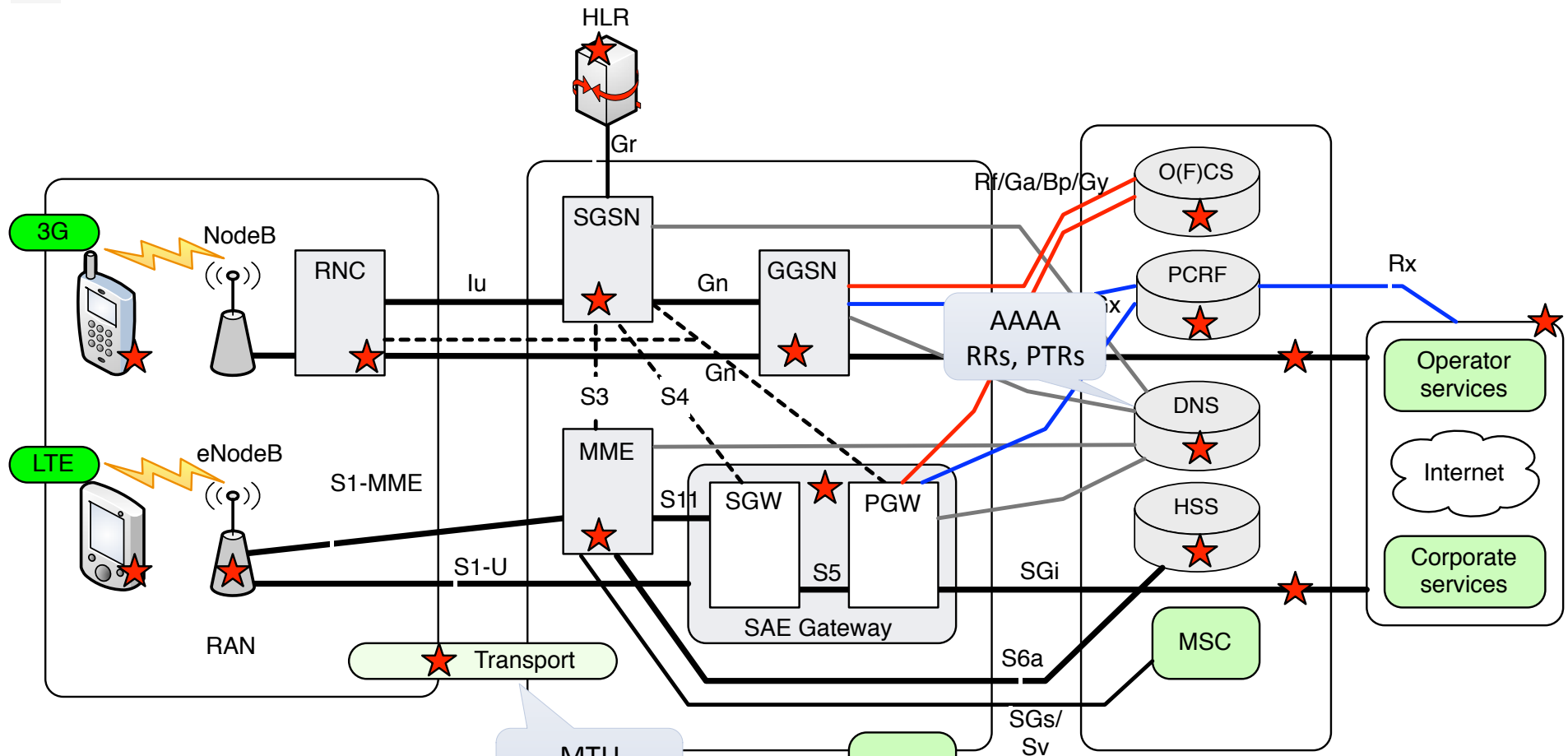
- Connectivity model:
 - Based on PPP-based dial-up ideology; each “connection” is a pipe with a silo view of the network.
 - 3GPP loves gateways; the GGSN/PGW is the “IP aware” gateway connecting to external **Packet Data Networks** (PDN) such as Internet or operator’s walled garden.
 - An **Access Point Name** (APN) names a GGSN/PGW that connects to a desired PDN (e.g. “internet”).
 - In 3GPP lingo IP connections are called PDP Contexts (GPRS) or Bearers (EPS) or **PDN Connections** (EPS). Term “PDN Connection” is a good generalization but be aware of spec. police ;-)
- A PDN Connection is IP version aware: **PDN Type IPv4, IPv6 or IPv4v6** (i.e. dual-stack):
 - The “layer-2” cannot mix different PDN Types; this design decision has caused a lot of headache.
 - One specific example is mimicking dual-stack connectivity using two PDN Connections, which has both technical and commercial concerns.
 - There can be **at most one IPv6 prefix** and IPv4 address for each PDN Connection; multiple IPv6 prefixes require multiple PDN Connections, which then equals multi-homing.
- Address configuration and management has its specialties:
 - 3GPP system **cares about the IPv6 prefix** assigned to the mobile device not the address.
 - IPv6 IIDs can be anything except for the **link-local addresses that are coordinated by GGSN/PGW**.
 - **SLAAC is the only available** IPv6 address configuration method (for 3GPP accesses).
 - DHCPv6 is supported for prefix delegation; however, the prefix assigned to the mobile device itself must aggregate with the delegated prefix.

Basic concepts cont'd..

- 3GPP architecture separates **user plane** (end user IP), **control plane** (signaling), and **transport plane** (i.e. transmission):
 - Each plane is independent IP version wise; it is possible to use IPv6 on user plane while e.g. transport plane remains IPv4. This design helps with the IPv6 transition.
 - As a side effect **3GPP architecture tunnels everything**; GTP tunnels are everywhere.
 - Signaling protocols have always been IPv6 aware at the **Information Element** level. Unfortunately, it does not guarantee the vendor has **implemented** e.g. Diameter APVs to carry IPv6 prefix
- 3GPP Release-based system allows phased transition and guarantees backwards compatibility on many technical features including IPv6.. however:
 - The fallback scenarios from native IPv4v6 connection establishment attempts to IPv4-only or IPv6-only or both at the same time is not trivial to get right; not in the mobile device, not in the network and also quite challenging to provision without headache.
 - There is an annoying feature discrepancy between EPS Release-8 and GPRS pre-Release-9 regarding the native IPv4v6 dual-stack connectivity; this complicates inter-RAT handovers.
- Network is always in control:
 - Everything is modeled as pipes; session concept is tightly bolted in and link layers follow that.
 - Network follows the mobile device; 3GPP has deployed IP mobility where IETF has failed..
- Regardless of the “plane separation” design enabling IPv6 on the user plane there is a surprising large impact to the 3GPP system; see the following slides...

Some IPv6 facts that might be good to know..

End user IPv6 service impact to 3GPP system



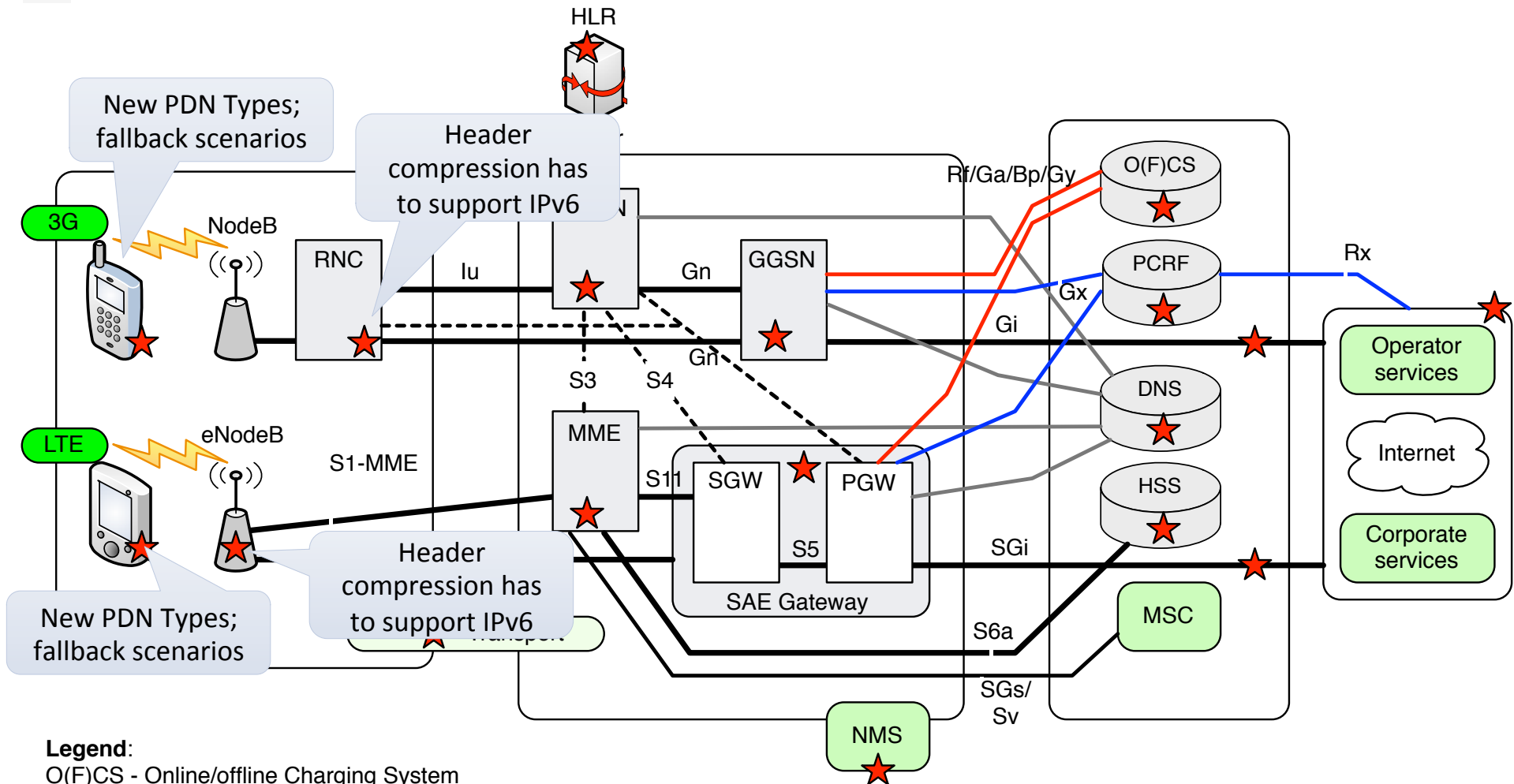
Legend:

- O(F)CS - Online/offline Charging System
- NMS - Network Management System
- PCRF - Policy and Charging Rules Function
- MSC - Mobile Switching Center
- SAE - System Architecture Evolution

Management and provisioning system has to understand IPv6

Picture adapted from "Deploying IPv6 in 3GPP Networks: Evolving Mobile Broadband from 2G to LTE and Beyond" - With the permission of Wiley.

End user IPv6 service impact to 3GPP system

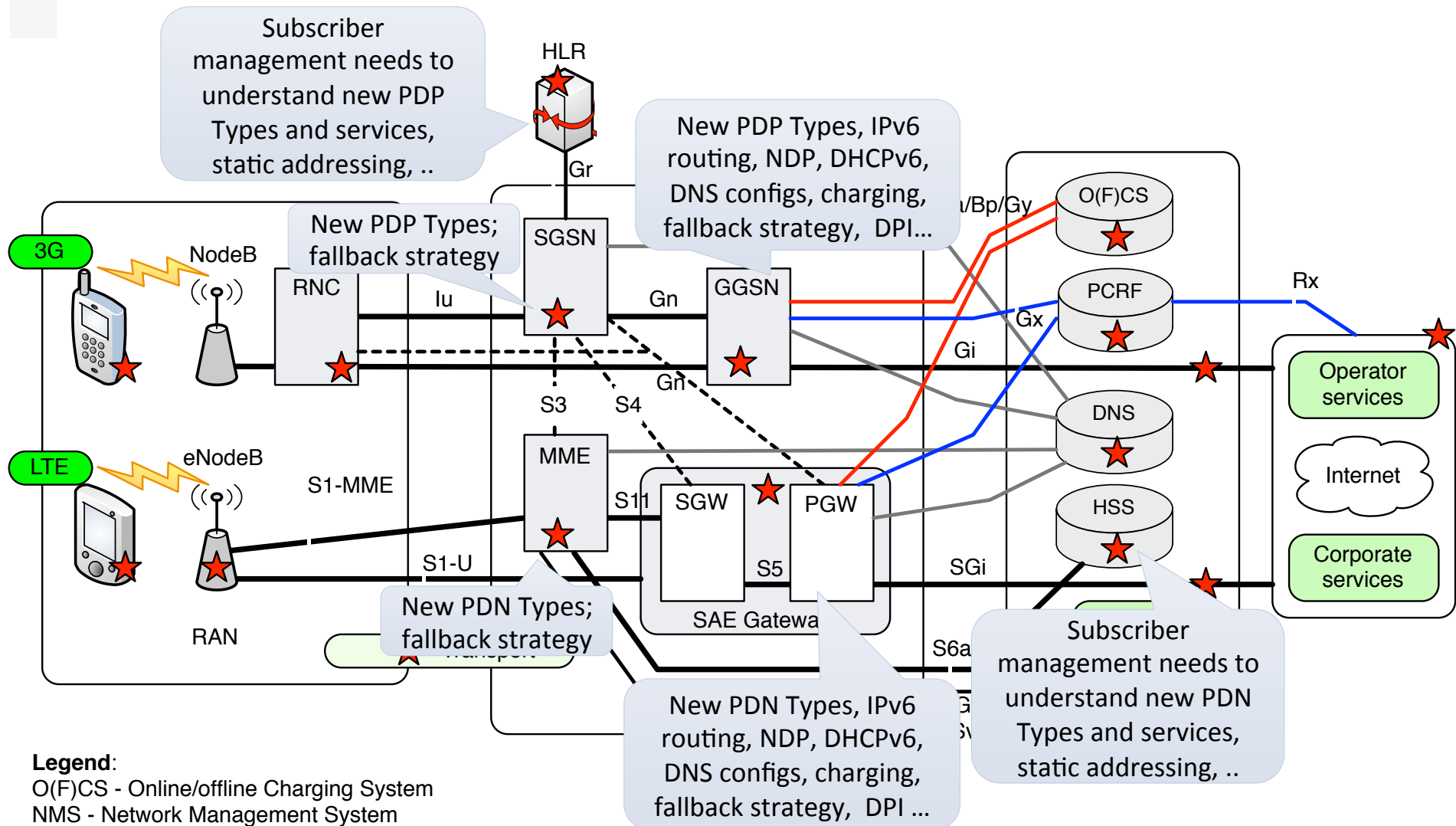


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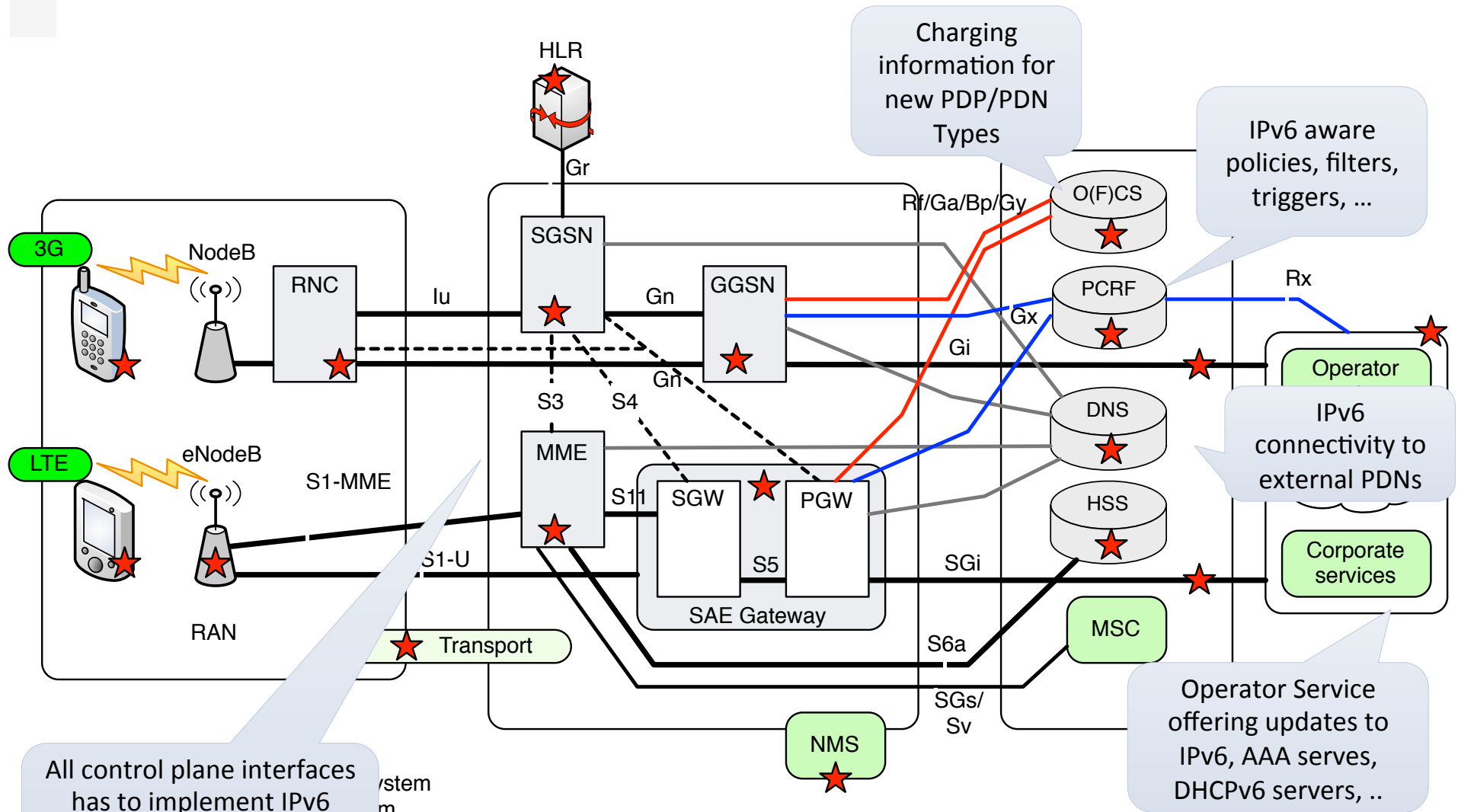


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End user IPv6 service impact to 3GPP system



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Impacts cont'd..

- The fact is IPv6 (and/or dual-stack) as the end user service impacts basically every component in the 3GPP system architecture.
 - For a network equipment vendor the situation is cumbersome. Combined nodes with both 3G and LTE support may have nasty feature discrepancy surprises to operators.
- IPv4 and IPv6 features & capabilities on the external PDN facing (SGi and Gi) interfaces may not be at the same level; it is not a surprise if the IPv6 feature set is a subset of IPv4.
- Rolling out end user IPv6 services is an interesting journey:
 - How to provision mobile devices? Need for new SIM cards?
 - New HLR/HSS profiles or re-provisioning? Can provisioning be avoided/simplified?
 - A new or parallel APN for the IPv6 services? What about the APN naming?
 - Is there a need for some IPv6 transition tools outside 3GPP?
 - What if 3GPP's view of transition does not meet operator's own plans/architecture?
 - How do I steer IPv6 enabled users away from core & radio network segments that do not support IPv6 services? What are the tools for that and are those vendor specific?
 - What about my IPv4 needs?
 - Are the in-house systems up to date?
 - Does the charging and policy backend and service logic work with IPv6?
- Inter-operator roaming is a completely different story of its own.

Transition made complex – long legacy tail

- One of the major obstacles in (user plane) IPv6 service enabling has been the long tail of legacy support; the operational network is a mixture of networking nodes and mobile devices from different 3GPP releases. A flag day approach does not usually work:
 - And very few operators have the luxury of starting from a clean slate (there are few, though).
- Certain key features have taken far too long to materialize; take PDP/PDN Type IPv4v6 (dual-stack) support as an example:
 - When it finally is in place in core network nodes for LTE, it might be missing from 3G side, from the subscription databases or from the (inter-operator) charging systems etc..
 - And yes, it does not solve the lack of available IPv4 addresses..
- 3GPP defined a set of fallback scenarios and behavior when there is a mismatch of the requested/provisioned/configured/available IPv6 or dual-stack user plane service.
- Fallback combinations are nontrivial for:
 - a mobile device vendor to get it right; and still there is room for vendor specific improvements,
 - an operator to configure the network and rollout services appropriately,
 - and for an end user to understand why some application or service still does not work.. ;-)

An example of IP version fallback combinations

- An excerpt of the end user IPv6 and/or IPv4v6 service enabling in 3GPP system and what to consider for fallbacks.
- Simpler scenarios would lead to less fallback scenarios i.e. an operator does not need to support all possible combinations.
- What if an operator provides its own transition tools and required software to mobile devices to simplify the fallback and general end user IPv6 service use cases?

UE Req.	Subscribed	DAF	NW Req.	PGW	Result
IPv4	IPv4, IPv4v6, IPv4_or_IPv6	-	IPv4	IPv4, IPv4v6	IPv4
IPv6	IPv6, IPv4v6, IPv4_or_IPv6	-	IPv6	IPv6, IPv4v6	IPv6
IPv4	IPv4v6	-	IPv4	IPv4, IPv4v6	IPv4
IPv6	IPv4v6	-	IPv6	IPv6, IPv4v6	IPv6
IPv6	IPv4v6	-	IPv4	IPv4, IPv6, IPv4v6	IPv4
IPv6	IPv4v6	pre-rel-9 SGSN	-	-	Reject
IPv4v6	IPv4	-	IPv4	IPv4, IPv4v6	IPv4
IPv4v6	IPv6	-	IPv6	IPv6, IPv4v6	IPv6
IPv4v6	IPv4, IPv4v6	-	IPv4	IPv4, IPv4v6	IPv4
IPv4v6	IPv6	-	-	-	Reject
IPv4v6	IPv4, IPv6, IPv4_or_IPv6	-	IPv4	IPv4, IPv6, IPv4v6	IPv4
IPv4v6	IPv4, IPv6, IPv4_or_IPv6	-	IPv6	IPv4, IPv6, IPv4v6	IPv6
IPv4v6	IPv4v6	-	IPv4v6	IPv4	IPv4
IPv4v6	IPv4v6	-	IPv4v6	IPv6	IPv6
IPv4v6	IPv4v6	-	IPv4v6	IPv4, IPv6	IPv4 or IPv6
IPv4v6	IPv4v6	unset	IPv4v6	IPv4v6	IPv4
IPv4v6	IPv4v6	unset	IPv4v6	IPv4v6	IPv6
IPv4v6	IPv4v6	set	IPv4v6	IPv4v6	IPv4v6

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That sounded tough.. is it really that hard..?

And what then?

- Will the sky fall when end user IPv6 gets turned on? **NO!**

However..

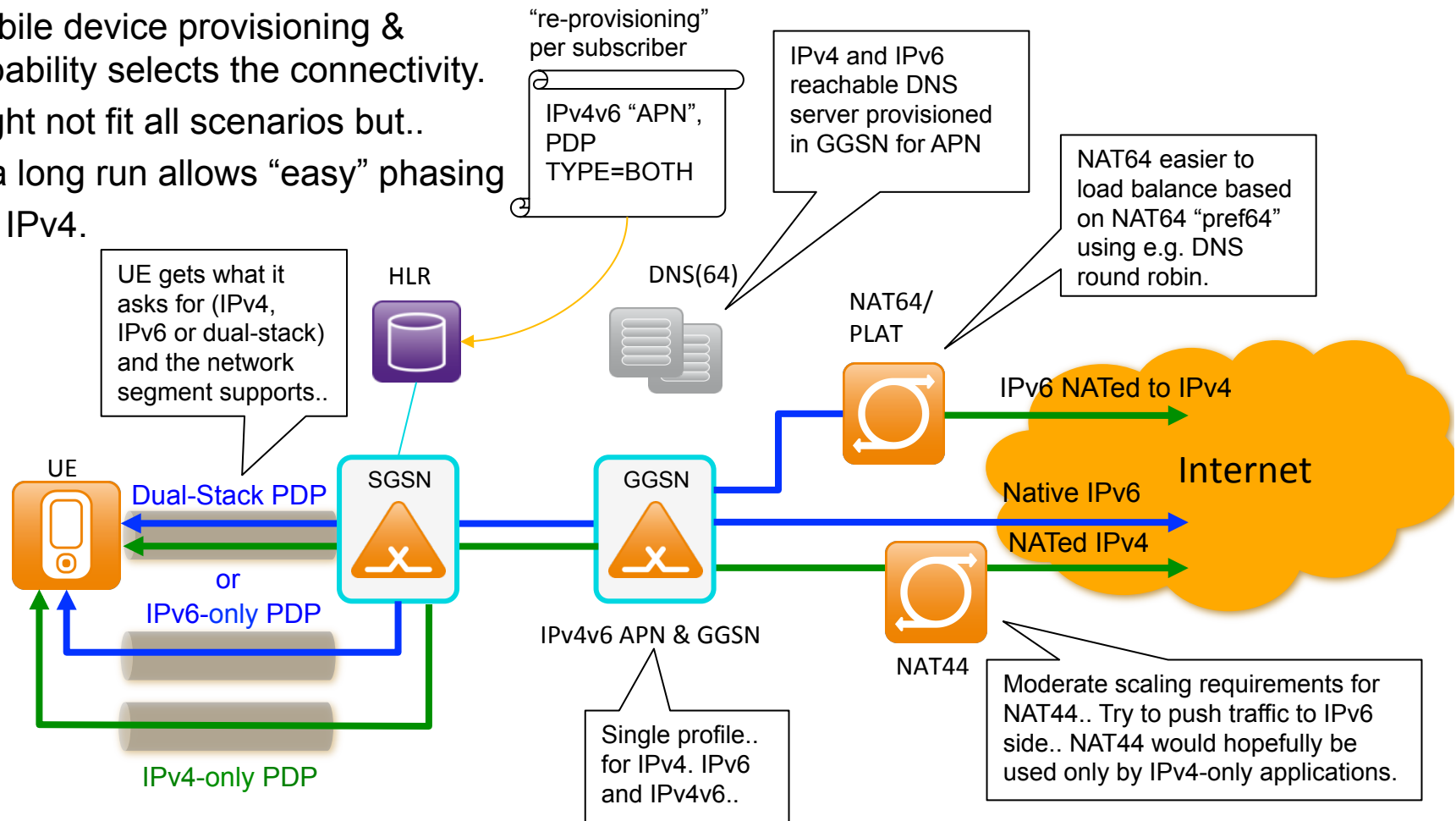
- **Nothing will progress unless people start experimenting in live with IPv6 !**
- **Every creditable modem platform has a proper IPv6 & IPv4v6 support these days:**
 - The selection of (modern) IPv6 capable mobiles & dongles is steadily getting better.
- And there is no excuse about the lack of content anymore..
- There are going to be hiccups but those will sort out.. when operational experience grows and the deployment strategy becomes clearer.
- Some existing applications potentially cause gray hair:
 - Use a baseball bat or other equivalent method to “convince” developers to ship updates :-)

So.. what to do then?

- First, **figure out where you want to be in the future**; then sort out the steps in between the present and the intended goal in the future:
 - This may involve IPv6 transition and IPv4 lifetime extension solutions that eventually get phased out.
 - **Make a decision whether it is OK to require/supply operator specific transition software** in mobile devices -> this has an impact on the available IPv6 transition tool set!
 - **Partner with mobile device and modem vendors who care that IPv6 works.**
- Do not try to solve all pieces and issues at the same time; **phased rollouts** and **start with something that is “doable”** as an engineering exercise on your existing infrastructure with minimized impact:
 - Ship to voluntary subscriber groups, selected set of services (like M2M) and network segments..
 - Figure out provisioning.. e.g., whether IPv6 is available only for new devices/subscriptions..
 - Turn on “advanced” features (like charging ;-)) when they are ready.
- Examples for initial IPv6 deployments:
 - IPv6-only PDN Connections with NAT64.
 - “Dual-stack” over IPv6-only PDN-Connections using XLAT464.
 - “Native” dual-stack with a single or multiple bearers and hefty NAT44 clusters.
 - Etc...

One example deployment approach – all in one

- Provision dual-stack APNs.
- Prepare network to handle all possible combinations.
- Mobile device provisioning & capability selects the connectivity.
- Might not fit all scenarios but..
- In a long run allows “easy” phasing out IPv4.



Are we done? As a conclusion..

Summary

- 3GPP has had a support for the end user IPv6 services from the beginning; unfortunately that has not materialized in the running networks. **However, there are no blocking technical reasons why this could not change.**
- Enabling IPv6 as an end user service has surprisingly wide impact on the 3GPP system architecture; there is a lot testing ahead especially in a multivendor networks. **But this does not prevent deployments – every “new” feature has issues and hiccups.**
- 3GPP IPv6 transition story has its issues; it does not necessarily meet the deployment reality and requirements. **However, there are plenty of IPv6 transition tools outside 3GPP regime to utilize; do not get stuck with “no 3GPP blessing”.**
- IPv6 and dual-stack related fallback scenarios are complex & nontrivial. They are one source for uncertainty. **Make hard (provisioning) decisions to reduce combinations! There is no point trying to please all the legacy.**
- Operational aspects take time; specifically how to rollout IPv6 services in parallel with the legacy network offering. **Get hands-on operational experience.**



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