

Adventures in VoIP!

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Columbia College Background

- Traditional day students at the Columbia campus
- Evening classes at Columbia, and Nation wide through our 30+ AHE campuses
- Online classes represent our fastest growth
- Nearly 30,000 unique students last year

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Telephone System

- Migration from a ROLM PBX to Cisco's VoIP solution completed summer 2007.
- Columbia campus uses a Cisco network, VoIP phones work nearly flawlessly.
- All remote campuses have independent telephone systems (Partner, Meridian, Iwatsu, etc.)

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WAN Network Background

- Added a second Internet connection in 2009
 - AT&T and MOREnet
- Use BGP to advertise IP space and influence incoming traffic weights
- One bandwidth shaper is attached to each edge router

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A Growing Campus

- Our Online department was growing beyond it's available physical space.
- We had used IP Soft phones with a VPN client in a pinch a few times with success.
- The question was raised about moving our IP phones off campus to that one employee could work from home...

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Our SOHO test

- We tried working from home with a soft phone and VPN client, but performance wasn't up to expectations for day-to-day use.
- The user's laptop experience was noticeably better when used with a home router to provide VPN access
- Our first SOHO router configuration was born!

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First Generation: Crude, but effective

- Two ports for the office computer (Vlan 1),
Two ports for home equipment (Vlan 250)
- VPN for work equipment, but not for home.
- If the phone wasn't plugged into the right port,
it wouldn't work.
- The first call to a phone at the come campus
would fail
- If an access point was attached to an office port...

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When an employee's spouse receives new orders...

- We then had an employee's husband receive
orders to be stationed at Okinawa Japan!
- The only ISP doesn't provide static IP addresses.
Only DHCP behind a cable modem!
- Can we make it simpler to plug in the phone,
computer, and any home equipment?

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Second Generation: Now we're starting to work!

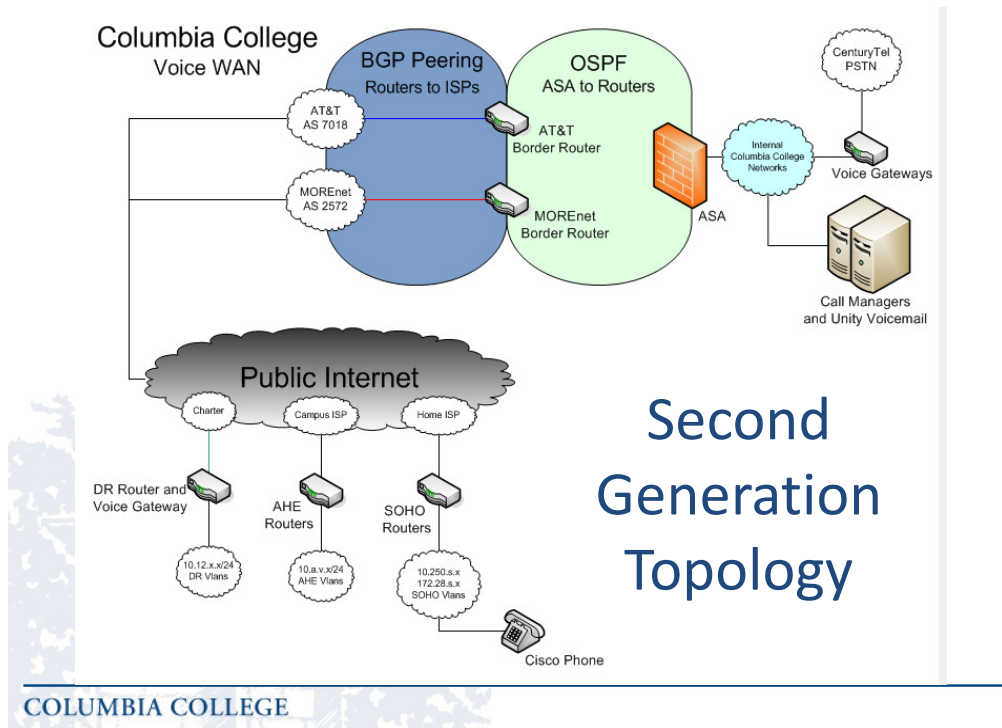
- Subnet our VPN'ed IP space
 - Use CDP to auto-assign the phone to the Voice Vlan
 - Use a DHCP reservation and secondary IP address on vlan 250 to move the work laptop into VPN IP space
- The phone and laptop now work from any port
 - If home wireless is used, a VPN client is required on the laptop as the DHCP reservation is for the cabled port only (by MAC address).
- Easy to abuse, but harder to accidentally break.

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However...

- Dialing from one SOHO to another requires opening an “outside” line and then 7-digit dialing the other party
- The routers we are using only support 10 VPN peers, a mesh VPN isn't possible (or desirable)
- VPN Hair pinning to the rescue!
- If a needed VPN tunnel is not already active, the first flow (call) will be dropped as the tunnel is being built.

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Desired Environment

- “Business” DSL/Cable service with a static IP
 - Allows for easy SSH access to router for installation/troubleshooting
- 871 Router prep with auto-sensing ports for VPN
- DHCP can work, but requires the VPN to be operational for remote access
- Static IP via PPPoE over DSL is possible, but ~~painful to prep and troubleshoot~~

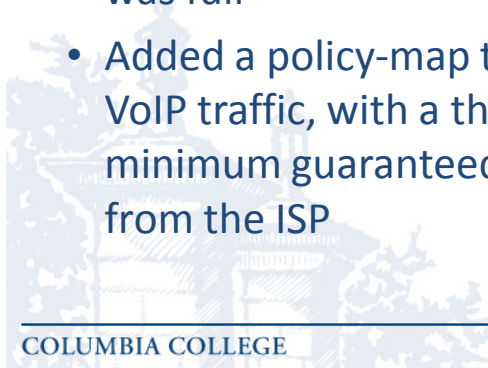
Now we're rolling!

- Three SOHO offices added, two retired
- Installations are going smooth, call quality is very good.
- Until...



First significant failure

- Home worker could hear participants in a conference call, but they could not hear her
- Home router outbound internet connection was full
- Added a policy-map to prioritize outbound VoIP traffic, with a threshold set at the minimum guaranteed outbound bandwidth from the ISP



Getting a local line at SanDiego

- First installation with multiple phones and PCs
- No copper is available from the base
- It is not possible to bring in POTs service
 - Over 14 months to install a T1 connection
 - Apart from a flex T1 phone/data circuit
- We would like for callers to have a local number to reach the base
- Let's try Google Voice, after all, it's free...

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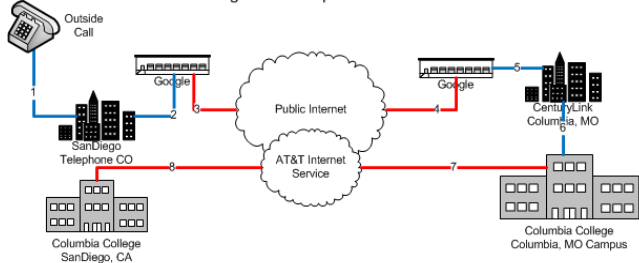
You [don't] get what you [don't] pay for.

- Call quality was TERRIBLE
 - Calls routed to San Diego, CA
 - Encoded as Google VoIP and sent to Columbia, MO
 - Converted to POTs and delivered to CC via PRI
 - Reencoded as VoIP and sent back to San Diego via VPN
- Four-way conference call confirmed Google voice as a primary factor.
- Installed a new 800 number in Columbia instead

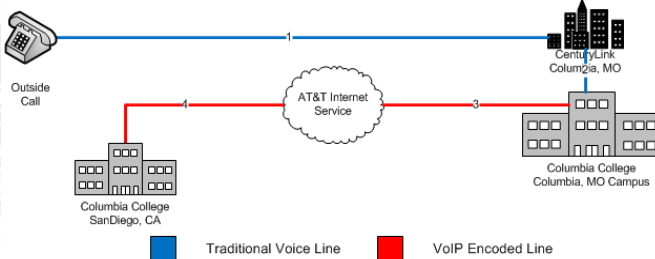
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Much cleaner service

Google Voice Implementation:



New Implementation: Toll Free (800) number in Columbia mapped to CAB Phones



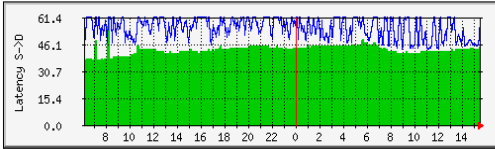
■ Traditional Voice Line ■ VoIP Encoded Line

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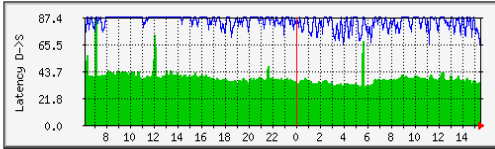
Working again, but monitoring needed

- Our monitoring program had an add-on to measure network health for VoIP
- Required an external router to act as monitor
- MRTG can poll the same data for free
- Single direction latencies are the most telling statistic (< 100ms)

SOHO4 (Spring Hill, FL) Columbia to SOHO Latency



SOHO4 (Spring Hill, FL) SOHO to Columbia Latency



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Rolling well until Fall term resumes

- Main campus bandwidth is saturated during the business day (~9:00am - ~9:00pm)
- Average daytime traffic reached ~34mbps.
- Remote office workers are having a hard time being heard by other parties on the phone.
 - Not as bad for calls to home campus as outside calls
- Latency to Columbia campus would spike when the physical circuit was full.

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Chasing bandwidth & Prioritization

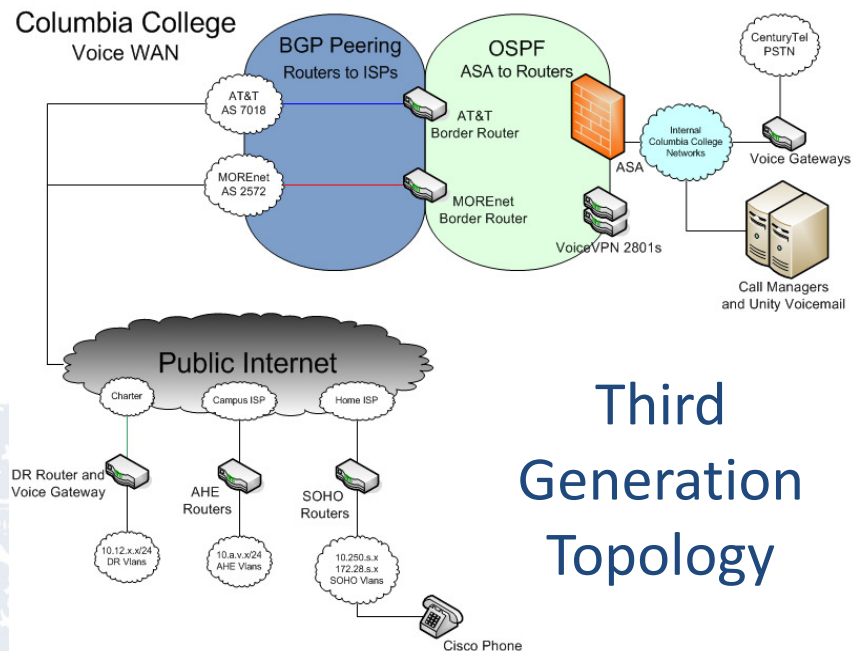
- Main campus bandwidth congestion was adding latency and dropped packets to calls
- VPN traffic had been granted a high priority in our bandwidth shaper, but overall VPN traffic was higher than the minimum reservation
 - Calls were competing for bandwidth with other office VPN traffic
 - Since VPN requests were still being limited, static and artifacts were creeping into calls

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Prioritize VoIP and only VoIP!

- So how to prioritize just one part of a VPN?
 - Same endpoints for all VPN traffic
 - All traffic seen as ipsec/isakmp
- Let's change one end of the VPN!
 - A 2801 was setup as a VoIP VPN hub at Columbia
 - Parallel VPNs are established to this router
 - New VPNs serve ONLY VoIP traffic
 - We can now prioritize traffic to/from this new hub

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Shared vs. Reserved Bandwidth

- While these new reservations helped, call quality still suffered when the Columbia connection carrying the VPN was at capacity.
- New virtual circuit was created exclusively for the shaping the VoIP VPNs
- Existing data circuit bandwidth was reduced
- Total allocated bandwidth was verified (and corrected) against physical circuit bandwidth

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Add more Bandwidth

- VoIP difficulties were only one symptom of our Internet connectivity congestion
- Upgraded our MOREnet circuit
 - 20mbps to 100mbps
- Increased the virtual circuit for VoIP traffic in our shapers to better accept connections.
 - 88kbps native, but 110kbps in an IPsec tunnel

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Much better again... For a while.

- VoIP service for all customers was greatly improved (near flawless) for the next month or two.
- Our San Diego campus works well the majority of the time (T1)
- Home offices still have intermittent problems
 - High latency is seen when neither circuit is near capacity.
 - No service guarantees by broadband providers

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So where do we stand now?

- Migrate from g711ulaw to isac codec?
- Service is acceptable over a T1 circuit.
- Business needs are not being met over home office circuits for customer calls.
 - Currently looking into removing VoIP from home offices.
 - A dedicated land line or cell phone will offer better quality.
- No SOHO attempts with a satellite ISP!

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Lessons Learned

- Flexibility with connections is hard but possible.
- Shape outbound traffic that you can control.
- Shape inbound traffic as much as possible.
- Work to lower latency
- Monitor connectivity for latency, jitter, and loss
- Mesh or hairpin VPN connectivity for ease of use
- Don't count on perfect performance

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