# WiMAX Networking Implications for IETF 16ng

IETF-68, Prague
2007-03-19
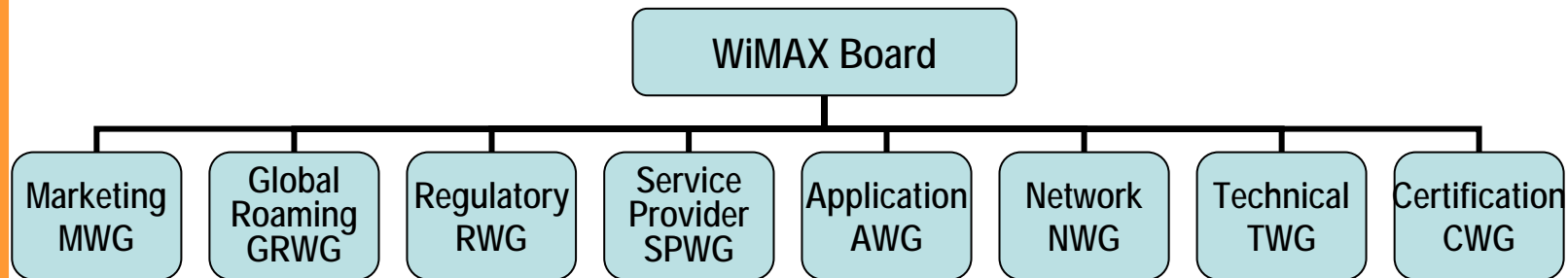
Max Riegel
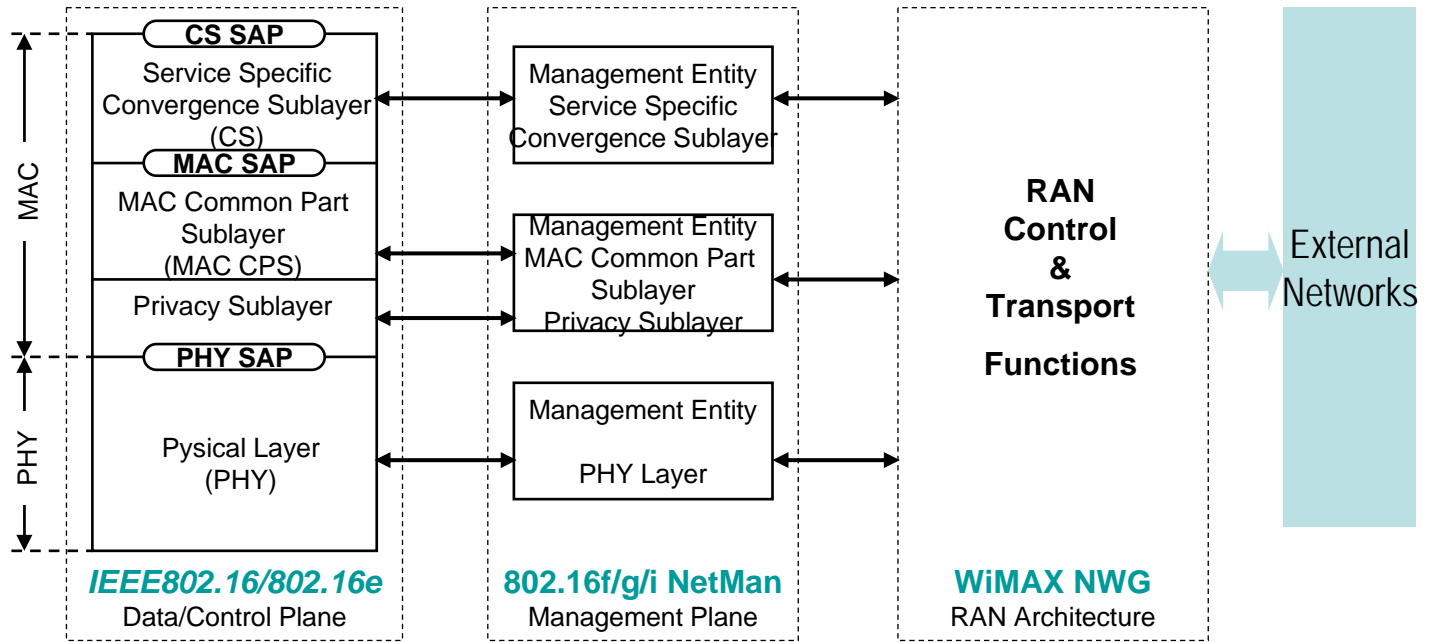NWG Vice-chair
<maximilian.riegel@siemens.com>

# Overview

- Scope of WiMAX Forum
- Mobile WiMAX Network Architecture
- WiMAX Network Reference Model
- Reference Points in Mobile WiMAX
    -> Implications for 16ng
- ASN Anchored Mobility
- ASN Profiles and Implementation Options
- Deployment Options
    -> Implications for 16ng
- Relays in Mobile WiMAX
- Multiple Hosts Support
    -> Implications for 16ng
- Summary: WiMAX NWG Release 1 Features
- Conclusion

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# WiMAX: Worldwide Interoperability for Microwave Access

- The WiMAX Forum promotes the deployment of broadband wireless access networks by supporting a global standard and certifying interoperability of products and technologies.
  - Support IEEE 802.16 standard family
  - Propose and promote access profiles for their IEEE 802.16 standard
  - Certify interoperability levels both in the network (IIOT) and the radio interface (RCT/PCT/NCT)
  - Achieve global acceptance
  - Promote use of broadband wireless access overall

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                          ┌──────────────┐
                          │  WiMAX Board │
                          └──────┬───────┘
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| Marketing MWG | Global Roaming GRWG | Regulatory RWG | Service Provider SPWG | Application AWG | Network NWG | Technical TWG | Certification CWG |
|---|---|---|---|---|---|---|---|

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# Relation between IEEE802.16 and WiMAX NWG



- IEEE802.16-2004 & 802.16e define data and control plane
  - Management plane functions are part of 802.16 NetMan
- IEEE P802.16 does not deal with the radio access network
- The standardization of the missing parts of a nomadic and mobile WiMAX radio access network is the scope of the WiMAX NWG.

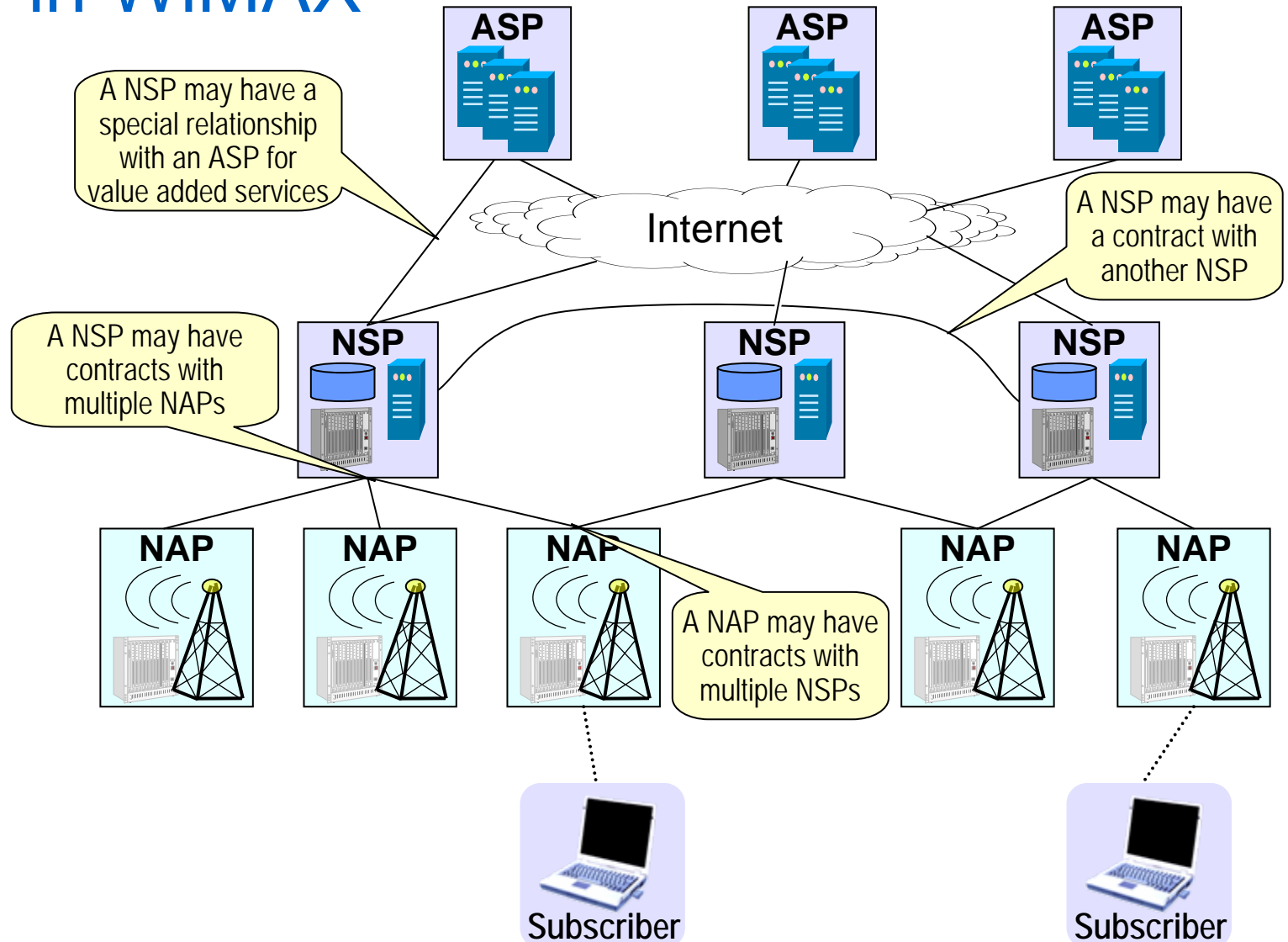2007-03-19

# A Wireless Access Network for the Internet
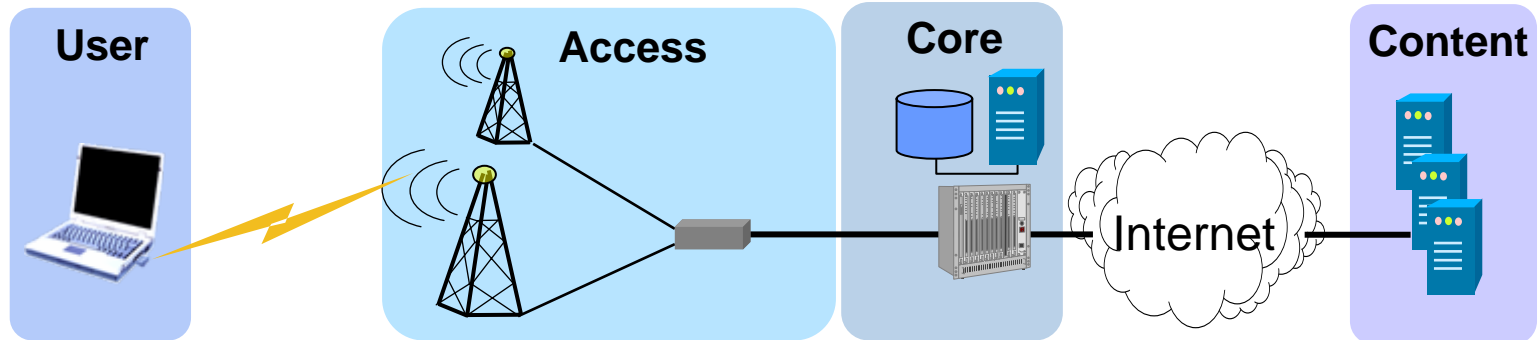


- The Internet decouples the Content from the Core
  - Split between Application Service Provider and Network Service Provider
- Often Access is not owned by Network Service Provider but operated as independent business
  - Network Access Provider does not deal with the particular subscriber but concentrates on establishment and operation of network infrastructure
  - Possibility to sell network access to multiple service providers enables economy of scale and reduces ROI

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# Network Operator Roles in WiMAX

- Network Access Provider (NAP)
  - A business entity that provides radio access infrastructure to one or more Network Service Providers.
- Network Service Provider (NSP)
  - A business entity that provides IP connectivity and network services to subscribers compliant with the Service Level Agreement it establishes with sub-scribers. 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. ASPs) for providing IP services to subscribers.
- ASP (Application Service Provider)
  - Provides and manages applications on top of IP
  - Provides value added services, Layer 3+ (e.g. VoIP, corporate access, ...)

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# Network Operator Relationships in WiMAX



**ASP** **ASP** **ASP**

A NSP may have a special relationship with an ASP for value added services

Internet

A NSP may have a contract with another NSP

A NSP may have contracts with multiple NAPs

**NSP** **NSP** **NSP**

**NAP** **NAP** **NAP** **NAP** **NAP**

A NAP may have contracts with multiple NSPs

Subscriber Subscriber

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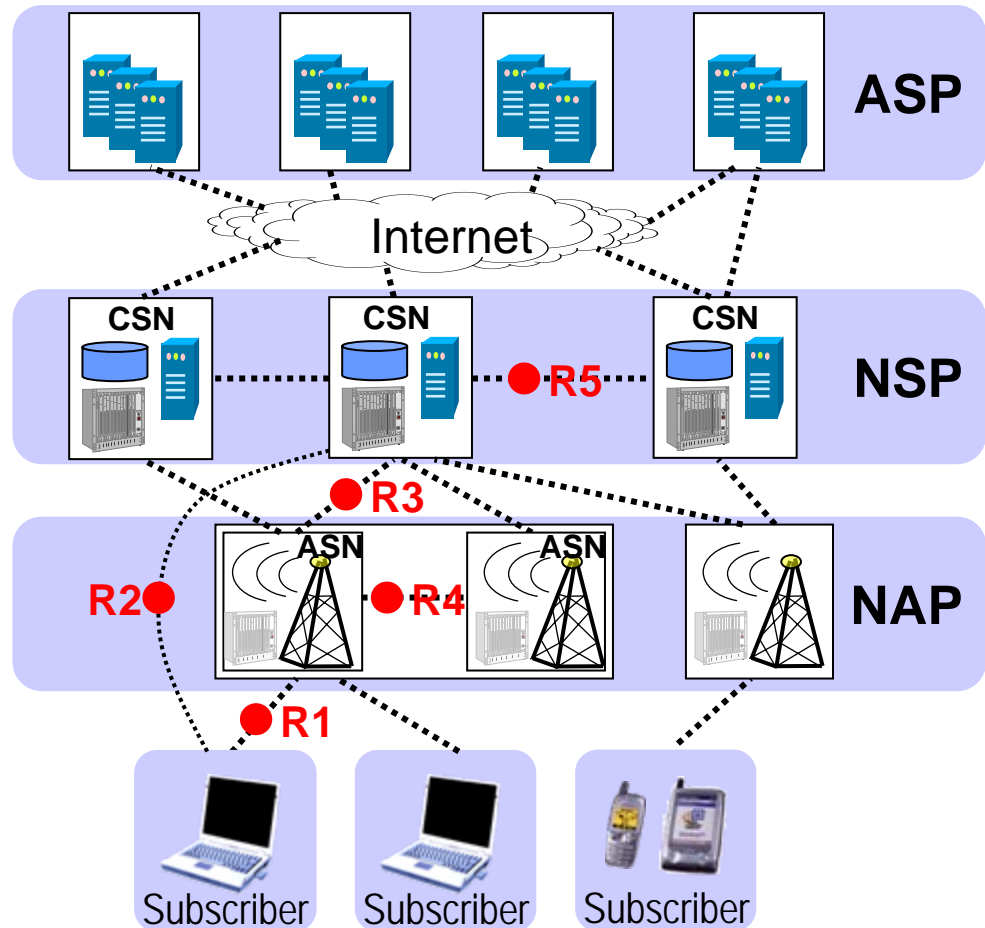# Definition of the WiMAX Network Reference Model

- Based on logical network entities for NSP and NAP
    - CSN: Connectivity Serving Network
        - Logical representation of the functions of a NSP, e.g.
            - Connectivity to the Internet, ASPs
            - Authentication, authorization and accounting
            - IP address management
            - Mobility and roaming between ASNs
            - Policy & QoS management based on a SLA
    - ASN: Access Serving Network
        - Logical representation of the functions of a NAP, e.g.
            - 802.16 interface w/ network entry and handover
            - Radio Resource Management & Admission ctrl.
            - L2 Session/mobility management
            - QoS and Policy Enforcement
            - Foreign Agent (FA)
            - Forwarding to selected CSN
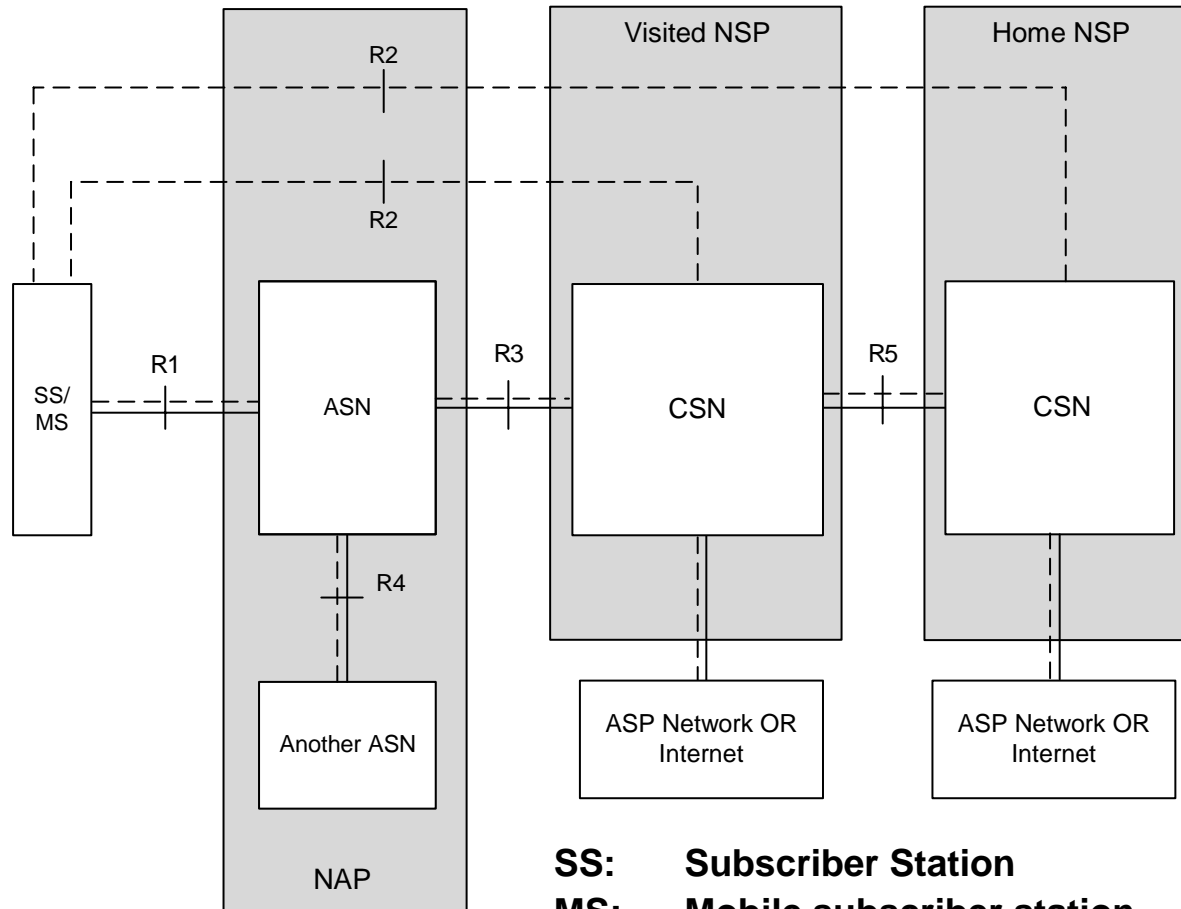
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# Mobile Network Architectures
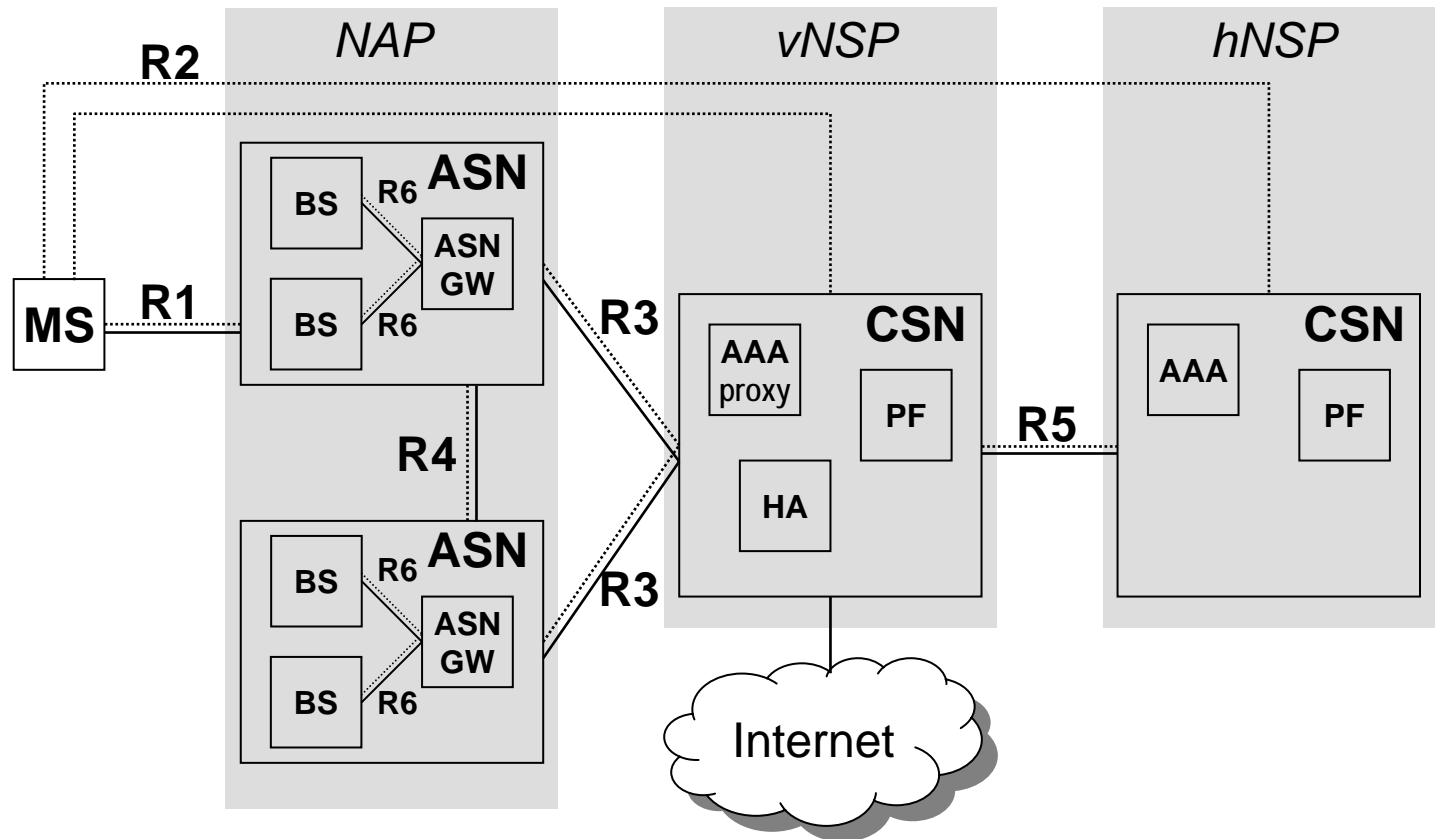
**Legacy Architecture**
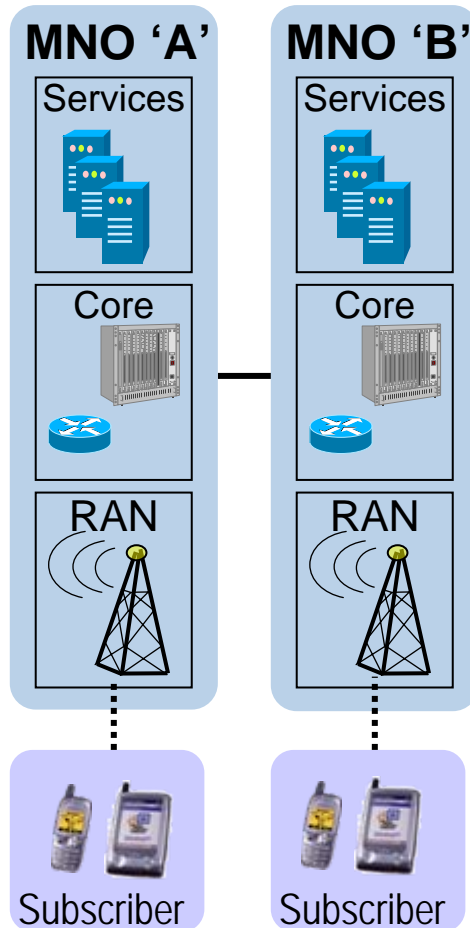
**Mobile WiMAX Network Architecture**

# Mobile WiMAX
# Network Reference Model (NRM)



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

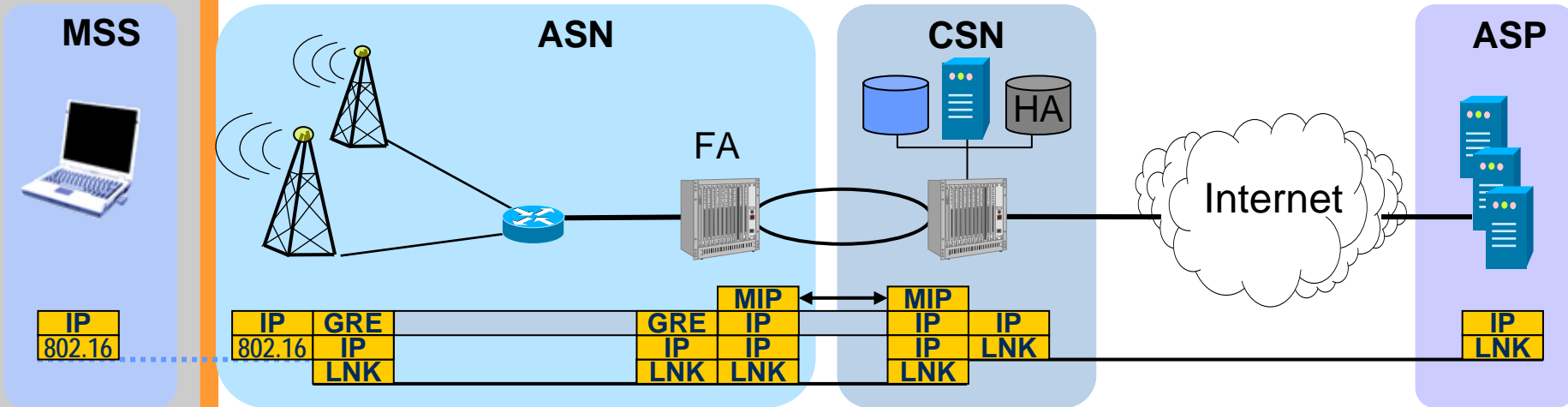control plane - - - - - - -
data plane ———

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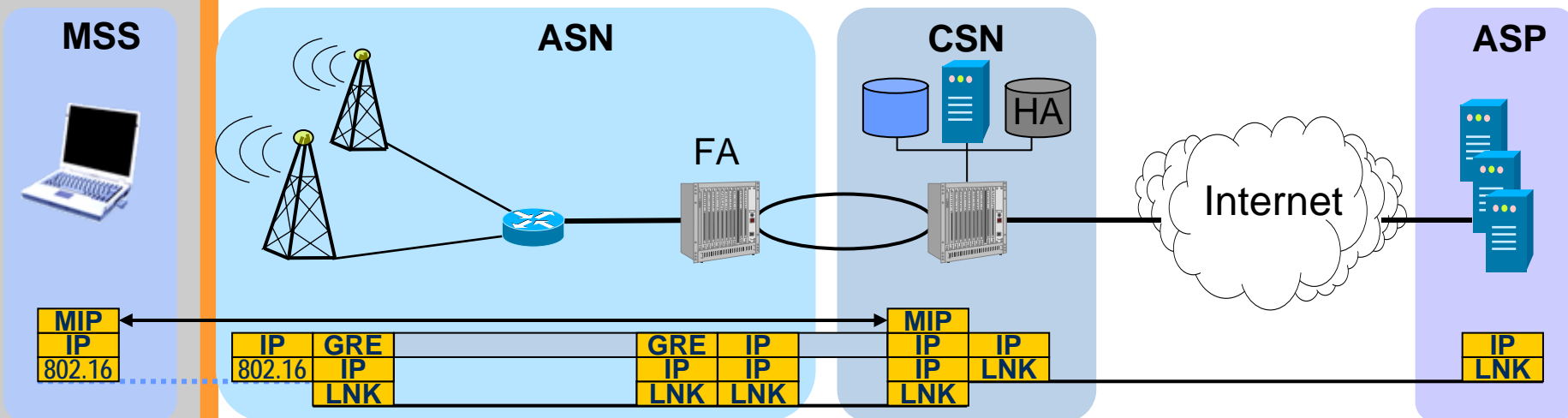# WiMAX Network Reference Model (roaming case, HA in vNSP)



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

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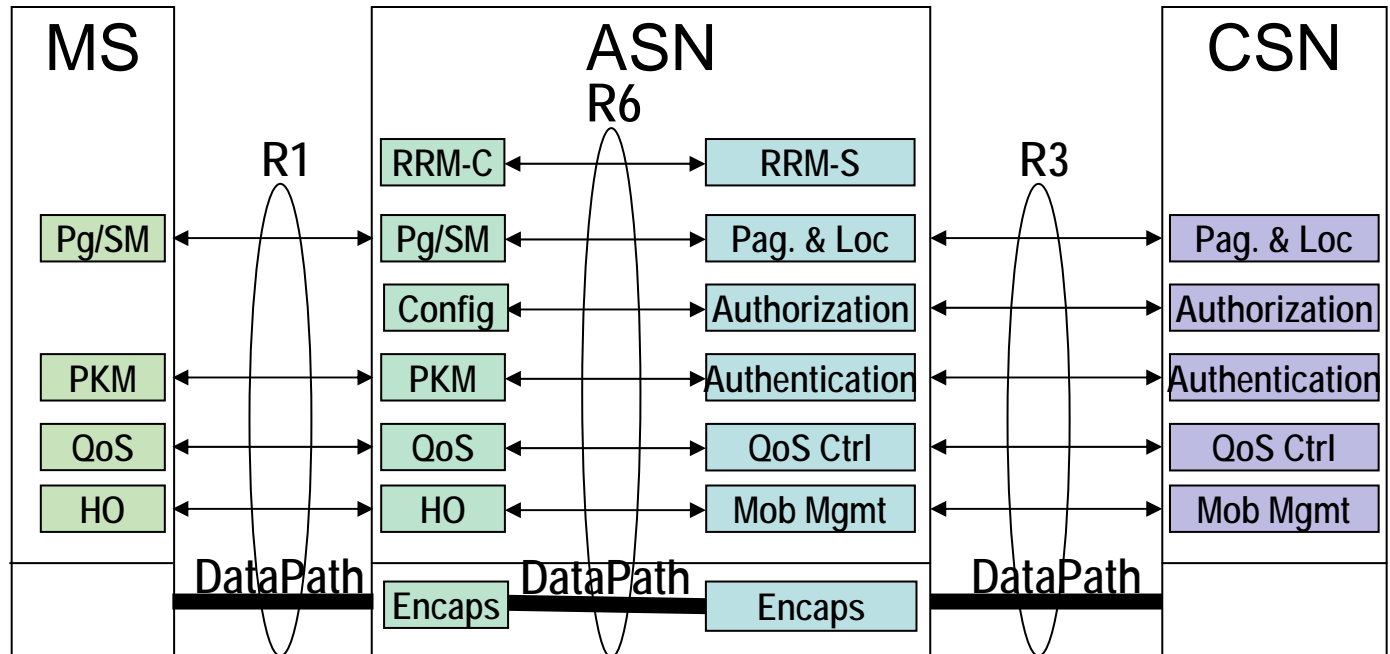# WiMAX CSN Anchored Mobility Management

**Proxy-MIP:** MIP Client resides in ASN-GW



**Client-MIP:** MIP Client resides in MSS
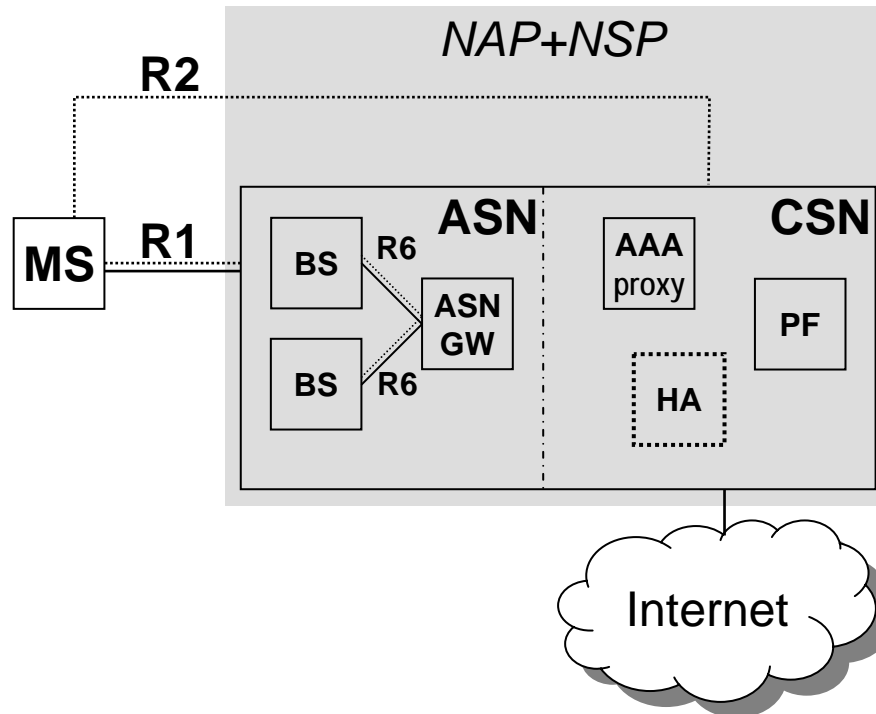
# WiMAX Reference Points



- NRM Reference Points represent a bundle of protocols between peer entities
  - Similar to a real IP network interface
- The implementation of a particular protocols over a reference point is optional
  - If a particular protocol is present, it must conform to the WiMAX specification

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# WiMAX NRM Considerations

- 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 single physical ASN or CSN topology is mandated – allowing room for vendor / operator differentiation

- Optional:
  Further decomposition of ASN into logical entities
    - BS: Base Station
      - IEEE802.16 interface
    - ASN-GW: ASN-Gateway
      - Centralized control and traffic concentration
      - L2 mobility anchor
      - Authenticator and accounting entity
  - Several interoperable ASN Profiles

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# WiMAX NRM: *The simple case*
# Stationary network deployment option



- Direct attachment of a CSN to an ASN without exposing R3 results in a stationary network model without need for MIP
  - L2 mobility still available for load balancing
    - As well as R6 reference point for 'standard' BS

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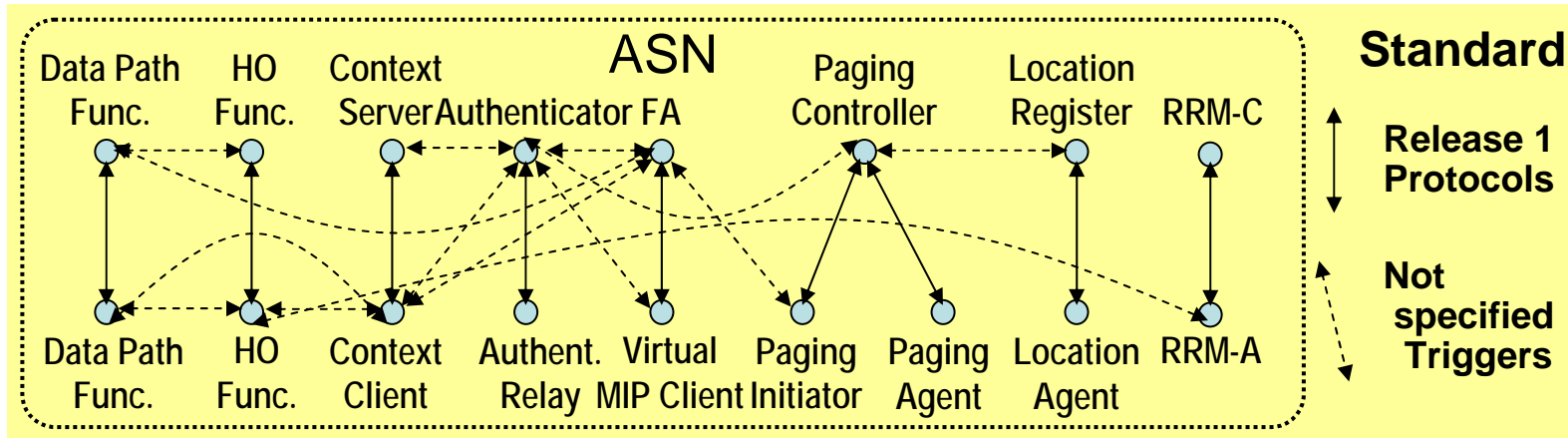# Real deployments will be a mixture of scenarios
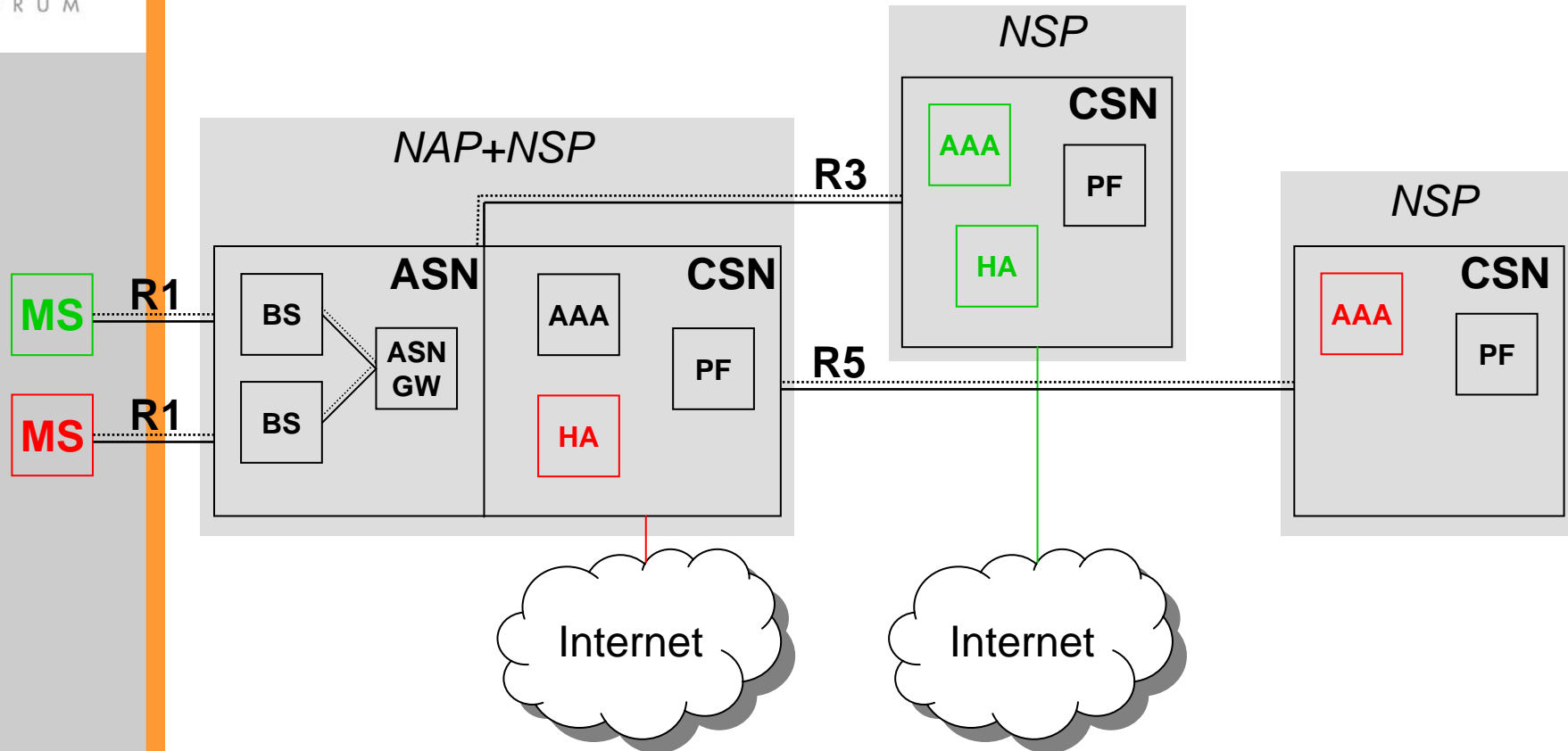


- Many access provider will implement direct Internet connectivity by a co-located CSN to minimize transport.
  - Eventually only for roaming users (no own service provider business)
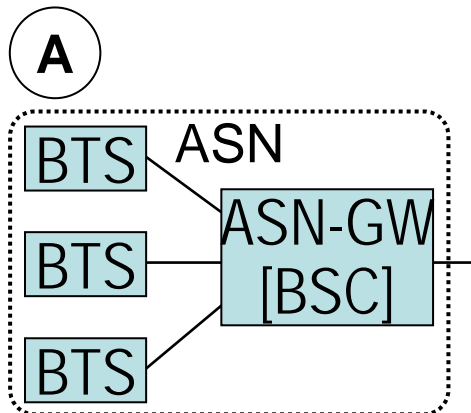
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# WiMAX Network Model Implications for 16ng

- Support for access network sharing
  - Separation of user traffic of different NSPs
  - Overlapping IP address spaces (IPv4)
  - Enforced forwarding of all user traffic to the CSN
    - Legal intercept
    - E911
    - Route optimization

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# 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)

2007-03-19                    (Credits to Domagoj Premec)

# Mapping Functions to ASN Profiles



**Standard**

ASN

Data Path Func. — HO Func. — Context Server — Authenticator — FA — Paging Controller — Location Register — RRM-C

Data Path Func. — HO Func. — Context Client — Authent. Relay — Virtual MIP Client — Paging Initiator — Paging Agent — Location Agent — RRM-A

**Release 1 Protocols**

**Not specified Triggers**

## WiMAX ASN Profiles:

**A**

BTS
BTS
BTS
ASN
ASN-GW [BSC]

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

**B**

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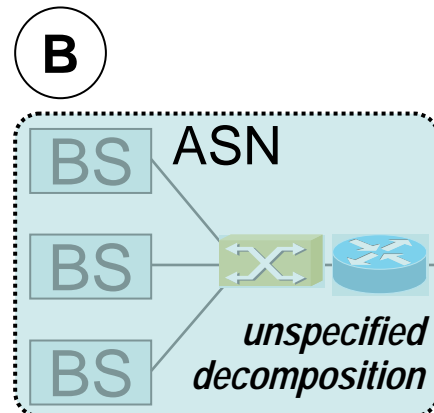
- **e.g.** most ASN functions in BS
- BS anchored by standard router
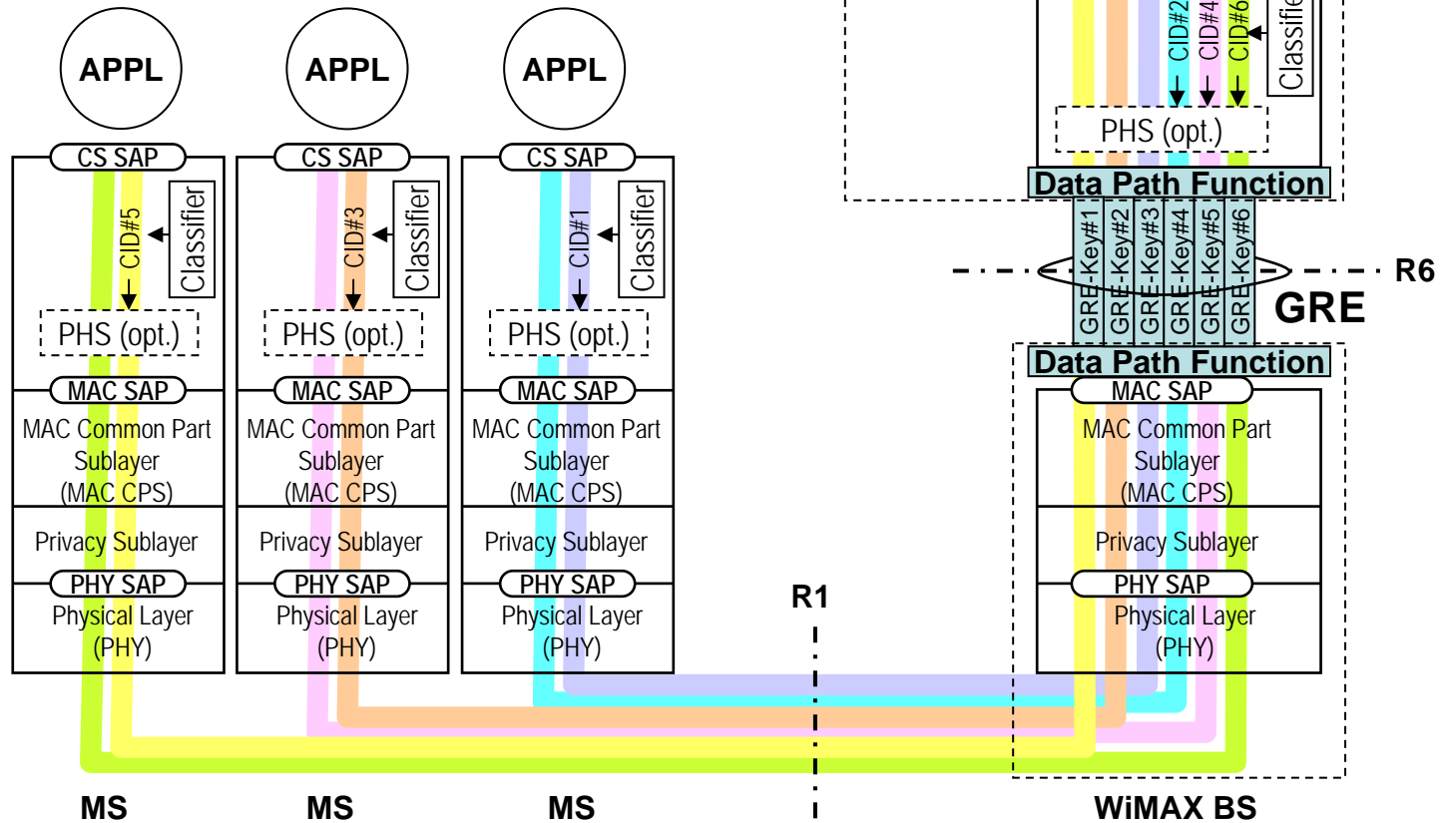- Inter BS control over Ethernet

**C**

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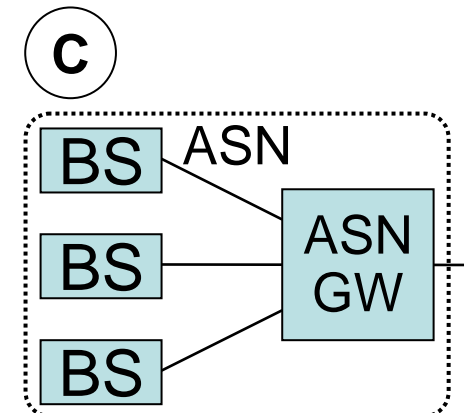
- All radio-specific functions in BS
- Handover-Ctrl (RRM) in BS
- Routing and AAA/Pg in ASN-GW

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# ASN Data Plane (IP-CS Case)

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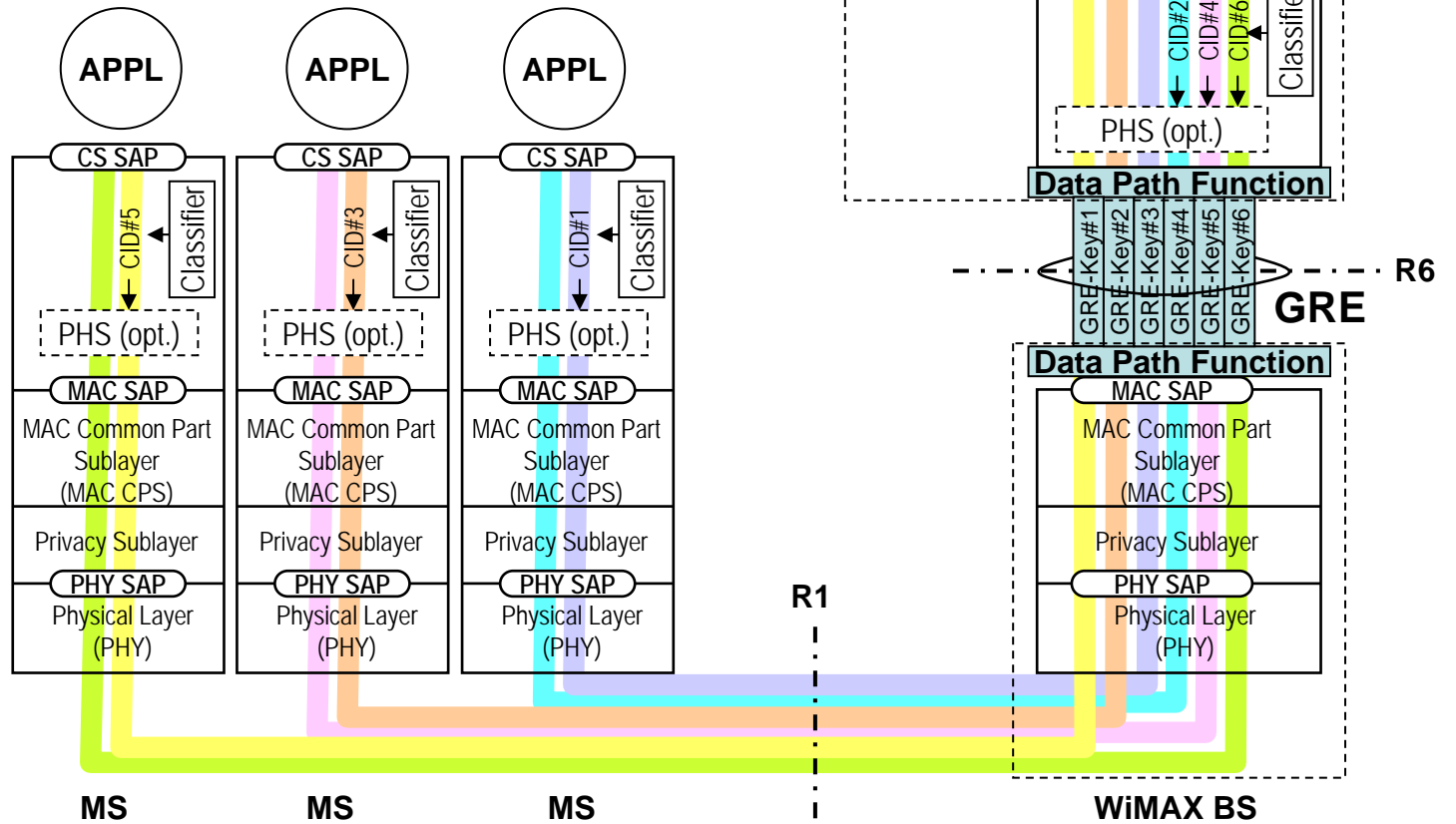
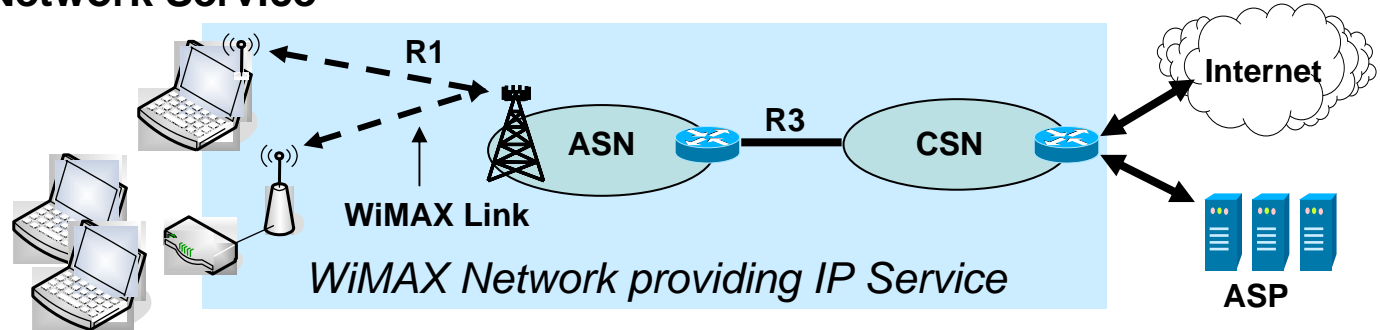# ASN Data Plane (IPoETH-CS Case)

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# Control Plane and Data Path Protocol Layering

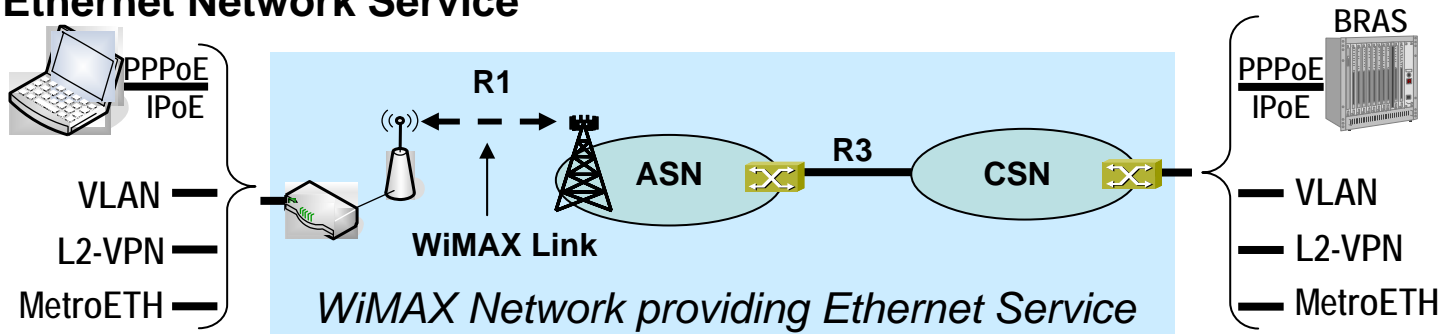2007-03-19
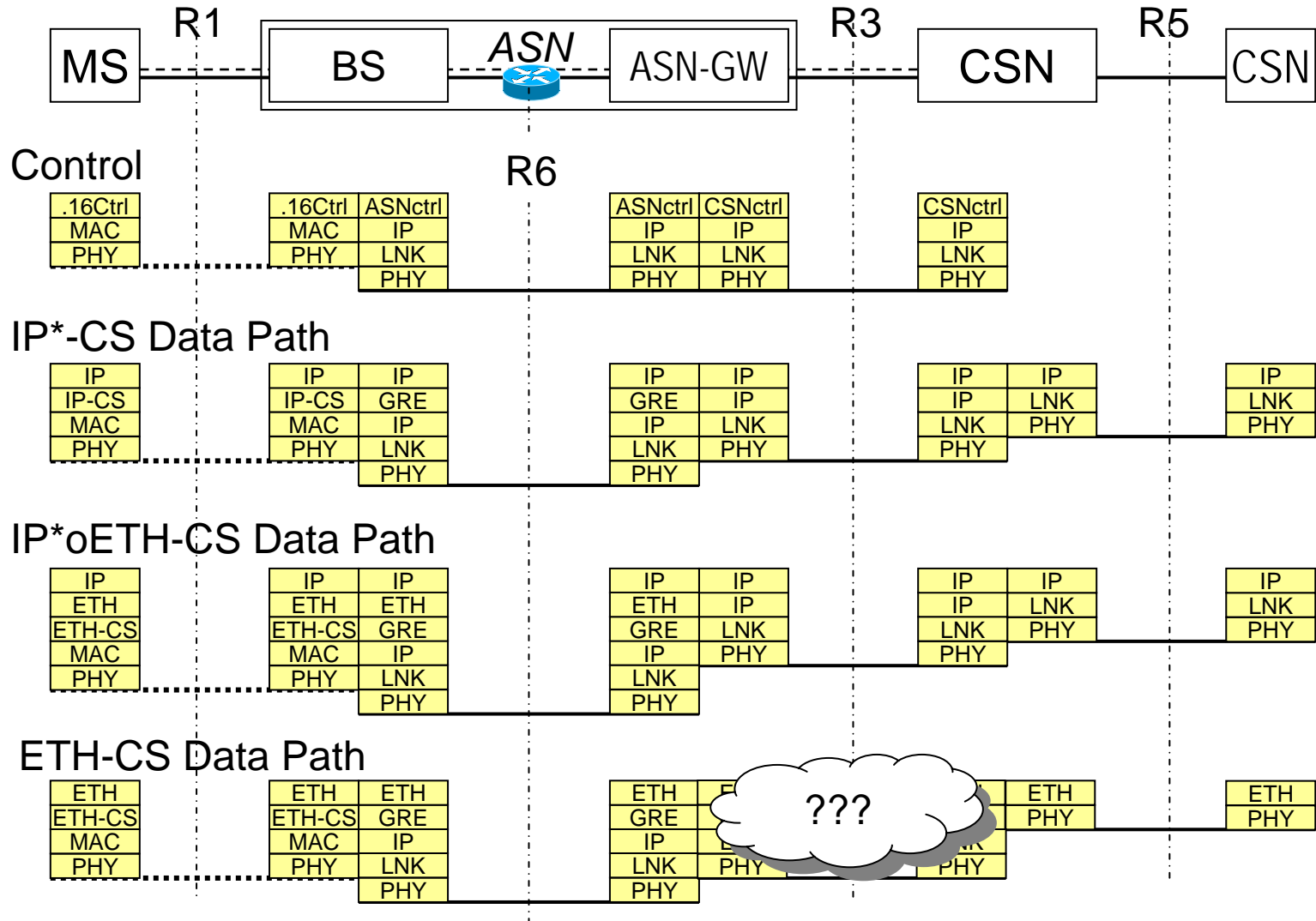
# IP Network Service vs. Ethernet Network Service

- **IP Network Service**



*WiMAX Network providing IP 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

- **Ethernet Network Service**



*WiMAX Network providing Ethernet Service*

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

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# WiMAX Interworking with DSL
## (over V-interface)
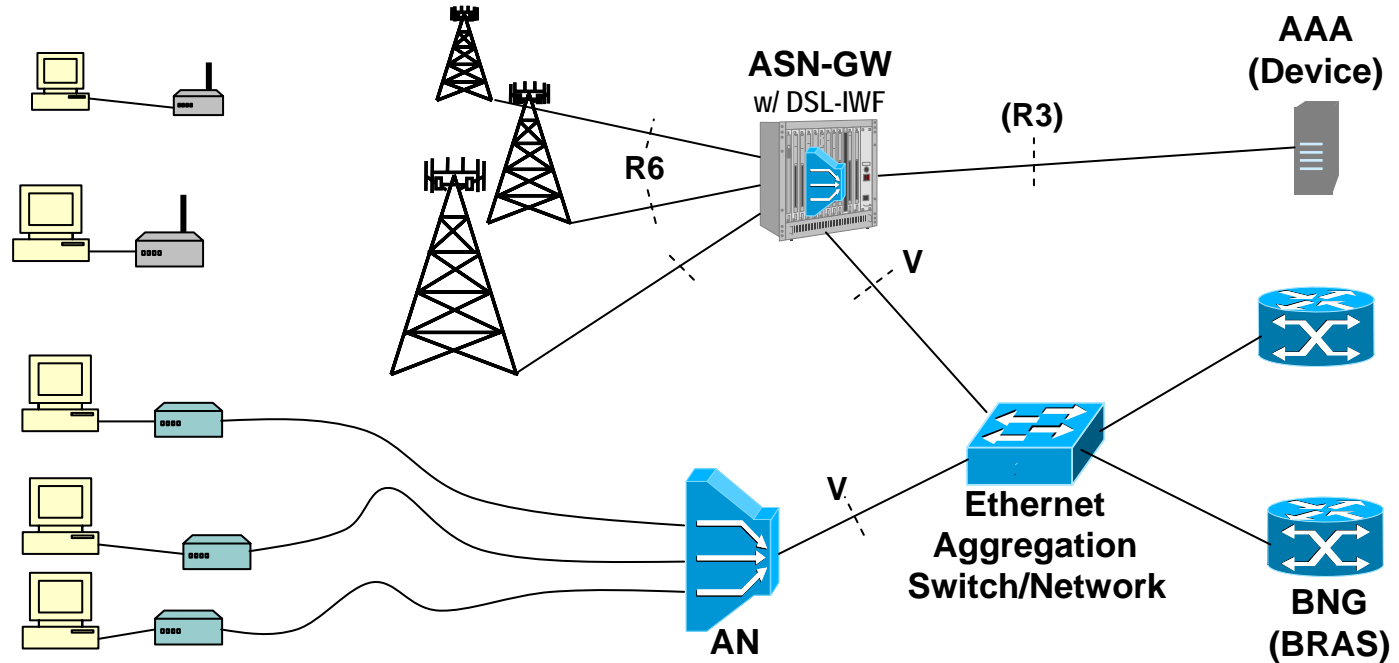


- ASN-GW w/ DSL-IWF looks like an AN towards the DSL aggregation network
- WiMAX AAA provides device authentication, QoS set-up and session accounting per device
- Ethernet Bridge and access router resides outside of the WiMAX network

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# WiMAX ASN Model Implications for 16ng

- An ASN is able to serve IP-services as well as ETH-services
  - ETH-CS: Bridge and access router may reside outside of the WiMAX network
    - But still serving IP services
- ASN may have to concurrently support IP-CS, IPoETH-CS and ETH-CS
  - WiMAX assumption: A MS is deploying only one kind of Convergence Sublayer at a time
- WiMAX mandates per-SF tunneling between BS and ASN-GW
  - Convergence Sublayer is implemented in ASN-GW

# Relays in Mobile WiMAX

## Rationale:

## Poor 'indoor' penetration, even more when in move



### How far does it go? It depends where your terminal is!

Consider a hypothetical broadband (1Mb/s) wireless network
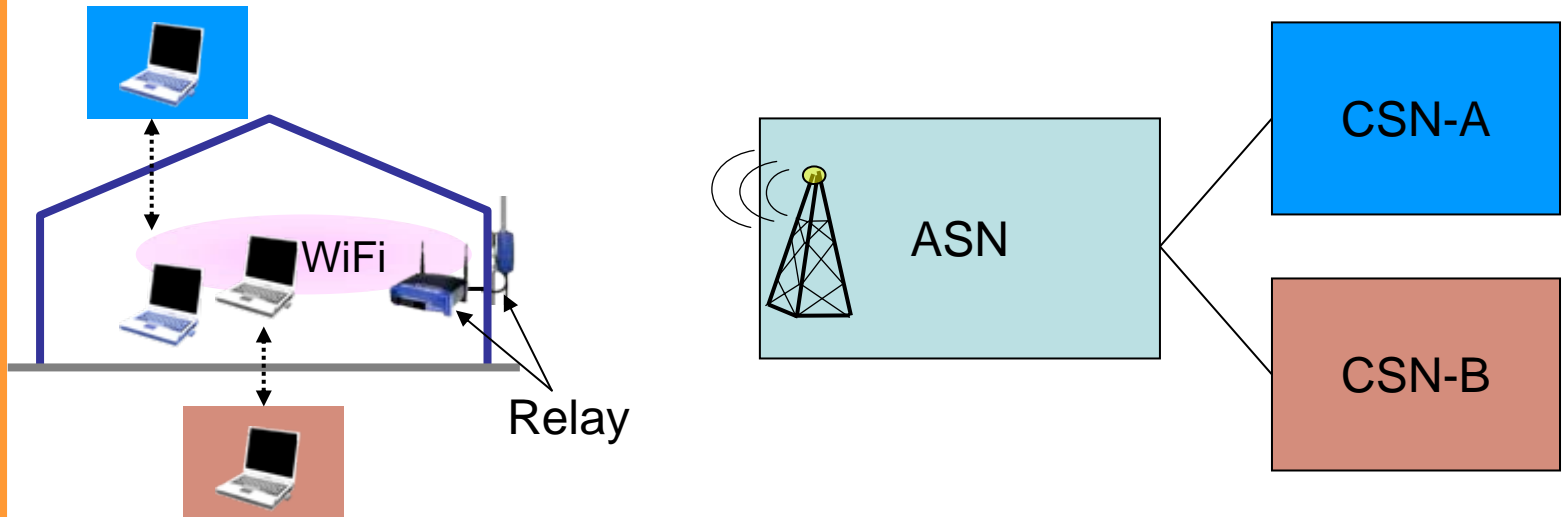
3 Sector base station at 25m to:

| | Gain | Height | Building loss | Range | Relative site count |
|---|---|---|---|---|---|
| Rooftop – LOS | 10 dBi | 8 m | 0 dB | > 30km | |
| Rooftop NLOS | 10 dBi | 8 m | 0 dB | 6.2 km | 1 |
| Terminal / Gateway in upstairs window | 3 dBi | 5 m | 0 dB | 1.8 km | 12 |
| Outdoor PCcard | 0 dBi | 1.5 m | 0 dB | 780 m | 60 |
| Indoor PCcard - Suburban | 0 dBi | 1.5 m | 10 dB | 410 m | 230 |
| Indoor PCcard - Urban | 0 dBi | 1.5 m | 20 dB | 210 m | 800 |

All figures except LOS based on COST231-Hata model with 10dB shadow margin and no cable losses. System operates at 2GHz with 1Mb/s from 24dBm EIRP terminal TX, 3dB Eb/No, 5dB NF RX. BS antenna = 18dBi

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# WiMAX – Wi-Fi relays



WiFi

Relay

ASN

CSN-A

CSN-B

- WiMAX devices may be dual mode Wi-Fi/WiMAX devices
  - Very likely for WiMAX equipped notebooks
- WiMAX – Wi-Fi relays can be applied to solve the indoor penetration issues of WiMAX
- Relays may be concurrently used by several WiMAX subscribers belonging to different CSNs
  - Can WiMAX subscription be re-used behind relay?
    - Setting up WiFi security context and accounting

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# WiMAX NWG Definitions for Multiple Hosts Support
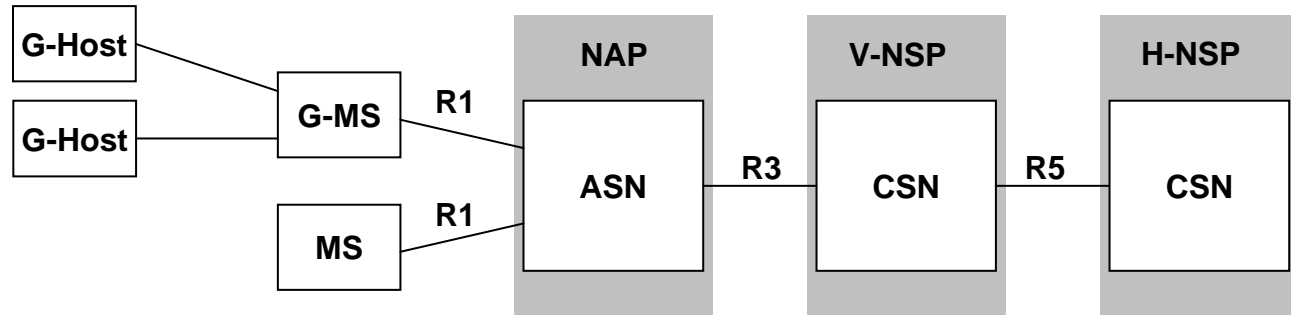


- Gateway-MS (G-MS)
  Mobile WiMAX SS/MS that provides the multiple hosts support
- Gateway-Host (G-Host)
  Host attached to the G-MS to leverage the WiMAX network facility for external access.
  - Full Host
    - Host with direct or indirect subscription to access the WiMAX network; appears to the network like an ordinary Mobile WiMAX MS with full QoS support.
  - Limited Host
    - Host without WiMAX subscription (NAT user)

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# Network Sharing and Roaming with Relay w/ Multiple Hosts Support



CSN-B

CSN-A

CSN-D

CSN-C

Internet

ASN
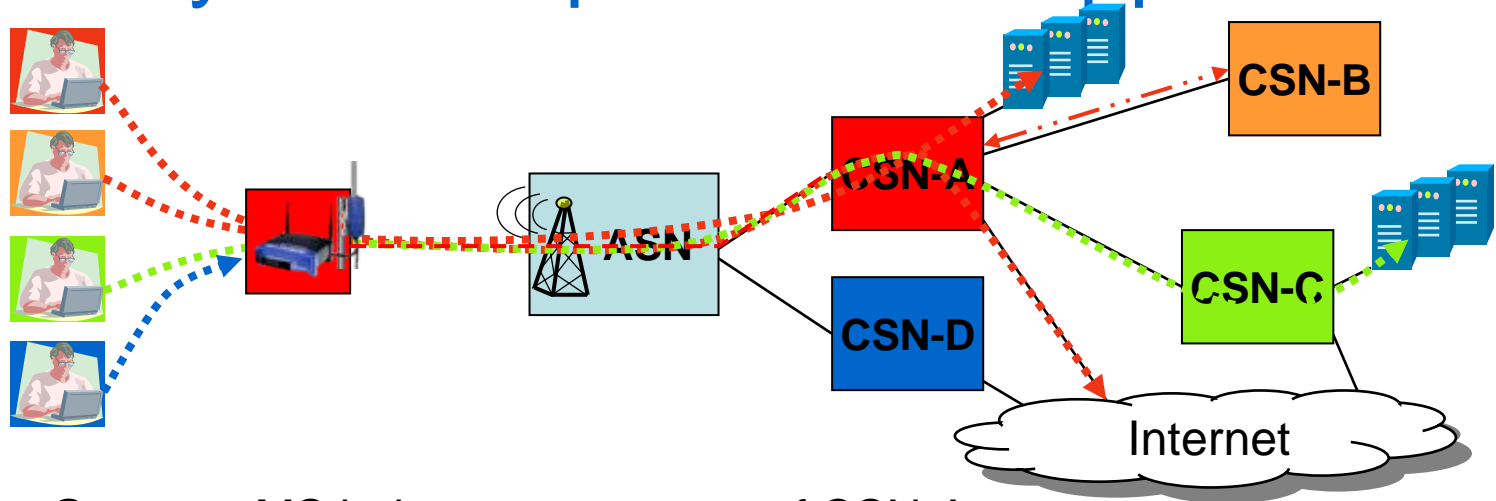
- Gateway-MS belongs to operator of CSN-A
  - Establishes control connection to AAA server in CSN-A
- User A gets access over the G-MS belonging to CSN-A
  - Authentication is provided by AAA server in CSN-A
- User B gets Internet Access over G-MS and CSN-A
  - Roaming without data forwarding to home
- User C gets access to his services over CSN-A
  - Roaming with data forwarding to home
- User D does not get access due to missing authentication path

**CSN-B and CSN-C are not aware of the G-MS in the path**

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# WiMAX Multiple Hosts Support Implications for 16ng

- A MS may be a gateway serving multiple WiMAX subscriptions
  - Home NSPs may be not aware that subscriber is connected via G-MS
  - G-MS has to connect multiple independent hosts to the ASN
    - Bridging or Routing
    - Overlapping IP address spaces
    - Individual connection management

*Multiple Hosts Support will be addressed in WiMAX NWG Release 1.5*

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# Summary:
# WiMAX NWG Release 1 Features

- Network discovery and selection with roaming support
- Authentication and Authorization based on EAP and RADIUS
- IP & Ethernet support (Ethernet optional)
- Mobility management inside ASN and directly between ASNs
- Mobility Management between ASN and CSN based on Mobile IP
  - Client MIP support as well as DHCP with Proxy MIP
- Radio Resource Management procedures inside ASN
- Sleep/Idle mode and paging support
- Pre-provisioned QoS framework
- No standardized functional decomposition inside CSN
- Two different ASN profiles for standardized function splits between BS and ASN-GW
  - Optional to implement

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# The End

- Questions?
- Comments!

*Thank you for your attention!*

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