Network Overview

Building router uplinks: mix of single or dual attached 1Gbps and 10Gbps
Core network: 10Gbps
ISPs: Cogent 2Gbps, HOT, 2Gbps, Allstream 4Gbps, ORION 10Gbps

BGP routing with the internet as assigned by ARIN
Uwaterloo exists as AS12093
ipv4: 129.97.0.0/16
Ipv6: 2620:101:f000::/47

Traffic takes the best route to its destination, we do not engineer traffic

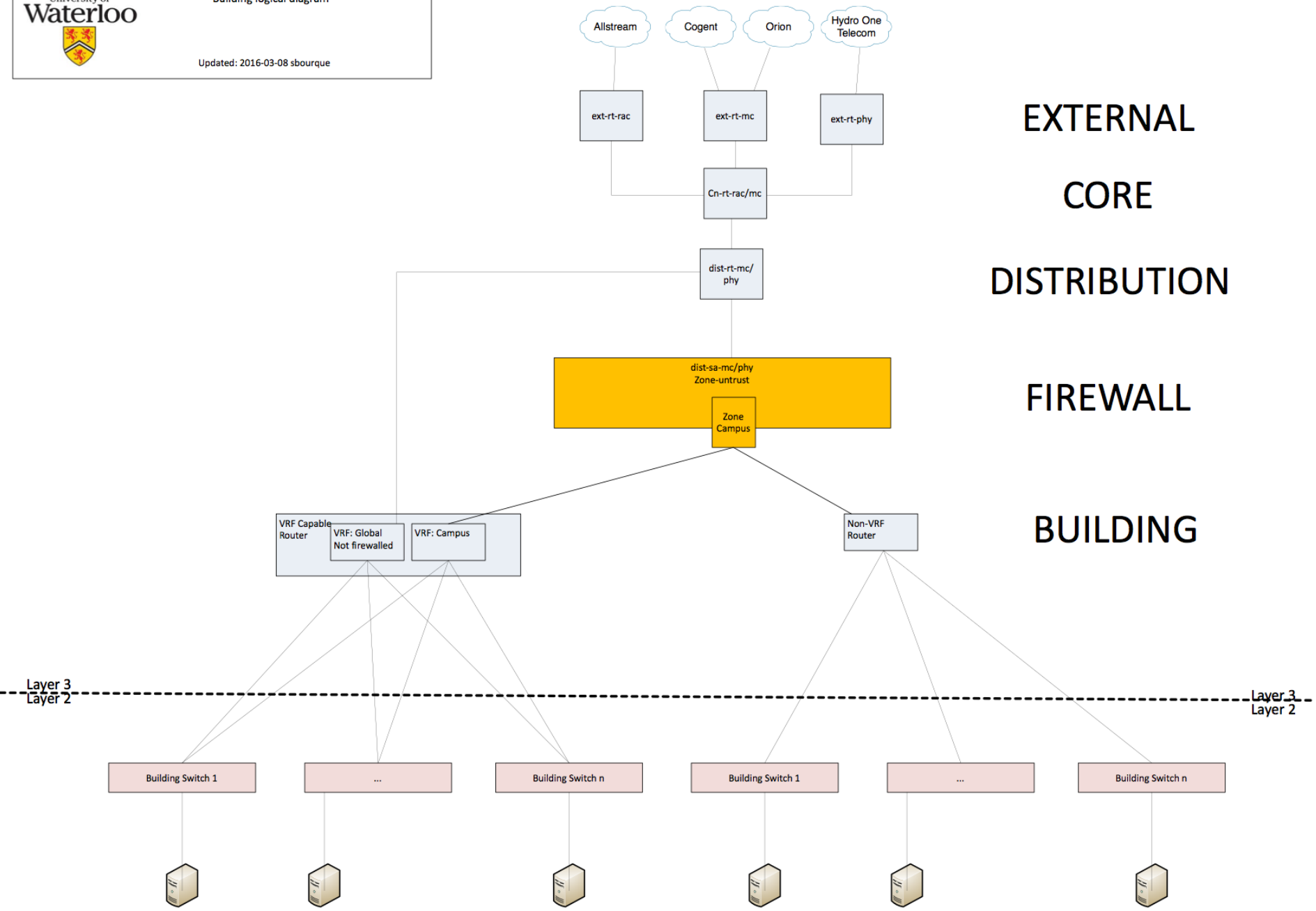
IPV6 is enabled on all wireless and residence traffic

https://uwaterloo.ca/information-systems-technology/external-router-traffic-5-minute-interval

University of Waterloo

Building logical diagram

Updated: 2016-03-08 sbourque



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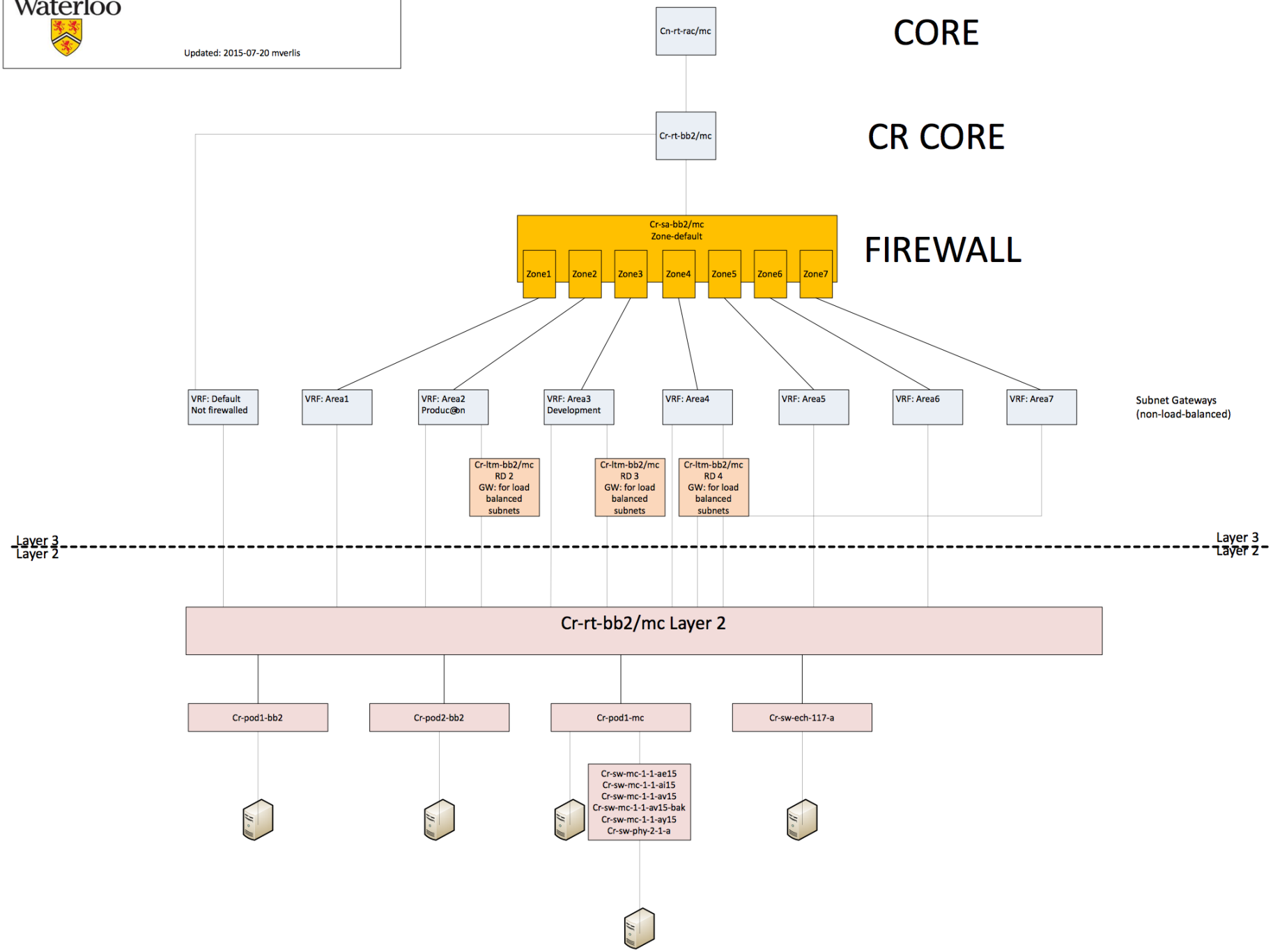
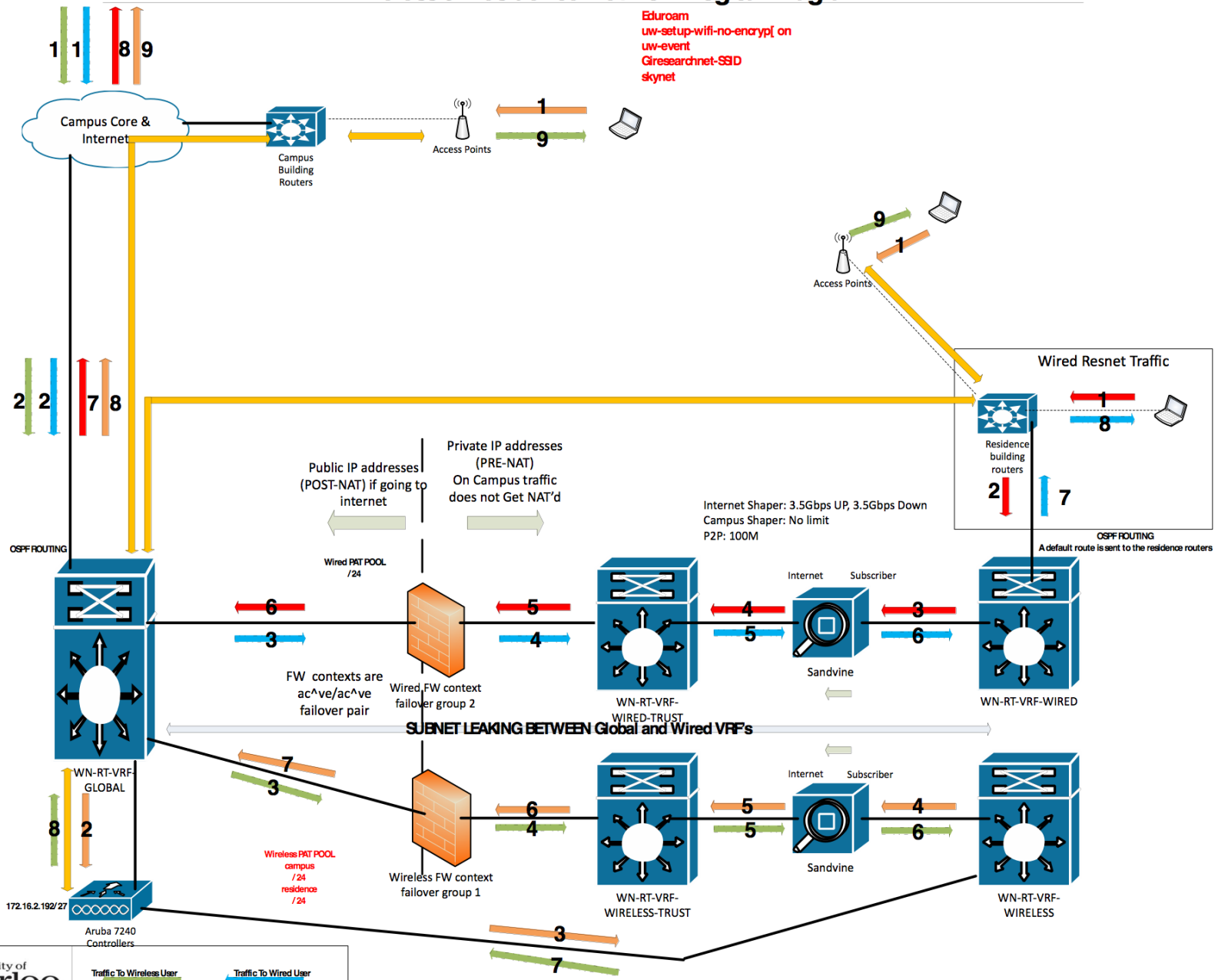
Data center logical diagram

Updated: 2015-07-20 mverlis



Wireless & Residence Network Logical Diagram



UPDATED: March 08, 2016
BY: Steven Bourque

Wi-Fi Basics

- **Wireless networks are half duplex on a shared medium**
- Only one device can transmit at a time (on a channel in an area)
- Contention based and collisions = gibberish
- Resources are divided up among all the users (on the channel)
- More devices = More Collisions potential = **Lower performance**
- Collision domain extends to the Preamble Detection (PD) boundary which requires an SNR of only 4dB
  - Clients within the collision domain stay quiet when someone is transmitting (even if they cannot interpret the data portion)
  - The size of the collision domain changes with time and clients. (clients with different locations transmitting with different power levels at different times send frames with preambles that can be interpreted at varying distances.)

- **Channels (frequency) and power levels are important, you cannot just install another AP**
- Wi-Fi uses radio waves.
- More power makes the waves go farther
- Typical power of a client device is between 30mw and 100mw
- Management/control is the same regardless of the size of the data payload (so sending small frames is inefficient)
- Adding AP's is a solution for two problems and the source of other problems
  - Beacons for each SSID on every AP

Shaping

- Wireless traffic is shaped on campus.
- Aggregate shapers are used
- Bit-torrent and similar protocols are shaped to near 0.
- Everything else exists in our overall shaper 3.5G up/dn.
- Traffic staying on campus is not shaped

Essential Elements of Healthy RF

AIRHEADS 2013

Signal Strength

Client NIC

Good Noise Floor

Low Interference

Channel Utilization

Aruba Lab testing

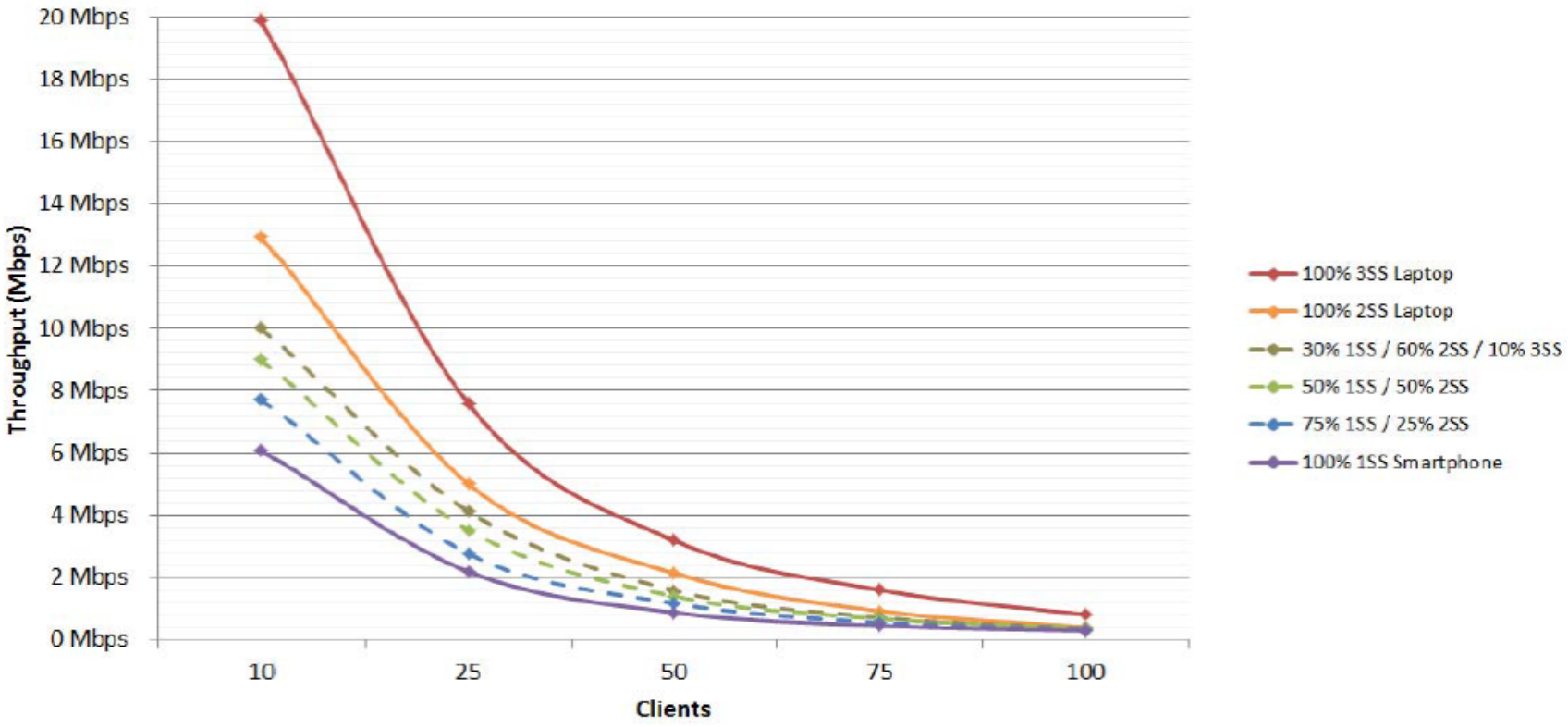


Figure T4-10 Average Per-Device Throughput (AP-225, VHT20, TCP Bidirectional)

Design and Decisions

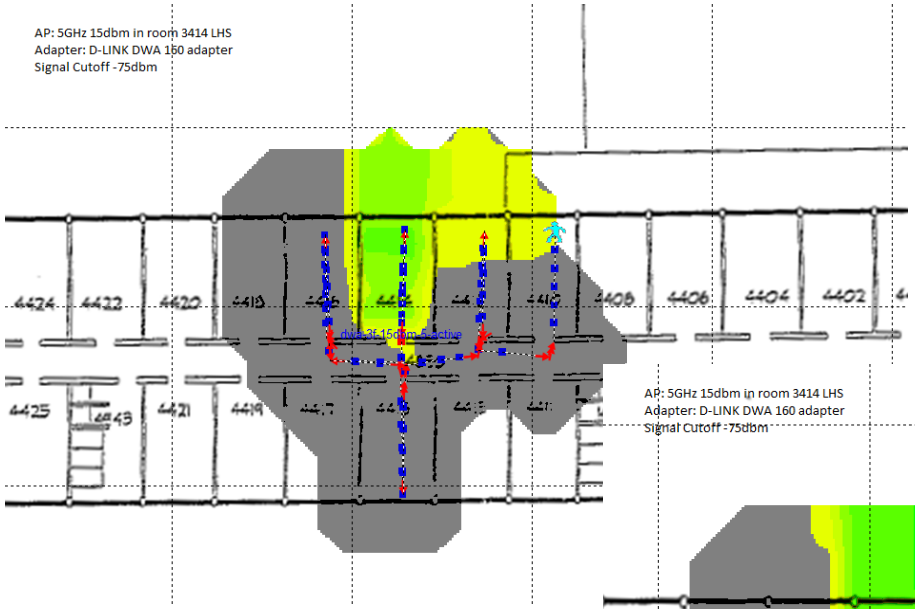
- large flat subnet for wireless users
- We use 4x /16 & 4x /64 networks
- Possible because
  - we already deny inter-client communication
  - we already convert bcast/mcast to unicast
- Benefits: we no longer have issues with vlan pools filling up
- Drawbacks: chrome-cast doesn't work
  - Airplay using Bluetooth discovery and apple-tv on the no security network works with client on eduroam

Design and Decisions

- Plot floor plans and visit locations
- AP RF propagation pre-design surveys
  Campus: measured through different wall/ floor types found on campus

  Residence: measured in each residence type, AP setup and number of rooms covered at the defined signal level was determined.

AP: 5GHz 15dbm in room 3414 LHS
Adapter: D-LINK DWA 160 adapter
Signal Cutoff -75dbm



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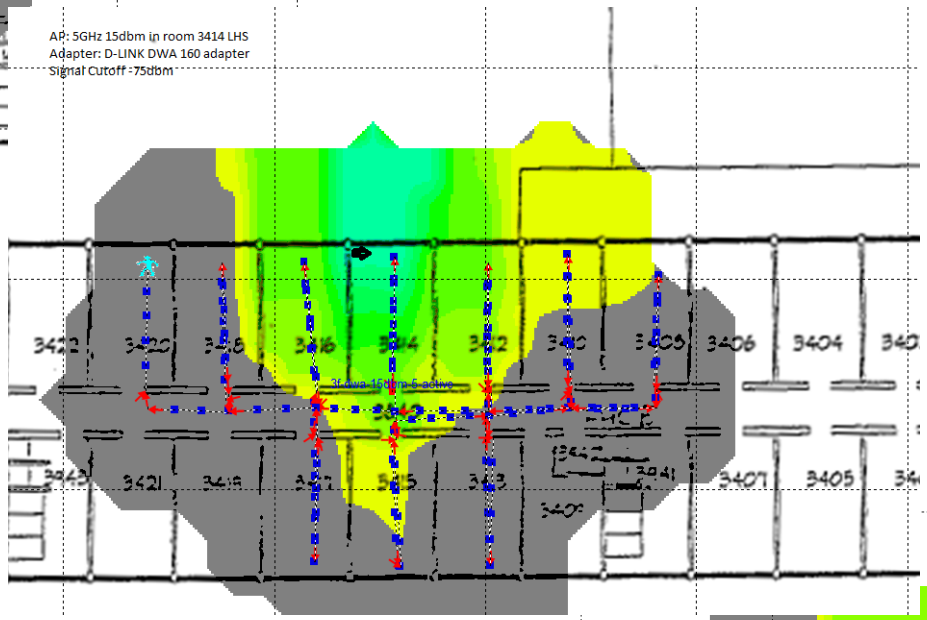
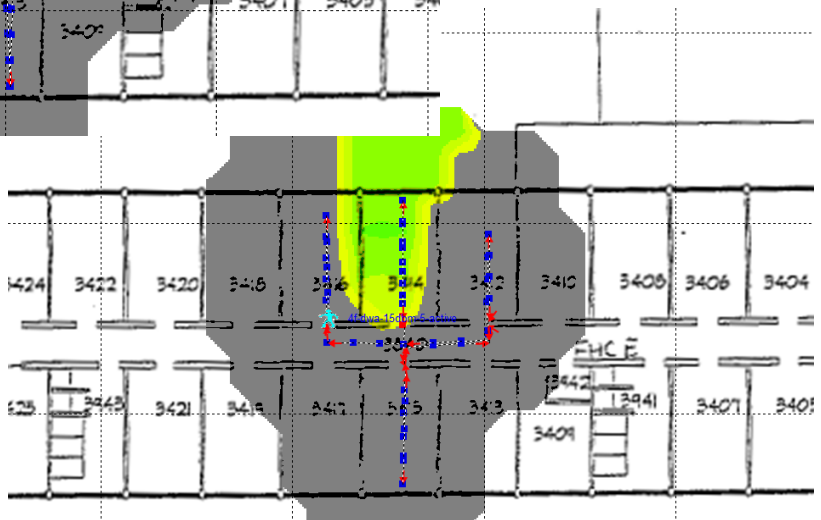
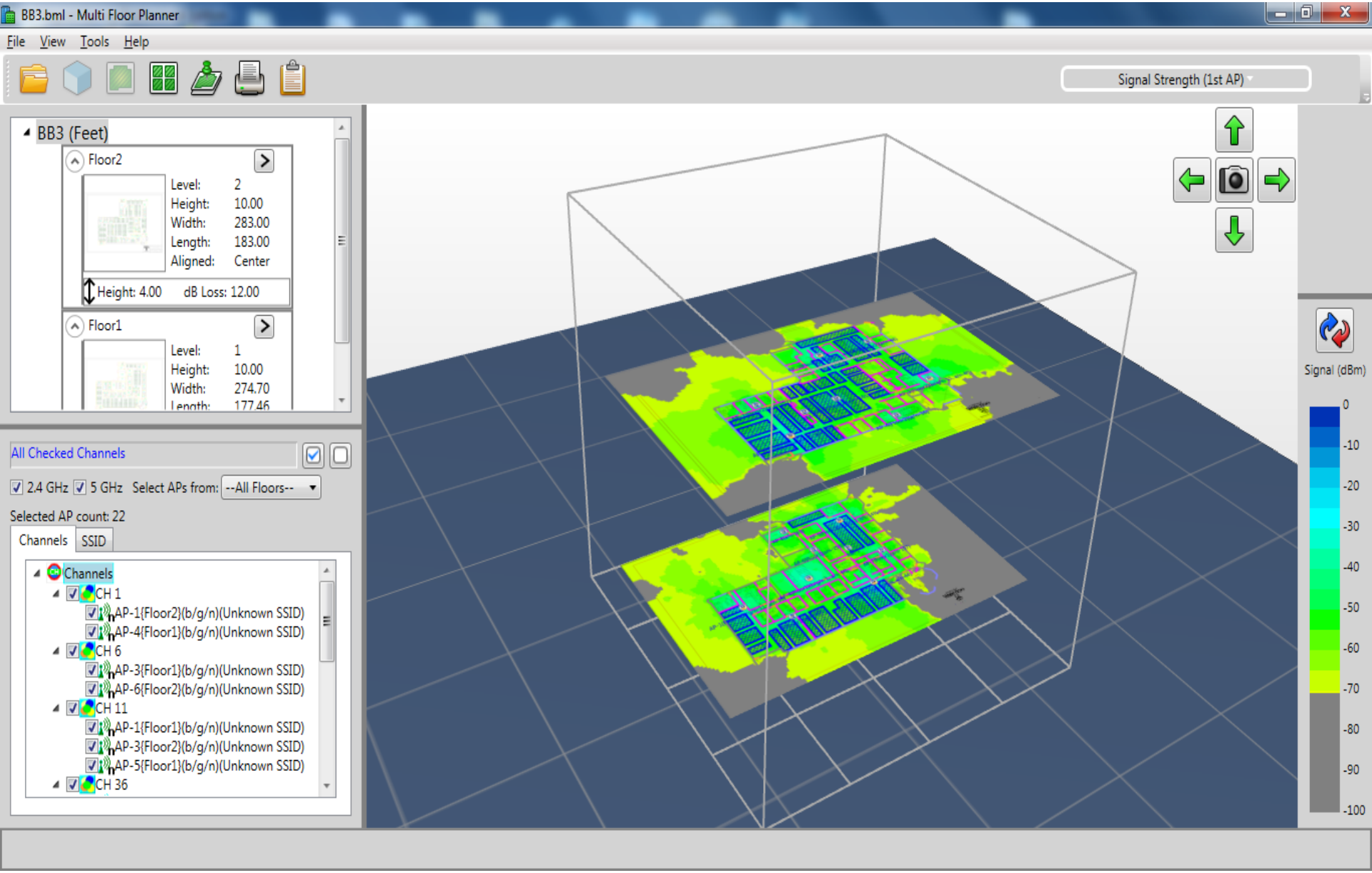





BB3.bml - Multi Floor Planner
File View Tools Help
Signal Strength (1st AP)
BB3 (Feet)
Floor2
Level: 2
Height: 10.00
Width: 283.00
Length: 183.00
Aligned: Center
Height: 4.00 dB Loss: 12.00
Floor1
Level: 1
Height: 10.00
Width: 274.70
Length: 177.46
All Checked Channels
2.4 GHz 5 GHz Select APs from: --All Floors--
Selected AP count: 22
Channels SSID
Channels
CH 1
AP-1{Floor2}(b/g/n)(Unknown SSID)
AP-4{Floor1}(b/g/n)(Unknown SSID)
CH 6
AP-3{Floor1}(b/g/n)(Unknown SSID)
AP-6{Floor2}(b/g/n)(Unknown SSID)
CH 11
AP-1{Floor1}(b/g/n)(Unknown SSID)
AP-3{Floor2}(b/g/n)(Unknown SSID)
AP-5{Floor1}(b/g/n)(Unknown SSID)
CH 36
Signal (dBm)
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100

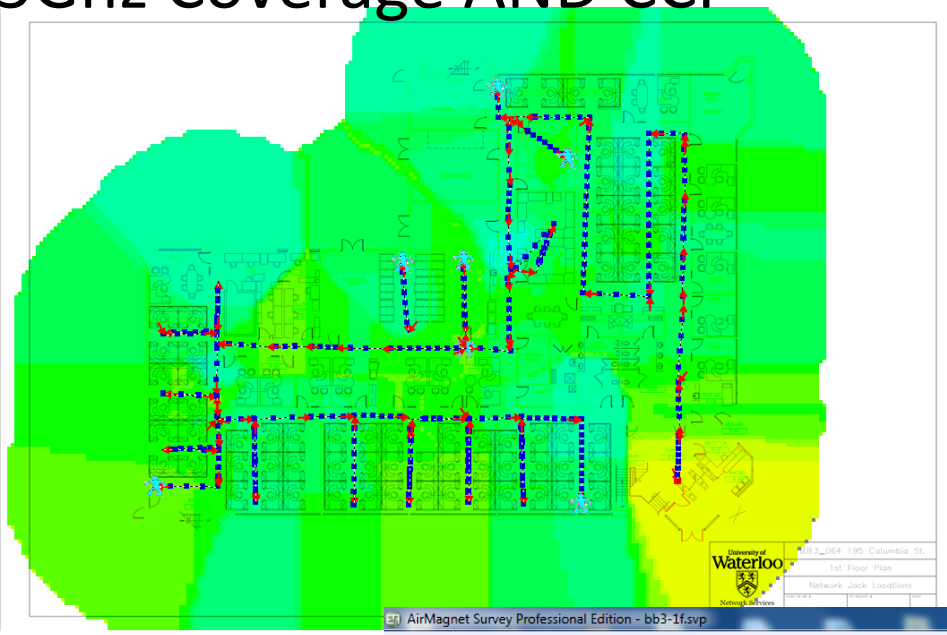
Projects – Design and Decisions

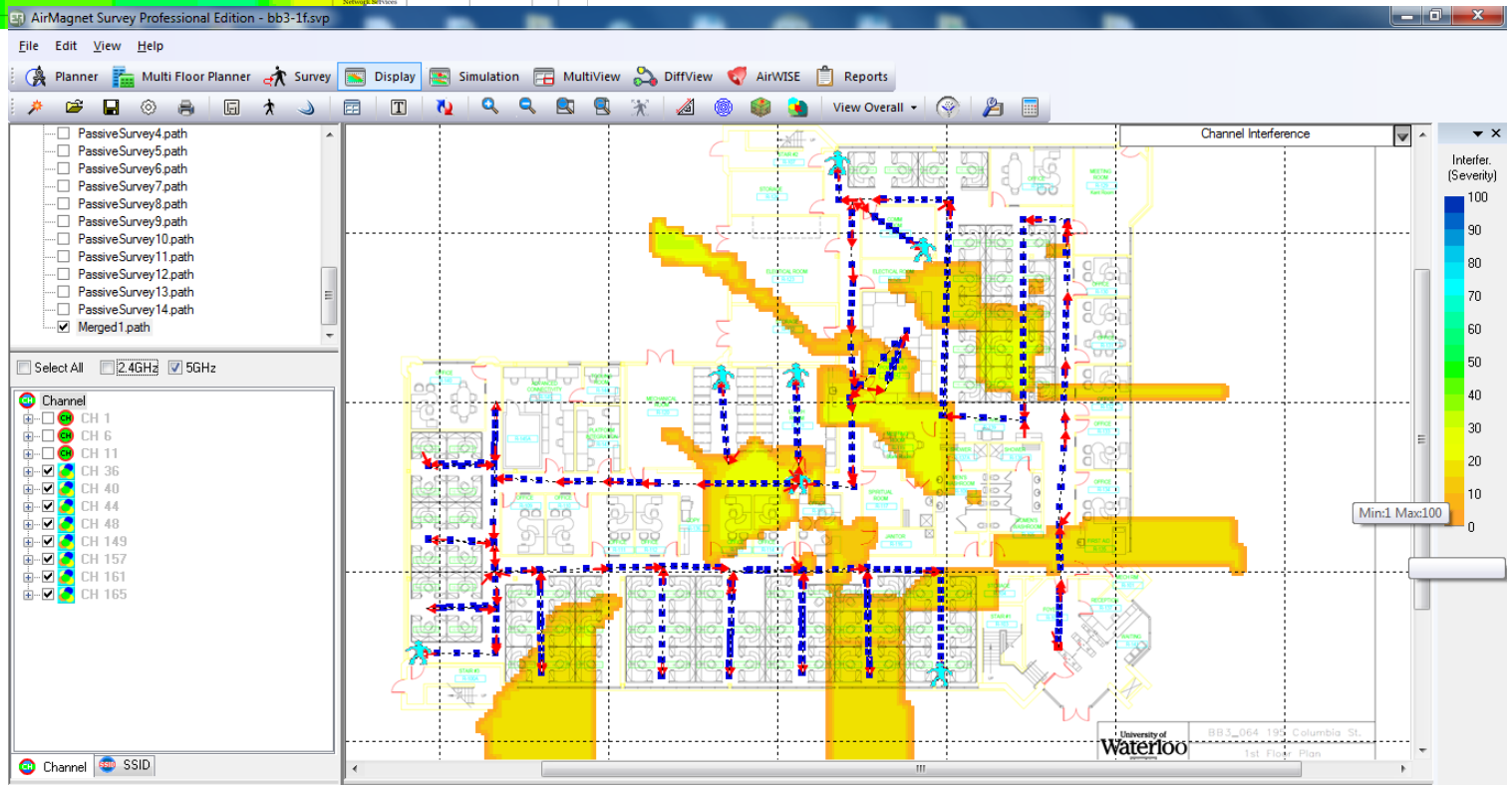
- Predictive modeling for campus designs based on measured values
- Combination of a full pre-install coverage survey and predictive model for residences
- Faceplate 2x2:2 2.4Ghz OR 5Ghz AP used in residence
- 2x2:2 simultaneous dual band AP used on campus. (3x3:2 in new buildings)

Project – Post-Install

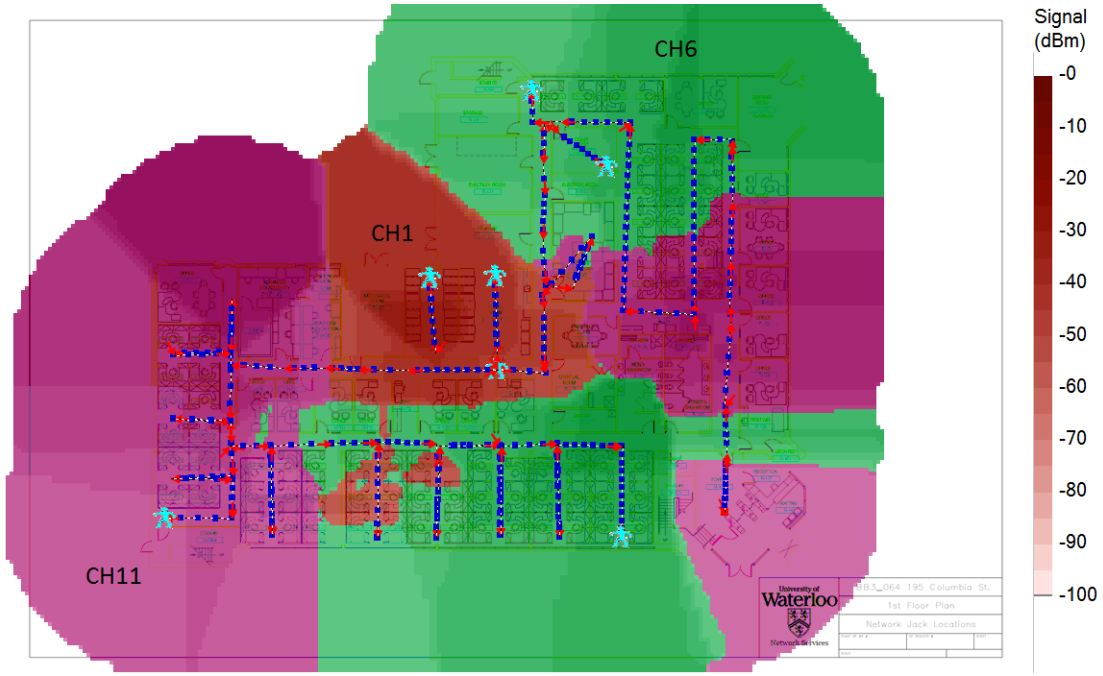
- Always do post installation site surveys
- Passive survey on the laptop (2.4Ghz and 5Ghz)
- Keep an eye on mobile device (it maintains an active video stream)
- If coverage issues or CCI issues exist: change the configuration, move an AP
- Then survey again

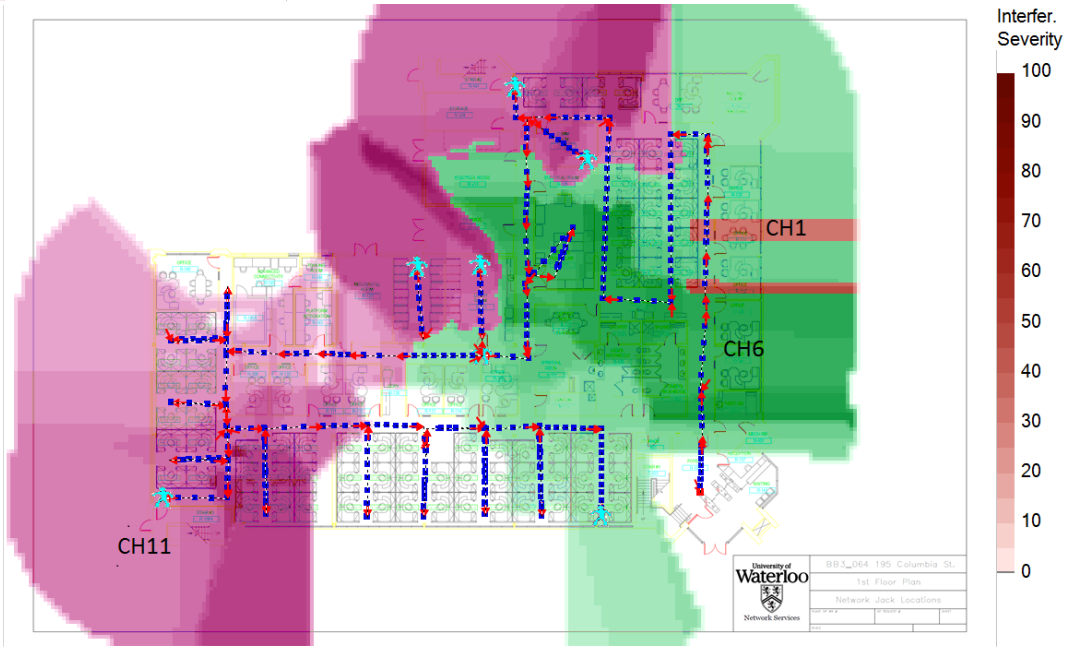
5Ghz Coverage AND CCI





2.4Ghz Coverage AND CCI





Our current design process

On all new buildings

- Mandatory 5Ghz coverage ‘everywhere’
- Design 5Ghz to -67 at all locations
- Design 2.4Ghz to -75 (CCI is hard);
  2.4Ghz is slowly going away…
- AP’s in the room/office, not the hall
- Setup survey AP’s in offices and measure the 3D coverage pattern (whenever possible)
- Power level 15dbm – majority of our clients are android/ios
- Create floor plans with Acrobat Pro & plot for installers

Challenges – Rogue AP's

- Not feasible to walk around removing them
- WIPS to disable those seen on both the wire and wirelessly
- Procedure created for exceptions
  A custom SSID on our hardware
  Or
  Register the user AP as neighbor
  Google.ca: uwaterloo wifi rogue

Challenge's – Non-Wi-Fi interference

- A problem in some locations for 2.4Ghz
- As a policy we don't allow interfering devices
- Some things you have to live with
- By setting up spectrum monitors at locations we can get close to the issue
- Engage local I.T. to contact users
- Knock on doors
- We don't have a GOOD/QUICK way to locate sources

- **Noise**
  - **Random** 'background' that has got mixed up with your signal. Fairly Static.
- **Interference**
  - **Additional** signals are added to the one you want. Can be intermittent or persistent.

802.11 Source	Non 802.11 Source
• Your APs (over-designed) • Somebody else's APs (neighbor) • Municipal Wi-Fi Network • iPhone Personal Hotspots • Neighboring clients • APs • Faulty Clients	• Blue-tooth (headset, keyboards, mouse, speaker) • Microwave Oven • Cordless phones, mouse • Very strong out-of-band source(GSM tower/DAS) • Baby monitor • WiMax (2.5GHz) • ZigBee (802.15.4) • Video or security cameras • Faulty anything

Challenges – 2.4Ghz Majority

- Currently 65% 2.4Ghz usage on campus
- High client loads per channel
- Educate the users about 5Ghz adapters when we have contact
- Expect this to be the norm until budget laptops come with 802.11ac

Bestbuy.ca laptops are still BGN (no 5Ghz) – Aug 17, 2015

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- Graduate students
- Faculty | Instructors
- Staff
- IT support staff

WiFi charts

Menu:

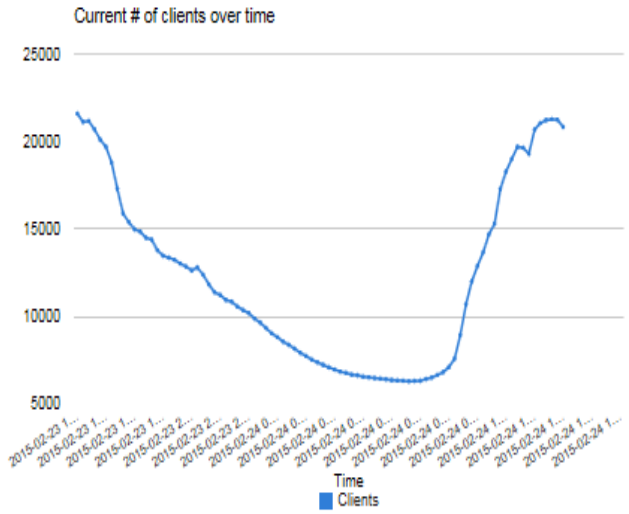
- UWaterloo campus data
- Map of buildings
- Index of buildings

Number of clients: 20821
Current total download speed: 1.762 Gb/s
Current total upload speed: 321.885 Mb/s
(Last updated: 2015-02-24 13:00)

Jump to:

- Clients over time
- Network usage over time

View raw data for these charts



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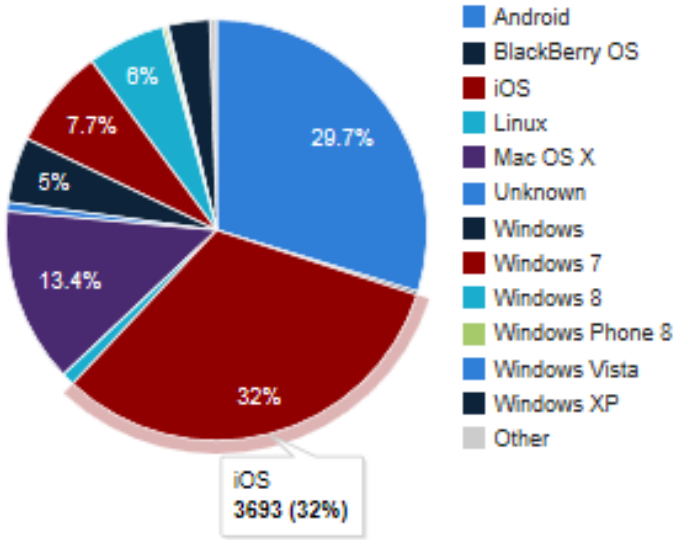
Device OS 24h breakdown



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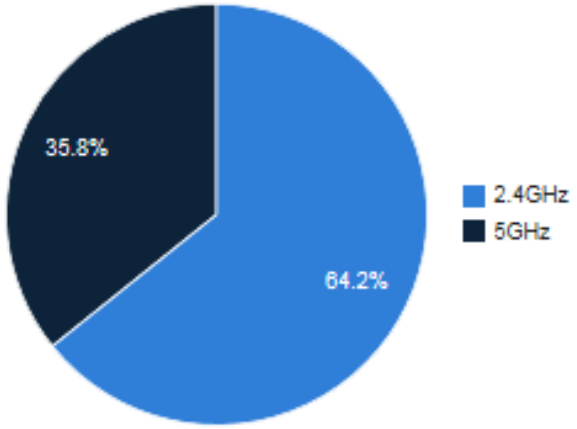
Connection mode 24h breakdown



William G. Davis Computer Research Centre

Menu:

- UWaterloo campus data
- Map of buildings
- Index of buildings

Number of clients: 1854
Current total download speed: 143.616 Mb/s
Current total upload speed: 22.935 Mb/s
(Last updated: 2015-02-24 13:00)

Jump to:

- Clients over time
- Network usage over time
- Device OS breakdown
- Connection mode breakdown
- % of clients per connection mode over time

View raw data for these charts