Key technologies for mobile relays in WiBro (Mobile WiMAX)

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Overview

- Why relays in Mobile WiMAX?
- Radio Relays
- Mobile Multihop Relays - IEEE802.16j
- Serving Wi-Fi Devices
- WiMAX – Wi-Fi Relaying issues
- Multiple Hosts Support in the Mobile WiMAX Network
- Conclusion

Why relays in Mobile WiMAX? Motivation #1:

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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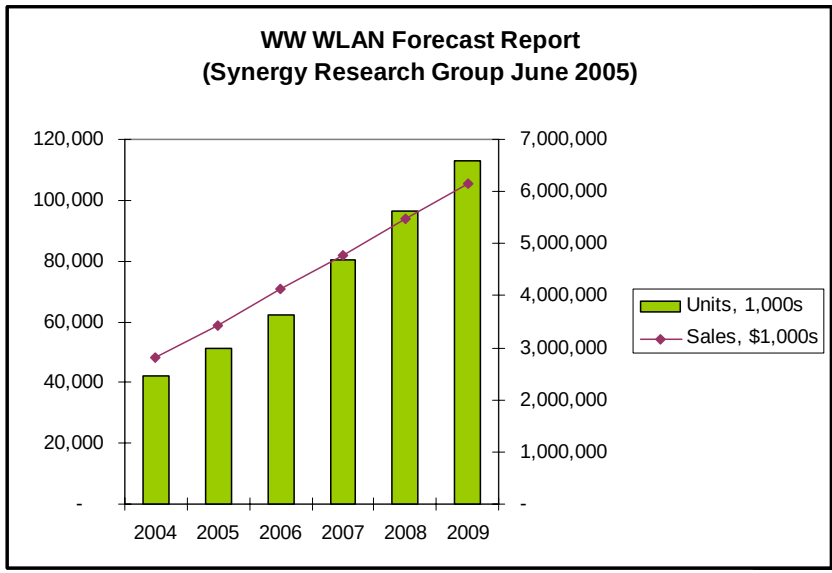
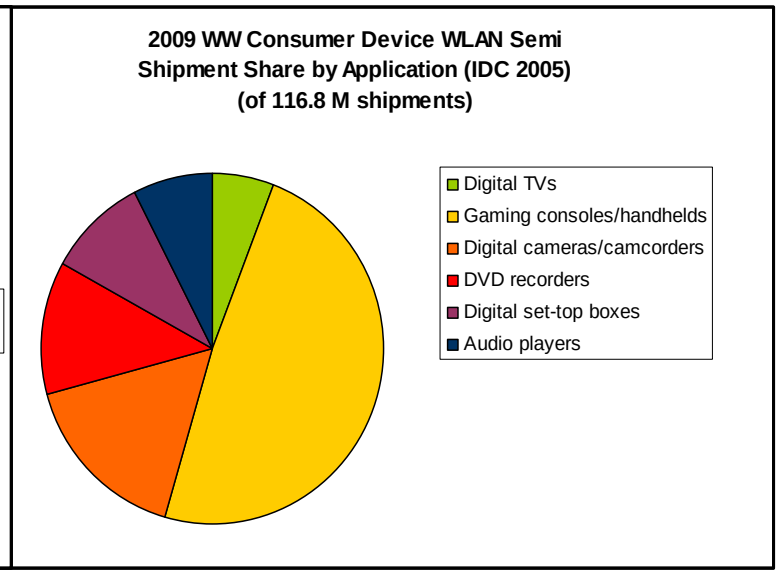
Why relays in Mobile WiMAX? Motivation #2:

- There are a hundred million Wi-Fi devices:

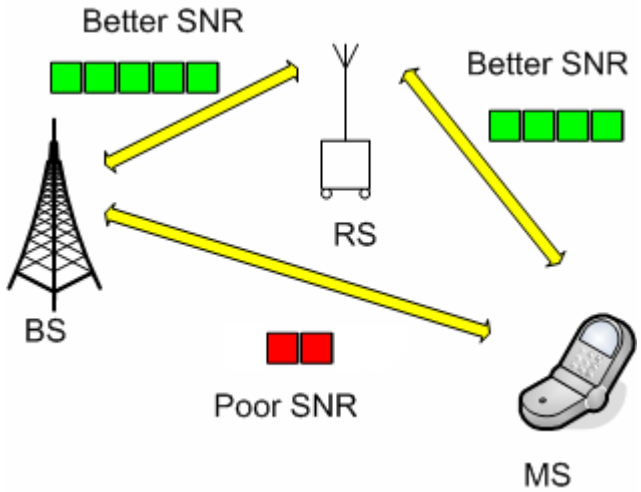


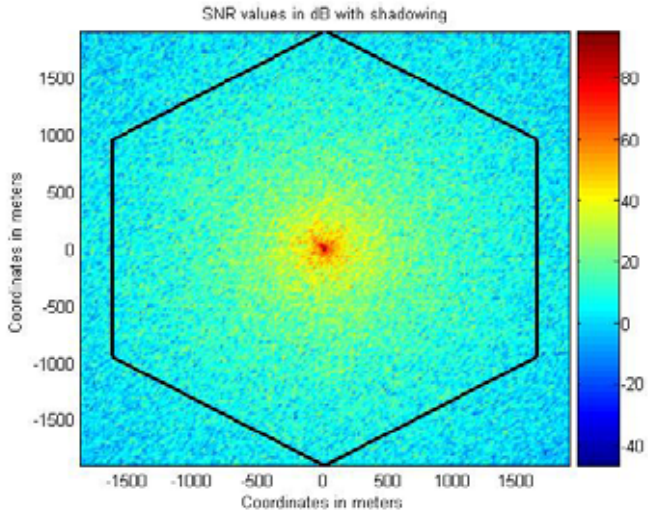


- And even more in future…
  - E.g. 55 -100 million Wi-Fi smart phones in 2010 (SenzaFilli, IDC and ABI)

Source: Wi-Fi Alliance, 2005

Radio Relays: Improving Link Quality

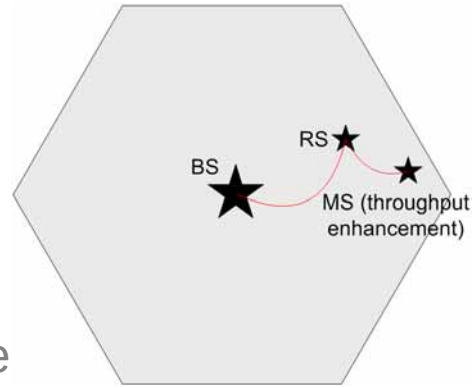




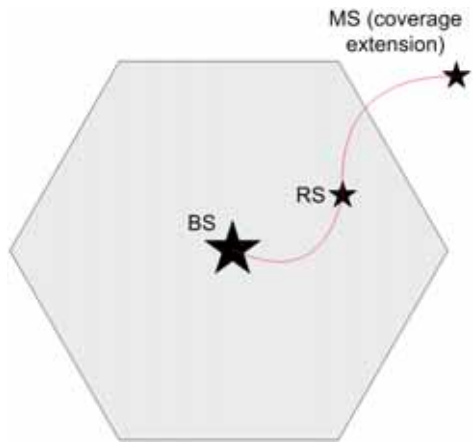
- Relay station helps improve SNR but more radio resource allocation may be needed
  - Tradeoff cell capacity with range (coverage extension)
- With better SNR, higher data rate can be used instead of more robust data rate
  - Relay replaces low SNR link with substantially higher SNR multi-hop links
  - Additional overhead and delay

Radio Relays
Throughput vs. Coverage

- Throughput enhancement
  - Target MS located in base station coverage
  - Higher average SNR over multiple links
    - Increased link data rate
  - Relay station behavior (e.g.):
    - Relay of DL and UL unicast data messages
    - Control messages directly from the base station or (selectively repeated) by RS

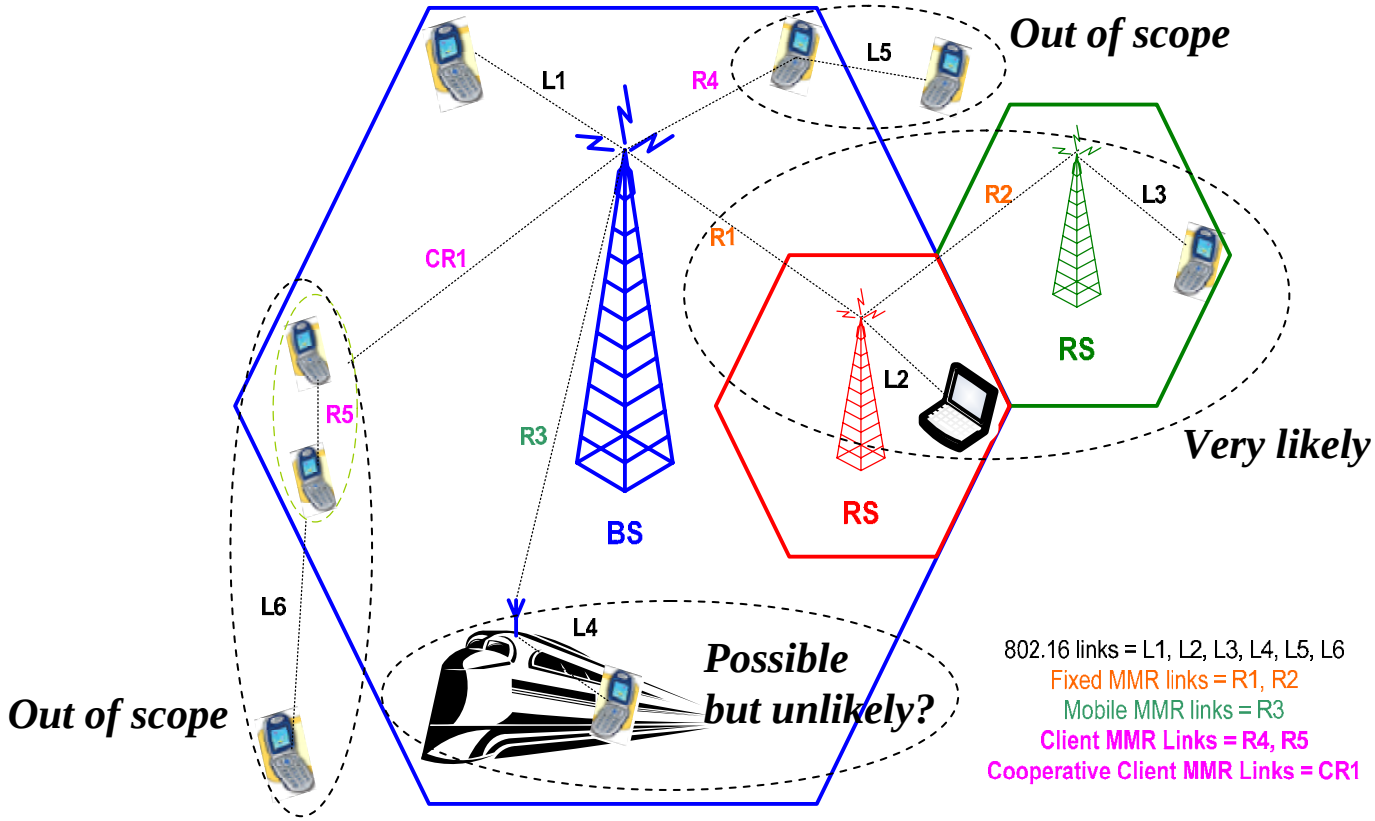


- Coverage extension
  - Target MS might be located outside of base station coverage
  - Extend coverage beyond base station's cell boundary
  - Relay station behavior (e.g.):
    - Own preamble
    - Broadcast control messages and unicast data messages
    - Support during network entry procedure

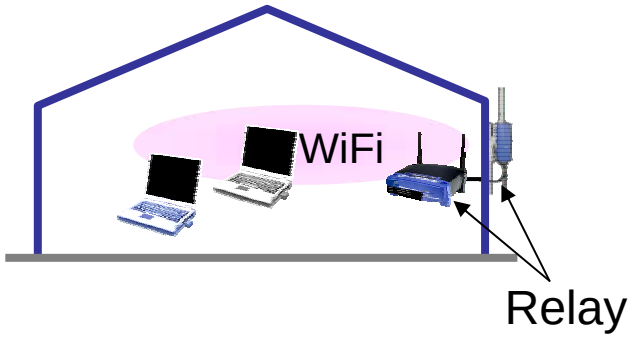


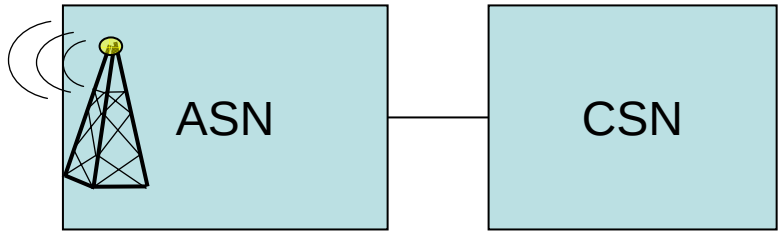
Mobile Multihop Relays
IEEE 802.16j Task Group – Scope

- *IEEE802.16j specifies OFDMA physical layer and medium access control layer enhancements to IEEE Std 802.16 for licensed bands to enable the operation of relay stations. Subscriber station specifications are not changed.*



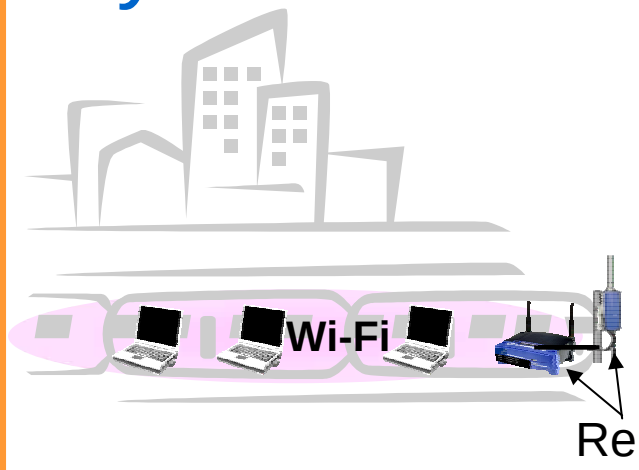
Serving Wi-Fi devices by Mobile WiMAX networks

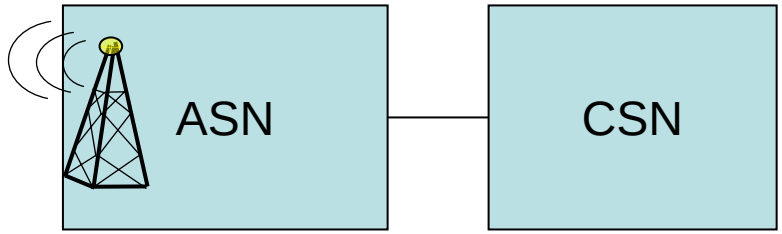




- A relay consists of a Mobile WiMAX CPE connected to a Wi-Fi Access Point
  - NAPT may be applied to allow several Wi-Fi devices to concurrently use the WiMAX uplink
- All the hosts behind the NAPT appear to the CSN as a single host.
  - Usually sufficient for plain Internet access and nomadic use cases.

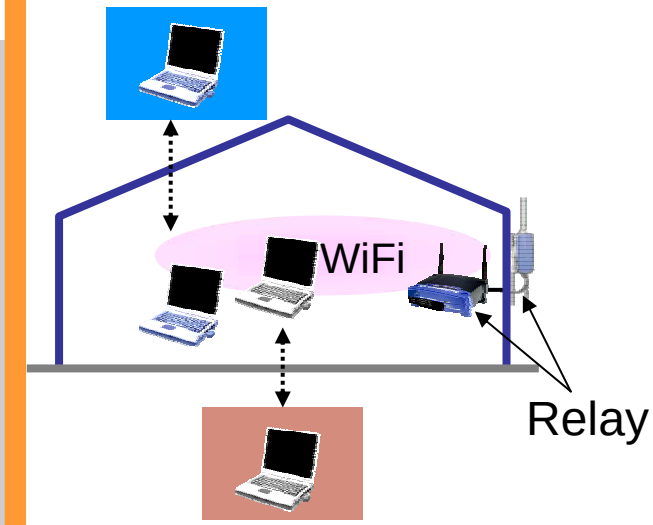
Serving *moving* Wi-Fi devices by Mobile WiMAX networks

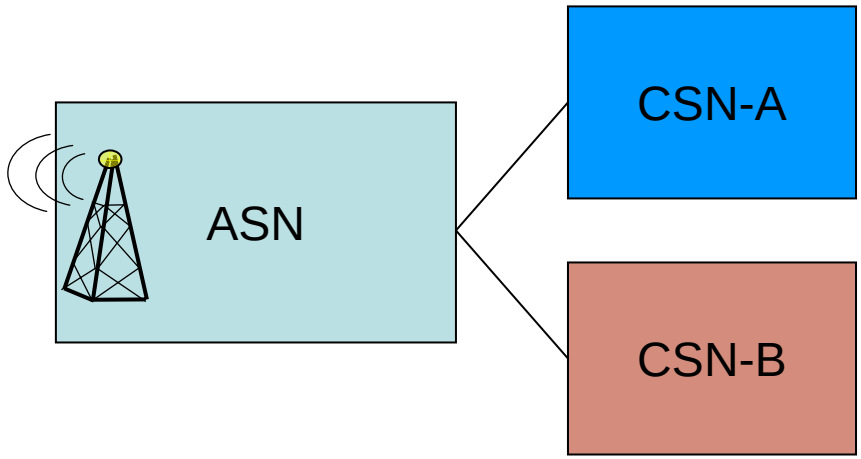




- Putting a Mobile WiMAX – Wi-Fi relay on a vehicle provides mobility to all the Wi-Fi devices on the vehicle.
  - Like a Mobile Public Wi-Fi Hotspot
- Only simple service models feasible due to NAPT on the link to the CSN
  - No service differentiation on the WiMAX link
  - Difficult and expensive accounting & billing

WiMAX – Wi-Fi relaying issues

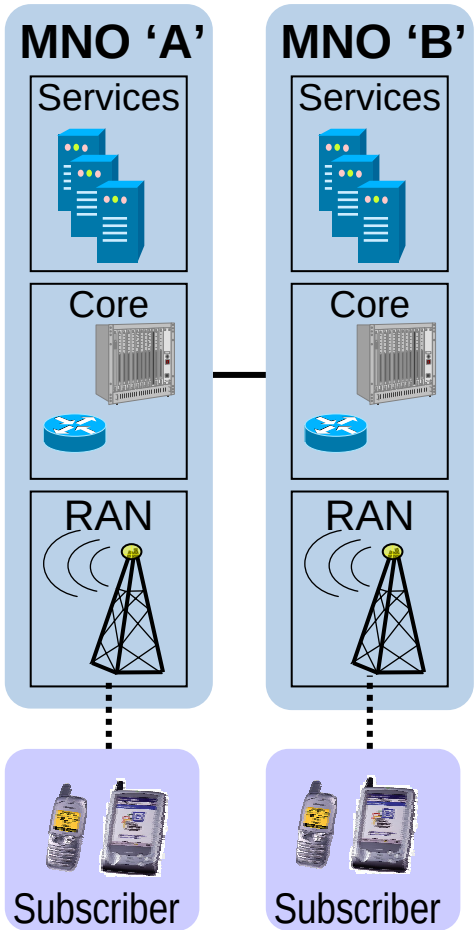




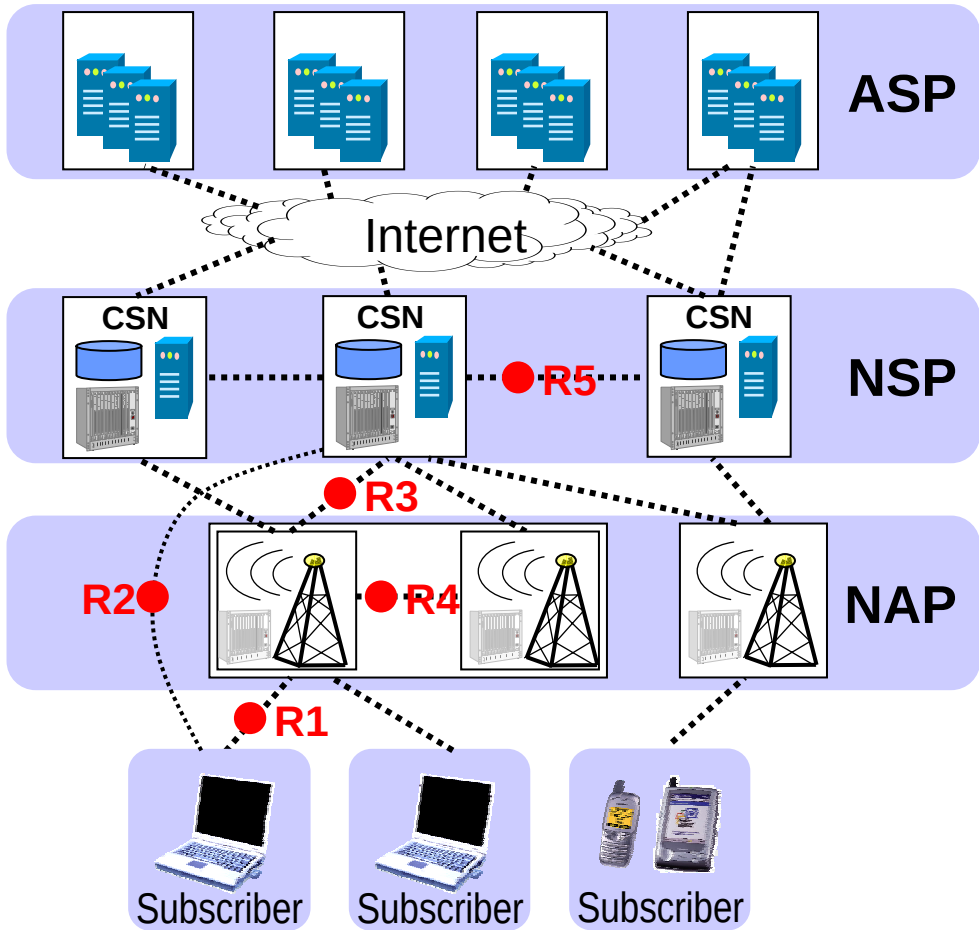
- Wi-Fi devices may be dual mode Wi-Fi/WiMAX devices
  - Very likely for WiMAX equipped notebooks
- WiMAX – Wi-Fi relays may be applied to solve the indoor penetration issues of WiMAX
- Relays may be concurrently used by several Wi-Fi devices
  - The WiMAX subscriptions should be usable behind a WiMAX - Wi-Fi relay
  - WiMAX subscriptions may belong to different CSNs

Mobile Network Architectures

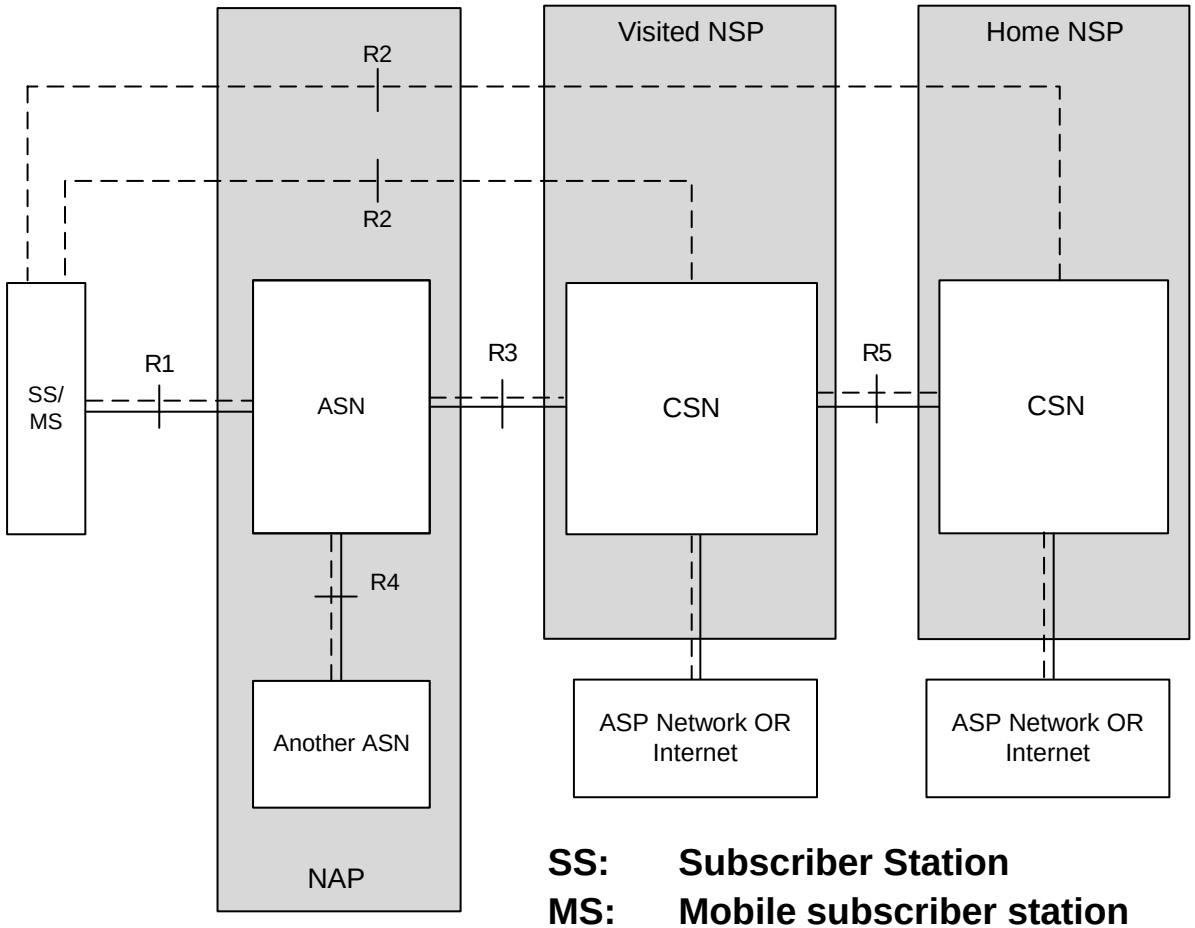
Classical Architecture



Mobile WiMAX Network Architecture

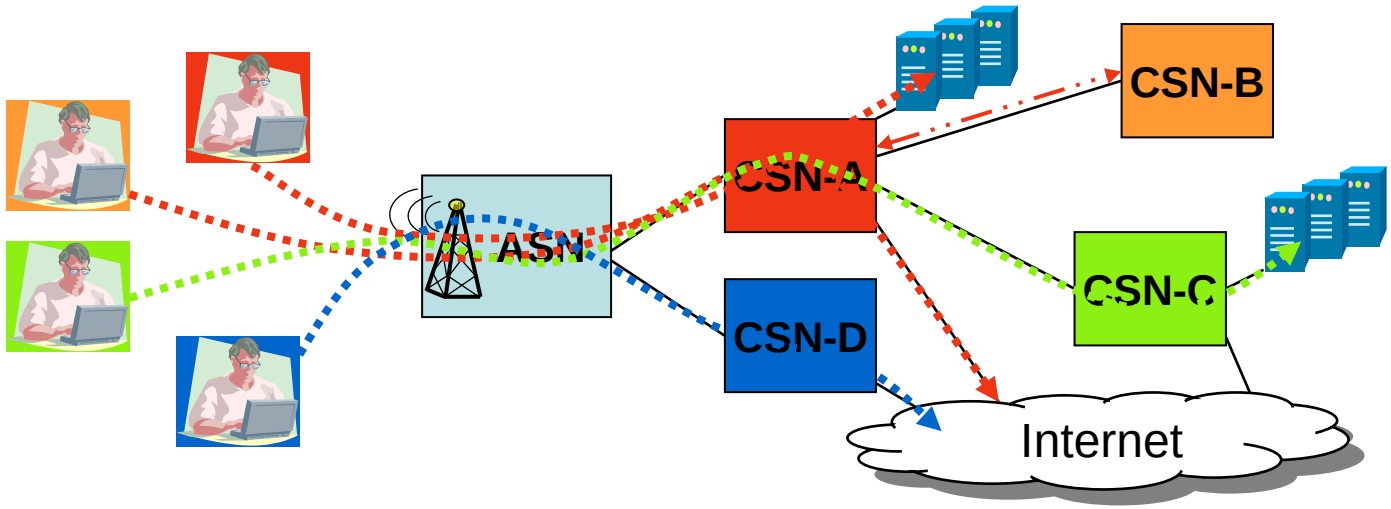


Mobile WiMAX
Network Reference Model (NRM)



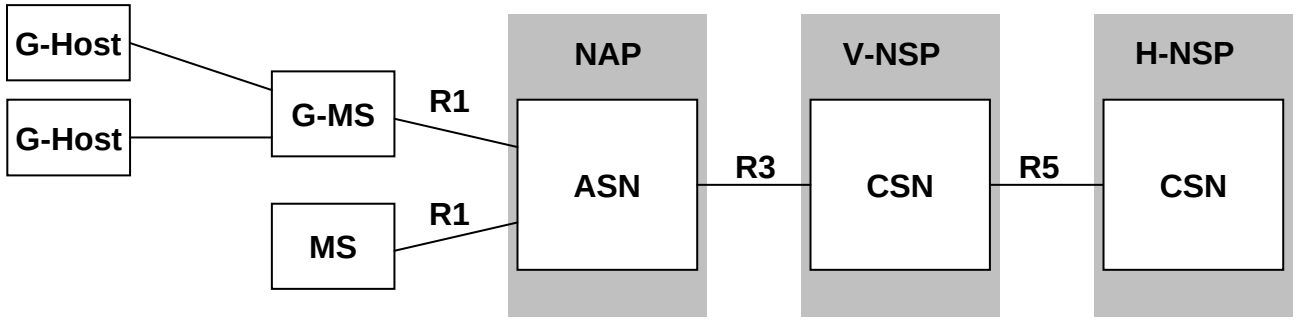
SS: **Subscriber Station**
MS: **Mobile subscriber station**
ASN: **Access Serving Network**
CSN: **Connectivity Serving Network**

Network Sharing and Roaming in Mobile WiMAX



- User A gets access to the services of his provider
- User B gets Internet Access over 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 gets Internet Access over CSN-A
  - Network sharing of ASN

WiMAX NWG Definitions for Multiple Hosts Support

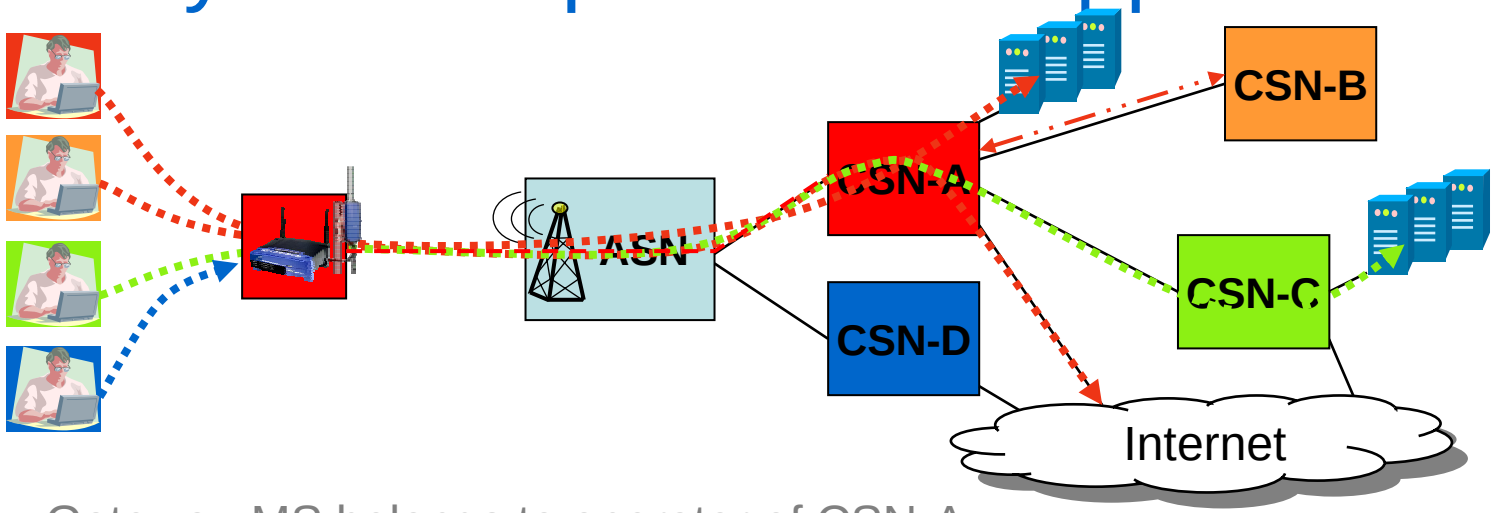


- Gateway-MS (G-MS)
  Mobile WiMAX SS/MS that provides the multiple hosts support
- Gateway-Host (G-Host)
  Host attached to the G-MS to leverage the WiMAX network facility for external access.
  - Full Host
    - Host with direct or indirect subscription to access the WiMAX network; appears to the network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

WiMAX NWG Multiple Hosts Support Primary requirements

- Mobility has to be supported
- Multiple host behind a single Gateway-MS
- All hosts will have a separate account
- Host can connect via Wi-Fi
- Host can have accounts with roaming partner
- Gateway-MS should support both CMIP and simple IP devices
- NAPT solutions are not acceptable
- MAY:
  - Different host may connect to different HAs
  - QoS support
  - Header compression

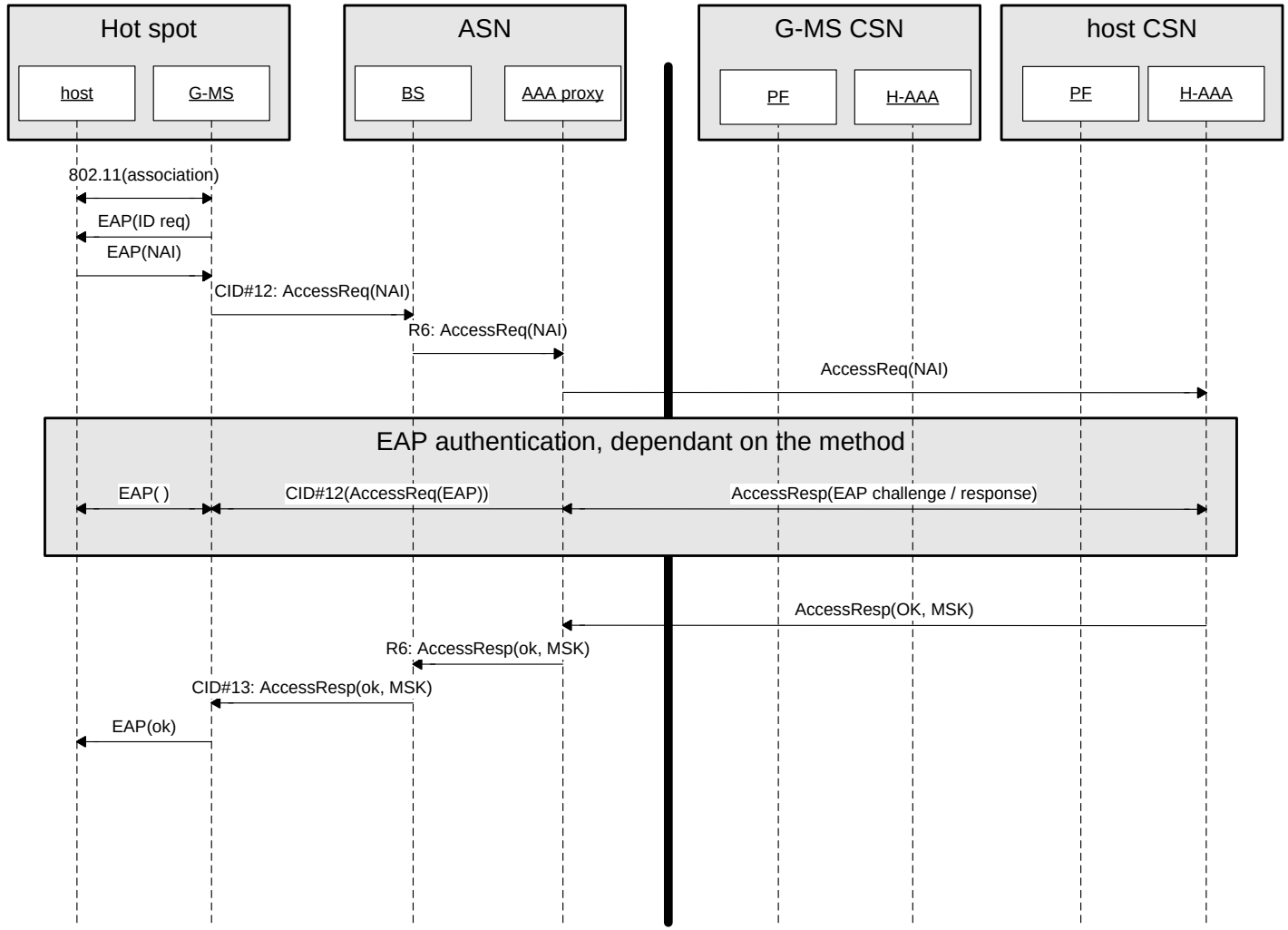
Network Sharing and Roaming with Relay w/ Multiple Hosts Support



- 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

How multiple hosts support work: e.g. Authentication of a G-Host



Conclusion

- Mobile Multihop Relays as well as Multiple Hosts Support provide mobile relaying functions
  - Mobile Multihop Relays defined by IEEE802.16j
  - Multiple Hosts support defined by WiMAX NWG in a future release
- Both solutions supplement each others
  - Mobile Multihop Relays for Network Access Providers
  - Multiple Hosts support for Network Service Providers and Subscribers to enable easy-to-install public and private Wi-Fi hotspots with enhanced capabilities.

The End

- ***Thank you for your attention!***

- ***Questions, Comments?***