



Dan Baxter – PA
Senior Sales Engineer
dan.baxter@opengear.com
814-933-9829



INTRODUCTION TO CELLULAR ROUTING AND OOB

Why this is important...

- Cellular adoption is a huge growth area
- There are now more cell phones in the USA than people
- People are now expecting to access the Internet over their cell
- Vendors and Carriers are offering very affordable options

- You need to know the realities, security issues, costs, and management options in order to make the best decisions about adopting this emerging technology

What are we talking about exactly...

- **Cellular Routing** refers to network devices that use either an integrated cellular modem or an external cellular modem to provide an IP network path using an IP route provided by a cellular carrier
- **Cellular Out-of-Band (OOB)** refers to using either an integrated cellular modem or an external cellular modem to provide management access to an OOB device using an IP route provided by a cellular carrier

Cellular Routing vs. Cellular OOB

- Both share the idea of primary and failover interfaces
- Both share similar security concerns
- Both share the same carrier IP plan options

- Data plan costs differ because the usage varies

- Primary application of cellular enabled OOB is to provide access to a single remote management device – not pass traffic

Embedded Cellular Routing form factors

- Router Modules



- External Modems



- Embedded Cellular
Consumer



- Industrial

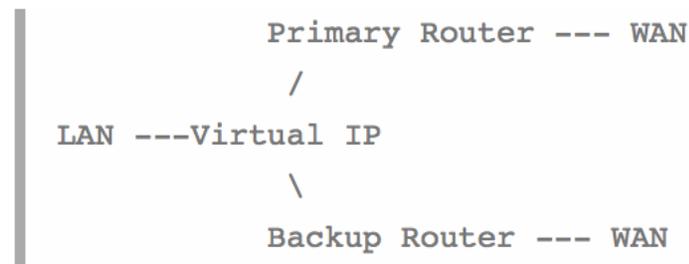


Cellular Routing Strategies - HA

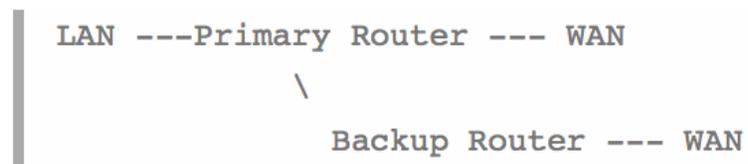


Cellular Routing Strategies

- HA – cellular router becomes the default gateway



- IP Pass Thru – cellular router is a secondary path for the primary router



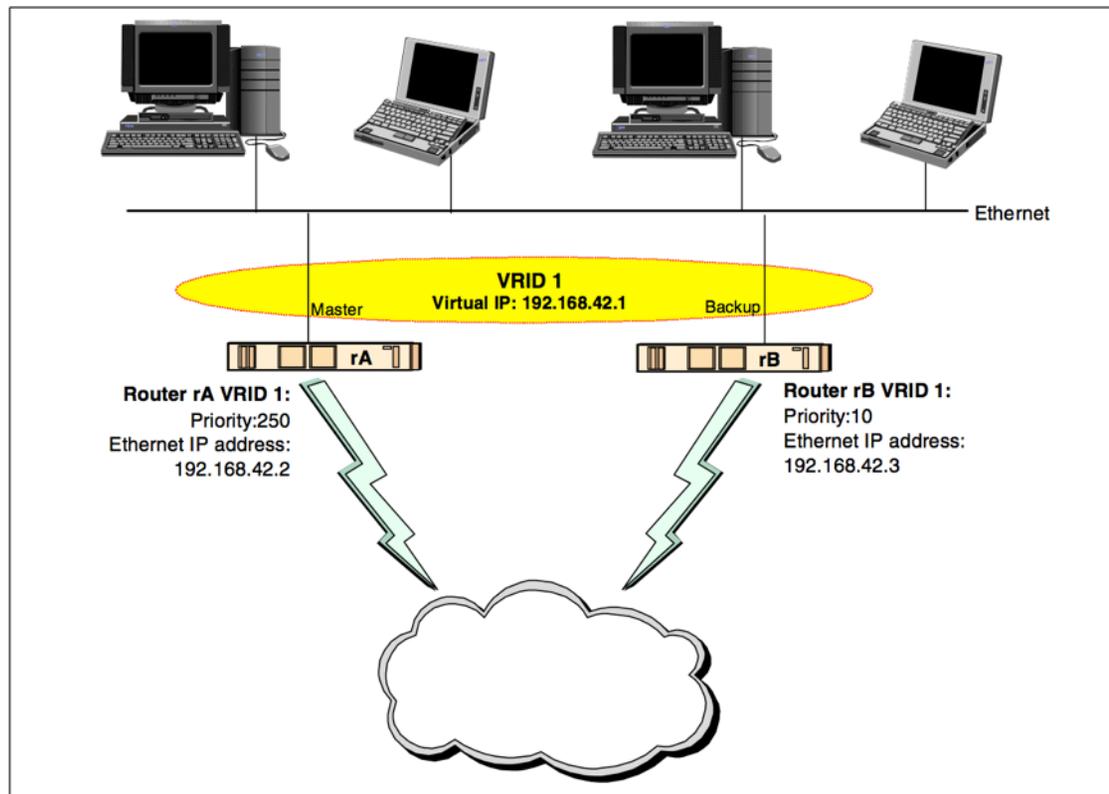
- Standalone – cellular router is the only router

Cellular Routing Strategies - HA

- High Availability Model – HA protocols handle failover
 - HA Failover pairs the backup router with the primary site router
 - When the primary router fails or WAN connectivity fails, the redundancy protocol selects the backup router to become the gateway
 - Systems continue to be able to reach the WAN, transparently
 - The backup router continues to be reachable via its WAN connection, and an always up LAN alias.

Cellular Routing Strategies – HA & VRRP

- VRRP is a commonly used protocol in cellular backup solutions when the cellular router is separate from the primary router



Cellular Routing Strategies – IP Pass Thru

- IP Pass Thru – primary router handles failover
 - Turns the backup router into a “modem” for the primary router
- The primary router handles all routing functionality including failover to the backup cellular connection in the event of a WAN connectivity failure

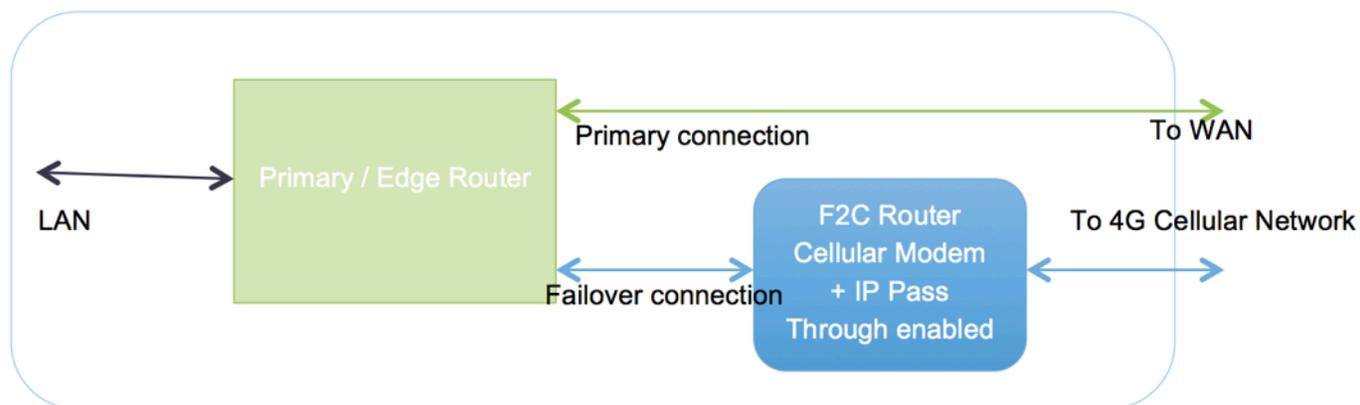


Figure 1 Typical deployment and usage of the F2C Router

Cellular Routing Strategies – Best Practices

- Challenges:
 - Different modes address different situations/vulnerabilities
 - IP Pass Thru depends on primary router staying active
 - Does not protect against primary router failure
 - VRRP may require re-configure of remote site routers
- Best Practices:
 - Design around what you consider the most likely failure
 - Router failure?
 - WAN link failure?

Cellular OOB Strategies



Cellular OOB form factors

- Embedded Cellular OOB – cell inside



- OOB with External Cellular Modems



Cellular OOB Strategies

- External Modems
 - Works well for legacy devices that do not have cellular support
 - Adds a point of failure
 - Vendor support for 3rd party devices may be limited



Cellular OOB Strategies

- Embedded
 - Reduces points of failure
 - Recently engineered hardware more likely compatible with cellular
 - Well integrated into feature set
 - Matched to carriers – cannot be field changed



Cellular OOB Strategies

- Products with a primary design focus around OOB
 - RJ-45 form factors – complete OOB feature set
 - Failover handling
 - Alerting and notification leverages the cellular modem



Cellular OOB Strategies

- Products with OOB as an add-on
 - DB9 form factor – subset of OOB features
 - Re-purposing the local console port
 - Usually a lower port count
 - Meant for remote sites more than Data Centers



Cellular OOB Strategies

- IP Failover to Cellular Interface
 - Common triggers
 - PING
 - Interface state change
 - Interface state handling
 - Active all the time vs. dormant
 - Default route handling
 - Per-Interface-Routing

Failover	
Failover Interface	<input type="text" value="Internal Cellular Modem (cellmodem01)"/> A device to fail to in case of outage. <i>Devices must be configured and enabled for failover to work.</i>
Dormant Failover Interface	<input type="checkbox"/> If the failover interface should stay active at all times, only being routed through in failure situations.
Primary Probe Address	<input type="text"/> The address of the first peer to probe for connectivity detection.
Secondary Probe Address	<input type="text"/> The address of the second peer to probe for connectivity detection.

Cellular OOB Strategies – Best Practices

- Challenges:
 - Vendor focus influences form factor
 - Legacy devices may require external cell modems
 - Vulnerability and cost considerations
 - Carrier specific
- Best Practices:
 - Do you need cellular as an add-on or integrated?
 - Do you need cellular across high port densities?
 - Avoid external dongles
 - Identify VPN requirements – are they supported?
 - Know the focus of your vendor – correlates to the level of support they will be able to provide
 - Does your device have sufficient security for a Static IP?

Cellular Considerations



Mobile . . .

Sprint®

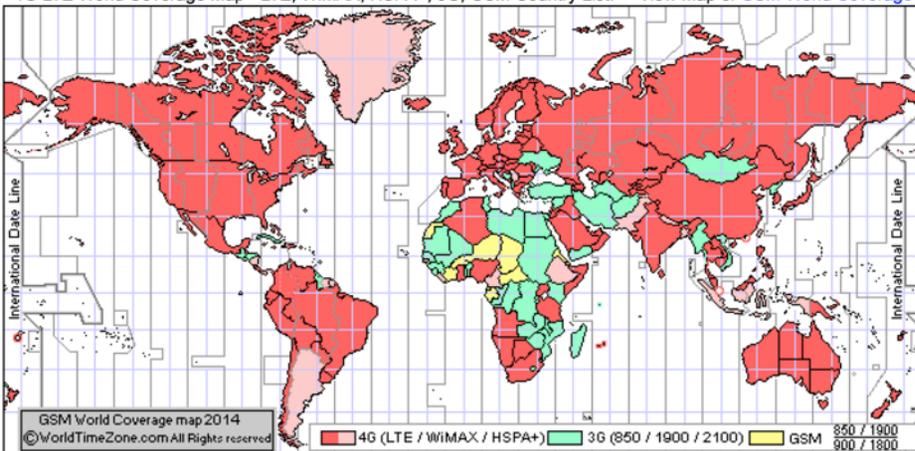


at&t

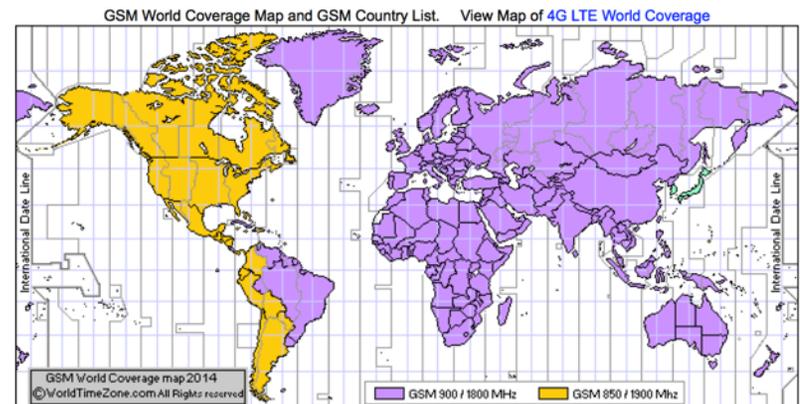
Carrier Considerations

- Bands and wavelengths
 - **There is no one-size-fits-all – yet....**
 - Wavelength and Band will vary by country
 - USA is very carrier specific
 - Internationally more about wavelength than Carrier
 - Modems are matched to a specific wavelengths/bands

4G LTE World Coverage Map - LTE, WiMAX, HSPA+, 3G, GSM Country List. View Map of [GSM World Coverage](#)



LTE



GSM (Group Special Mobile) - Global System for Mobile communications - most popular standard for mobile phones in the world.
GSM 900 / GSM 1800 MHz are used in most parts of the world: Europe, Asia, Australia, Middle East, Africa.
GSM 850 / GSM 1900 MHz are used in the United States, Canada, Mexico and most countries of S. America.

GSM

Carrier Considerations

- Bands and wavelengths - USA
 - Devices are usually matched to carriers for the most part
 - Some devices can support multiple carriers but there is a cost increase
 - Different Carriers support different bands
 - **ATT Frequency Bands:** LTE 700 MHz (**Band 17**)
 - **Verizon Frequency Bands:** LTE 700 MHz (**Band 13**)
 - Carriers **certify/police** devices allowed on their networks
 - They hand **out IMEI#s** that allow that device on their network
 - An ATT SIMM card will not work in a device certified for Verizon
 - You order devices **by Carrier** and 3G or LTE
 - Internationally - you have more flexibility
 - One modem/SIMM may work in several countries with several carriers
 - **International Frequency Bands:** LTE 800/900/1800/2100/2600 MHz
 - You order **by 3G or 4G** but not carrier

Carrier Considerations

- 3G vs. 4G – USA – differences in speed and coverage
 - 4G is also called LTE
 - 4G devices can fail over to 3G if 4G is not available
 - **4G usually has better coverage** (10 db in some cases)
 - 4G line speeds = Upload **50 Mbps/Download 100 Mbps**
 - 3G line speeds = varies – Upload **1.8 Mbps/Download 3.1 Mbps**
 - **3G is more common internationally**
 - 4G is gaining adoption internationally
 - Future proof? XLTEW?

Carrier Considerations

- Matching countries, carriers and equipment
- Bands and wavelengths – USA – WIKI
- Hopefully the vendor has made this process easy

Frequency bands recommended by ITU (UMTS) [\[edit\]](#)

Main article: UMTS frequency bands

ITU-R approved in June 2003 the following bands to the terrestrial Mobile telecommunication **IMT-2000**: 806–960 MHz, 1,710–2,025 MHz, 2,110–2,200 MHz and 2,500–2,690 MHz.

United States Carrier Frequency Use [\[edit\]](#)

Carrier	UHF Voice Frequencies				3G UHF Frequency / Band name			4G UHF Frequency / Band number							3G Technology		4G Technology	
	800 MHz	850 MHz	1700 MHz 2100 MHz	1900 MHz	850 MHz	1700 MHz 2100 MHz	1900 MHz	700 MHz	750 MHz	800 MHz	850 MHz	1700 MHz 2100 MHz	1900 MHz	2500 MHz	GSM HSPA+	CDMA EVDO	WiMax	LTE
					CLR	AWS	PCS	12,17	13	26	5	4	2,25	41				
AT&T Mobility	✗	✓	✗	✓	✓	✗	✓	✓	✗	✗	✓	✓	✓	✗	✓	✗	✗	✓
T-Mobile US	✗	✗	✓	✓	✗	✓	✓	🕒*	✗	✗	✗	✓	🕒*	✗	✓	✗	✗	✓
Sprint Corporation	✓	✗	✗	✓	✗	✗	✓	✗	✗	✓	✗	✗	✓	✓	✗	✓	✓†	✓§
Verizon Wireless	✗	✓	✗	✓	✓	✗	✓	✗	✓	✗	✗	✓	✗	✗	✗	✓	✗	✓
U.S. Cellular	✓	✗	✗	✓	✓	✗	✓	✓	✗	✗	✓	✗	✗	✗	✗	✓	✗	✓

*Promised/in construction.
† 2010 - Current.
§ 2012 - Current.

Carrier Considerations

- Bands and wavelengths – International - Asia - WIKI

Asia [\[edit\]](#)

Operator	Country	$f^{[F 1]}$ (MHz)	Band	Duplex mode	Launch date Cat. 3	Launch date Cat. 4	Launch date Cat. 6	Notes
Bhutan Telecom / B-Mobile	 Bhutan	1800	3	FDD	Oct 2013			[247]
DSTCom	 Brunei	1800	3	FDD	Nov 2013			[248] [249]
Smart	 Cambodia	1800	3	FDD	Jan 2014			[248] [250]
China Mobile	 China	2500	41	TDD	Dec 2013			[248] [251] [252] [253] (↓↑) 2575 – 2635 MHz Accessible with devices supporting band 38 by using MFB^[E 1].
China Telecom	 China	2500	41	TDD	Feb 2014			[248] [254] [255] [256] (↓↑) 2635 – 2655 MHz NOT accessible with devices supporting band 38. ^[citation needed]
China Unicom	 China	2500	41	TDD	Mar 2014			[248] [257] [258] [259] (↓↑) 2555 – 2575 MHz Accessible with devices supporting band 38. ^[citation needed]
Aquaфон	 Georgia	(?)	(?)	(?)	Aug 2014			[260] [261]
3	 Hong Kong	1800	3	FDD	Oct 2012 (?)			[262]
China Mobile	 Hong Kong	1800	3	FDD	Oct 2013			[263]
China Mobile	 Hong Kong	2600	7	FDD	Apr 2012			[262] [264] (↓) 2675 – 2690 MHz / (↑) 2555 – 2570 MHz
China Mobile	 Hong Kong	2300	40	TDD	Dec 2012			[20] [264] [265] (↓↑) 2330 – 2360 MHz
cs.l.	 Hong Kong	1800	3	FDD	Aug 2012	(?) 2013	Feb 2014	[262] [266] [267] [268] [269]
cs.l.	 Hong Kong	2600	7	FDD	Nov 2010	May 2013	Feb 2014	[262] [266] [267] [268] [269] (↓) 2655 – 2675 MHz / (↑) 2535 – 2555 MHz
Genius (3 & PCCW)	 Hong Kong	2600	7	FDD	May 2012	Jun 2013		[262] [270] [271] [272] (↓) 2620 – 2640 MHz / (↑) 2500 – 2520 MHz
PCCW	 Hong Kong	1800	3	FDD	Aug 2012			[262] [271]

Carrier Considerations

- Consumer vs. Business accounts
 - Consumer
 - Example may be the Verizon store
 - Tablet plans are commonly used for M2M
 - More suited for home use - more expensive – less options
 - Meant more for tablets and Hot Spots
 - Business
 - You will have a Sales Rep and SE
 - Options specifically for routing or OOB
 - Quantity discounts
 - Self-serve portals
 - Diagnosis and management visibility

Carrier Considerations

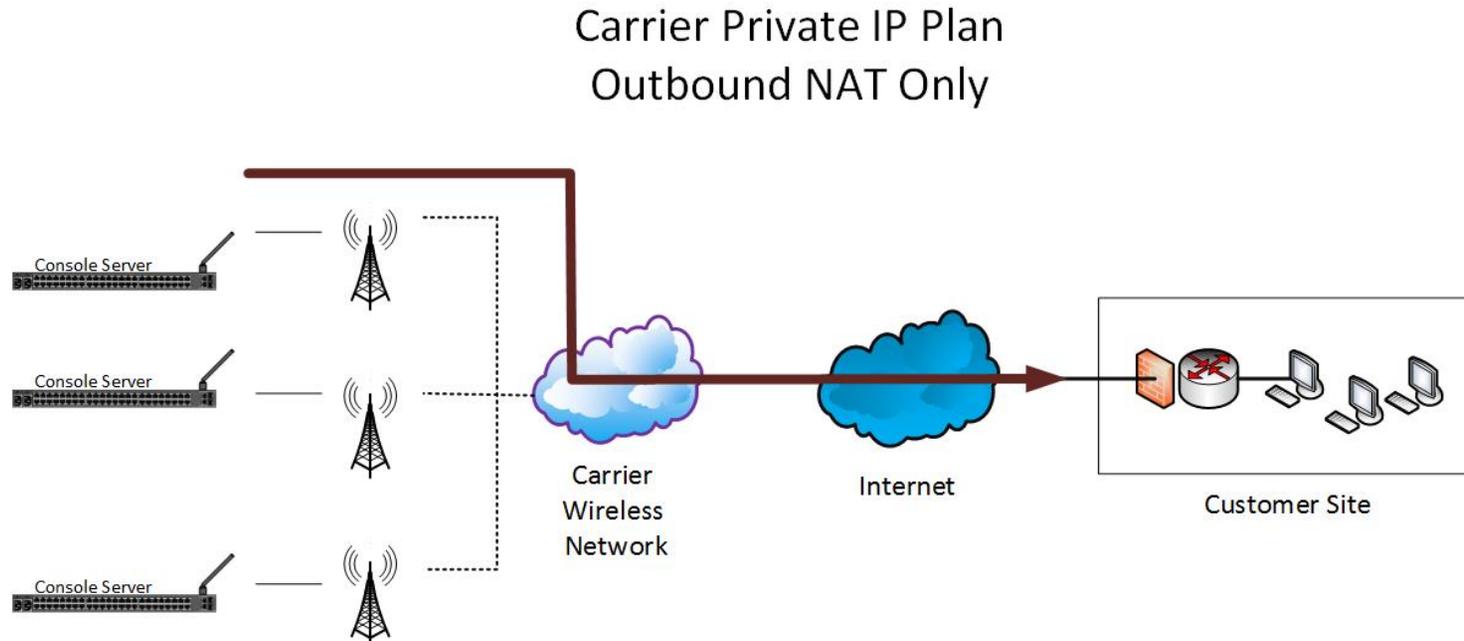
- LTE Routing vs. LTE M2M plans
 - LTE Network Routing
 - Multiple device traffic
 - Designed to route all site traffic or subset during outages
 - **30GB is the smallest data allowance** you can order
 - LTE M2M Device Routing
 - Historically smaller traffic – usually single device only
 - **1MB is the smallest data allowance** you can order
 - Priced structured around M2M/Internet of Everything
 - OOB uses M2M cellular plans to access the OOB device only
 - Sometimes used for VPN networking but usage is expected to be small

Carrier Considerations

- IP Plan Options:
 - The cellular modem interface is an IP interface vs. an analog modem for example
 - The IP address is given by the carrier
 - The type of address and how it is accessed will depend on the plan
- Three common plan types
 - Private
 - Public IP
 - Private Carrier Network

Carrier Considerations

- Private IP Plans:
 - Used where traffic may be outbound – POS, ATMs or telemetry device
 - The address will be a private NAT address
 - Very low cost data pools



Carrier Considerations

Plan Pros and Cons: Private NAT Address

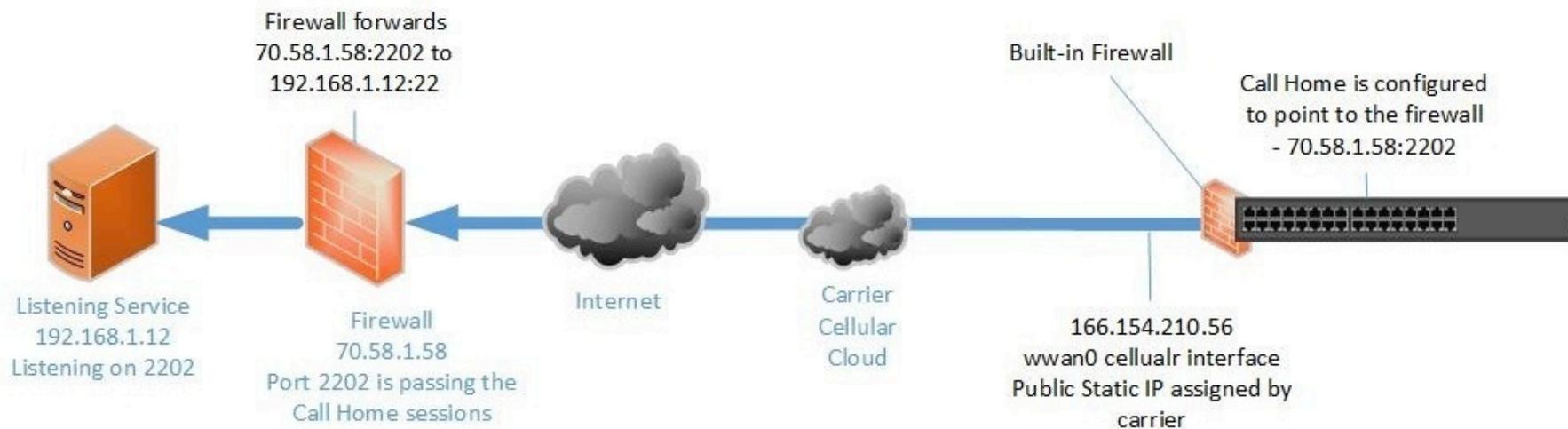
Plus	Considerations
Very cost effective	Cannot Browse or SSH directly to the device over the Internet
Can be very easy to setup via Lighthouse without adding additional routers, firewalls and VPN gateways	The console server must always initiate an outbound Call Home session or VPN tunnel
Requires no VPN or IPsec knowledge when using Lighthouse	If Call Home gateways are not available you cannot access the console server via the cellular network

Cost Consideration: Private NAT IP Address = per device (1MB pool)

Type	Activation	Monthly	Total (yearly)
Private NAT IP	\$20	\$5	\$80 1 st Year

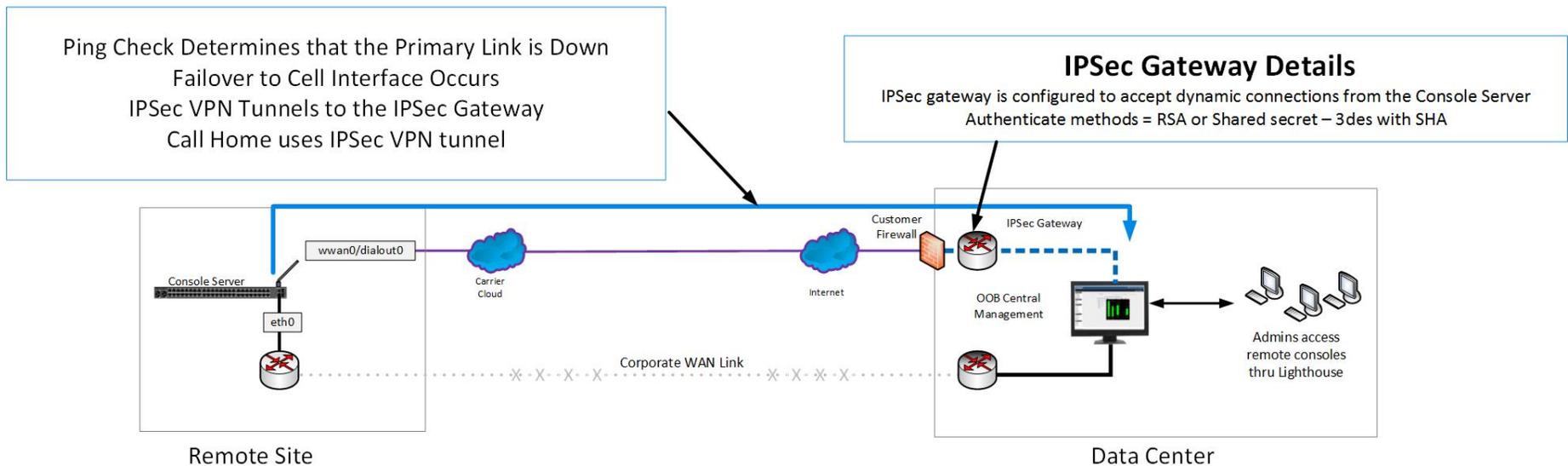
Carrier Considerations

- Private IP Plans: Overcoming NAT Challenges
 - Reverse SSH (Call Home)



Carrier Considerations

- Private IP Plans: Overcoming NAT Challenges
 - Reverse Sessions - VPN – IPSEC, OpenVPN, PPTP

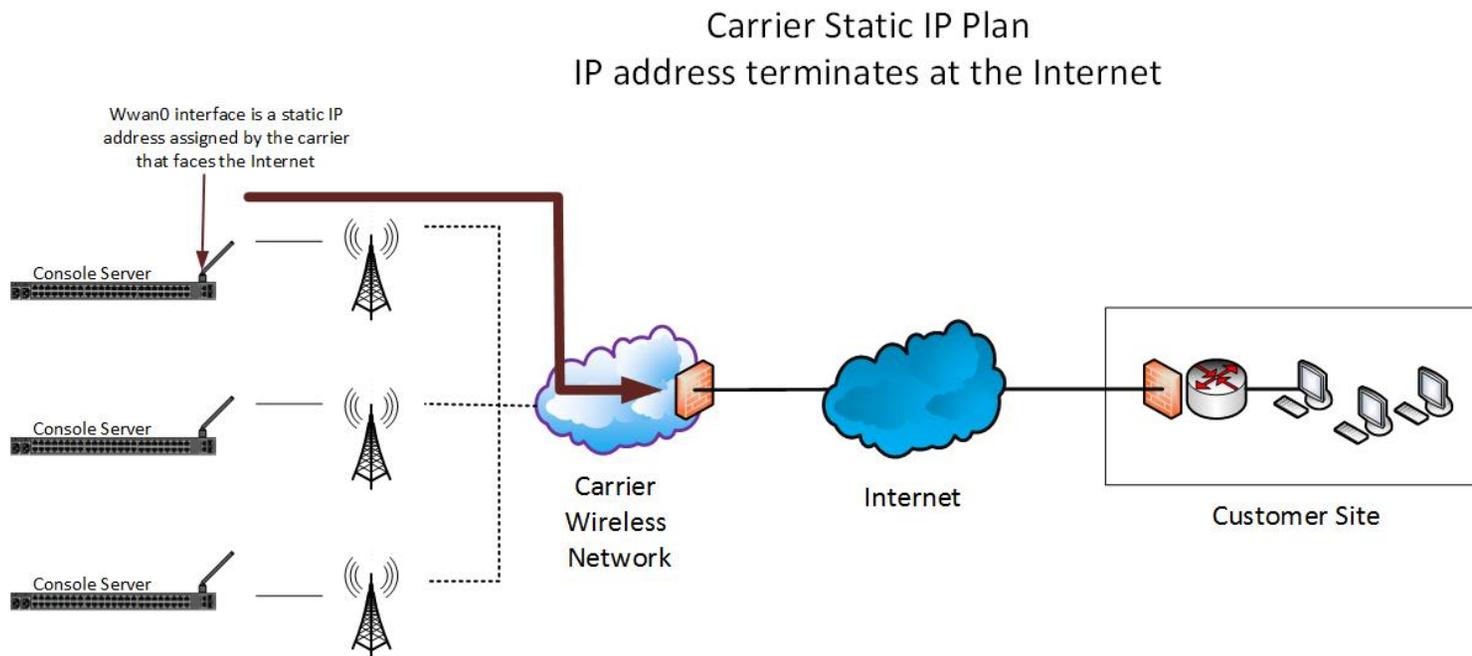


Carrier Considerations

- Public IP:
 - Can be static or DHCP - depends on carrier/country
 - This address faces directly on to the Internet
 - May need to leverage DDNS if the address is DHCP
 - If the Carrier notes private packets they disconnect the cellular modem – be sure to prevent bleeding
 - Routing between sites will obviously need to involve encryption
 - Well suited for road warriors if using VPN to route to remote network
 - Can leverage VPN gateways and VPN networking
 - Easy to access – will need strong security
- A one time setup fee of \$500 for each pool – not each device

Carrier Considerations

- Carrier Static Public IP: Faces the Internet



- Pro – its on the Internet Con – its on the Internet

Carrier Considerations

- Public Static IP Plans: Challenges
 - Security – Security – Security
 - Firewall rules
 - Service Control
 - Fail2Ban
 - Alerting
 - Hardened
 - Availability
 - Always up but not the DG
 - Only up when failover occurs
 - Shoulder tap
- Make sure your vendor supports all of these

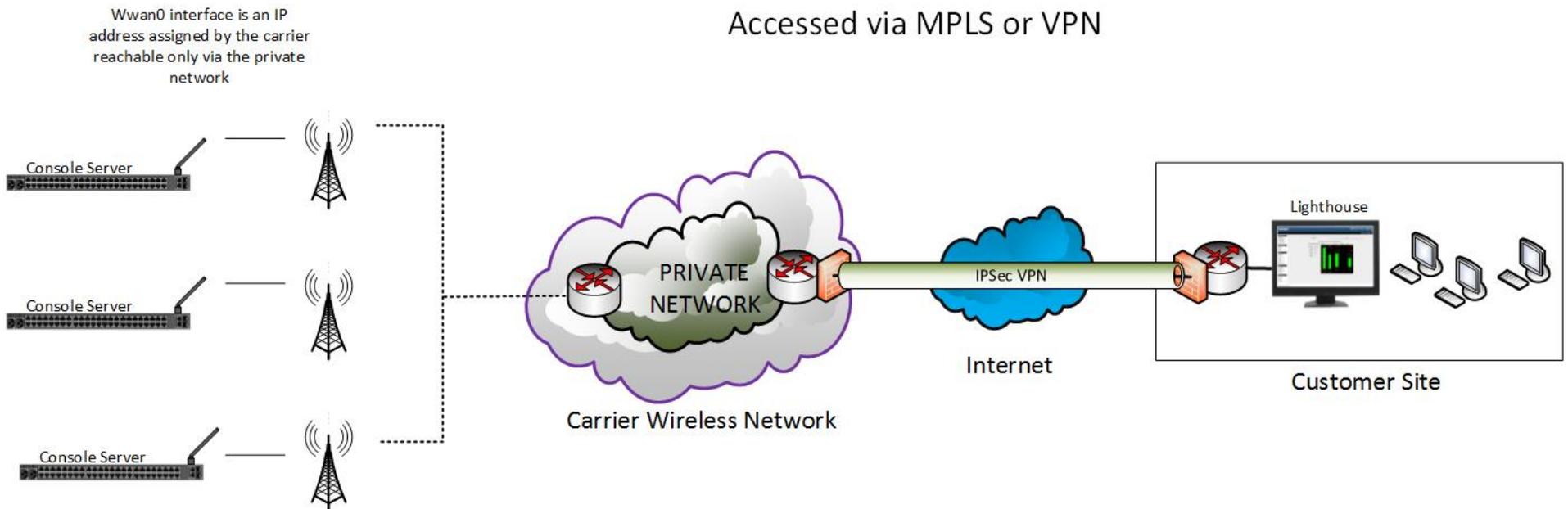
Carrier Considerations

- Carrier Private Network:
 - Well suited for larger deployments or secure/business critical needs
 - Carrier isolates all traffic between your cellular devices
 - Your ingress to the private network is via VPN or MPLS
 - You can route between those devices and corporate networks
 - BGP – carrier required
 - IPSEC/GRE – carrier required
 - You can specify the IP addressing – DHCP vs. Static
 - Options are available to give you visibility into performance and troubleshooting
 - There is a self-serve portal available to help you manage and provision
- A one time setup fee of \$500 for each pool – not each device

Carrier Considerations

- Carrier Private Network: Accessible only via VPN or MPLS

Carrier Private Network
Carrier creates isolated network
Accessed via MPLS or VPN



Carrier Considerations

- Carrier Private Network Challenges/Benefits
 - Got VPN?
 - MPLS costs factored in?
 - What about road warriors?
 - How much management do you want? Self-serve portals?
 - Carriers are particular about the packets they see
 - No private address bleeding – will disconnect the modem
- Best option for large and secure deployments – you can ping and connect to all devices – you can even specify the addressing :)

Cellular Plans and Bands - Best Practices

- Choose based on your security and access needs
- Pursue business plans – buy in bulk
- Get to know your reps and SEs
- Do you have a mobility group?
- Select the right plan for your access modes and security
- Ask yourself how will you access the devices
 - Road warrior – maybe Static IP
 - Secure company network – carrier private network may be best
- Put some data behind your data plan size estimate

Cellular Costs



Carrier Considerations - Costs

- LTE Routing Costs: Generally speaking.....\$185/month
 - Router plans include:
 - monthly fee
 - data GB allowance limit
 - possible overage costs



LTE Router

	FOR VOICE & DATA PRICING		FOR DATA ONLY PRICING
Monthly Data Allowance	30 GB	40 GB	50 GB
Monthly Account Access	\$185/mo 25 Lines Max	\$260/mo 25 Lines Max	\$335/mo 25 Lines Max

Carrier Considerations - Costs

- LTE OOB Costs: Generally speaking.....\$5/month
 - M2M plans include:
 - monthly fee
 - data GB allowance limit
 - possible overage costs



LTE OOB devices

Monthly Access Per Line	Shared Data Allowance	4G USB Modem / Jetpack	Notebook / Tablet / Netbook	Connected Devices
\$5	1 MB			✓
\$10	75 MB			✓
\$30	2 GB		✓	✓
\$50	5 GB	✓	✓	✓
\$80	10 GB	✓	✓	✓

Carrier Considerations – How Much Data?

- Why M2M plans are less expensive than Routing plans
 - 100KB per remediation incident/management session
 - 1MB data pool for each device is more than enough
 - M2M telemetry sessions are very small traffic wise

- Data usage for incident response using LTE
 - SSH to the OOB device
 - cisco device is rebooted
 - auto-Response breaks into ROMmon
 - print some diagnostics
 - continue to boot & watch boot messages
 - show running-config & then disconnects

Cellular Security



Cellular Security

- Not your Dad's modem.....



- It is an IP interface.....the usual rules apply
- The plan will dictate the security policy

Cellular Security – what to do

- Standard firewalling practices will apply
- Specifics of the IP plan should drive specifics of the security policy
- Consider tunneling over carrier private networks
- Consider turning off services on cell facing interfaces
- Public IP failover interfaces should be dormant until needed
- Make sure the product supports fail2ban-like mechanisms for Public IP
- Implement alerting on interface changes
- Be sure to leverage the cell interface for alerting during outages –
NMS need to send traps out the interface

Deployment Considerations



Deployment Considerations

- Signal Strength
 - RSSI is the measure for LTE (-50 = very strong -98 = bad)
 - Cell phones use bars but can be a good rough estimate
 - The cellular OOB or router can be used to survey RSSI
 - Antennas can be moved up to 30 meters using low loss cables
 - Cellular amplifiers can be used

Output from Sierra Wireless
MC7750 cell modem

lte-signal = strength\

-75 is OK

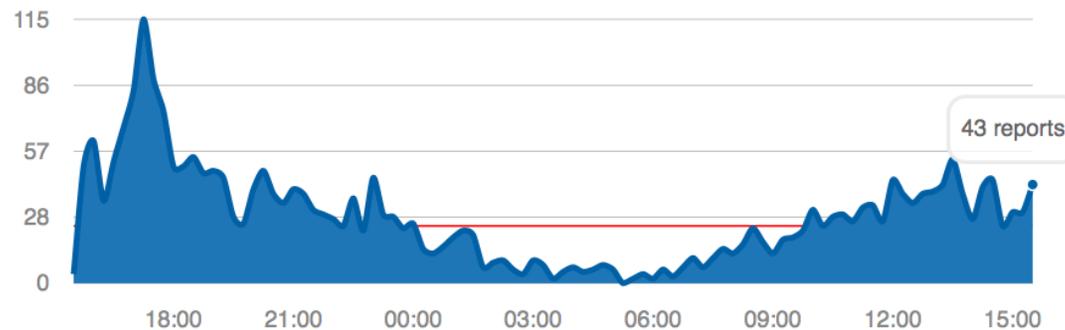
```
1. ssh
# cellctl -ils
product MC7750
technology CDMA2000 1X/CDMA2000 (1xEV-DO)
imei 990000562098071
esn 803BBE87
meid A000003566F746
serial N/A
firmware 20
mode_prefs cdma2000 1X, cdma2000 HRPD, LTE
band_prefs Band Class 0, A-System, Band Class 0, B-System, Band Class 0 AB, GSM
850 band, Band Class 1, all blocks
lte_band_prefs E-UTRA Operating Band 13
interface_aquisition_order cdma20001x, cdma2000hrpd, gsm, lte, umts
sim-status SIM Initialized
sim-lock SIM_READY
pin1-status PIN is disabled
pin1-retries-left 3
pin1-unblocks-left 10
pin2-status PIN is enabled, not verified
pin2-retries-left 3
pin2-unblocks-left 10
lte-signal -75
network Verizon Wireless
```

Deployment Considerations

- Cell Network Availability – downdetector.com

Problems at AT&T

AT&T problems last 24 hours



Map



Recent reports mainly originated from: [Los Angeles](#), [Dallas](#), [Springfield](#), [Norcross](#), [Chicago](#), [Houston](#), [Rantoul](#), [Lafayette](#), [Jamaica](#), and [Boston](#). [View on map](#)

[I have a problem with AT&T](#)

[Check past issues](#)

Most reported problems:

- Mobile > Internet (60%)
- Mobile > Phone (22%)
- Landline > Internet (16%)

Resolved issues:

- **16 September:** [Problems at AT&T](#)
- **16 September:** [Problems at AT&T](#)
- **15 September:** [Problems at AT&T](#)

17 September: Problems at AT&T

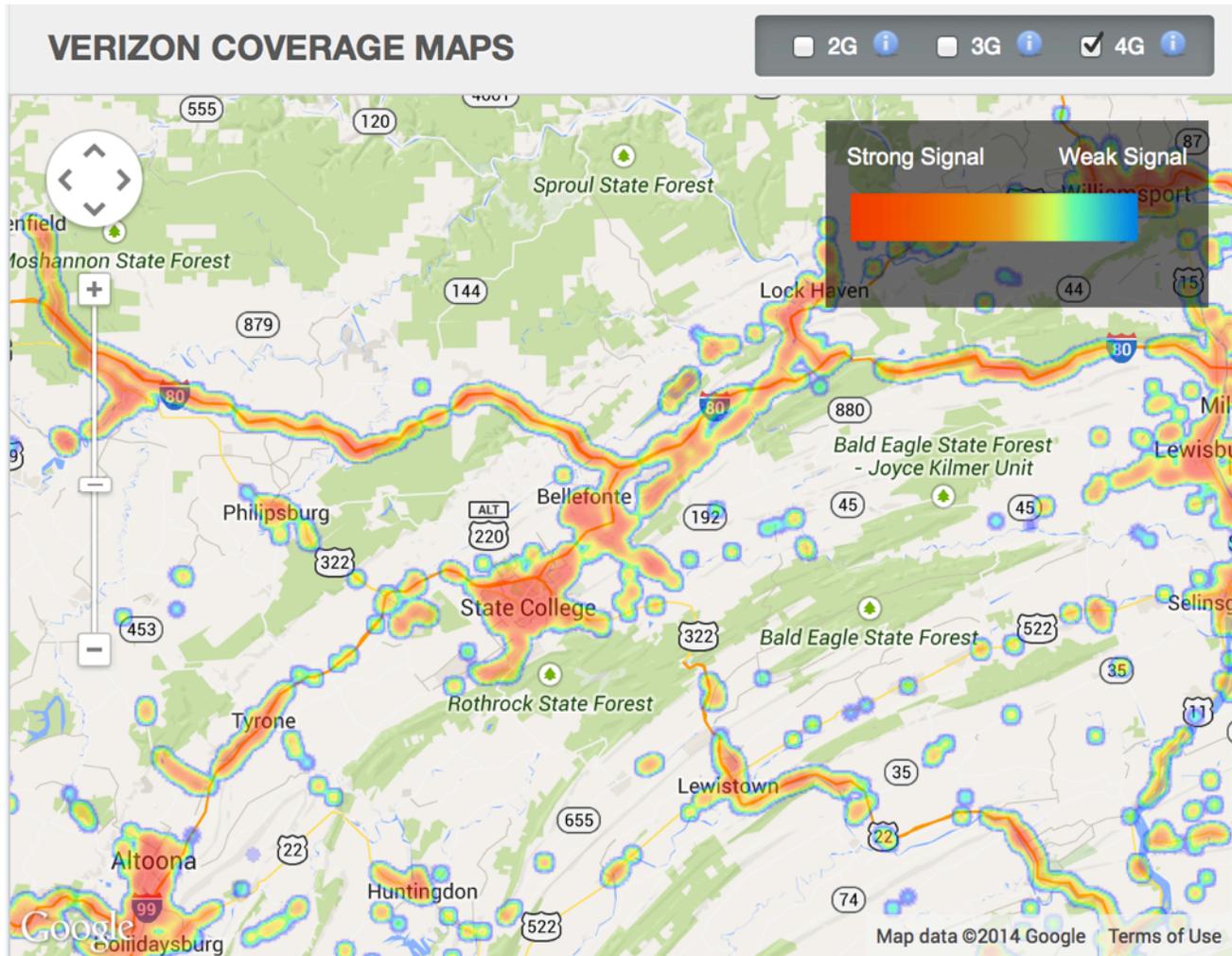
Deployment Considerations

- Cell Network Availability – OpenSignal



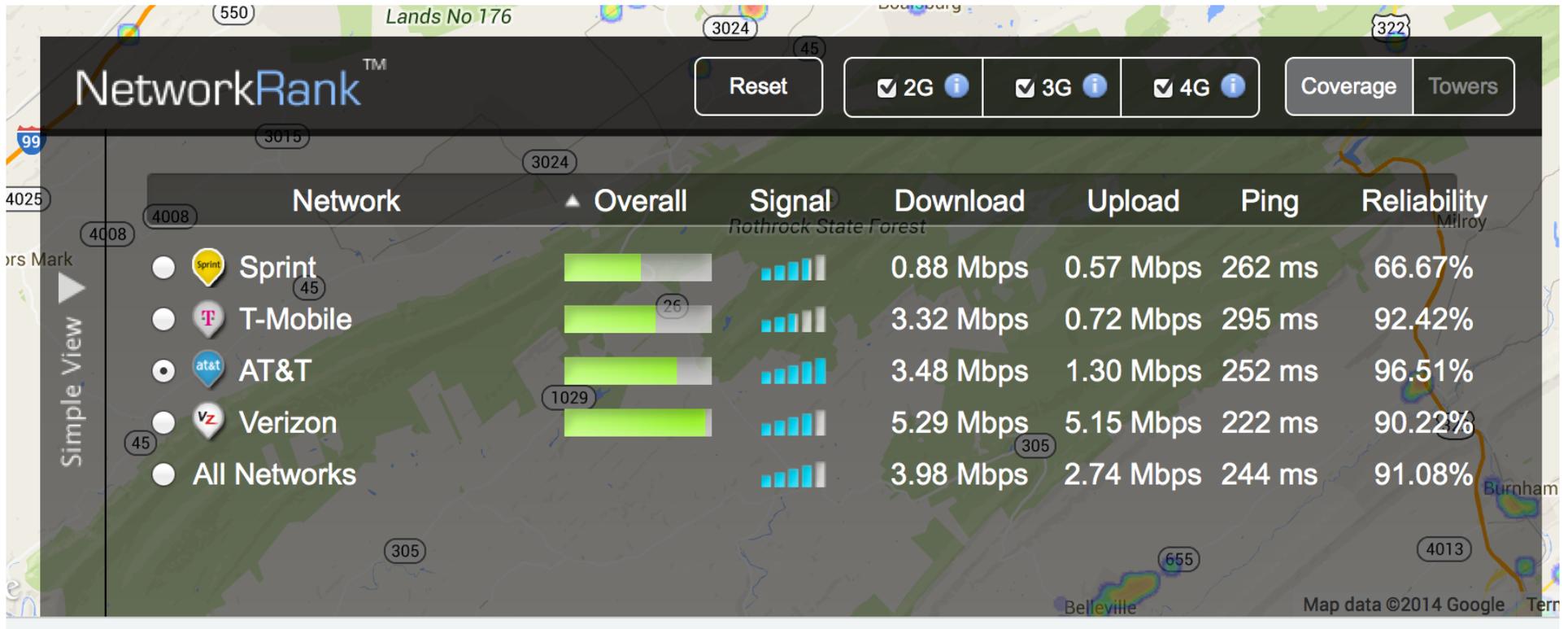
OpenSignal

Find the best network in your area



Deployment Considerations

- Cell Network Availability – OpenSignal



Deployment Considerations – Best Practices

- Site survey - my experience....
 - 4G has better coverage – significantly in some cases
 - Cell phones can be conservative – don't have dual antennas
 - Being able to move the antenna has made a big difference in some installs
- Antennas are better outside the racks

Deployment Considerations – Best Practices

- Site survey – tools

Smartphone cell strength icons – good – usually



Better - G Net Tracker



Even Better – an actual embedded cellular device



Best – measurement tools



Deployment Considerations

- How customers are deploying cellular OOB:
 - A single gateway device in the data center
 - Cell per device for remote site deployment
 - Cell per device in remote closets
 - Moving antenna vs. moving devices near the window
 - Top/bottom of rack actually makes a difference

Deployment Considerations

- Interface handling
 - Consider how hosts will route to new gateway of the cell router
 - Dormant until needed for OOB
 - Restrict unnecessary chatter across the cell interface
 - Consider QoS control to limit unnecessary traffic
 - Set cell data restrictions via the device
 - Set notifications on over usage on the plan itself

Best Practices Summary – Choices

- Conduct Site Survey
- Educate yourself on the options – plans, carriers, routing
- Choose the plan ahead of time – hard to change later
- Call the carrier – get to know them – single point of contact
- Know your international options
- Don't forget budgeting for the monthly costs
- Can you roll into existing monitoring fabrics?

- Make sure your vendor is an expert.....and focused....



Q & A