LTE in Public Safety

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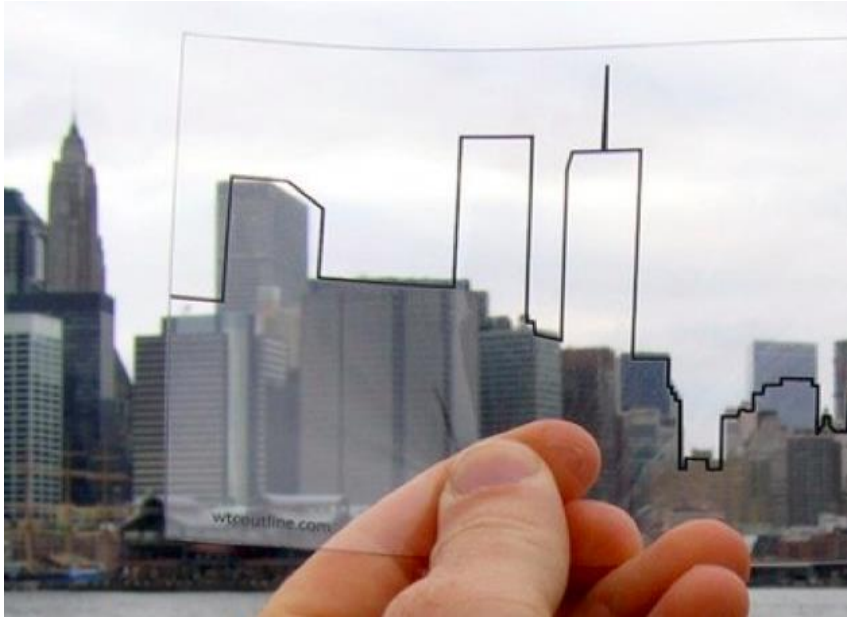
On September 11, 2001 shortly after the South Tower collapsed, an officer in a police helicopter radioed to his colleagues, “I don’t think this has too much longer to go. I would evacuate all people within the area of that second building.”
Police officers inside the building and on the ground proceeded to evacuate.

Most got out.



However, **because their radios were not compatible with those of the police, firefighters inside the tower could not hear the message.**
121 firefighters died inside the North Tower when it collapsed twenty-one minutes after the first warning was issued over police.(*)

(*) Continuing Lessons of 9/11, http://www.nytimes.com/2004/05/20/opinion/continuing-lessons-of-9-11.html

Public safety is a core responsibility of any government. Emergency responders require a secure network to improve response times and enhance situational awareness

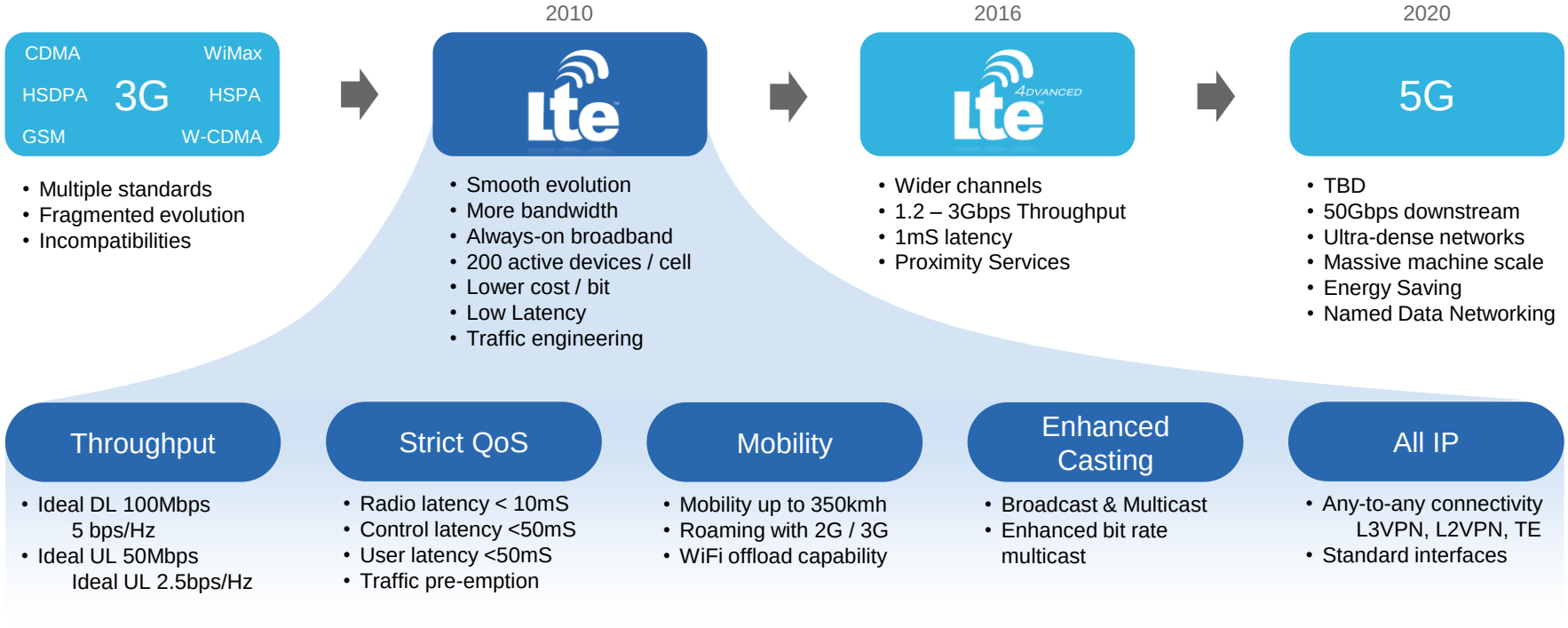
Voice communications has always been the main mission-critical application

But data communications are increasingly being used to support a number of Public Safety data-rich applications

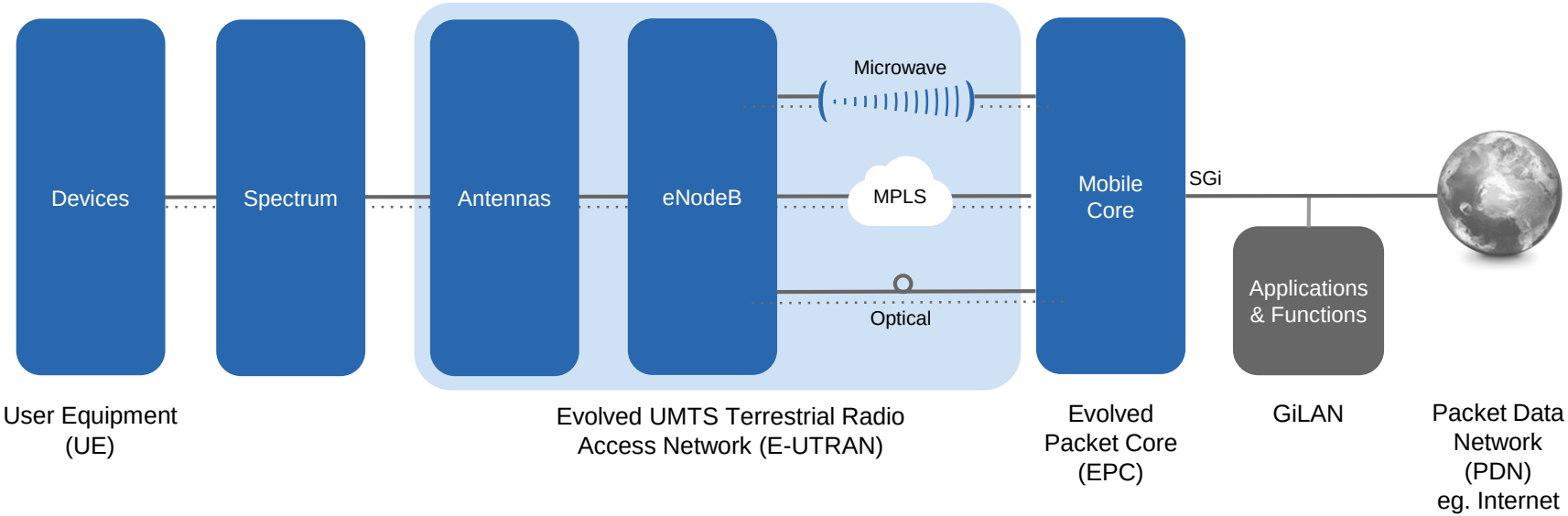
Security challenges have raised public awareness and call for Public Safety organizations capability enhancements

What is LTE and why is good for Public Safety?

The Long Term Evolution



High Level System View



User Equipment (UE)

- User Interface to network services and applications
- Supports LTE uplink and downlink interfaces
- Mobility & Session Management & Call Control into network
- Monitors radios and conveys performance to network

MT
Mobile Termination
Communications Functions

TE
Terminal Equipment
Terminates Data Streams

UICC
Universal Integrated Circuit Card
USIM

Universal Subscriber Information Module

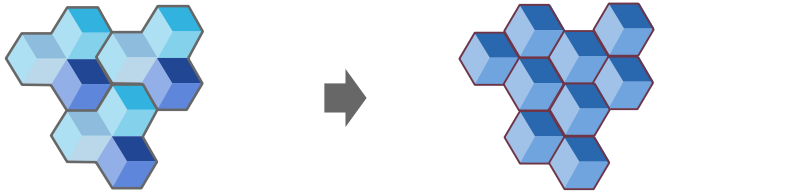
- Basis of UE authentication and access
- Coded by network operator
- Unique user & network identifiers
- Preferred roaming network details
- Cipher keys paired to Network

Wireless Specification	UE Category	Maximum DL rate (Mbps)	Maximum UL rate (Mbps)
LTE	1	10	2
	2	50	25
	3	100	50
	4	150	50
	5	300	75
LTE-A	6	300	50
	7	300	150
	8	1200	600

Spectrum

- LTE operates in licensed bands
- Bands licenses issued by country regulator
- Requirements / restrictions vary by market
  - Availability – metro, urban, rural
  - Applicability – anyone / industry / licensed carriers only
  - Variants – experimental, apparatus, types, classes
  - Acquisition – Fees, Auction, Sub-Lease (3rd Party Authorisation)

Cell-Based Reuse Increases Coverage and Capacity

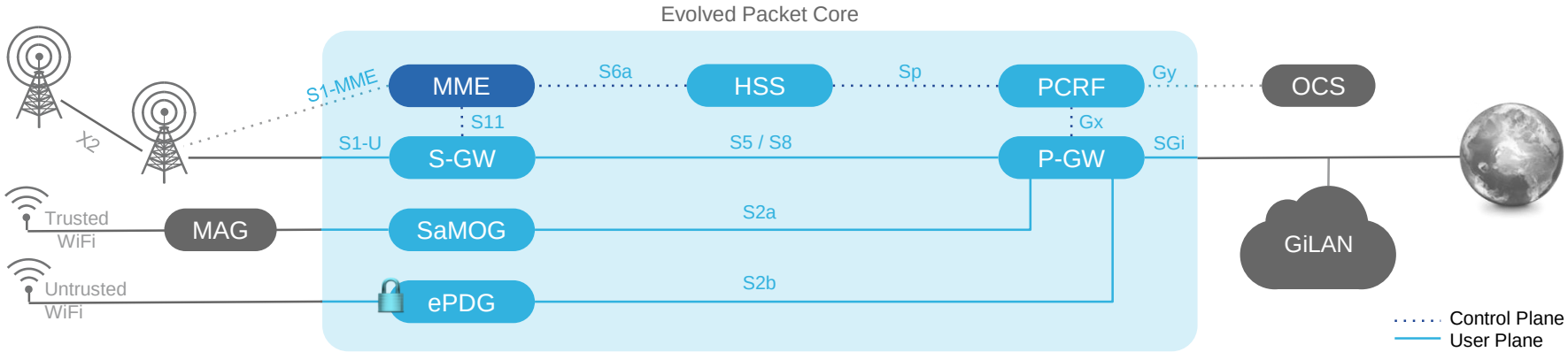


Traditional Cellular
3x3 Pattern
Reuse = 1/3

LTE with Beamforming and
Inter-Cell Interference Coordination (ICIC)
Reuse = 1

FDD Band	Frequencies (MHz)	TDD Band	Frequencies (MHz)
1	1920-1980 / 2110-2170	33	1900-1920
2	1850-1910 / 1930-1990	34	2010-2025
3	1710-1785 / 1805-1880	35	1850-1910
4	1710-1755 / 2110-2155	36	1930-1990
5	824-849 / 869-894	37	1910-1930
7	2500-2570 / 2620-2690	38	2570-2620
8	880-915 / 925-960	39	1880-1920
9	1750-1785 / 1845-1880	40	2300-2400
10	1710-1770 / 2110-2170	41	2496-2690
11	1428-1448/1476-1496	42	3400-3600
12	698-716 / 728-746	43	3600-3800
13	777-787 / 746-756		
14	788-798 / 758-768		
17	704-716 / 734-746		
18	815-830 / 860-875		
19	830-845 / 875-890		
20	832-862 / 791-821		
21	1448-1463 / 1496-1511		
23	2000-2020 / 2180-2200		
24	1626.5-1660.5 / 1525-1559		
25	1850-1915 / 1930-1995		
26	814-849 / 859-894		
27	807-824 / 852-869		
28	703-748 / 758 - 803		
29	717-728		
30	2305-2315 / 2350-2360		
31	452.5-457.5 / 462.5-467.5		
32	1452-1496		

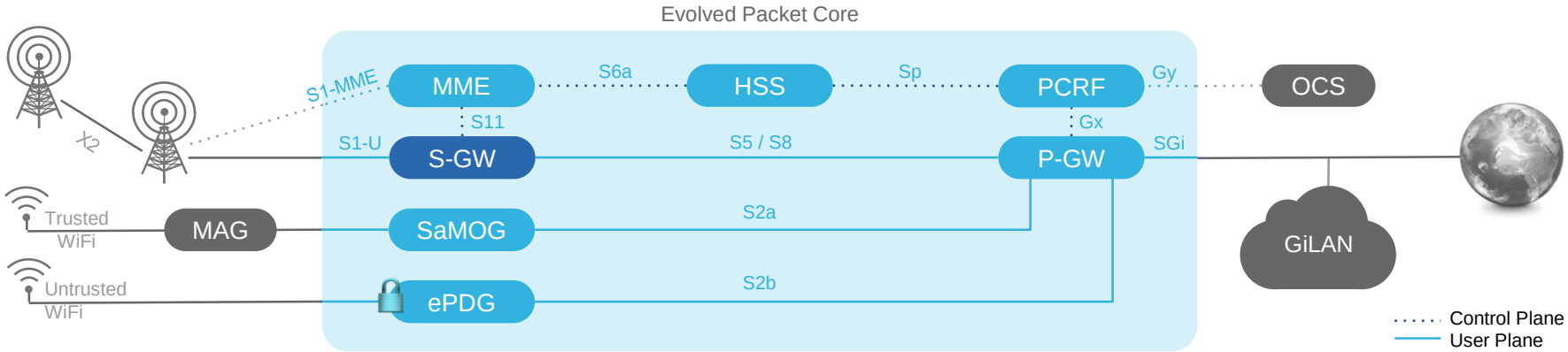
Evolved Packet Core (EPC)



MME – Mobility Management Entity

- Control plane for UE's connecting to the network
- Session and subscriber management
- Manages signaling for access to and security of E-UTRAN
- Idle mode UE reachability
- Area list management
- Roaming and Area handoff management

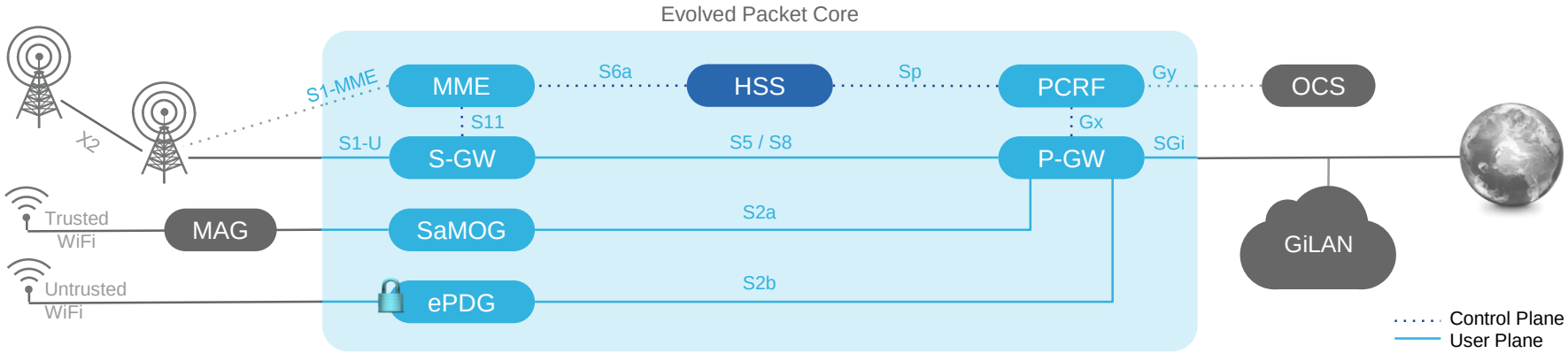
Evolved Packet Core (EPC)



S-GW – Serving Gateway

- Anchor point for mobile device traffic into the network
- Anchors sessions as they handover inter-nodeB
- Lawful interception
- Packet routing / forwarding
- QoS packet marking (Uplink & downlink)

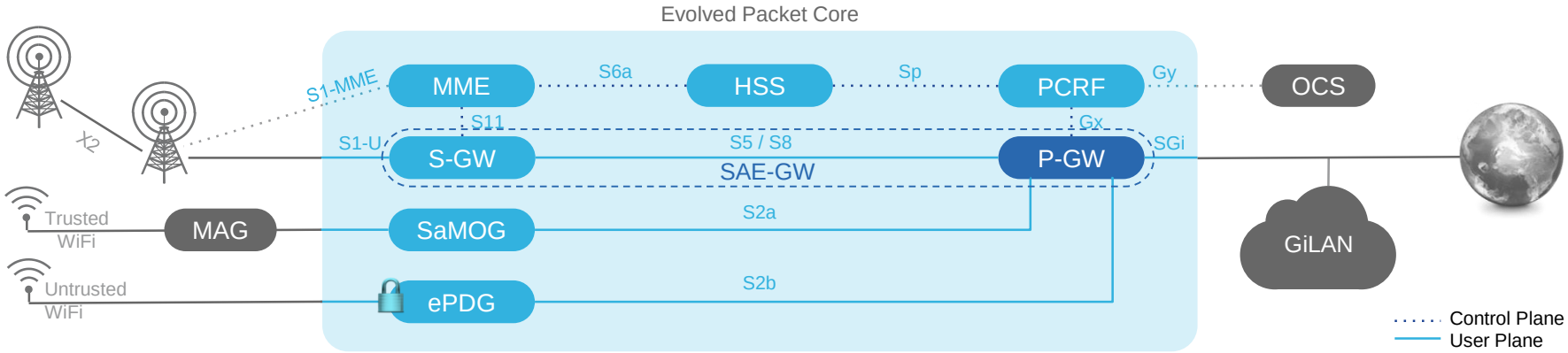
Evolved Packet Core (EPC)



HSS – Home Subscriber Server

- Database of user and subscription information
- Cipher key pairs to published USIMs
- Identification, Authentication & Addressing
- Profile / Policy data
- Network-terminal authentication
- Roaming restrictions lists and Accessible Access Points

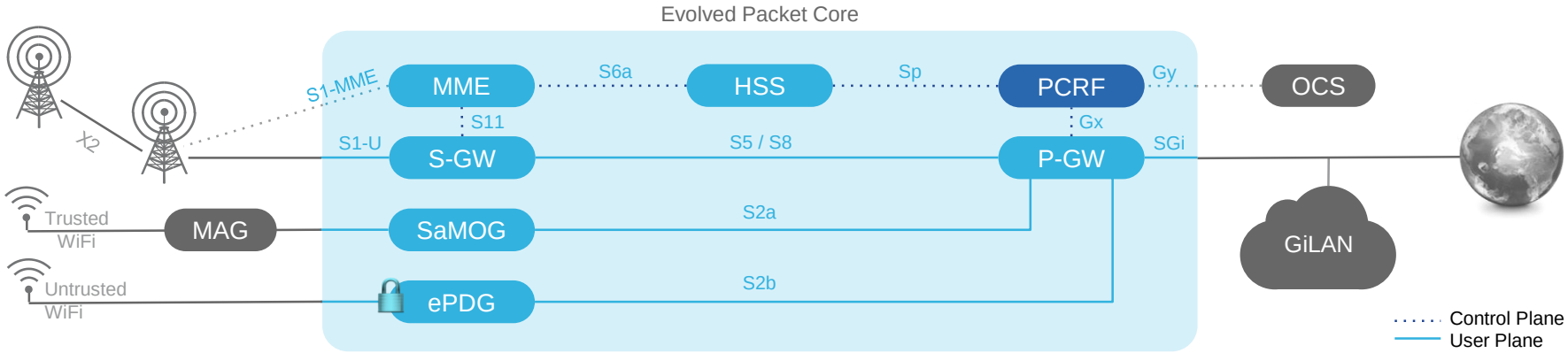
Evolved Packet Core (EPC)



P-GW – Packet Data Network Gateway

- Anchor point for sessions into external IP networks
- Policy enforcement
- Traffic filtering & downlink packet marking
- UE IP Address allocation
- Service level charging, gating and rate enforcement
- Can be combined with SGW in an SAE-GW

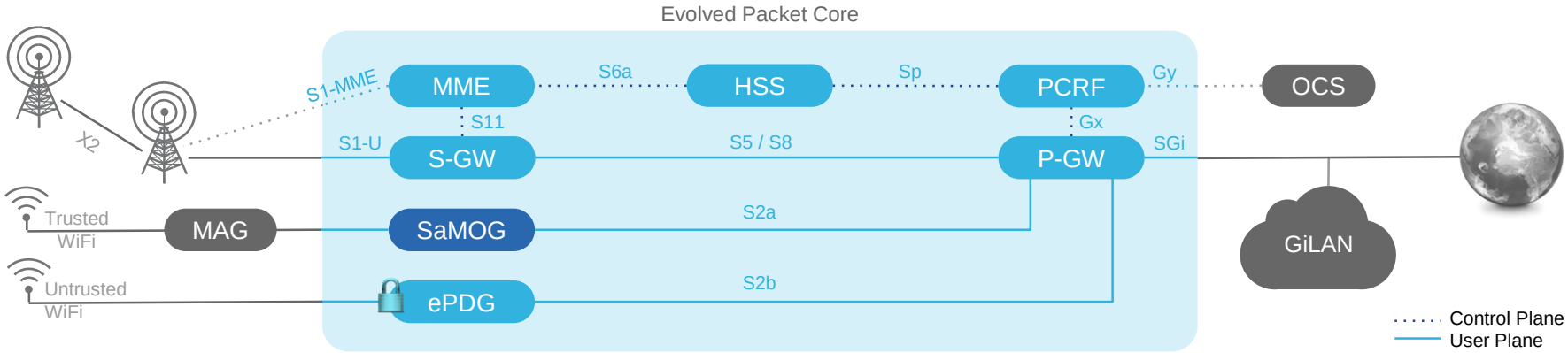
Evolved Packet Core (EPC)



PCRF – Policy and Charging Rules Function

- Defines and makes real-time policy decisions
- Maps user subscriber policy to PGW service treatment
- Defines active subscriber experience
- Provides links to online and offline charging systems
- Supplies Traffic Flow Templates for bearers
- Provides charging instructions to network

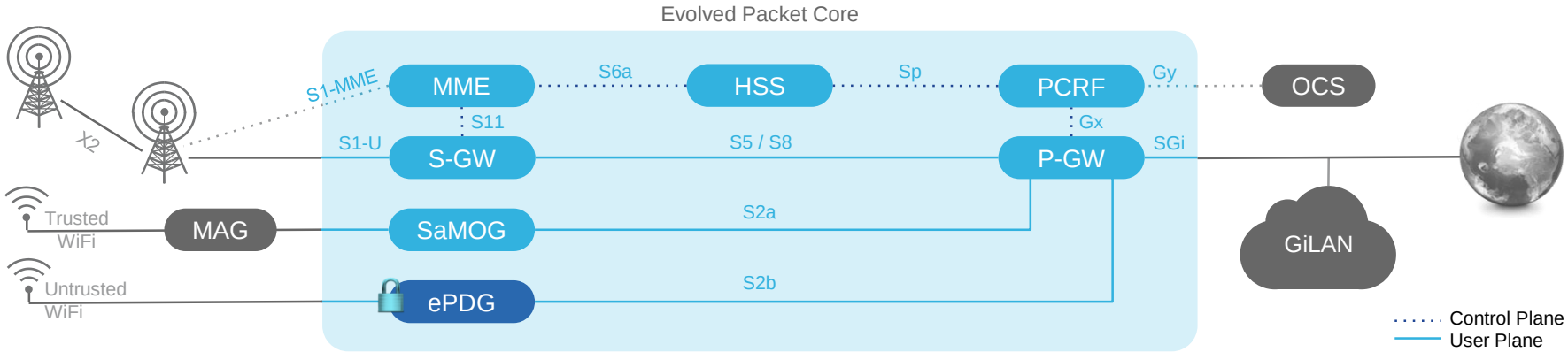
Evolved Packet Core (EPC)



SaMOG – S2a Mobility over GTP

- Interworking function between EPC and trusted WiFi
- Allows Media Access Gateway (MAG) in Wireless controllers to be 'seen' like an eNodeB's
- Extends subscriber policy and authentication model to WiFi
- SP authenticates users on the WiFi network (trusted)
- Uses Proxy Mobile IP to allow mobility to WiFi with same IP

Evolved Packet Core (EPC)

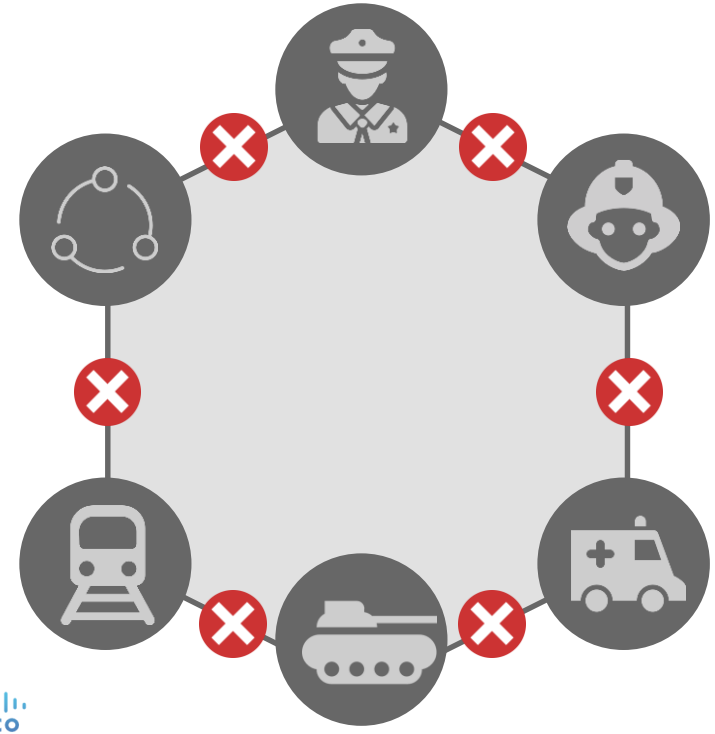


ePDG– evolved Packet Data Gateway

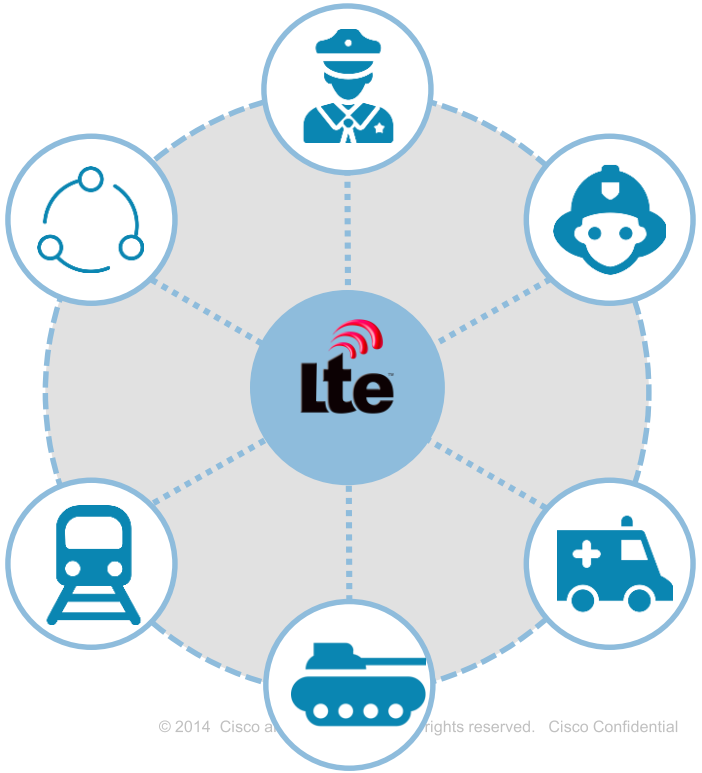
- Interworking function to un-trusted networks (eg. WiFi)
- Access from networks where the SP doesn't authenticate
- Terminates IPSec tunnels to provide EPC access
- Uses Proxy Mobile IP when users roam to untrusted WiFi
- Extends subscriber policy and charging to any network
- Mechanism used for Apple iOS8 WiFi Calling feature

Well, why it is good for Public Safety?

Different Technologies &
Different Frequencies



Same Technology &
Same Frequencies



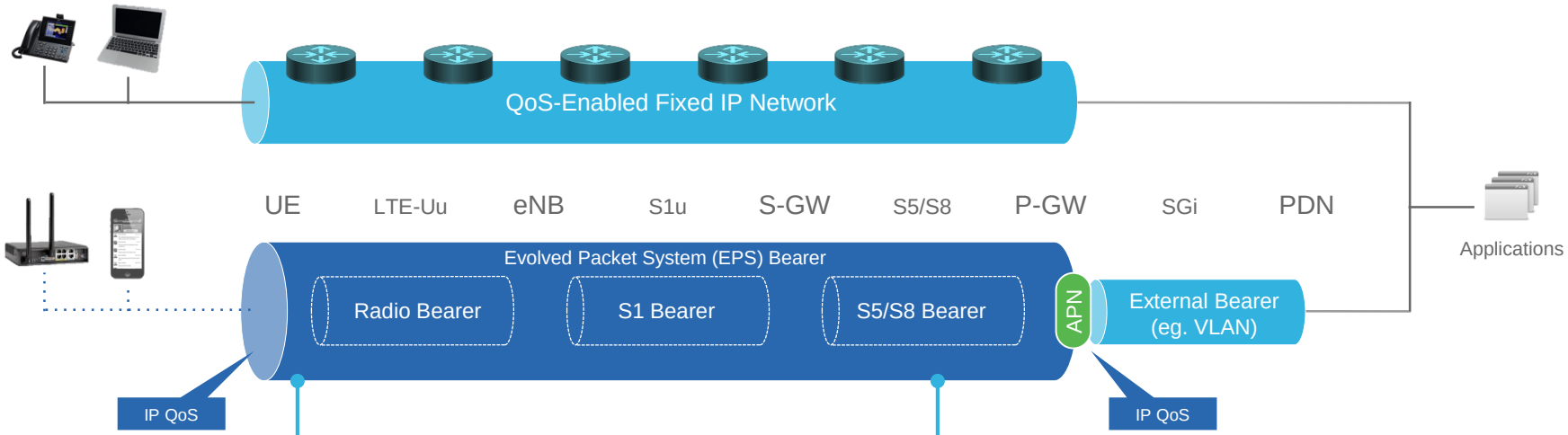
Quality of Service

"LTE as a standard has more control over priority services, the ability to pre-empt users and quality of service, than any other previous wireless broadband technology"

Public Safety Communications Research, US Department of Commerce

DSCP	Bearer	QCI	TFT	eNB Scheduler	ARP
Differentiated Services Code Point	Default and Dedicated	QoS Class Identifier	Traffic Flow Template	eNodeB MAC Scheduling Interface	Allocation and Retention Priority
Classifies packet priority at network ingress.	Established between UE and eNB.	Specifies treatment parameters and service levels for bearer traffic.	Assign packets to a QCI and bearer based on 5 tuple.	Manages bearer requests and resources across all UE's in a cell.	Used to accept / modify / drop bearers in case of resource limitation

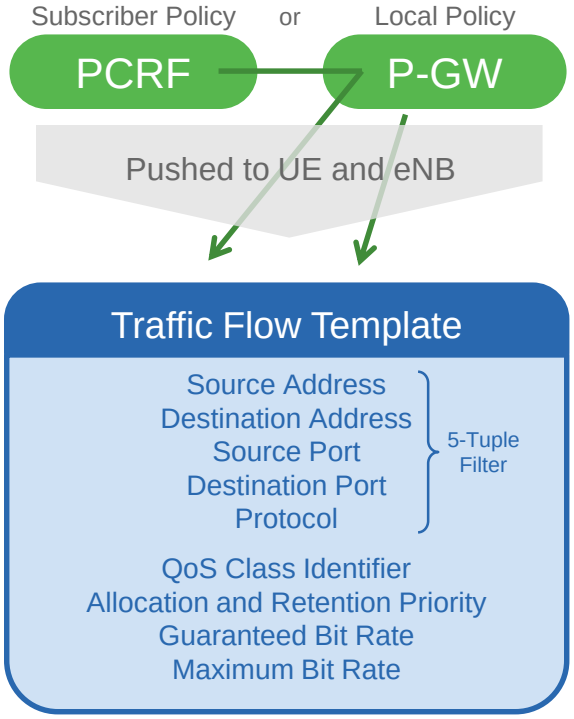
LTE Bearer Constructs



Types
Default bearer - Non-GBR (Guaranteed Bit Rate)
Dedicated bearers - GBR or Non-GBR

Attributes
Non-GBR – UE-AMBR, A-AMBR (Aggregate Maximum BR)
GBR – GBR (Minimum BR), MBR (Maximum BR)
Traffic Flow Template
ARP Allocation & Retention Priority
L-EBI (Linked EPS Bearer ID – default bearer)

Traffic Flow Templates & LTE QCI



QCI	Resource Type	Priority	Packet Delay Budget (mS)	Packet Error Loss Rate	Example Service
1	GBR	2	100	10^{-2}	Conversational Voice
2	GBR	4	150	10^{-3}	Conversation Video (live streaming)
3	GBR	3	50	10^{-3}	Non-Conversation video (buffered streaming)
4	GBR	5	300	10^{-6}	Real-time gaming
5	Non-GBR	1	100	10^{-6}	IMS signaling
6	Non-GBR	6	300	10^{-6}	Voice, video (live streaming)
7	Non-GBR	7	100	10^{-3}	Video (buffered streaming)
8	Non-GBR	8	300	10^{-6}	TCP-based (WWW, messaging, file transfer)
9	Non-GBR	9	300	10^{-6}	Best Effort

Public Safety Specification Efforts

3GPP is defining new specifications and requirements to support specific services and architecture for Public Safety deployments.

This standardization effort has started with 3GPP Release 12 and continues also in the new 3GPP Release 13

New specifications have been created and some existing ones are being enhanced to accommodate the new requirements for Public Safety Market.

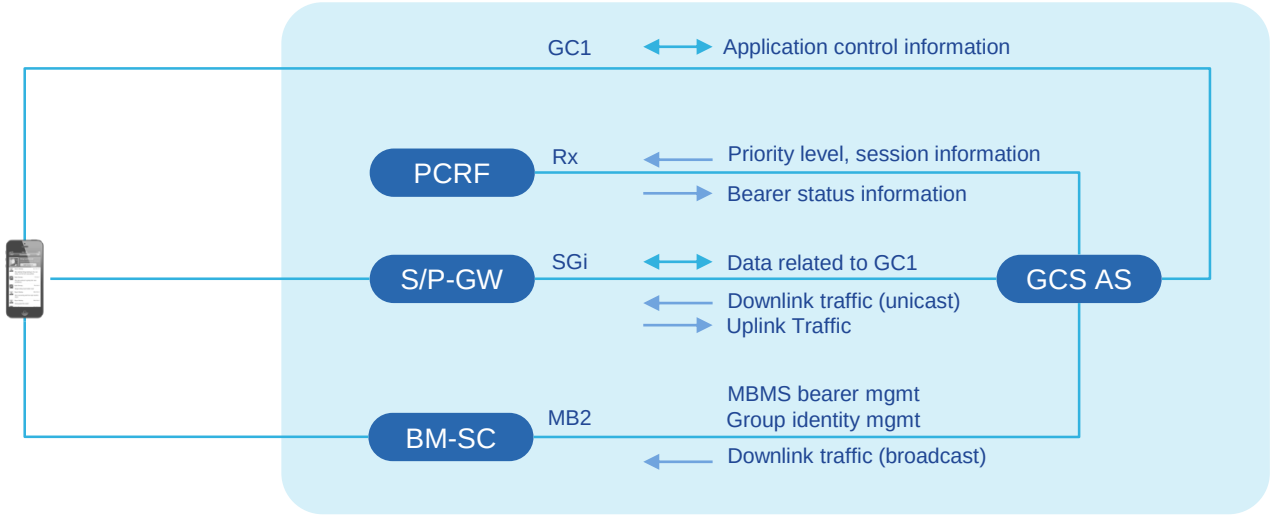
New relevant 3GPP Specifications

- 3GPP TS 23.468 Group Communication System Enablers for LTE (GCSE_LTE); Stage 2
- 3GPP TS 23.303 Proximity-based services (ProSe); Stage 2
- 3GPP TS 22.179 Mission Critical Push to Talk (MCPTT); Stage 1
- 3GPP TS 23.179 Functional architecture and information flows to support mission critical communication services ; Stage 2
- 3GPP TS 22.346 Isolated E-UTRAN operation for public safety (IOPS); Stage 1

Group Communications and MC-PTT

Group communications with PTT features are central capabilities in mission-critical voice services

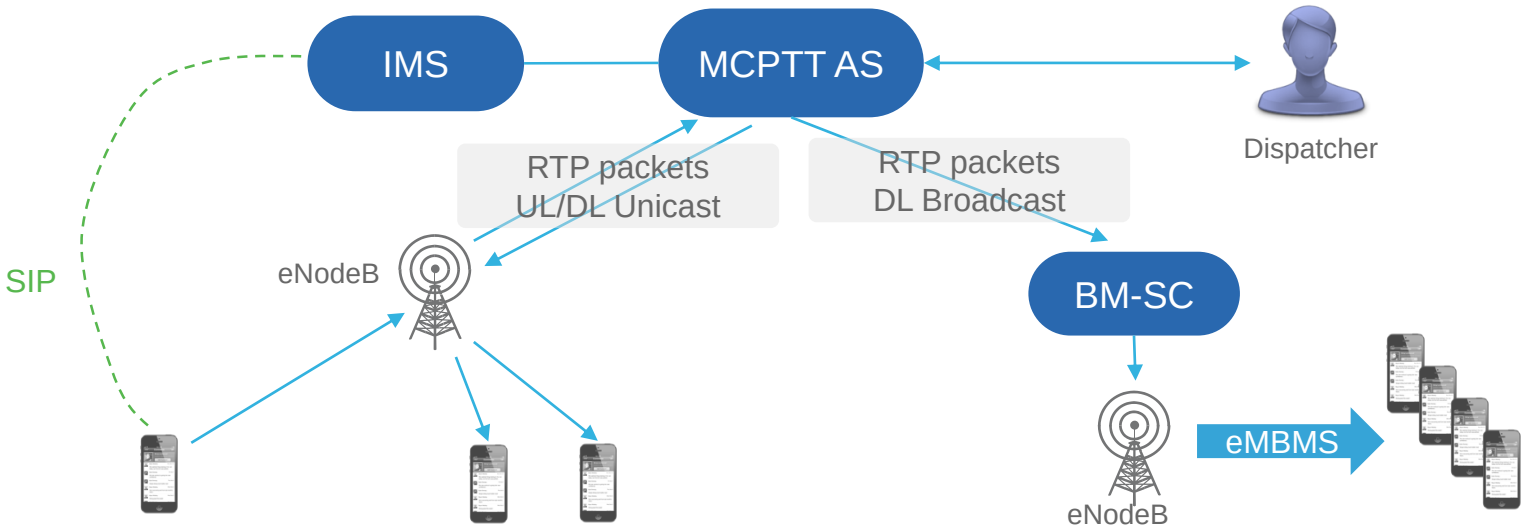
Group Communication Architecture



Group Communication Service Application Server

- It provides a means for both one-to-one and one-to-many communication services
- Public safety devices use the GC1 reference point to initiate, modify or terminate group communication sessions
- The GCS AS makes the decision to use either unicast or broadcast mode for sending traffic.
- In unicast mode, uses GC1 control signaling to derive the priority level and communicates with PCRF on Rx interface.
- The PCRF uses this information to create an appropriate EPS bearer
- In broadcast mode, the GCS AS uses eMBMS to deliver traffic to the public safety devices, via the MB2 interface.

MC-PTT Communication Architecture



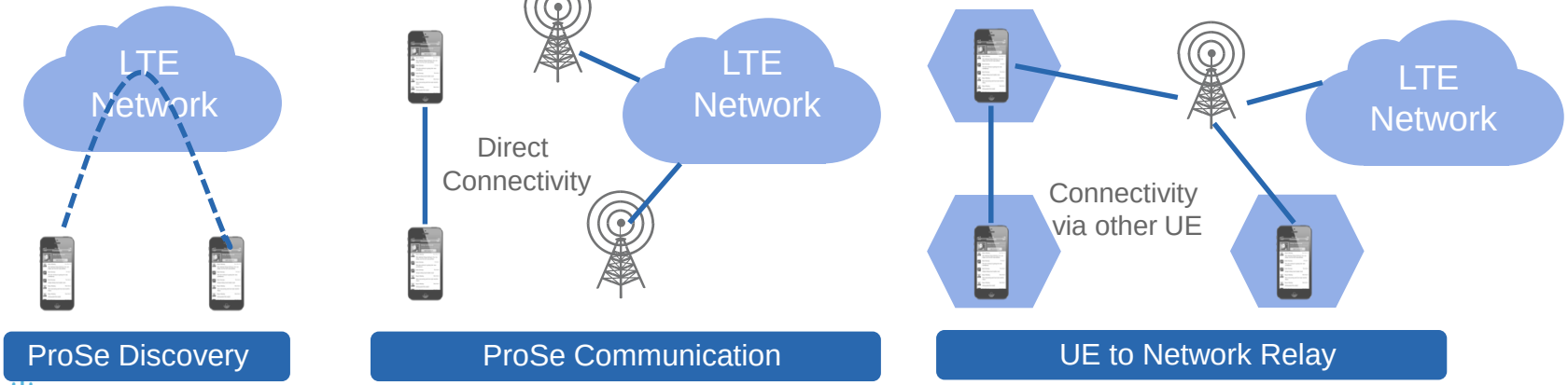
Mission Critical Push To Talk Service

- The push to talk service for group communication is based on multi-unicasting and broadcasting.
- GCS is a generic function for voice, video and data, MCPTT is a voice communication service.
- Each sending device sends packet data traffic to a dedicated mission critical push to talk application server and the server then copies the traffic to all the recipients

Proximity-based Services (ProSe)

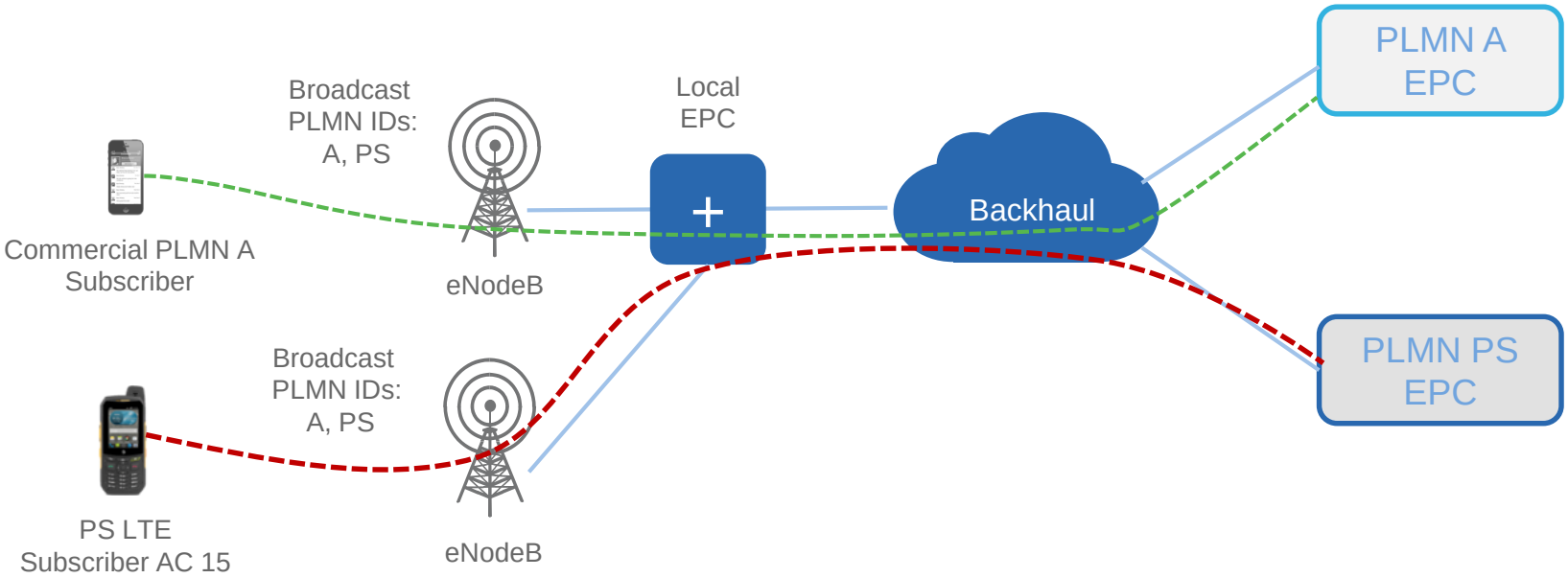
Proximity Services

The Public Safety Network needs to support communication between public safety users when the devices are in proximity and even if the network is down or when the device is out of coverage.

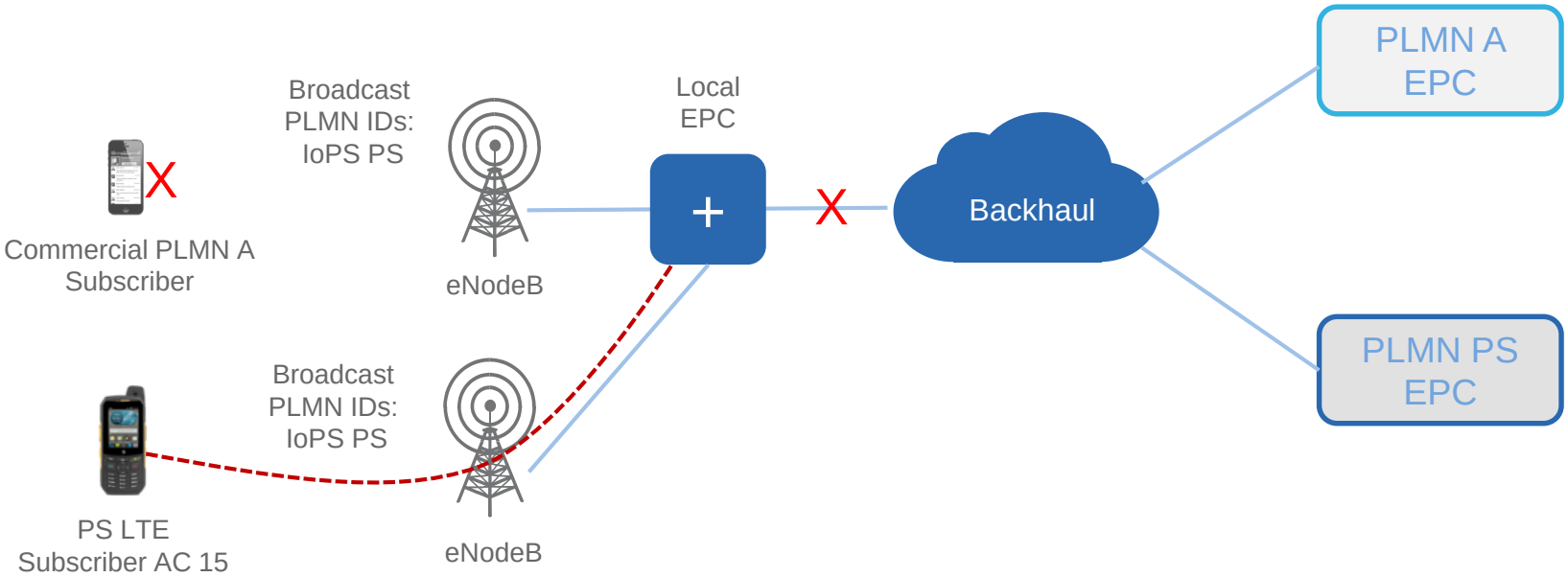


Isolated UTRAN Operation For Public Safety (IoPS)

IoPS – Normal Mode



IoPS – Backhaul Failure



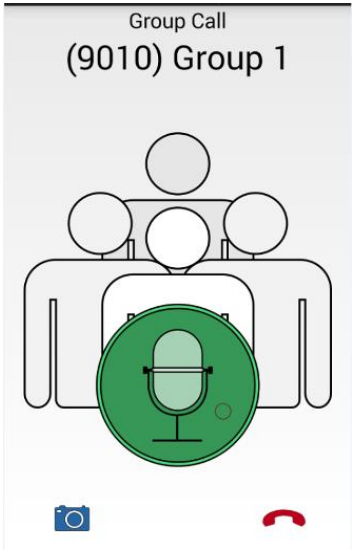
Where do we go from here?

Conclusions

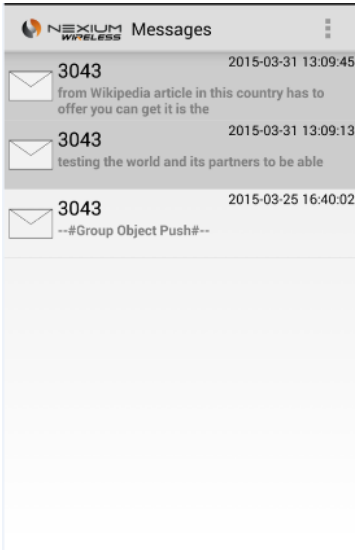
- The evolution from current narrowband systems to LTE based public safety will take several years and will happen gradually.
- During the transition period, public safety agencies are expected to use existing TETRA and P25 systems in parallel with LTE based systems.
- The first and the simplest step is to rely on TETRA and P25 in mission critical voice and messaging, while LTE can offer enhanced data services, potentially with slightly lower reliability.
- In the distant future we assume that TETRA and P25 technologies will no longer be maintained and all public safety service requirements will be fulfilled by LTE networks. Service interworking will be crucial in the evolution to public safety solutions based on LTE alone.

TOMORROW starts here.

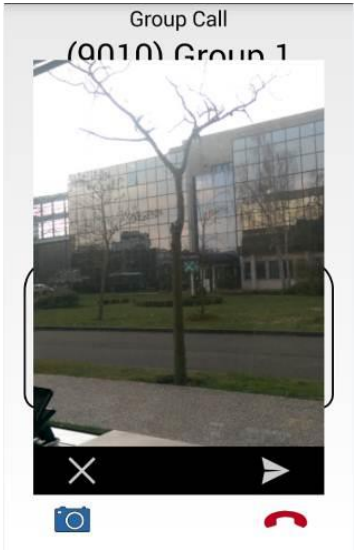
Mission Critical Push-To-Talk Services



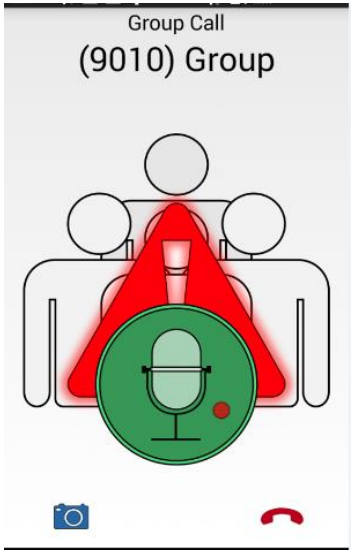
Group Call



Messaging



Push to video



Emergency call