Mobile WiMAX Network Architecture

Max Riegel, 2006-09-25

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Outline

- **Relation IEEE802.16 - WiMAX**
- **Tenets for the Mobile WiMAX network**
- **The Mobile WiMAX network reference model**
  - extended applications
  - logical vs. physical model
- **ASN profiles**
- **Mobility in WiMAX**

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Relation IEEE802.16 - WiMAX

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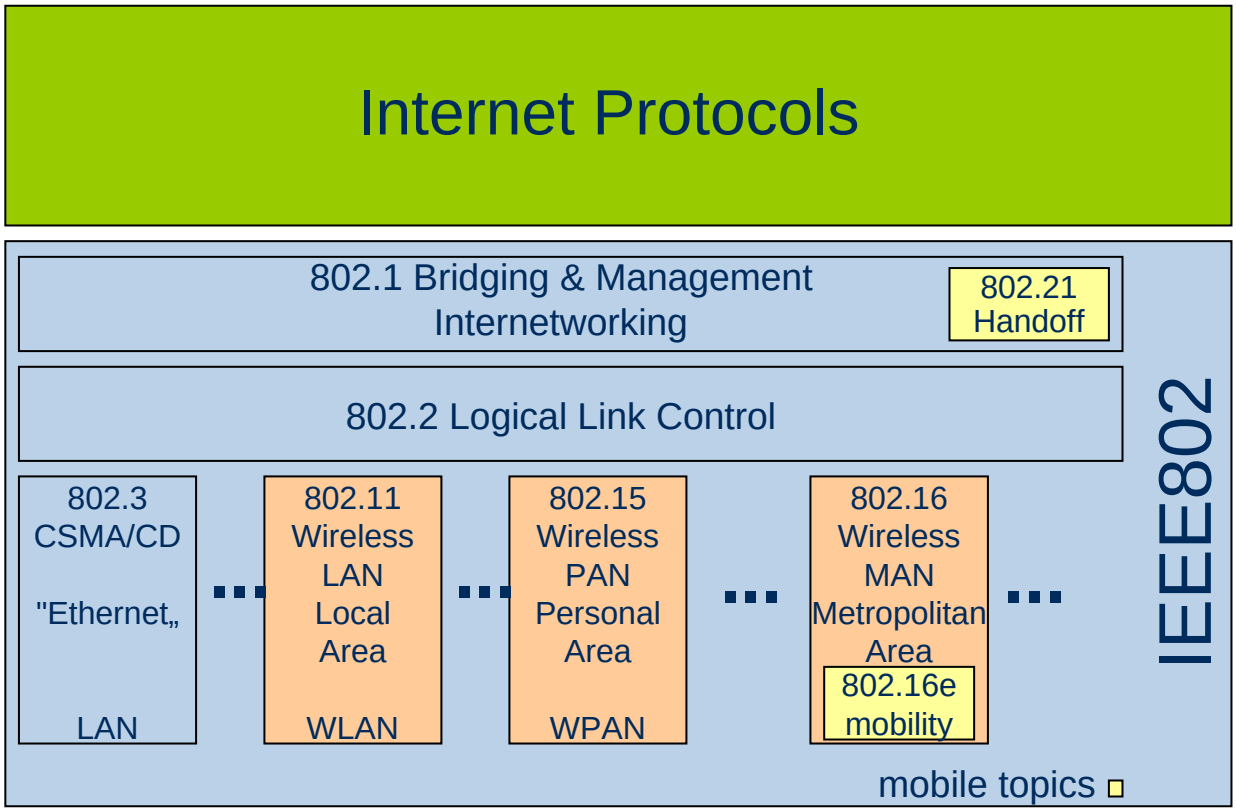
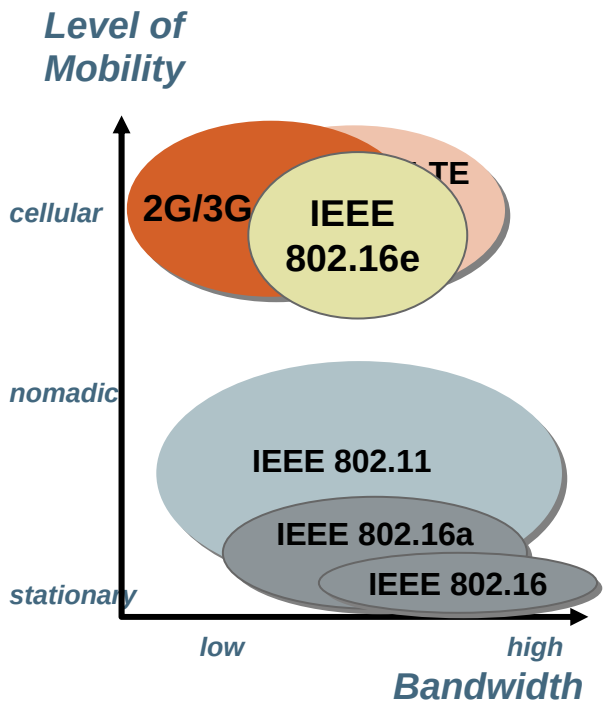
Wireless Mobility in IEEE802





IEEE802 provides specifications for Local and Metropolean Networks

- **Wireless topics: WPAN (802.15), WLAN (802.11), WMAN (802.16)**
- **IEEE802.16e provides cellular support including full mobility**

IEEE802 has become the leading 'radio' standardization organization

- **e.g. MMR (802.16j), Cognitive Radio (802.22)**

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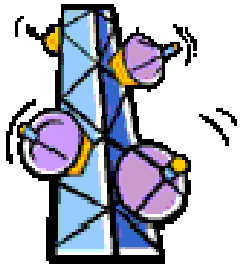
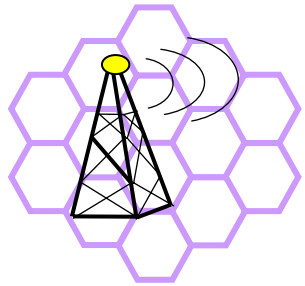
IEEE 802.16 – 2004: *'One standard fits all'*





	Feeding	FWA	Cellular
Completed	December 2001	January 2003	June '04/Mobility '05
Spectrum	10 - 66 GHz	< 11 GHz	< 6 GHz
Channel Conditions	Line of Sight Only	Non Line of Sight	Non Line of Sight
Bit Rate	32 – 134 Mbps in 28MHz channel bandwidth	Up to 75 Mbps in 20MHz channel bandwidth	Up to 15 Mbps in 5MHz channel bandwidth
Modulation	Single Carrier QPSK, 16QAM, 64QAM	OFDM 256 sub-carriers QPSK, 16QAM, 64QAM	1x Scalable OFDMA QPSK, 16QAM, 64QAM
Mobility	Fixed	Fixed	Portable Mobile (up to 120 km/h)
Channel Bandwidths	20, 25 and 28 MHz	Scalable 1.5 to 20 MHz	Scalable 1,25 to 20 MHz
Typical Cell Radius	2-5 km	7 to 10 km Max range 50 km	1-5 km

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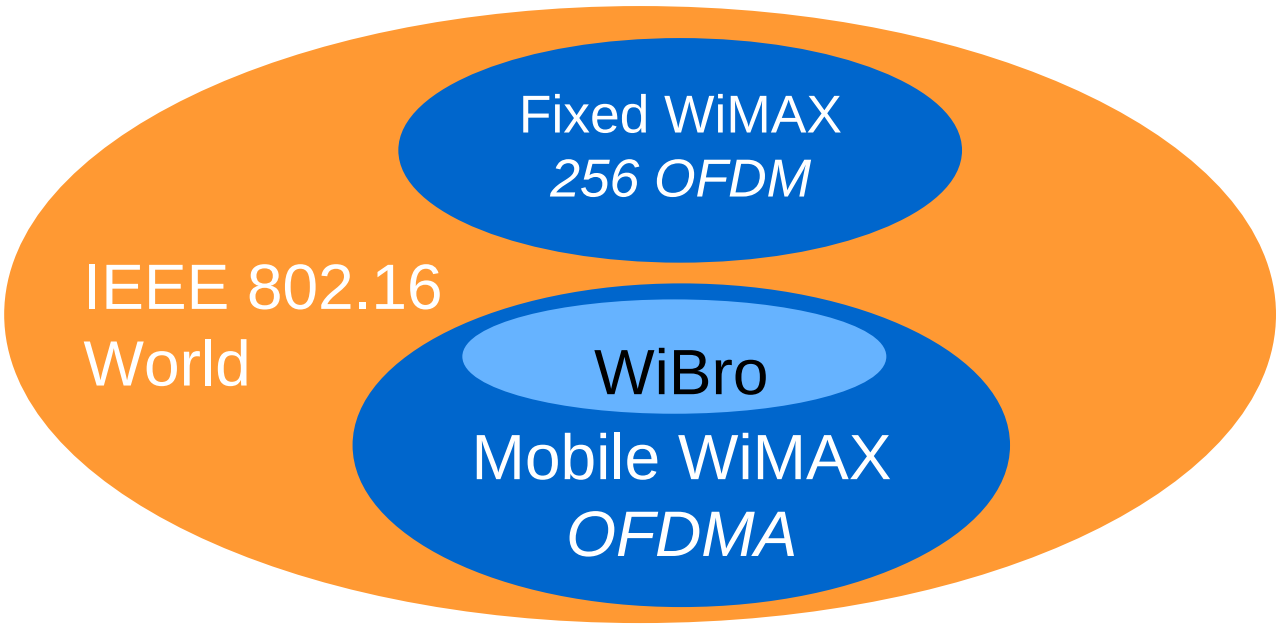
WiMAX and IEEE 802.16

- **WiMAX is a subset of IEEE 802.16**
  - No new features can be added
  - Mandatory features in 802.16 are mandatory in WiMAX, if included
  - Optional features in 802.16 may be optional, mandatory or not included



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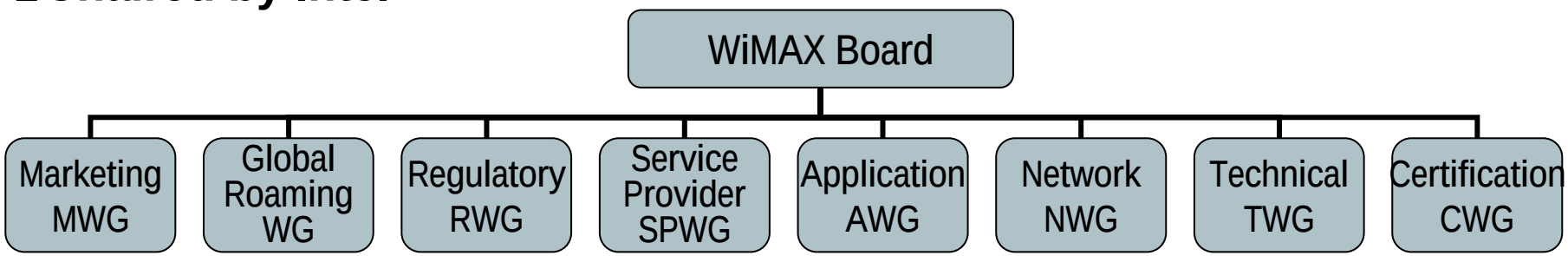
Worldwide Interoperability for Microwave Access

- **The purpose of WiMAX is to promote deployment of broadband wireless access networks by using a global standard and certifying interoperability of products and technologies.**
  - Support IEEE 802.16 standard
  - Propose and promote access profiles for their IEEE 802.16 standard
  - Certify interoperability levels both in network and the cell
  - Achieve global acceptance
  - Promote use of broadband wireless access overall
- **WiMAX Forum grew up to more than 370 members within 2 years**
- **Chaired by Intel**



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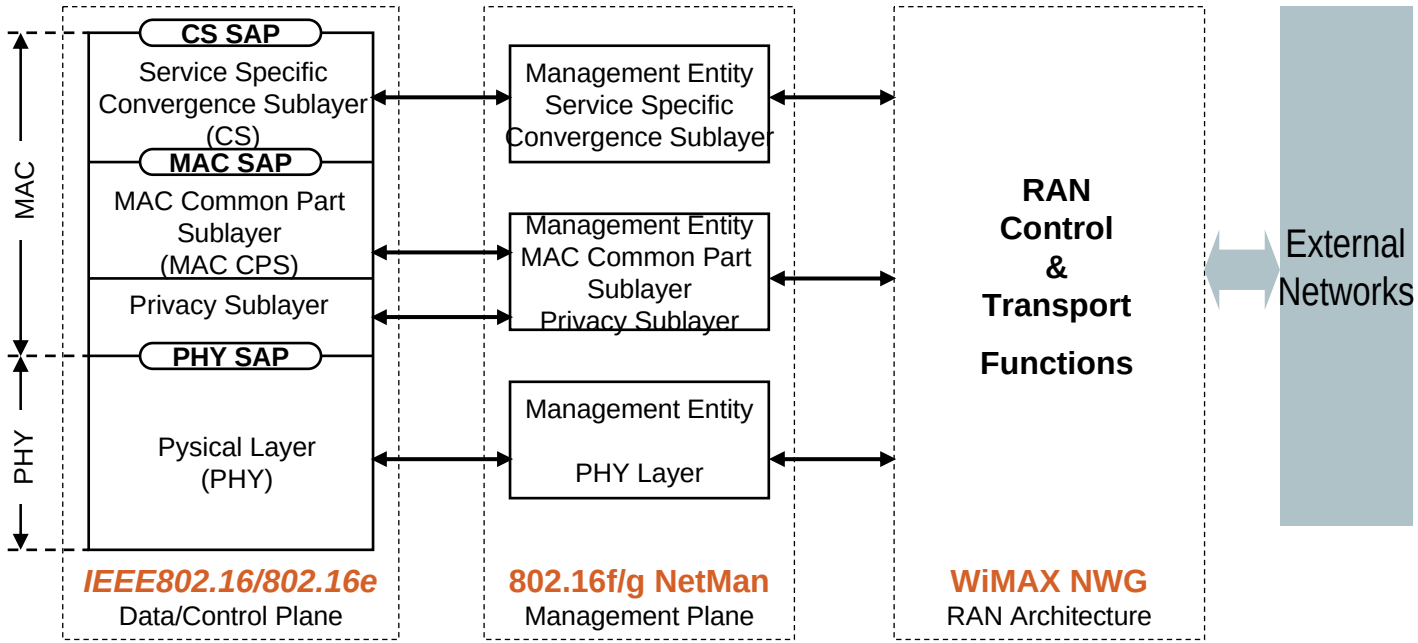
Relation between IEEE802.16 and WiMAX NWG



- **IEEE802.16-2004 & 802.16e define only data and control plane**
  - Management plane functions are added by 802.16f & g (NETMAN)
- **IEEE P802.16 does not deal with functions usually provided by the RAN**
- **The standardization of these missing parts of a portable/mobile WiMAX access network is the scope of the WiMAX NWG.**

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The roots of the ‘WiMAX Network WG’: WiMAX E2EARCH WG (MINA)

- **Founded by Intel in June 2004 for development of an end-to-end industry specification for WiMAX portable and mobile wireless broadband systems**
  - Address interfaces, RAN infrastructure elements and interworking - beyond the scope of 802.16
  - Provide foundation for subsequent system level interoperability specs driven through WiMAX Forum
- **Invited companies: Alvarion, Arraycomm, Alcatel, Cisco, Intel, Motorola, (Nortel, left in September ‘04) Samsung, Siemens, ZTE**
- **Process aligned to 3GPP/3GPP2 with Stage 1 (Requirements), Stage 2 (Architecture) and Stage 3 (Protocols)**
- **Fast progress and demand for more interaction with Service Provider WG led to transition into WiMAX NWG in January ’05**
- **Extremely tight schedule for NWG: Release 1:**
  - Stage 2 (Architecture): End of ‘05
  - Stage 3 (Protocols): End of ‘06

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Tenets for the WiMAX Network Architecture

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Tenets for WiMAX RAN Architecture
(Siemens contribution to MINA; July '04)

- **WiMAX is evolving out of wireline broadband access:**
  - DSL/Cable -> FWA -> Nomadic -> Portable -> Mobile
- **Align WiMAX network architecture to common DSL/Cable architectures**
  - smaller networks may follow WiFi hotspot concepts
- **Keep regulatory issues of broadband access in mind**
  - 'unbundeled access'/'bitstream access' in Europe
  - nomadic scenario without handover
- **Support network sharing**
  - faster deployment possible
- **Do not stick with existing 3G core networks**
  - 3G optimized for small-to-medium data rates per user
  - may become too expensive for broadband usage

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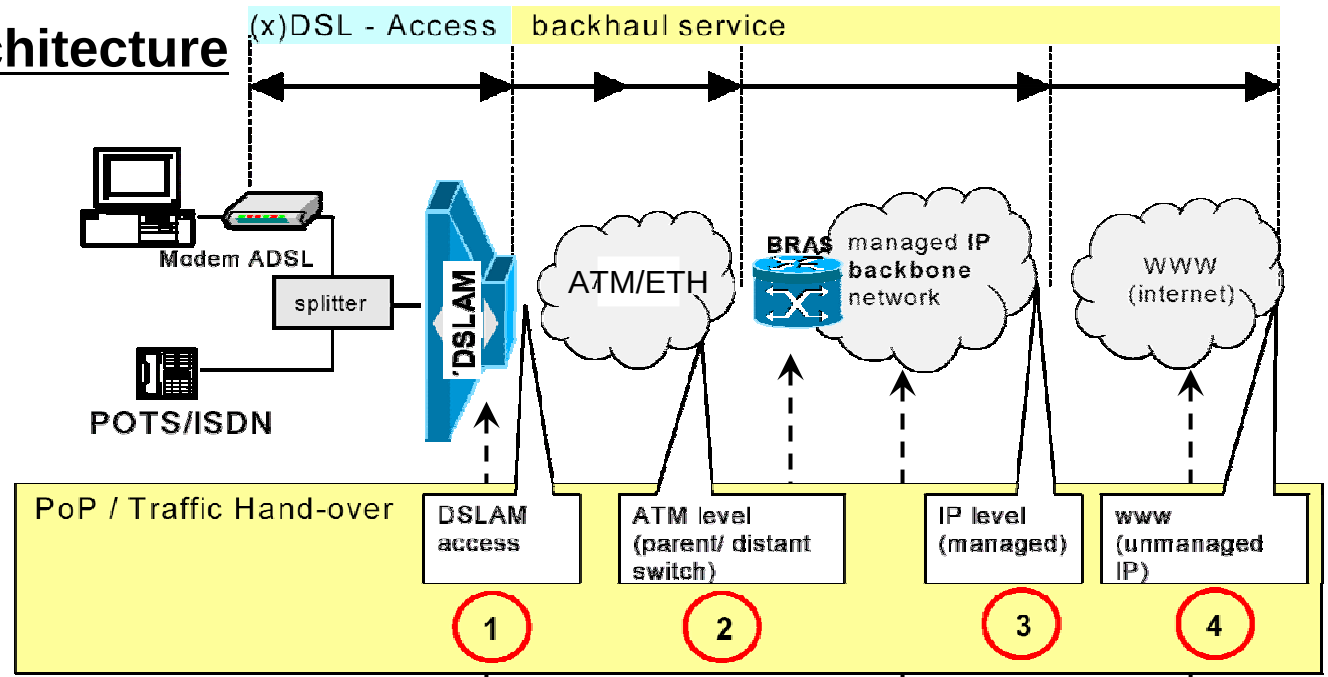
WiMAX is aligned to broadband architectures

DSL Architecture



Abbreviations:

UE
User Equipment

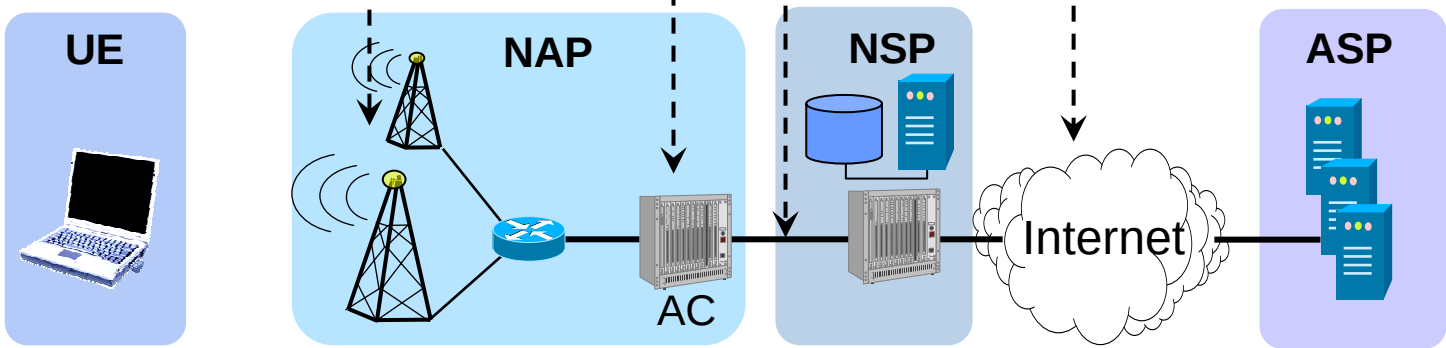
NAP
Network Access Provider

AC
Access Concentrator

NSP
Network Service Provider

ASP
Application Service Provider

WiMAX Architecture



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Network Operator Relationships

Network Access Provider (NAP)

- A business entity that provides WiMAX radio access infrastructure to one or more WiMAX Network Service Providers (NSPs). A NAP implements this infrastructure using one or more Access Service Networks (ASN)

Network Service Provider (NSP)

- A business entity that provides IP connectivity and WiMAX services to WiMAX subscribers compliant with the Service Level Agreement it establishes with WiMAX subscribers. To provide these services, an NSP establishes contractual agreements with one or more NAPs.
- An NSP may also establish roaming agreements with other NSPs and contractual agreements with third-party application providers (e.g. ASP or ISPs) for providing WiMAX services to subscribers.

ASP (Application Service Provider)

- Provides value added services, Layer 3+ (e.g. IMS, corporate access, ...)
- Provides and manages applications on top of IP

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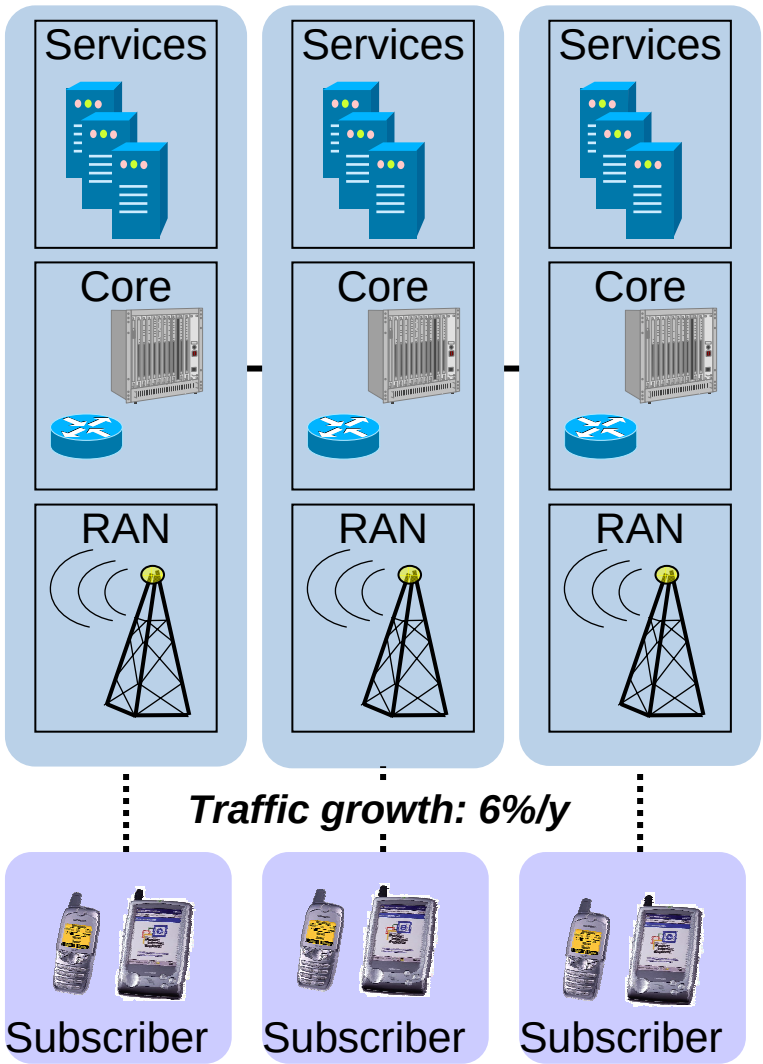
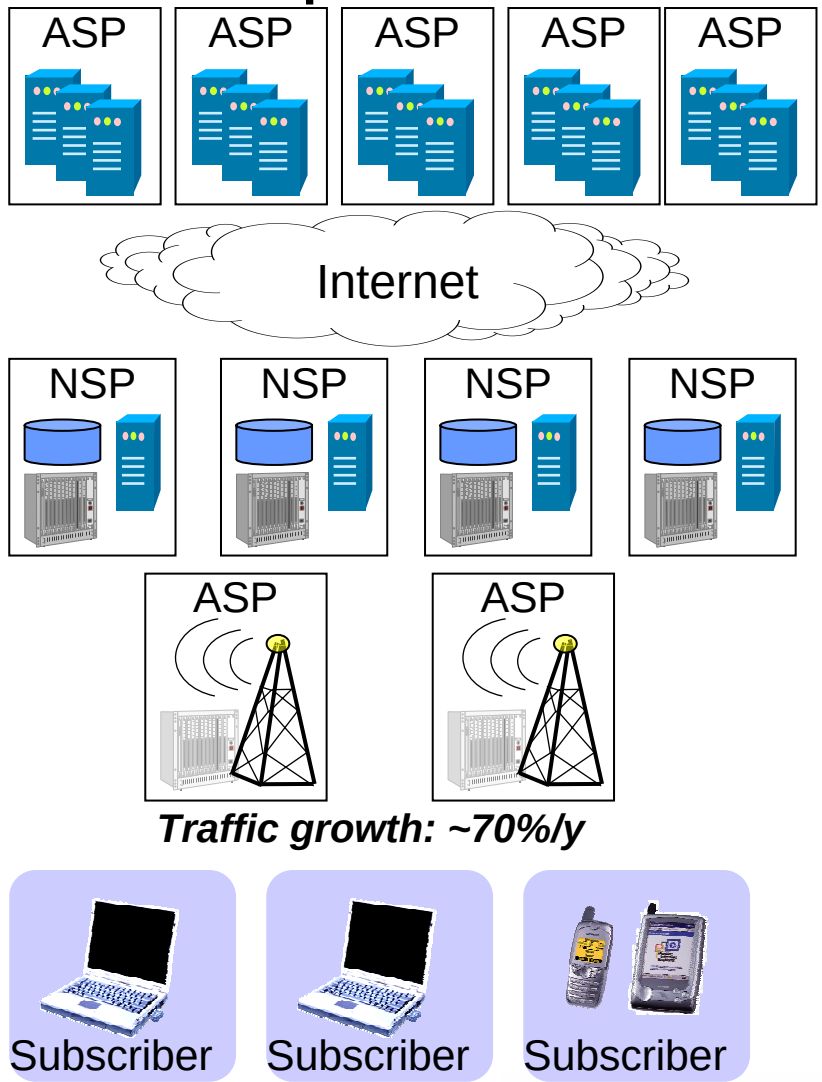
WiMAX addresses the broadband business

Classical MNO value chain



WiMAX value pattern



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Basic Tenets for WiMAX Network Architecture

The WiMAX NWG end-to-end architecture framework shall be modular and flexible enough to not preclude a broad range of flexible implementation and deployment options ranging from:

- **Centralized or fully distributed or hybrid architectures**
- **Cost effective small-scale to large-scale (sparse to dense radio coverage and capacity) deployments**
- **Urban, suburban and rural radio propagation environments shall be accommodated**
- **Licensed and/or licensed exempt frequency bands**
- **Hierarchical, non-hierarchical or flat access topologies**
- **Co-existence of fixed, nomadic, portable and mobile usage models**

The challenge: Come up with an architecture framework that enables vendor-interoperability without sacrificing implementation flexibility and avoiding over-specification

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The WiMAX Network Reference Model

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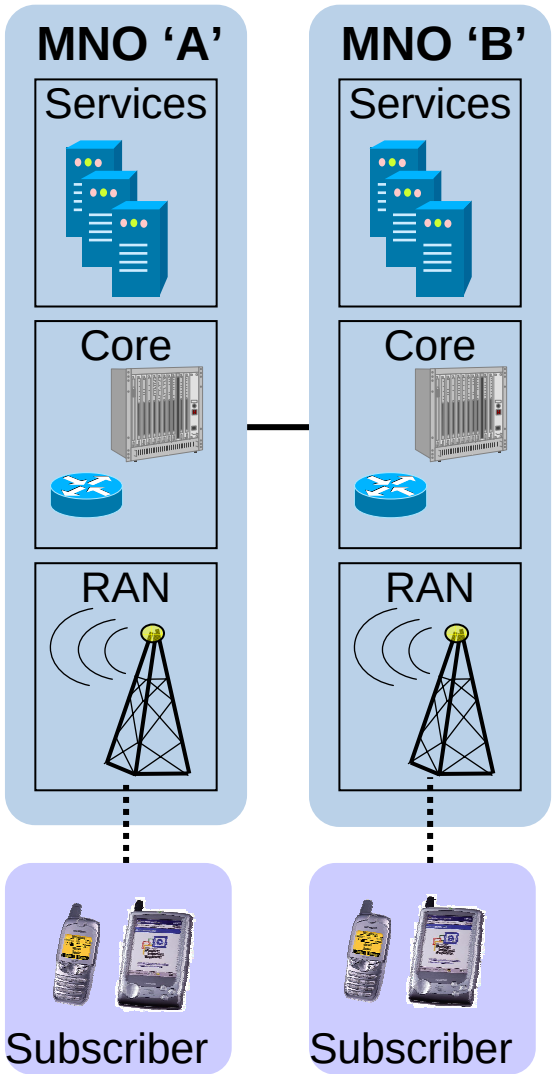
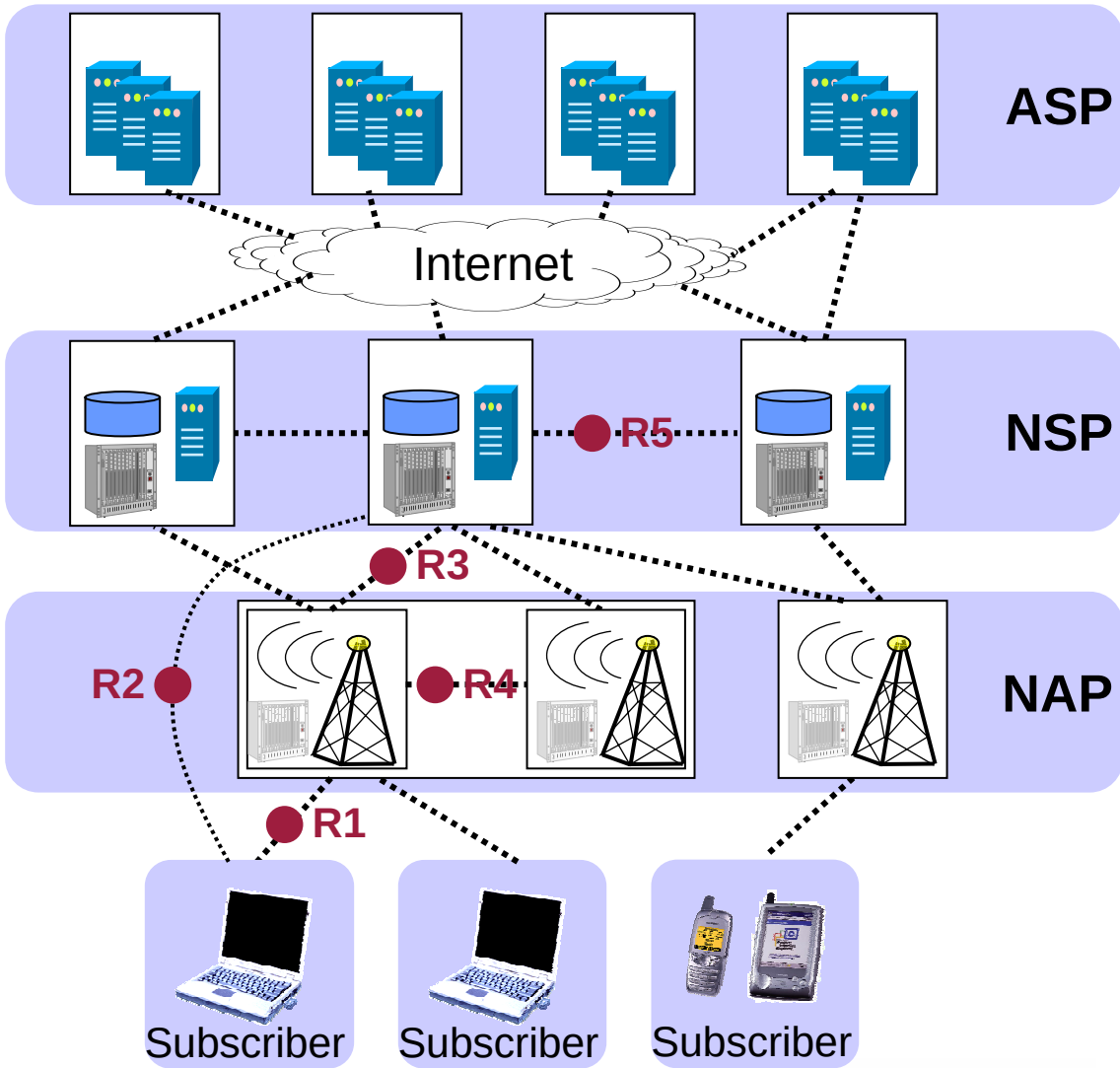
WiMAX Network Reference Points

Classical Architectures



WiMAX Network Architecture



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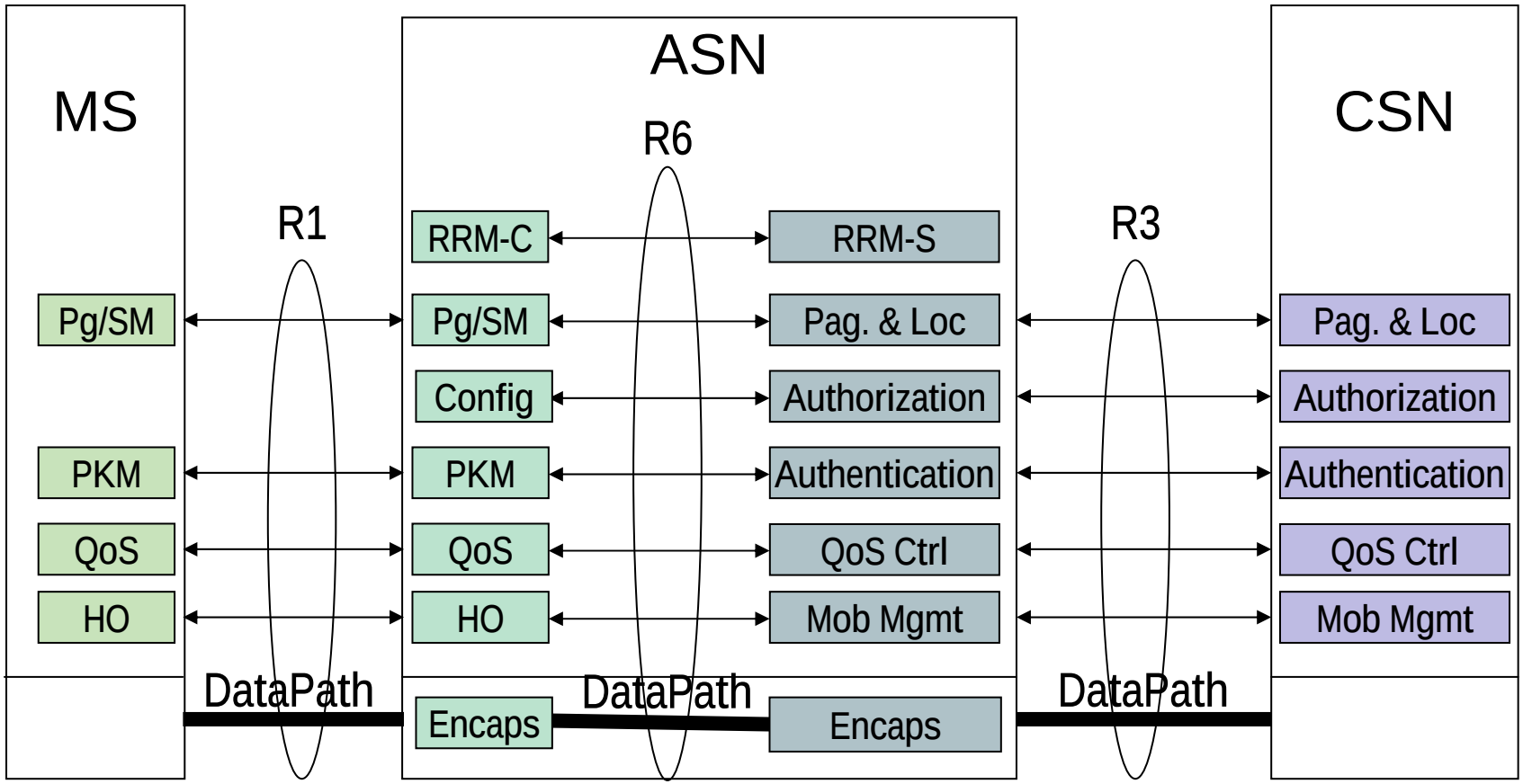
Reference Point Structure



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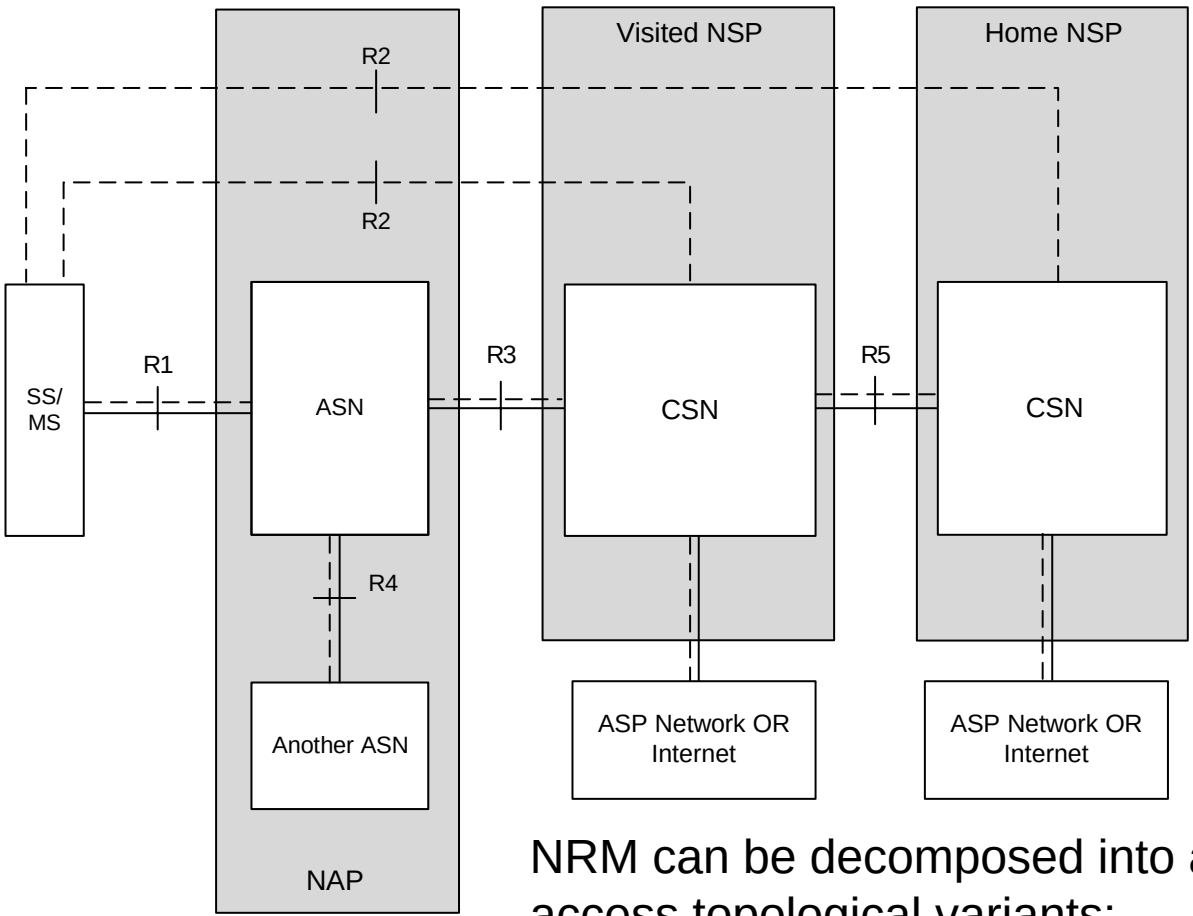
WiMAX Network Reference Model (NRM)



SS: **Subscriber Station**
MS: **Mobile subscriber station**
ASN: **Access Serving Network**
CSN: **Connectivity Serving Network**

NRM can be decomposed into a number of WiMAX access topological variants:

- Flat/Distributed,
- Hierarchical/Centralized,
- Decomposed versus Integrated BS …

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Points to note about Reference Model!

- Interoperability enforced via reference points without dictating how vendors implement edges of reference points
- Introduces the notion of functional entities – which can be combined or decomposed by vendor and/or operator
- No specific physical entities are introduced like SGSN, PDSN from the 3G world
- No single physical ASN or CSN topology is mandated – allowing room for vendor / operator differentiation

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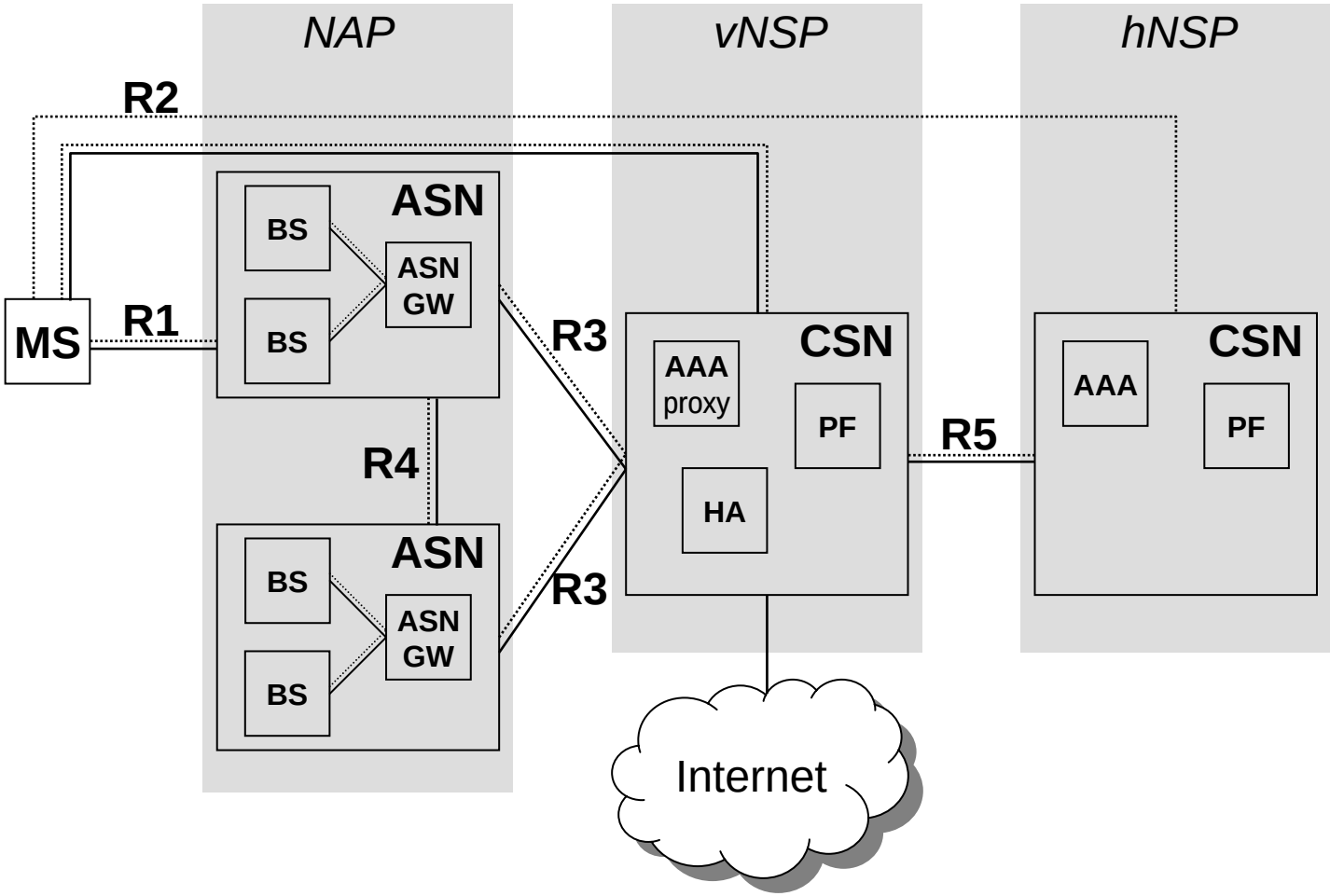
WiMAX Network Reference Architecture (roaming case, HA in vNSP)



- **The NRM defines a logical decomposition inside the ASN (BS, ASN-GW)**
  - Most implementations follow this logical structure

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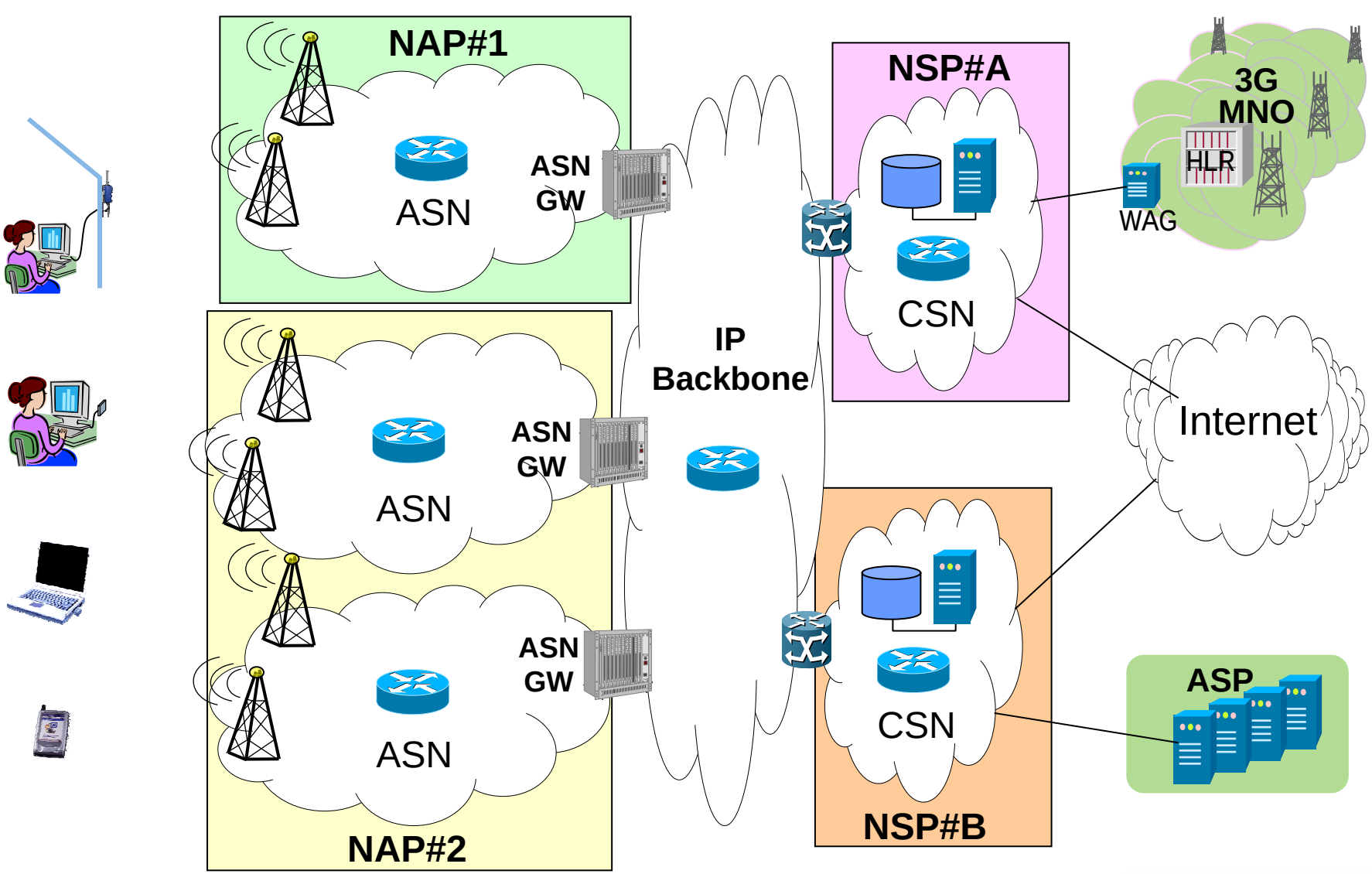
WiMAX Network Deployment w/ NAP sharing



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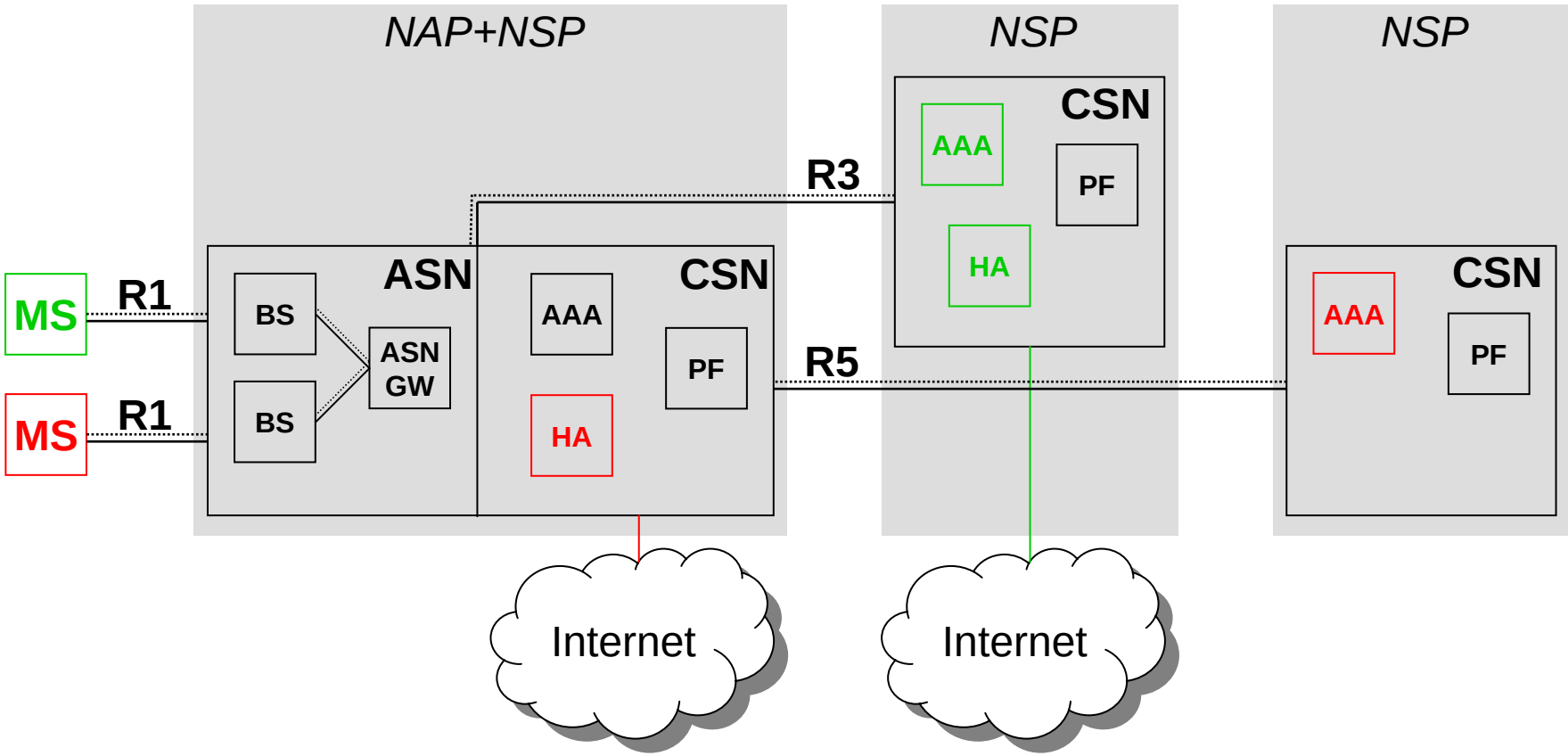
Real deployments are a mixture of scenarios



- **Most access provider will implement direct Internet connectivity by a co-located CSN to minimize transport costs.**
  - Eventually only for roaming users (no own service provider business)

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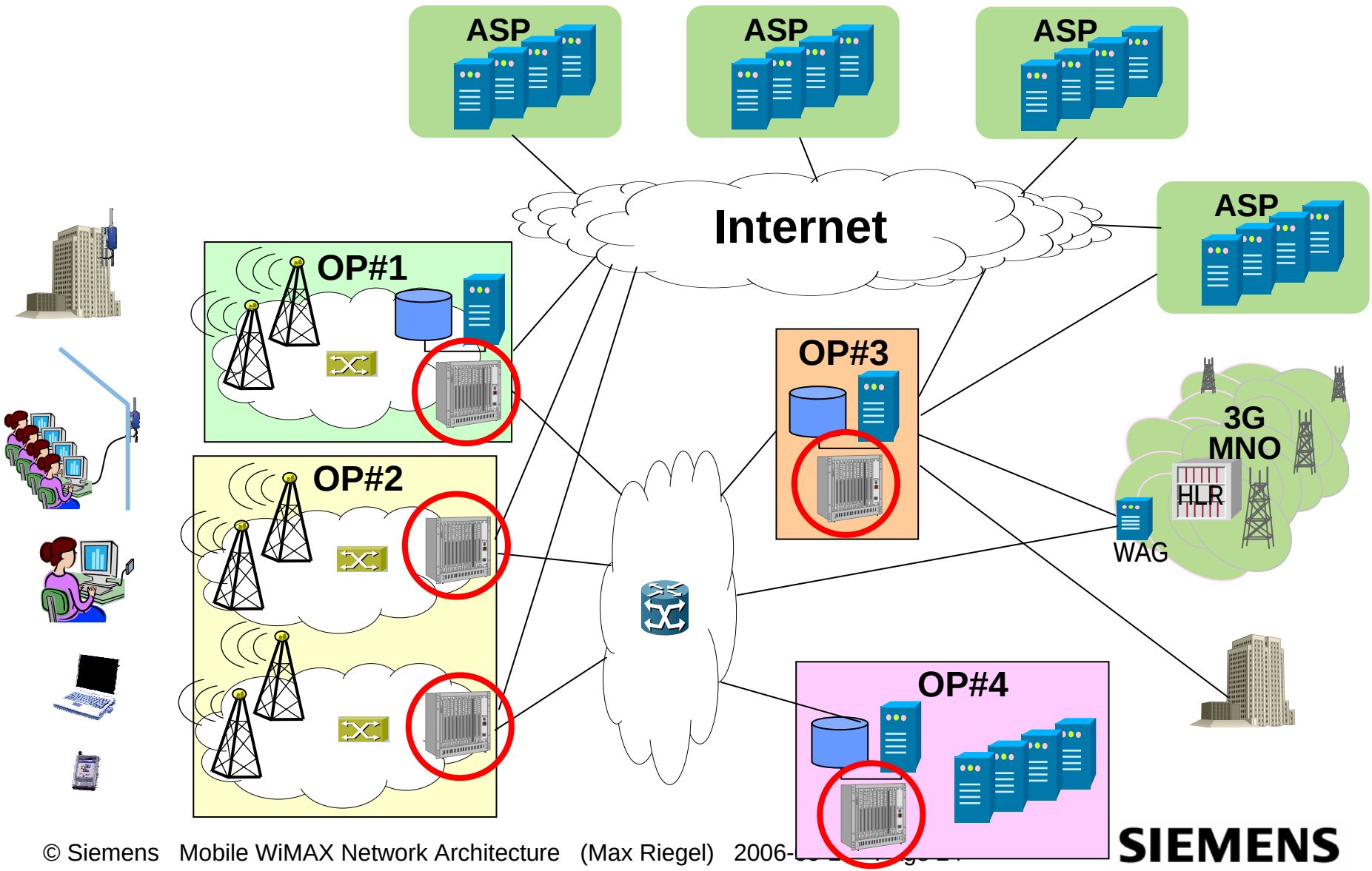
‘Very flat’ WiMAX Deployment Scenario



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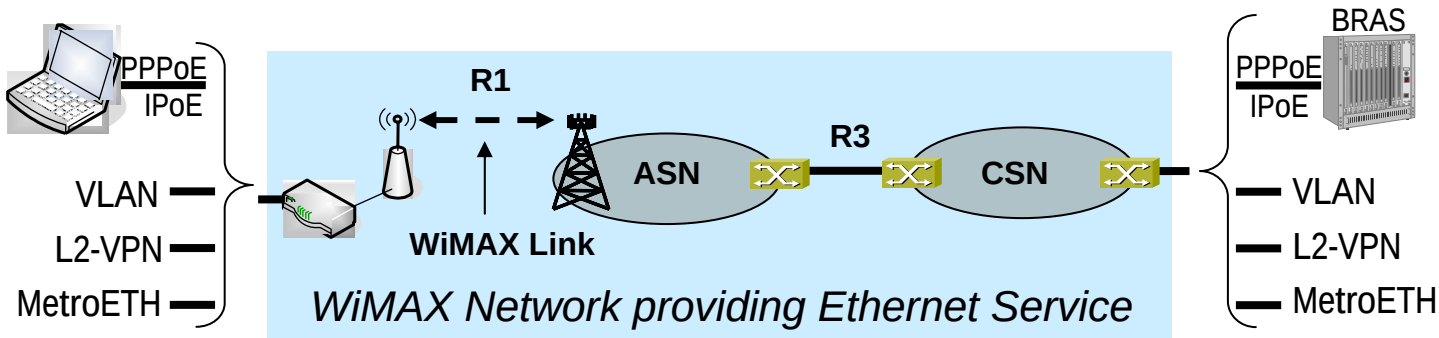
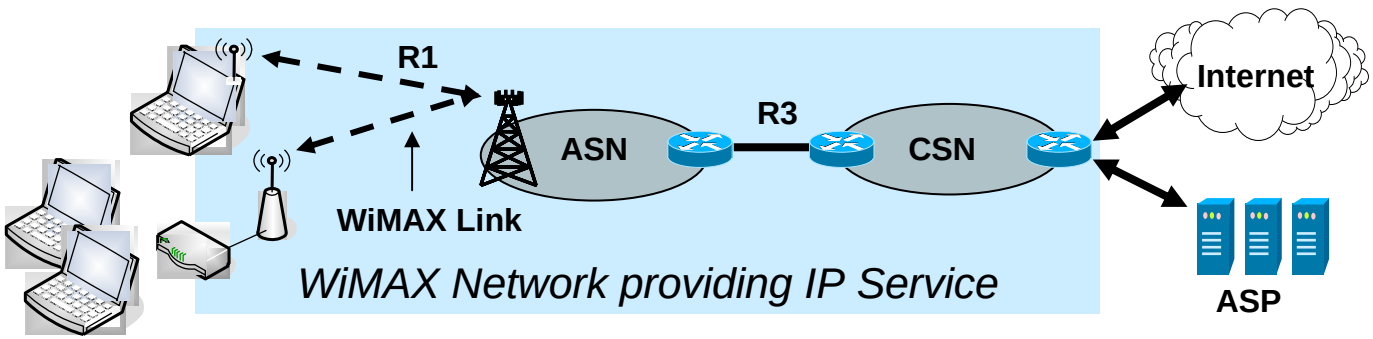
The same WiMAX network can serve two different kind of services

VLAN Network Service



- **The WiMAX network provides plain Ethernet connectivity end-2-end.**
  - Like a DSL network, but without wires.

IP Network Service



- **The WiMAX network provides IP connectivity to the Internet and operator services for single hosts or multiple hosts behind a gateway.**
  - Like a 3GPP or 3GPP2 mobile network

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WiMAX ASN Profiles

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Release 1 Features

- **Network discovery and selection with roaming support**
- **Authentication and Authorization based on EAP and RADIUS**
- **Accounting support for post-paid as well as pre-paid**
- **IP & Ethernet support over the air (Ethernet optional)**
- **Mobility management inside ASN and directly between ASNs**
  - Enhanced handover procedures but no soft-hand-over/soft-combining
- **Mobility Management between ASN and CSN based on Mobile IP**
- **Radio Resource Mgmt. procedures inside ASN**
- **Sleep/Idle mode and paging support**
- **Simplified QoS framework for data services**
- **Support (QoS) for VoIP without support for emergency services**
- **No standardized functional decomposition inside CSN**
- **Two implementation profiles of ASN for standardized BSs and ASN-GWs**
  - Enable interoperability between BSs and ASN-GWs of different vendors
  - Third ASN profile provides full flexibility, but is still interoperable to other ASNs

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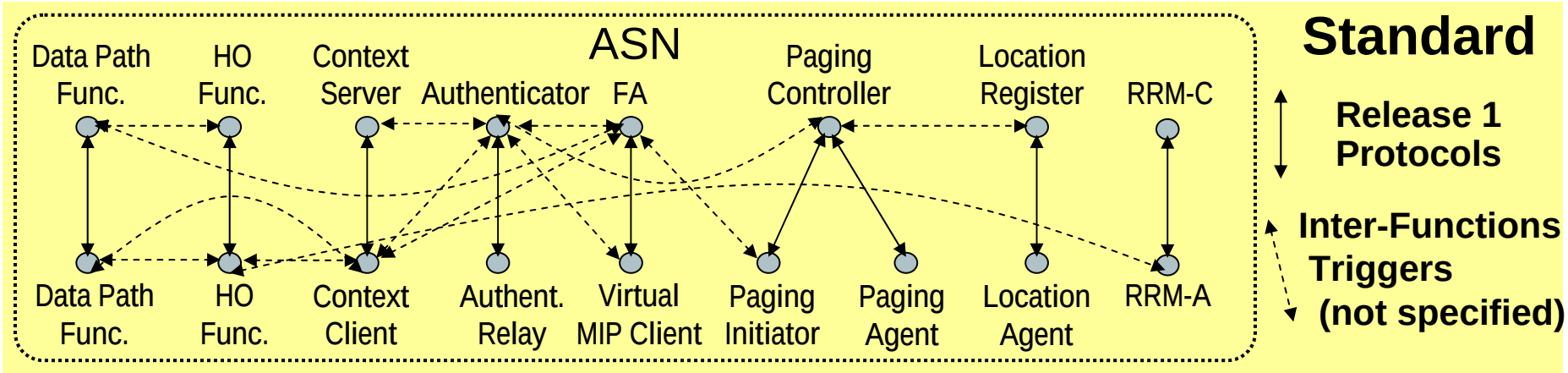
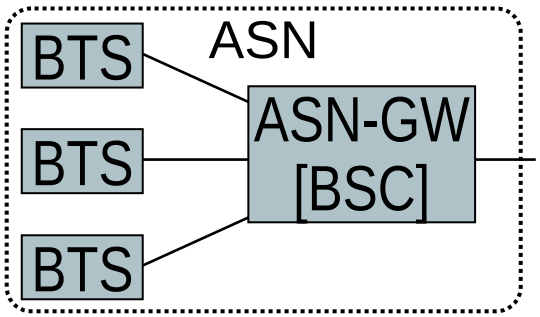
Mapping functions to ASN Profiles



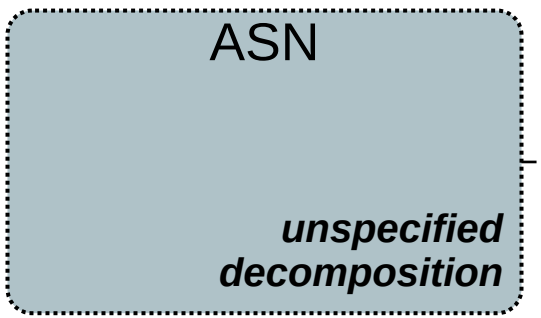
Rel. 1 ASN Profiles:

A



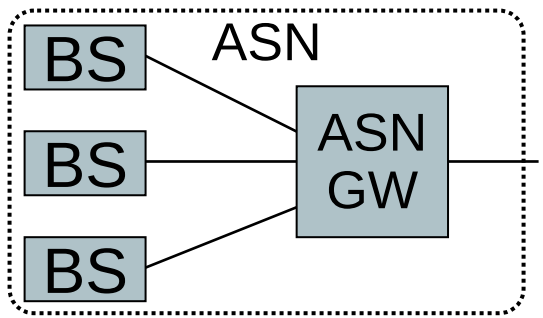
- PHY and partly MAC in BTS
- Handover-Ctrl (RRM) in ASN-GW
- Routing and AAA/Pg in ASN-GW

B



- **e.g.** most ASN functions in BS
- BS anchored by standard router
- Inter BS control over Ethernet

C



- All radio-specific functions in BS
- Handover-Ctrl (RRM) in BS
- Routing and AAA/Pg in ASN-GW

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Mobility in WiMAX

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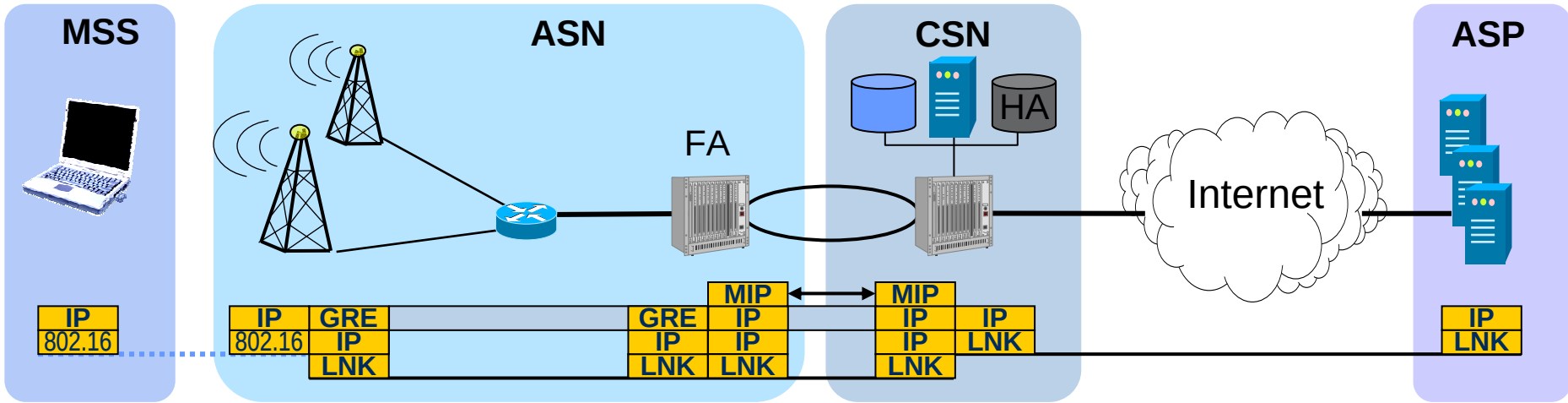
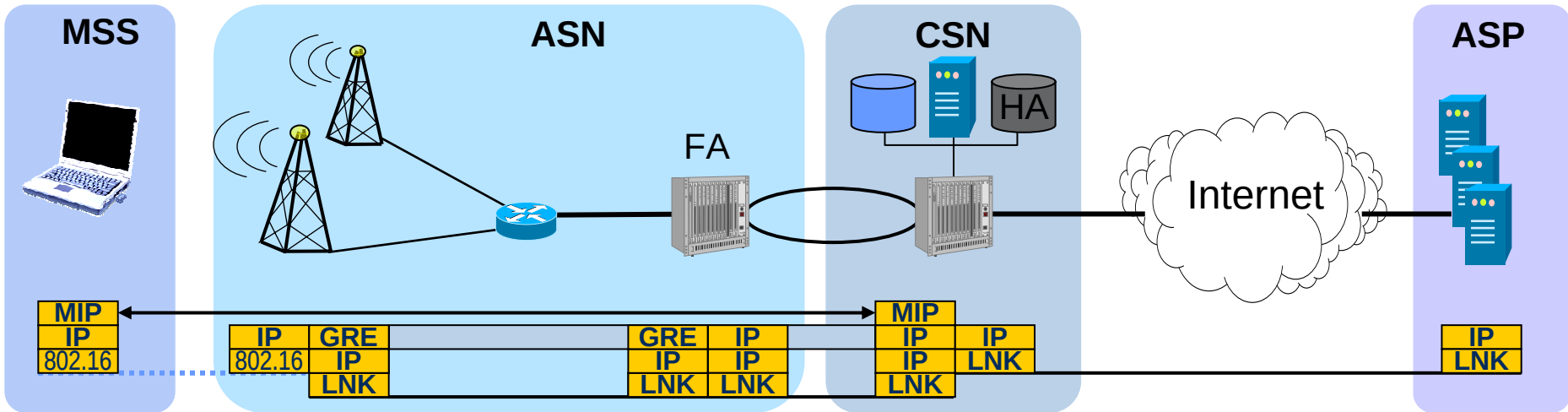
Proxy-MIP/Client-MIP Mobility

Proxy-MIP: MIP Client resides in ASN-GW



Client-MIP: MIP Client resides in MSS



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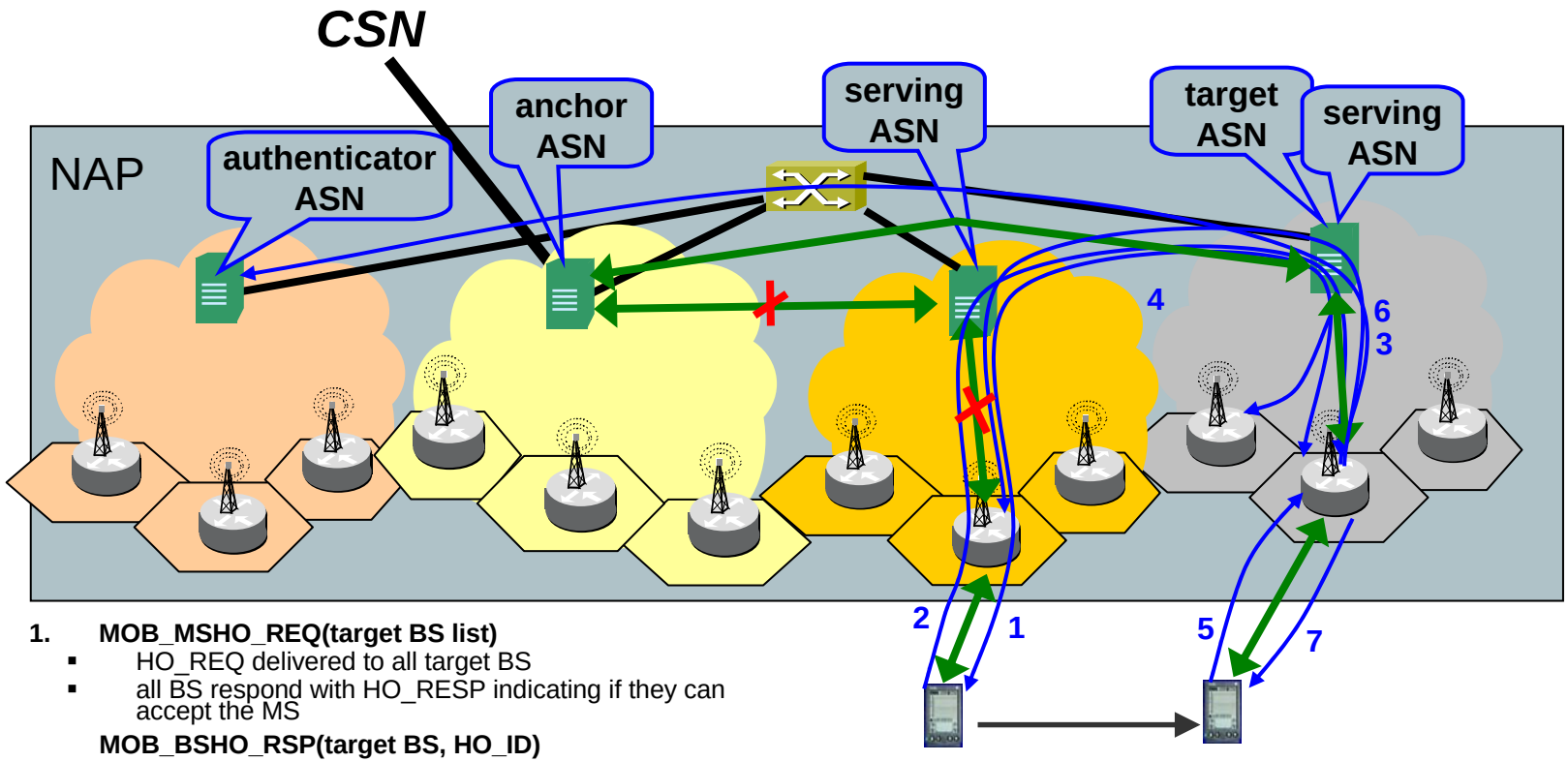
General ASN anchored hand-over case



1. **MOB_MSHO_REQ(target BS list)**
   - HO_REQ delivered to all target BS
   - all BS respond with HO_RESP indicating if they can accept the MS

   MOB_BSHO_RSP(target BS, HO_ID)

2. **MOB_HO_IND(target BS)**
   - HO_Confirm delivered to the target BS

3. **Retrieve Key**
   - authenticator ID is part of MS context

4. **Data path to anchor GW**
   - anchor GW ID is part of MS context

5. **RNG_REQ(HO_ID, serv. BS)**

6. **HO_Complete**

7. **RNG_RSP(new CID to SF mapping)**

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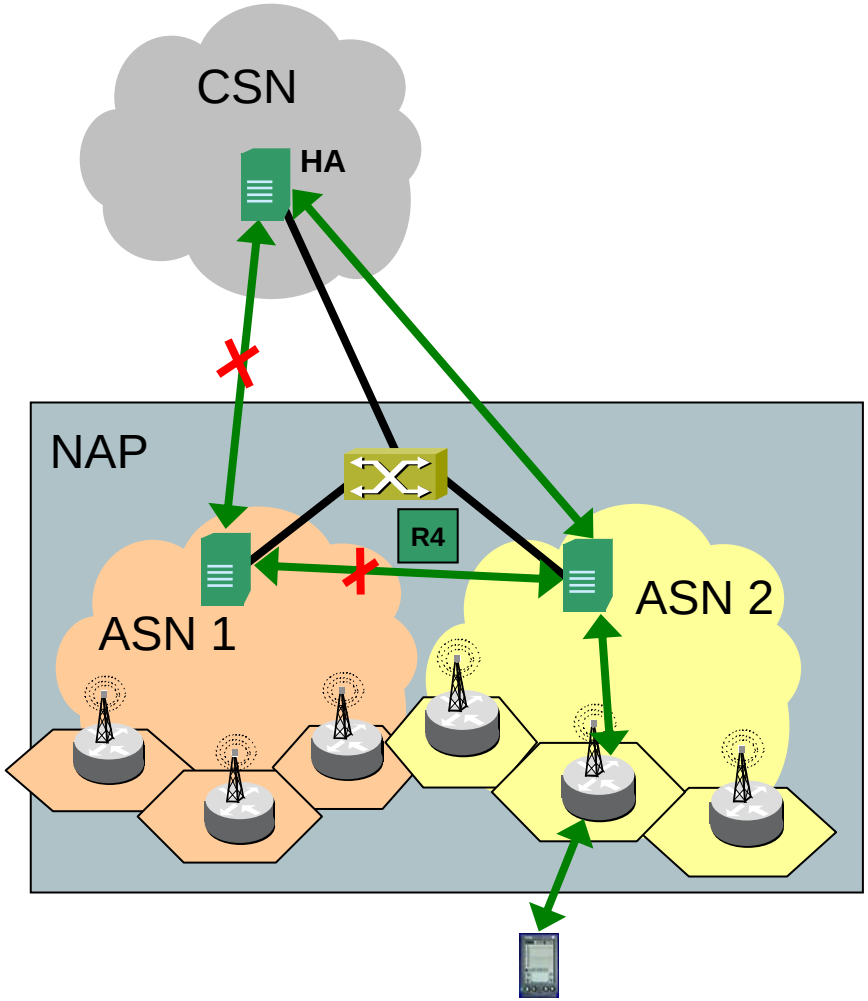
CSN anchored mobility



Resulting configuration after ASN MM

- CSN not aware of the handover at all.
- routing within NAP not optimal

CSN-anchored mobility

- needed to update the CSN (home agent) of the current MS location
- goal is to move the anchor GW to the serving gateway, i.e. to provide optimized path

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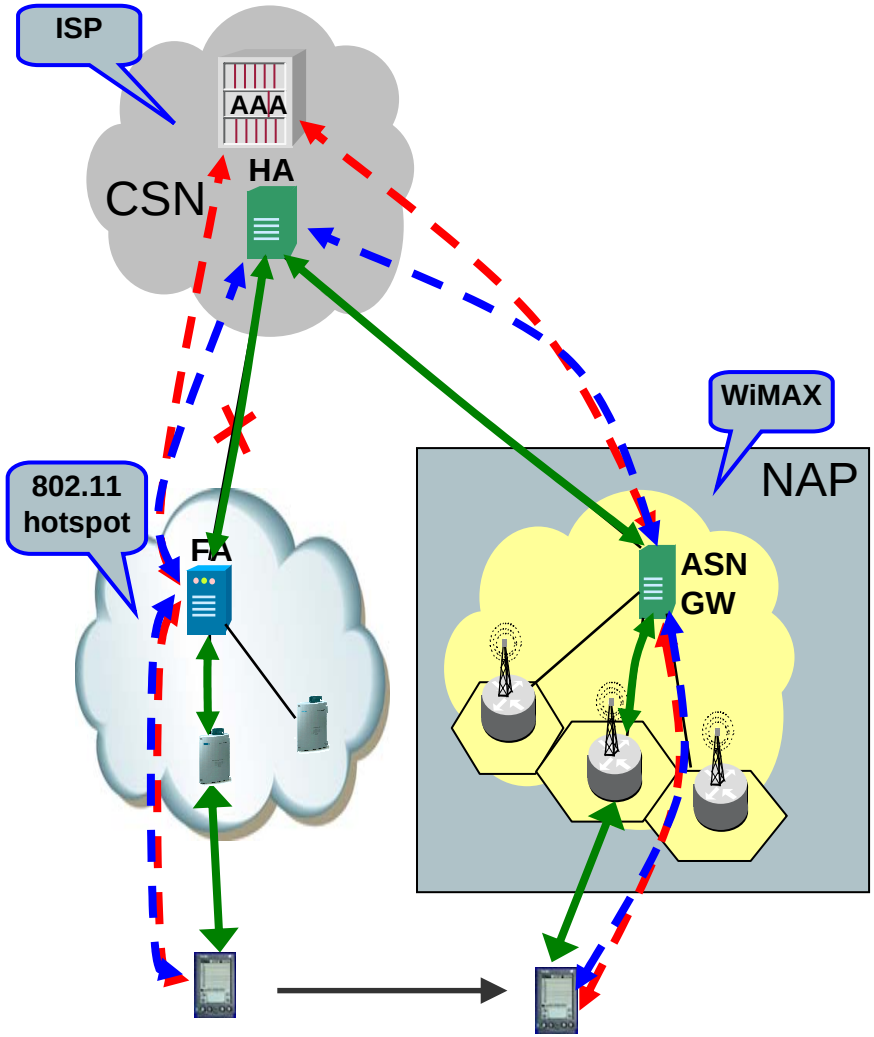
Inter-technology Handover



1. **Assumptions**
   - only client MIP terminals
   - same HA, independant of access technology
   - ideally, same subscription in both technologies
2. **Attach to hot spot**
   - link layer establishment
   - authentication with home service provider
3. **MIP Registration (NAI, CoA)**
   - MS to FA
   - FA relays RegReq to HA
   - HA assigns HoA
   - MIP tunnel established
4. **Switch to different technology**
   - link layer establishment
   - authentication with home service provider
   - MIP binding in 802.11 hotspot still active
5. **MIP Registration(NAI, new CoA, same HoA)**
   - through FA
   - HA verifies if HOA is allowed for this subscriber
   - new MIP tunnel established
6. **Optimizations**
   - Hot spot may release resources after timeout
   - HA may send RevocationRequest to old FA
   - establishment of link layer connectivity on the new link in advance, including the authenticaiton

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The End

Thank you for your attention!

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