Wireless Networks at Umass-Amherst

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UMASS-Amherst Network Vital Statistics

- Class B network (umass.edu - 128.119)
- 142 buildings
- All 42 Residential buildings networked
- 8800 Residence hall connections (port-per-pillow)
- 5500 Academic building connections
- 900- Cisco 24 port Switches (1900 and 2900 series)
- 5 Cisco 6509 core switches, 2 Cisco 5500 switches
- 600 Off-campus dial-in modem lines
- (2) DS-3 (45mb/s) commodity Internet connections
- DS-3 - Internet2 connection

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UMASS at night

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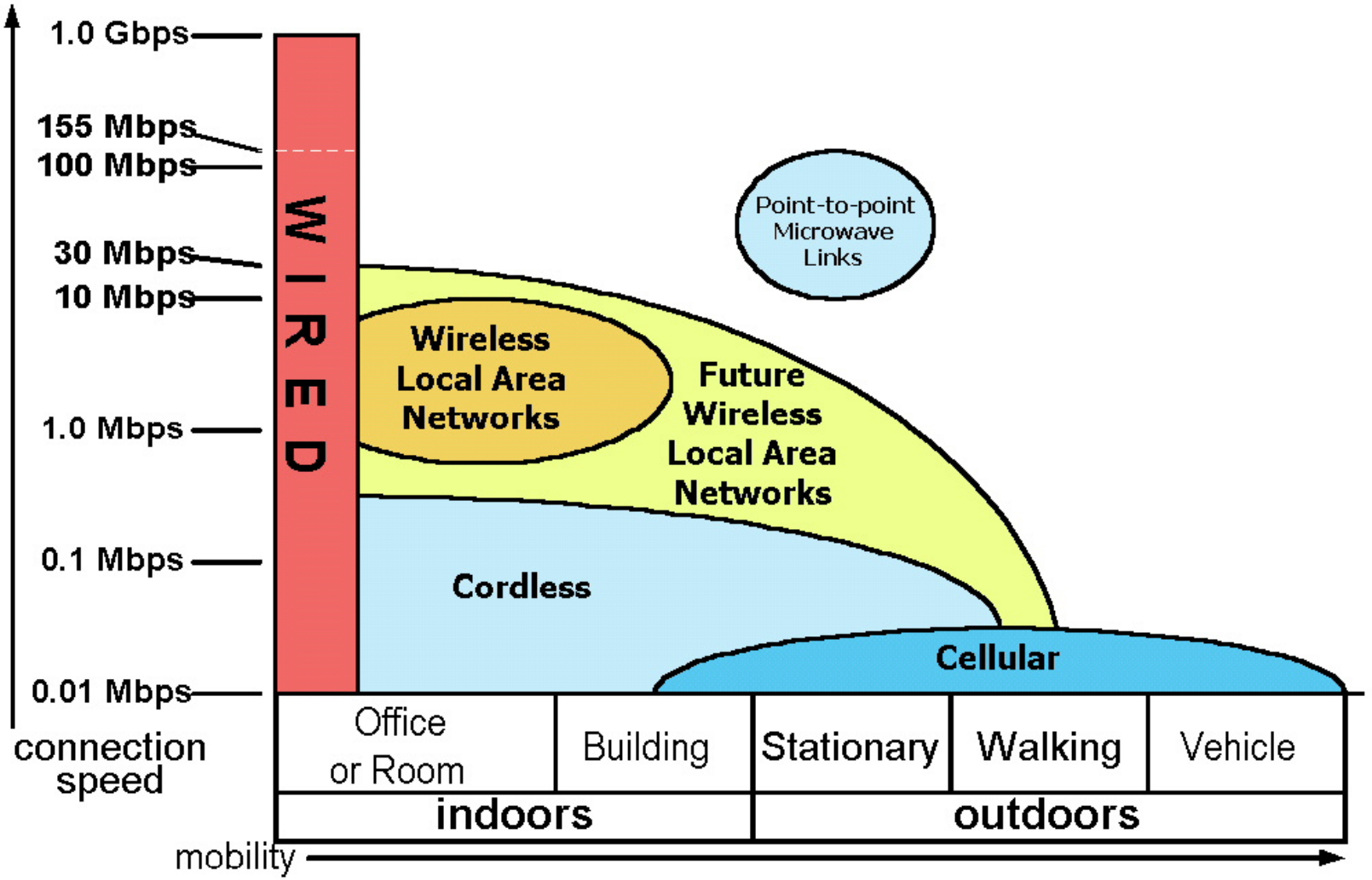
Wireless = Mobility



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Equipment used

- 802.11b – 2.4ghz – 11mbps
- Cisco Aironet 350 series
- Cisco switches
- Aironet antennas

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Typical Enclosure installation

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Library Installation

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Inside of Enclosure

Ceiling Mount Antenna

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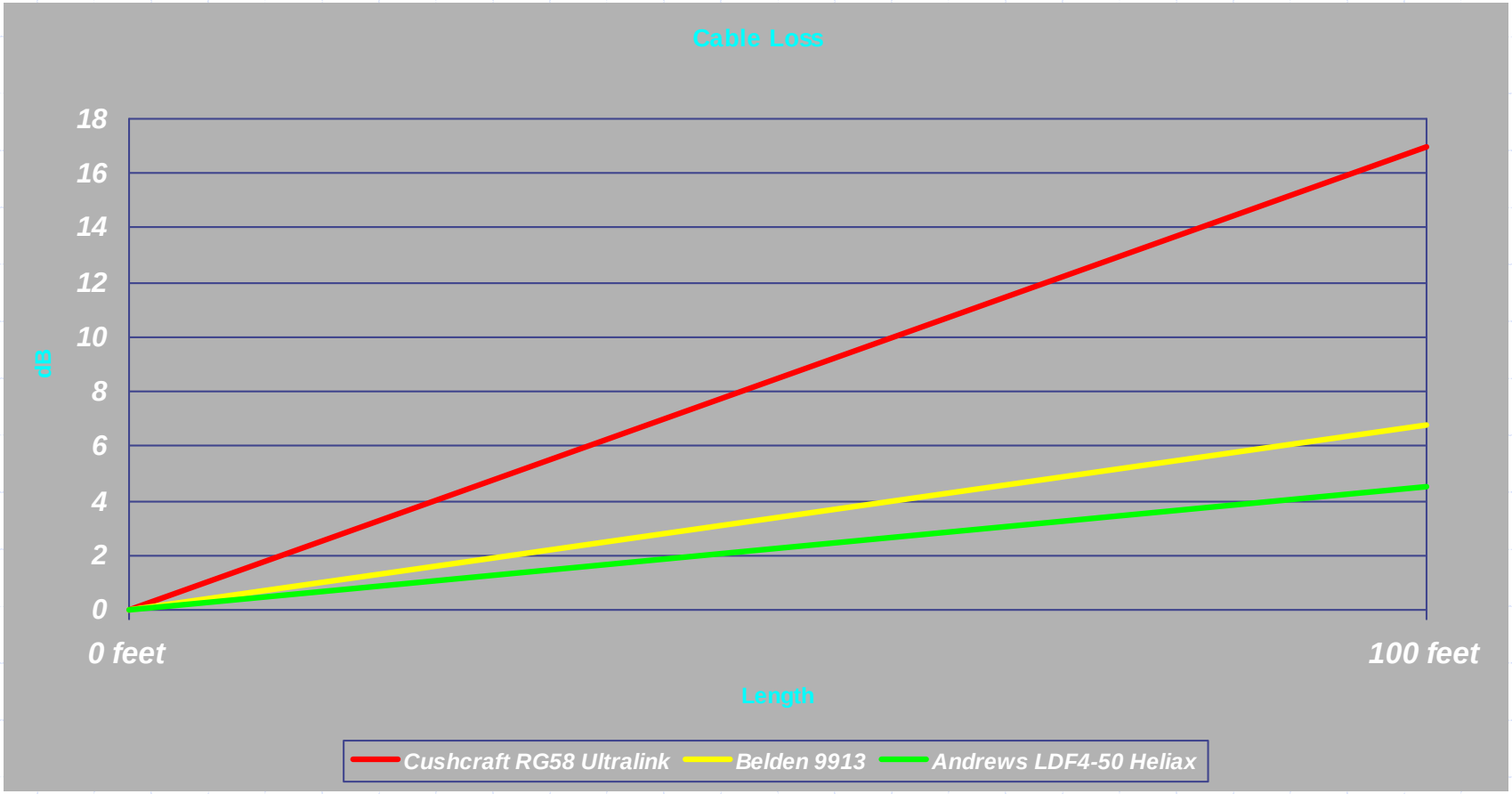
Cable Losses



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dB Factors

Increase	Factor	Decrease	Factor
0dB	1x	0db	1x
1dB	1.25x	-1dB	.8x
3dB	2x	-3dB	.5x
6dB	4x	-6dB	.25x
10dB	10x	-10dB	.1x
12dB	16x	-12dB	.06x
20dB	100x	-20dB	.01x
30dB	1000x	-30dB	.001x

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Connectors

- Warning ! FCC Part 15 and rule 94 requires the use of RTNC Connectors !
- These are different from ordinary TNC connectors.
- RTNC connectors are “transsexual” – They use the male body and the female dielectric and pins.

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Omnidirectional Antennas

- Good choices where antenna is placed in the “middle” of the area to be covered.
- Tend to have low gain since signal is divided over 360 degrees.

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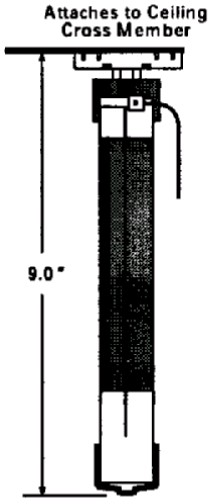
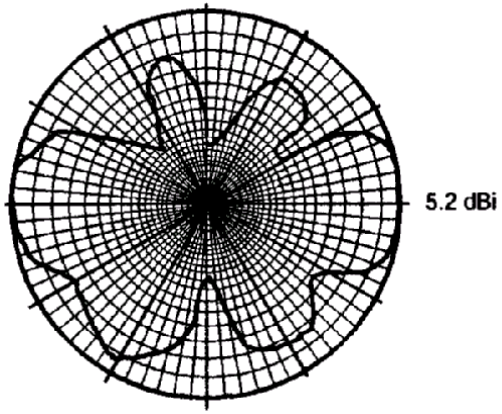
Omnidirectional Antennas

Dimensions and Mounting Specifications



Vertical Radiation Pattern



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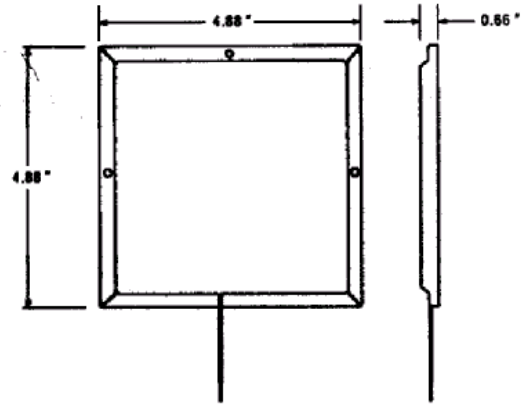
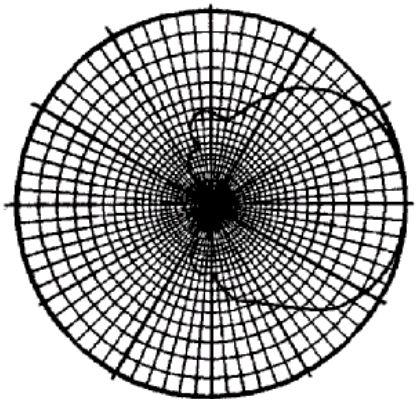
Directional Gain Antennas

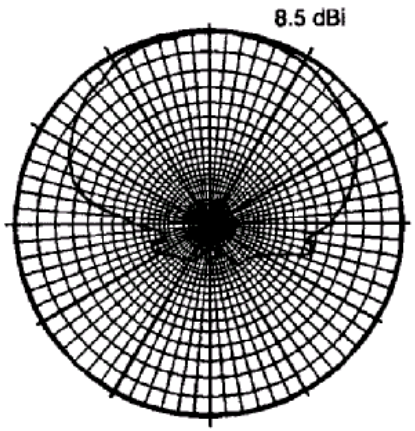
Dimensions and Mounting Specifications



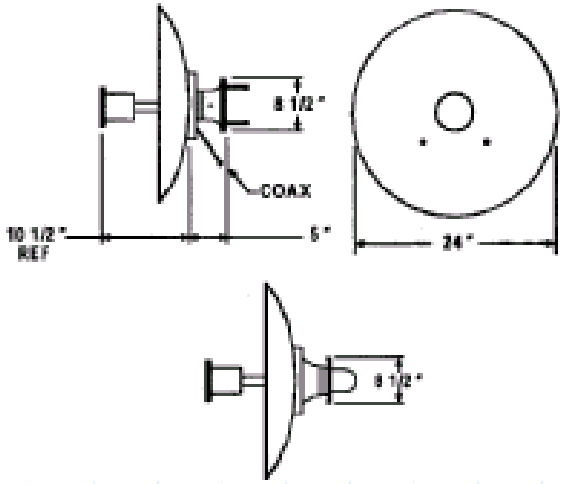
Vertical Radiation



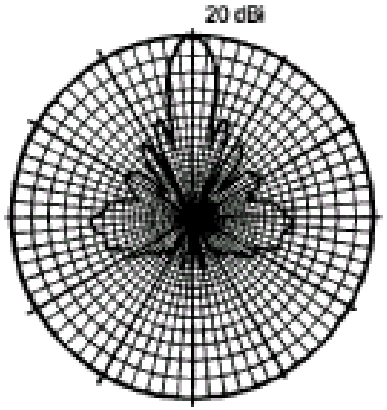
Horizontal Radiation



Dimensions and Mounting Specifications



Radiation Pattern



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Diversity Antennas

- Diversity antennas have 2 antennas in a single enclosure.
- Diversity antennas are good choices where there will be signal reflections.
  - The Cisco Aironet 350 “votes” for the stronger signal by antenna at the start of receiving each packet, then transmits out the same antenna.

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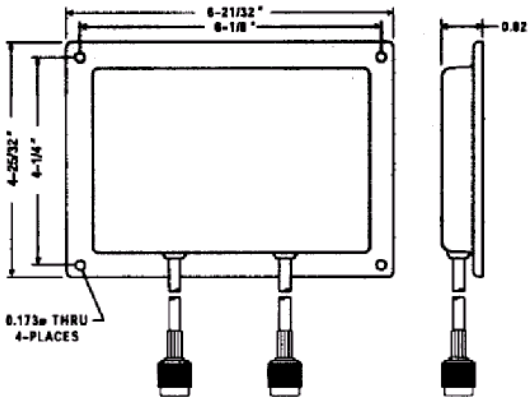
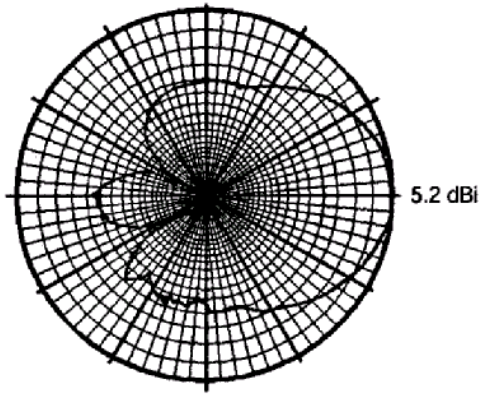
Diversity Antennas

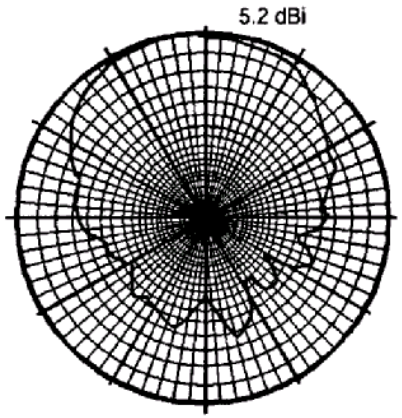
Dimensions and Mounting Specifications



Vertical Radiation



Horizontal Radiation



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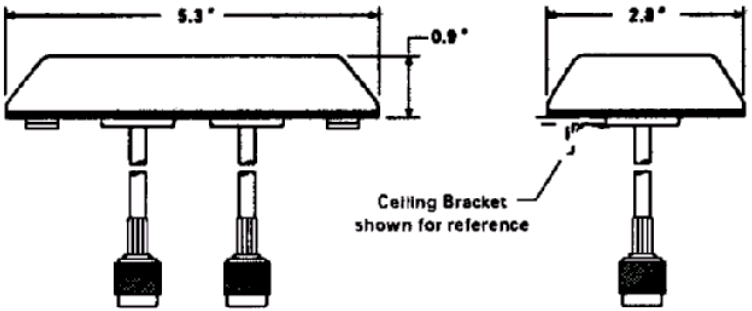

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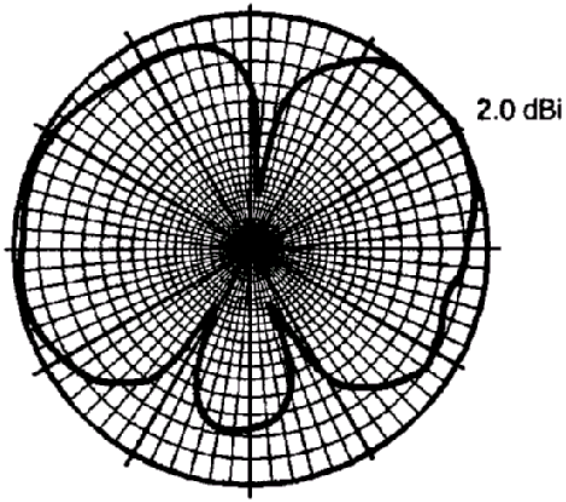

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Site Surveys

- Start with Blueprints
  - Never believe the prints !
  - Walls move...
  - Construction materials not shown
- Walk-around
  - Select antenna/enclosure locations
  - Pay attention to wall materials !

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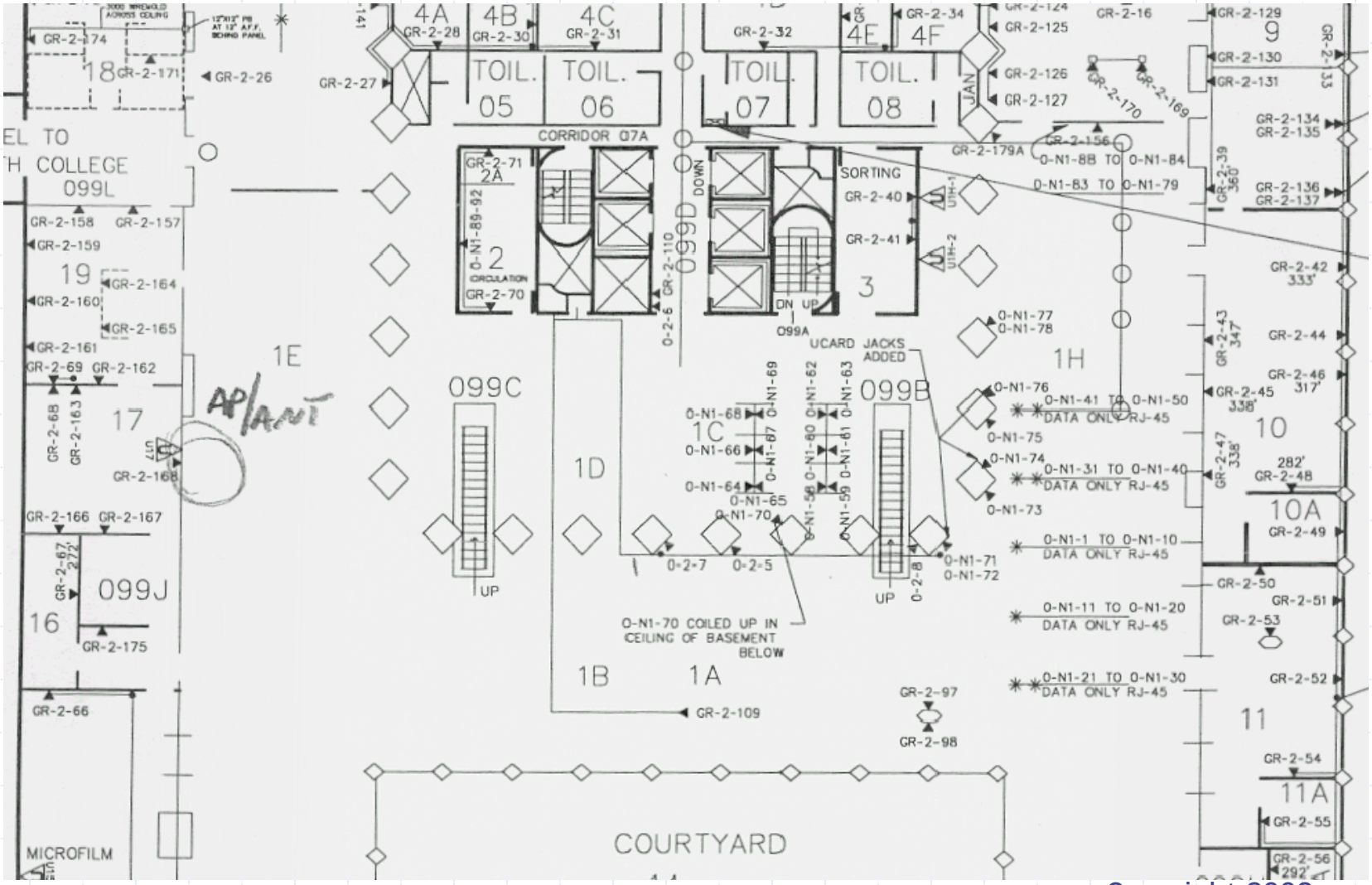
Never Believe Prints...



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Library Structure

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RF-Hell...

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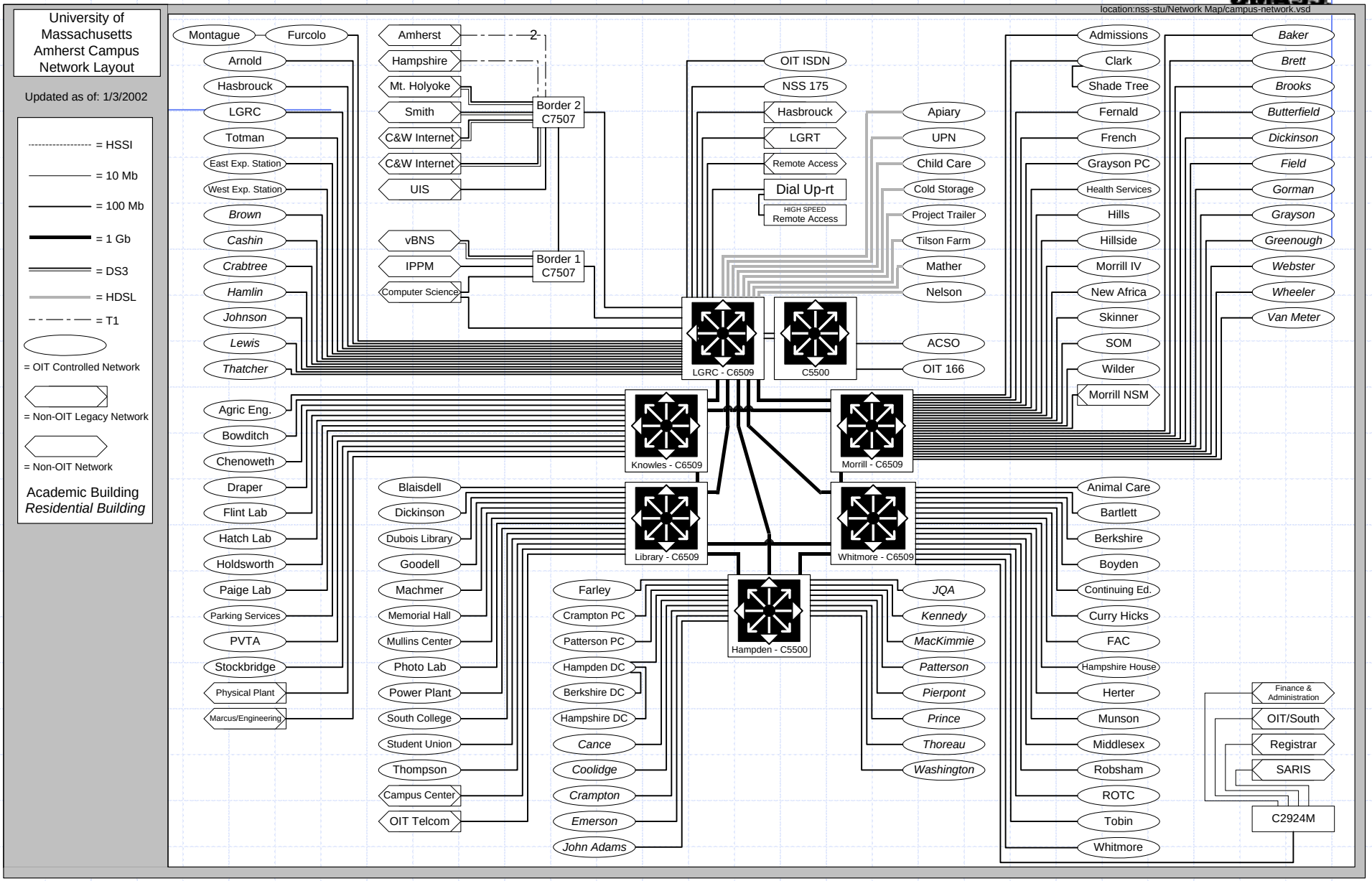
UMASS-Amherst Network Map



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Initial Design Goals

- Virtual Classroom
  - We closed some labs due to budget constraints
  - Wireless network is meant to reproduce similar function
- Focused at public areas where students gather
  - Not initially a ‘campus-wide’ rollout
- Scalable
  - Although initial rollout is targeted, design must fit campus-wide

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Initial Design Requirements

- Identification & Authentication
  - We register all MAC addresses in Residence Halls
  - Accountability
- Encryption
  - Too many plaintext protocols still in use
- Card heterogeneity
  - We don’t enforce a single vendor for wired network cards...
  - This limited our set of solutions

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Initial Constraints

- Short time to implement
  - First pilot discussed in late November 2001
  - First pilot went live late January 2002
  - Phase 1 production rollout March 2002
- Didn't want a campus wide VLAN
  - VLANs are local to our 6 major nodesites
  - We don't switch VLANs across our backbone
  - This meant a parallel rfc1918 network
- Management driven

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Initial Assumptions

- No pre-existing campus wireless implementation
  - Some local deployments
  - Netstumbler is your friend
- MAC address filtering doesn't scale
  - Based half on fact
  - Didn't feel 'right'
- WEP alone is likely insufficient

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WEP Weaknesses

In case we haven't all seen this already...

- WEP uses RC4 encryption
- Fluhrer, Mantin, and Shamir described a passive, ciphertext-only attack against RC4
  - Specifically targeting the key scheduling algorithm of RC4

http://www.cryptonomicon.net/papers/rc4_ksaproc.pdf

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WEP Weaknesses

- Stubblefield, Ioannidis, and Rubin implemented the attack against the RC4 weakness (6 Aug 2001)
  - Using only off-the-shelf hardware, and some custom software
  - Large amounts of data are needed for the attack
    - *"We conclude that 802.11 WEP is totally insecure, and we provide some recommendations. "*
  - http://www.cs.rice.edu/~astubble/wep/

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WEP Weaknesses

- Nikita Borisov, Ian Goldberg, and David Wagner did an an analysis 30 Jan 2001
  - “Wired Equivalent Privacy (WEP) isn't”
  - http://www.isaac.cs.berkeley.edu/isaac/wep-faq.html
- We felt justified in saying WEP is insufficient for our implementation
  - We are network security guys. We try do design secure systems...

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Authentication and Access Control

- We considered four options
- Wireless with WEP
  - Insufficient...
- Wireless with dynamic WEP
  - Dynamic WEP is better, but...
  - Basically a race condition
  - Most implementations require card homogeneity

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Authentication and Access Control

- We considered four options
- Wireless with WEP and VPN
  - WEP didn't improve the situation in this model
  - Added management overhead
- Wireless with VPN, no WEP
  - What we ended up going with
  - Maybe not the best solution, but the best for us given our environment

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Wireless Network Topology

- Private DHCP/DNS for wireless network
- Same hostname for VPN from wireless and wired
  - To minimize client configuration changes
  - Really just DNS spoofing
- Runs over campus network backbone
- Using rfc1918 address space
- Parallel mapping to routable IP space
  - If bldg is 128.119.10.0/24, wireless is 172.17.10.0/24

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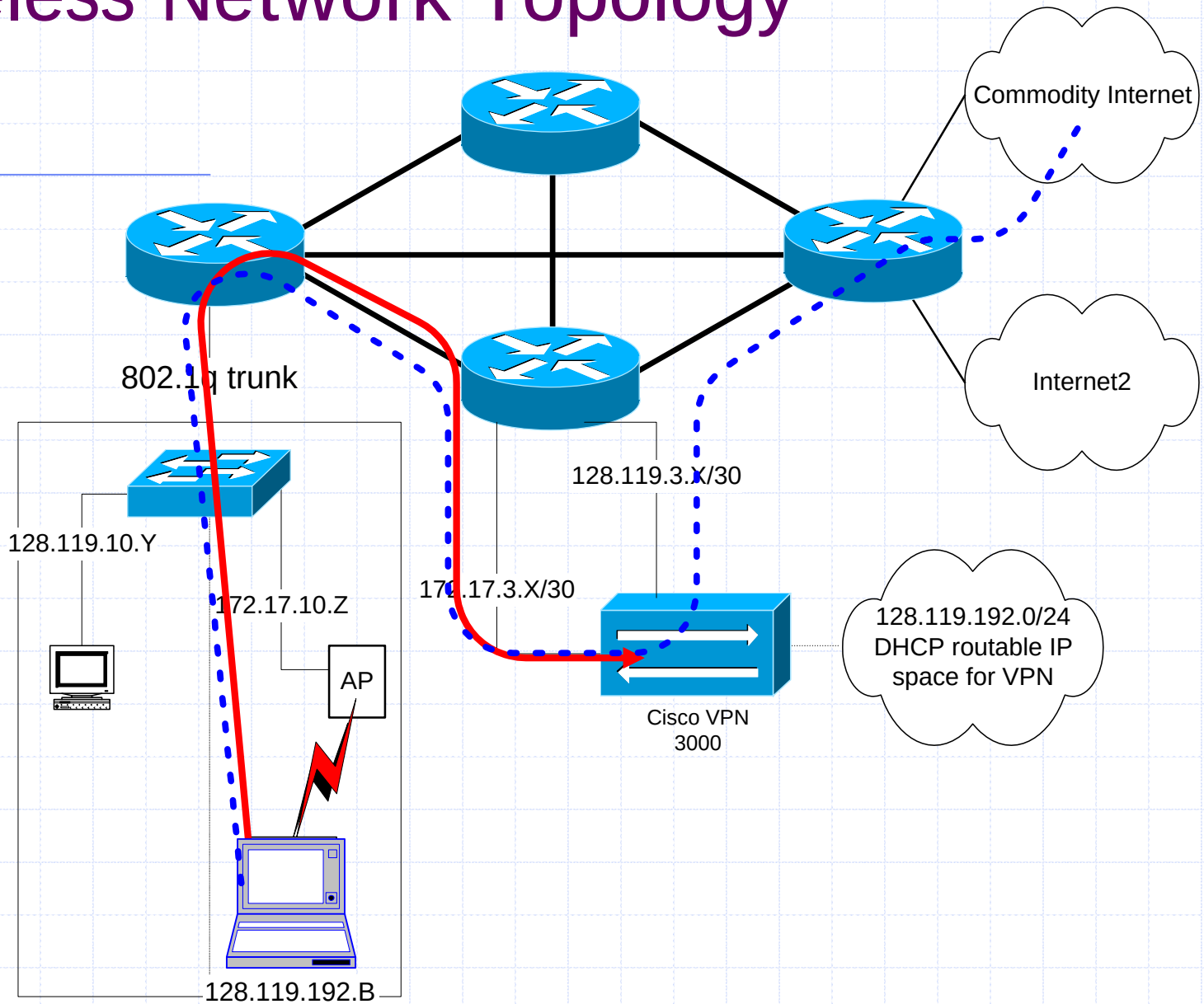
Wireless Network Topology



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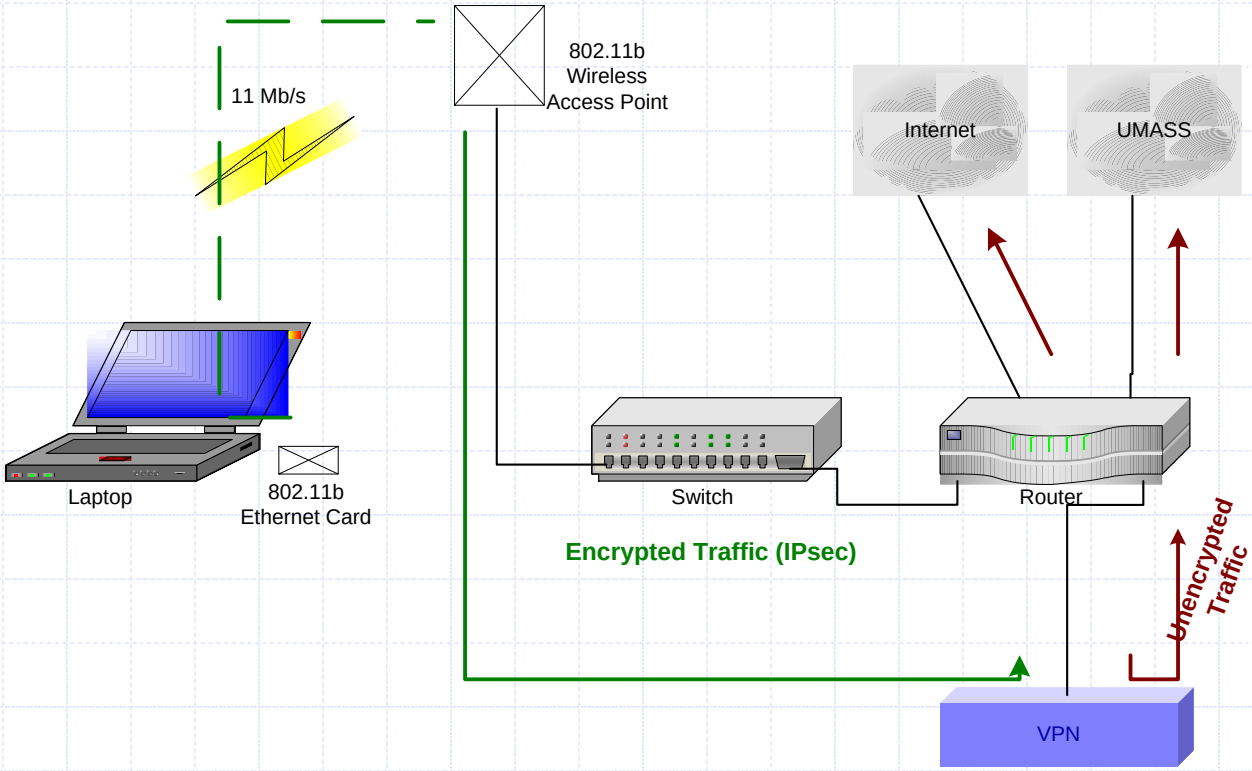
Basic Diagram for our Users



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Enforcing the use of VPN

- Rules without consequences are merely suggestions
- Enforced with Cisco ACLs

```
access-list 120 permit esp 172.17.78.192 0.0.0.63 host
    172.17.3.190
access-list 120 permit udp 172.17.78.192 0.0.0.63 host
    172.17.3.190 eq isakmp
access-list 120 permit udp 172.17.78.192 0.0.0.63 host
    172.17.175.14 eq domain
access-list 120 permit udp 172.17.78.192 0.0.0.63 host
    172.17.166.14 eq domain
access-list 120 permit tcp 172.17.78.192 0.0.0.63 host
    172.17.175.14 eq domain
access-list 120 deny   ip any any log
```

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Benefits and Drawbacks

- Benefits
  - VPN provides encryption and authentication
  - Use of VPN is required for any access outside of wireless network
  - Not necessary to track/filter MAC address
  - Limited to authorized users
- Drawbacks
  - Client software install required
  - No free Mac client for Cisco VPN 3000
  - Increased overhead
  - No easy access for visitors

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Where are we going next?

- Looking at some gateway software
  - VPN without the client?
  - 802.1x
- Scalability of VPN
  - VPN concentrators at major nodesites?
- Roaming Access
- Easier access for authorized visitors
- 802.11a or 802.11g?

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Summary

- Maybe not the best solution
  - But the right one for us at this time
  - Only time will tell...
- Questions?

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