Electrical and Computer Engineering Department

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Independent Study – Wireless Repeater

Final Report

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Two-Channel Wireless Repeaters

1. Introduction

Wireless Repeater is a range extender with capable of providing higher data rate. It simply regenerates a network signal in order to extend the range of the existing network infrastructure. It does not physically connect by wire to any part of the network. Instead it receives radio signals from an access point, end user device or any other repeater and retransmits the frames. Research shows that by putting the wireless repeater between transmitter and receiver, we can increase the range by more than 100%.

Repeaters are very useful as they provide connectivity to remote areas that normally would not have wireless network access. Wireless repeater acts as a relay for frames traveling back and forth between the user and the access point. Most of the repeaters currently available are built in with access point but there are few, which are independent to access point. The difference is a cost. Independent repeater is cheaper than the one which is built in with access point. The range of the radio transmission depends on several factors like position of the repeater, number of repeaters, etc.

Basically, there are three set up options based on repeaters and transmitters in the system. In “Single Transmitter, Single Repeater installation”, there is only one transmitter, one repeater and one or more receivers. In “Daisy Chain Installation (Multiple Transmitter)”, there are up to 8 repeaters in succession to increase the range between the single transmitter and one or more receivers. In “Network Installation (Multiple Transmitters)”, there are multiple transmitters, repeaters and receivers in a complex network.

Repeaters are an excellent way to increase the radio range of an existing WLAN, especially if it’s not practical to install an additional access point to fully cover the location. The popular standard for WLANS is IEEE 802.11, which has changed the face of networking, providing tremendous flexibility for mobile worker and hassle-free Internet sharing for home users.

There are number of companies which make wireless repeater like Motorola, BELKIN, Orinoco, Cisco, D-Link, Intel, Buffalo Air Station, Apple Airport Extreme, etc. Data rate, throughput, range and compatibility are four main factors to measure the performance. The latest wireless standard is IEEE 802.11g, which uses all same technologies as 802.11a and is backward compatible with 802.11b. Most of the companies make wireless repeaters with the current IEEE standard 802.11g and with two operation modes, access point as well as repeater. Technically, there is a switch in the device, so when user wants to use it as an access point then he has to keep the switch at one position while for repeater he has to keep switch on the other position. Most of the current wireless range extenders provide maximum range up to 328 feet inside the home/office and 1500 feet outside with data rate up to 54 Mbps and throughput of 22-26 Mbps.

2. Association and Channel Selection

How does a mobile node (MN) associate with the AP? IEEE 802.11b uses DSSS (Direct sequence spread spectrum) signaling technique. It divides 2.4 GHz band into 14 MHz channels. Three out of 14 are non-overlapping channels. The key contribution of the wireless LAN standard was to standardize the physical layer support of two new speeds, 5.5 Mbps and 11 Mbps.

The 802.11b MAC layer is responsible for how a MN associates with an access point. When an 802.11b client enters the range of one or more APs, it chooses an access point to associate with, based on signal strength and observed packet error rates (AP periodically, e.g. every 100ms, sends beacons with information such as BSSID and timestamp, where BSSID is usually the MAC address of the AP). MN registers itself with the AP (how the associated information is maintained in DS is not specified in the standard) and tunes to the radio channel to which the AP is set.

Periodically (or received signal strength of AP's beacon becomes weak) it surveys all 802.11b channels in order to assess whether a different access point would provide it with better performance characteristics. MN chooses the AP with the strongest beacon and sends a reassociation request to the new AP, which contains information on MN and

old AP. How old AP is informed about the handoff is not specified in the standard. There is an emerging standard called, IAPP or inter-access point protocol. Please refer [1] for more information.

A repeater (RP) defines a BSS, manages its associated MNs and constructs an ESS with the original AP. Thus, all MNs reachable from a RP but not from an AP would consider themselves within the BSS of the AP. (If the RP does not define its own BSS but just forwards packets, the RP should duplicate all the packets from the AP as well as from MNs, which does not make sense.) When the AP receives data packet that is destined to a MN in the RP's BSS, it must deliver the packet to the RP through the DS (FromDS / ToDS are all "1" in MAC data format).

3. Use of Two Channels in a Repeater

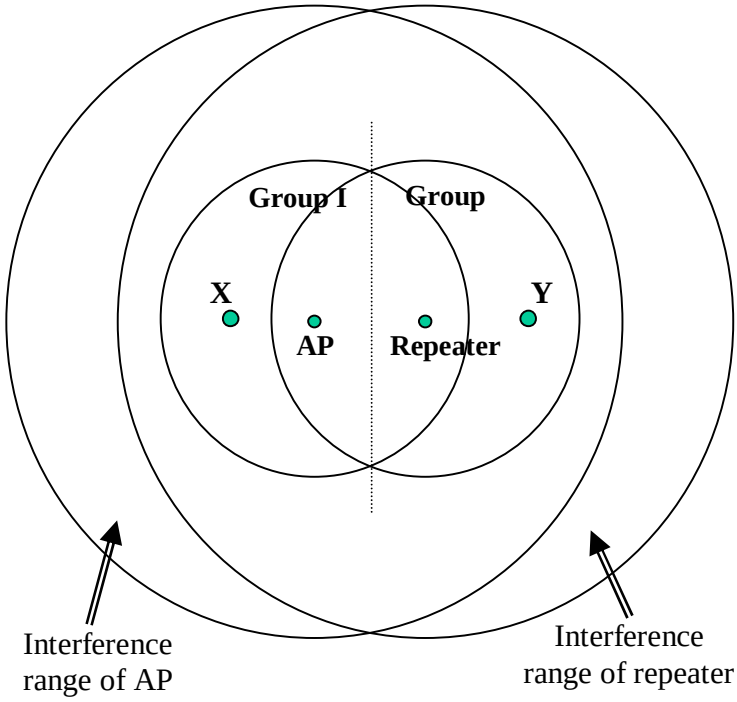

Figure 1: A simple mobile network with one AP and one RP.

Does the use of two channels improve the performance? Since the interference range is usually more than double the transmission range (e.g., 550m versus 250m), all MNs, AP and RP compete for gaining access right to the medium as depicted in Figure 1.

And the offered load is about 150% of the original load since packets destined to or originated from Region II are duplicated by the RP. (Here, we assume that node density is the same between around AP and around RP, which may not be true in real implementations.)

On the other hand, if two separate channels are used for AP and RP (e.g., channel 1, 6 and 11 are non-overlapping channels defined in 802.11b), AP and MNs in region I would feel 100% offered load while RP and MNs in region II would feed 50% of the offered load. A caveat of the approach is that the RP must be able to switch channels in a time-multiplexed way or equipped with two NIC cards, each capable of communicating with a different channel. We consider the second case because the first alternative seems not feasible. Figure 2 compares the performance with the assumption that the MAC layer protocol is simply a slotted ALOHA. (Exact analysis of backoff mechanism-based protocol such as IEEE 802.11's DFWMAC is still an open question [3-5].)

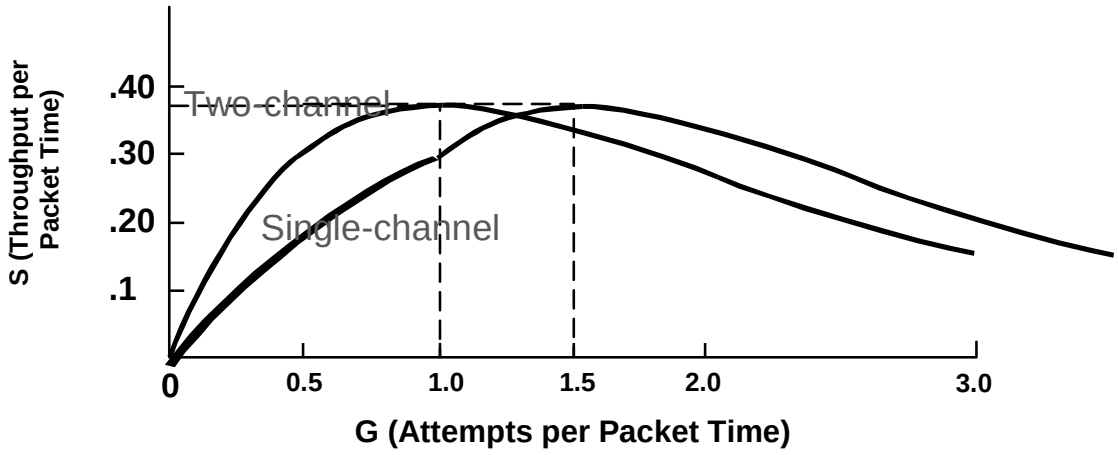

Figure 2: Performance comparison between two- and one-channel repeaters.

However, it is not clear whether or not this multi-channel solution is scalable with more than two BSSs with more than two RPs. For example, consider a more complicated repeater network as exemplified in Figure 3. In the extreme case, every RP has to equip with three NICs (channel 1, 6 and 11), which is expensive and may requires a sophisticated data queueing and forwarding among the NICs. This issue and more accurate assessment of performance comparison will be the future work.

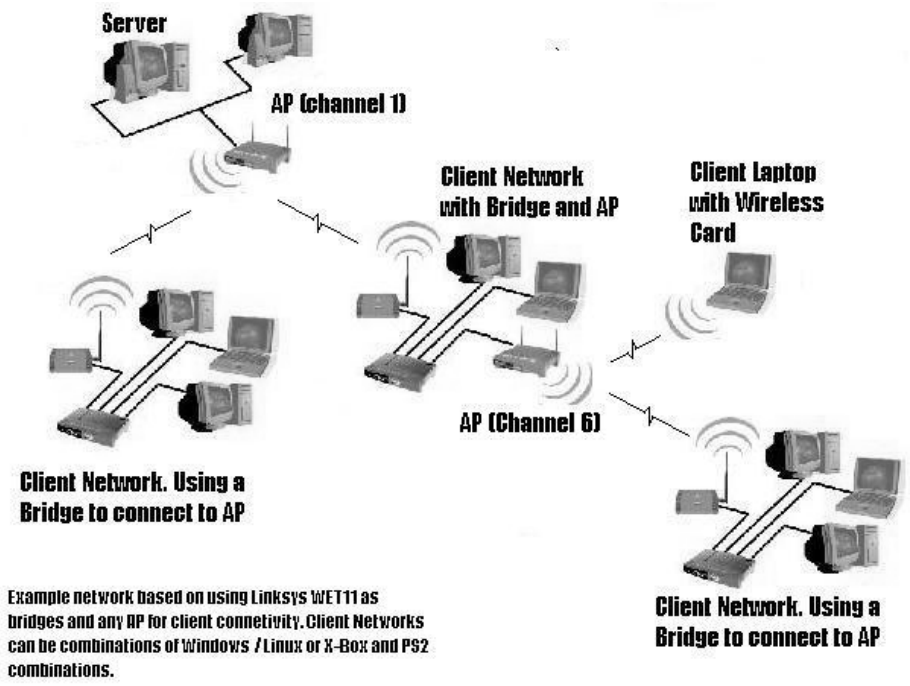

Figure 3: Example mobile network with multiple RPs and multiple BSSs [5].

[1] Pahlavan, K., and Krishnamurthy, P., "IEEE 802.11 WLANs," Ch. 11, Principles of Wireless Networks, Prentice Hall PTR, Upper Saddle River, New Jersey, 2002.

[2] Khurana, S., Kahol, A., Gupta, S. K. S. and Srimani, P. K., "Performance Evaluation of Distributed Co-Ordination Function for IEEE 802.11 Wireless LAN Protocol in Presence of Mobile and Hidden Terminals," MASCOT'99, pp. 40-47, 1999.

[3] Weinmiller, J., Woesner, H., Ebert, J.-P., Wolisz, A., "Analyzing and Tuning the Distributed Coordination Function in the IEEE 802.11 DFWMAC Draft Standard," MASCOT'96, 1996.

[4] Cali, F., Conti, M., and Gregori, E., "Dynamic Tuning of the IEEE 802.11 Protocol to Achieve a Theoretical Throughput Limit," IEEE/ACM Tr. Networking, Vol. 8, No. 6, pp. 785-799, Dec. 2000.

[5] "Community Wireless Project," http://www.retro-city.co.uk/bovistech/wireless/help.htm