Trends in Mobile Network Architectures

3GPP LTE | Mobile WiMAX | Next Generation Mobile Networks

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Outline

1 Next Generation Mobile Networks

2 New Radio Access Network Architectures

3 Some Technology Trends

4 Conclusions

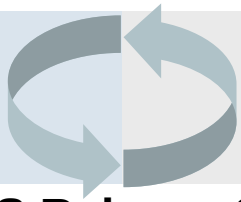
Next Generation Mobile Networks

Siemens NGMN Vision

Mobile broadband network architecture that delivers services at fixed line quality with costs of IP technologies

- **IP-optimized mobile network for all types of communications services**
  - Enables network and service consolidation on IP technology
  - Simplified architecture in order to reduce total cost of ownership
- **New packet-optimised radio technologies for mobile broadband**
  - Evolution beyond UMTS and High Speed Packet Access (HSDPA/HSUPA)
  - Full support of mobility, security and quality of service
  - Improved throughput, latency and cost per bit

Significant interdependence between Radio Technology and Radio Access Network Architecture



Radio Technology	RAN Architecture
UMTS Release 99:	
▪ Wideband CDMA with macro-diversity combining	▪ All radio layers terminate in the Radio Network Controller
▪ Quasi circuit-switched mode of operation	▪ Support of both circuit-switched and packet-switched CN domain
HSDPA (UMTS Release 5) and new OFDM-based radio technologies:	
▪ No macro-diversity combining between base stations	▪ Functions move into the Base Station
▪ Packet-optimised scheduling	▪ Improved throughput & latency
▪ Hybrid ARQ (combining error correction and automatic repeat request)	▪ Only one type of core network (packet-switched)

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New Radio Access Network Architectures

Emerging mobile broadband radio technologies:

- IEEE 802.16-2004/802.16e (Portable and **Mobile WiMAX**)
- **3GPP Long Term Evolution** ("Evolved UTRA and UTRAN")
- **Others** (e.g. Flash-OFDM and WiBro) with proprietary RAN architectures

Corresponding Radio Access Network Architectures:

WiMAX Network Working Group's
WiMAX RAN Architecture

- Aligned to **DSL/cable architecture** and regulatory issues of broadband access
- Allows **separation of business roles**: Network **Access** Provider, **Network Service** Provider and **Application Service** Provider
- Based on **functional entities** and **reference points** that ensure interoperability without mandating specific network implementations

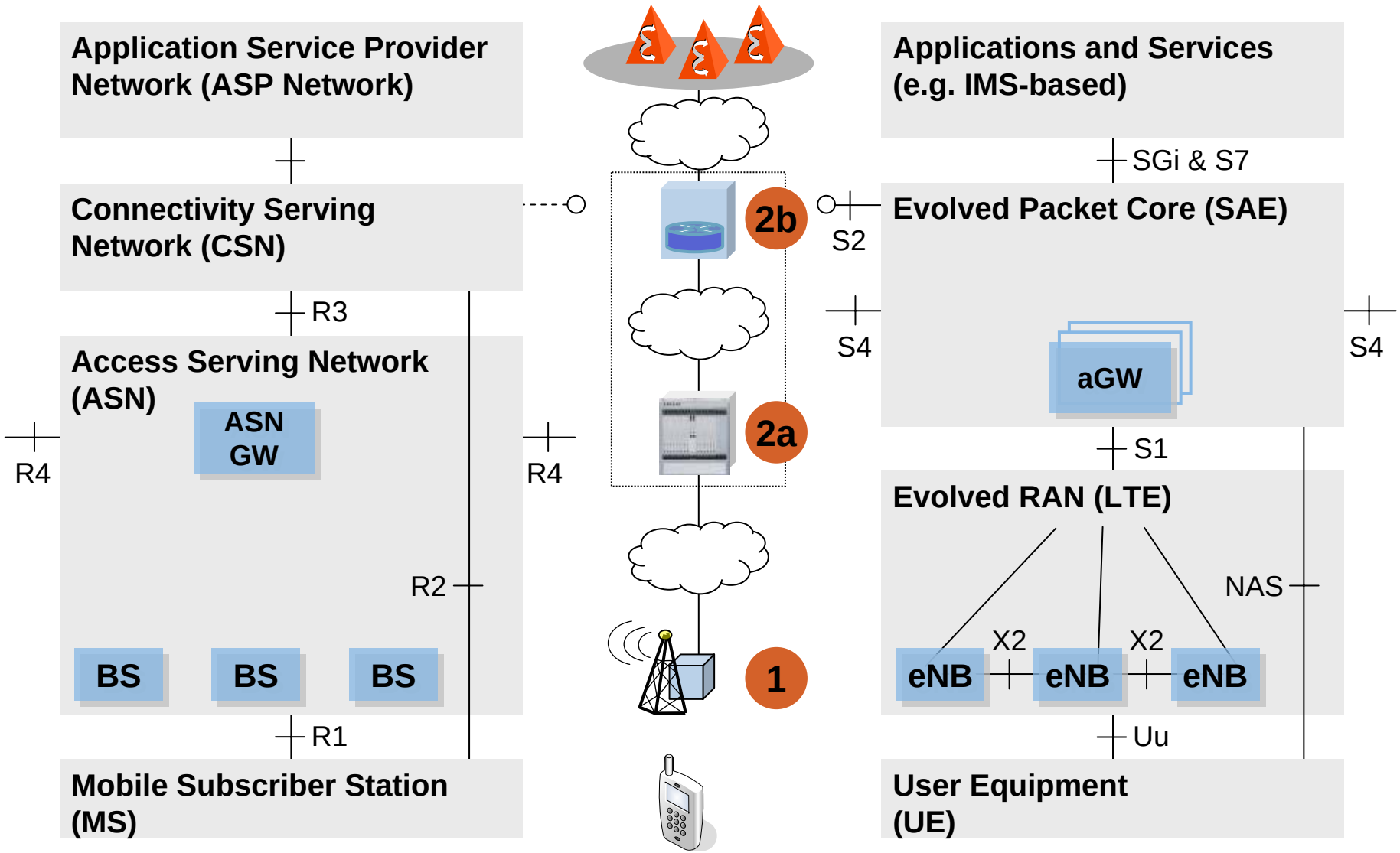
Evolved UTRAN (LTE)
accompanied by 3GPP System Architecture Evolution (SAE)

- Aligned to **existing 3GPP network deployments** and service architectures
- **Simplified architecture** for QoS-enabled high throughput / low latency services
- **Handover and interworking** with other 3GPP Radio Access Technologies (e.g. UMTS, HSPA and HSPA+) for a **smooth service introduction**

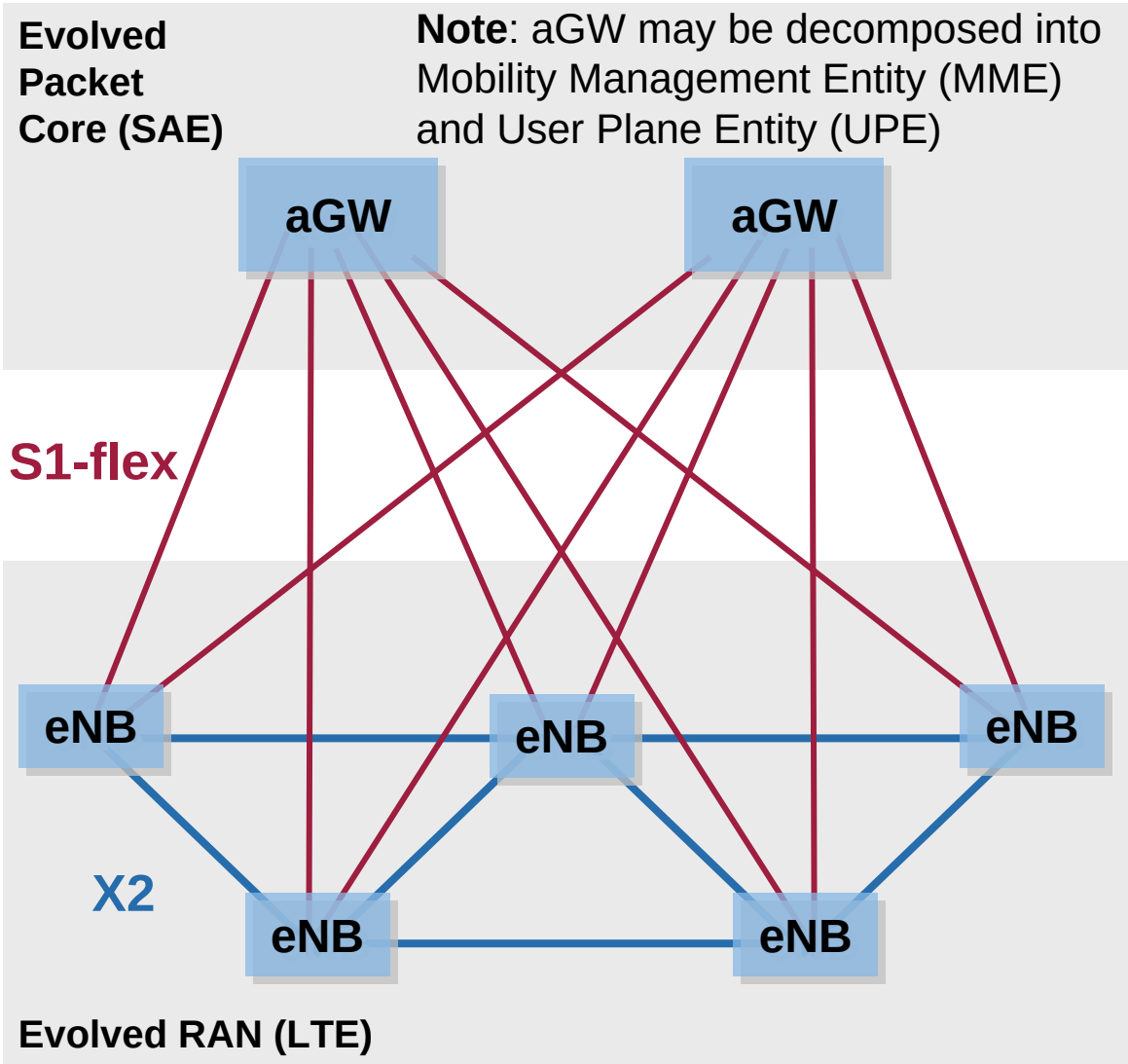
Network Architectures have 2 or 3 Types of Nodes

A) WiMAX Network Architecture

B) 3GPP LTE/SAE



3GPP LTE Network Architecture



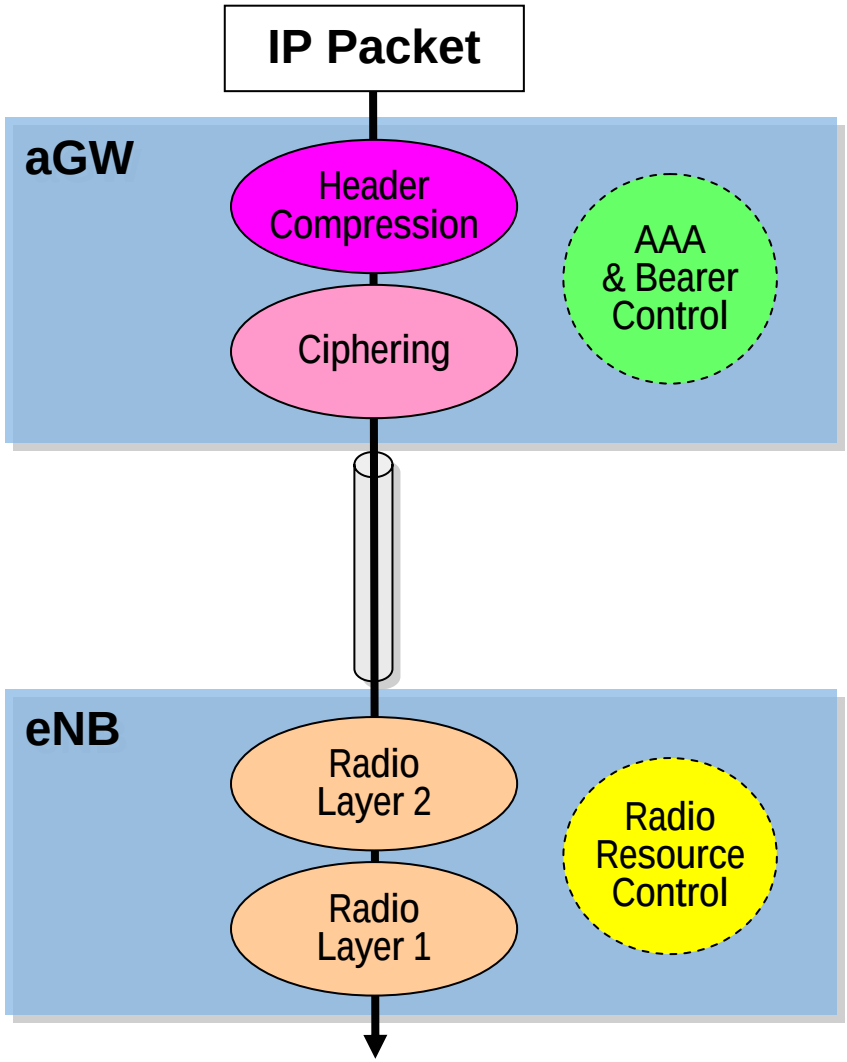
Two types of interfaces:

- **S1-flex:** Many-to-many relationship between "**enhanced NodeBs**" (eNB) and core network nodes (**Access Gateways**, aGW)
- **X2:** Direct interfacing between adjacent eNBs for handover and RRM

Advantages:

- Minimises single points of failure above eNBs
- All radio-related issues are handled in the RAN
- Allows RAN Sharing

3GPP LTE Network Architecture: Function Split



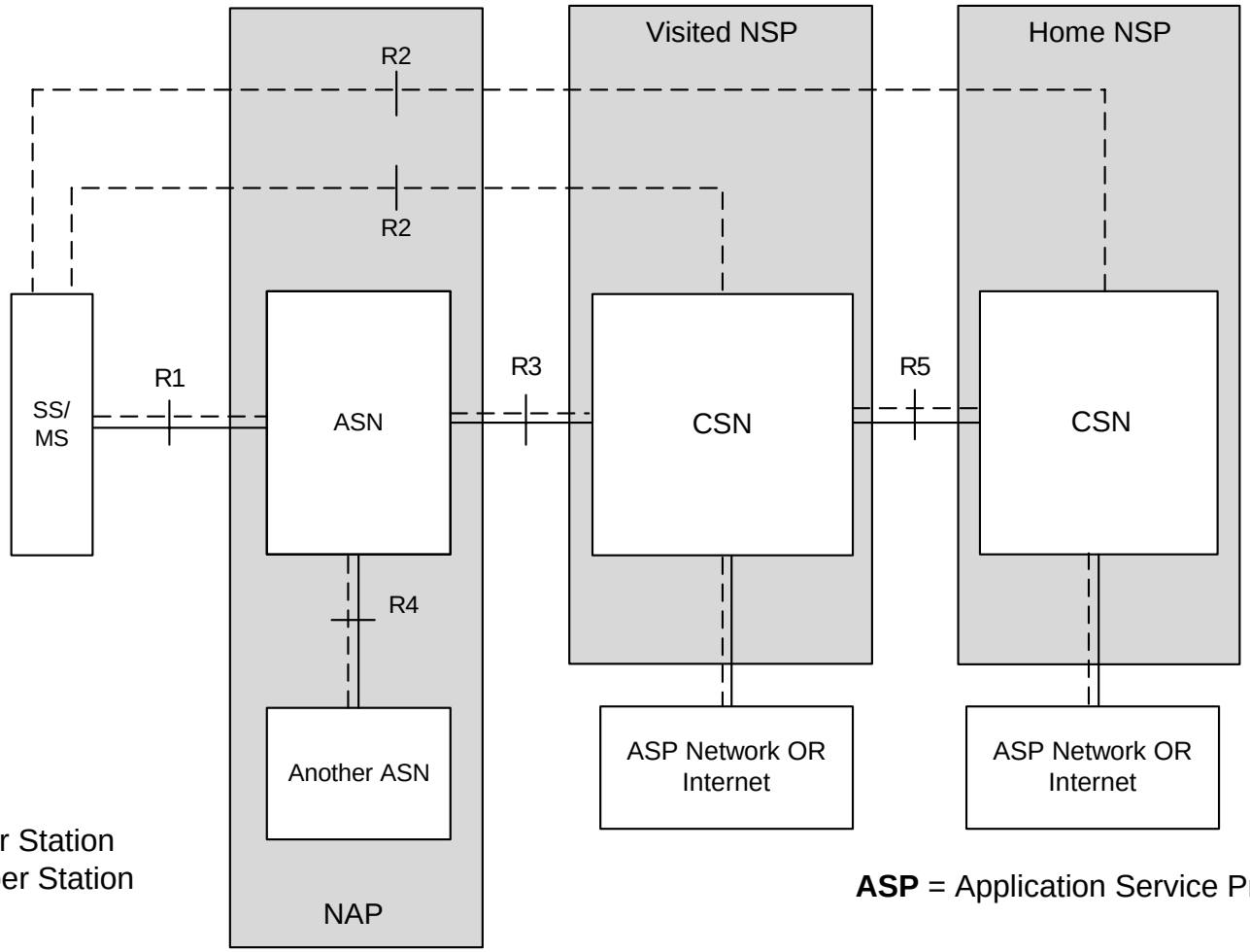
Strong security architecture:

- Sensible functions in the aGW:
  - Ciphering of User Traffic
  - Authentication and Authorisation of users and services
- Base stations can be connected over less secure networks
- (Successful) attacks on the base station have small impact

All radio-related functions in the eNB:

- high throughput / low latency packet-based scheduling
- operation of RAN is relatively autonomous from the core network (e.g. basis for RAN Sharing)

WiMAX Network Reference Model (NRM)



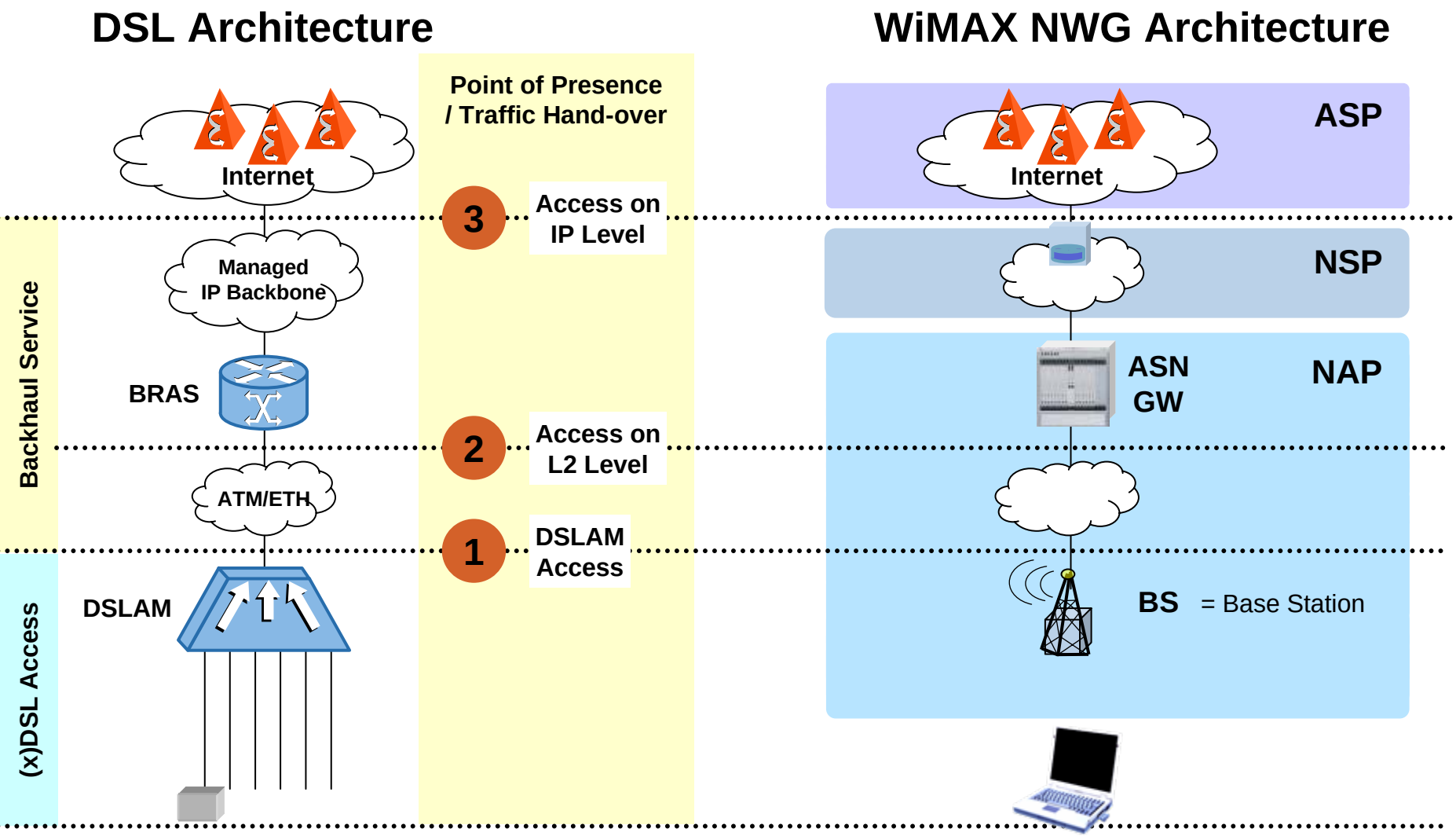
SS/MS = Subscriber Station / Mobile Subscriber Station

ASP = Application Service Provider

NAP = Network Access Provider
ASN = Access Serving Network

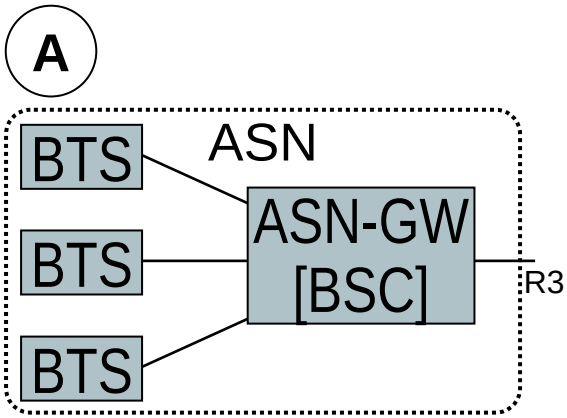
NSP = Network Service Provider
CSN = Connectivity Serving Network

WiMAX addresses the DSL/cable business

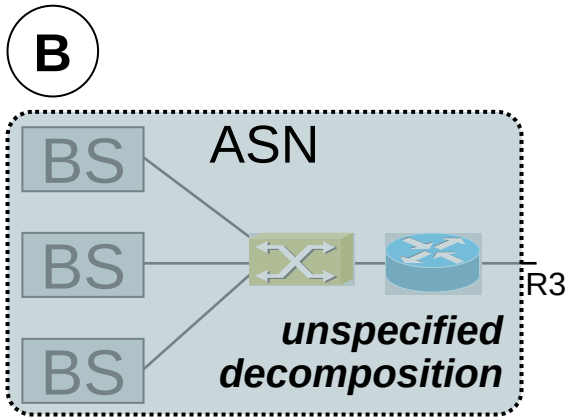


Function Split in the WiMAX Network Architecture

Three profiles defined for the Access Serving Network in Release 1:

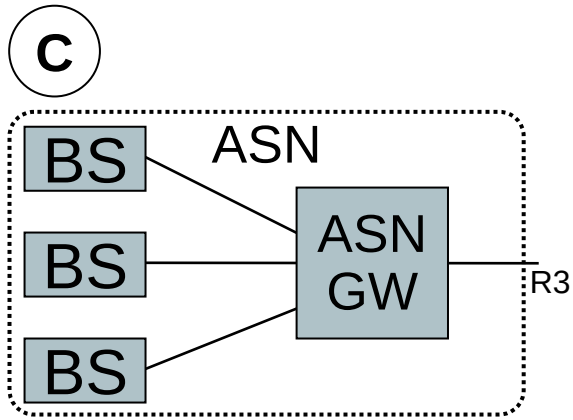


- PHY and partly MAC in BS/BTS
- **RRM in ASN-GW**
- Routing, AAA and Paging in the ASN-GW



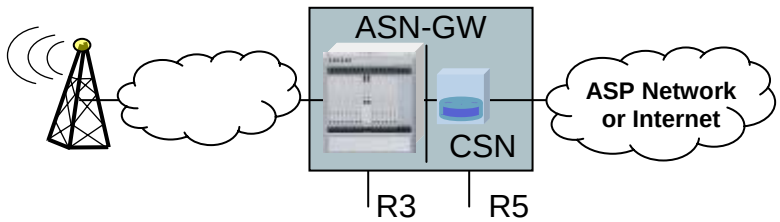
Unspecified, e.g.:

- most ASN functions in BS
- BS anchored by standard router
- Inter BS control over Ethernet



- **All radio-specific functions in the Base Station (BS)**
- **RRM in BS**
- Routing, AAA & Pg. in ASN-GW

Real deployments may combine parts of different functional entities within on network element. Example: ASN-Gateway with incorporated CSN functionality:



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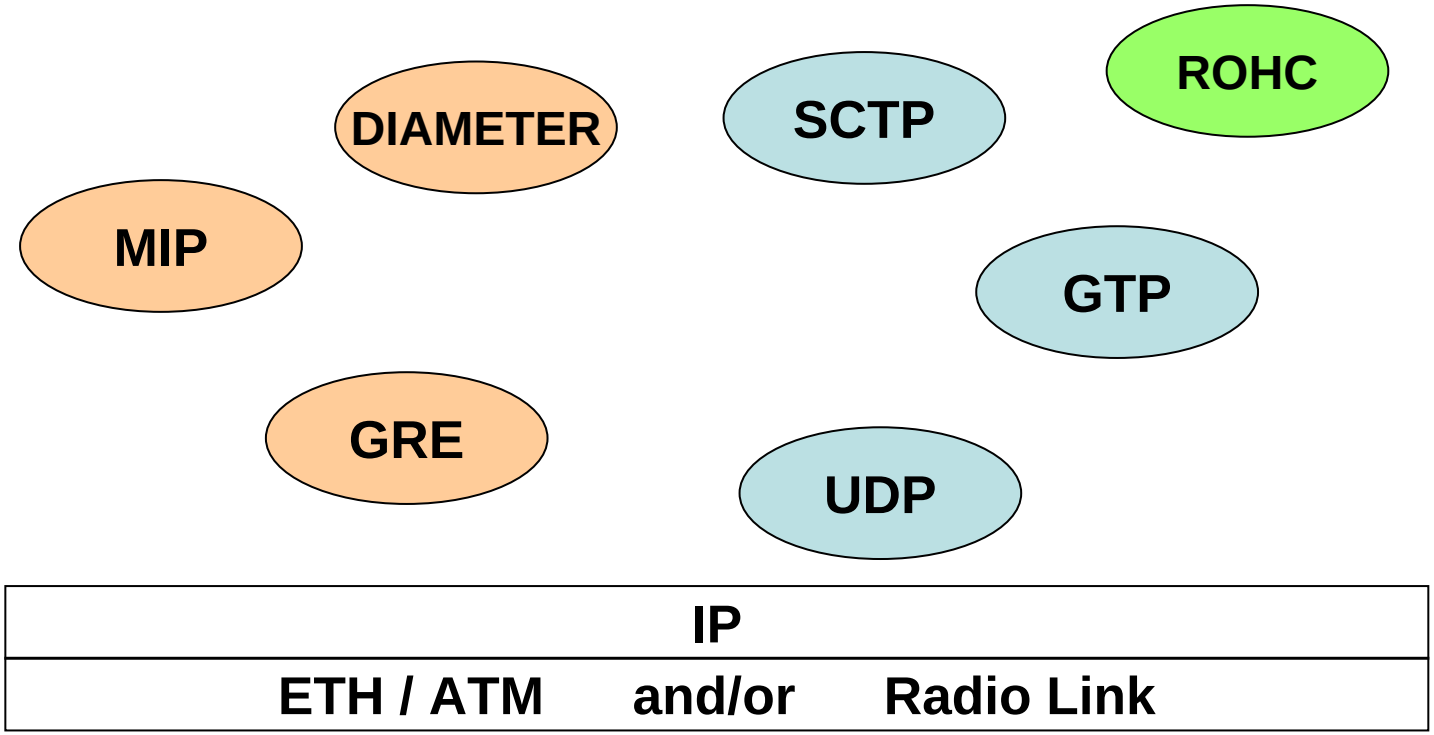
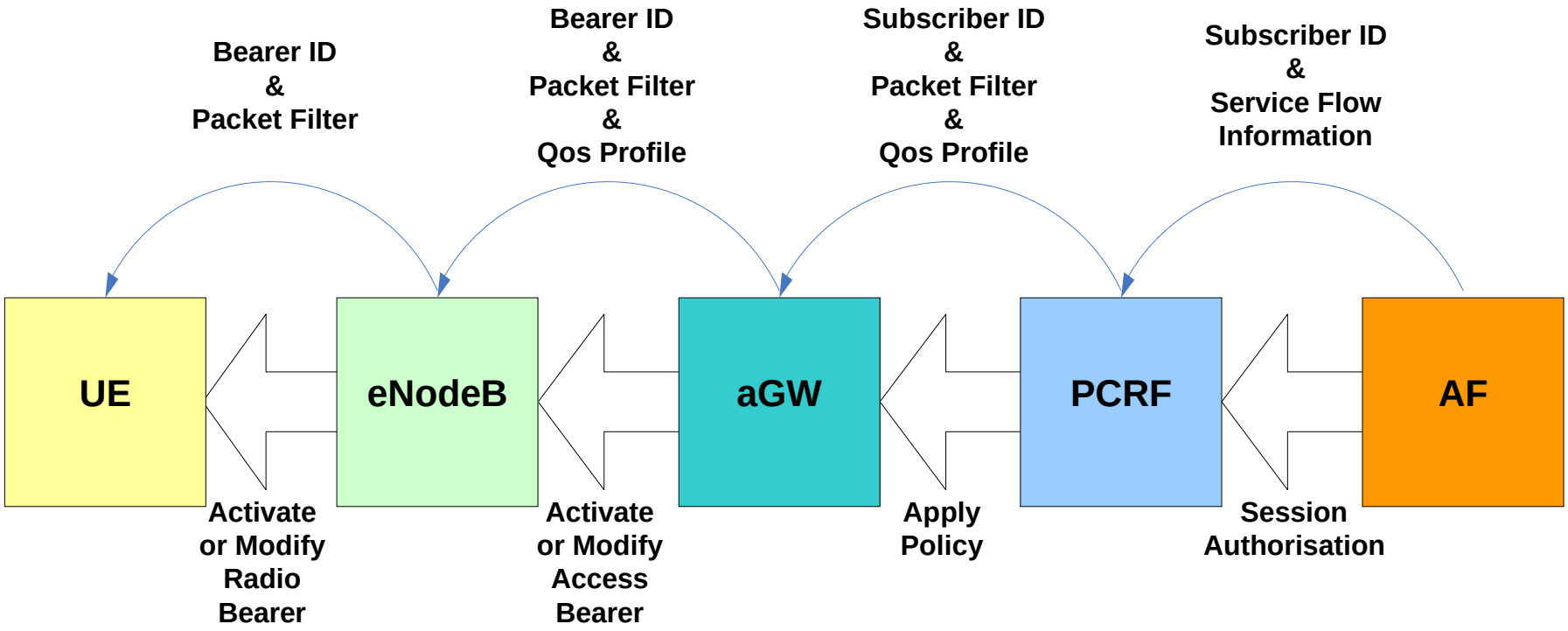
IP-based Transport and use of IP Protocols



All protocols relevant for LTE have already been introduced in 3GPP. Some (e.g. SCTP) are however used in a slightly different way.

Possibility to push QoS Profiles into the network
(from the application layer within the network)

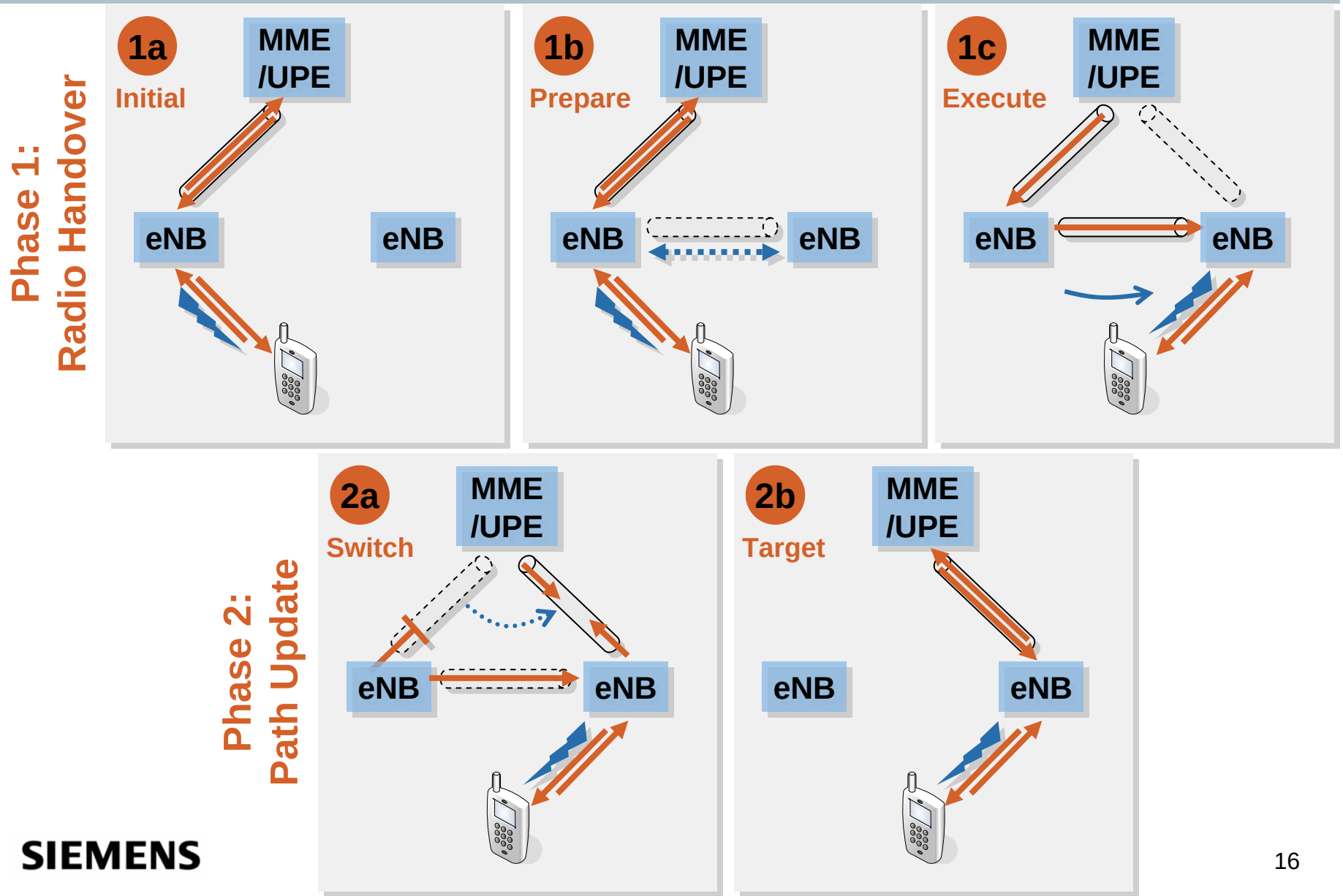
LTE/SAE QoS Architecture:



(similar approach in WiMAX)

PCRF = Policy & Charging Rules Function
AF = Application Function

Mobility mainly handled in the Access Network c.f. Handover in 3GPP LTE



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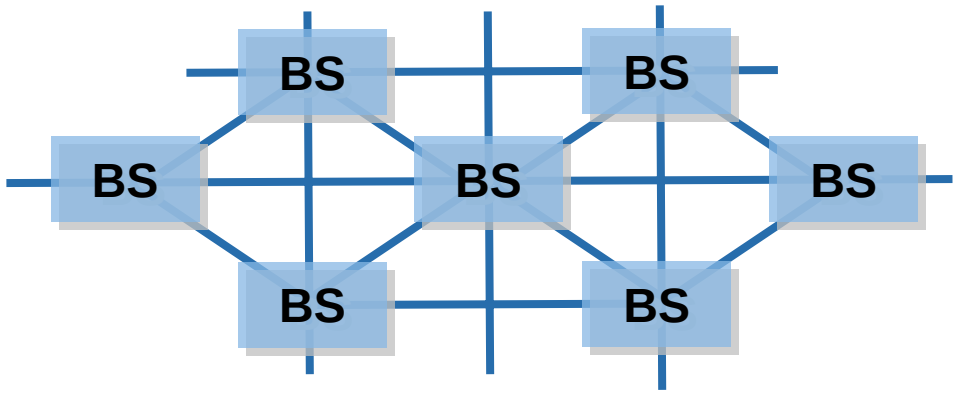
Challenges (1/2)
Inter-Cell Radio Resource Management (RRM)

Adjacent cells usually use the same frequency band.

Interference avoidance through co-ordination of radio resource usage between base stations is recommended.

Different approaches are conceivable:

- Semi-static (controlled by O&M)
- More dynamic / adaptive
  - Time-scale is in the order of seconds or higher (e.g. minutes)
  - Communication / co-ordination between base stations



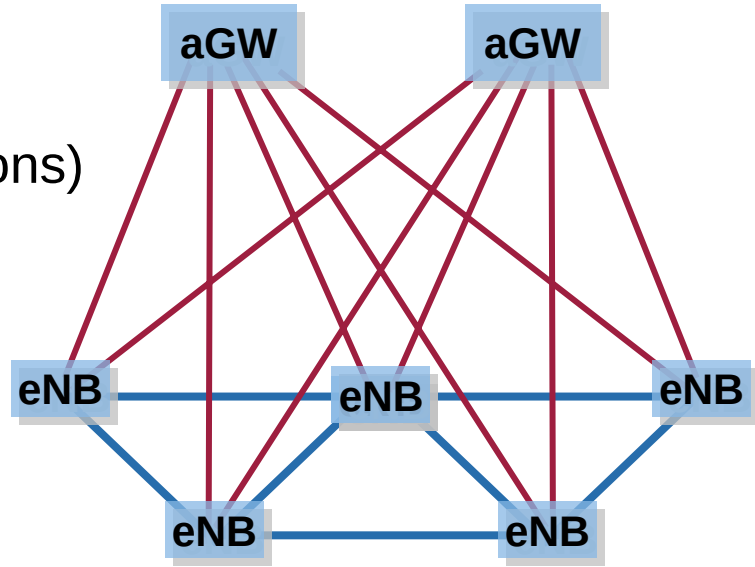
Peer-to-peer?

Hierarchical?

RRM Server?

Challenges (2/2)
Operation and Maintenance

Many interfaces
Many relationships (e.g. security associations)
Many parameters
No central “controllers” (e.g. RNC)



Approaches:

- Controlled by Operation and Maintenance Centre (OMC)
  + maybe some kind of “Logical O&M Server”
- More dynamic approaches (probably in addition to OMC):
  - Self optimisation (c.f. RRM)
  - Self testing and self healing
  - Maybe even self-configuration (“Plug-and-Play”)

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Conclusions (1/2)
New trends are already visible in recent UMTS Releases

Already in the UMTS Releases after Release 99 (i.e. Rel'4, Rel'5 & Rel'6), new trends in mobile network architectures set in:

- **IP-based transport** between network elements
- **Separation of Control and User Plane** in the Core Network
- HSPA **services towards the packet domain only**
- **Many-to-many relationships** between RAN and Core Network (Iu-flex and RAN Sharing / Multi-Operator Core Network)
- **More functions in the base stations** (Node Bs):
  - for fast packet-based scheduling (HSPA)
  - with Hybrid-ARQ techniques
  - based on constantly increasing processing performance

Conclusions (2/2)
New trends are continued and emphasised in NGMNs

Radio Access Network Architectures for NGMN continue these new trends and emphasise them:

- **Use of IP-based protocols** throughout the system
- **Separation of Control and User Plane** in nodes above the base station (at least as an option in 3GPP systems)
- **Packet domain services only** (for all types of applications)
- **Flat / distributed network architectures** with less types of network nodes and peer-to-peer & many-to-many interfaces
- **Support of RAN Sharing** to get radio coverage cheaper/faster and to satisfy business models / regulatory requirements
- **Most or all radio-related functions in the base stations**:
  - for fast and flexible packet-based scheduling and QoS-enabled high throughput / low latency services
  - no centralised network node / exploiting economy of scale

The End

Thank you for your attention.

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