

3GPP Core Network migration path for HSPA+ and LTE

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Topics of this presentation

3GPP Core Network

- EPS Architecture
- EPC Core Network
- Security
- Multi-mode network selection

Optimised for IP traffic

- Terminal initiated QoS
- Network initiated QoS
- Dual-Stack IPv4/6 connectivity
- Local IP Access (LIPA)
- Selective IP Traffic Offloading (SIPTO)
- WLAN offloading
- Multiple PDN Connections to Same APN (MUPSAP)





LTE voice solution

- CS and PS voice service capabilities
- CS and PS voice service architecture
- Emergency calls in LTE
- Emergency call routing
- CS Fallback (CSFB)
- Single Radio Voice Call Continuity (SR-VCC)

LTE Deployment

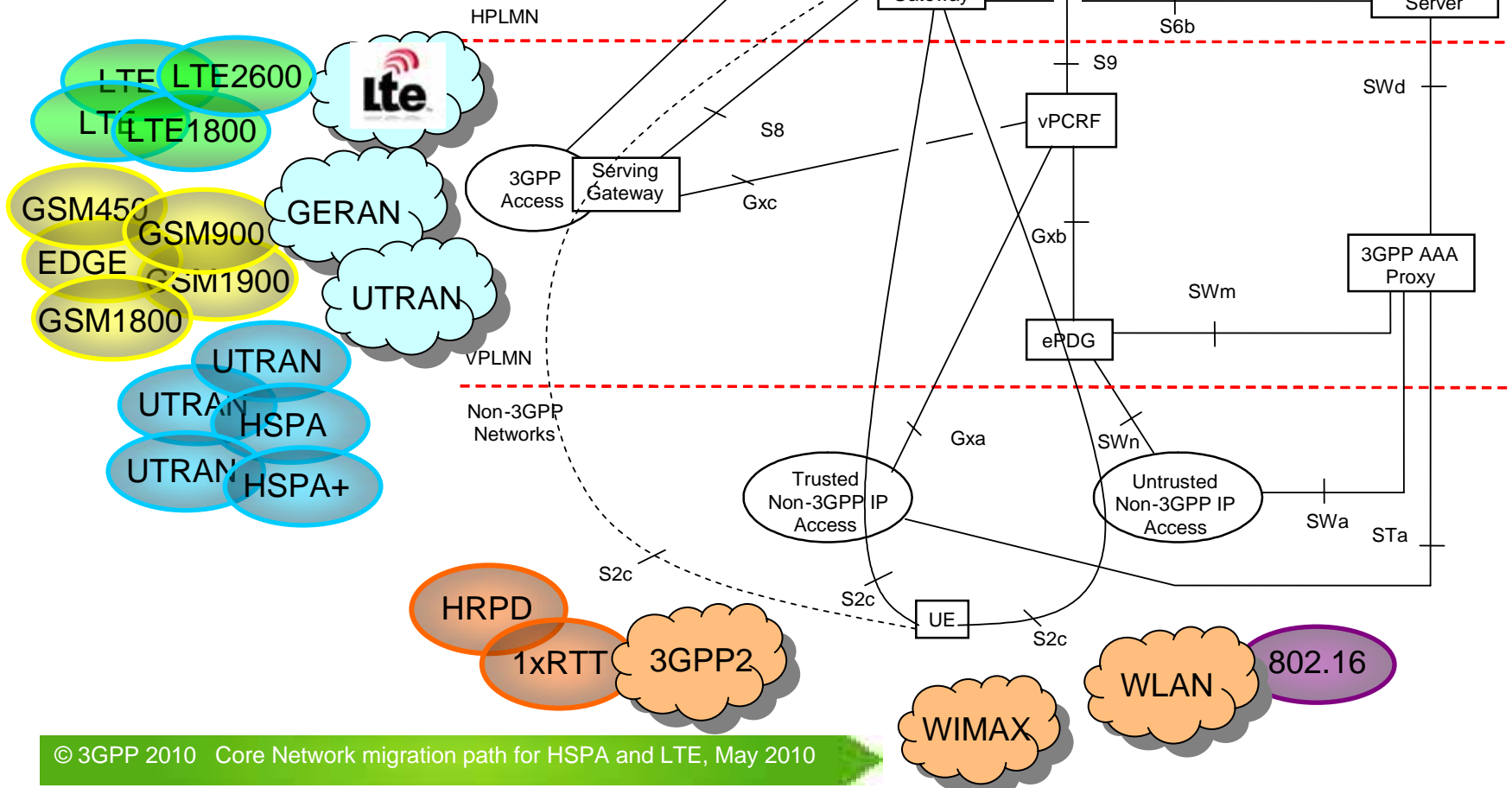
- Different deployment scenarios
- LTE deployment scenarios

3GPP Core Network

-  EPS Architecture
-  EPS Core Network
-  Security
-  Multi-mode network selection

EPS architecture

- Multiple roaming models
- Mobility between access technologies
- Many 3GPP access technologies
- Non-3GPP access



EPC Core Network

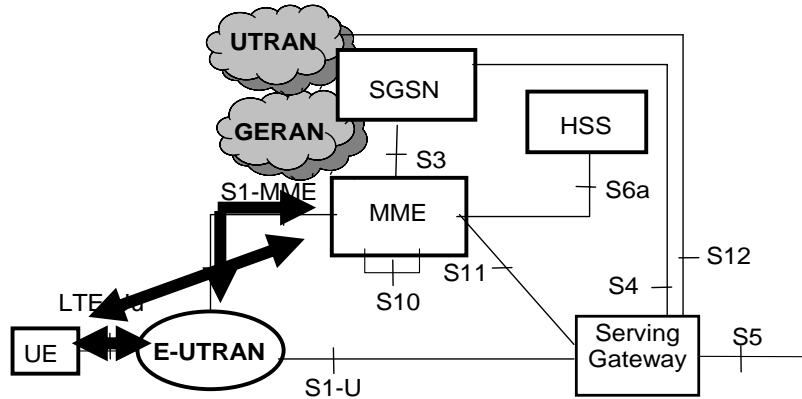
- Flat EPC architecture with only two network nodes for EPC control plane
 - PS-only architecture
- Interoperability
 - GTP and PMIP roaming interface (S5/S8)
 - Multiple security mechanisms
 - Optimised interworking with legacy cellular systems, incl. CDMA
 - Interworking with non-3GPP access technologies
- Access networks supported by 3GPP Core Network (EPC)
 - 3GPP and non-3GPP
 - Trusted and untrusted
 - Mobile and fixed
 - Different security, QoS, mobility
 - GERAN frequency bands: 13 bands
 - LTE frequency bands: 19 FDD and 8 TDD bands
 - UTRAN frequency bands: 17 bands
 - IMT-A in Rel-10 is expected to be connected to the same Rel-9 EPC

Security

- EPS Security motivators
 - New architecture with AS security terminating in eNodeB
 - Interworking with legacy and non-3GPP access/system
 - Allowing eNodeB in untrusted location
 - New business environments with different trust levels
- EPS security compared with 2G/3G
 - No SIM access to EPS, USIM is always required
 - Logical IMC entity as alternative to ISIM for non-3GPP access
 - Improved security of eNodeB
 - Secure environment inside eNodeB protects cryptographic functions and data against unauthorised access attempts
 - Mutual authentication and authorisation between eNodeB and O & M systems protects the confidentiality and integrity of SW and configuration updates of eNodeB
 - Two sets of algorithms from day one (Rel-10 work in progress for third set)
 - If one set is compromised the other one is immediately available
 - Extended authentication and key agreement
 - More robust key hierarchy
 - More comprehensive interworking security
 - Re-selection and handover between 3G and LTE using native and mapped keys
 - IMS media security for IMS calls over multiple access with different security levels
 - User media is protected by Secure RTP (SRTP is IETF RFC 3711)
 - Either End-to-end or end-to-edge-of-the-network (P-CSCF)
 - MIPv4, PMIP and DSMIP with IPsec with IKEv2 to interoperate with non-3GPP networks

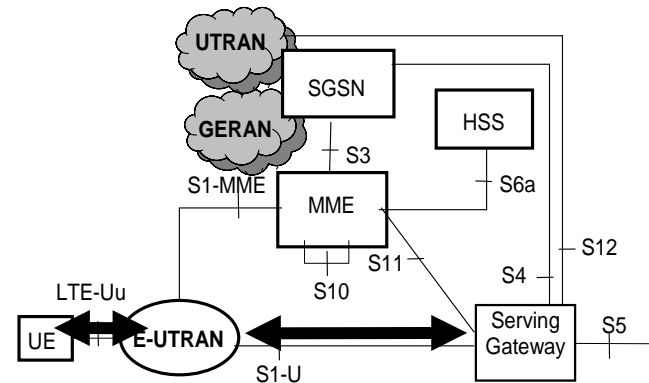
Confidentiality and integrity

Signaling



- 📶 RRC signaling between UE and E-UTRAN
- 📶 NAS signaling between UE and MME
- 📶 S1 interface signaling
 - protection is not UE-specific
 - optional to use

User data



- 📶 S1-U protection is not UE-specific
 - Enhanced network domain security mechanisms (based on IPsec)
 - Optional to use
- 📶 No integrity protection for various reasons, e.g.:
 - performance
 - Limited protection for application layer

Multi-mode network selection



Network selection comprises two parts

- Network operator (PLMN) selection
 - The goal, based on commercial agreements
 - Home operator determines the preferred visited operators
- Access technology selection
 - The means, based on technical criteria
 - Serving visited operator determines access technology, frequency band and cell

3GPP PLMN selection is extendable

- PLMN selection is based on ITU-T defined Mobile Country Code (MCC) and Mobile Network Code (MNC) and it can be extended to any system supporting MCC+MNC
- 3GPP2 access technologies are already supported

Access network selection

- ANDSF = Access Network Discovery and Selection Function
- ANDSF can (optionally) download network selection policy
 - Access technology preference, policy for changing access technology, etc





Common network selection rules are a strength of 3GPP system

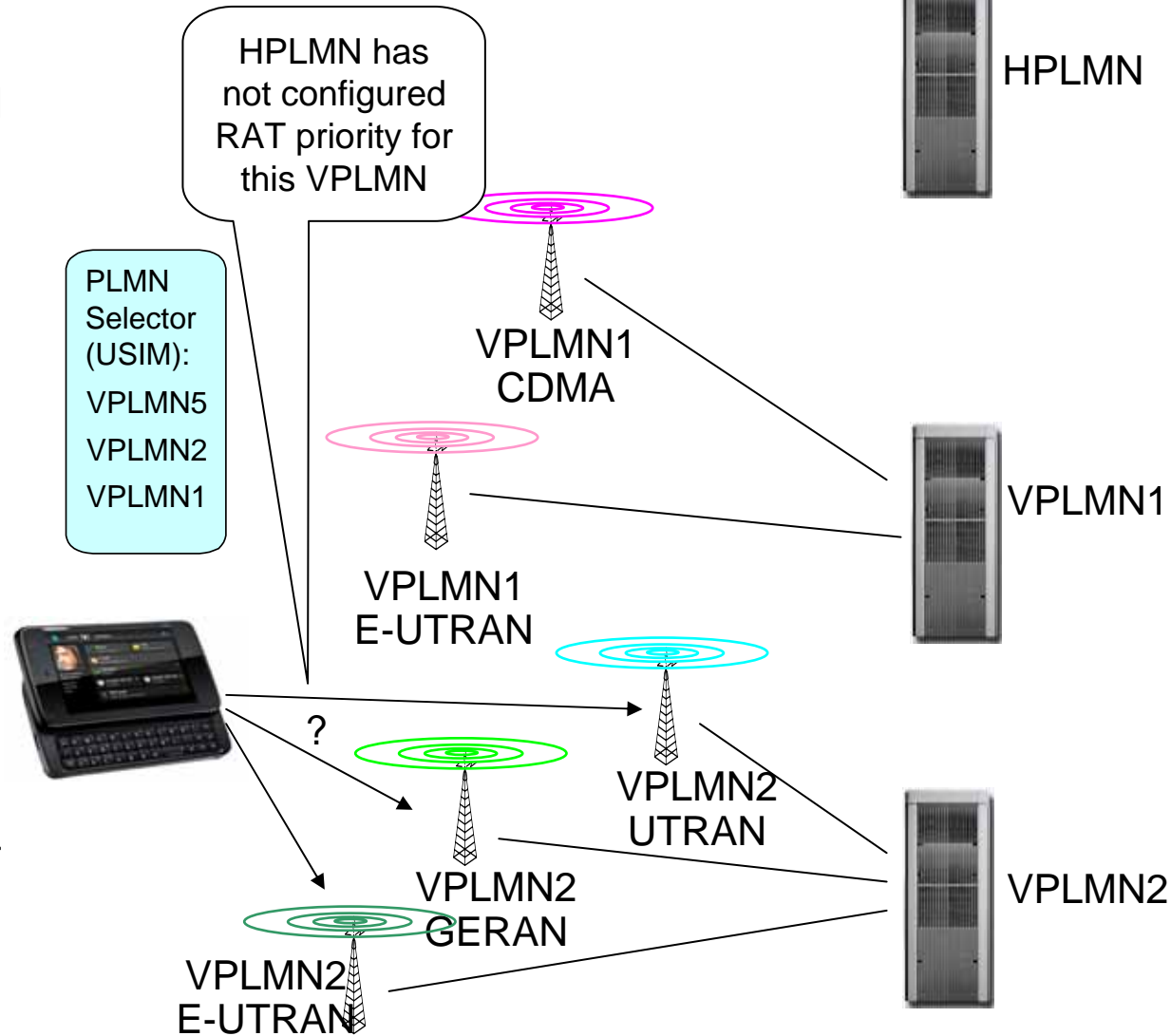
- Economies of scale via common UE logic to adapt to different network configurations
- Automatic roaming to the best available operator (based on subscription to HPLMN)
- Automatic roaming to best available RAT (based on serving operators configuration)

Multi-mode terminals and networks,

Outbound roaming example

A GLOBAL INITIATIVE

-  HPLMN is not available
-  Prioritized VPLMNs are listed with no associated RAT in PLMN selector with access technology:
 - VPLMN5 is not available
 - VPLMN1 is available
 - VPLMN2 is available
-  VPLMN2 is selected via 2G, 3G or E-UTRAN
 - USIM configured RAT preference possible
-  After PLMN selection normal idle mode is resumed
 - Cell & RAT may change within the selected PLMN
 - Inter-RAT priority
 - Background scan for higher priority network



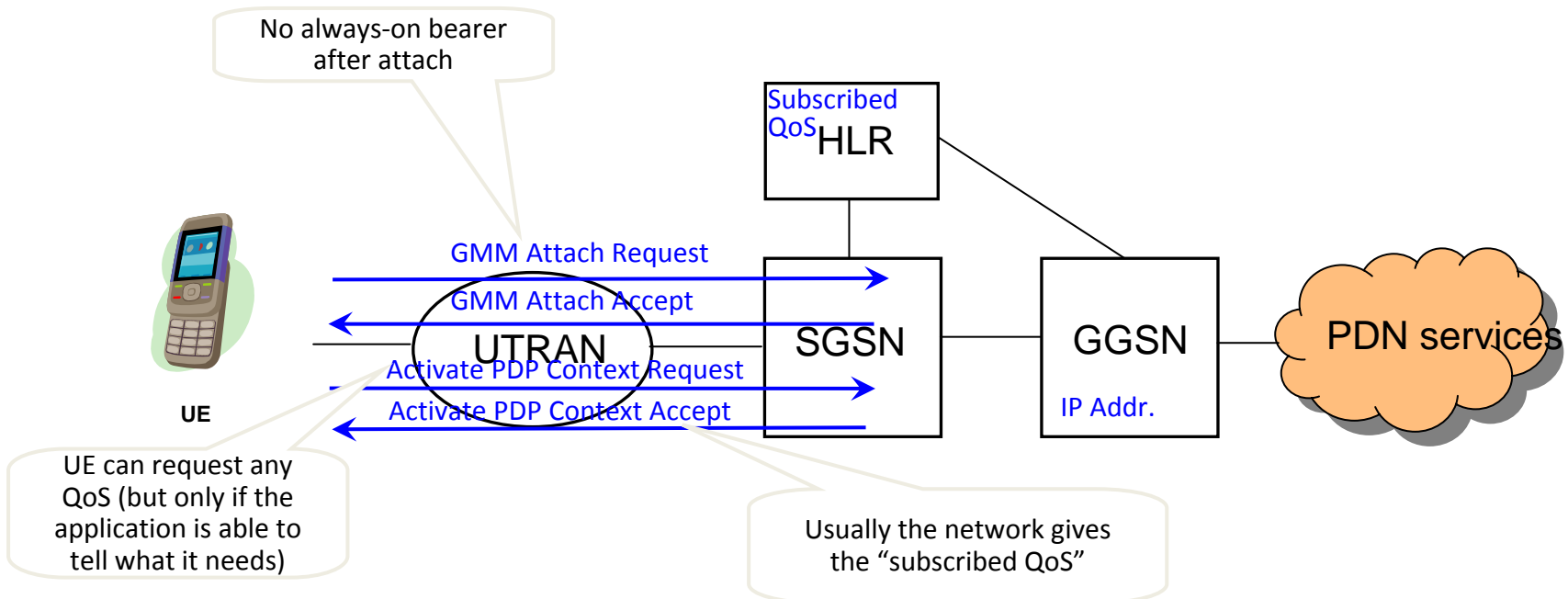
RAT = Radio Access Technology,
PLMN = Public Land Mobile Network

Optimised for IP traffic

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- Network initiated QoS
- Dual-stack IPv4/6 connectivity
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- WLAN offloading
- Multiple PDN Connections to Same APN (MUPSAP)

Terminal initiated Quality of Service (QoS)

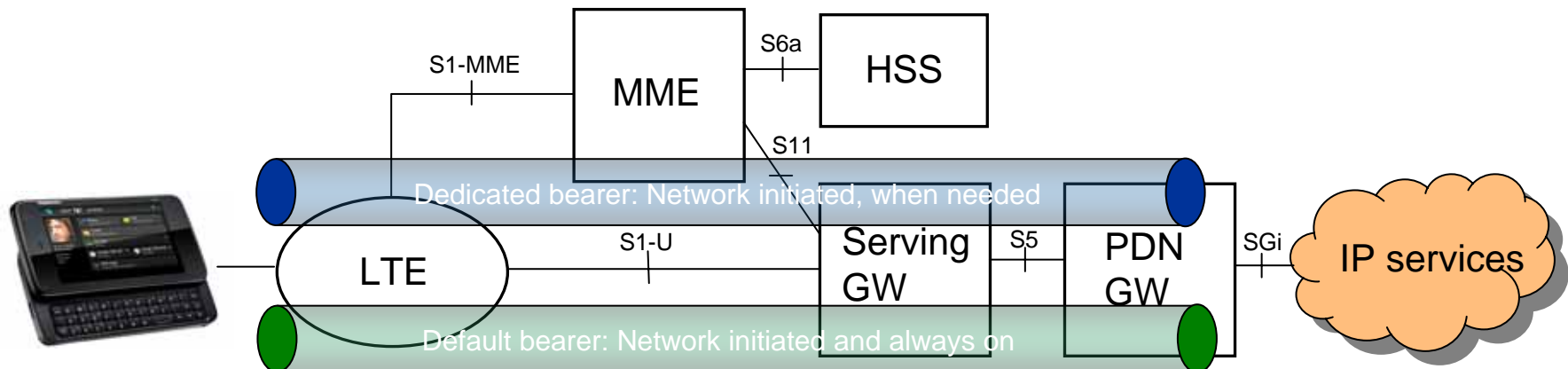
- Rel-6 GPRS negotiation contains all the necessary parameters to determine QoS, but...
 - Only very few UE applications can indicate their QoS needs to the UE protocol layers
 - Any QoS request from the UE must be considered against real-life restrictions
 - Subscribed maximum QoS
 - Available capacity in the network and radio interface
 - Parallel PDP context with the same UE + IP version to the same APN is considered an error
 - UE initiated QoS is not widely used and in practice “subscribed QoS” PDP context is used



Network initiated Quality of Service (QoS)

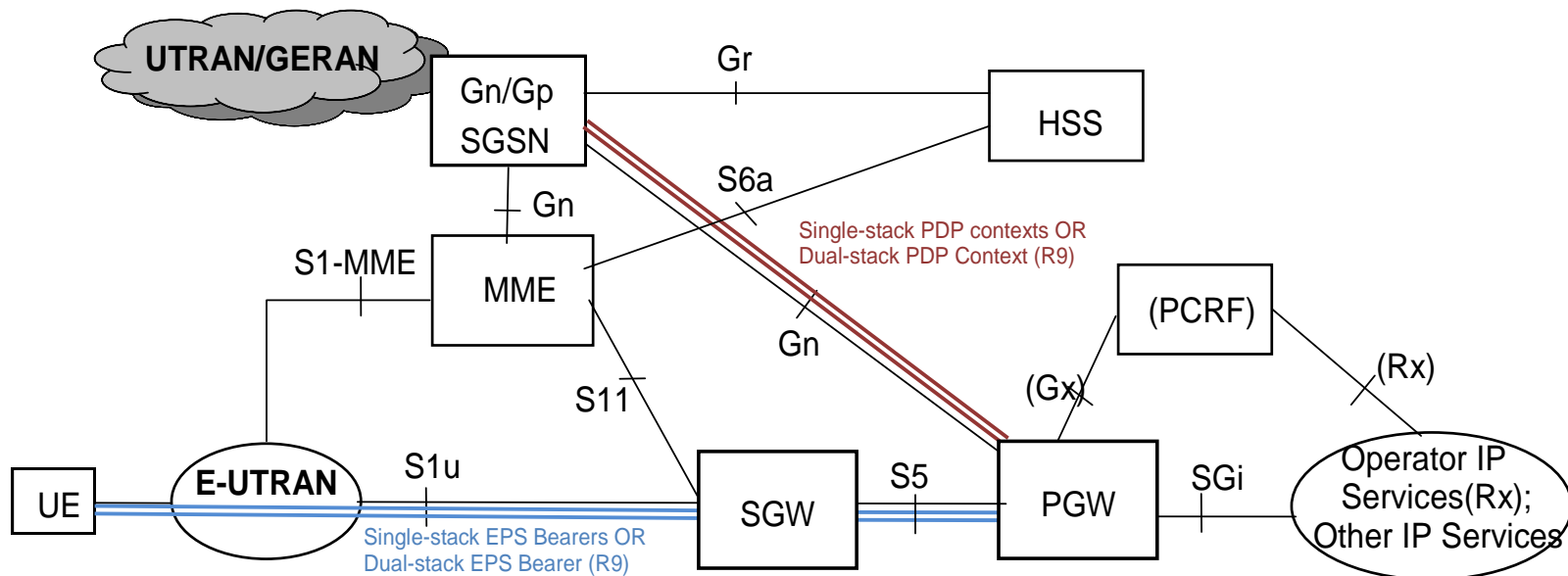
Improvements in EPS QoS negotiation

- **Default bearer** is assigned during attach and provides always-on IP connectivity
 - Internet-like default connectivity for QoS-agnostic needs (browser, email, etc.)
- **Dedicated bearer** is assigned only when needed to provide guaranteed bit rate QoS control
 - Assigned only for those QoS sensitive applications that can be recognised
- Rel-8 allows also 2G/3G GPRS to use the EPS principle of network initiated QoS negotiation
- QoS differentiation improves cost-efficiency via assigning QoS only when needed
 - Different service packaging and priorities are possible
 - Mapping of different applications to different bearer pinpoints QoS to the applications that needs it
- Operator control on QoS is improved via enabling different deployment models
 - User differentiation (different users have different subscribed QoS)
 - Service differentiation (different identified services have different QoS)
 - Mixture of user based default QoS enhanced by service based QoS for identified higher QoS needs



Dual-stack IPv4/6 connectivity, GPRS and EPS

- Pre-release 8 GPRS specifications support DS connectivity by allowing the activation of two parallel single-stack PDP contexts (one v4 and one v6) towards a single APN
- The support for dual-stack v4v6 PDP contexts is added to the GPRS MS from release 8 and to the SGSN and GGSN in release 9
- For interoperability reasons, single-stack PDP contexts need to be used in order to support inter-RAT handovers until all SGSNs have been upgraded to support dual-stack PDP contexts

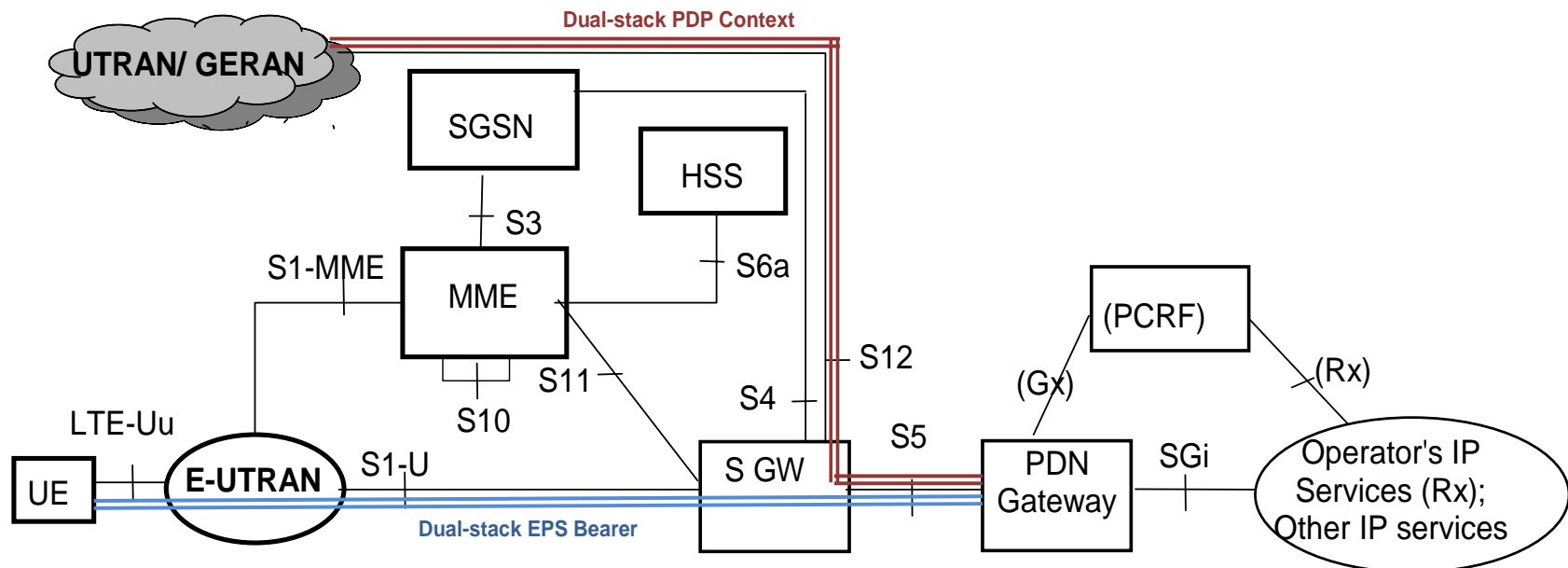


Dual-stack IPv4/v6 connectivity in EPS

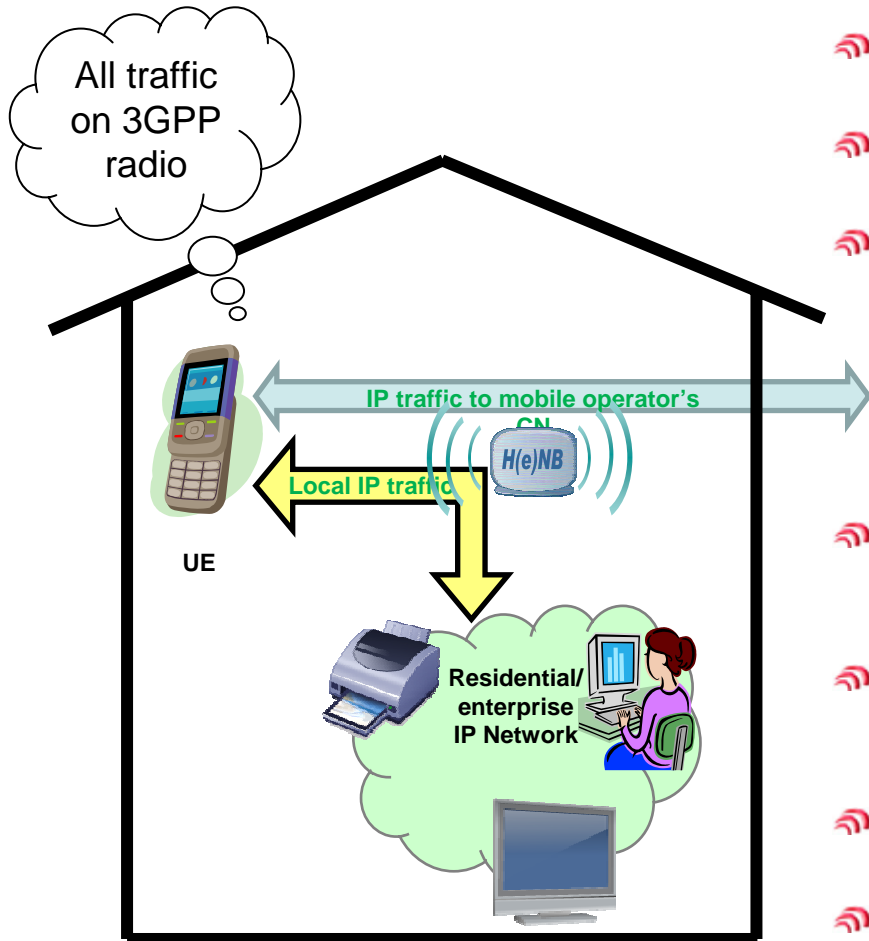
In 3GPP release 10, the requirements for supporting migration to IPv6 were studied in 3GPP TR 23.975

- The current EPS and GPRS specifications already support DS connectivity and provide the necessary tools for IPv4 and IPv6 co-existence and subsequent transition to IPv6
- DS connectivity may additionally require the use of private IPv4 addressing within the network

In the EPS network (including the S4-SGSN) the basis for IPv4 and IPv6 coexistence is the provisioning of DS connectivity within one v4v6 EPS bearer or one v4v6 PDP context.





Local IP Access (LIPA) in 3GPP



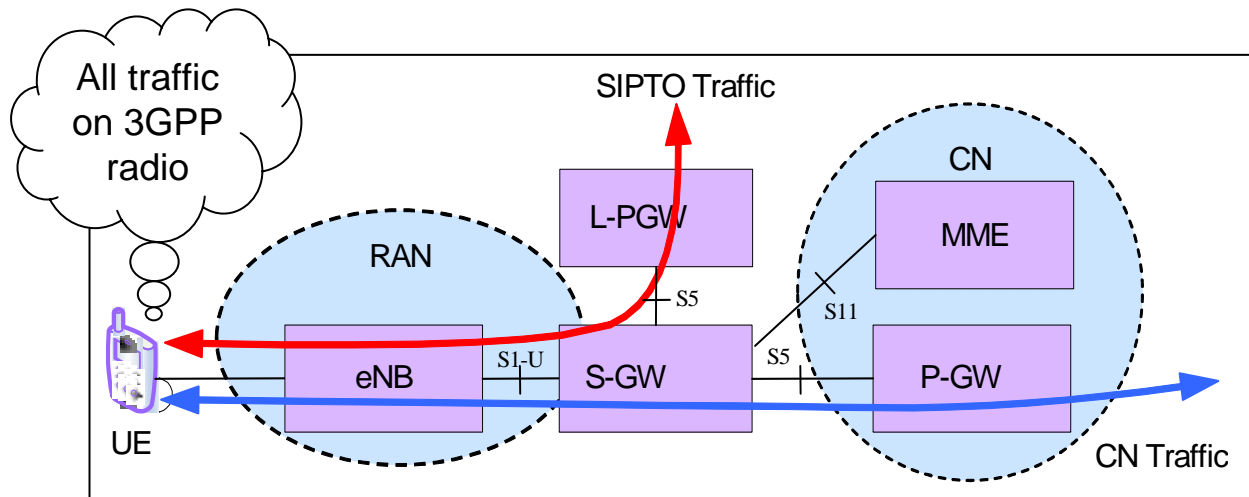
- 📶 LIPA is primarily for end user's benefit, to allow access to local residential or corporate network through a 3GPP device
- 📶 Consequently, LIPA service does not need to be transparent, but the end user may have to "select" LIPA access
- 📶 Home (e)NodeB may advertise the available LIPA access (tbd.)

- 📶 LIPA provides access for IP capable UEs that are connected via a H(e)NB subsystem (i.e. using H(e)NB radio access) to other IP capable entities in the same residential/enterprise IP network.
- 📶 Simultaneous access from a UE to the mobile operator's core network and Local IP Access to a residential/enterprise IP network will be supported.
- 📶 A UE must have a valid subscription with the mobile operator in order to use Local IP Access.
- 📶 A UE must be able to use Local IP Access in a visited network subject to roaming agreement between mobile operators.
- 📶 Pre-Rel 10 UEs should be able to use Local IP Access.

 logical connection for mobile operator IP traffic
 scope of Local IP access





Selective IP Traffic Offloading (SIPTO)

- 📶 Optimising “cost per bit” is becoming essential in the “flat rate” era
- 📶 SIPTO is a specific routing scenario within the operator’s network, allowing *selective* offloading of the traffic away from the Evolved Packet Core network
 - Selective offloading e.g. based on the QoS needs of the service
- 📶 SIPTO benefits the cellular operator and it is transparent for the end user
- 📶 SIPTO is intended for allowing cost optimized handling of the internet traffic that is not intended for the operator’s core network (i.e., operator services)

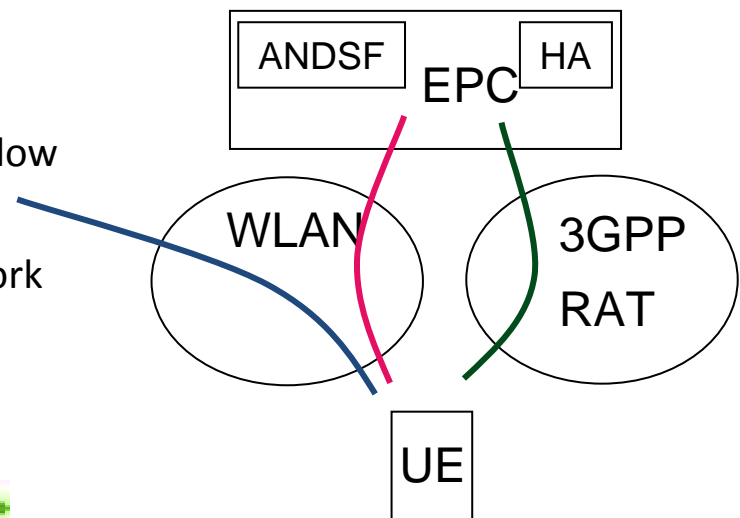


Baseline approach for “SIPTO above RAN” scenario. Local GW is selected for the traffic to be offloaded

WLAN Offloading



-  WLAN offloading refers to the dual radio scenario where part of the traffic (PDN connections, IP flows) is routed via WLAN access and part via 3GPP access
 - Assumes a UE capable of operating WLAN and 3GPP radios simultaneously
-  The 3GPP Evolved Packet Core network (EPC) as the common core network serves both 3GPP radio access technologies and non-3GPP radio access technologies
-  WLAN offloading covers both the scenario where the traffic via WLAN radio is anchored in the EPC (i.e., seamless offloading) and the scenario where it is not anchored (i.e., non-seamless offloading)
-  Access Network Discovery and Selection Function (ANDSF) is there to provide the UE with the access network discovery information and the policy on how to use the available access networks
 - Available access networks
 - Preferred routing of the traffic per APN, per IP flow

There is no mobility support in 3GPP network for flows offloaded in non-seamless way









MUPSAP - Multiple PDN Connections to the Same APN for PMIP-based Interfaces

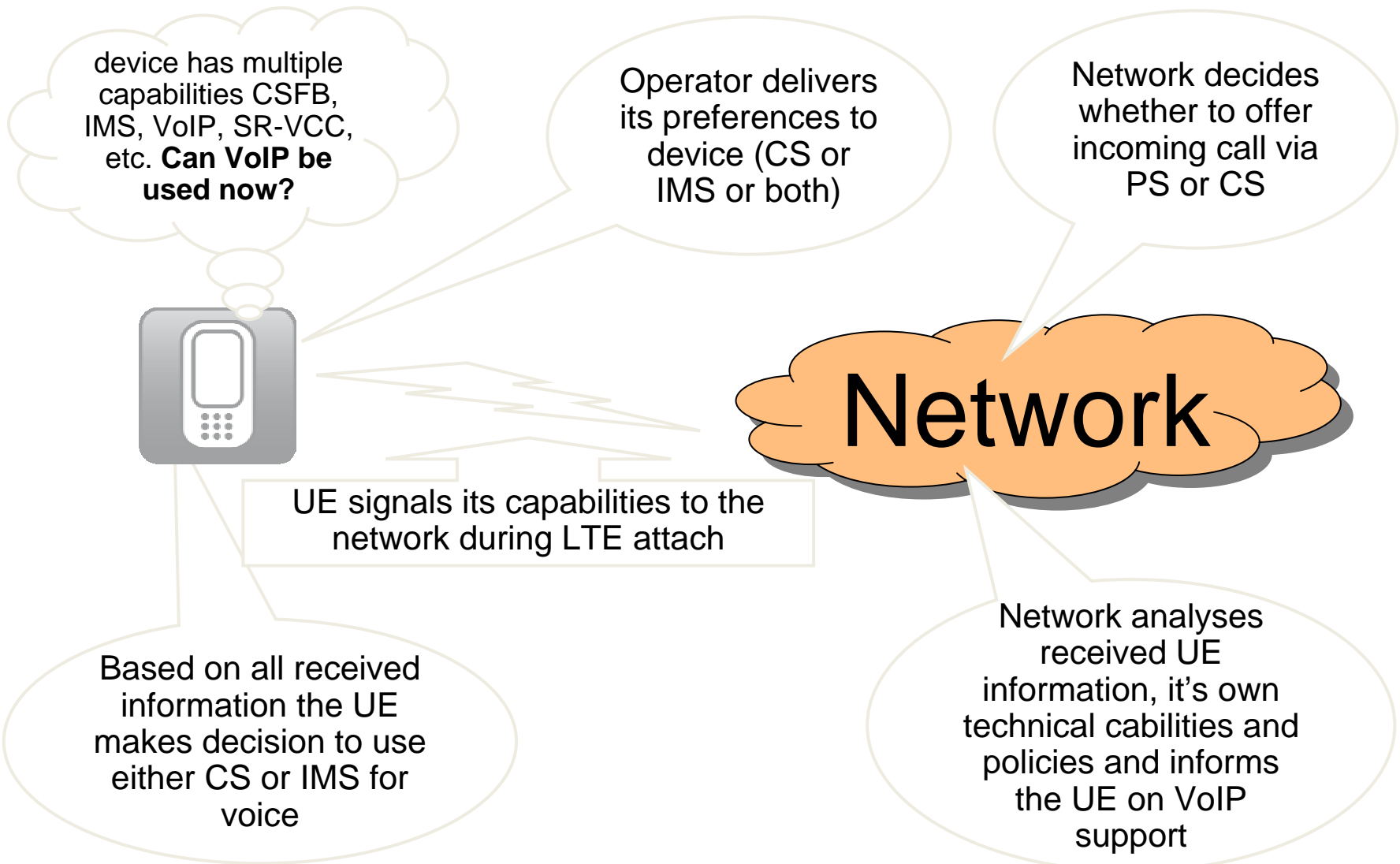


-  GTP – based core network interfaces (Gn/Gp and GTP S5/S8) inherently support the activation (and inter-access handover) of multiple PDN connections to the same APN.
 - Multiple PDN connections to the same APN can be established due to dual-stack connectivity (v4 + v6) or within a dial-up use case where an integrated terminal acts as a modem for a TE whilst maintaining a PDN connection of its own in parallel
-  The support for PMIP based interfaces was added in release 9 to add the same capabilities to all core network protocols.
 - For PMIP S5/S8, the PDN GW can differentiate the PDN connections to the same APN based on the EPS bearer identity signalled by the Serving GW
 - For PMIP based S2a and S2b, the PGW can differentiate parallel connections to the same APN based on specific identifier assigned and signalled by MAG

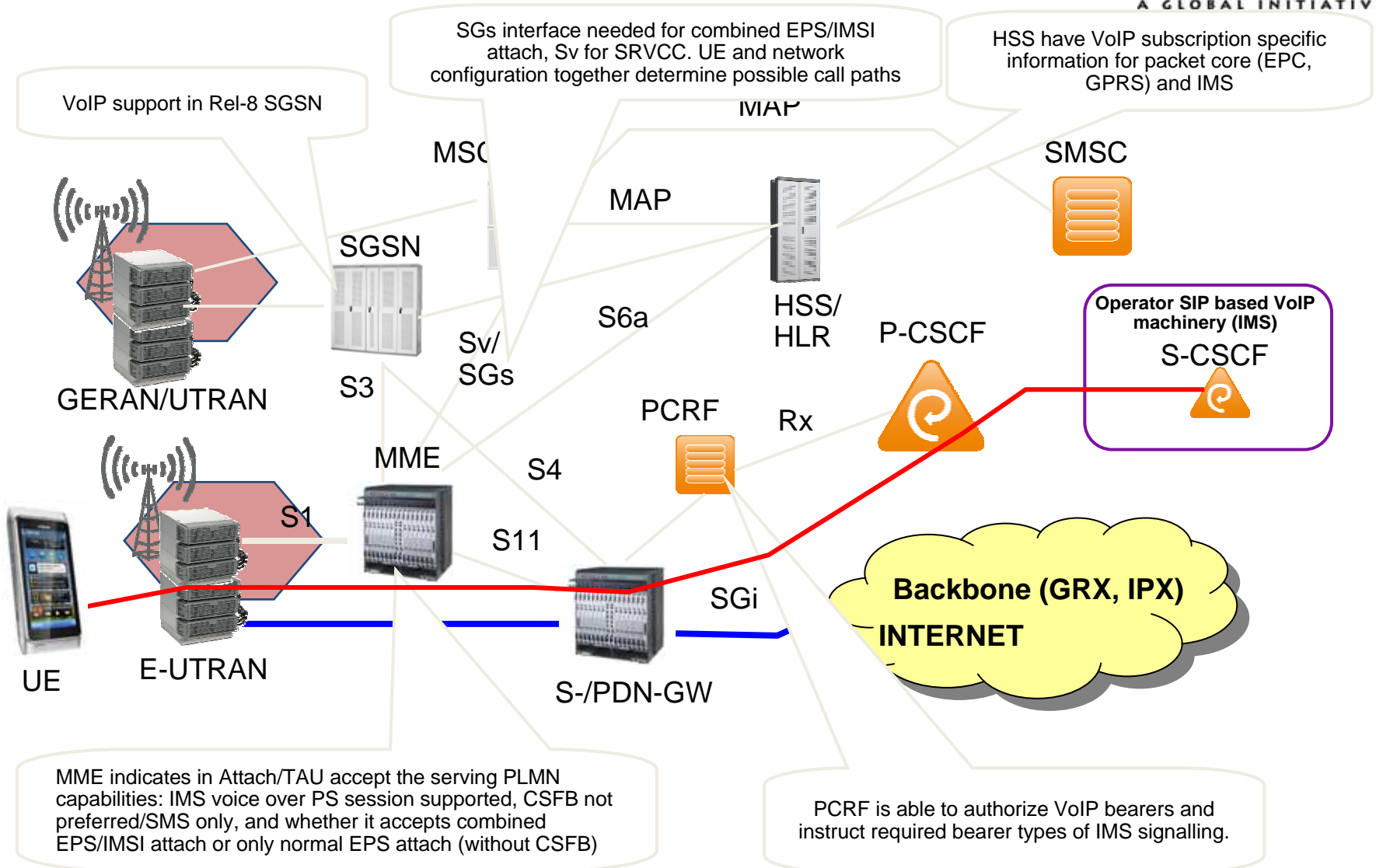
LTE voice solution

-  CS and PS voice service capabilities
-  CS and PS voice service architecture
-  Emergency calls in LTE
-  Emergency call routing
-  CS FallBack (CSFB)
-  Single Radio Voice Call Continuity (SR-VCC)

CS and PS voice service capabilities



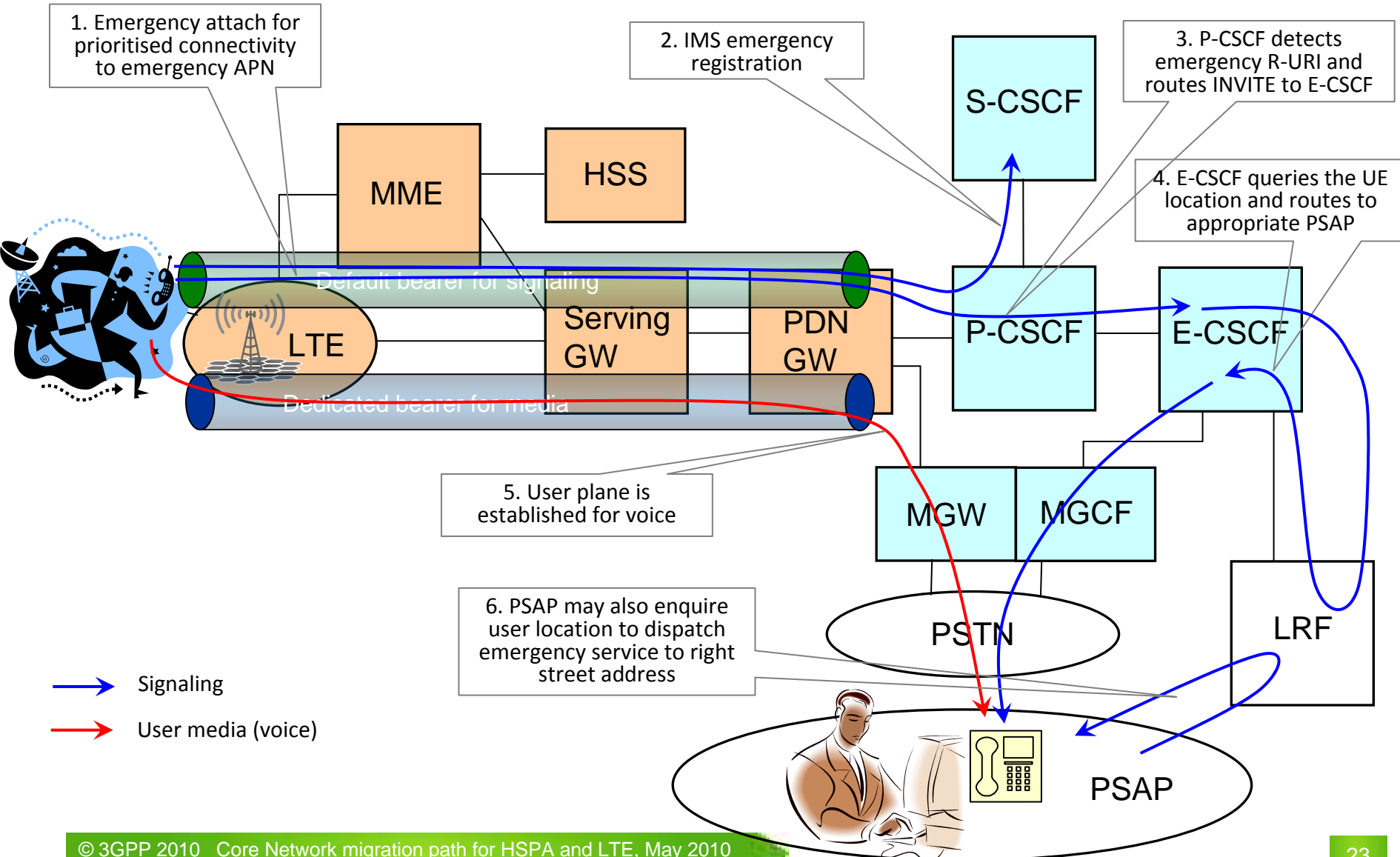
CS and PS voice service architecture



Emergency calls in LTE

- Regulatory requirement of emergency calls is supported in Rel-9 for LTE
 - Detection of emergency numbers in UE
 - Indication and prioritisation of emergency calls
 - Location services, both for routing and user location data for PSAP
 - Callback is possible, but processed as normal call without exceptions
- UE matches digits dialled by the user with list of known emergency numbers
 - Emergency number list in the UE is common for CS and PS domain use
 - Default 112 and 911, USIM pre-configuration, downloaded in MM procedure
 - In case of match, the UE shall initiate the call as an emergency call
- In IMS emergency calls the UE translates dialled number into emergency service URN
 - Service URN with a top-level service type of "sos" as specified in RFC 5031
 - Additionally, sub-service type can be added to indicate emergency category if information on the type of emergency service is known (fire, ambulance, police,...)
- P-CSCF must also be prepared to detect emergency call if the UE is not aware of local emergency call
 - This is backup for those cases when the (roaming) UE does not have full information of all local emergency call numbers and initiates a normal call
 - From EPC perspective, it will be a normal PDN connection
- Benefit of location information
 - P-CSCF discovers the regionally correct PSAP to take the emergency call
 - PSAP gets information on the precise user location

Emergency call routing

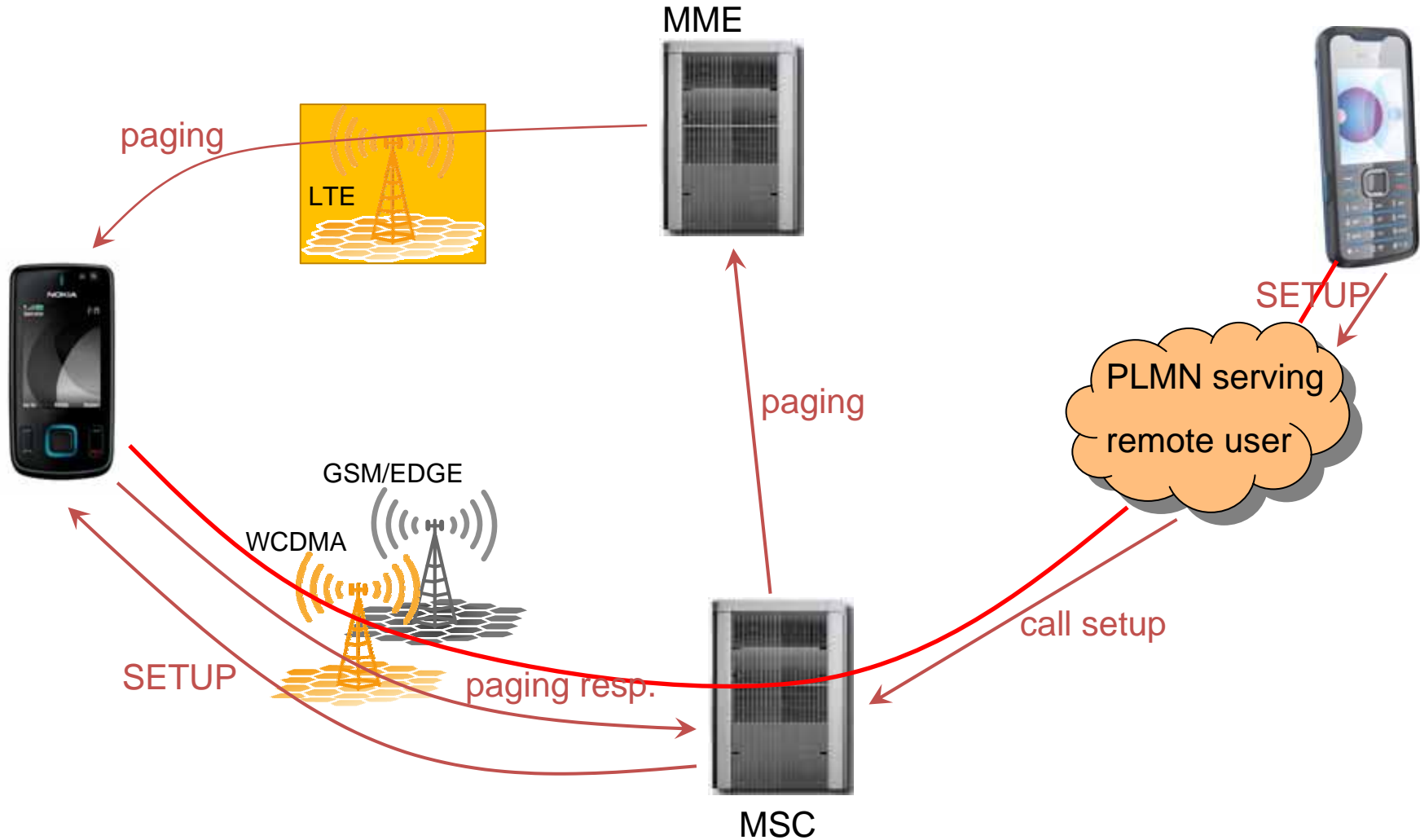


CS Fallback (CSFB)

- 📶 CS FallBack from EPS to CS domain
- 📶 CSFB reuses voice and other CS-domain services provided by legacy CS infrastructure
- 📶 EPS redirects the UE to CS Domain for CS services
 - SMS can be delivered to the UE without redirecting to CS Domain
 - After CS service the UE returns to LTE, depending on coverage and policy
- 📶 User can decide, based on CLI, whether to accept CSFB request
- 📶 Application of CSFB:
 - CS capable device camping on LTE cell can establish/receive CS services
 - Reuse of existing CS infrastructure for voice service until IMS VoIP is deployed
 - Provide voice roaming support with LTE
 - Support E911 using existing CS infrastructure
 - Rel-9 IMS provides full emergency call support
 - Requires overlapping CS domain coverage
 - CSFB applies between LTE and GSM, WCDMA and 1xRTT

CSFB procedure

Directing the UE from LTE to 2G/3G for CS service



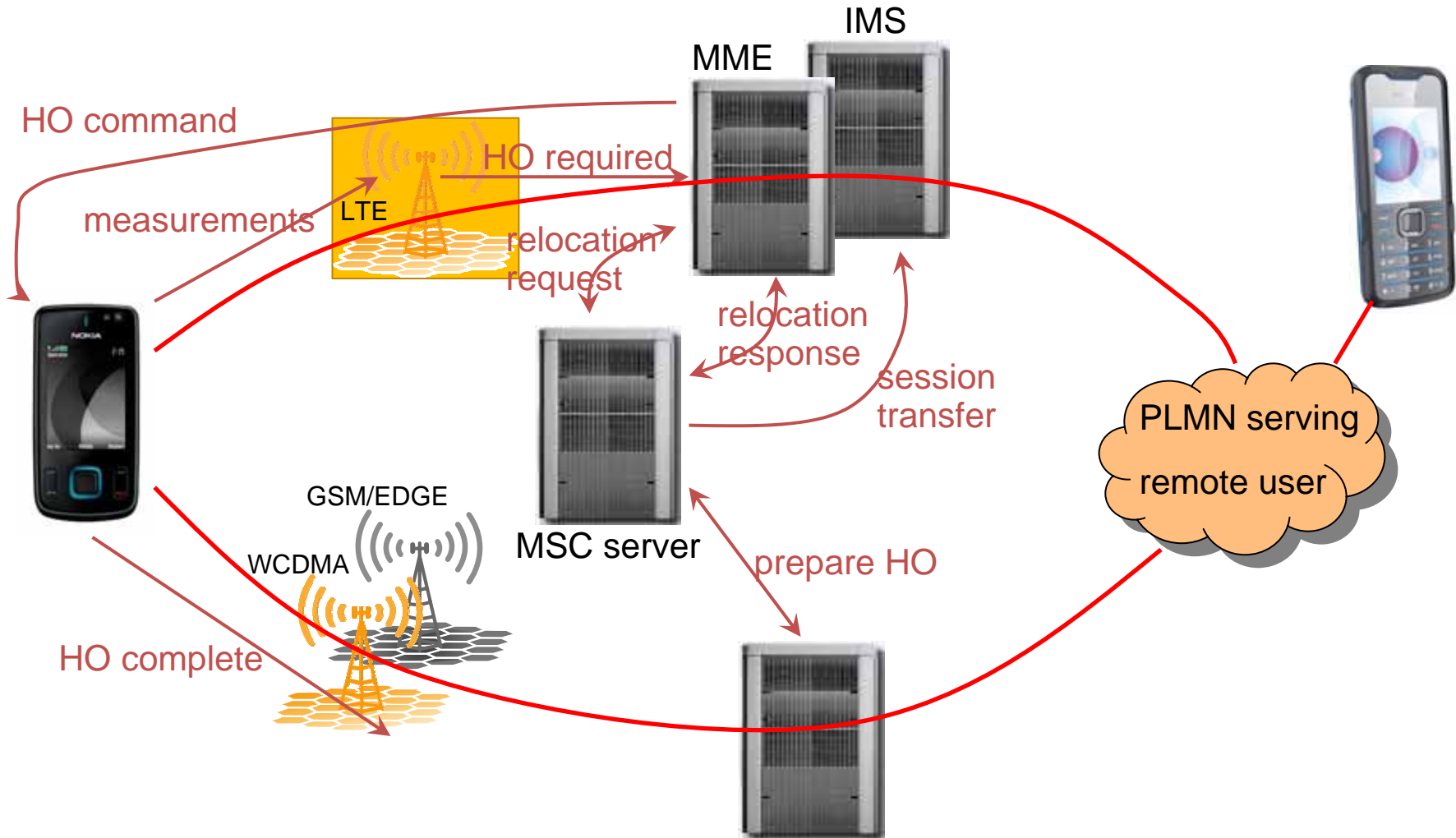
Single Radio Voice Call Continuity (SR-VCC)



- SR-VCC use case
 - IMS call initiated in LTE can continue in CS domain after moving outside of LTE coverage area
 - SR-VCC is invoked if no other VoIP capable PS system (e.g., HSPA/eHRPD) is available for VoIP PS-PS HO
 - Only HO of a single voice bearer from PS to CS is specified
 - Requires overlapping with 1xRTT/GSM/WCDMA coverage
- SR-VCC allows a voice calls are anchored in IMS
 - One-way HO from PS to CS systems (LTE to GSM/UMTS or LTE to 1xRTT)
 - No simultaneous operation of different radio transceivers needed
- Rel-9 SR-VCC improvements
 - IMS support of mid call services (e.g., HOLD, MPTY)
 - SR-VCC support for emergency calls
- Video calls, reverse direction from CS call to IMS and optimisations are being studied in Rel-10

SR-VCC procedure

Transfer from LTE to 2G/3G with active call (not all entities shown)



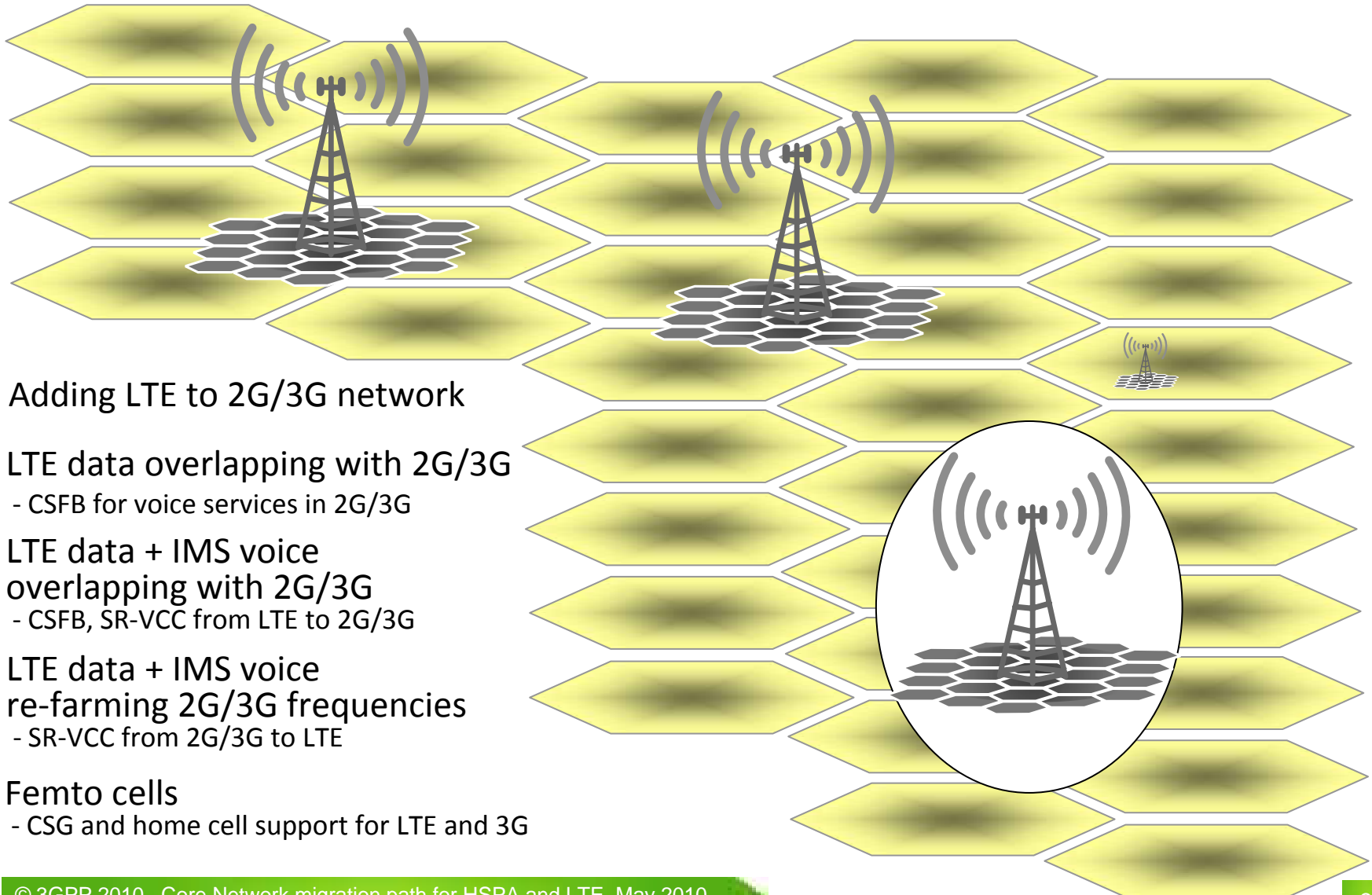
LTE deployment

-  Different deployment scenarios
-  LTE deployment scenarios

Different deployment scenarios

- LTE can co-exist alongside other technologies in multiple configurations
 - Evolutionary approach to upgrade of networks and migration from 2G/3G networks
- LTE overlapping with 2G/3G, data only
 - Saturation of fixed internet subscriptions and growth growth of mobile subscriptions requires faster mobile connections
 - As an example, Finnish internet subscription statistics are showing decline of fixed subscribers and huge growth of mobile internet subscribers since early 2008
- LTE with speech and multimedia support
 - Voice and Multimedia solution for LTE is IMS
 - Rel-9 supports full speech call service in IMS
 - GSMA has published a global solution for VoLTE:
<http://www.gsmworld.com/newsroom/press-releases/2010/4634.htm>
 - Regulatory emergency call and public warning system PWS support
 - Comprehensive set of supplementary services and IMS centralised services (CS-IMS)
- Re-farming of 2G/3G legacy frequencies for LTE use
 - Requires voice call continuity between 2G/3G and LTE in both directions
 - Feasible only as a later step
- Femto-cells is implemented in 3GPP via CSG and Home Cell
 - Home Cell (eNodeB and NodeB) are supported in Rel-8 and Rel-9
 - Configurable Closed Subscriber Group for Home cell

LTE deployment scenarios



Adding LTE to 2G/3G network

LTE data overlapping with 2G/3G

- CSFB for voice services in 2G/3G

LTE data + IMS voice overlapping with 2G/3G

- CSFB, SR-VCC from LTE to 2G/3G

LTE data + IMS voice re-farming 2G/3G frequencies

- SR-VCC from 2G/3G to LTE

Femto cells

- CSG and home cell support for LTE and 3G