



**WiMAX FORUM® WiMAX™ ROAMING INTERFACE**  
*based on WiMAX Forum Certified™ Products*

***Stage 2 Part 5: Interconnection Release 1.0 Version 2***

**WMF-T42-006-R010v02**  
***WiMAX Forum Approved***  
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# 1 Roaming Interconnections

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## 1.1 Introduction

---

WiMAX™ roaming requires interconnections between visited Network Service Provider (NSP) and home NSP to transport traffic for financial settlement/clearing, AAA and data traffic. The purpose of this document is to discuss connection options and define network interface/reference point requirements to establish roaming without expanding on all the logical functions of the WRI Architecture. See WiMAX™ Roaming Interface (WRI) Stage 2: Part 0 [1] for a high-level description of the WRI architecture and a list of commonly used references, acronyms, and terms. Direct connections between visited and home NSP are discussed as well as connections that go through a 3<sup>rd</sup> party roaming exchange.

In the figures of this document:

- Dashed and solid lines have been used to differentiate the type of traffic between network elements. A solid line indicates the flow of bearer traffic only or a combination of bearer and signaling traffic. A dashed line indicates the flow of signaling traffic.
- Reference Points starting with:
  - Prefix R (i.e. R1, R3, and R5) are described in Network Architecture Release 1.0 Stage 2 and Stage 3 referenced in [1].
  - Prefix X (i.e. X5 and X6) are detailed in other parts of the WRI Stage 2 set of specifications. For additional details, see [1].

### 1.1.1 Scope

---

This document defines Financial Settlement/Clearing, AAA traffic and bearer traffic IP data network interface/reference point requirements to establish roaming between the visited network and home network. It covers:

- Settlement/Clearing Connections
- AAA network connections
- Data Traffic Connection
- 3<sup>rd</sup> party roaming exchange connections
- Mobile IP V4 (MIPv4)
- Internet and Data Services access via visited NSP and home NSP

This document does not cover:

- Network Supported Simple IP
- Mobile IP V6 (MIPv6)
- Specific requirements for IP Multi-Media System (IMS), VoIP/Session Initiation Protocol (SIP)
- Multi-Protocol Label Switching (MPLS)
- Quality of Service (QoS) requirements other than IETF Differentiated Service

- Internet/Data Service/peer-to-peer service via visited or home Network Access Provider (NAP).
- Internet/Data Service Access via the 3<sup>rd</sup> party roaming exchange

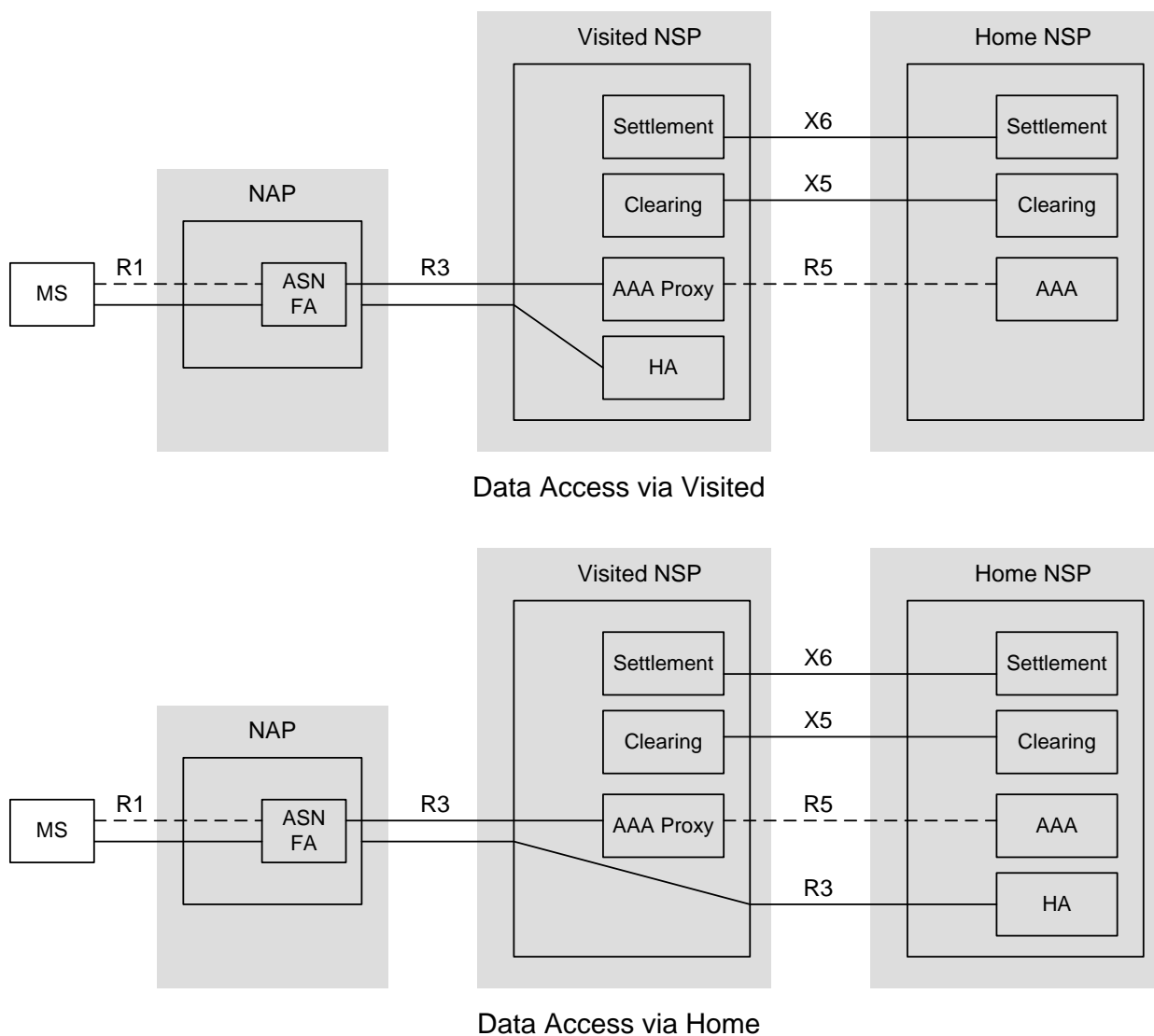
## 1.1.2 References

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- [1] WMF-T42-001-R010 WiMAX Forum® WiMAX™ Roaming Interface based on WiMAX Forum Certified™ Products Stage 2 Part 0: Overview Release 1.0.

## 1.2 Roaming Network Architecture Reference Model

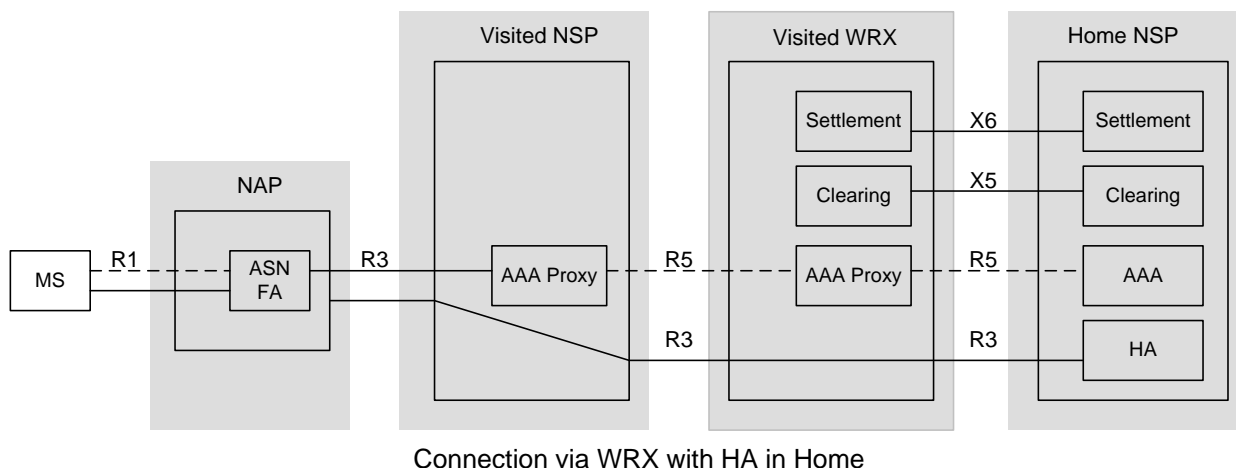
When a Subscriber Station (SS) roams in another network, data service can be provided either by the visited NSP (vNSP) or by the home NSP (hNSP) in accordance with the roaming agreement. In either scenario the home AAA (hAAA) will authenticate the subscriber station.



**Figure 1: Basic Roaming Architecture**

The Access Service Network (ASN) in the visited network will act as the Mobile IP Foreign Agent (FA) and create a tunnel with the serving Home Agent (HA). All data traffic to and from the SS to the Internet will be routed by the FA to the HA. The visited AAA (vAAA) will forward the real time RADIUS accounting records to the hAAA. The WRI Clearing and Settlement logical systems at home and visited will gather aggregated accounting files to calculate the amount of roaming charges the home owes to the visited NSP. This can be settled directly or via a 3<sup>rd</sup> party WiMAX™ Roaming eXchange (WRX) as illustrated in Figure 1 and Figure 2 respectively. When a 3<sup>rd</sup> party WRX is used, to connect the hAAA and vAAA (instead of connecting directly connect to the proxy AAA of the 3<sup>rd</sup> party WRX), the proxy AAA

also collects the accounting records to independently calculate the roaming charges the hNSP owes to the vNSP and provides the settlement reports. Typically a 3<sup>rd</sup> party WRX may also provide interconnection service to connect to the proxy AAA as well as the IP backbone network to transport data traffic between the home and the visited. Hence, it is also referred to as WiMAX™ Roaming Exchange (WRX). A WRX can also peer with other WRXs to extend its capability to reach more NSPs. In all diagrams shown in this document where a WRX is involved, connectivity to the WRX can be used to support the transport of bearer traffic only, AAA traffic only, or both bearer and AAA traffic.



**Figure 2: Roaming Architecture with interconnection via WiMAX Roaming eXchange**

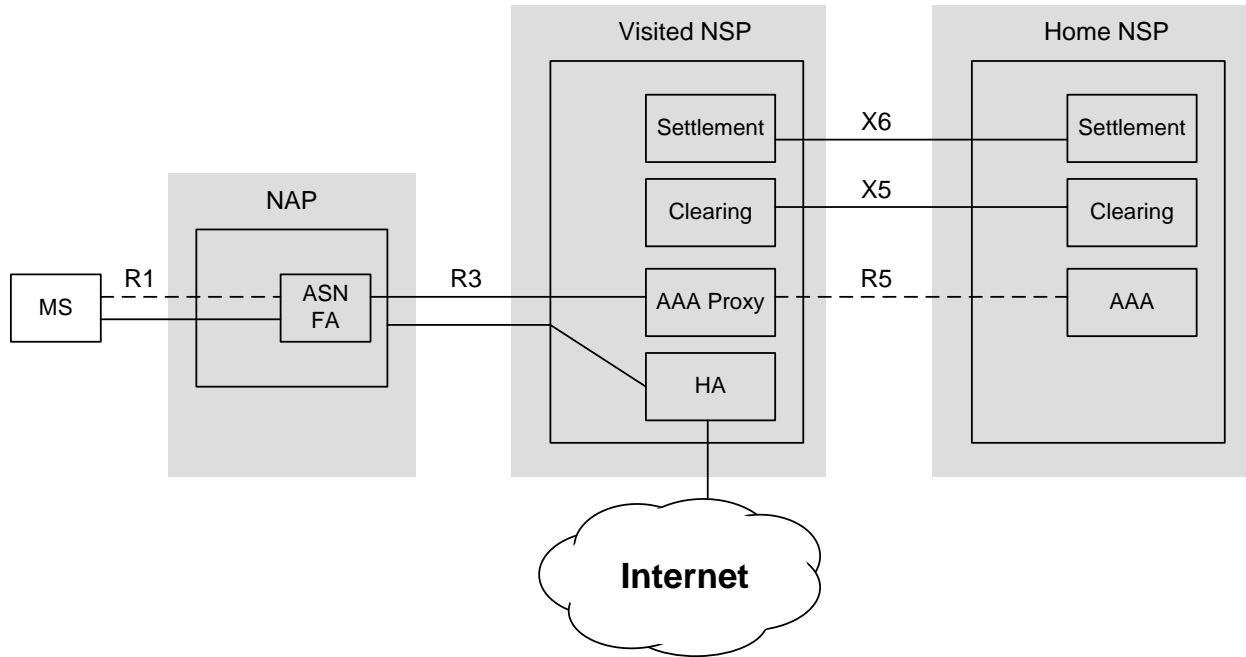
In a typical WiMAX™ Roaming Interface Architecture, the following reference points are implemented between the home and the visited domain:

- Interconnection for Clearing (X5)
- Interconnection for Financial Settlement (X6)
- Interconnection for AAA (R5)
- Interconnection for Data Traffic (R3)

Depending on traffic volume, QoS and security requirements, interconnections can be established via the Internet, or direct point-to-point circuits, or a combination of both.

### 1.2.1 Internet Access via Visited NSP

As described in the previous section, the SS can access the Internet when the HA is located in the vNSP. In this case, the R5 “interface” will implement only the AAA interconnections. Data Traffic interconnection should not be required. One possible configuration is illustrated in Figure 3.

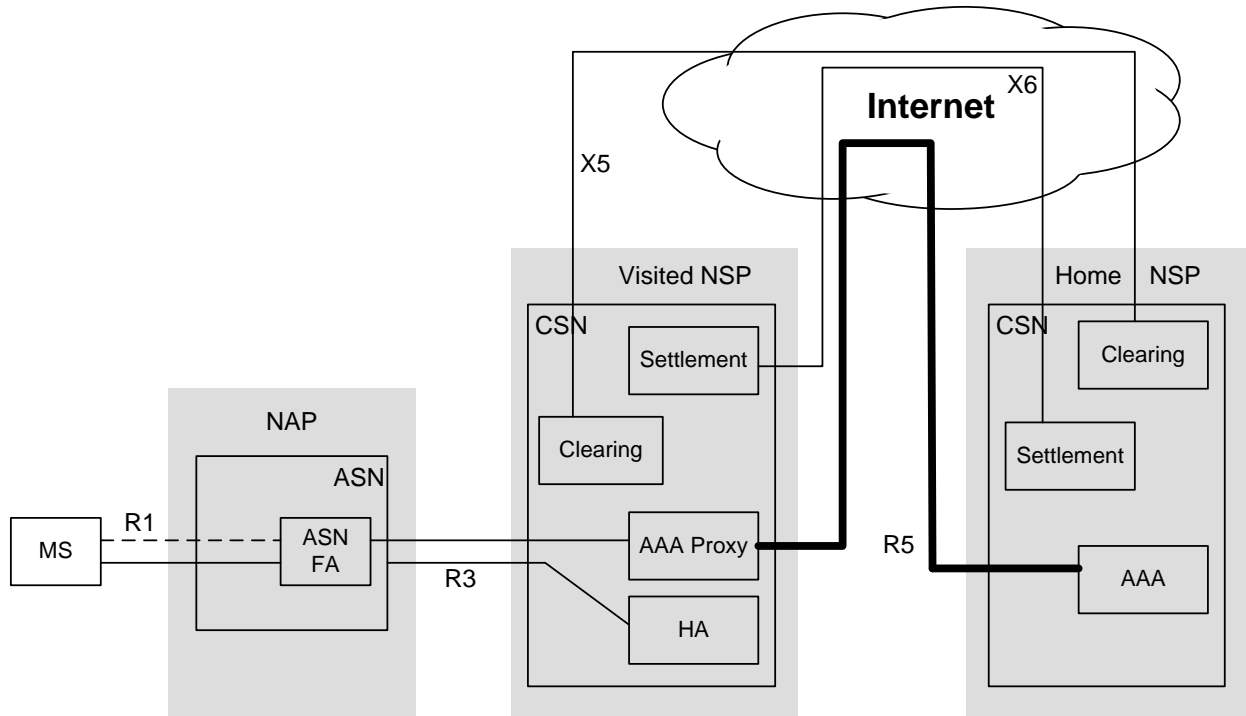


**Figure 3: Internet Access via the visited NSP**

The interconnections between the visited and home can be implemented using Internet (Virtual Private Network (VPN) or dedicated direct circuits.

### 1.2.1.1 Connection using Internet VPN

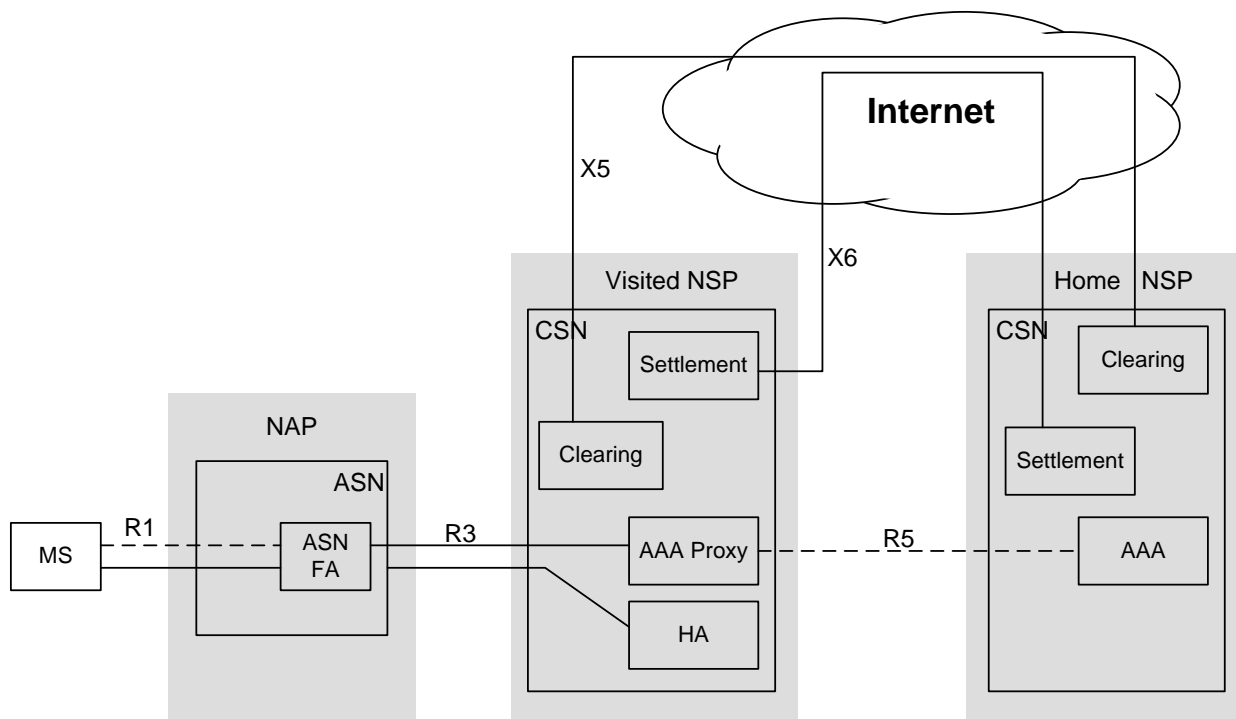
As shown in Figure 4, the AAA Interconnection can be implemented through VPN circuits over the Internet. The interconnection for WRI Clearing and Settlement logical functions may use File Transfer Protocol (FTP) over the Internet.



**Figure 4: Home and visited AAA interconnection using VPN**

### 1.2.1.2 Connection using Dedicated Circuits

When the roaming subscriber number is high, secure point to point dedicated links for AAA interconnection should be used. Interconnections for WRI Clearing and Settlement logical functions can use FTP over the Internet or dedicated circuits as shown in Figure 5.



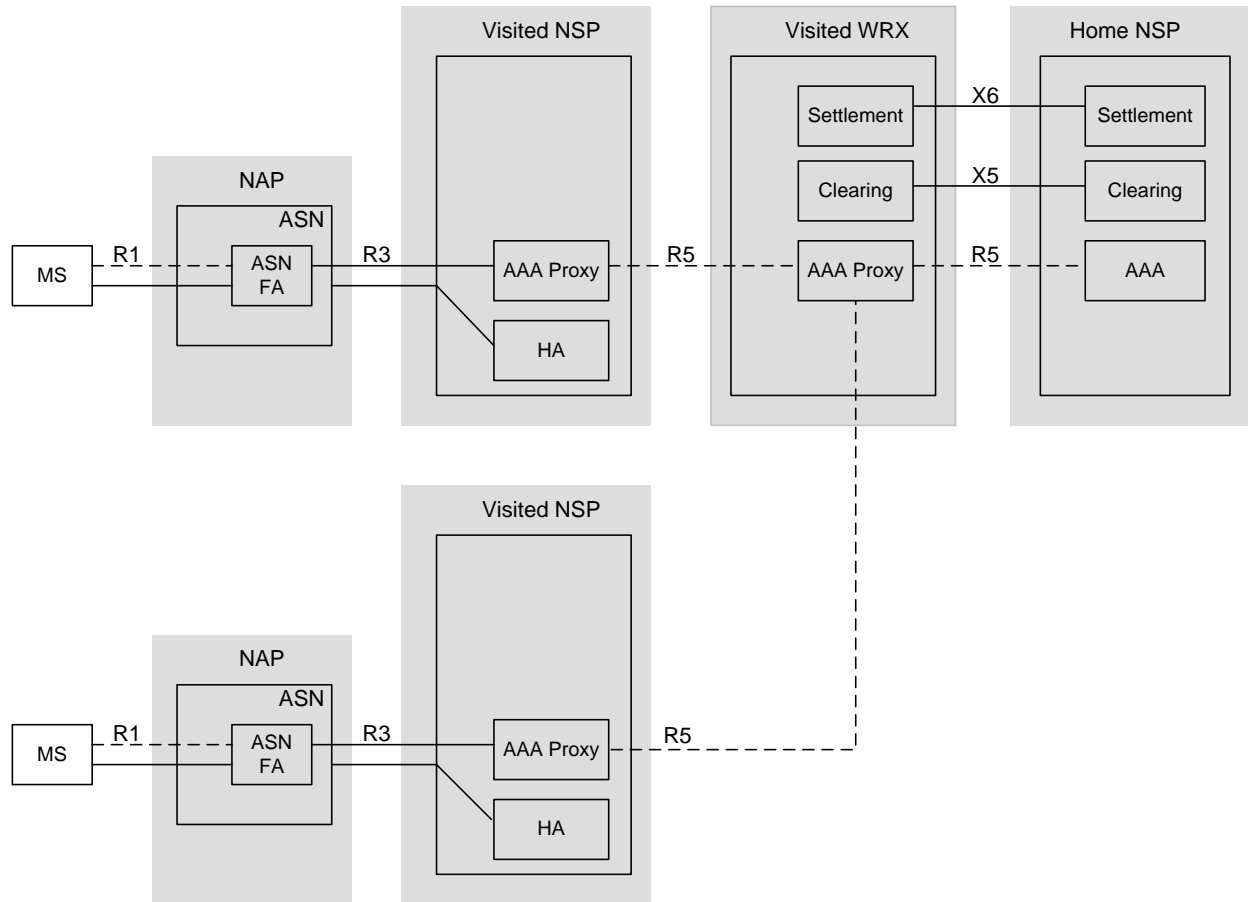
**Figure 5: Home and visited AAA interconnection with dedicated circuits**

### 1.2.1.3 Connection using WRX

When there are multiple roaming partners, connections via a WRX may reduce the number of required physical connections. A WRX can provide interconnection between many roaming partners via a single interface point. AAA interconnections between the visited domain and a WRX, and between the home domain and a WRX, can be via dedicated circuits or over the internet. When the number of roaming subscribers is high, secure point to point dedicated links for AAA interconnections should be used.

The interconnection for WRI Clearing and WRI Settlement logical functions can use either FTP over the Internet or dedicated circuits.

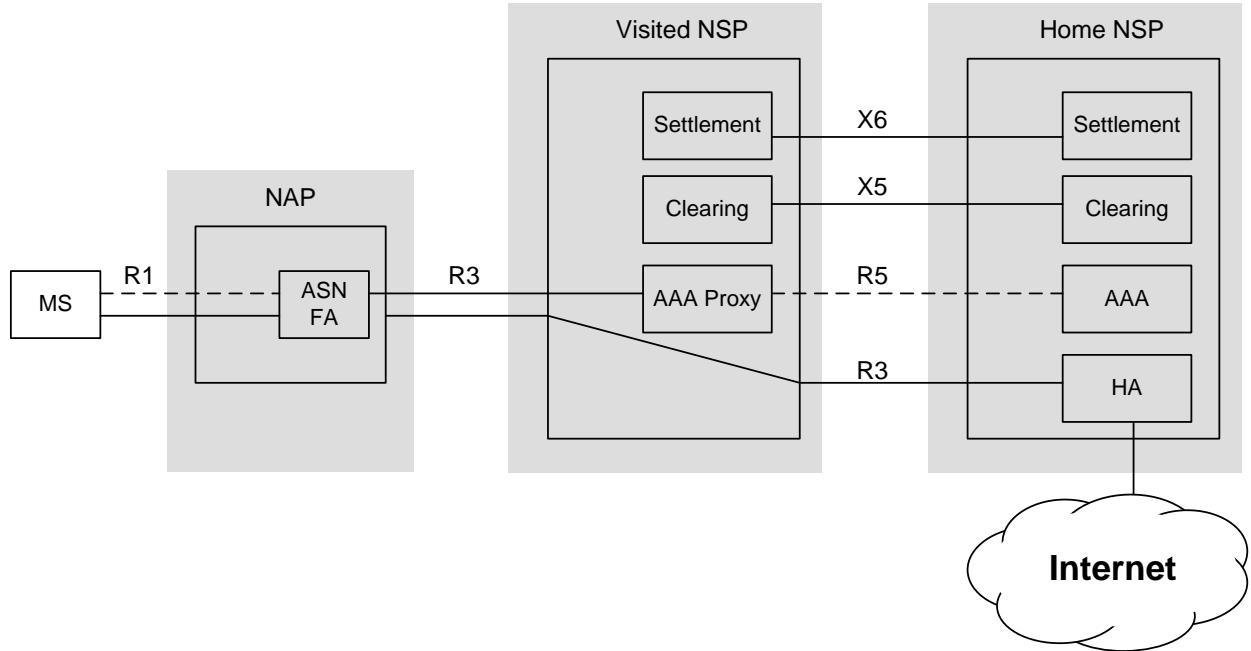
Figure 6 shows interconnections via the WRX when the HA is located in the vNSP.



**Figure 6: Internet access via WRX with HA in visited NSP**

### 1.2.2 Internet Access via Home NSP

In order to support Internet access via the home NSP, the HA in the home shall be the serving HA. The visited ASN (vASN), which acts as the FA, will connect with HA in hNSP via the R3 “interface”. The vNSP will route the traffic between the vASN/FA and the home HA. The Data Traffic, AAA, WRI Clearing and Settlement Interconnections information can be transported via dedicated circuits or can be routed via the internet. Figure 7 illustrates a possible scenario.

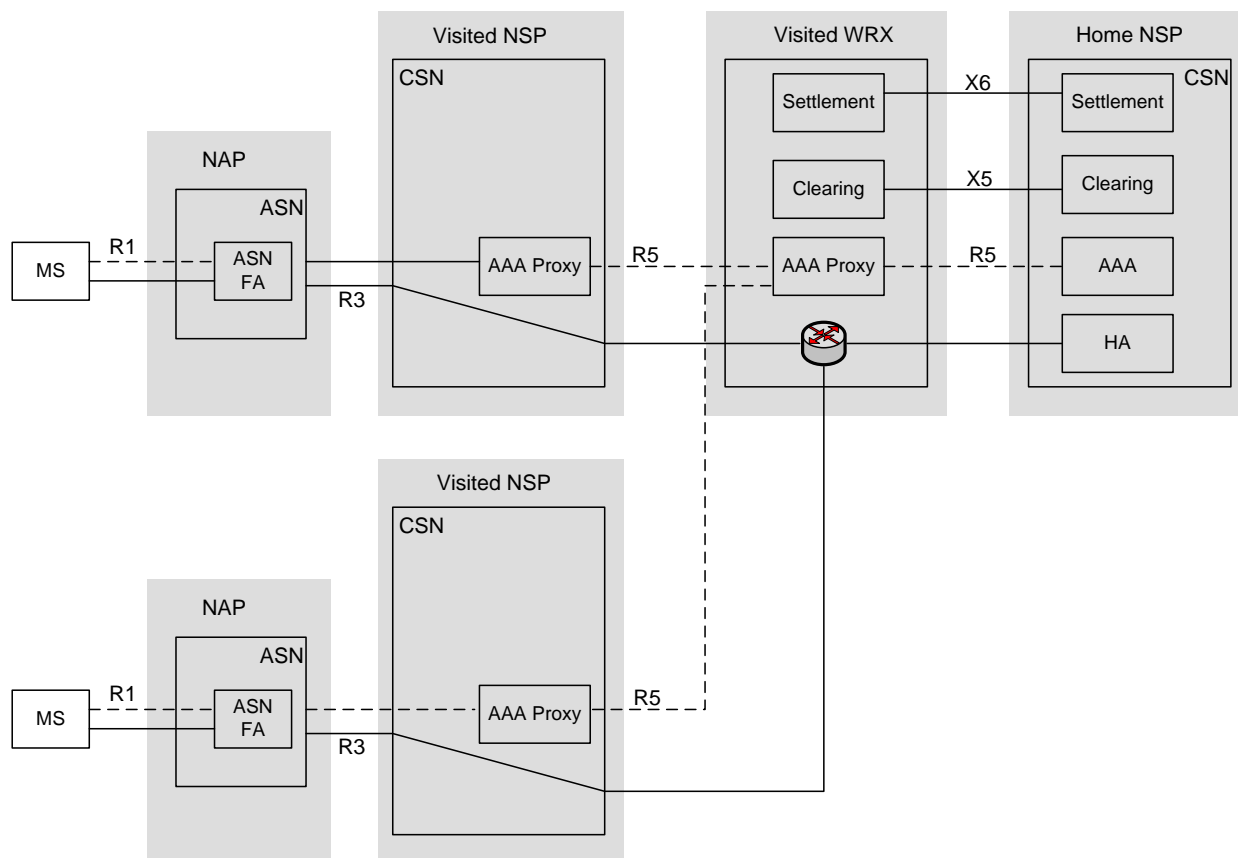


**Figure 7: Internet access via home NSP for a roaming subscriber**

### 1.2.2.1 Connection using WRX

When there are multiple roaming partners, connection via a WRX may reduce the number of required physical connections. Figure 8 illustrates one possible scenario.

Methods of interconnection must be agreed across all parties. Possible methods of interconnection include internet VPN, dedicated circuits, or managed IP networks. The interconnection for WRI Clearing and Settlement logical functions must support FTP over the Internet or via dedicated circuits.



**Figure 8: Internet access via WRX with HA in home NSP**

## 1.3 Minimum Requirements Specifications

This section specifies the minimum set of requirements for interconnections and WRX.

R-[I-R5-S2-1] The WRX can contain all the logical functions described in this release of the WRI. The WRX SHALL be able to support functionality required for reference points R5, R3, X2, X3, X4, X5 and X6.

### 1.3.1 Financial Clearing/Settlement Interconnection

R-[I-X5-S2-1] X5 Reference Point SHALL be used for daily exchange of session usage and charging summary files between the visited NSP and home NSP or with the WRX.

R-[I-X5-S2-2] FTP and secure FTP SHALL be supported as default protocols unless otherwise agreed between the responsible entities exchanging X5 Reference Point files.

R-[I-X6-S2-1] X6 Reference Point SHALL be used for periodic exchange of financial settlement files between the visited NSP and home NSP or with the WRX.

R-[I-X6-S2-2] FTP and secure FTP SHALL be supported as default protocols unless otherwise agreed between the responsible entities exchanging X6 Reference Point files.

### 1.3.2 AAA Interconnection

---

R-[I-R5-S2-2] R5 Reference Point SHALL be used for AAA Interconnection between the visited and home AAA servers or with the WRX proxy AAA server.

R-[I-R5-S2-3] R5 Reference Point SHALL support real-time exchange of RADIUS records. This interconnection SHOULD be secure as well as redundant.

### 1.3.3 Data Traffic Interconnection

---

R-[I-R3-S2-1] R3 Reference Point SHALL be used for Data Traffic Interconnection between the visited and home NSPs or with the WRX.

R-[I-R3-S2-2] R3 Reference Point SHALL transport data traffic between the FA in the visited NSP and the HA in the home NSP.

R-[I-R3-S2-3] The interface between the FA and HA SHOULD be able to transport high bandwidth delay sensitive traffic.

R-[I-R3-S2-4] The interface between the FA and HA SHOULD be secure and redundant.

Note: *A direct link is assumed to be secure by default.*

*When the FA and HA are in the visited domain, there is no R3.*

### 1.3.4 WRX

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A 3<sup>rd</sup> party WiMAX Roaming Exchange may provide a combination of services as described in this section.

R-[I-WRX-S2-1] A WRX MAY provide wholesale rating, clearing, financial settlement and their interconnections.

R-[I-WRX-S2-2] A WRX MAY provide RADIUS AAA Proxy service and AAA Interconnections.

R-[I-WRX-S2-3] A WRX MAY provide Data Traffic Interconnections.

R-[I-WRX-S2-4] WRX SHOULD act as a pass through network to transport data traffic between the visited and home NSP.

### 1.3.5 Autonomous System Number Management

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R-[I-R5-S2-4] Home network, visited network and WRX SHALL have unique public Autonomous System Number.

### 1.3.6 IP Address Management

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R-[I-R5-S2-5] The network elements and interconnections SHALL support IPv4.

R-[I-R5-S2-6] The network elements and interconnections MAY support IPv6.

R-[I-R5-S2-7] The network elements connected to the R5 Reference Point in the visited network, home network, and WRX SHALL be accessible to each other and SHALL be inaccessible via the public internet.

R-[I-R5-S2-8] In order to ensure security, routes to the Internet domains and addresses SHALL not be advertised between the network interfaces.

### **1.3.7 DNS Service**

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R-[I-R5-S2-9] Unless otherwise agreed differently in roaming agreement the network providing Internet access to the SS SHALL provide the DNS service.

### **1.3.8 Security/Firewall**

---

R-[I-R5-S2-10] Authentication and security key exchange procedures SHOULD be established between the routing processes transporting information via the R3 and the R5 reference points. The recommended default protocol is IPsec.

R-[I-R5-S2-11] IPsec data encryption SHOULD be used.

R-[I-R5-S2-12] Security measures SHOULD be taken to block traffic directed to WRI reference points from unwanted domains or unwanted IP address ranges.

R-[I-R5-S2-13] Intrusion detection and prevention SHOULD be supported.

### **1.3.9 IP Header and Payload Compression**

---

R-[I-R5-S2-14] IP header and payload compression MAY be used if agreed between two end points of the link.

### **1.3.10 Availability**

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R-[I-R5-S2-15] Each network element involved in roaming (CSN, HA, FA) as well as roaming interconnections SHOULD avoid a single point of failure.

R-[I-R5-S2-16] Each network element involved in roaming (CSN, HA, FA) as well as roaming interconnections SHOULD support Layer 2 and Layer 3 fail over without affecting data services.

R-[I-R5-S2-17] When redundancy is implemented between network elements involved in roaming (CSN, HA, FA) as well as roaming interconnections, data MAY be synchronized between the redundant elements and roaming interconnections when the Layer 2 fails.

R-[I-R5-S2-18] Each network element involved in roaming (CSN, HA, FA) SHOULD gracefully recover from a failure without affecting data services.

R-[I-R5-S2-19] Each network entity providing roaming services (NSP, WRX) SHOULD implement appropriate performance monitoring tools and preventive maintenance processes to reduce the number of faults in the links and network equipment providing roaming service.

### **1.3.11 Redundancy**

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R-[I-R5-S2-20] Geographically redundant links and network equipments SHOULD be used to provide fail over.

### **1.3.12 QoS**

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R-[I-R5-S2-21] The visited network, home network, and WRX SHOULD take required measures to maintain the pre-agreed link and network level QoS requirements.

### 1.3.13 Network Service Level Agreements (SLA)

The SLA refers to the agreement between interconnecting parties to commit to a set of agreed network performance requirements. It may include QoS requirements, availability requirements, bandwidth requirements, troubleshooting, operations support and response times. Two separate SLA agreements will typically be made, one between the NSP and WRX provider, and the other between the home NSP and the visited NSP.

An end-to-end network reference point diagram for SLA is shown in Figure 9. It is assumed that both the vNSP and the hNSP have their own WRX provider and that there is peering between the WRXs. Where there is no WRX, the border gateway of the vNSP is connected to the border gateway of the hNSP. Where a WRX is involved the demarcation points are the border gateway of the NSP and the edge router of the WRX.

The links between the border gateways of the NSPs, or between the border gateways of the NSPs and edge routers of the WRXs can represent the R3, R5, X5, X6, or any combination of these Reference Points. The demarcation points and points of measurement are made from the border gateways and edge routers. Within the SLA separate values may be provided for each reference interface.

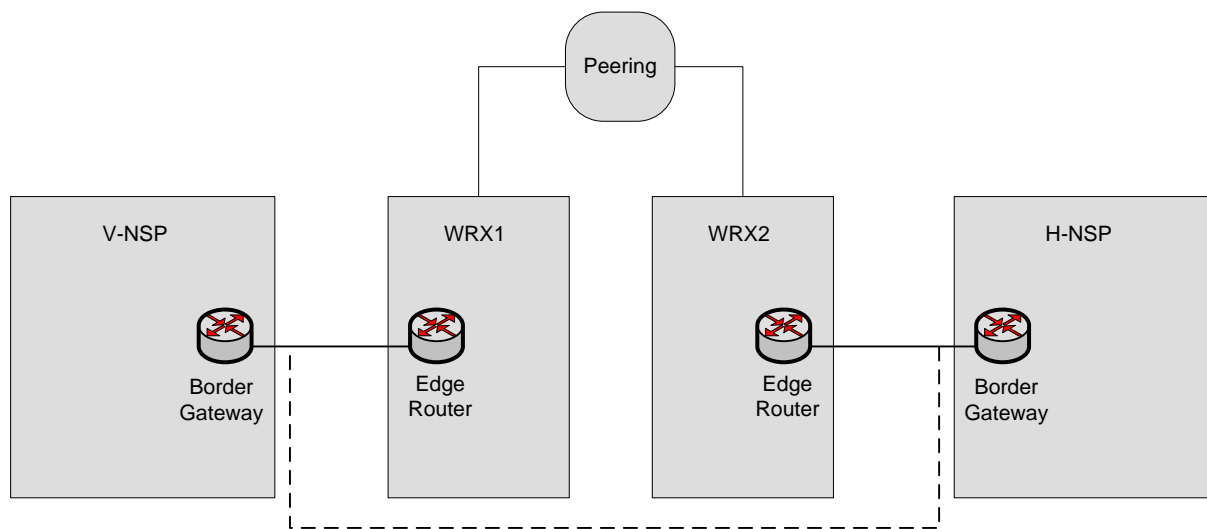


Figure 9: End-to-End Network Reference Point Layout for SLA

#### 1.3.13.1 SLA for R3 Reference Point

The R3 Reference Point covers the data traffic between the visited and home NSPs.

Measurable SLA parameters will include Latency, Jitter, Packet Loss and Network Availability.

##### Latency:

Latency refers to the delay from transmitting an IP packet from one destination to the time it is received at the other destination.

One way latency between a vNSP and a hNSP is recommended to be no more than 400 ms

One way latency between an NSP and a WRX is recommended to be no more than 133 ms to satisfy the end to end NSP requirements assuming 2 WRXs with peering between them.

##### Jitter:

Jitter is the delay variation among the IP packets sent from one destination to the other.

Jitter is recommended to be no greater than 20 ms of standard deviation.

**Packet Loss:**

Packet loss is the percentage of dropped packets between two Service Providers' border gateways.

The maximum packet loss is recommended to be 0.1% on monthly basis.

**Network Availability:**

Network availability refers to the percentage of time the network is up. Many factors may affect the network availability including the following:

- Network links between NSPs
- Network links between NSPs and WRXs
- WRX provider's IP backbone uptime
- Availability of peering points
- Equipment functionality within the NSPs and WRXs

NSPs should agree bilaterally between themselves and with the WRXs on the level of network availability.

**Service Offerings:**

NSPs should agree among themselves the services to be offered to their roaming partners and reflect this in the WiMAX™ Roaming Agreement document. For this release, only best effort Internet service is supported.

With respect to the agreement between the NSP and WRX, services offered will be transport and routing of the data traffic between the home NSP and visited NSP.

**Network Support and Responsibilities:**

NSPs should agree among themselves on the level of network support that will be provided to their roaming partners. This should include the hours of operation, the phone numbers and responsibilities entailed, as well as, the procedures for notification and logging of events.

NSPs should also agree on the above support and responsibilities with their respective WRX providers.

**1.3.13.2 SLA for R5 Reference Point**

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The R5 Reference Point supports the AAA traffic between the home and visited NSPs, and the AAA traffic traversing the WRXs. SLA agreements are similar to those for the R3 Reference Point.

**Service Offerings:**

With respect to the agreement between the NSP and WRX provider, the services offered are the routing of AAA traffic between the visited and home NSP. It may also involve modification of the AAA packets in order to ensure all fields are filled in correctly and routing of packets to the clearing and/or financial settlement providers.

**Network Support and Responsibilities:**

Similar to those for the R3 Reference Point.

**Network Availability:**

Similar to those for the R3 Reference Point.

**Latency:**

The AAA Latency refers to the delay from transmitting a RADIUS Request message from the AAA Server to the time that the Response message is received to that message.

AAA latency is recommended to be no more than 1 second. This includes the round trip relay and processing delay for the request originated from the visited ASN-GW and the response received from the home AAA. The request and response may transverse several different network entities.

Internal latency of handling information within an AAA Proxy is recommended to be a maximum of 20 milliseconds.

The SLA refers to the agreement between two network providers to commit to the agreed network performance requirements. It should include QoS requirements, availability requirements, bandwidth requirements, troubleshooting, operations support and response times.

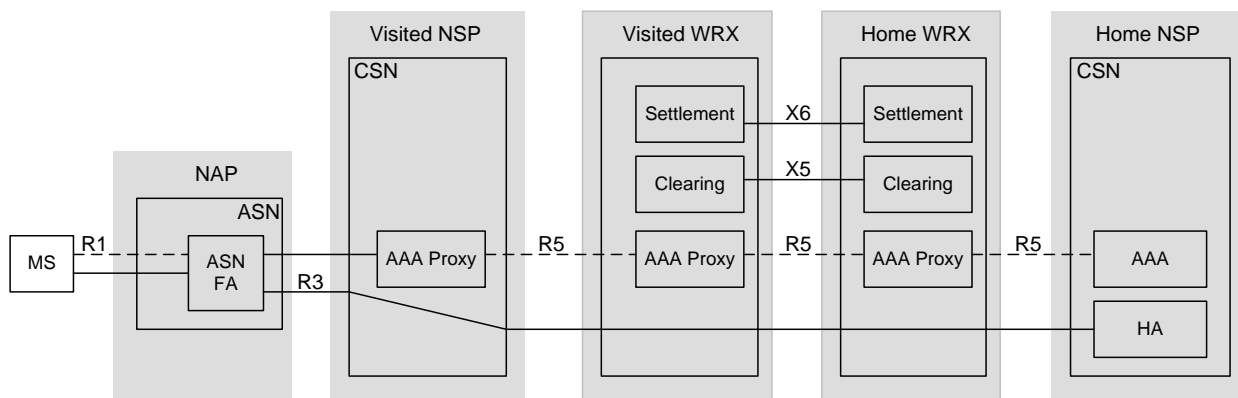
R-[I-R5-S2-22] Each interconnecting party SHOULD commit to link level and network level SLA.

R-[I-R5-S2-23] Each interconnecting party SHOULD implement appropriate fault detection, reporting, ticketing, troubleshooting and escalation processes.

R-[I-R5-S2-24] Each interconnecting party SHOULD implement SLA administration processes.

### 1.3.14 WRX Peering

A NSP should be able to select a single WRX vendor and roam with NSPs that are connected to other WRX vendors. A WRX vendor must peer with other WRX vendors in order to achieve this goal. Peering may be established via 3<sup>rd</sup> party central peering points. A central peering point is a location that facilitates the exchange of traffic between WRX vendors and is managed and maintained by a 3<sup>rd</sup> party neutral service provider other than WRX vendors. The central peering point should meet all carrier-hosting requirements in terms of security and SLA guarantees. Figure 10 illustrates one possible WiMAX Roaming eXchange peering model.



**Figure 10: WiMAX Roaming eXchange peering model**

R-[I-WRX-S2-5] A WRX vendor SHOULD directly peer with other WRX vendors.

In this release, a maximum of two WRXs must be allowed be in the path between the visited and the home network service providers. The potential exists that this model can be extended by 3<sup>rd</sup> parties, commonly known as, aggregators, consolidators, and Mobile Virtual Network Operators (MVNOs).

R-[I-WRX-S2-6] Peering with a WRX vendor via another WRX vendor SHALL be avoided.

R-[I-WRX-S2-7] A WRX vendor SHOULD provide QoS measurements to verify that it meets the service level agreement requirements.

## 2 Revision History

Revision	Changes	Date
1	Initial Publication	August 4, 2008
2	Several editorial changes were introduced.  Editorial changes include: a) Added the letter S2 to all requirements. b) Changed "Copyright ©" to "Copyright" c) Applied the recommended ® and TM where appropriate d) Changed Interface to Reference Point where applicable e) Introduced Revision History section	March 13, 2009
2	Several Editorial changes were introduced: a) Added the proposed document number in the header. b) Expanded the first occurrence of some abbreviations. c) Added text in the introduction on where additional information can be found on Reference Points mentioned in this document. d) Inserted the words WRI and logical function when WRI Architecture logical functions are described in the text. e) Modified text to clarify that WRI logical functions are performing the WRI procedures. f) Modified the Cover Page.	May 3, 2009
2	Modified Figures 2, 6, 8, 10 to remove unnecessary WRI logical functions.	May 15, 2009
2	WiMAX Forum Board of Director Approved	June 24, 2009