Wireless Distribution Service Systems

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Abstract:

This paper identifies problems and offers solutions for large-scale wireless distribution systems in low-power environments. Many situations require fast deployment of low cost, long distance wireless access points in areas where little to no electrical power is available, such as public parks, disaster areas, and construction sites. Issues such as solar power and wind power alongside batteries are considered, along with power efficient protocols. Mechanisms to control bandwidth along distributed wireless networks such as Wireless Distribution Service are also analyzed. Various types of cheap and effective hardware and firmware are also discussed. All of these components are brought together to form a possible practical solution that is power friendly, cost effective, and relatively power stingy.

1.1 History

Wireless systems have been in development for decades now. Technology has advanced from basic radio communication presented as a back pack device and truck mounted equipment all the way to the current minimal size of the Razor phones. From our cell phones to our laptops to satellite television, wireless communication stands inseparable from our lives, and without it we would never have the conveniences of today's world.

2 Importance

2.1 Networking

Networking has revolutionized the world. Since the original telegraph transmissions allowed news to travel across the world in seconds, the world began shrinking. Technology has transformed communication, bringing everyone into such close contact that now, there is an imperative need to be attached to the network. Rapid communication with your friends and allies allows for watchful eyes on your adversaries. With up-to-the minute information at our disposal, rapid response and quick changes of strategy enable effective maneuvering in critical situations.

2.2 Modern Demand

The Internet now exists as an essential tool for any business to succeed, as well as for any modern person to cope in day to day life.

Without network connectivity, and the Internet as a whole, most business would not succeed. Credit would fail and be reduced the pre-electricity days of credit, where consumers are taken at a word rather than history as a result of the lack of electronic data available to check credibility.

2.3 Areas of Interest

In many situations, the deployment of computer networks is critical, yet establishing a wired network is unfeasible. In this case, completely wireless networks, or networks with no significant distance wiring, are required. The arrangement and configuration of the many access points and the possible protocols are areas of interest. Directed mid-range wireless signals, on the order of hundreds of feet, create long-range noise, polluting valuable and limited spectrum. Sharing a wireless spectrum between the back-bone signals (the equivalent of the wired part of a typical wireless network) and the users becomes yet another problem. Data routing in this case is simplified, as all of the access points are geographically static, and paths are constant. Power supply is an issue, in cases where the access points are placed in areas where no steady electrical supply is available.

3: Implementations

3.1 Existing Technologies

3.1.1 Wireless Distribution Systems (WDS)

The technology for Wireless Distribution Service already exists, though public adoption is still relatively scarce. WDS creates a wireless backbone between access points in the same wireless network. It functions similarly to a traditionally wired network. New IEEE specifications allow for static routing of data though such a network.

A WDS devices acts in two ways, either as a standard access point for wireless devices, a bridge connecting access points together, or both. DD-WRT, a highly customizable firmware for the WRT-54GL allows WDS, and supports mapping. This allows a cyclic loop of WDS stations without a data cascade, meaning that data will not infinitely travel though the network. Looped networks offer fault tolerance, so that a dropped link will not cause a network failure.

WDS halves the network bandwidth for each access point added to the system, as each signal needs to be received then retransmitted. Clever channel distribution and multiple gateways can reduce the total amount of network traffic.

3.1.2 Antennas

Existing antennas offer great flexibility. Commercially available antennas sport high gain and low loss transmission, highly controlled fields of transmission, and high prices. The same kinds of antennas used for cellular communication are available for Wi-Fi along with many other signal bands, but are out of a low-end price range. [3]

3.1.3 Multiple Gateway

Multiple access points to the greater internet can provide broad ranges of data flow. Should the network become clogged, data can be routed through the best point of access, or if the network is free and open, traffic can be sent to all gateways in order to accelerate downloads and uploads. [2]

3.2 Hardware

The most important part of this project is the hardware, without which there would be no access point. This project is aimed at lowest-cost equipment in order to facilitate installation and implementation.

3.2.1 Access Points

The Linksys WRT 54-GL router is an off-the-shelf unit retailing for extremely low prices compared to high-end commercial electronics. It is sold as a household wireless access point, firewall, gateway, and NAT server all in one box. It is highly customizable, running Linux firmware and sporting detachable antennas. Power consumption is relatively low.

3.2.2 Firmware

At least a dozen versions of firmware exist for the WRT 45G-L. Several versions are listed here. All support WDS, NAT server, simple Access Point, and Gateway mode, and can selectively activate or deactivate each feature. The default firmware does not provide WDS support yet, however it allows all other modes. The default firmware can be used in a pinch if there is no available way to flash new firmware. The DD-WRT firmware allows adjustment of broadcast strength, allowing a reduction in power consumption while still maintaining a clear signal. It allows tree based routing and static routing methods. Can be configured to run without maintenance, in a "fire-and-forget" fashion. It also can be configured to ghost other access points, so that as far as any one wireless device can tell, any access point is the same as another. [5] Tomato offers a better user interface, relatively easier to use. Capable of plug-and-play. [6]

3.3 Unit Design

The design of each unit is the ultimate decided in power consumption. The better the design, the lower the power demand.

3.3.1 Dual Unit

At each physical location, two network devices can be used. Each WRT-54GL has two antennas, and with two devices a total of 4 antennas can be delivered to each location. One device can act as a WDS, using a specific channel, connecting the two neighboring nodes and the other local WRT device. The WDS device can have two highly directed antennas, linking up and down the chain to other WDSs. The other local device, acting as an AP, is fitted with two biquad antennas. This makes it a focused antenna, nearly 180 degrees.

3.3.2 Single Unit Repeater

Alternately, other types of APs can be created for less cost but less backbone support. A single Linsys device at a location can be fitted with two biquad antennas and have it act as a repeater, or to simply "turn the corner" around an obstruction.

3.3.3 Transmission

Extensive research on antenna optimization exists, though are not applicable to this project. The purpose of this project is to keep costs as low as possible, and homemade antennas are not as finely-tuned as professional equipment. The exact measurement required for perfect transmission is not achievable on homemade equipment.

Clients attempting to access the network can connect to these devices, and the overall network coverage can be increased if the clients also enhance their signals with directional antennas. Network bandwidth can be increased if the AP and WDS act on different channels. The AP and WDS devices can be wired, their distance apart is negligible, about 2 inches.

3.4 Channeling

Using the Wi-Fi standard 3 non-overlapping channels, cross-talk between networks can be nearly eliminated. If they are devoted properly using coloring schemes or just foresight, network volume can be tripled. [3]

4 Issues

4.1 Power

Academic papers describing battery power supplies are limited. There are many discussing theoretical power and power supplies, along with ways to generate power. Using batteries, solar panels, and AC power to power the devices is not a matter of academic research, rather a matter of applied electrical engineering. [3]

4.1.1 Batteries

Battery draw and recharge is the critical issue for these units. Each location requires at least 12 hours of battery life, and this may end up exceeding the price of the access points. Fortunately, battery technoogy is improving, and as the country becomes more energy aware, power consumption is dropping.

4.1.2 Solar

Solar power technology has unfortunately stagnated, and is not improving at any significant rate. However, the amount of power required to run the devices is relatively low, less than a half amp, and solar power is plenty capable of generating low-current power. It is a viable option for these access points.

4.1.3 Wind

Small wind turbine have been in use on private sailboats for years. They are compact, lightweight, and efficient, but they require facing the wind and pricing is not very low.

4.1.4 Grid

Taking power directly from electrical transmission lines is the most obvious way. Unfortunately, this project is targeting areas with no or limited power supply. This could

still be tapped in the event that the power is intermittent and can be used to charge the batteries.

4.2 Antennas

4.2.1 Omnidirectional

Omnidirectional antennas are the most basic, simplest, and most common available. They cover a 360 degree wide range and offer effective gain in a close area. Traveling beyond the transmission range causes signals to drop precipitously until they fade to near zero. They are only effective at close range. [8]

4.2.2 BiQuad

The Bi-Quad antenna is a basic ground plate with a quarter, half, or full wavelength wire receiver. They offer moderate to high gain, around 10 dBi if built correctly, around 5 if there is a construction problem. They offer nearly 180 degree spreads and offer a longer range but a geographically separated area. [7]

4.2.3 Yaggi

Directional antennas, particularly D.I.Y. directional antennas, have been known to reach 10 mile links. This is extremely useful to create large-scale networks, however, testing and development is complicated, isolating the units to test are hard to do with signal range exceeding several hundred feet. Also, links shorter than this, which will be the general case, will cause noise at great distances and cross talk. It does also allow for redundancy, a node failure will not be a problem if the devices can simply talk over it. [8]

4.3 Wiring

Some devices local to a transmission point can be hard wired. This can be used to update firmware, or to link two devices in the same location. It can also be used to connect tiers in order to not pollute yet another channel for transmission in order to keep the sections isolated.

4.4 Weather

This is the biggest hurdle. Each component needs to be secured from Mother Nature, including extreme heat and cold, rain and drought, humidity and ice. Lack of wind and sun can prevent recharging of batteries.

5 Future Work

First and foremost, a proof of concept WDS system with two units must be established. Power supply at this point is irrelevant, as the first system should be designed to test bandwidth and data-loss over a relatively large connection. These units would employ grid-based power and use two custom made long range antennas to link them, with a short-range omnidirectional to evaluate their local use. All access points are configured to be Wireless Distribution Service points. WDS points allow for a series of wireless access points to act as a single point from the perspective of the

client. The first installed point is at a gateway to the Internet, if necessary or capable. It is equipped with a directional or focused antenna to direct the signal flow towards the coverage area.

The next access point is placed in line with the sightline of the first access point, configured with a WDS system, and a directional antenna back towards the first point, another directional antenna toward the next point. This can be repeated indefinitely into the distance, provided there is enough bandwidth and power. This constitutes a single tier. Provided this works a third unit would be added to the mix in order to measure the long-range effectiveness. This would be an attempt to discover the unit's optimum max-range while maintaining a low signal-to-noise ratio. Once these links are functioning and data-loss and packet-loss have been minimized, power consumption will be evaluated. Batteries, initially simple off-the-shelf batteries, will be used to evaluate their lifespan in operation, then solar cells will be equipped to ensure that a basic recharger can supply the power demands for each unit.

6 Sources

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