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Wi-Fi Renewal

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Practical problems with the old wireless solution was that it did not have enough coverage to provide seamless connection for clients in the company premises and therefore clients got disconnected when moving from one place to another. This prompted the need for replacing the old solution. Signal coverage was measured for 2.4GHz and 5 GHz frequencies to determine best coverage for the premises. Main aim was to provide a robust and seamless solution which can be extended relatively easy if needed in the future. In this thesis project company confidential reports were used in the planning and implementing phase the solution. Due to the security reasons those reports were not included in the report.

Keywords	Wi-Fi, renewal

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List of Abbreviations

PoE	Power over Ethernet. Device with PoE capability doesn't need external power adapter. Switches with PoE+ can provide power through Ethernet cable to PoE compatible devices.
SNR	Signal to Noise Ratio.
WLC	Wireless Controller. Device which can control multiple access points.
AP	Access point.
ISE	Identity Service Engine is a policy management and control platform for wired, wireless, and VPN. It supports BYOD, guest access and secure access, and Cisco TrustSec services.

1 Introduction

The purpose of this thesis was to be able to provide users seamless wireless connection inside Airbus Defence and Space Oy premises and at the same time to provide standardized and safe solution for every user in the company premises including customers and training personnel. The solution should be more robust and more mobile than the current solution. Previous solution had very limited access and operational range. It was limited only to certain areas and users were not able to connect to company network without VPN-dongle, which made it very slow to operate and you would not be able to move from one meeting room to another without getting disconnected since there was not enough access points to provide full coverage in the company premises, which the new solution provides.

2 Preparation and Requirements

2.1 Preparation

At the beginning of this project, it was discussed whether some access points should simply be upgraded or whether a full company standardized solution should be provided. A decision was made to proceed with full coverage. First step is to have site survey and create mapping from building blueprints so that used software “Ekahau wireless design” could calculate the attenuation that the walls have impact on the signal strength and how many access points are required to provide full coverage with best connectivity and where to set up the access points. Since the basic idea of wireless network is that if the signal also known as coverage is low, then the network is unreliable and therefore data throughput is low. Therefore by implementing the full coverage to the premises users are able to remain connected to the network even when moving from one place to another with least amount of disruptions to the network connection. Required physical works such as cabling and installation of the access points were ordered to be done by a subcontractor.

2.2 Requirements

In order to make the new solution viable the following devices and services were ordered. Cisco Aironet 2800 series Access points, Cisco WLC 3500 series Wireless Controller, Cisco ISE Virtual Machine, Cisco Catalyst 3850 series switches, Cisco Catalyst 2960-X series switches. The subcontractor was requested to perform physical installation of the access points and for cabling installations, network topology had to be finished before device configurations could be started so that all devices have names and IP-addresses dedicated to the each devices.

2.2.1 Pre-work and requirements for the finalization of the Wi-Fi solution

The following steps had to be done to complete this project successfully.

- Obtaining and testing of DWG Files for Network Management and Site Survey
- Performing predictive site survey in Helsinki
- Performing predictive site survey in Jyväskylä
- Finalizing Internet DMZ Readiness
- Implementing ESX server in Helsinki
- Implementing Efficient IP systems for DDI (VM)
- Implementing Policy Service Nodes (ISE) for guest authentication (VM)
- Refurbishing of internet DMZ switches
- Hardware staging and preparation Wireless Controller
- Gathering all necessary information to generate configuration for WLC in internet DMZ
- Finalizing WAN Readiness (routing)
- Finalizing LAN Readiness (AP Network, WLC Network)
- Finalizing LAN Readiness Wi-Fi divisional (Client Network international area)
- Finalizing DDI readiness
- Implementing Policy Rule Set on wireless ISE for local guest authentication
- Implementing firewall CRs
- Configuring and updating of Controllers
- Extending international campus core in Helsinki
- Extending international campus core in Jyväskylä

- Physical installation of dedicated Wi-Fi switches with PoE+
- Delivering switch configuration for dedicated Wi-Fi switches
- Configuring dedicated Wi-Fi switches
- Installing HW for Wireless Controller
- Physical hardware installation of 2 wireless controllers
- Remote support for cabling controllers
- Connectivity testing between Helsinki <=> Germany
- AP Rollout
- Preparation of Rollout List
- Further in house cabling for access points
- Physical access point installation
- Configuration of Access Point Ports on Switch
- Configuration of Access Points
- Post Survey will be done later in the year 2019
- Post installation of Access-Points (configuration)
- Documentation
- Integrating to Spectrum
- Updating Wi-Fi Visio
- Updating operational handbook
- Entering into Service
- Handing over to NOC

3 Network topologies (simplified) for Helsinki and Jyväskylä.

This chapter describes how the network operates. Each area represents different part of the company premises (floors). Each access point groups are connected to different PoE-switches and PoE-switches are then connected to a switch and through that to Wireless Lan Controller (WLC) (which are then controlled through console router). All traffic is monitored and logged to SPLUNK for security reasons, which in turn provides necessary information to the firewalls so that depending on the rule sets in the fire-walls, connection is either allowed or blocked. All access points in Helsinki and Jyväskylä are controlled through WLC's located in Helsinki site.

3.1 Helsinki Wi-Fi network topology

Figure 1 shows roughly how the Wi-Fi solution works in Helsinki. The access points are connected to PoE-swithces, and from there on the PoE-switches are connected to distribution switch in datacenter and from there to and that switch connects to WLC and through there to firewall and from firewalls to the internet.

Due to company sensitive data and security reasons, network topologies had to be simplified.

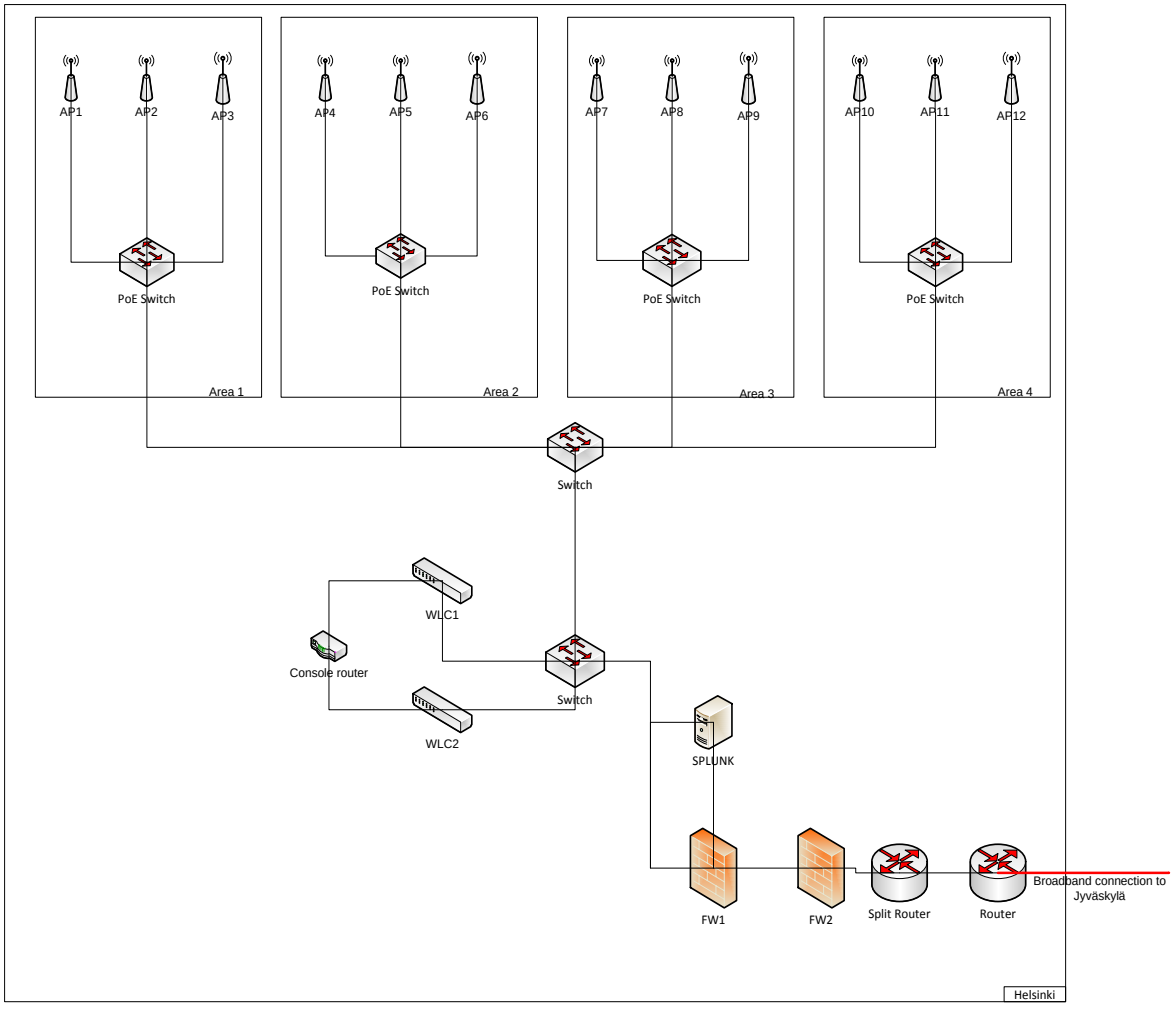

Figure 1 Helsinki site Wi-Fi topology (simplified)

3.2 Jyväskylä Wi-Fi network topology

Figure 2 demonstrates roughly how the Wi-Fi solution works in Jyväskylä. The access points are connected to PoE-swithces and from there on the PoE-switches are connected to distribution switch in datacenter and from there to and that switch connects to WLC and through there to the firewall, from firewalls to split-router and then to a router and then to the internet.

Due to company sensitive data and security reasons, network topologies had to be simplified

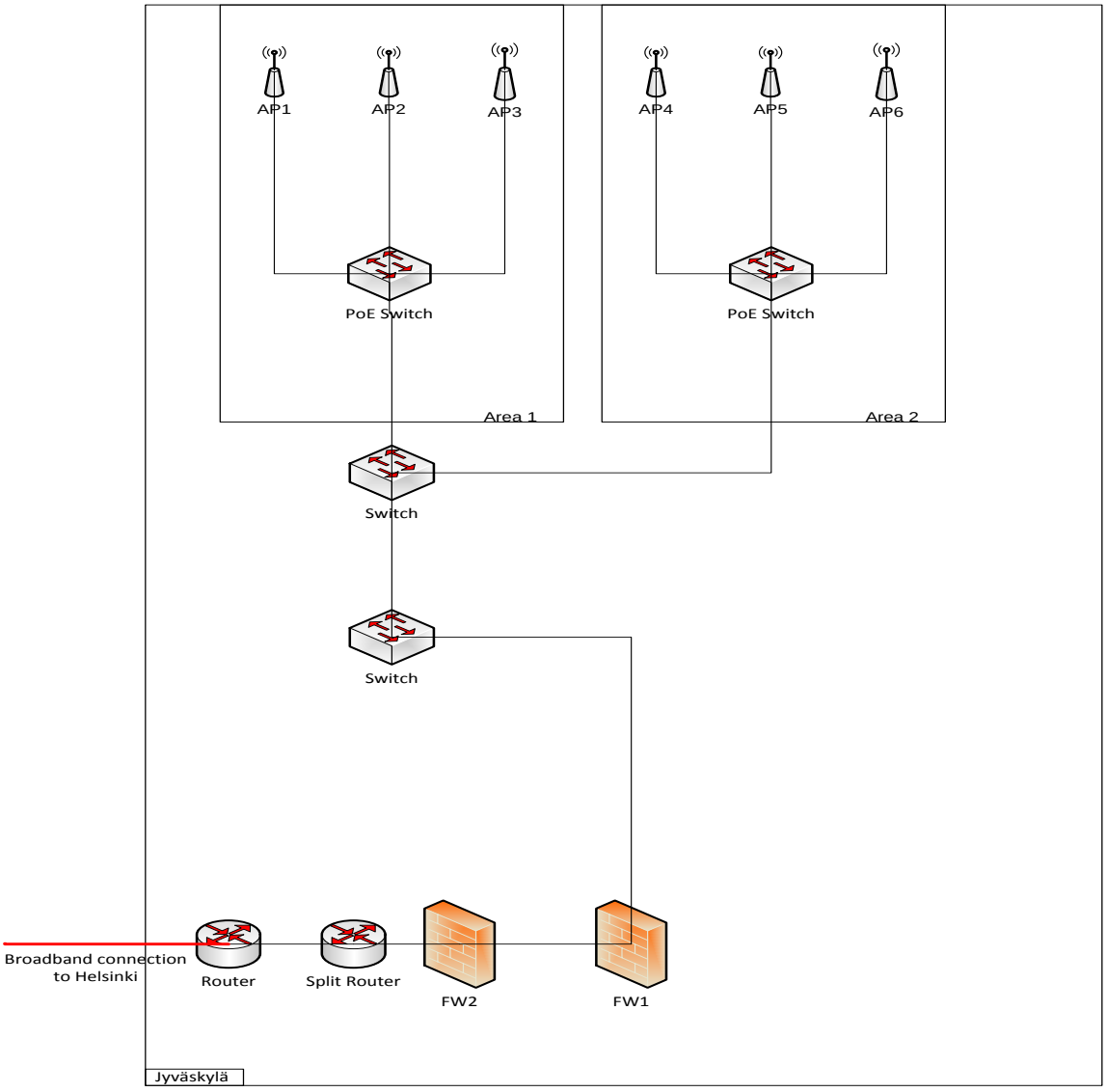

Figure 2 Jyväskylä site Wi-Fi network topology (simplified)

When the user connects to one of the access points monitoring system is able to provide accurate login, location and connectivity (connection quality) information in case there should be any issues with the network.

4 Survey and predicted coverage for Wi-Fi in Helsinki site

Initial site survey was done in order to determine the ideal physical locations for access points and to determine signal strengths for 2.4 GHz and 5.0 GHz and determine Signal To Noise Ratio (SNR) in company premises. SNR – indicates how much the signal strength is stronger than the noise (co-channel interference). Signal must be stronger than noise (SNR>0) in order for data transfer to be possible. If it is only barely stronger than the noise, occasional drop-offs are likely to happen as shown in the site survey report (see attachment). Survey Area 1 and Area 3 have almost identical base layout and Area 2 and 4 have almost identical layouts in Helsinki site. Jyväskylä site has also identical layouts between Area 1 and Area 2.

Figure 3 estimated capacity and minimum coverage reguirements (Wi-Fi Network report Helsinki, 2019)

Coverage Requirement: **Voice + Data**	Signal Strength Min	**-67.0 dBm**
	Signal-to-noise Ratio Min	**20.0 dB**
	Data rate Min	**12 Mbps**
	Number of Access Points Min	**2 at min. -75.0 dBm**
	Channel Overlap Max	**2 at min. -85.0 dBm**
	Round Trip Time (RTT) Max	**200ms**
	Packet Loss Max	**2.0 %**
Capacity Requirement		
	50	Generic Laptop [Background Sync]
	50	Generic Smartphone [Background Sync]
	50	Generic Tablet [Background Sync]
	50	Generic VoIP Phone [Background Sync]
	Total: 200 (100 Mbits/s)	
Notes		

4.1 Predicted Wi-Fi signal strength on the 2.4GHz bandwidth.

Figure 4 illustrates the predicted coverage on 2.4GHz bandwidth on Helsinki site Area 1 and Figure 5 shows the predicted signal strength. The greener the color, the better the signal strength is. Some areas are colored grey which means that there's bad coverage.

Figure 4 predicted coverage on Helsinki Area 1 and Area 3 (Wi-Fi Network report Helsinki 2019)

Signal quality is indicated with colors in Figure 5, grey color means bad quality and green means good quality in signal strength

Figure 5 Signal strength on the 2,4Ghz bandwidth (Wi-Fi Network report Helsinki 2019)

4.1.1 Predicted signal to noise ratio on 2.4GHz bandwidth

As seen in the Figure 6 and Figure 7, the predicted SNR on2.4GHz is strong enough to provide required coverage for this area. The darker the green color is, the better the signal and the data throughput are.

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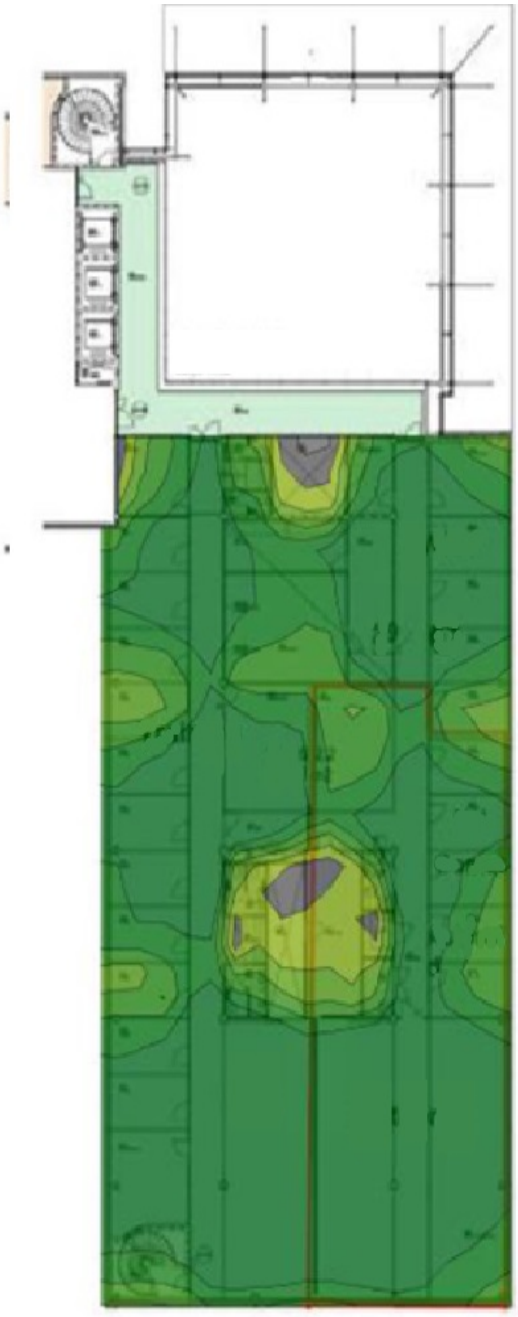

Figure 6 Predicted SNR on the 2.4GHz bandwidth in Helsinki Area1 and Area 3 (Wi-Fi Network report Helsinki 2019)

The grey color in Figure 7 indicates that the SNR relation is bad and the green color indicates good relation.

Figure 7 Signal to Noise Ratio (Wi-Fi Network report Helsinki 2019)

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4.1.2 Data rate for 2.4 GHz bandwidth on Helsinki site Area 1 and Area 2

Data rate is the highest possible speed (measured in megabits per second) at which wireless devices transmit data. In reality it is usually half of the announced speed or less so in this case if the speed would be 225Mb/s then true data rate would be around <100Mb/s depending on the environment. As shown in figures 8 and 9 the transfer data should remain relativily high through the whole area.

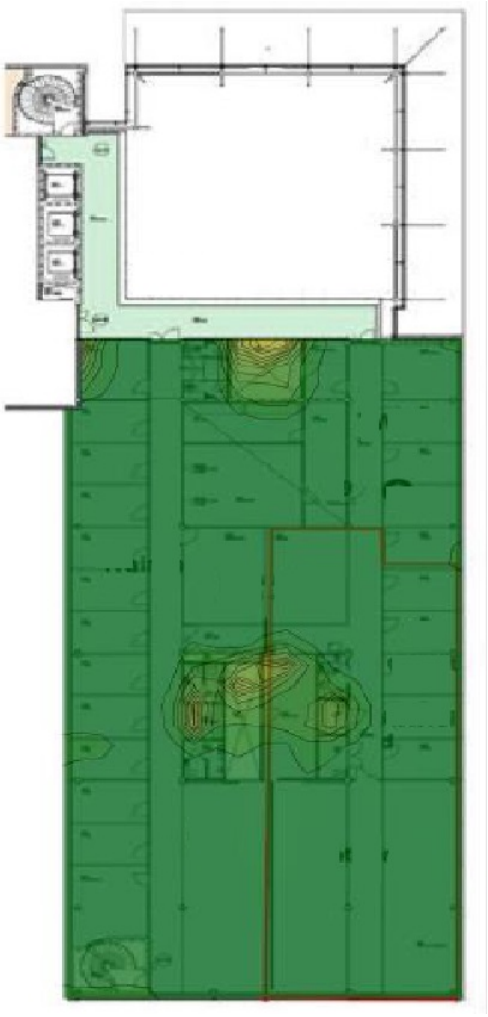

Figure 8 Predicted Data rate for Helsinki site Area 1 and Area 3 on 2.4GHz (Wi-Fi Network report Helsinki 2019)

DTR quality is indicated with differen color shades in Figure 9. The darker the green is, the better quality DTR has.

Figure 9 Predicted Data rate (Wi-Fi Network report Helsinki 2019)

4.2 Predicted Wi-Fi signal strength for the 2.4 GHz bandwidth in Helsinki site Area 2 and Area 4

Coverage (Signal strength) is the basic requirement for a wireless network. As in general, low signal strength means unreliable connection, and low data throughput. As can be seen in Figure 10, coverage is sufficient to provide reliable connections.

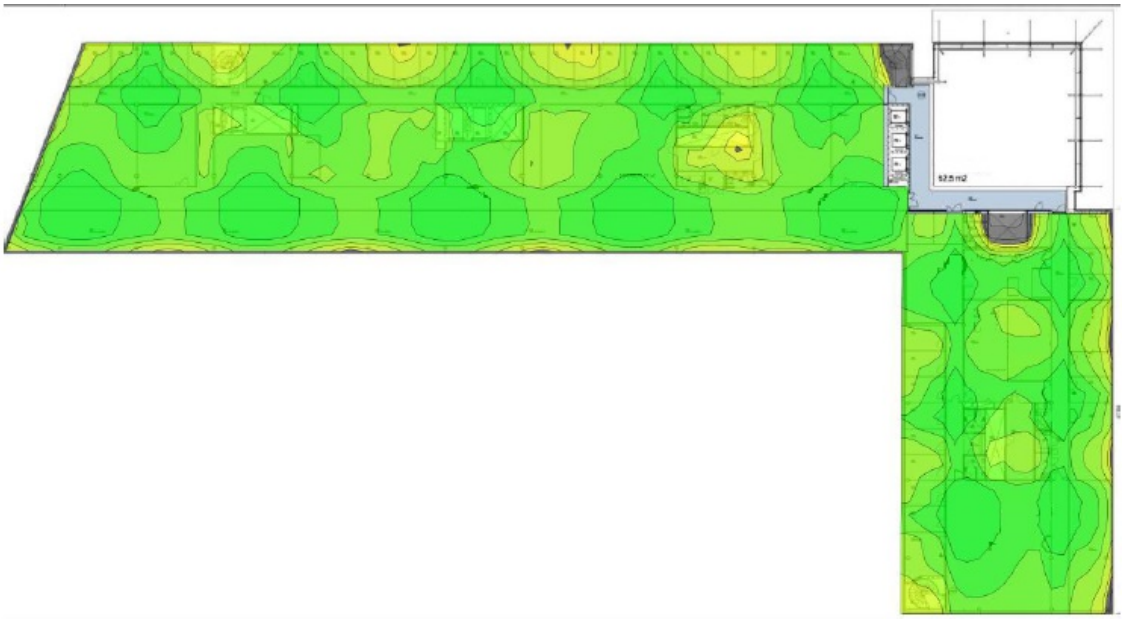

Figure 10 Predicted coverage for the 2.4GHz in Helsinki site Area 2 and 4 (Wi-Fi Network report Helsinki 2019)

Signal quality is indicated with colors (Figure 11), grey color means bad quality and green means good quality in signal strength.

Figure 11 Signal strength (Wi-Fi Network report Helsinki 2019)

4.2.1 Predicted Signal-to-Noise Ratio for 2.4GHz bandwidth in Helsinki site Area 2 and Area 4

SNR indicates how much the signal strength is stronger than the noise (co-channel interference). Signal must be stronger than noise (SNR > 0) for data transfer to be possible. If the signal is barely stronger than noise, you may encounter connection drop-offs. As can be seen in Figure 12 and Figure 13 the SNR is sufficient to provide reliable connection to clients.

Figure 12 SNR for 2.4GHz in Helsinki site Area 2 and Area 4 (Wi-Fi Network report Helsinki 2019)

The grey color in Figure 13 indicates that the SNR relation is bad and the green color indicates good relation.

Figure 13 Signal to Noise Ratio strength (Wi-Fi Network report Helsinki 2019)

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4.2.2 Data transfer rate in Helsinki site Area 2 and Area 4 for 2.4GHz bandwidth

Data rate is the highest possible speed at which wireless device can transmit data. Data rate is measured in Mb/s. In reality, the speed is usually half or less from the highest possible speed. Figure 14 shows that the maximum data transfer rate can be achieved.

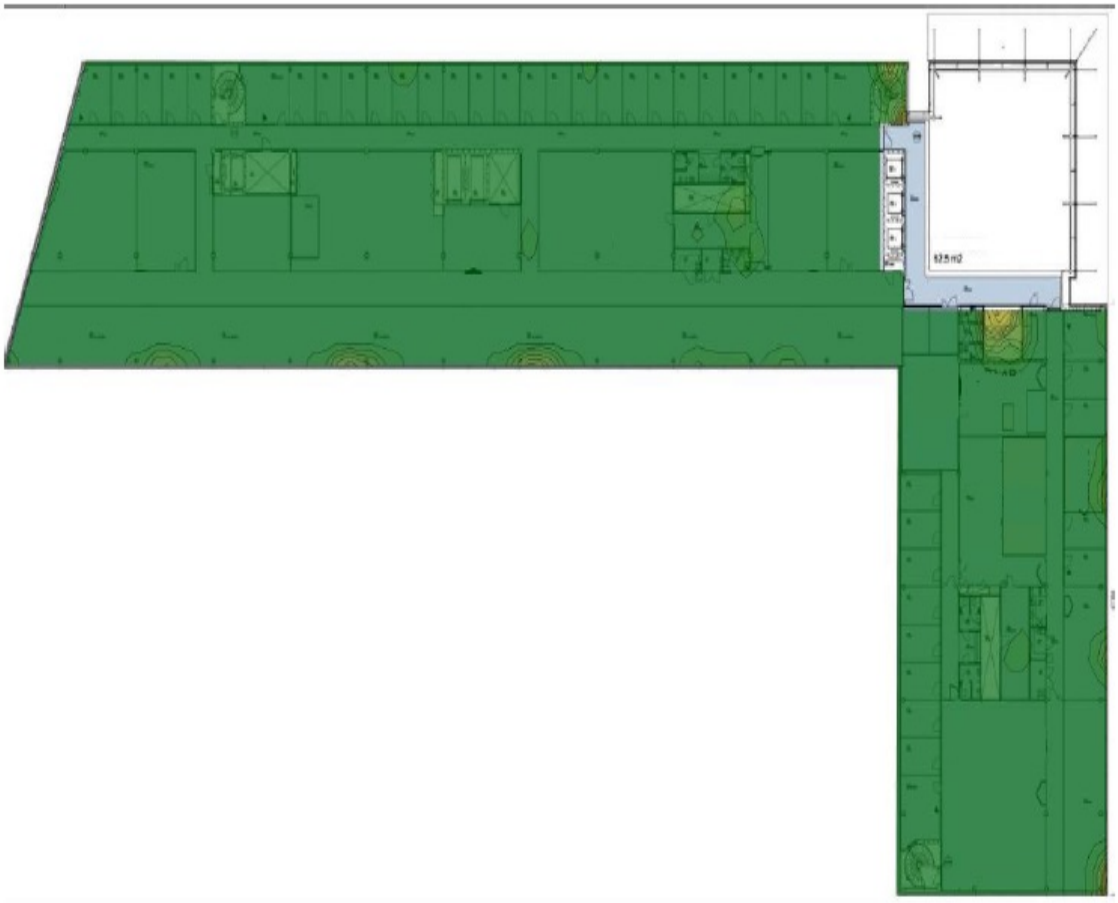

Figure 14 Data transfer rate for 2.4GHz in Helsinki site Area 2 and Area 4 (Wi-Fi Network report Helsinki 2019)

DTR quality is indicated with different color shades. The darker the green is, the better quality DTR has.

Figure 15 Data transfer rate in Mb/s (Wi-Fi Network report Helsinki 2019)

4.3 Predicted Wi-Fi signal strength for 5GHz bandwidth in Helsinki site Area 1 and Area 3

Coverage is basic requirement for wireless environment; without good coverage data throughput is low and connection will be unreliable. As Figure 17 indicates, coverage should be sufficient to provide reliable connections to clients.

Figure 16 Predicted 5 GHz coverage in Helsinki site Area 1 and Area 3 (Wi-Fi Network report Helsinki 2019)

Signal quality is indicated with colors, grey color means bad quality and green means good quality in signal strength

Figure 17 Signal strength in dBm (Wi-Fi Network report Helsinki 2019)

4.3.1 Predicted SNR for 5GHz in Helsinki Site Area 1 and 3

SNR indicates how much the signal strength is stronger than the noise (co-channel interference). The signal must be stronger than noise (SNR > 0) for data transfer to be possible. If the signal is barely stronger than noise, you may encounter connection drop-outs. Figure 18 and Figure 19 shows that the signal is stronger than the noise.

Figure 18 Signal to Noise Ratio for 5GHz in Helsinki site Area 1 and Area 3 (Wi-Fi Network report Helsinki 2019)

The grey color in the Figure 19 indicates that the SNR relation is bad and the green color indicates good relation.

Figure 19 SNR is measured in dB (Wi-Fi Network report Helsinki 2019)

4.3.2 Predicted Data Transfer Rate for 5GHz bandwidth in Helsinki site Area 1 and 3

Data Rate is the highest possible speed (measured in megabits per second) at which the wireless devices will be transmitting data. In this case the maximum transfer speed is 700Mb/s. Typically, the true data throughput is about half of the data rate or less and in this case, transfer speed should be 350 Mb/s or less with 5GHz bandwidth. As shown in the Figure 20 and Figure 21.

Figure 20 DTR in 5GHz in Helsinki site Area 1 and Area 3 (Wi-Fi Network report Helsinki 2019)

DTR quality is indicated with differen color shades. The darker the green is, the better quality DTR has.

Figure 21 DTR measured in Mb/s (Wi-Fi Network report Helsinki 2019)

4.4 Predicted coverage for 5GHz bandwidth in Helsinki site Area 2 and Area 4

Coverage is basic requirement for a wireless network to work properly. As in general, low signal strength means unreliable connections, and low data throughput. As can be

seen in Figure 22 the coverage is sufficient to provide reliable connection to wireless clients. Signal strength is measured in dBm.

Figure 22 Signal strength for 5GHz in Helsinki site Area 2 and Area 4 (Wi-Fi Network report Helsinki 2019)

Signal quality is indicated with colors, grey color means bad quality and green means good quality in signal strength.

Figure 23 Signal strength measured in dBm (Wi-Fi Network report Helsinki 2019)

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4.4.1 Predicted Signal to Noise Ratio for 5GHz bandwidth in Helsinki site Area 2 and Area 4

SNR indicates how much the signal strength is stronger than the noise (co-channel interference). Signal must be stronger than noise (SNR > 0) for data transfer to be possible. If the signal is barely stronger than noise, you may encounter connection drop-offs. Figure 24 and Figure 25 shows that the SNR is sufficient to provide reliable connection to clients. SNR is measured in dB.

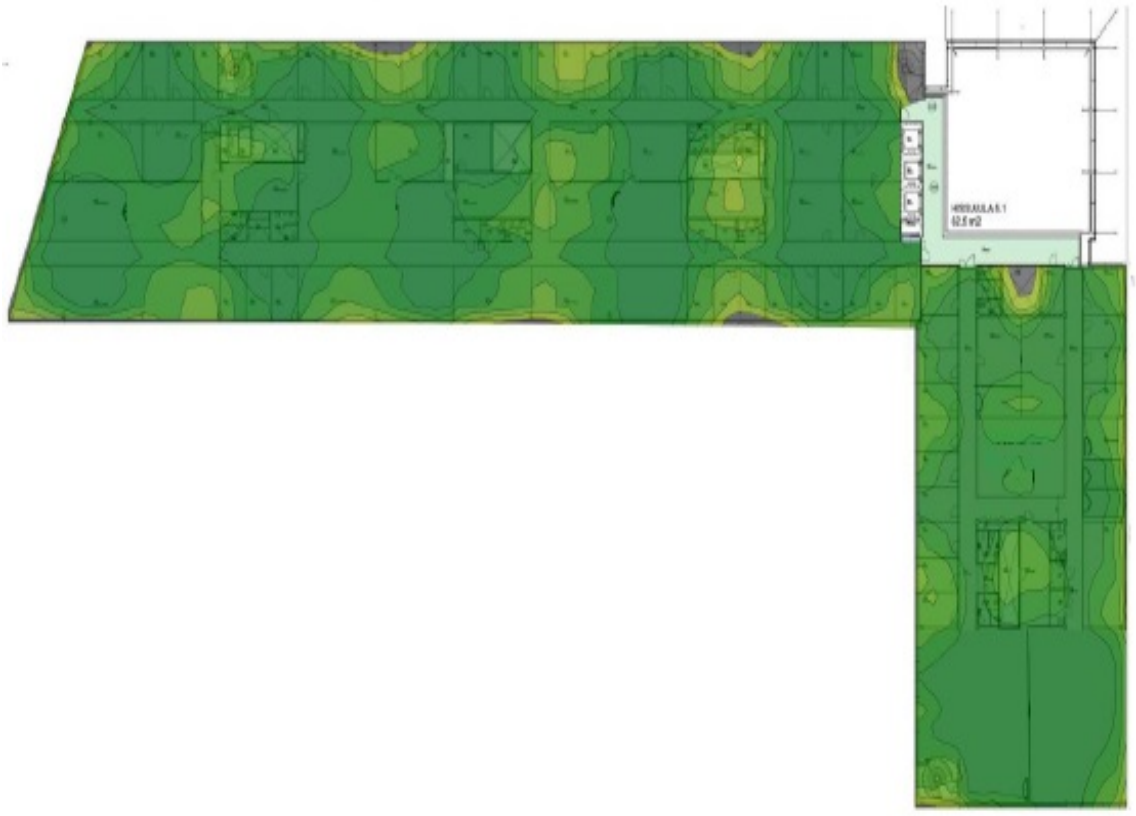

Figure 24 Signal to Noise Ratio for 5GHz in Helsinki Site Area 2 and Area 4 (Wi-Fi Network report Helsinki 2019)

The grey color in the Figure 25 indicates that the SNR relation is bad and the green color indicates good relation.

Figure 25 SNR strength is measured in dB (Wi-Fi Network report Helsinki 2019)

4.4.2 Predicted Data Transfer Rate for 5GHz in Helsinki site Area 2 and Area 4

DTR is the highest possible speed (measured in megabits per second) at which the wireless devices will be transmitting data. In this case maximum transfer speed is 700Mb/s. Typically the true data throughput is about half of the DTR or less, and in this case, transfer speed should be around 350Mb/s with 5GHz bandwidth. As shown in Figure 26.

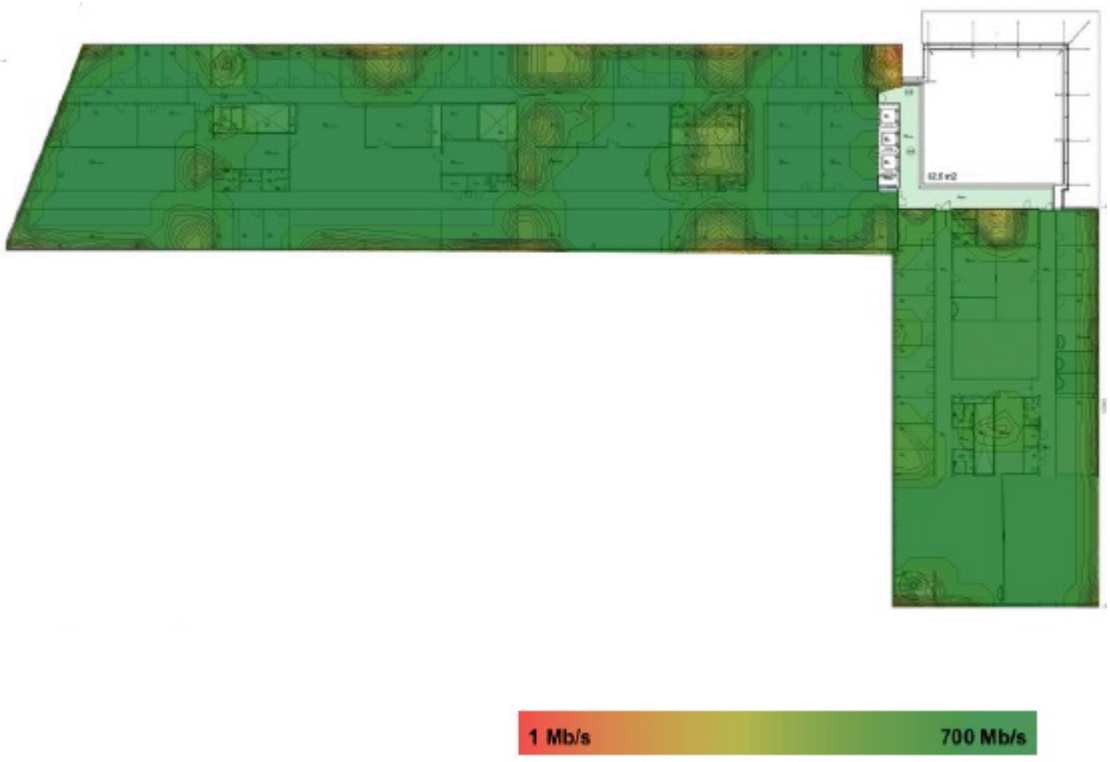

Figure 26 Data Transfer Rate for 5GHz in Helsinki site Area 2 and Area 4 (Wi-Fi Network report Helsinki 2019)

5 Jyväskylä site survey and predicted coverage

Initial site survey was done in order to determine the best physical locations for access points and to determine signal strengths for the 2.4 GHz and 5.0 GHz bandwidths and the signal-to-noise ratio (SNR) in company premises. SNR – indicates how much the signal strength is stronger than the noise (co-channel interference). Signal must be stronger than noise (SNR>0) in order to data transfer to be possible. If it is only barely stronger than the noise, occasional drop-offs are likely to happen. Survey Area 1 and Area 2 have identical base layout in Jyväskylä site. Initial requirements for Jyväskylä can be seen in Figure 27.

Figure 27 Jyväskylä requirements (Wi-Fi network report Jyväskylä 2019)

Coverage Requirement: **High Speed Connectivity**	Signal Strength Min	**-70.0 dBm**
	Signal-to-noise Ratio Min	**16.0 dB**
	Data rate Min	**12 Mbps**
	Number of Access Points Min	**2 at min. -80.0 dBm**
	Channel Overlap Max	**3 at min. -80.0 dBm**
	Round Trip Time (RTT) Max	**300ms**
	Packet Loss Max	**5.0 %**
Capacity Requirement		
	50	Generic Laptop [Background Sync]
	50	Generic Smartphone [Background Sync]
	50	Generic Tablet [Background Sync]
	50	Generic VoIP Phone [Background Sync]
	Total: 200 (100 Mbits/s)	

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5.1 Predicted Wi-Fi signal for 2.4GHz bandwidth in Jyväskylä site Area 1 and Area 2

Coverage (signal strength) is basic requirement for a wireless network. In general the better the coverage more reliable and stable wireless connections for clients are. Signal strength (coverage) is measured in dBm. The Figure 28 shows that the coverage should be able to provide sufficient high speed connections to client devices.

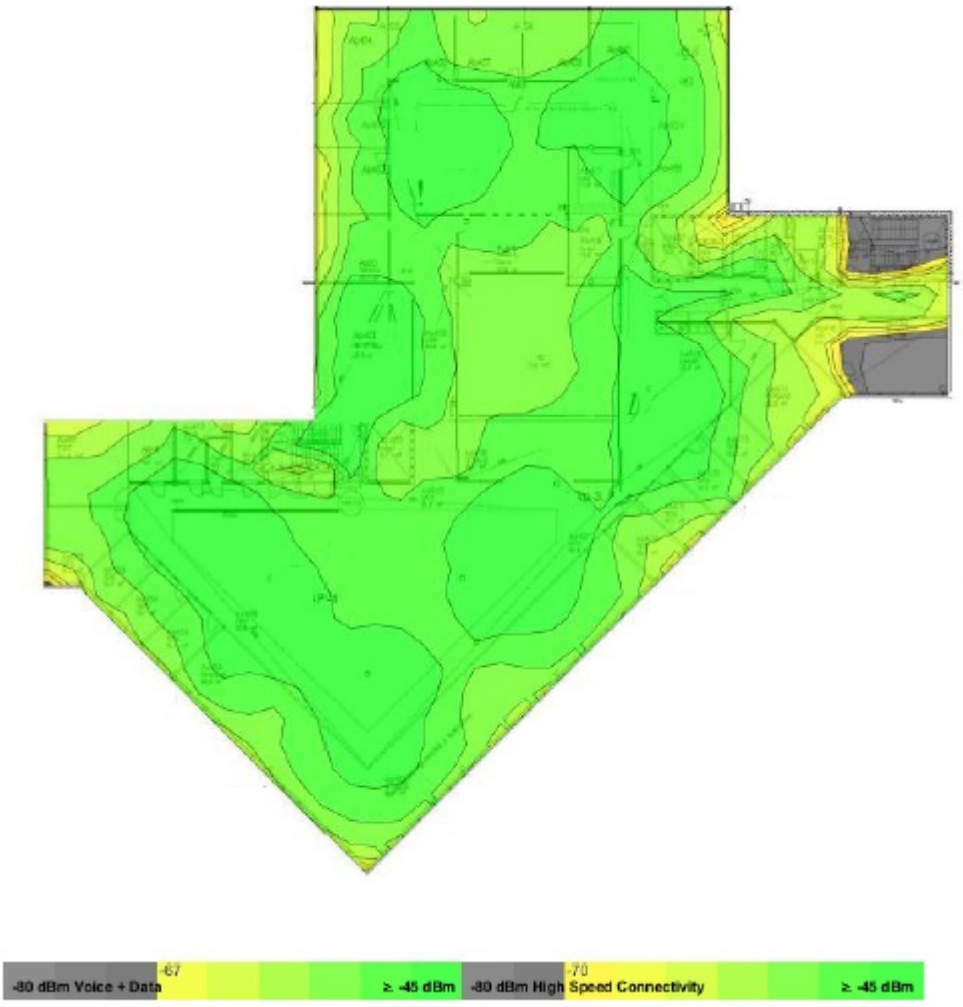

Figure 28 Signal strength in Jyväskylä site for Area 1 and Area 2 (Wi-Fi network report Jyväskylä 2019)

5.1.1 Predicted Signal to Noise Ratio for 2.4GHz in Jyväskylä site Area 1 and Area 2

Signal to Noise Ratio (SNR) indicates the relation between signal strength and noise. SNR should always be greater than zero if it is not then there will be occasional drop-outs for connected clients. As long as the ratio stays above zero connectivity to wireless network should be stable. SNR is measured in dB, The Figure 29 shows that the network should provide stable connectivity and connections.

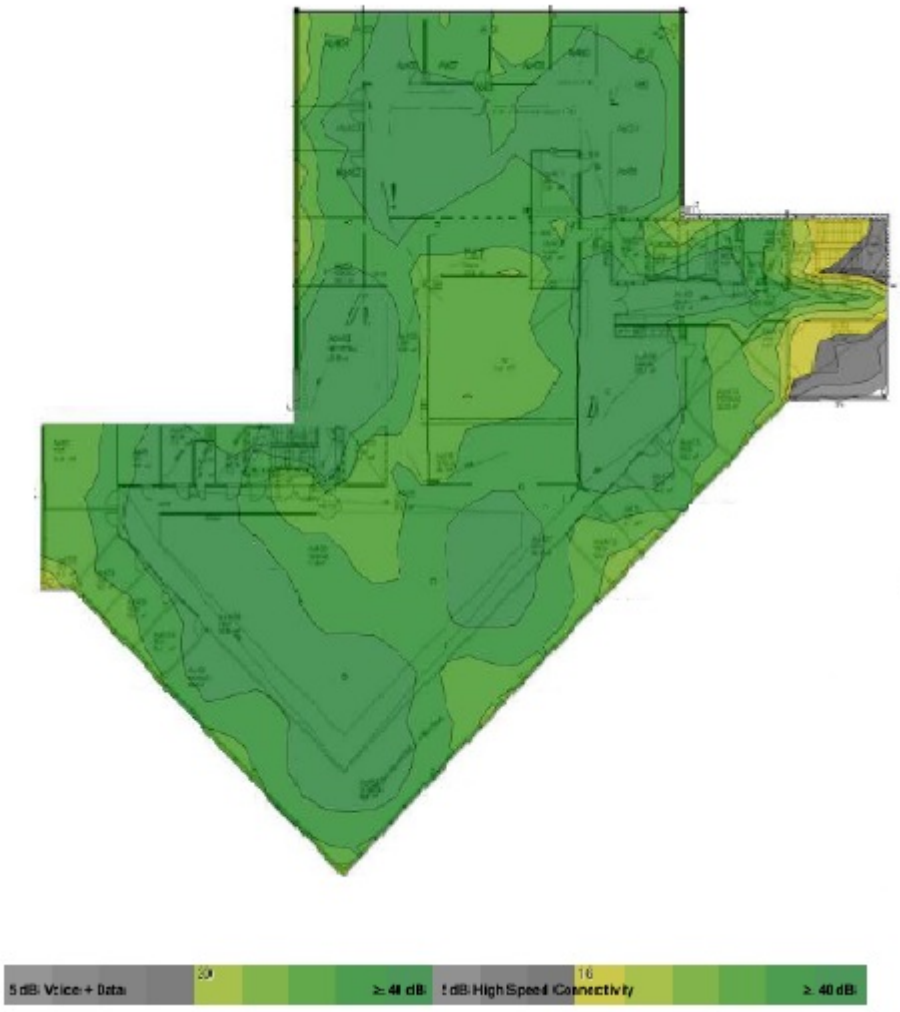

Figure 29 Signal to Noise Ratio for 2.4GHz in Jyväskylä site for Area 1 and Area 2 (Wi-Fi network report Jyväskylä 2019)

5.1.2 Predicted Data Transfer Rate for 2.4GHz in Jyväskylä site Area 1 and Area 2

DTR is the highest possible speed (measured in megabits per second) at which the wireless devices will be transmitting data. In this case maximum transfer speed is 225Mb/s. Typically true data throughput is about half of the DTR or less and in this case, transfer speed should be around 110Mb/s with 2.4GHz bandwidth. As shown in the Figure 30. As the figure indicates the whole wireless solution should be able to provide reliable DTR for connected clients.

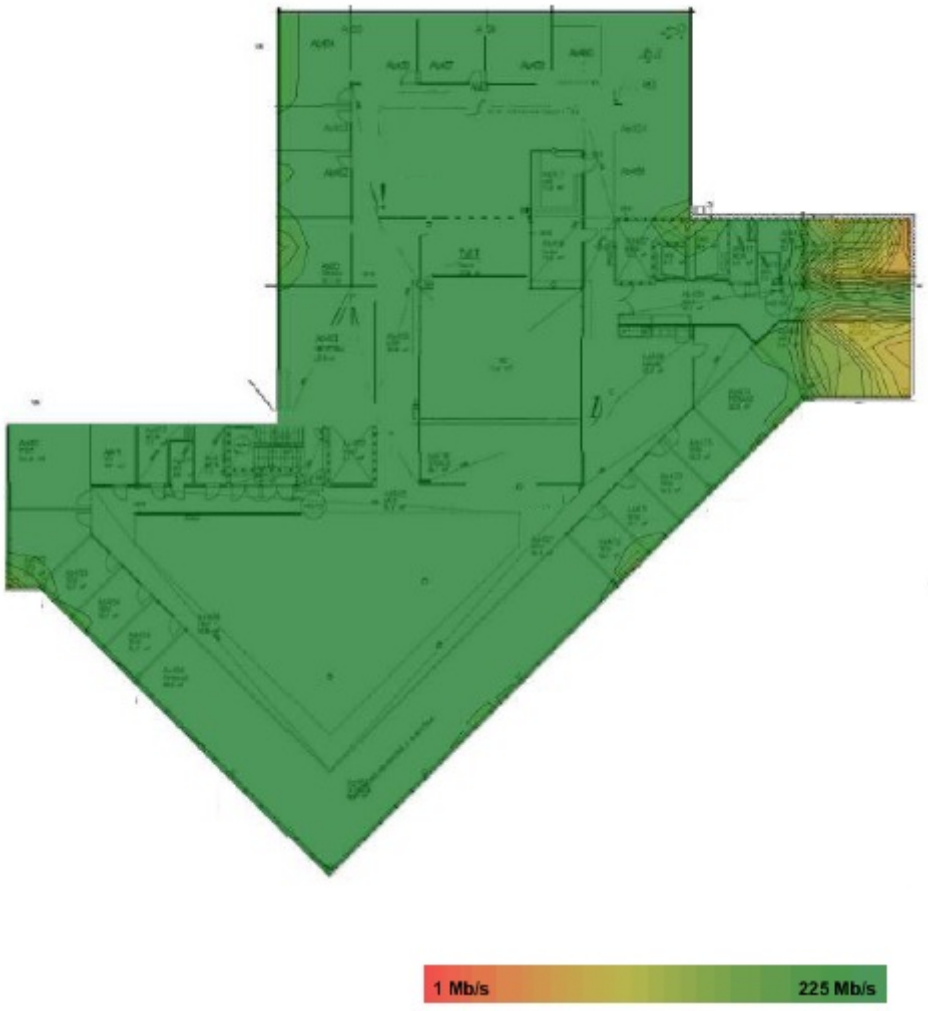

Figure 30 Data transfer rate for 2.4GHz in Jyväskylä site Area 1 and Area 2(Wi-Fi network report Jyväskylä 2019)

5.2 Predicted Wi-Fi signal for 5GHz in Jyväskylä site, Area 1 and Area 2

Coverage (signal strength) is basic requirement for a wireless network. In general the better the coverage more reliable and stable wireless connections for clients are. Signal strength (coverage) is measured in dBm. The Figure 31 shows the coverage should be able to provide sufficient high speed connections to client devices.

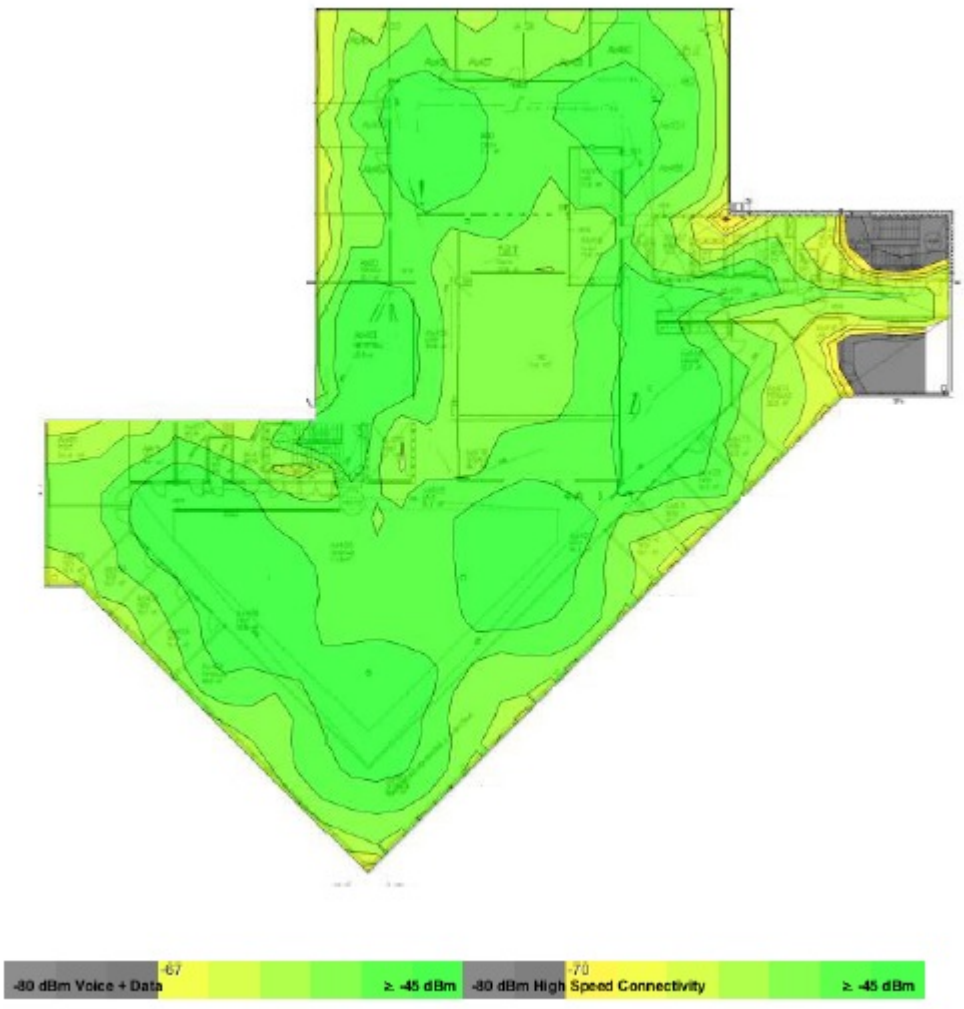

Figure 31 Signal strength for 5GHz in Jyväskylä site Area 1 and Area 2(Wi-Fi network report Jyväskylä 2019)

5.2.1 Predicted Signal to Noise Ratio for 5GHz in Jyväskylä site, Area 1 and Area 2

Signal to Noise Ratio (SNR) indicates the relation between signal strength and noise. SNR should always be greater than zero if it is not then there will be occasional drop-

outs for connected clients. As long as the ratio stays above zero, connectivity to wireless network should be stable. SNR is measured in dB. The Figure 29 shows the network should provide stable connectivity and connections.

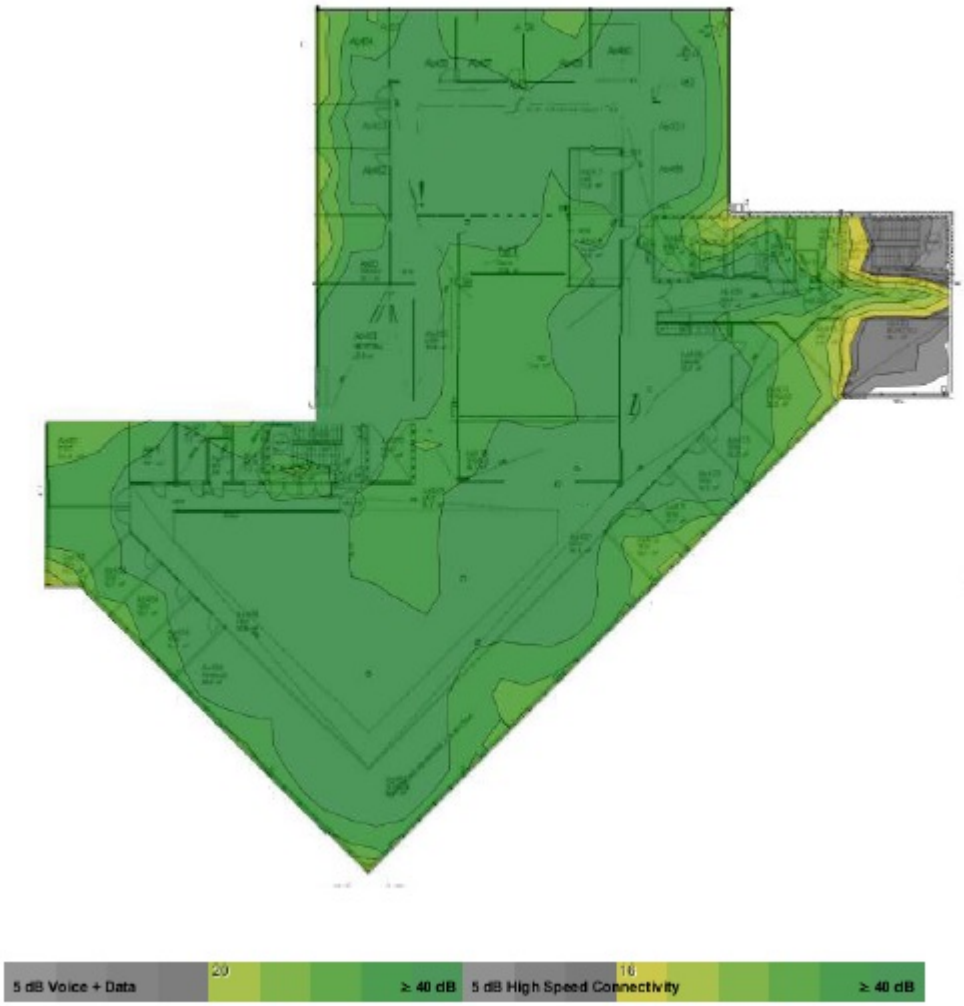

Figure 32 Signal to Noise Ratio for 5GHz in Jyväskylä site, Area 1 and Area 2 (Wi-Fi network report Jyväskylä 2019)

5.2.2 Predicted Data rate for 5GHz in Jyväskylä site, Area 1 and Area 2

DTR is the highest possible speed (measured in megabits per second) at which the wireless devices will be transmitting data. In this case maximum transfer speed is 700Mb/s. Typically true data throughput is about half of the DTR or less and in this case, transfer speed should be around 350Mb/s with 5GHz bandwidth. As shown in the

Figure 33. As the figure indicates the whole wireless solution should be able to provide relatively good DTR for connected clients.

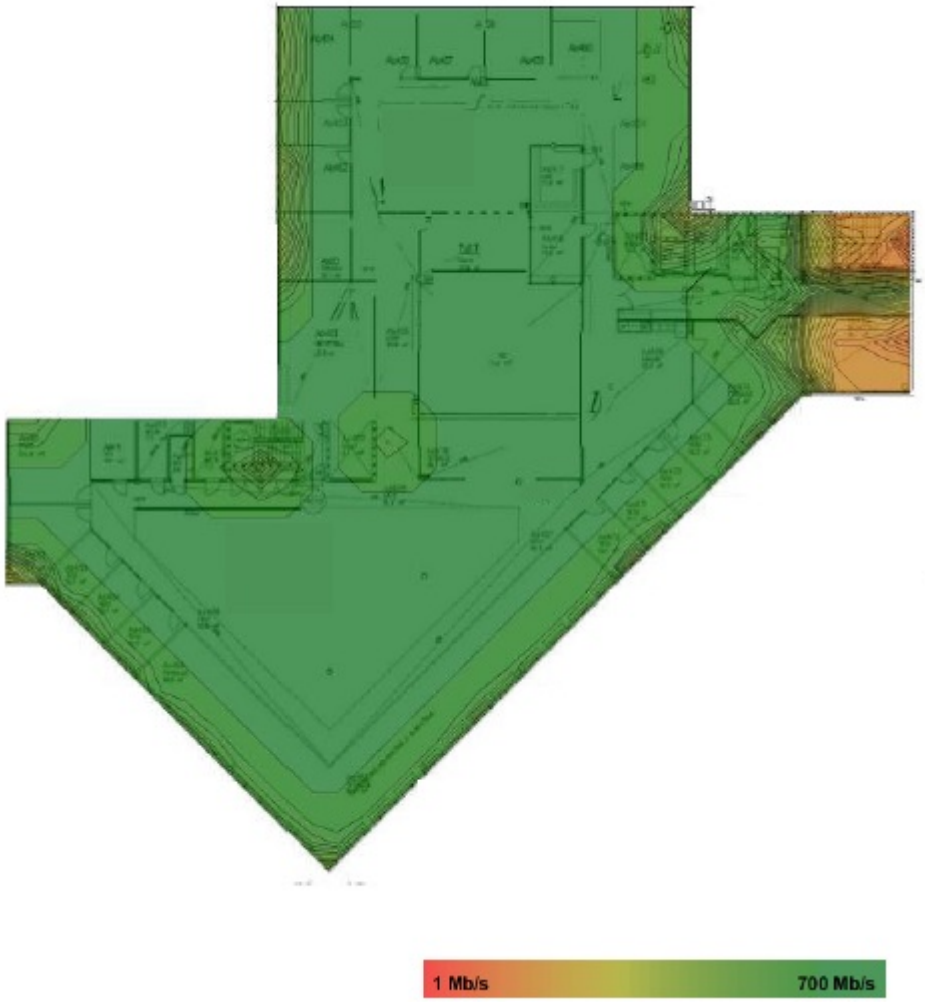

Figure 33 Data Transfer Rate fro 5GHz in Jyväskylä site, Area 1 and Area 2 (Wi-Fi network report Jyväskylä 2019)

6 Perfomance and Benefits of the New Wi-Fi Solution

New Wi-Fi solution provides users seamless connectivity for their wireless client devices, which means that when moving connected client device from one place to another. Connected device stays connected to secured network and users will not have to re-connect again. The new Wi-Fi solution provides different SIDs in use, one is meant for employees, one is meant for smart-devices and one is for visitors to have access to internet. Employees should get certificates automatically for their laptops and company provided SMART-devices (e.g. Smart phones). Visitors will be provided certificates that remain active for the duration of their visit. These certificates can be provided by authorized persons. When the device connects to the network, the connection and the connected device are authenticated via ISE and the connection is logged in to SPLUNK, which stores the connection information for certain amount of time.

References

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2 Cisco 3504 Wireless Controller Installation Guide, December 6th 2018

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4 Wi-Fi Jyväskylä site survey report 2019 (confidential)

5 Wi-Fi network topology 2019 (confidential).