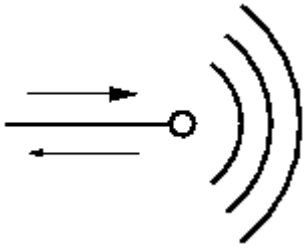
THE UNIVERSITY OF BRITISH COLUMBIA
Department of Electrical and Computer Engineering

PROJECT REPORT



MAJOR COURSE PROJECT

AURORA Testbed
Task 2

prepared by

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in Partial Fulfillment of the Requirements for

ELEC 411 - Antennas and Propagation

Date submitted: FRI, 20 DEC 2019

Abstract

UBC is looking to extend the AURORA testbed and include new node locations. This report explores the viability of the existing Wi-Fi mesh network for proving a sufficient connection to node locations.

We were provided ten locations of interest around the UBC campus. To document the viability of the existing network at these locations, we measured signal power strength, signal-to-noise ratio, current rate and connected access point names at points around each location using a Cisco access point connected to antennas and a computer- using SSH protocol.

We have found that six of the ten locations have acceptable Wi-Fi coverage, two locations have poor Wi-Fi coverage and two locations have no Wi-Fi coverage. Coverage however, may improve as the receiving antenna height is increased.

Aurora Testbed- Task 2

1- Objectives

The main objective is to estimate 'ubcprivate' Wi-Fi coverage at ten locations for implementing roadside equipment for AURORA connected vehicles testbed. We are using the Cisco Access Point AIR-CAP1532E-A-K9 which, at implementation, will be used in Workgroup Bridge mode. [1]

A Workgroup Bridge (WGB) can provide a wireless infrastructure connection for Ethernet-enabled devices. Devices that do not have a wireless client adapter in order to connect to the wireless network can be connected to the WGB through the Ethernet port and it connects Ethernet-enabled devices to a Wireless LAN (WLAN). The WGB associates to the root access point through the wireless interface. In this way, wired clients obtain access to the wireless network. Thus, all equipment at each RSEs (DSRC, IPCAM, etc.) will be connected to the UBC wireless network and it enables backhaul communications between AURORA network operation center and all roadside equipment.[2]

2- Approach

Our team was provided with ten sites of interest for implementing road side equipment for AURORA testbed. Locations of interest are identified below in figure 1.

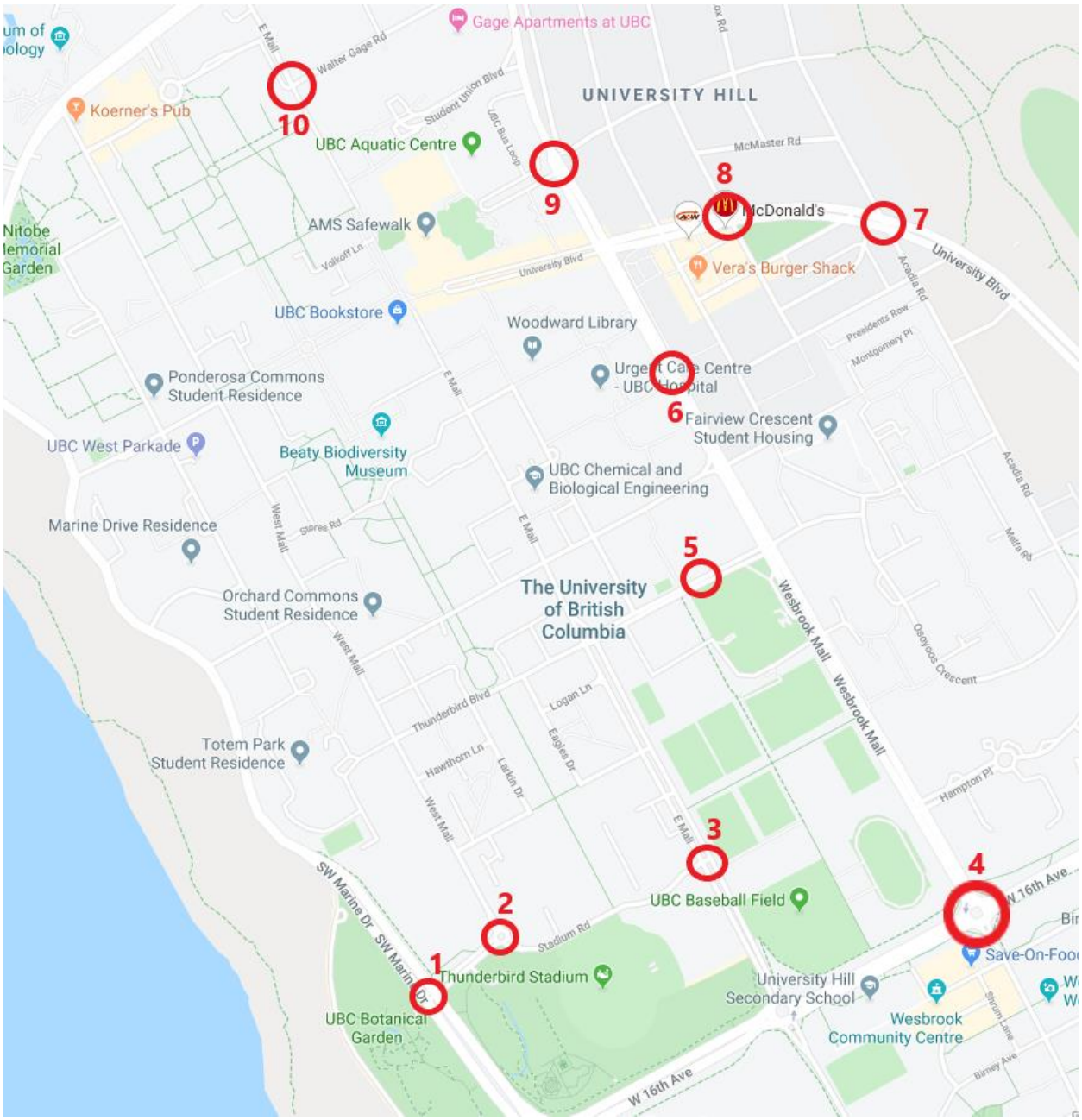
We verified 'ubcprivate' Wi-Fi coverage in these locations in two steps. First, we identified multiple points for taking measurements around each location; these points are identified in the appendix. Then, at each point of interest, we tried to connect to the closest access point by pointing the receiving antennas in the respective access point's direction. The azimuth angle of the receiving antennas was fine tuned for maximum signal reception.

The receiving antenna height was approximately 10 feet with respect to ground level at point of measurement.

At each point of interest, we gathered the following information:

- Signal power strength in dBm
- Signal-to-noise ratio in dB
- Current Rate
- UBC access points' name

Figure 1: Map of locations of interest



3- Test Set-up

In our setup, the ROU was connected to the POE (power over ethernet) unit for power and to a computer-running PuTTY- using ethernet for SSH connection. Since we needed to take measurements outdoors without access to wall outlets, we required portable power, for which we used a lead-acid battery and an inverter. Below in figure 2, we show connection diagram, then in figure 3, receiving antennas and ROU is shown, in figure 4, portable power supply is shown and in figure 5, the complete setup is shown at a point of interest.

Figure 2: Connection Diagram

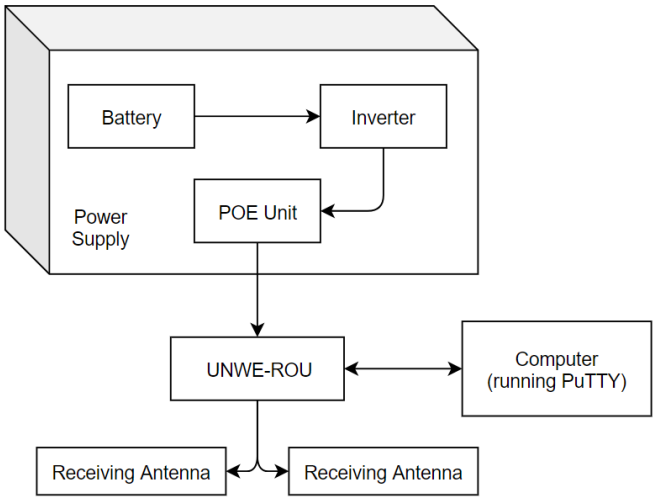


Figure 4: Antennas and ROU

Figure 3: Portable power supply

Figure 5: Complete test setup

4- Results

This section summarizes the collected results for signal power strength, signal-to-noise ratio, and UBC access point's name at AURORA testbed locations, as identified in the appendix.

Results can be summarized as follow:

- 6 locations have an acceptable coverage.
- 2 locations have no UBC Wi-Fi coverage.
- 2 locations have a weak connection (see appendix).
- Current rate for all locations is 'm15-2'.

Tables for signal power strength, signal-to-noise ratio and access point names are provided below.

Table 1: UBC Wi-Fi Signal Power Strength

Signal Power Strength (dBm)								
Locations	a	b	c	d	e	f	g	Max
Location 1	-78	-78	-68					-68
Location 2	-77	-61	-66					-61
Location 3	-66	-65	-70					-65
Location 4	-62	-66	-72	-64	-69	-69	-58	-58
Location 5	-57	-68	-59	-56				-56
Location 6	-68							-68
Location 7	N/A							
Location 8	N/A							
Location 9	-47	-55	-49					-47
Location 10	-57	-58						-57

Table 2: UBC Wi-Fi Signal-to-Noise Ratio

Signal-to-Noise Ratio (dB)								
Locations	a	b	c	d	e	f	g	Max
Location 1	17	19	28					28
Location 2	15	34	30					34
Location 3	26	27	25					27
Location 4	32	28	24	29	24	24	36	36
Location 5	38	27	36	37				38
Location 6	22							22
Location 7	N/A							
Location 8	N/A							
Location 9	41	30	41					41
Location 10	32	32						32

Table 3: UBC Wi-Fi Access Point Name

Access Point Name							
Locations	a	b	c	d	e	f	G
Location 1	MESH02-95R-TBIR	MESH02-67-TEA-H	MESH02-95R-TBIR				
Location 2	MESH02-95R-TBIR	MESH02-52-SCHOL	MESH02-52-SCHOL				
Location 3	MESH02-B2-NSDC-	MESH02-B2-NSDC-	MESH02-B2-NSDC-				
Location 4	MESH02-B3-NSDC-	MESH02-B3-NSDC-	MESH02-B3-NSDC-	MESH02-B3-NSDC-	MESH02-B3-NSDC-	MESH02-B3-NSDC-	MESH02-B3-NSDC-
Location 5	TWSC01-I0	TWSC01-I0	TWSC01-I0				
Location 6	BHLT01-C6						
Location 7	N/A						
Location 8	N/A						
Location 9	MESH02-D1-TRANS	MESH02-14-TRANS	MESH02-D1-TRANS				
Location 10	MESH02-B8-TW-W	MESH02-B8-TW-W					

5- Conclusion

Locations on and Wesbrook Mall had Wi-Fi coverage, all of them were decent enough for reliable packet delivery. Locations east of Wesbrook Mall, however, were not able to connect to the Wi-Fi network. Two locations however did not have a strong enough connection for reliable timely data packet delivery.

It must be noted that, when implemented, antennas would be placed on top of traffic signals and the height would be much greater than 10 feet, which could lead to stronger signal reception, and even Wi-Fi coverage at locations absent at lower height.

Hence, we have determined that use of Cisco access points as a workgroup bridge are a viable choice for implementation of AURORA testbed, at least at most locations.

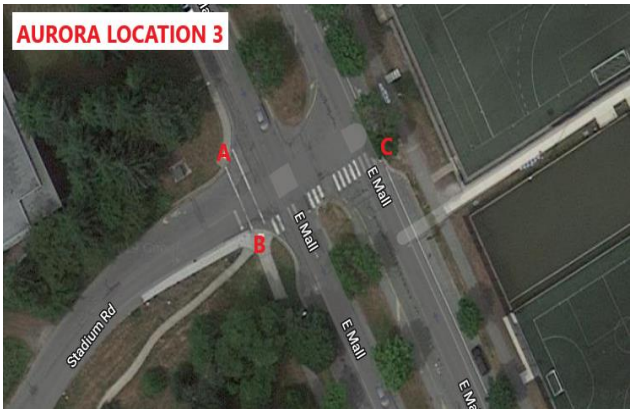
6- References

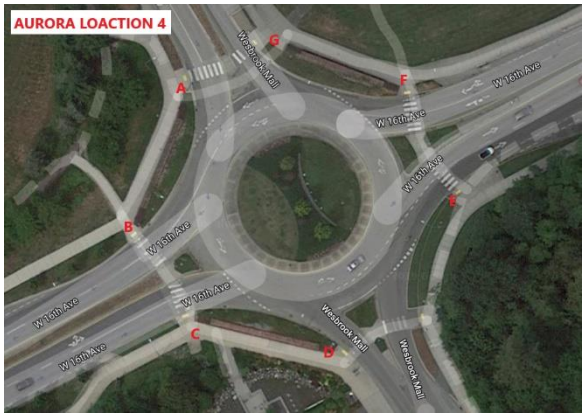
1. Support, P., Series, C. and Guides, I. (2019). *Cisco Aironet 1530 Series Outdoor Access Point Hardware Installation Guide - Overview of the 1532 Access Point [Cisco Aironet 1530 Series]*. [online] Cisco. Available at: https://www.cisco.com/c/en/us/td/docs/wireless/access_point/1530/installation/guide/1530hig/1530_ch1.html [Accessed 15 Dec. 2019].
2. Cisco. (2019). *Cisco Wireless Controller Configuration Guide Release 8.5 - Workgroup Bridges [Cisco Wireless LAN Controller Software]*. [online] Available at: https://www.cisco.com/c/en/us/td/docs/wireless/controller/8-5/config-guide/b_cg85/workgroup_bridges.html [Accessed 15 Dec. 2019].
3. Support.randomsolutions.nl. (2016). *Best dBm Values for Wi-Fi*. [online] Available at: https://support.randomsolutions.nl/827069-Best-dBm-Values-for-Wifi [Accessed 14 Dec. 2019].

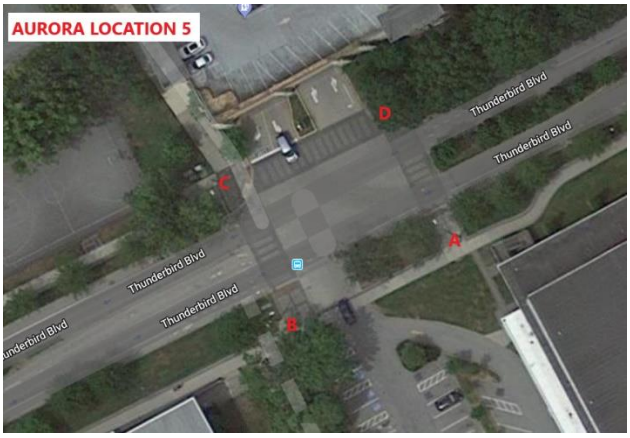
Appendix

Acceptable Wi-Fi coverage is defined as Wi-Fi signal power strength greater than -67 dBm. Wi-Fi signal strength between -67 dBm and -70 dBm translates to a weak Wi-Fi connection which is enough for reliable data packet delivery, however not enough for accurate timely data packet delivery. Wi-Fi signal strength below -70 dBm is not reliable as it can lead to loss of data packets. [3]

The following are figures of points of measurement at each location. Location 7 and 8 have been omitted since we connection could not be established at any point around location.






AURORA LOCATION 5
D
Thunderbird Blvd
Thunderbird Blvd
C
A
Thunderbird Blvd
Thunderbird Blvd
B


AURORA LOCATION 6
B
A
Wesbrook Mall
Wesbrook Mall


AURORA LOCATION 9
Wesbrook Mall
G
A
UBC Bus Loop
Wesbrook Mall
B


AURORA LOCATION 10
Buchanan Block
E Building
E Mall
Walter Gage Rd
A
B