
TOMORROW
starts here.
CISCO
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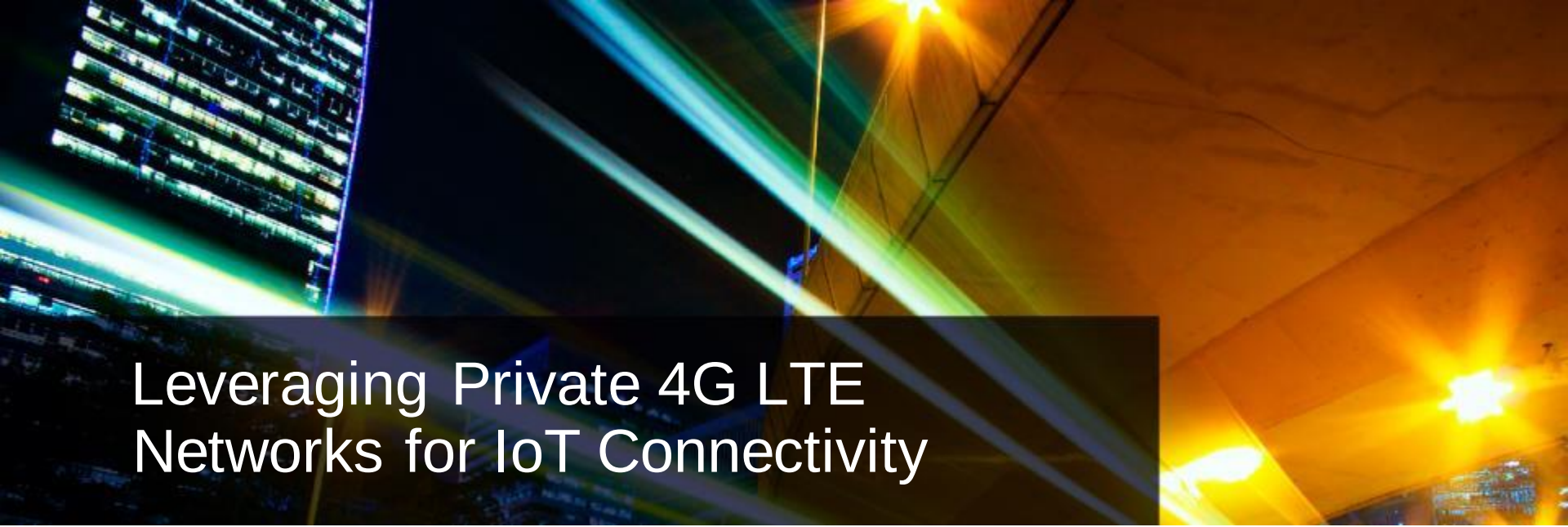

Leveraging Private 4G LTE Networks for IoT Connectivity

BRKIOT-2601

Ian Ross
Solutions Manager, Global Service Provider Mobility Innovation & Enablement

#clmel

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IoT(E) is Big – for Industry and Telco / IT

2020

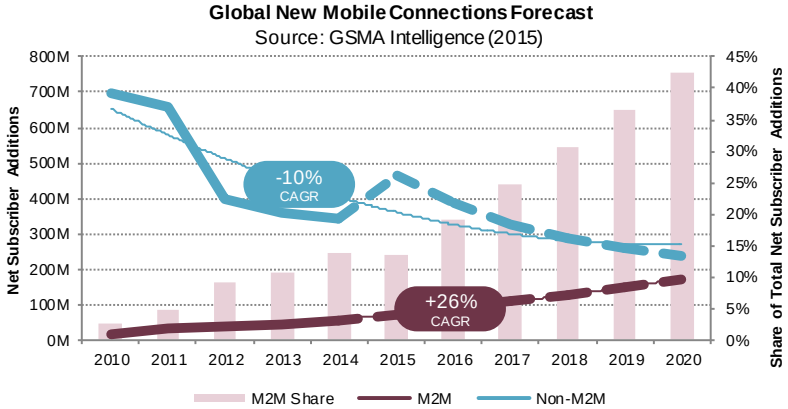
7.3B phones, tablets & PC's

26B IoT units

* High proportion of *ghost* devices;
devices that are capable but not activated

$309B hardware, software & services

$1.9T economic value-add



Wave 1 — Connect **People** with Mobility

Wave 2 — Targeted Segmentation

Wave 3 — Connect **Things** to Mobility

Source: Gartner (2014)

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The Connected Industry Revolution

Verticals are In Flux
Network-led Transformation

- Automation
  Cost-out & Safety
- Telemetry & Analytics
  Increase Efficiency
- Sensors & Security
  More IP, Better Access
- Rich Communication
  Unicast & Broadcast

Mining & Minerals

Fleet management & autonomy, telemetry and analytics

Public Safety

Unplanned event; mobility for emergency workers

Manufacturing

DECT replacement, M2M, production-line analytics

Transport

Modernise aged comms and signalling infrastructure

Energy Utilities

Backhaul networks for Smart Meters and network control

Military

Command Post & Connected Battlefield Enablement

LTE
Long Term Evolution

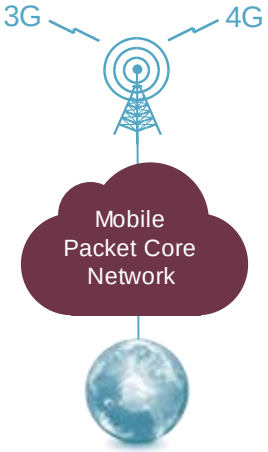
- Latency
- Throughput
- Range
- Mobility
- Traffic Management
- Standardisation

4G LTE and Cisco?

We have this …

Cisco Mobility Portfolio

Which does …



3G & 4G Core Networks

And used by these …

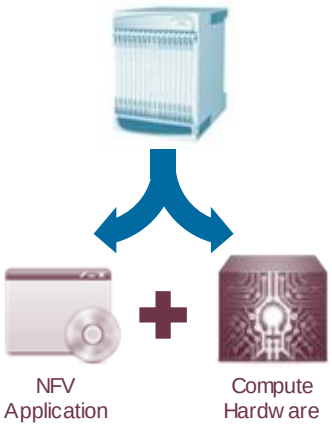
75 Service Providers
in 300 Countries

To do this …

Connected Mobile Users

4G LTE and Cisco?

But with virtualisation …

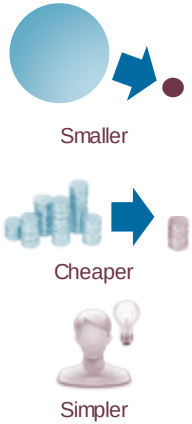


Software Network Functions

Which allows this …

COTS Compute Usage

Which results in this …



Lower Barriers to Entry

And allows this …

Exciting Possibilities

Agenda

LTE as a connectivity platform for IoT

An introduction, overview and common questions answered

1. LTE Technology – Is It Fit For Purpose?
2. LTE Networks – What's Required?
3. The Finer Points Of Operation
4. LTE In IoT – Making It Happen

LTE Technology

Is It Fit For Purpose?

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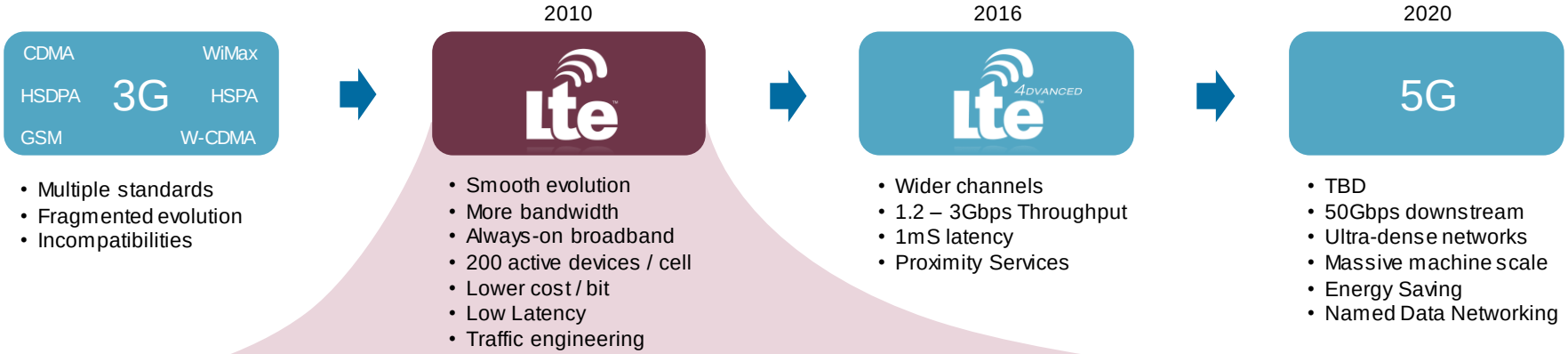
The Long Term Evolution



- Multiple standards
- Fragmented evolution
- Incompatibilities

- Smooth evolution
- More bandwidth
- Always-on broadband
- 200 active devices / cell
- Lower cost / bit
- Low Latency
- Traffic engineering

- Wider channels
- 1.2 – 3Gbps Throughput
- 1mS latency
- Proximity Services

- TBD
- 50Gbps downstream
- Ultra-dense networks
- Massive machine scale
- Energy Saving
- Named Data Networking

Throughput

- Ideal DL 100Mbps
  5 bps/Hz
- Ideal UL 50Mbps
  Ideal UL 2.5bps/Hz

Strict QoS

- Radio latency < 10mS
- Control latency <50mS
- User latency <50mS
- Traffic pre-emption

Mobility

- Mobility up to 350kmh
- Roaming with 2G / 3G
- WiFi offload capability

Enhanced Casting

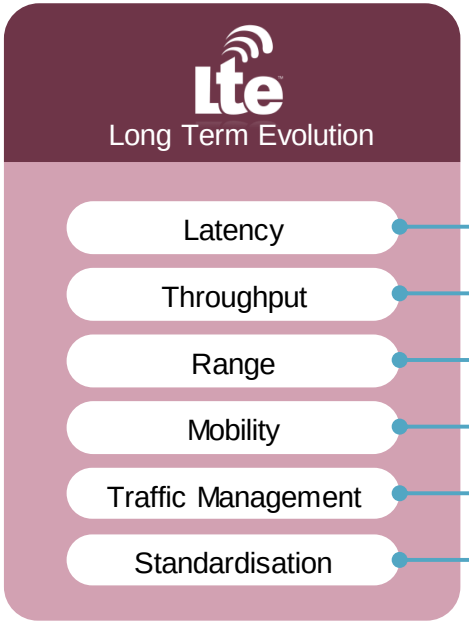
- Broadcast & Multicast
- Enhanced bit rate multicast

All IP

- Any-to-any connectivity
  L3VPN, L2VPN, TE
- Standard interfaces

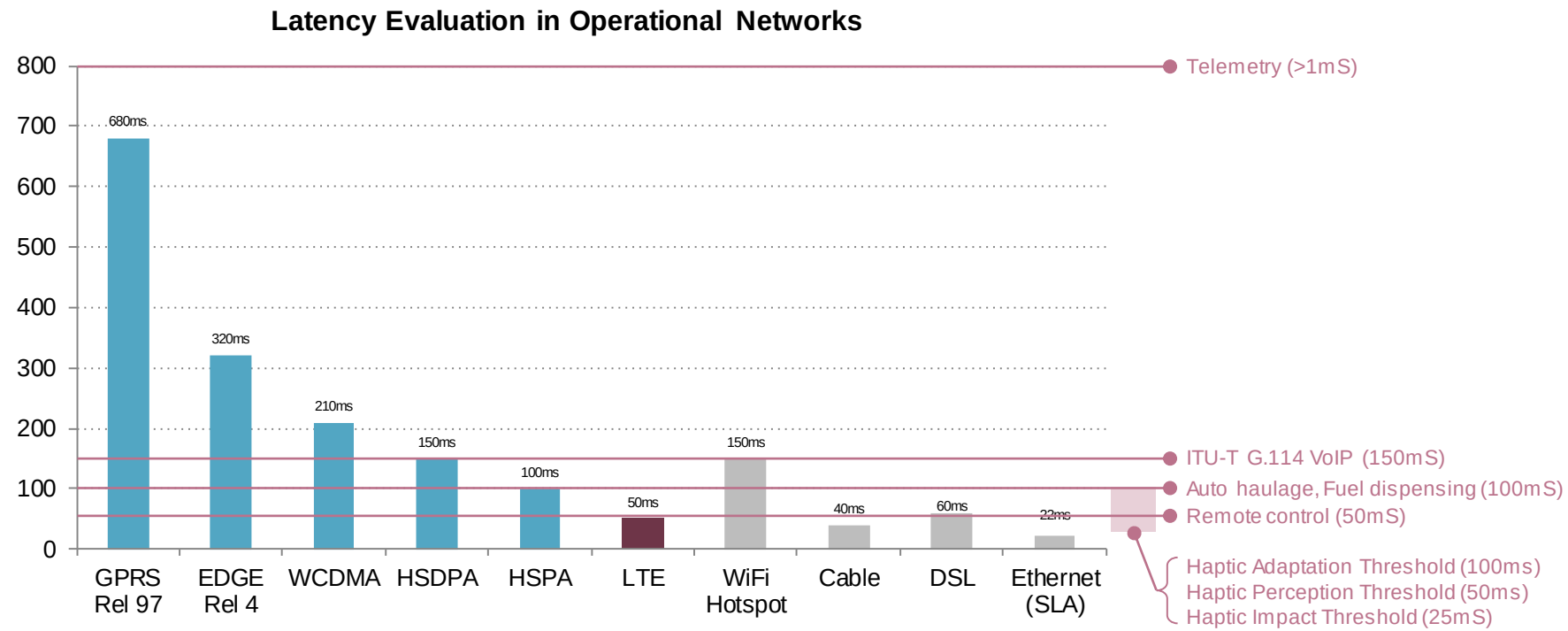
IoT Requirements

M2M / IoT Connectivity



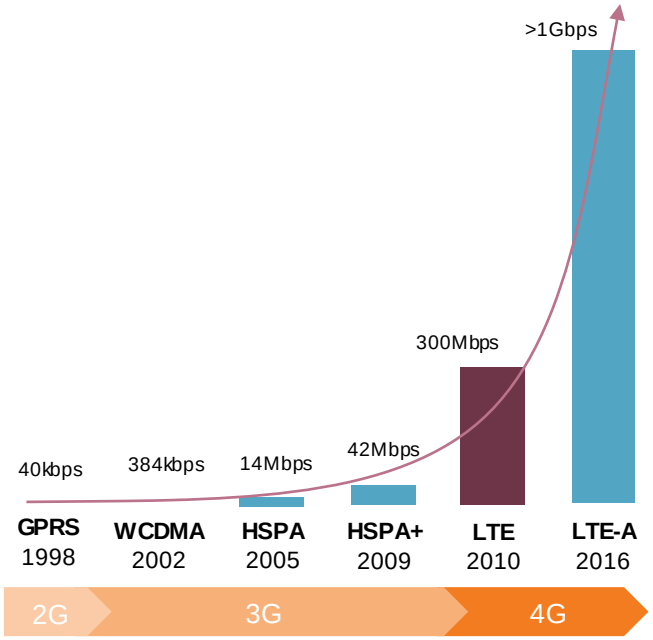
- Delay-sensitive control or collaborative applications
- Broadband data is the new voice
- Reduced complexity and backhaul infrastructure
- Things move … sometimes at speed
- Beyond Best Effort – guarantees and priority
- Critical mass, scale, global & future

Latency



Sources : Y. Xu, Latency and Bandwidth Analysis of LTE for a Smart Grid. Master Thesis, Royal Institute of Technology, Stockholm, Sweden
Jay, Glencross & Hubbold, Modelling the Effects of Delayed Haptic and Visual Feedback in a Collaborative Virtual Environment
Open Signal, Slashdot, DSL Reports

Throughput



Varies with the amount of bandwidth, distance to cell, cell loading, device type and indoor vs outdoor

Capacity Dimensioning

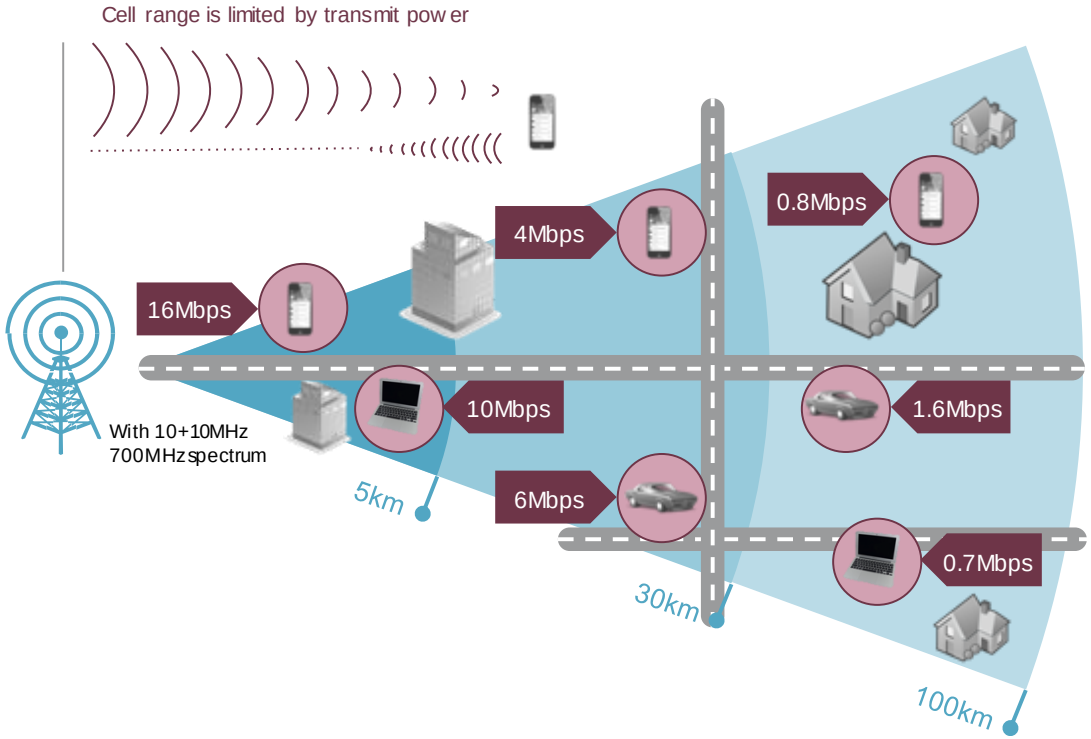
Channel Bandwidth (MHz)	1.25	2.5	5	10	20
Peak Download Mbps 4x4 MIMO	19	38	75	150	300
Peak User DL Mbps 2x2 MIMO	9	18	36	72	144
Peak User DL Mbps 4x4 MIMO	18	36	72	144	288

Throughput = Min(network capability, device capability)

Device Categories

UE Category	1	2	3	4	5
Peak DL (Mbps)	10	50	100	150	300
Peak UL (Mbps)	5	25	50	50	75

Range



Transmit power, frequency, terrain, height & antenna gain define range

Lower frequency = Less distance & penetration

Peak Sector Throughput
Theoretical Performance
86Mbps

Average Sector Throughput
Realistic Performance
26Mbps

Individual User Experience
Subscriber's rates vary from
0.7 – 20+Mbps

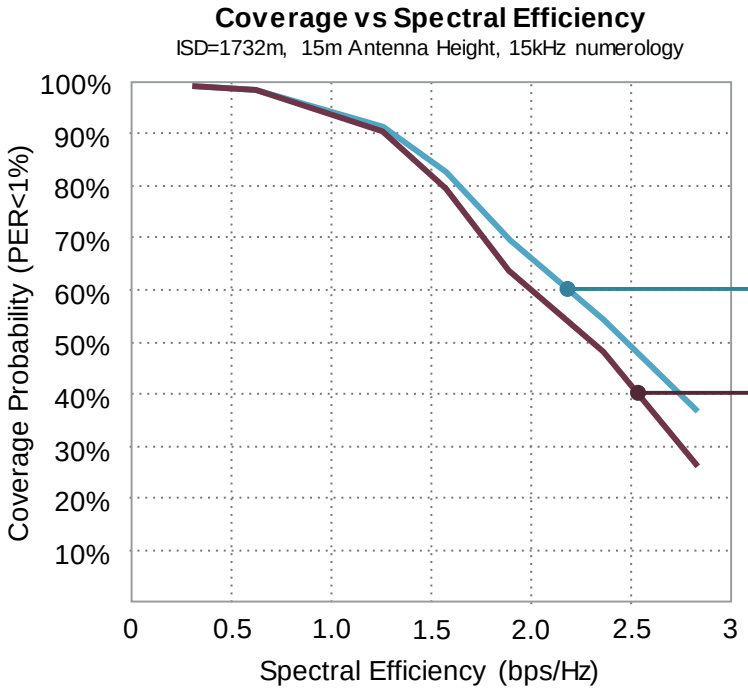
Range

Practical Deployment Comparison for model Energy Utility

		P25 IV&D 700MHz	LTE 700MHz	WiMax 2.5GHz	WiFi 2.4GHz, 5.4GHz
Data Rate Expectations		Low	High	High	Very High
Urban Site Coverage	Area	25 – 40 km^2	5 – 21 km^2	1.5 – 8 km^2	0.2 – 1.3 km^2
	Radius	3 – 4 km	1.5 – 2.5 km	0.5 – 1.5 km	0.2 – 0.5 km
Rural Site Coverage	Area	260 – 1810 km^2	52 – 260 km^2	18 – 78 km^2	Not Recommended
	Radius	10 – 24 km	5 – 12 km	2.5 – 5 km	
#Sites compared to P25		**1**	**2x – 7x**	**5x – 23x**	**>140x**
# Sites compared to LTE		**0.2 – 0.5**	**1**	**2.5x – 3.5x**	**>25x**

Source : Ittner & Pickrell, Private LTE can be a Reality for Critical Infrastructure, April 2013

Mobility



3kmh

350kmh

Source : UMTS Evolution – HSPA and SAE LTE, 3G Americas, 2008

Traffic Management

"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 (Differentiated Services Code Point)
IP Quality of Service (QoS)

Bearer
Radio categorisation paths – guaranteed and best effort

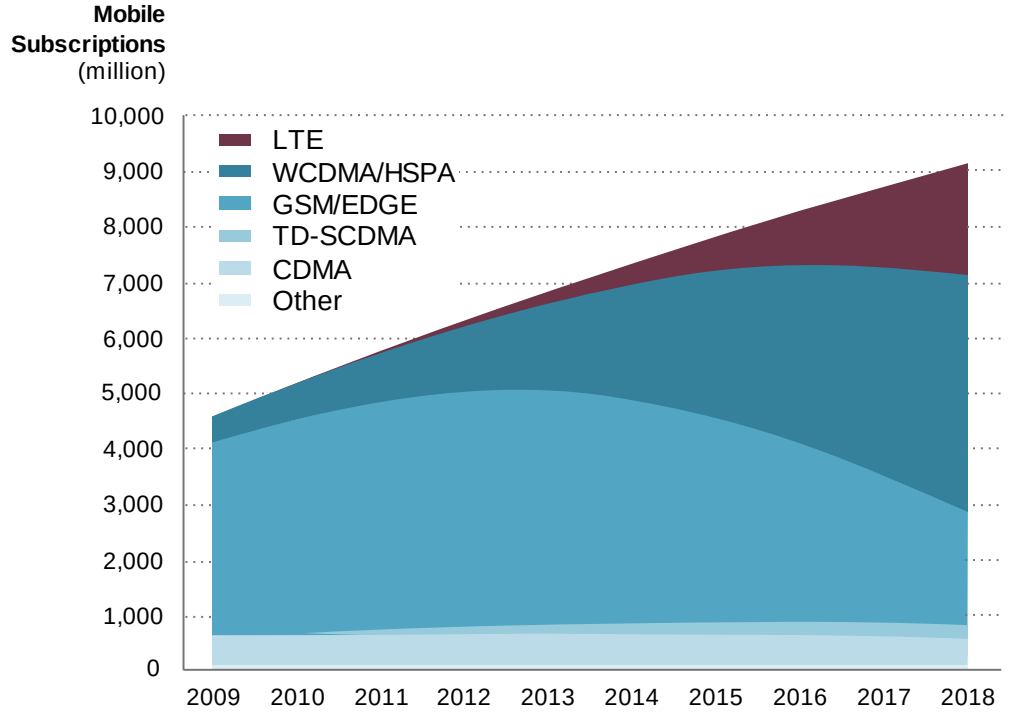
QCI (QoS Class Identifier)
Treatment levels for bearers

Scheduling
Traffic transmission prioritisation over radio spectrum

ARP
Allocation and Retention Priority

Source : http://www.pscr.gov/projects/broadband/700mhz_demo_net/meetings/inaug_stakeholder_mtg_042010/day_2/5_Priority_Preemption_and_QoS-final.pdf

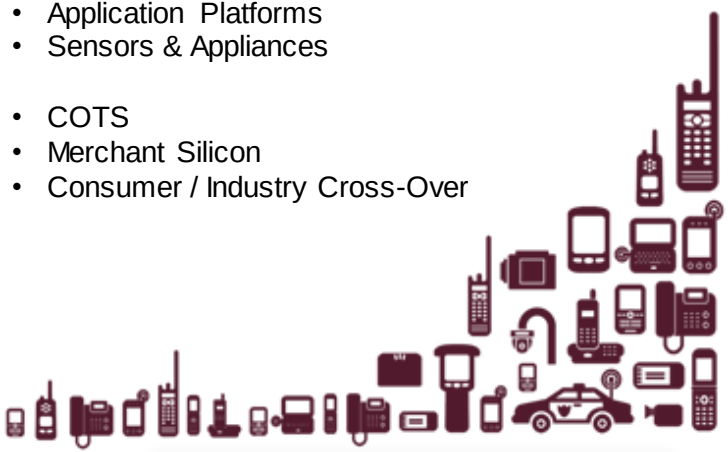
Standardisation



The first global broadband mobility standard

- Communications Devices
- Application Platforms
- Sensors & Appliances

- COTS
- Merchant Silicon
- Consumer / Industry Cross-Over



Source : Ericsson (June 2013)

Standardisation

Lifecycles, Consumerisation, Volume / Scale
Choice, Competition, Ecosystem, Dev Community

Sagecom 350R
GSM-R Phone

Peak DL = 85.6kbps
Peak UL = 42.8kbps

AUD$2467

Sonim XP6
Hardened LTE Phone

Category 3 LTE UE
Peak DL = 100Mbps
Peak UL = 50Mbps

AUD$672

Samsung Galaxy S4 Mini
LTE Smartphone

Category 4 LTE UE
Peak DL = 150Mbps
Peak UL = 50Mbps

AUD$249

- Standardised Frequency Bands
- Interchangeable Components
- Vendor Interoperability
- Variety of Solution Options

LTE Networks

What's Required?

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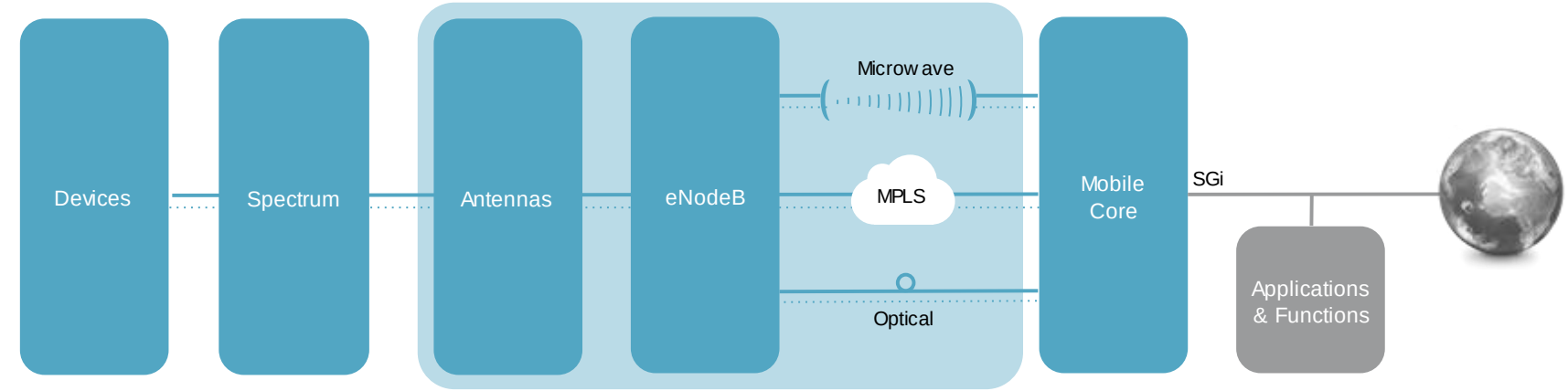
High Level System View



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

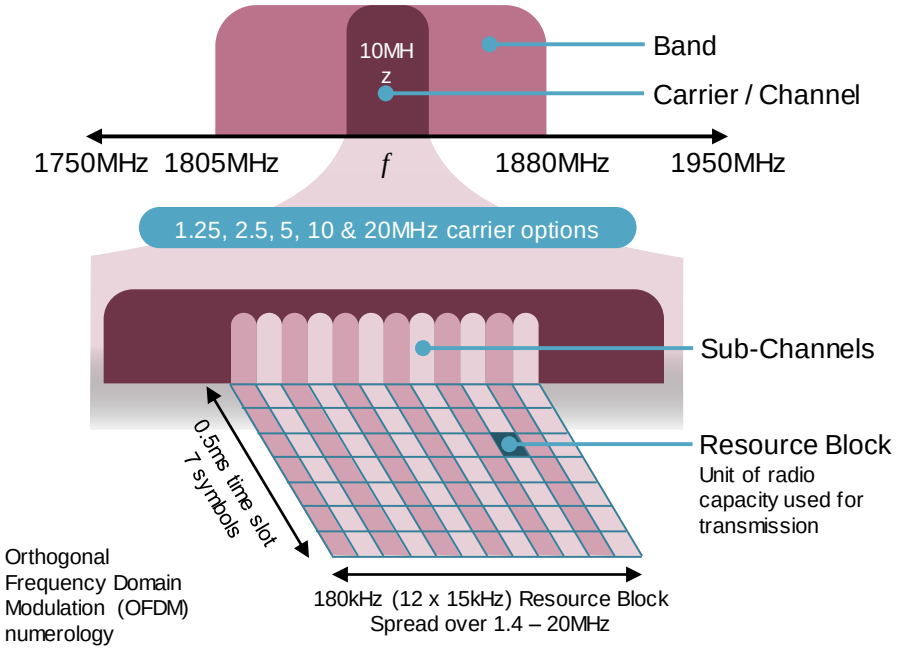
- Basis of UE authentication and access
- Coded by network operator
- Unique user & network identifiers
- Preferred roaming network details
- Cipher keys paired to Network

Universal Subscriber Information Module

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

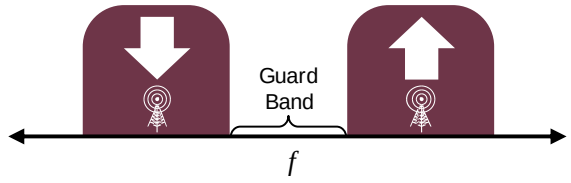
Spectrum

Allocating Spectrum to LTE Systems



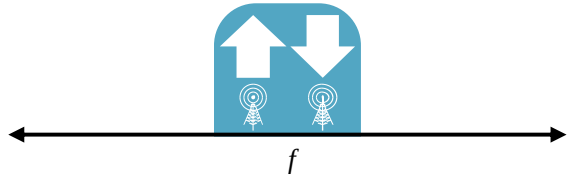
LTE Duplex Schemes

FDD
Frequency Division Duplex



Paired Carriers (eg. 10+10MHz)
Suited to Symmetric Services
Larger coverage areas

TDD
Time Division Duplex

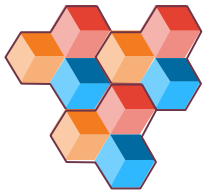


Single Carrier for TX and RX
Suited to Asymmetric Services
Bandwidth Efficiency

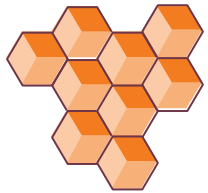
Spectrum

- 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		

TELSTRA Bands 1, 3, 7, 8, 28

OPTUS Bands 1, 3, 7, 28, 40

vodafone Bands 3, 5

TPG Band 7

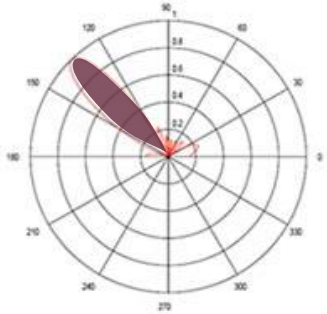
Antennas

NOKIA

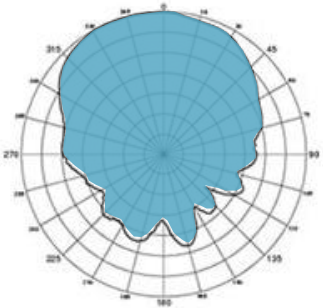
Flexi Multiradio Active Antenna
2 x 2 MIMO
Vertical Beamforming

Beamforming

Benefits
- Higher Signal-to-Noise Ratio
- Interference avoidance
- Interference rejection
- Higher Network Efficiency
- Downlink gains up to 70%
- Uplink gains up to 160%



Beamforming Antennas
Like a torch. Focuses radio beam in required direction.

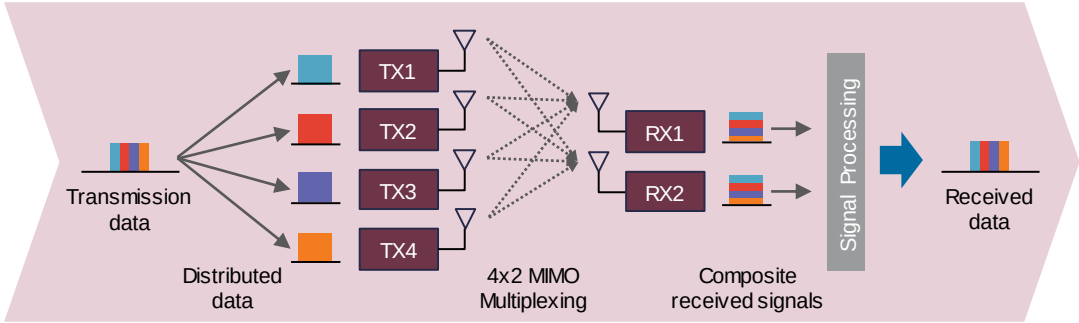


Traditional Antennas
Like a light bulb. Radiates energy in all directions.

MIMO
(Multiple Input Multiple Output)

1x1 2x2 4x2 4x4

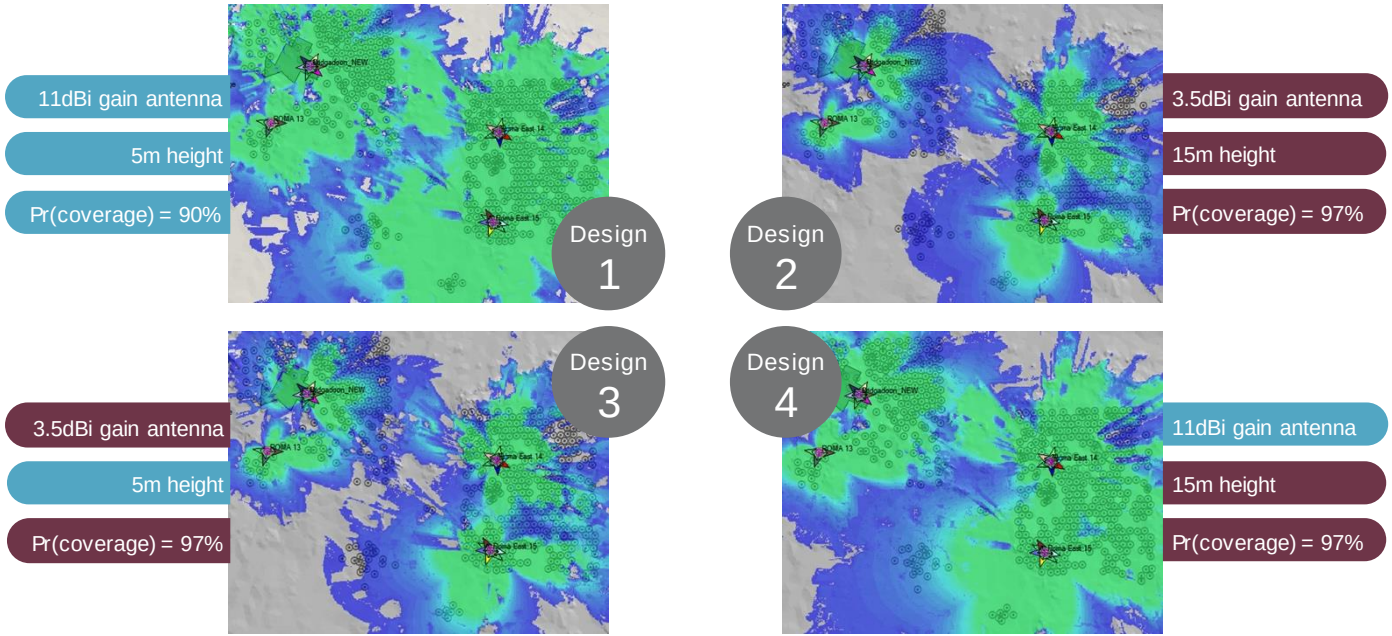
Benefits
- Increased capacity
- Reliability & diversity
- Resiliency



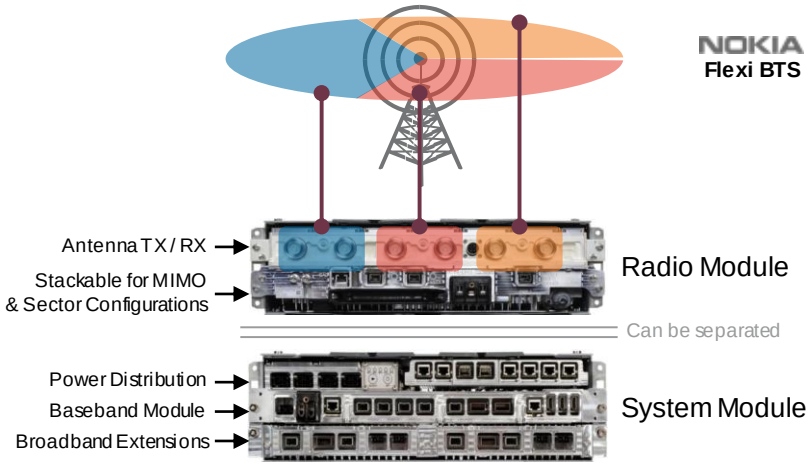
Antennas

Traditional Radio Principles Still Apply

Gas Field Design Example



eNodeB (eNB)



Configuration & Licensing Parameters

Frequency	MIMO Type
Carrier Bandwidth	Active Radio Users
Power	Active Packet Sessions
# Sectors	Advanced Interference Features

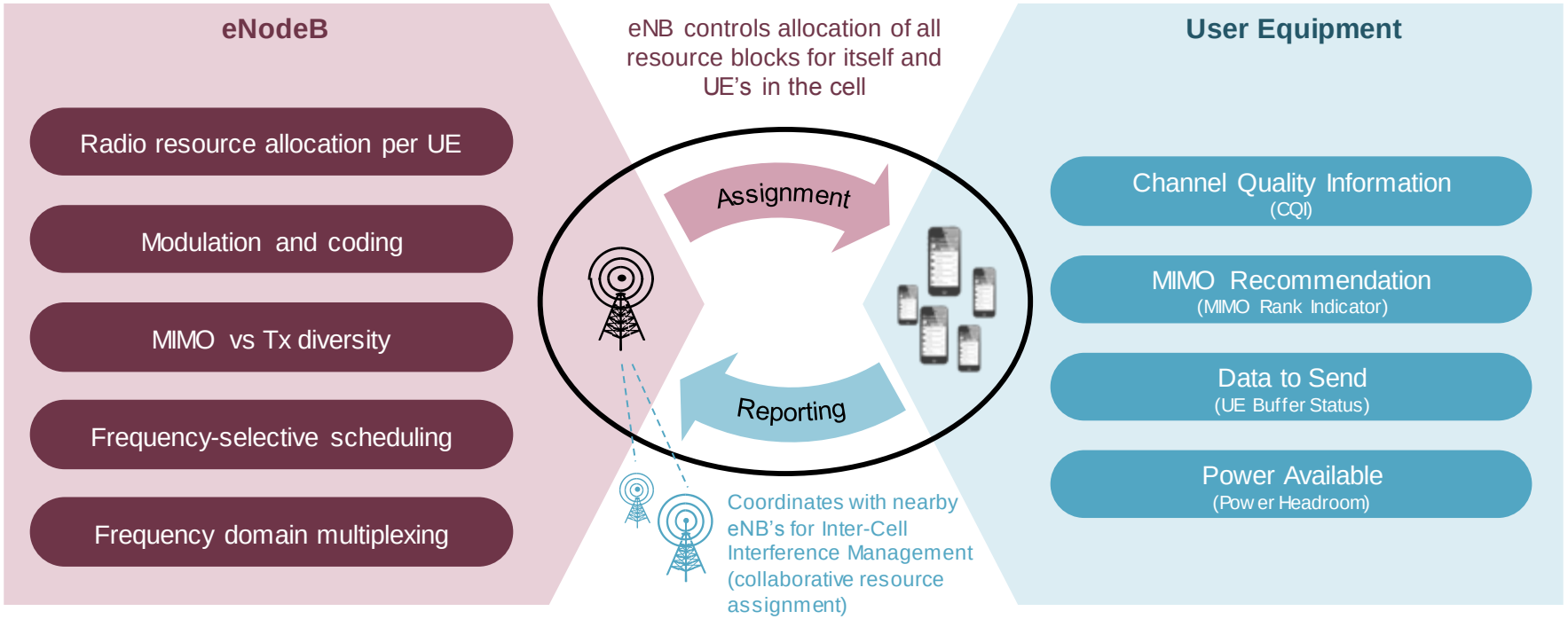
Variants & Functions

Femto Cell 10m* | Pico Cell 200m* | Micro Cell 2km* | Macro Cell 30km*

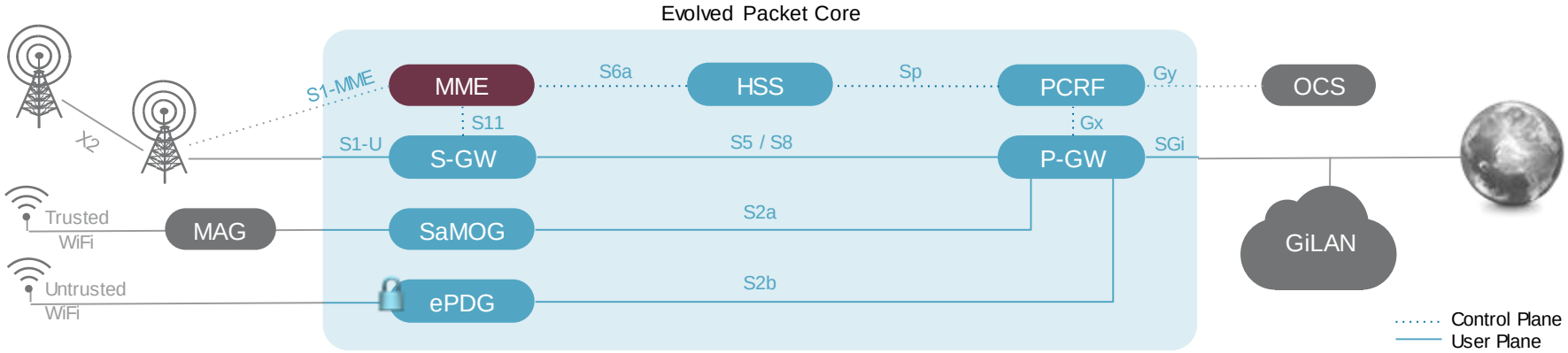
* Distances vary with environment and radio & capacity planning requirements

- Inter-Cell Radio Resource Management
- Radio Bearer Control
- Radio Admission Control
- Connection Mobility Control
- X2 Bearer Control to other eNB's
- Measurement and Reporting
- Paging
- IP Header compression and data ciphering
- Dynamic Resource Allocation (Scheduler)

eNodeB Scheduler



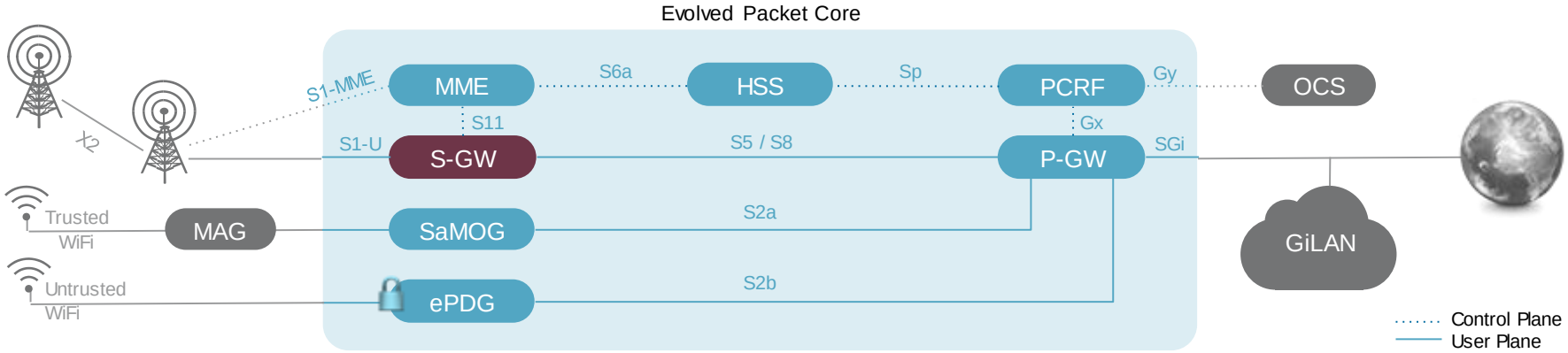
Evolved Packet Core (EPC)



MME – Mobility Management Entity

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

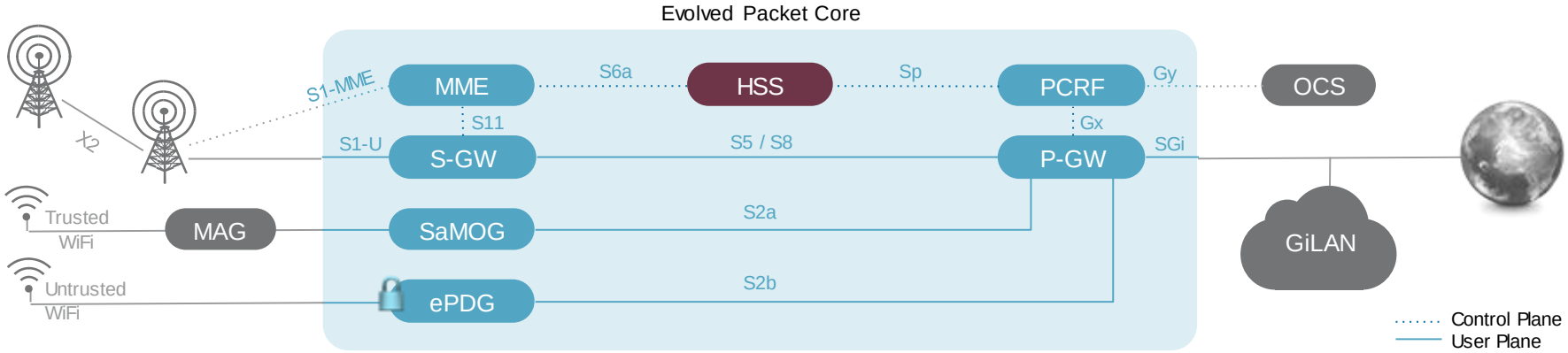
Evolved Packet Core (EPC)



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)

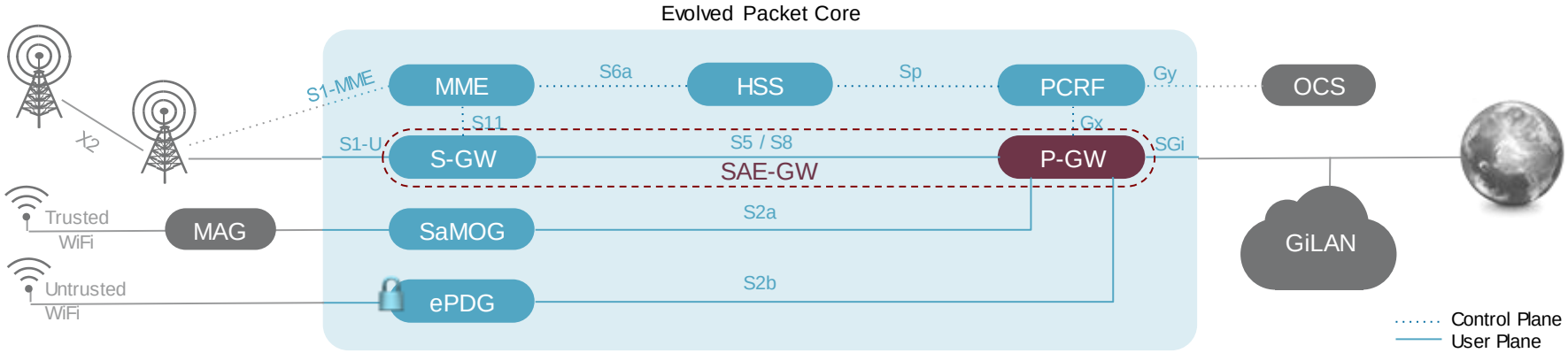
Evolved Packet Core (EPC)



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

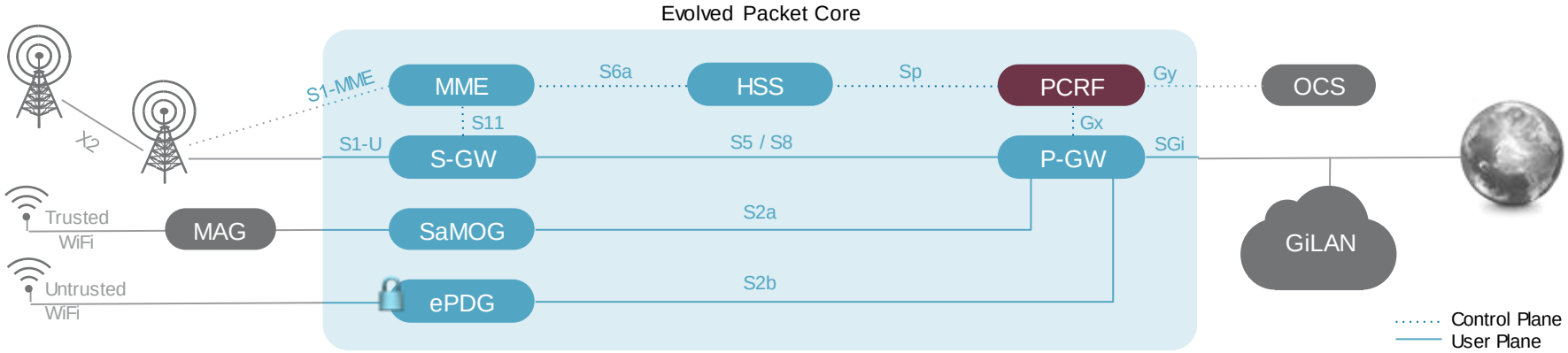
Evolved Packet Core (EPC)



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

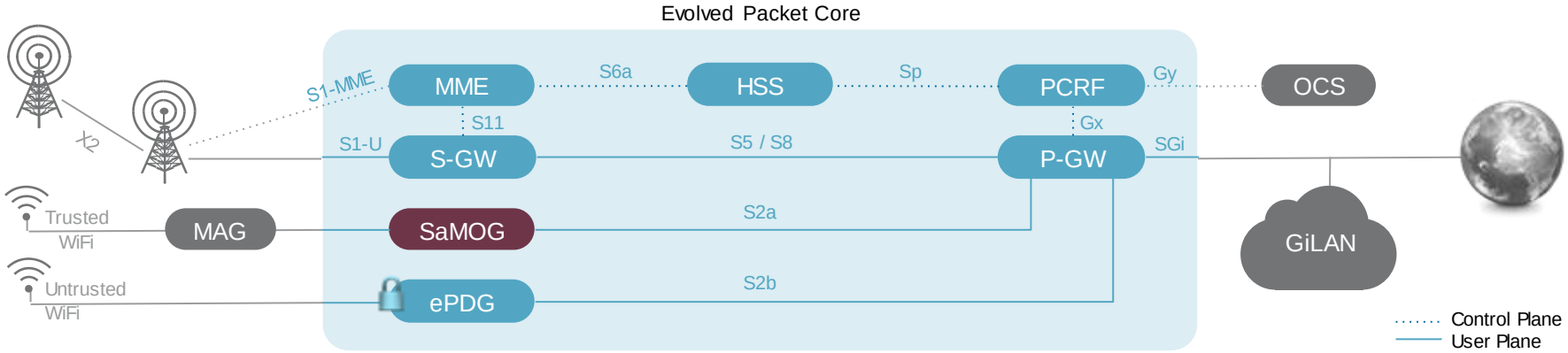
Evolved Packet Core (EPC)



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

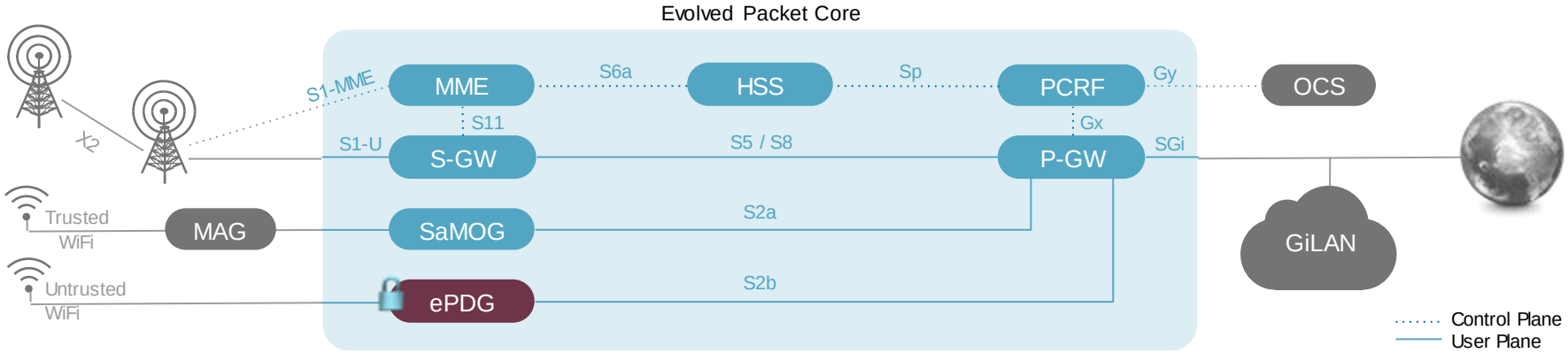
Evolved Packet Core (EPC)



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

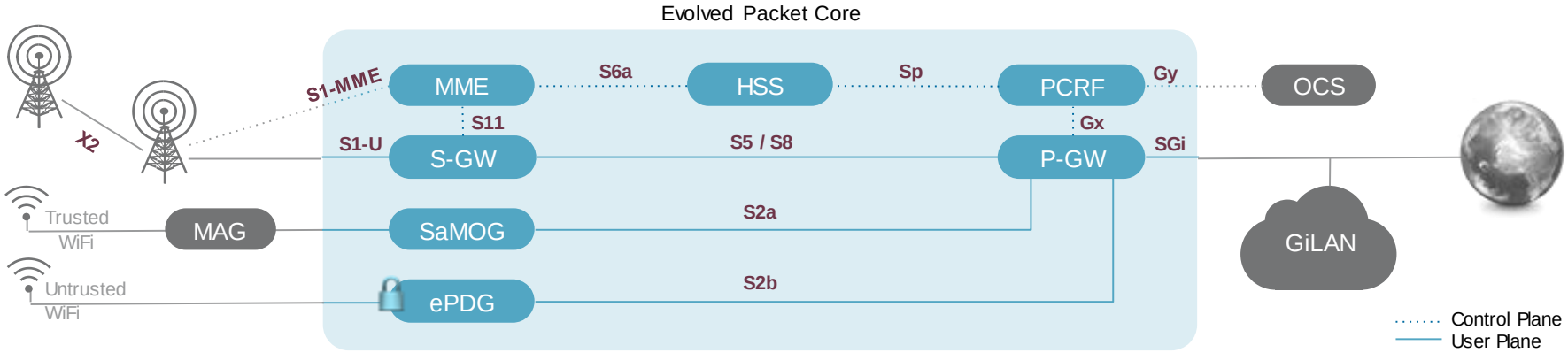
Evolved Packet Core (EPC)



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

Evolved Packet Core (EPC)



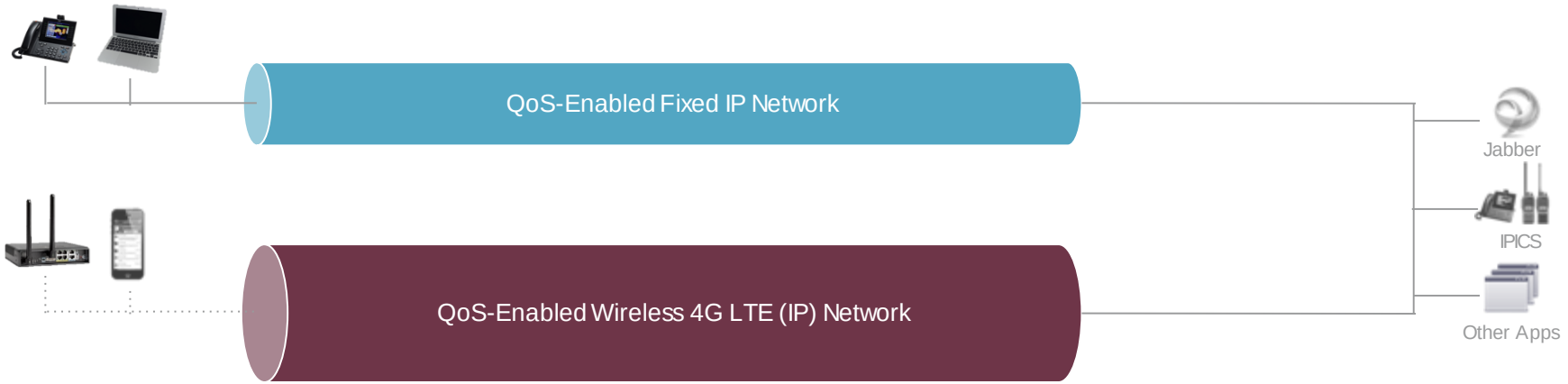
Diameter / SCTP Interfaces

- X2 – zero-packet loss handover & eICIC data exchange
- S1-MME – eNB to MME signalling
- S1-U – user plane between eNB and S-GW
- S11 – MME bearer establish and path switching control
- S6a – MME retrieval of subscriber data from HSS
- S5 / S8 – GTP bearer establishment from S-GW to P-GW
- S2a/b – PMIPv6 bearer establishment to P-GW
- Sp – Retrieval of per-subscriber policy data from PCRF
- Gx – Convey policy to P-GW and retrieve traffic data
- Gy – Online Charging System

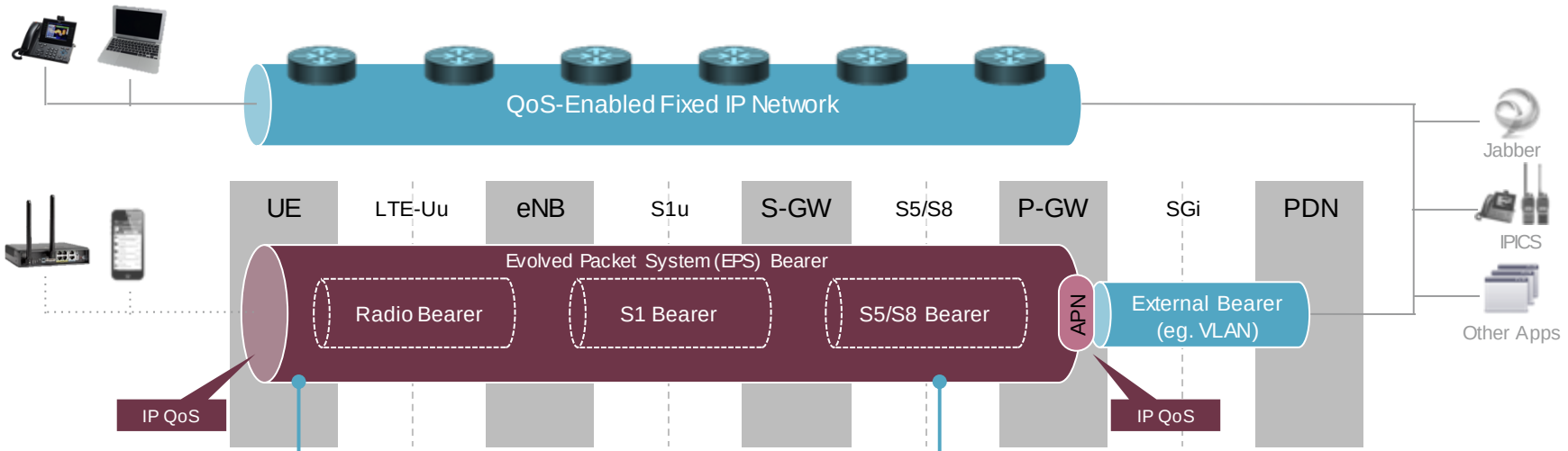
The Finer Points of Operation

Cisco live!

LTE Bearer Constructs



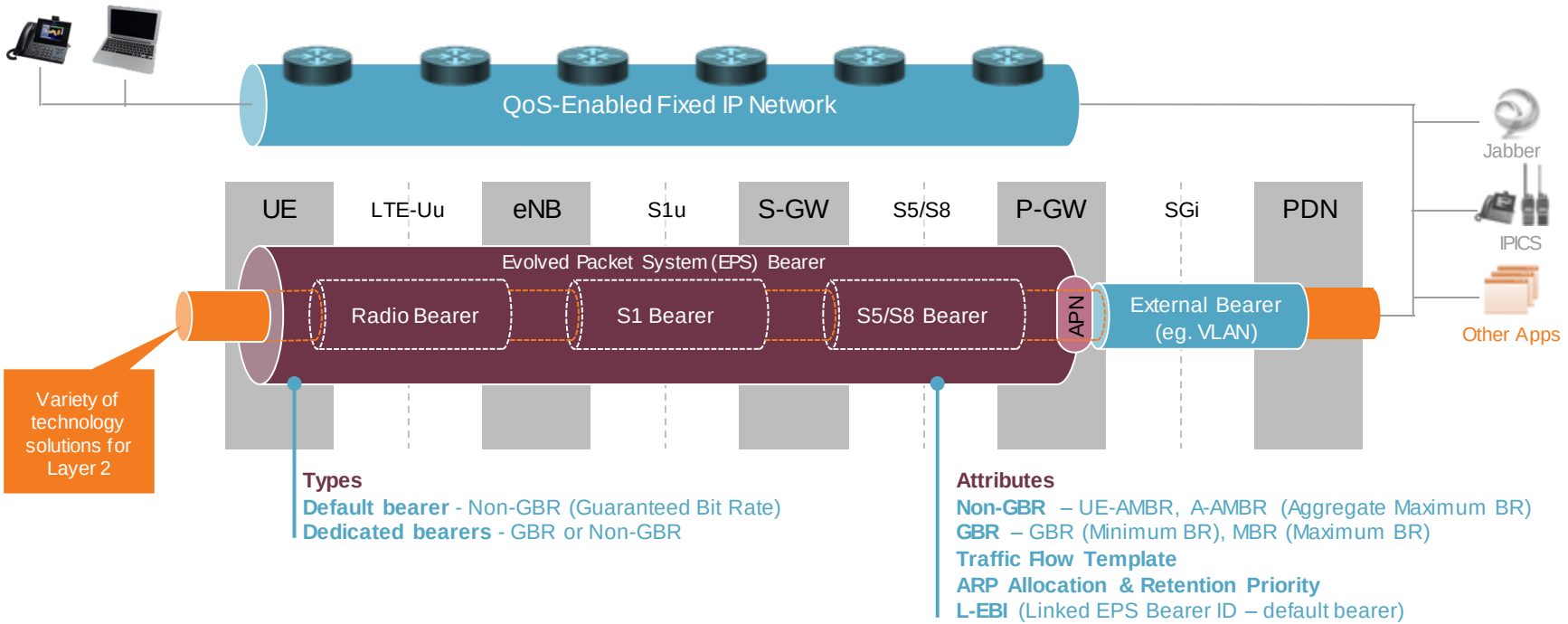
LTE Bearer Constructs



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

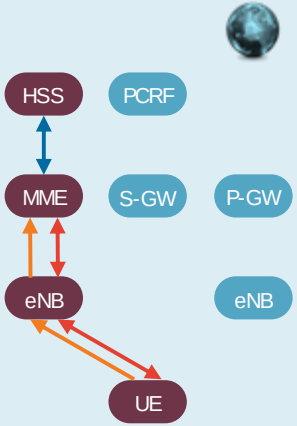
Attributes
Non-GBR – UE-AMBR, A-AMBR (Aggregate Maximum BR)
GBR – GBR (Minimum BR), MBR (Maximum BR)
Traffic Flow Template
ARP Allocation & Retention Priority
L-EBI (Linked EPS Bearer ID – default bearer)

LTE Bearer Constructs



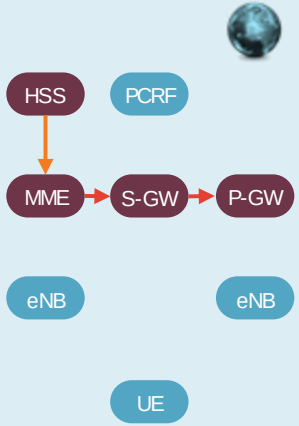
UE Initial Attach

1. Attach Request



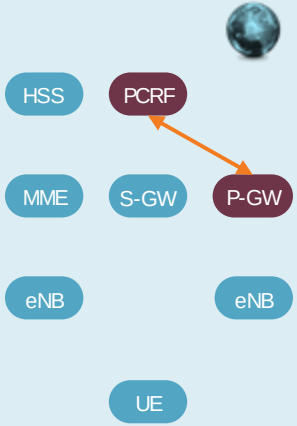
1. UE listens for resources
2. Attach Request
3. Identity Exchange
4. Authorisation

2. Bearer Request



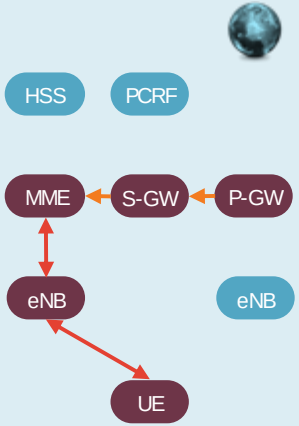
1. User Profile Download
2. Bearer Request

3. Bearer Authorisation



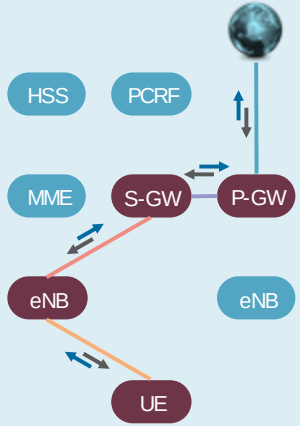
1. Policy and charging request & application, including bearer details & traffic flow

4. Bearer Accept



1. Bearer Accept
2. Attach Accept / Complete

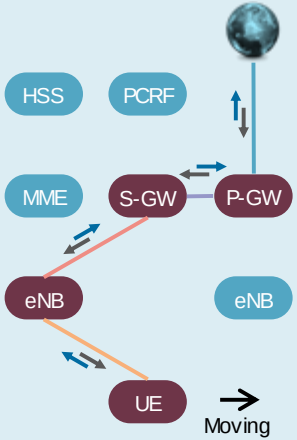
5. Uplink & Downlink



1. Radio Bearer
2. S1 Bearer
3. S5 Bearer
4. UL / DL Data

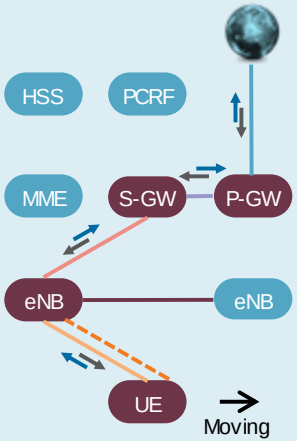
UE Inter-Cell Handover with X2

1. Before Handover



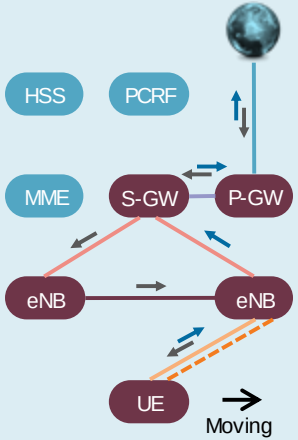
1. Radio Bearer
2. S1 Bearer
3. S5 Bearer
4. UL / DL Data

2. Handover Preparation



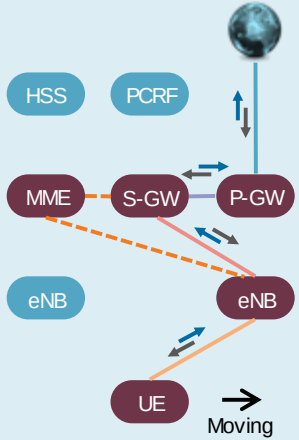
1. Source eNB makes handover decision
2. X2 Bearer setup between source and target eNB

3. Handover Execution



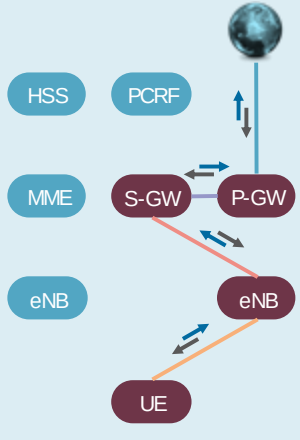
1. Source eNB breaks bearer
2. Target eNB buffers packets
3. Attach to Target eNB
4. Direct Packet Forwarding DL traffic from Source eNB

4. Handover Completion



1. Path Switch procedure between MME and Target eNB
2. Release Source eNB S1 bearer
3. Release X2 Bearer

5. After Handover

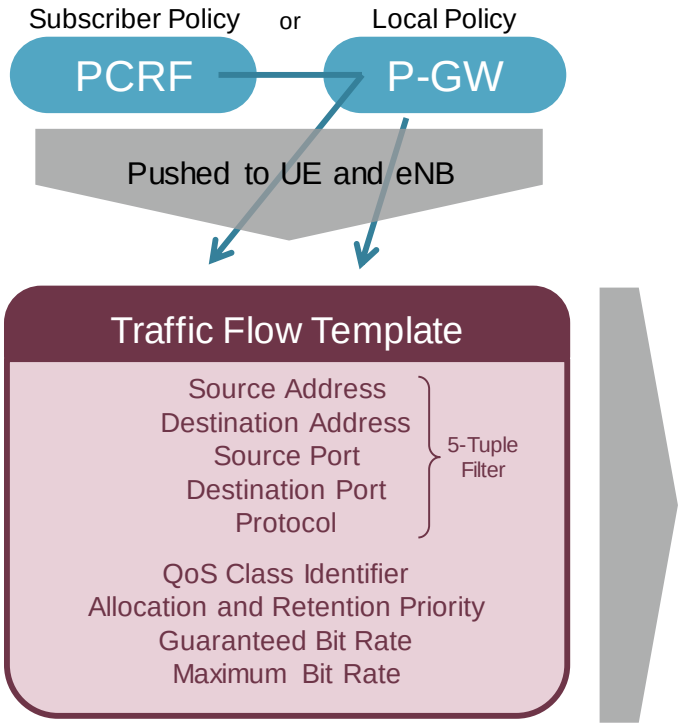


1. Radio Bearer
2. S1 Bearer
3. S5 Bearer
4. UL / DL Data

Quality of Service

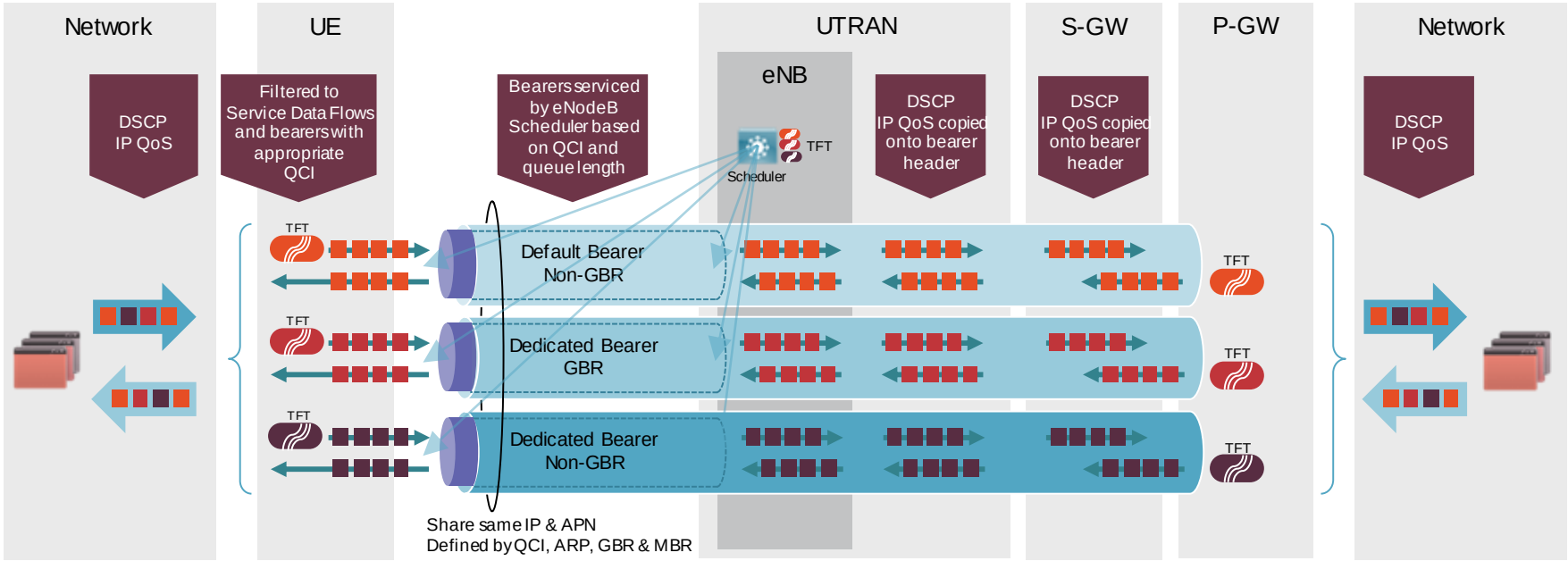
DSCP	Bearer	QCI	TFT	eNB Scheduler	ARP
Differentiated Services Code Point	Default and Dedicated	QoS Class Identifier	Traffic Flow Template	eNodeB MAC Scheduling Interface	Allocation and Retention Priority
Classifies packet priority at network ingress.	Established between UE and eNB.	Specifies treatment 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

Traffic Flow Templates and LTE QCI



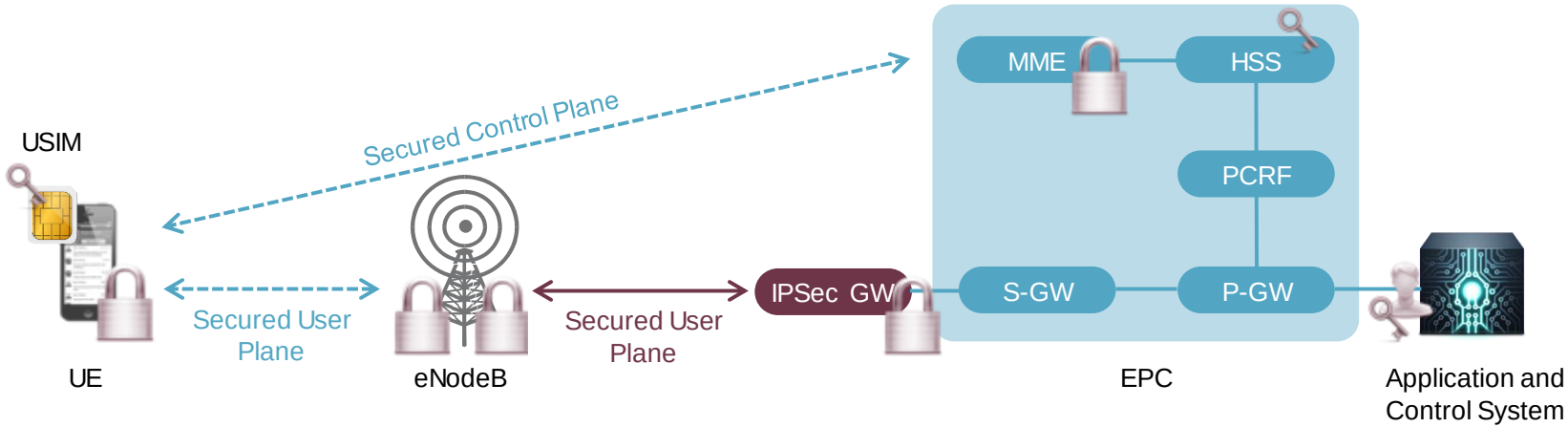
QCI	Resource Type	Priority	Packet Delay Budget (mS)	Packet Error Loss Rate	Example Service
1	GBR	2	100	10^{-2}	Conversational Voice
2	GBR	4	150	10^{-3}	Conversation Video (live streaming)
3	GBR	5	300	10^{-6}	Non-Conversation video (buffered streaming)
4	GBR	3	50	10^{-1}	Real-time gaming
5	Non-GBR	1	100	10^{-6}	IMS signalling
6	Non-GBR	7	100	10^{-3}	Voice, video (live streaming)
7	Non-GBR	6	300	10^{-6}	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

LTE QoS in Practice



Note **CAUTION** with Guaranteed Bit Rate bearers. If the eNB can't support the GBR and QCI, the bearer will fail onto the default non-GBR bearer. **Guaranteed is Guaranteed, not Attempted.**

Security

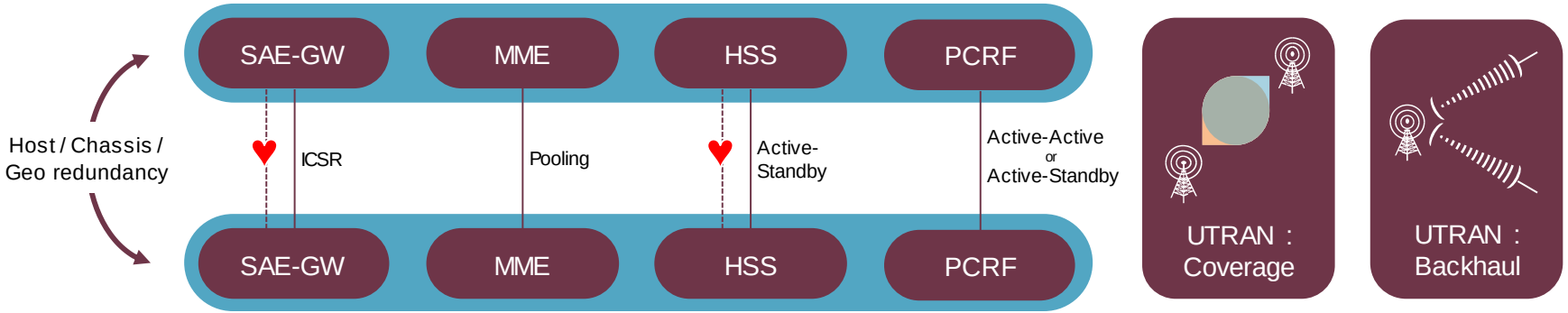


IoT risk is less from interception, more from DoS and/or device spoofing

1. USIM controls authenticated network access & ciphering. Risk = authorised USIM with unauthorised user or device
2. IPSec option to secure S1u – essential if RAN sharing
3. Token (USIM) PLUS application-level access to private systems recommended (tunnels)
4. IMEI (International Mobile Equipment Identity) whitelists; in HSS or policy (PCRF) to control legitimate device access

High Availability

High Availability



Active & Standby kept in lock-step by L2/L3 connection for Inter-chassis Session Recovery (ICSR).

Standby assumes control of Virtual IP when master failure detected.

MME's arranged as pooled resources.

No service impact to UE until next mobile management event (hand-over, timeout). UE's will detach bearer and re-attach via different MME in pool.

1:1 redundancy enabled by active-standby monitoring of heartbeat, with Virtual IP change on failure.

Configuration and counters changes cloned from active to standby at initialization and regular intervals.

PCRF (Cisco QPS) supports n+1 redundancy in active-active or active-standby configurations.

Separate carriers, overlapping sectors originating from the same or separate eNodeB sites.

200% coverage target.

Dual-home backhaul links over redundant systems / paths.

Unnecessary when providing 200% coverage from separate eNodeB sites.

LTE in IoT

Making It Happen

Cisco live!

Different Approaches Exist

LTE QoS

Leverage capabilities of LTE QoS, activated by SP to provide priority network access (eg ARP, QoS, QCI, LANES)

MVNO

Mobile Virtual Network Operator

Leverage SP UTRAN and Session Management infrastructure. Apply own policy, user management and network interfaces.

Private LTE

Establish coverage where public networks don't reach, or provide specific performance or control.

When Private LTE

Coverage

Inadequate breadth or depth of coverage.

Quality of Service

Not enabled, or available options not fit for purpose.

Allocation Retention

No pre-emptive dropping of lower-priority users.

Service Level Agreements

Performance and availability service levels don't meet needs.

Trust

Lack of faith in ability to meet service levels – zero tolerance for breach.

Commercials

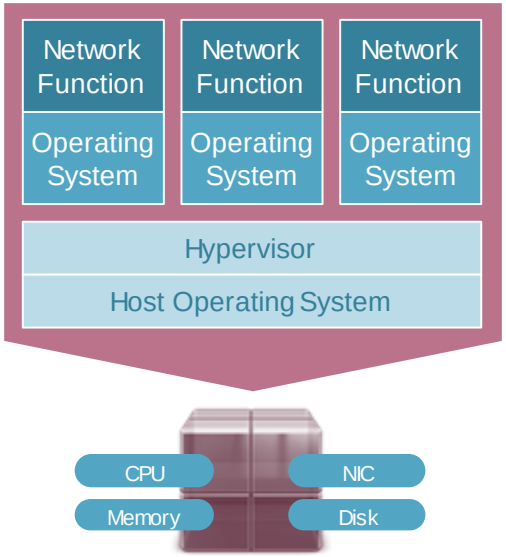
Cost (and structure) of providing services and features prohibitive.

Viability underpinned by economies of virtualisation

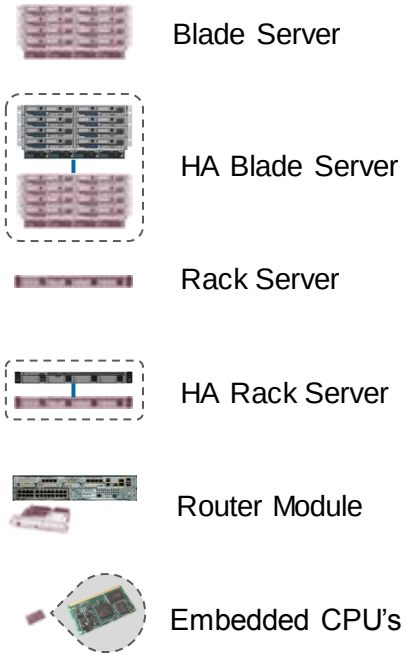
SP-grade infrastructure at enterprise price point

Virtualisation

Hardware Optimised Platforms



- Fast Scaling
- Platform Consolidation
- Auto-Restoration (Self-Healing)
- Miniaturisation

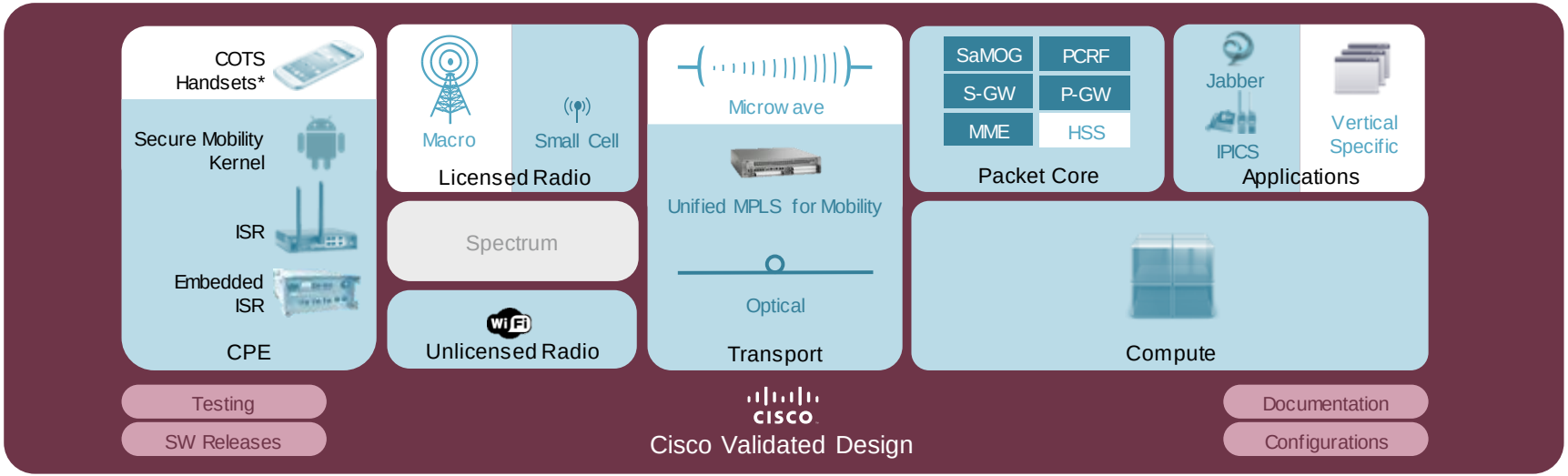


In Perspective …

Evolved Packet Core *for public LTE*

Evolved Packet Core *for Private LTE*

Cisco Premium Mobile Broadband Architecture

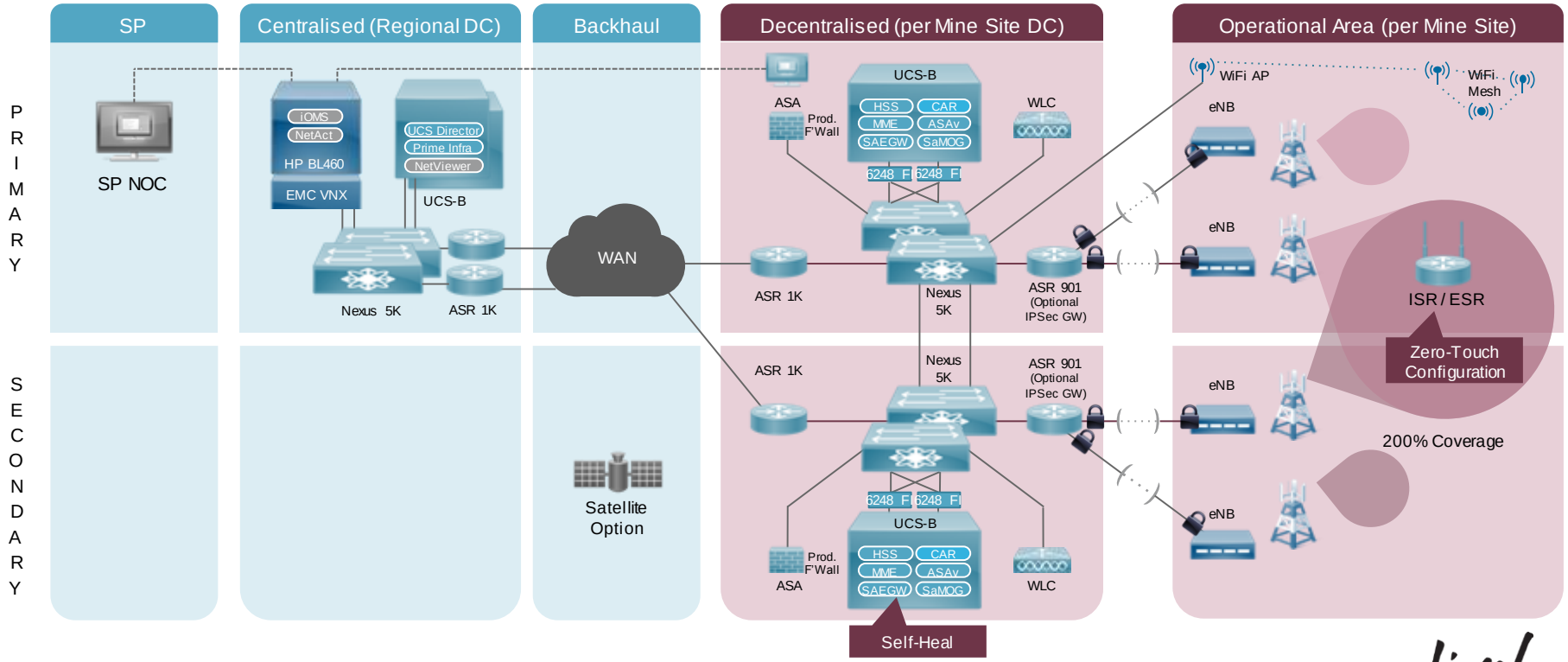


Static
(Site)

Tactical
(Portable / Vehicle)

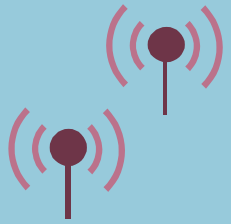
Tactical
(Personal)

Practical Implementation: Mining



Heterogeneous Networks

Single operational policy, security and charging* regime



HSS Authentication
PCRF Policy & Charging
Seamless Authentication
Content Accessibility

802.1X Auth & Policy
AAA / CDR Charging
Reduced complexity
Lower cost of service

Integrated or Separated

Macro

High Bandwidth
Broad Coverage
OT & Comms

Small Cell

High Bandwidth
Infill Coverage
OT & Comms

WiFi / Mesh

Very High Bandwidth
Focussed Coverage
IT, BYOA, General

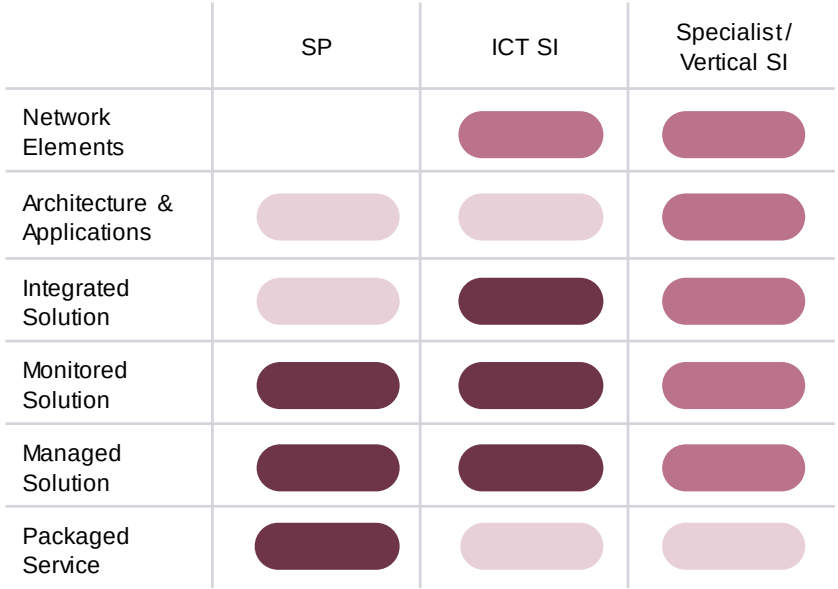
Private LTE Strategy Priorities

1. **Access to Spectrum**
2. **Device Options**
   Band, Form, Durability
   Performance, Cost
3. **Technology Selection**
   Band, Duplex
4. **Platform Selection**
   Form, Cost, Performance

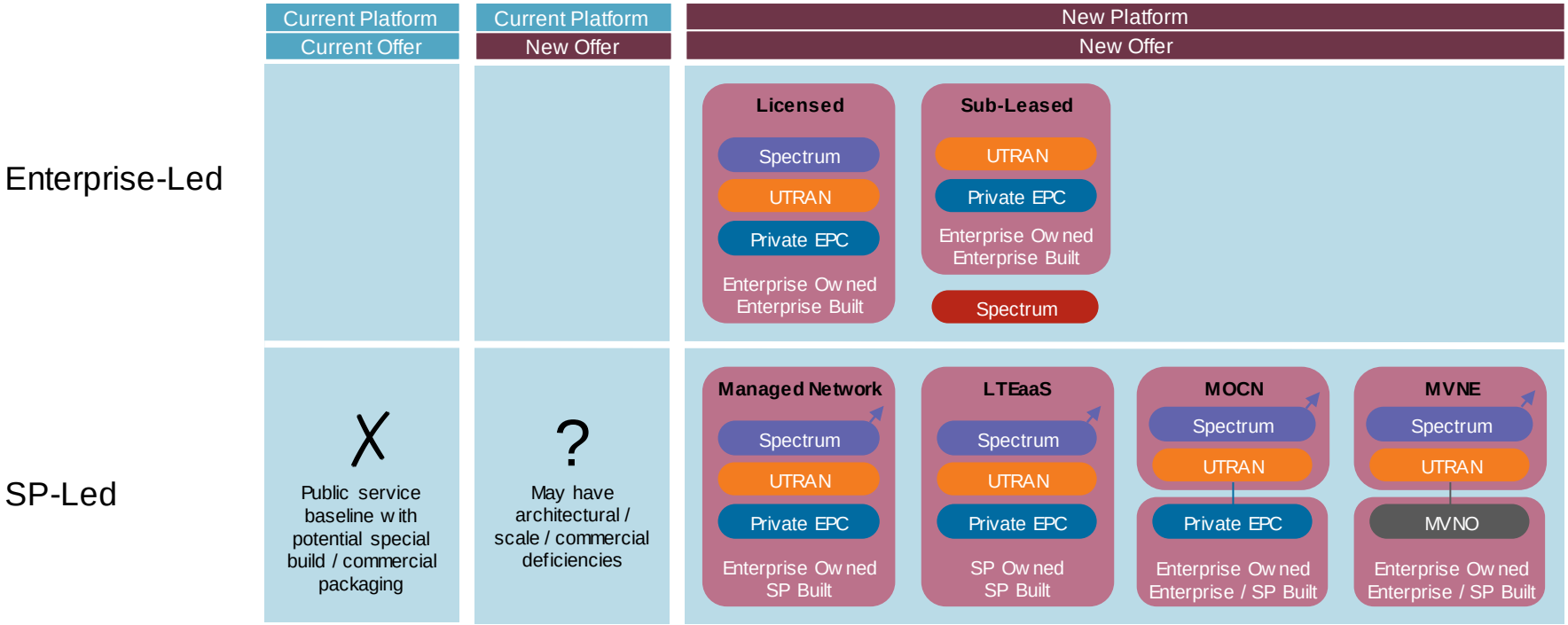
Procurement Considerations

- Spectrum
  - Are you entitled?
  - Is it available? Who has it?
  - How much are they using?
  - What bands?
  - License, Sub-license, Procure
- Technology & Solution
  - Build or Buy
  - End-to-end scope
  - Performance Requirements
  - Operational life
- Expertise
  - Design; network & radio
  - Implement / Integration
  - Operate
- Commercials
  - CAPEX or OPEX, Fixed or Variable Consumption
  - Risk Appetite

Required Outcome



Delivery Models



Private LTE Complications: Combined Attach

UE Attachment Modes
Ref. 3GPP Specification 24.301

1	PS Mode 1 UE registers to LTE-only services Usage setting is “voice centric”	Future VoLTE-only Phones	✓
2	PS Mode 2 UE registers to LTE-only services Usage setting is “data centric”	Data Modems / Routers	✓
3	CS/PS Mode 1 UE registers to LTE and non-LTE services Usage setting is “voice centric”	Today’s Phones & Tablets	
4	CS/PS Mode 2 UE registers to LTE and non-LTE services Usage setting is “data centric”		

- ✓ IP Multimedia Subsystem (IMS)
- ✓ Circuit-Switched Fallback
- ✗ No IMS
- ✗ No IMS, No Circuit-Switched Fallback
- ✓ API / Kernel change to PS Mode 1/2
- ✗ EPC IMS Spoofing (non-3GPP compliant)

CS/PS Mode 1 attaches with ‘IMS voice not available’ and ‘CS Fallback not preferred’ responses will disable E-UTRA (LTE) capability.

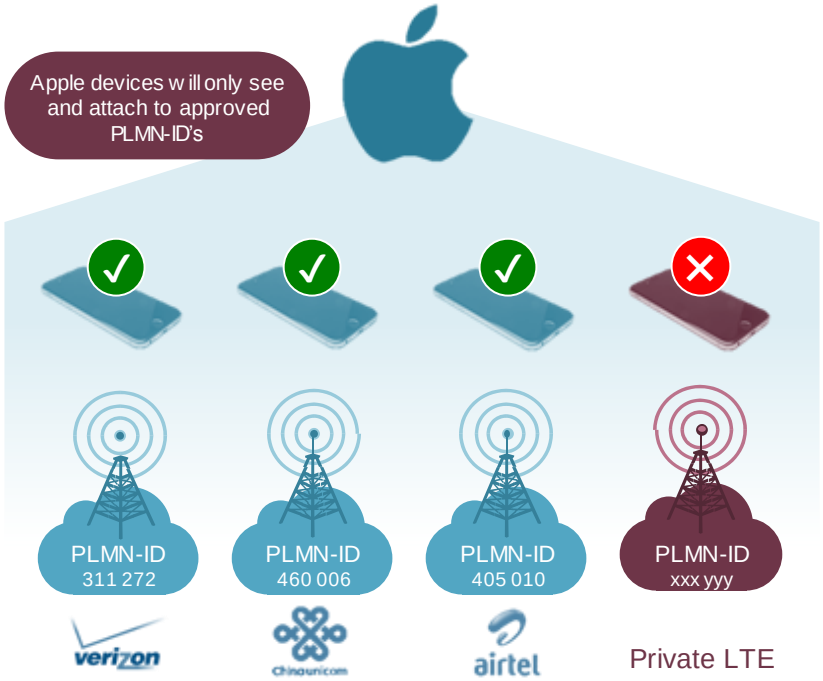
Private LTE Complications : Apple Compatibility

Public Land Mobile Network
Unique Identifier

PLMN-ID	
MCC	MNC

MCC = Mobile Country Code
Allocated by International Telecommunications Union (ITU)

MNC = Mobile Network Code
Allocated by Country Regulator



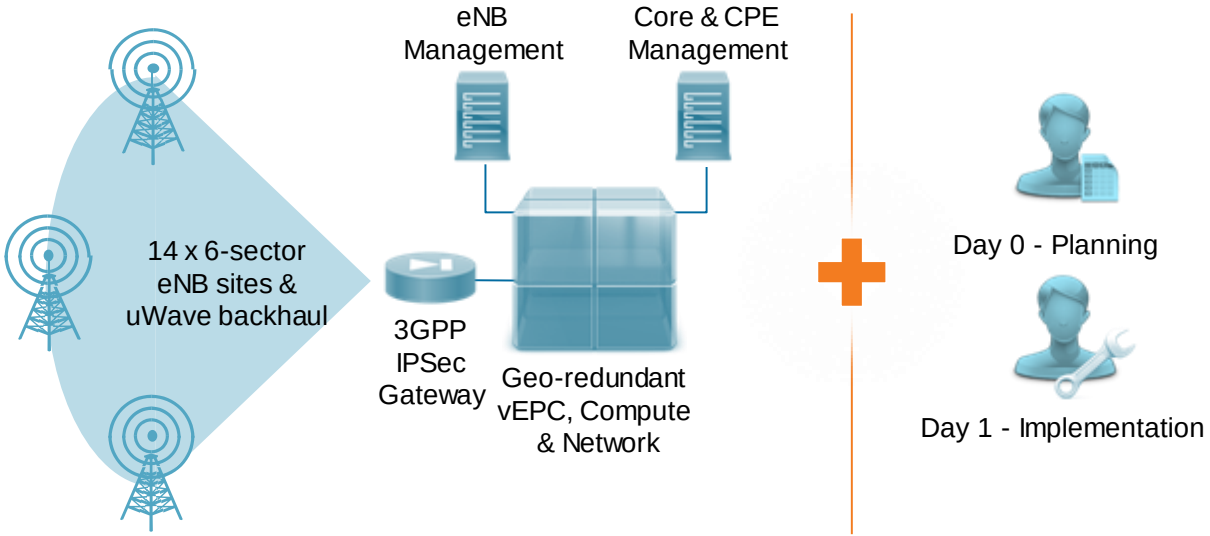
Supporting Apple Devices

Private LTE USIM

Private LTE USIM
Apple-approved deployment
Updated iOS release

Public SP LTE USIM
Existing PLMN-ID approval
Mngd Network, LTEaaS, MVNE

Commercial Profiling



Wrapping Up

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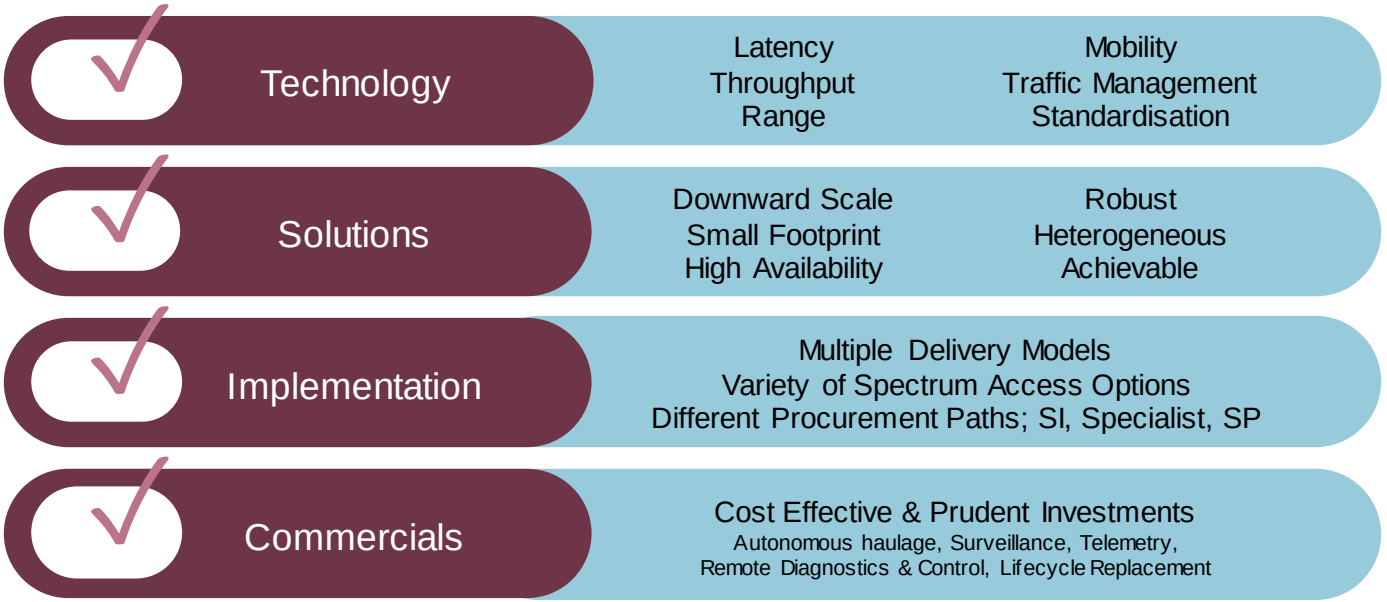
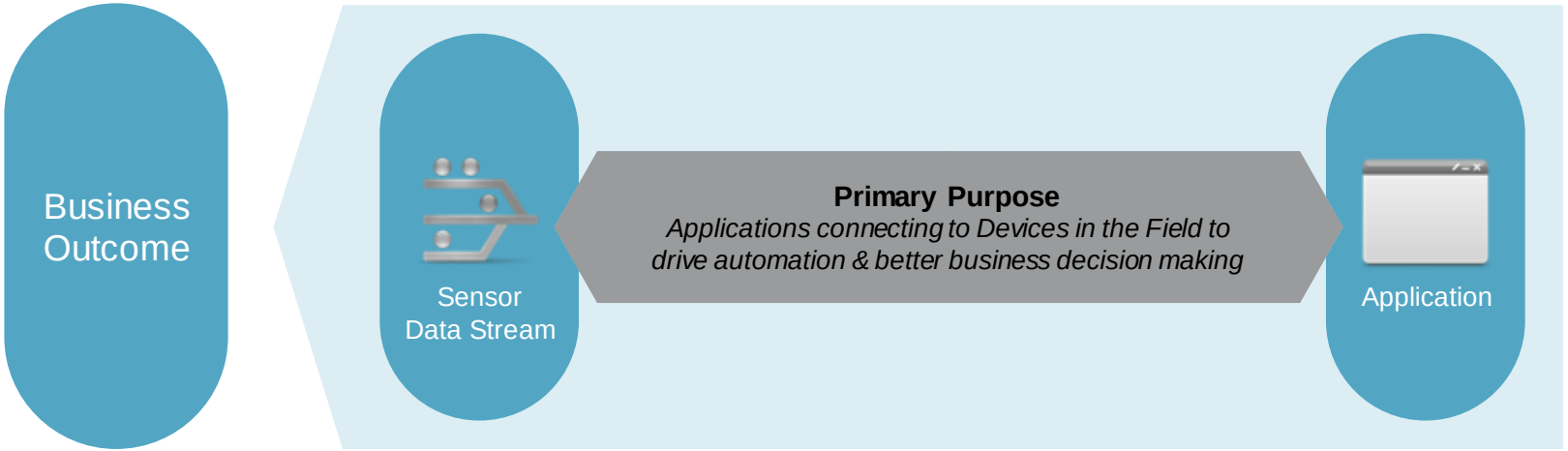
Viability Test – Private 4G LTE in IoT

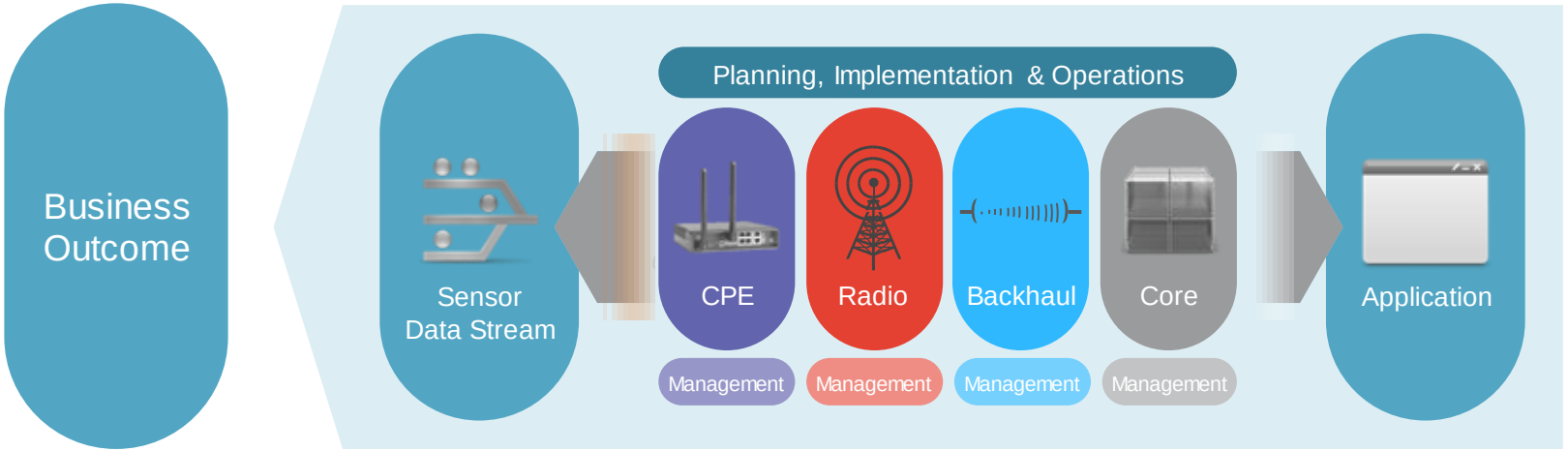


Keep the Objective in Mind



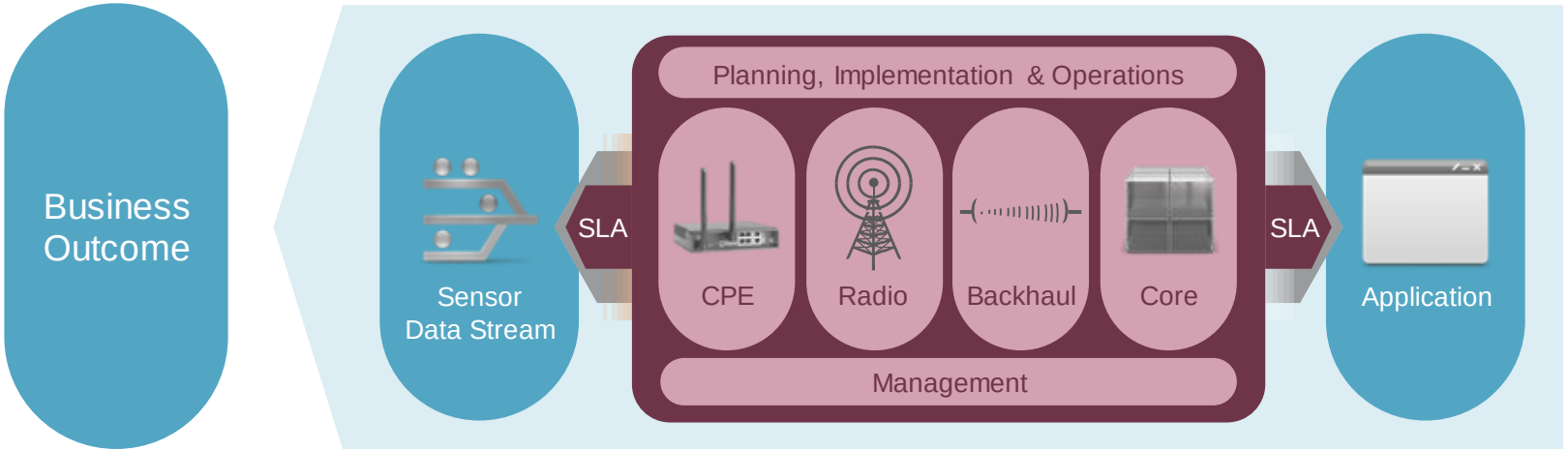
1 LTE is the Enabler, not the Solution

Keep the Objective in Mind



1. LTE is the Enabler, not the Solution
2. Avoid Pillars of Fragmentation

Keep the Objective in Mind



1. LTE is the Enabler, not the Solution
2. Avoid Pillars of Fragmentation
3. Pursue partners with End-to-End capabilities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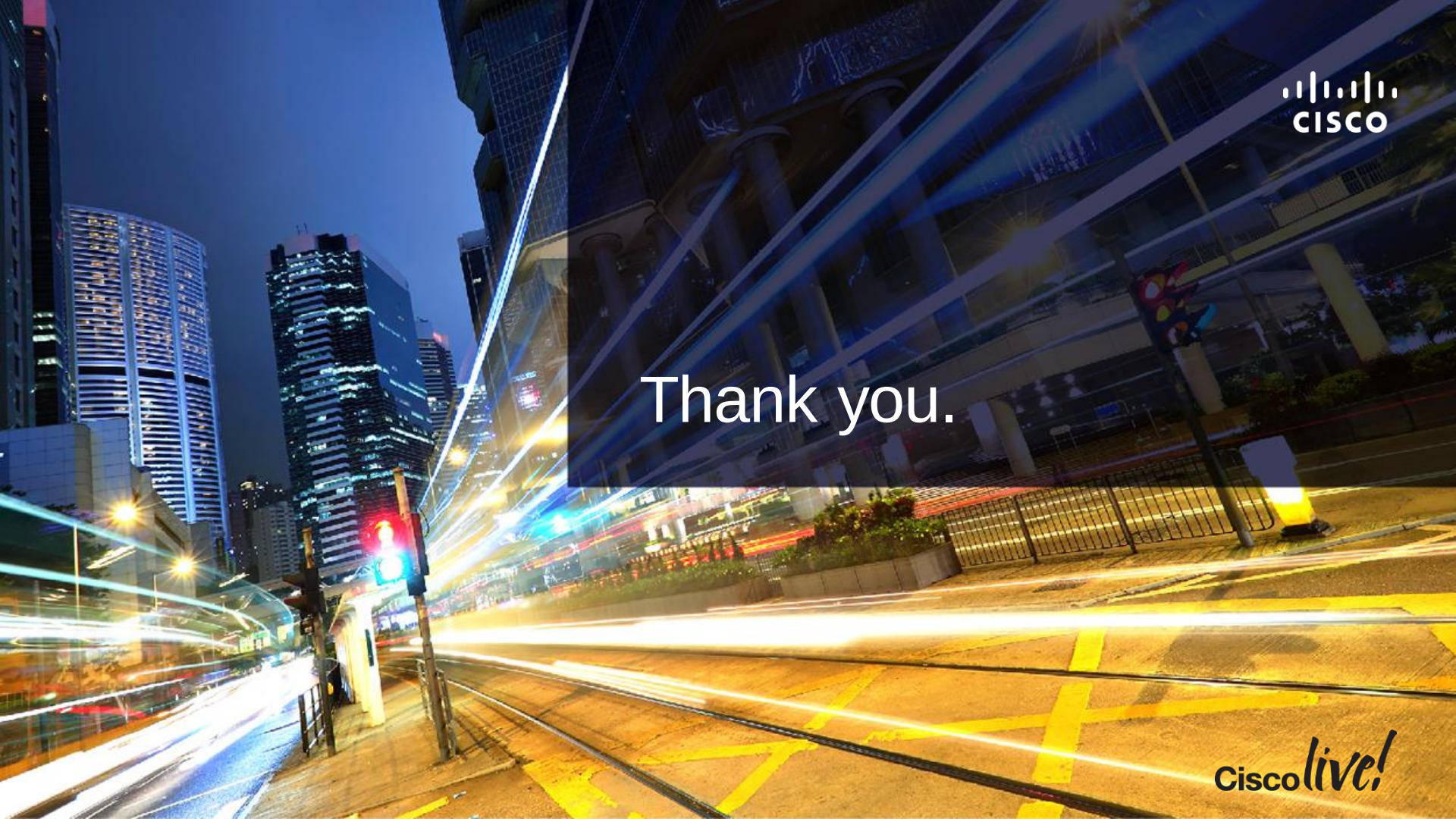
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