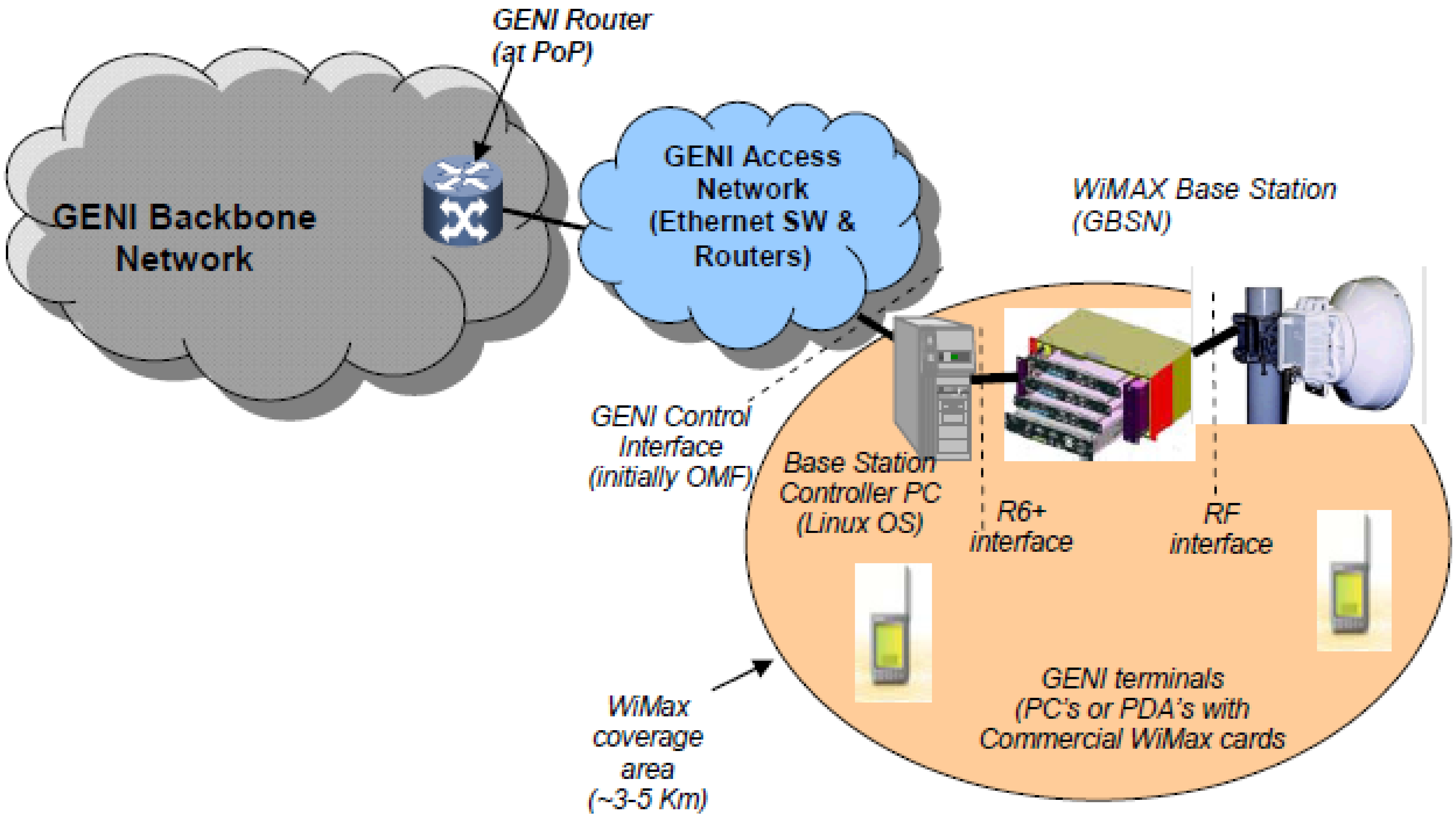
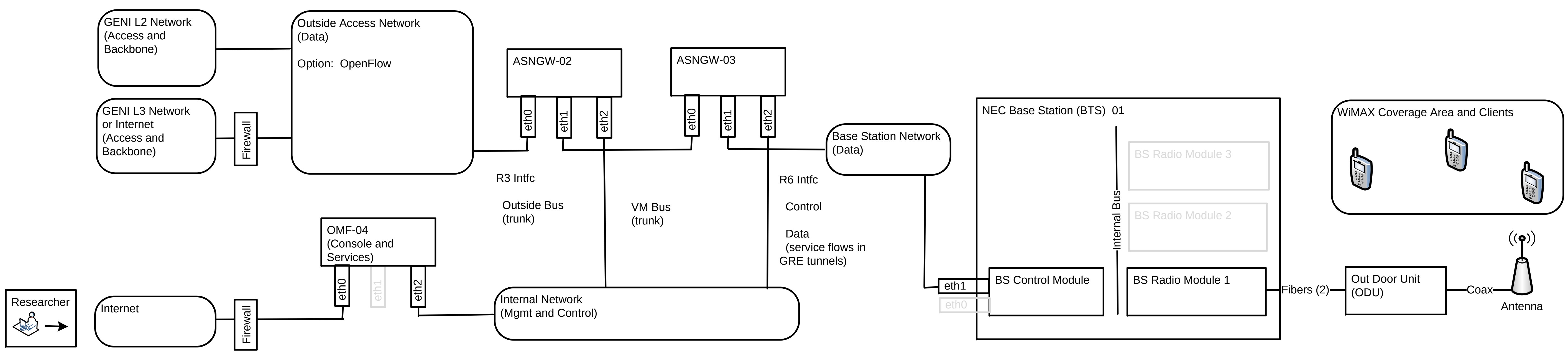
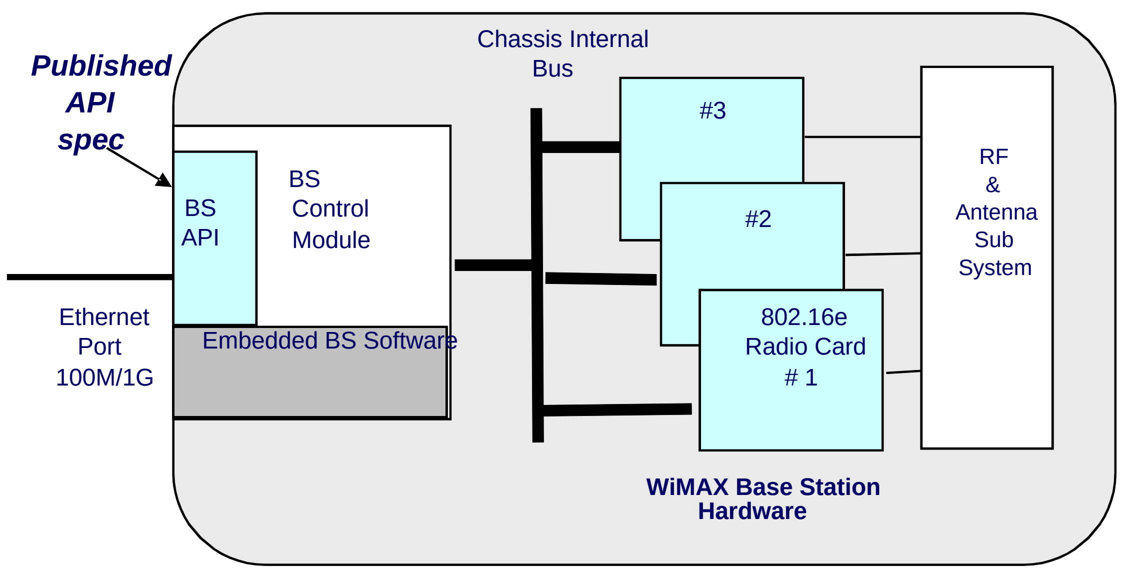

GENI Router
(at PoP)
GENI Backbone
Network
GENI Access
Network
(Ethernet SW &
Routers)
WiMAX Base Station
(GBSN)
GENI Control
Interface
(initially OMF)
Base Station
Controller PC
(Linux OS)
R6+
interface
RF
interface
GENI terminals
(PC's or PDA's with
Commercial WiMax cards
WiMax
coverage
area
(~3-5 Km)


GENI L2 Network (Access and Backbone)
Outside Access Network (Data)
Option: OpenFlow
ASNGW-02
ASNGW-03
eth0
eth1
eth2
GENI L3 Network or Internet (Access and Backbone)
Firewall
NEC Base Station (BTS) 01
WiMAX Coverage Area and Clients
Base Station Network (Data)
BS Radio Module 3
BS Radio Module 2
Internal Bus
R3 Intfc
Outside Bus (trunk)
VM Bus (trunk)
R6 Intfc
Control
Data (service flows in GRE tunnels)
OMF-04 (Console and Services)
Researcher
Internet
Internal Network (Mgmt and Control)
BS Control Module
BS Radio Module 1
Fibers (2)
Out Door Unit (ODU)
Coax
Antenna

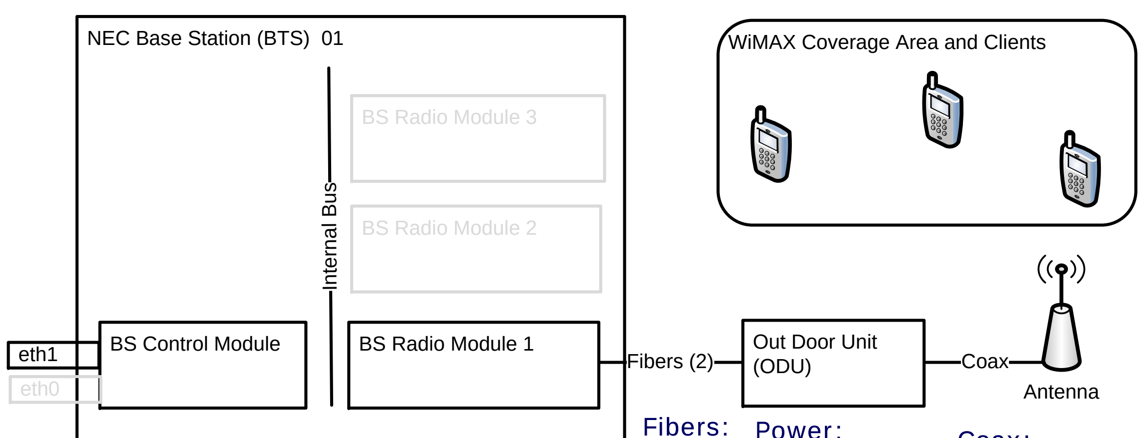


NEC Base Station (BTS)
Equipped with:
(blank)
(blank)
radio module #1
control module

NEC Outdoor Unit (ODU)
(shown indoors, but intended fro mounting with antenna)

Omni-directional antenna
(elev. < 6ft above roof)

WiMAX coverage area:
3-5km



Power:
-48VDC

Fibers:
long

Power:
-48VDC

Coax:
short
LMR-400,
or better

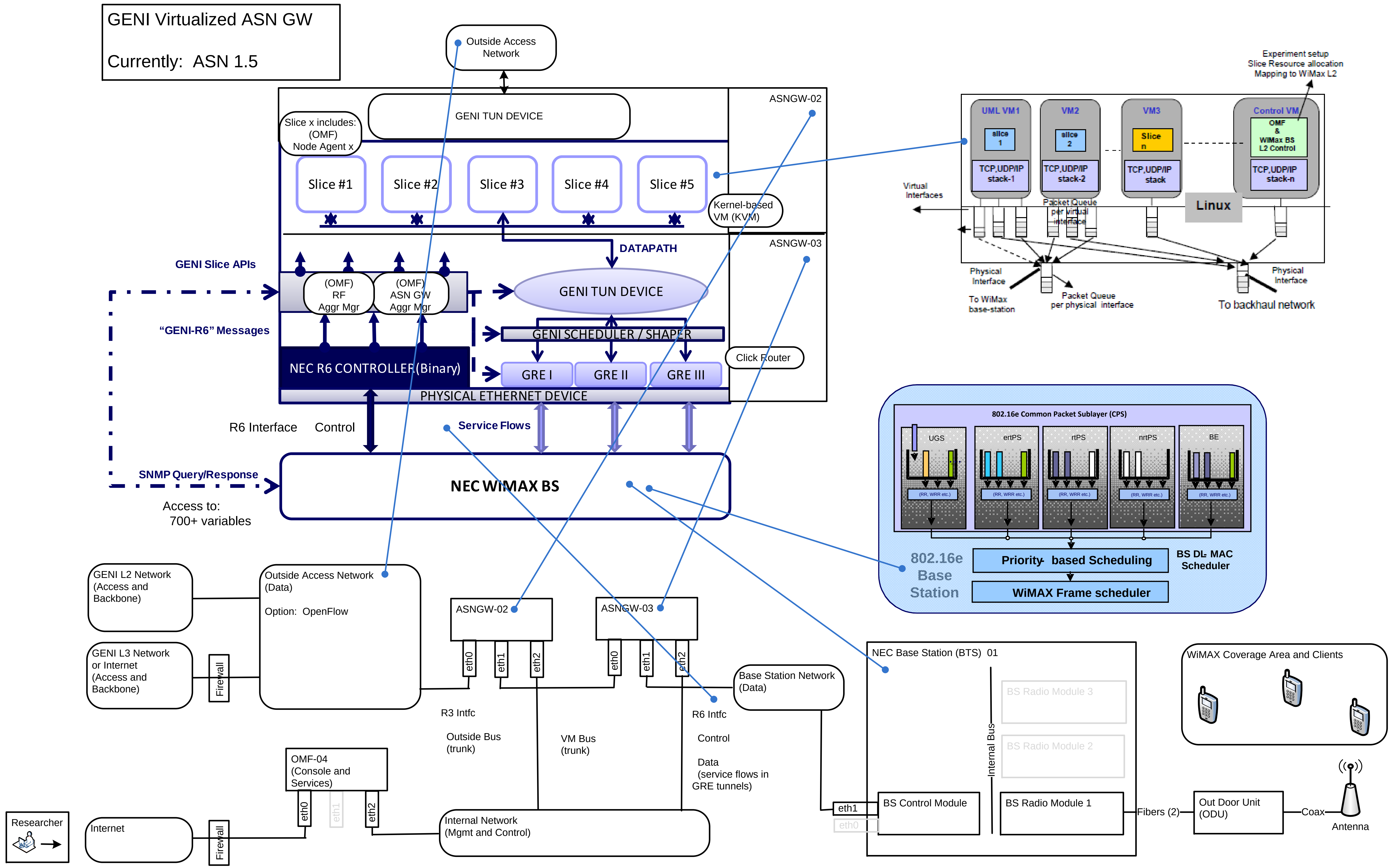
NEC Base Station (BTS)

Profile A

Supported service classes:

rtPS	real- time polling service
ertPS	enhanced real- time polling service
nrtPS	non real- time polling service
UGS	unsolicited grant service
BE	best effort

PHY	Access mode	SOFDMA/TDD
	Frequency	2535 ~ 2605 MHz
	DL:UL ratio	35:12, 26:21, 29:18
	Channel BW	10 MHz , 8.75 MHz
	FFT size	1024, 512
	Frame duration	5ms
	TX output Power	35dBm (max)
	# of sectors	3
MAC	Head compression	PHS
	ARQ	HARQ/CC, ARQ
	MBS support	Single BS, multiple BS MBS
	Resource management	Power control, mode control (idle, sleep etc.)
Networking	IP protocols	IPv4, IPv6
	Bridging/Routing	Transparent L2 switch, Bridging
	Packet handling	802.1Q VLAN, PHS**)



GENI Virtualized ASN GW
Currently: ASN 1.5
Outside Access Network
ASNGW-02
GENI TUN DEVICE
Slice x includes: (OMF) Node Agent x
Slice #1
Slice #2
Slice #3
Slice #4
Slice #5
Kernel-based VM (KVM)
ASNGW-03
DATAPATH
GENI Slice APIs
(OMF) RF Aggr Mgr
(OMF) ASN GW Aggr Mgr
GENI TUN DEVICE
"GENI-R6" Messages
GENI SCHEDULER / SHAPER
Click Router
NEC R6 CONTROLLER(Binary)
GRE I
GRE II
GRE III
PHYSICAL ETHERNET DEVICE
R6 Interface
Control
Service Flows
SNMP Query/Response
NEC WiMAX BS
Access to: 700+ variables
Experiment setup
Slice Resource allocation
Mapping to WiMax L2
UML VM1
VM2
VM3
Control VM
slice 1
slice 2
Slice n
OMF & WiMax BS L2 Control
TCP,UDP/IP stack-1
TCP,UDP/IP stack-2
TCP,UDP/IP stack
TCP,UDP/IP stack-n
Linux
Virtual Interfaces
Packet Queue per virtual interface
Physical Interface
To WiMax base-station
Packet Queue per physical interface
Physical Interface
To backhaul network
802.16e Common Packet Sublayer (CPS)
UGS
ertPS
rtPS
nrtPS
BE
(RR, WRR etc.)
802.16e Base Station
Priority- based Scheduling
BS DL- MAC Scheduler
WiMAX Frame scheduler
GENI L2 Network (Access and Backbone)
Outside Access Network (Data)
Option: OpenFlow
GENI L3 Network or Internet (Access and Backbone)
Firewall
ASNGW-02
ASNGW-03
eth0
eth1
eth2
eth0
eth1
eth2
R3 Intfc
Outside Bus (trunk)
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BS Radio Module 3
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WiMAX Coverage Area and Clients
OMF-04 (Console and Services)
eth0
eth1
eth2
Researcher
Internet
Firewall
Internal Network (Mgmt and Control)
eth1
eth0
BS Control Module
BS Radio Module 1
Fibers (2)
Out Door Unit (ODU)
Coax
Antenna

GENI-R6 Messages

1. MS_REG(MAC_Address,Status) : This message is sent from the NEC R6 Controller to the GENI controller indicating that a MS has registered successfully or unsuccessfully.

2. SF_CREATION(MAC_Address,SFIDs) : This message is sent from the NEC R6 Controller to the GENI controller specifying the Service Flows(SFIDs) created for that MS.

3. MS_POLICY(MAC_Address,Policy) : This message is sent from the GENI controller to the NEC R6 Controller for configuring the Service Flow policies for the specified MS.

GENI Open API

- **Network Entry Control**
  - Add the given MAC address to the ACL (access control list)
  - Remove the given MAC address from the ACL
- **Flow Level Service Differentiation**
  - Create service flow in the uplink/downlink direction for a particular connection ID based on a specified service class
  - Delete service flow
  - Create service class (BE/UGS/rtPS/nrtPS/ertPS)
  - Delete service class
  - Set the minimal or fixed modulation and coding scheme (MCS) to be used for that service class according to channel condition
- **Radio Level Service Differentiation**
  - Set radio resource values consulted during initial ranging and connection setup.
  - Set uplink-downlink ratio as a fraction of radio resource values.
  - Set QoS priority

Query Base Station State

Base Station State

- Radio resources (UL and DL)
- Time slots (UL and DL)
- Downlink burst profile
- Uplink burst profile
- Frequency
- Power
- Rate

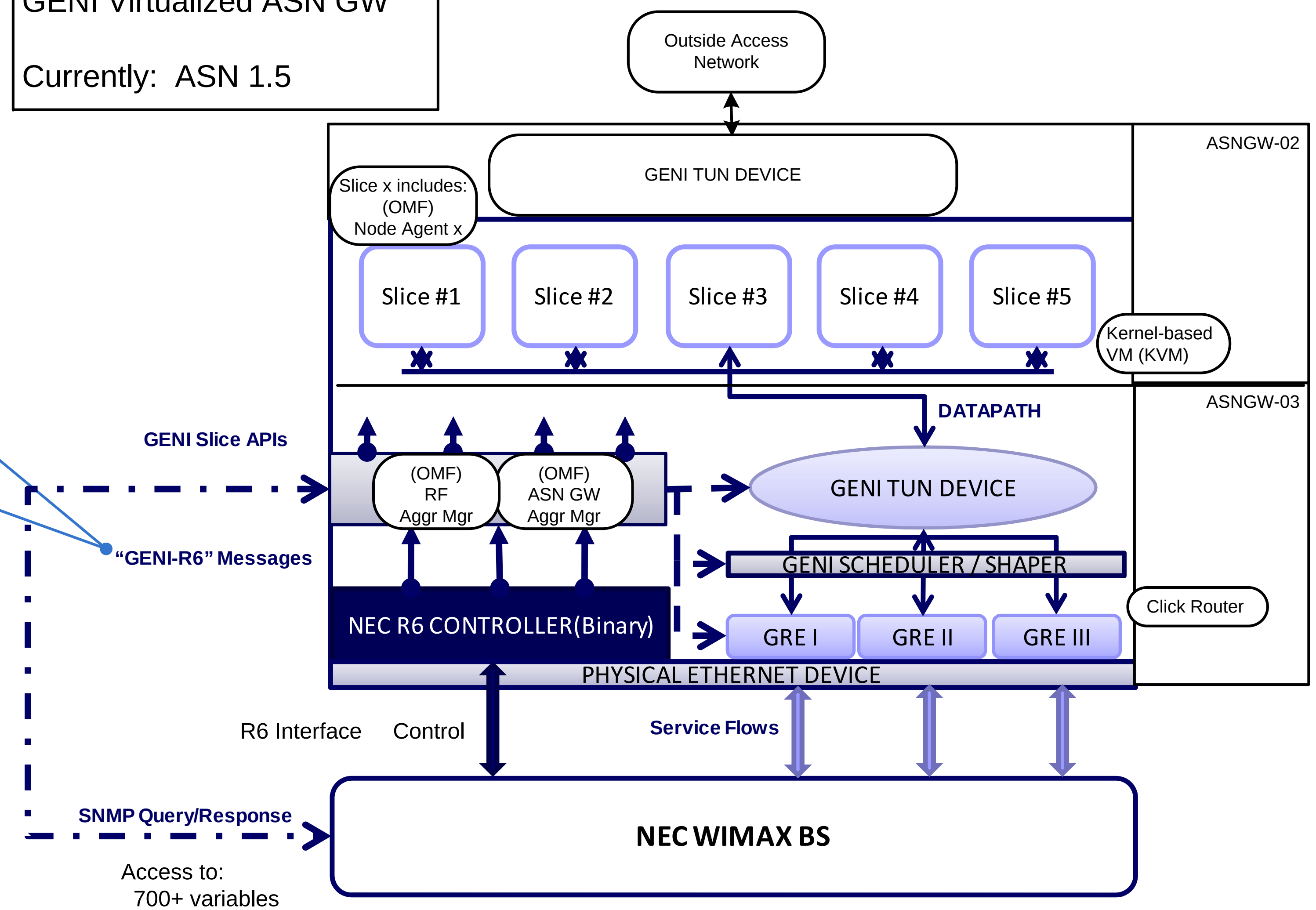
Set Base Station State

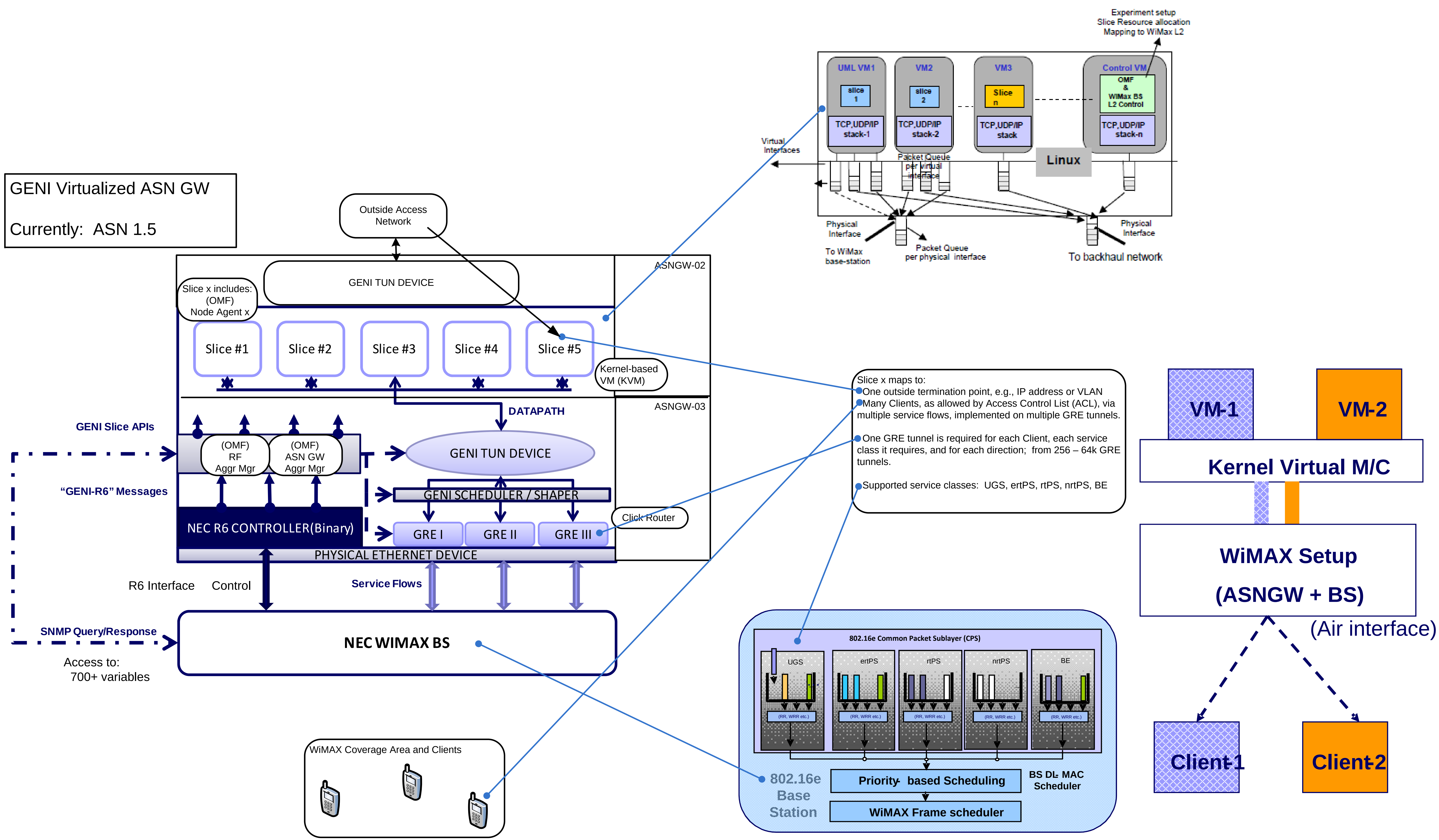
GENI Open API

- Maximum Bit Rate, Burst Rate
- Minimum Tolerable Sending Bit Rate
- Maximum Tolerable jitter
- Minimum Delay
- Scheduling Type (e.g., UGS, rtPs , nrtPs)
- Frequency of Operation
- Rate / Power requirements

GENI Virtualized ASN GW

Currently: ASN 1.5




GENI Virtualized ASN GW
Currently: ASN 1.5
Outside Access Network
ASNGW-02
GENI TUN DEVICE
Slice x includes: (OMF) Node Agent x
Slice #1
Slice #2
Slice #3
Slice #4
Slice #5
Kernel-based VM (KVM)
ASNGW-03
DATAPATH
GENI Slice APIs
(OMF) RF Aggr Mgr
(OMF) ASN GW Aggr Mgr
GENI TUN DEVICE
"GENI-R6" Messages
GENI SCHEDULER / SHAPER
NEC R6 CONTROLLER(Binary)
GRE I
GRE II
GRE III
Click Router
PHYSICAL ETHERNET DEVICE
R6 Interface
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TCP,UDP/IP stack-1
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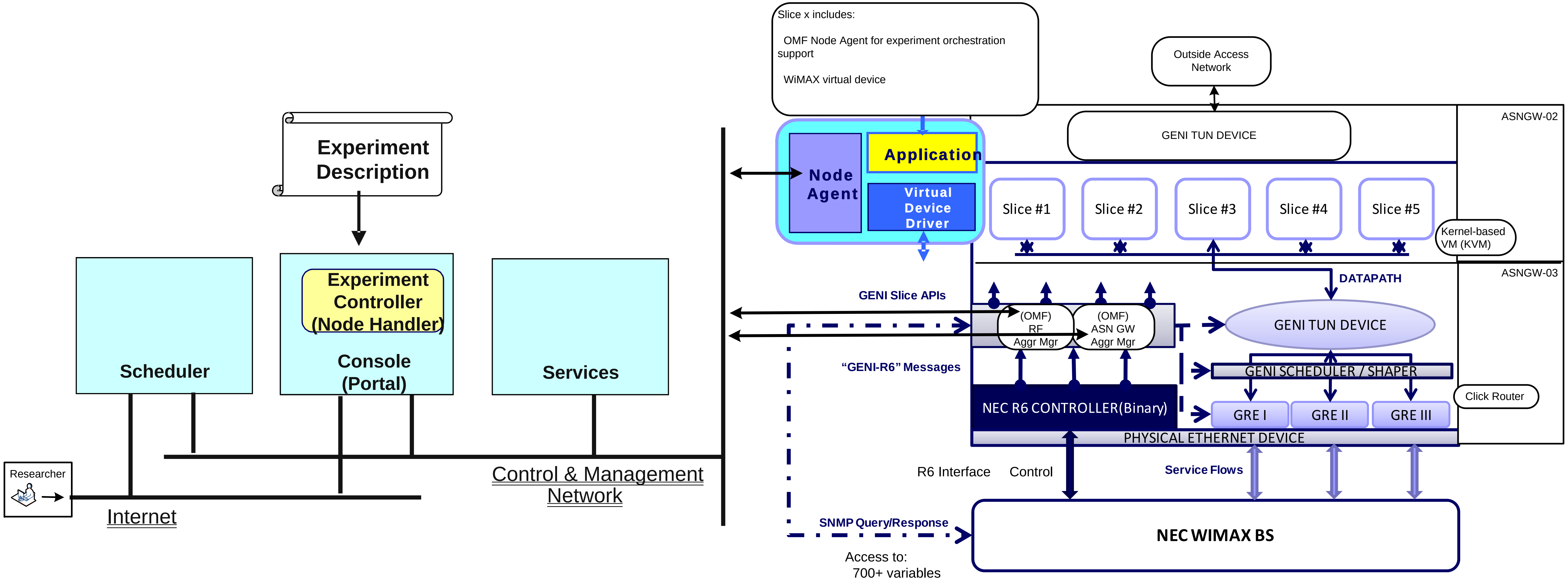
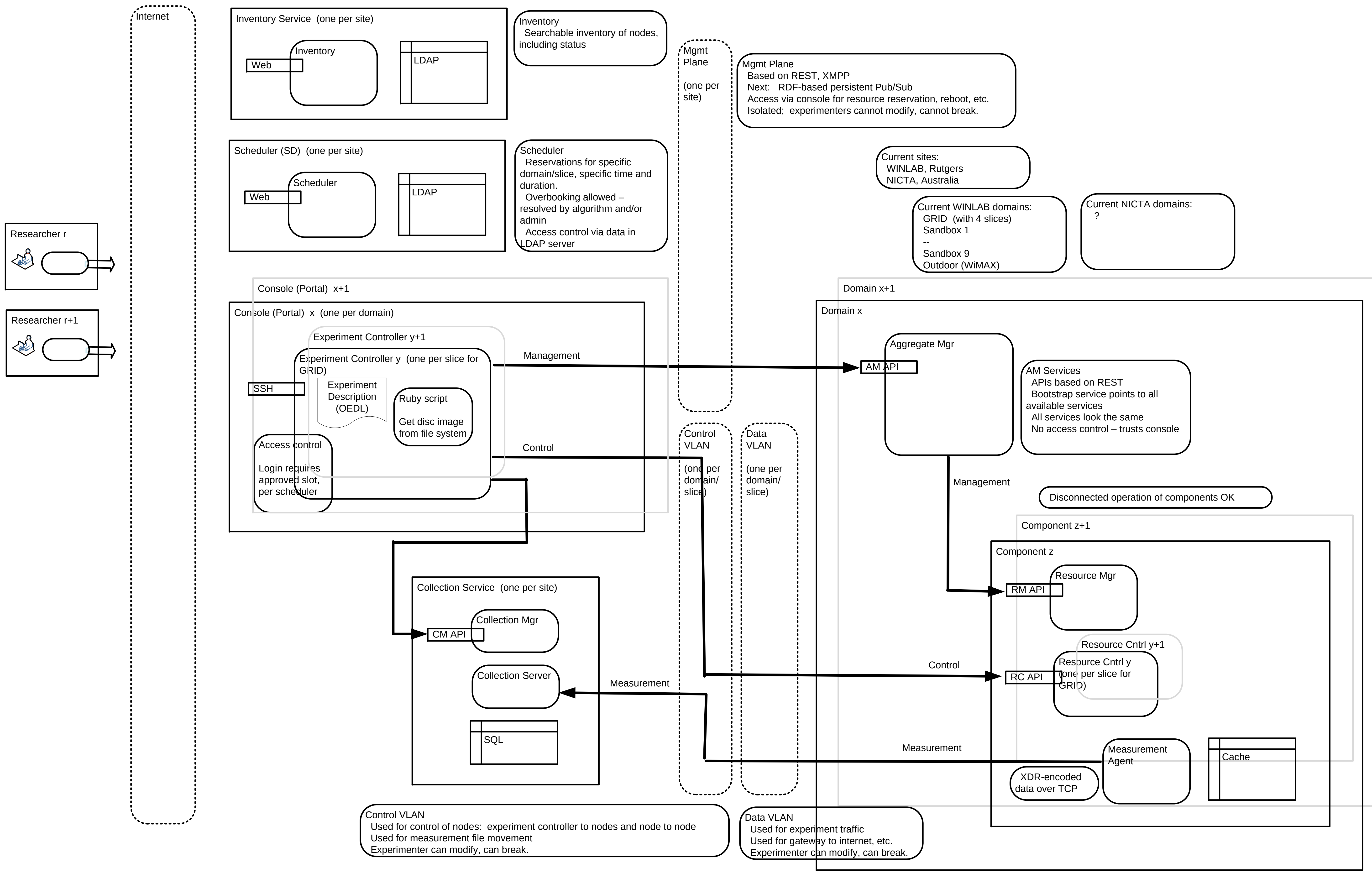
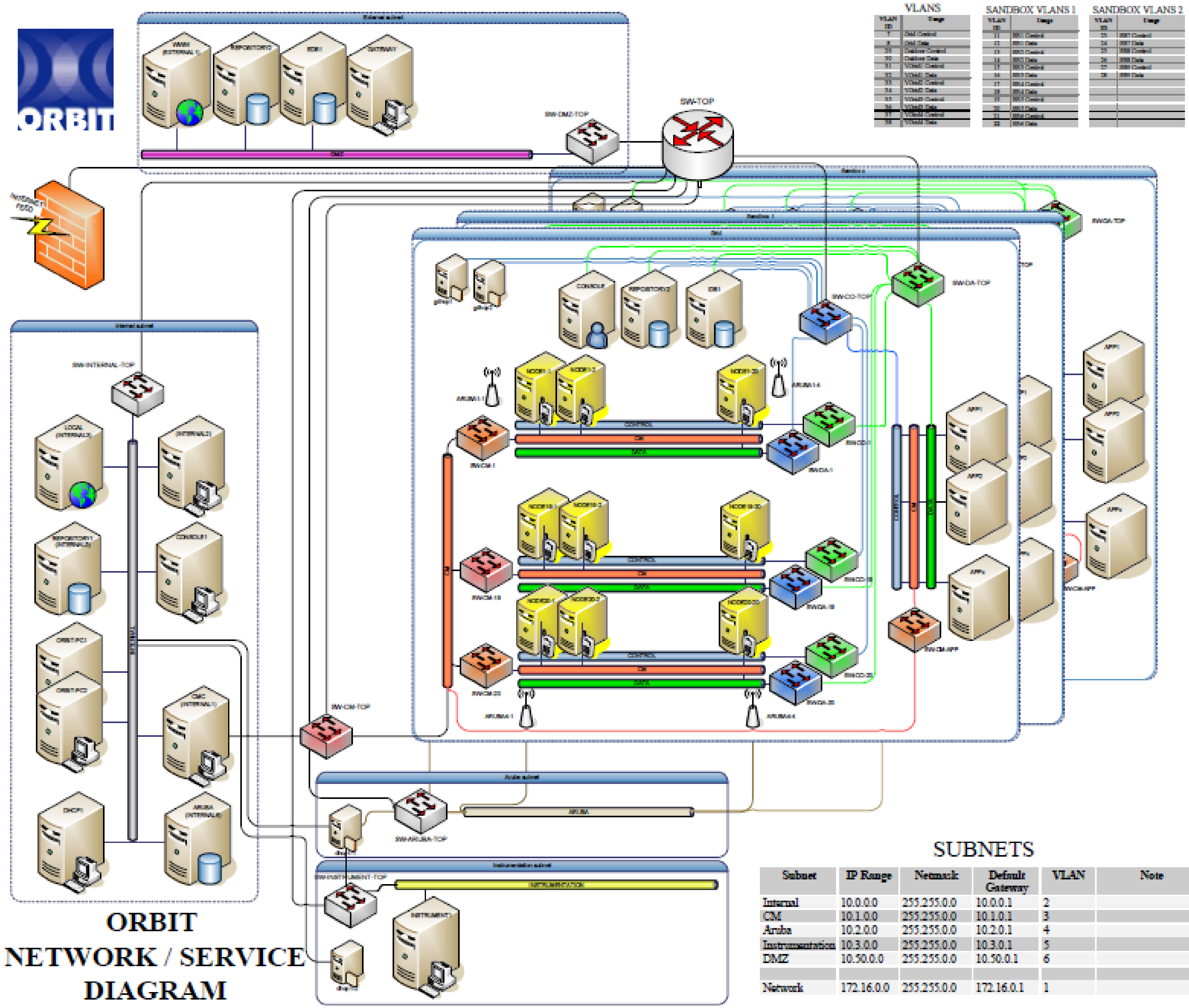
TCP,UDP/IP stack
TCP,UDP/IP stack-n
Virtual Interfaces
Packet Queue per virtual interface
Linux
Physical Interface
To WiMax base-station
Packet Queue per physical interface
Physical Interface
To backhaul network
Slice x maps to:
One outside termination point, e.g., IP address or VLAN
Many Clients, as allowed by Access Control List (ACL), via multiple service flows, implemented on multiple GRE tunnels.
One GRE tunnel is required for each Client, each service class it requires, and for each direction; from 256 – 64k GRE tunnels.
Supported service classes: UGS, ertPS, rtPS, nrtPS, BE
VM-1
VM-2
Kernel Virtual M/C
WiMAX Setup
(ASNGW + BS)
(Air interface)
Client-1
Client-2
802.16e Common Packet Sublayer (CPS)
UGS
ertPS
rtPS
nrtPS
BE
802.16e Base Station
Priority- based Scheduling
BS DL MAC Scheduler
WiMAX Frame scheduler


Slice x includes:
OMF Node Agent for experiment orchestration support
WiMAX virtual device
Outside Access Network
ASNGW-02
GENI TUN DEVICE
Experiment Description
Node Agent
Application
Virtual Device Driver
Slice #1
Slice #2
Slice #3
Slice #4
Slice #5
Kernel-based VM (KVM)
ASNGW-03
DATAPATH
GENI Slice APIs
(OMF) RF Aggr Mgr
(OMF) ASN GW Aggr Mgr
GENI TUN DEVICE
Scheduler
Experiment Controller (Node Handler)
Console (Portal)
Services
"GENI-R6" Messages
GENI SCHEDULER / SHAPER
NEC R6 CONTROLLER(Binary)
GRE I
GRE II
GRE III
Click Router
PHYSICAL ETHERNET DEVICE
Researcher
Control & Management Network
Internet
R6 Interface
Control
Service Flows
SNMP Query/Response
NEC WIMAX BS
Access to:
700+ variables


ASNGW-02
ASNGW-03
eth2
eth2
OMF-04 (Console and Services)
eth0
eth2
Researcher
Internet
Firewall
Internal Network (Mgmt and Control)


Internet
Inventory Service (one per site)
Web
Inventory
LDAP
Inventory
Searchable inventory of nodes, including status
Mgmt Plane
(one per site)
Mgmt Plane
Based on REST, XMPP
Next: RDF-based persistent Pub/Sub
Access via console for resource reservation, reboot, etc.
Isolated; experimenters cannot modify, cannot break.
Scheduler (SD) (one per site)
Web
Scheduler
LDAP
Scheduler
Reservations for specific domain/slice, specific time and duration.
Overbooking allowed – resolved by algorithm and/or admin
Access control via data in LDAP server
Current sites:
WINLAB, Rutgers
NICTA, Australia
Current WINLAB domains:
GRID (with 4 slices)
Sandbox 1
--
Sandbox 9
Outdoor (WiMAX)
Current NICTA domains:
?
Researcher r
Researcher r+1
Console (Portal) x+1
Console (Portal) x (one per domain)
Experiment Controller y+1
Experiment Controller y (one per slice for GRID)
SSH
Experiment Description (OEDL)
Ruby script
Get disc image from file system
Access control
Login requires approved slot, per scheduler
Management
Control
Domain x+1
Domain x
Aggregate Mgr
AM API
AM Services
APIs based on REST
Bootstrap service points to all available services
All services look the same
No access control – trusts console
Control VLAN
(one per domain/ slice)
Data VLAN
(one per domain/ slice)
Management
Disconnected operation of components OK
Component z+1
Component z
Resource Mgr
RM API
Resource Cntrl y+1
Resource Cntrl y (one per slice for GRID)
RC API
Control
Collection Service (one per site)
Collection Mgr
CM API
Collection Server
SQL
Measurement
Measurement
Measurement Agent
XDR-encoded data over TCP
Cache
Control VLAN
Used for control of nodes: experiment controller to nodes and node to node
Used for measurement file movement
Experimenter can modify, can break.
Data VLAN
Used for experiment traffic
Used for gateway to internet, etc.
Experimenter can modify, can break.



ORBIT NETWORK / SERVICE DIAGRAM

SUBNETS

Subnet	IP Range	Netmask	Default Gateway	VLAN	Note
Internal	10.0.0.0	255.255.0.0	10.0.0.1	2	
CM	10.1.0.0	255.255.0.0	10.1.0.1	3	
Aruba	10.2.0.0	255.255.0.0	10.2.0.1	4	
Instrumentation	10.3.0.0	255.255.0.0	10.3.0.1	5	
DMZ	10.50.0.0	255.255.0.0	10.50.0.1	6	
Network	172.16.0.0	255.255.0.0	172.16.0.1	1	