
**The University of Michigan
Network Working Group
IT Commons Initiative
Unlicensed Wireless Point-to-Point Technical Paper
August 3, 2005**

This document has been assembled and published to provide guidance for units who wish to install an unlicensed wireless point-to-point link. It is understood that factors such as funding, location, or other specific issues may require installations that need not completely follow the guidelines set forth. In such cases, these guidelines should still provide a useful starting point. We recommend that any departures from these guidelines should be made only after careful consideration of all relevant engineering and desired performance factors.

U-M units who have questions about or are interested in installing an unlicensed wireless point-to-point link should contact their ITCOM Project Manager:

<http://www.itcom.itd.umich.edu/customer/projectmanager.html>



Guidelines for Unlicensed Point-to-Point links at The University of Michigan

Introduction

RF (Radio Frequency) P-P (Point-to-Point) links are designed to provide connectivity between locations that is otherwise inaccessible or cost prohibitive using conventional copper or fiber methods. Like other RF technologies, the design must consider special constraints to insure maximum link reliability. This paper is intended to provide basic background information to support the design and installation of P-P links using unlicensed radio spectrum.

Requirements Capture

Like any other design, accurate requirements capture of the project determines whether the project is feasible, meets the needs of the user, as well as the budgeted cost targets. For P-P links, it is necessary to understand the maximum desired full-duplex link speed, distance between end points, necessary network protocol support (such as 802.1P or 802.1Q), physical constraints for antenna placement and power / data connections.

Desired full-duplex link speed and distance between end points can be mutually exclusive. Like indoor WLAN, as distance increases, throughput decreases. ITCOM has compiled a spreadsheet of equipment, and basic specifications to determine what choices might be available for maximum link distances vs. maximum throughput. Most equipment will support layer 3 protocols, but should be confirmed in advance.

Site Survey

The location of the physical equipment will need to be determined. Power and data should be available, and consideration should be made for ODU (Outdoor Unit), IDU (Indoor Unit) or both. In the case of ODU and IDU equipment, there will be RF or other cable between the devices. The locations should be as high as possible, and Visual LoS (Line-of-Sight) must be confirmed at this time. If there are buildings, trees / foliage, or other obstacles between locations, the link will likely not work and other alternatives should be investigated. The antennas must face each other at opposite ends of the link. A pair of binoculars may be required to better evaluate the visual link. It should be noted that visual LoS does not guarantee RF LoS.

Once approximate antenna / equipment locations have been determined, the best method to determine distances between locations is through the use of a GPS (Global Positioning System) receiver. Locations should be displayed in Longitude and Latitude, and subsequently recorded as part of the project. Using a program, or web-based calculator the distance in meters and / or kilometers can be obtained. Do not use miles or nautical miles for these calculations.

Knowing the exact distance, and the desired throughput, the proper equipment must be selected. Some equipment will require optional antennas; these will be determined when calculating the link budget (extra RF signal to account for weather or other conditions).

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If the distance and throughput don't match a particular piece of equipment then trade-offs of distance and throughput must be achieved before proceeding.

Vendor Technical Discussions

Many vendors, due to the competitive nature of the business, don't publicly publish technical documentation on their products. In many instances, there are derating factors or other equipment limitations that must be known or accounted for. An example might be the Crain Model rainfall zone for 60 GHz deployments.

Some items to consider and discuss with vendors may include:

- Are there differences in throughput for bidirectional and unidirectional traffic?
- Can the vendor provide throughput data for different MTU sizes or types of traffic?
- Does the PHY employ any form of FEC (Forward Error Correction)?
- For full-duplex radios is there sufficient receiver isolation to prevent self-interference?
- For integral antenna products, what additional losses must be considered in the link budget?
- What is the minimum receiver sensitivity and BER to support a particular PHY?
- Are there 50 Ω ports to monitor receiver or transmitter IF (Intermediate Frequency)?

Link Budget / LoS

Upon selection of a particular piece of equipment, the RF link budget and RF LoS must be verified. Each manufacturer provides information to easily calculate this information. The link budget considers coaxial cable and connector losses, antenna gain, transmitter output power, minimum receiver sensitivity and free space path loss over the calculated distance in meters or kilometers. It is strongly recommended that any design have a minimum 20db fade margin (overhead) for maximum reliability (~99.999%).

RF LoS is the first Fresnel Zone. The first Fresnel Zone is a cone / ellipse with the endpoints at each antenna. The maximum width of the ellipse is a function of the distance between the end points and the frequency. As distance increases, so does the size of the Fresnel Zone. As frequency increases, the Fresnel Zone size decreases. It is best to have no obstructions in the first Fresnel Zone, but up to a 40% blockage may be tolerable.

The maximum radius of the first Fresnel Zone, located at the midpoint of the link, for any given wavelength λ can be determined as follows:

$$R = \{ \lambda * [(1/2*D)^2 / D] \}^{1/2}$$

R – Radius in meters

D – Distance in meters

λ – wavelength in meters

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Physical Installation – Link Setup

The Site Survey and Link Budget performed above will dictate the type of equipment and antennas. After it has been confirmed that the ODU, IDU, or both can be installed in the desired location, the most critical piece is the antenna. The antenna, whether external or integral to the radios, must be mounted with the direction of radiation facing the other antenna. It must be mounted as securely as possible to minimize swaying due to wind or other weather as this may affect the quality of the RF link.

Each manufacturer provides PC based software to allow engineers / technicians on each end of the link to adjust their antennas for the best possible signal. This will require a knowledgeable person on each end of the link in constant communication while the antennas aligned. When both ends have confirmed the best possible signal strength, and with adequate fade margin, the antenna mounts must be secured and signals verified once again.

After the antennas are secured, final weather proofing of connectors and equipment must be completed. Do not weather proof prior to antenna / equipment alignment in case disassembly is required.

Final Confirmation

Upon completion of installation, the P-P equipment should be integrated with the networks on each end. Duplex mismatches of the network equipment are easily overlooked. Care should be taken upon final installation and confirmation to insure media converters, switch ports, radio interfaces, and other network equipment are properly configured for the correct speed and duplex setting.

An iPerf test is recommended to validate required throughput of the link prior to certification and cutover.