# A Mesh Networking using WDS

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Abstract. In this paper, we propose a new way of construct a mesh network and compare the performance with an existing routing protocol, the BATMAN-ADV. A mesh network can be built using the WDS feature of the IEEE 802.11, which run on Layer 2 of the OSI reference model. The BATMAN-ADV also run on Layer 2. The BATMAN-ADV routing protocol is one of a few protocols available in software package incorporated into the OpenWrt OS for embedded systems. Our experiments involve the throughput and delay performance measured on a linear mesh network over varying number of hops between two end nodes. The results show that WDS performs better in the throughput and the round trip time delay. The higher throughput and the lower delay of WDS is attributed to the structural efficiency of the WDS delivery mechanism.

Keywords: mesh networks, ad hoc networks, WDS

## 1 Introduction

The Internet Engineering Task Force (IETF) have proposed several routing protocols for mobile networks. The mobile ad hoc routing protocols can be categorized largely into three types: proactive (or table-driven) routing protocols, reactive (or on-demand) routing protocols, and hybrid routing protocols which are combinations of the two [1]. The proactive routing protocols broadcast the routing information periodically or whenever the network topology changes, to maintain the up-to-date routing table in the routers. They include DSDV (Destination Sequenced Distance Vector) [2], and BATMAN (Better approach to mobile ad-hoc networking) [3]. In the proactive routing protocols, the nodes always maintain the most recent routing information so that a packet can be delivered with limited delay, but periodic broadcasting of routing information uses up too much scant transmission bandwidth in the mobile environment. On the other hand, the on-demand routing protocols reduce the excessive overhead by searching a route to the destination immediately before a packet is transmitted when it is not available. They include AODV (Ad Hoc On-demand Distance Vector) [4] and DSR (Dynamic Source Routing) [5]. Due to the delay in the initial route search process, many on-demand routing protocols have been proposed to minimize the initial route search delay.

In this investigation, we have tested two wireless multihop delivery systems, one of which is a IEEE 802.11-based mesh network routing protocol package, BATMAN-ADV (Better Approach To Mobile Ad-hoc Networking - Advanced), and the other is the IEEE 802.11's own wireless distribution system (WDS). Note that WDS is not a routing protocol, but a delivery mechanism between APs (or STAs associated with the APs). Along with IEEE 802.11s' openlls package [6], the BATMAN-ADV routing mechanism is one of a few packages available to the public.

# 2 BATMAN-ADV and WDS

## 2.1 BATMAN-ADV

BATMAN-ADV is based on the IETF Internet Draft, "Better Approach To Mobile Ad-hoc Networking (B.A.T.M.A.N.)" [2]. BATMAN-ADV detects the presence of BATMAN-ADV Originators, no matter whether the communication path to/from an Originator (this term "Originator" refers to as any node within a BATMAN-ADV-based L2 network) is a single-hop or multi-hop communication link. The protocol does not try to find out the full routing path, instead it only learns which link-local neighbor is the best gateway (or neighbor) to each Originator.

On a regular basis every node broadcasts an originator message (or OGM), thereby informing its link-local neighbors about its existence as a first step. Link-local neighbors which are receiving OGMs are relaying them by rebroadcasting it, according to specific BATMAN-ADV forwarding rules. The BATMAN-ADV mesh network is therefore flooded with OGMs. In order to be able to find the best route to a certain Originator, BATMAN-ADV counts the OGMs received and logs which link-local neighbor relayed the message. Using this information BATMAN-ADV maintains a table with the best link-local router towards every Originator on the network.

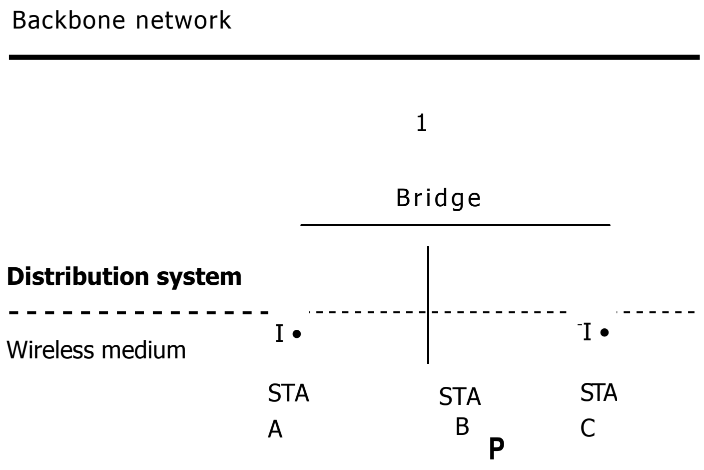


Fig. 1. The distribution system in IEEE 802.11

### 2.2 WDS (Wireless Distribution System)

Sometimes the mesh network may simply form a linear topology. The reason is two-fold: to provide a logical link to a remote location and to provide a service coverage to a line-shaped area. Most likely the network deployment along the street falls into the second category, which may be used for the **ITS** (Intelligent Transportation Systems). In this case, the linear formation may be constructed using a way other than mesh routing protocols.

The IEEE 802.11 standard describes the distribution system in terms of the services it provides to wireless stations. The distribution system provides mobility by connecting access points. When a frame is given to the distribution system, it is delivered to the right access point and relayed by that access point to the intended destination. The distribution system is responsible for tracking where a station is physically located and delivering frames appropriately. When a frame is sent to a mobile station, the distribution system is charged with the task of delivering it to the access point serving the mobile station. Most access points currently on the market operate as bridges. They have at least one wireless network interface and at least one Ethernet network interface. The Ethernet side can be connected to an existing network, and the wireless side becomes an extension of that network. Relaying frames between the two network media is controlled by a bridging engine.

Fig. 1 illustrates the relationship between the access point, the backbone network, and the distribution system. The access point has two interfaces connected by a bridging engine. Arrows indicate the potential paths to and from the bridging engine. Frames may be sent by the bridge to the wireless network; any frames sent by the bridge's wireless port are transmitted to all associated stations. Each associated station can transmit frames to the access point. Finally, the backbone port on the bridge can interact directly with the backbone network. The distribution system in Fig. 1 is composed of the bridging engine plus the wired backbone network.

Every frame sent by a mobile station in an infrastructure network must use the distribution system. Wireless stations in an infrastructure network depend on the distribution system to communicate with each other because they are not directly connected to each other. The only way for station A to send a frame to station B is by relaying the frame through the bridging engine in the access point.

The 802.11 specification supports using the wireless medium itself as the distribution system. The wireless distribution system (WDS) configuration is often called "wireless bridge" configuration because it allows network engineers to connect two LANs at the link layer. Wireless bridges can be used to quickly connect distinct physical locations and are well-suited for use by access providers. Most 802.11 access points on the market now support the wireless bridge configuration [7].

## 3 Experiments with BATMAN-ADV and WDS

We have used as an operating system the OpenWrt (kernel version 2.6.39.4) on five UBiQUiTi RouterStation Pro platforms which are equipped with a Atheros AR7161 CPU. The WLAN mini-PCI card uses an Atheros' AR9220 chip which supports 802.11a/b/g/n. As a driver for the WLAN Atheros AR9220 chip, Intel's mac80211 v.0.9.4 is used.

The channel assignment is as shown in Fig. 2. Each mesh node except the end nodes is equipped with two WLAN cards, each of which is assigned a different channel to avoid interference in transmitting and receiving frames simultaneously. The radio interfaces are configured to be bridged together in each node so frames are routed within the bridge automatically. Channels have been assigned in such a way that the interference is minimum between neighboring channels. For the 802.11n mode, we have used the HT (high throughtput) mode so the maximum throughput could reach up to 300 Mbps (in the physical layer) For WDS, we need to tie two neighboring nodes together manually to establish a linear topology.

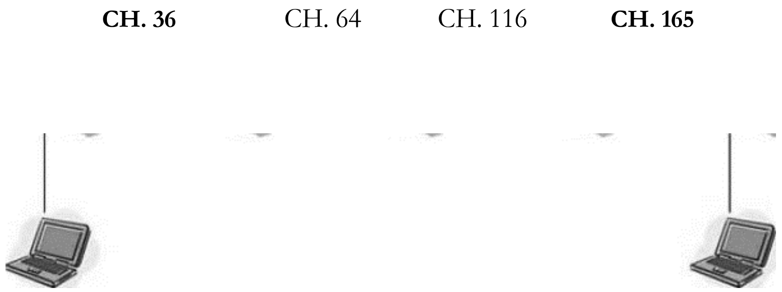


Fig. 2. The channel assignment in the linear topology

The throughputs have been measured for different numbers of hops between two laptops. That is, the first laptop in Fig. 2 is always connected to the leftmost node through an Ethernet connection and the second laptop is connected through an Ethernet connection to different nodes to form different numbers of hops. We have used the *iperf* measuring tool for 30 seconds and the delays have been measured using the ping command for 100 packets. Those measurements are repeated three times and averaged.

Fig. 3 shows the throughputs and delays for various number of hops between nodes. The throughput graph in Fig. 3 show that WDS performs better for all different number of hops. The average throughput degradation for 4 different hop cases is 13.1% for 802.11a and 14.7% for 802.11n. The average throughput degradation for BATMAN-ADV is 20.3% for 802.11a. As the RTT (routing trip time) delay graph in Fig. 3 indicates, WDS again performs better for all cases (different number of hops). Approximately the delay increases by 1 ms every hop.

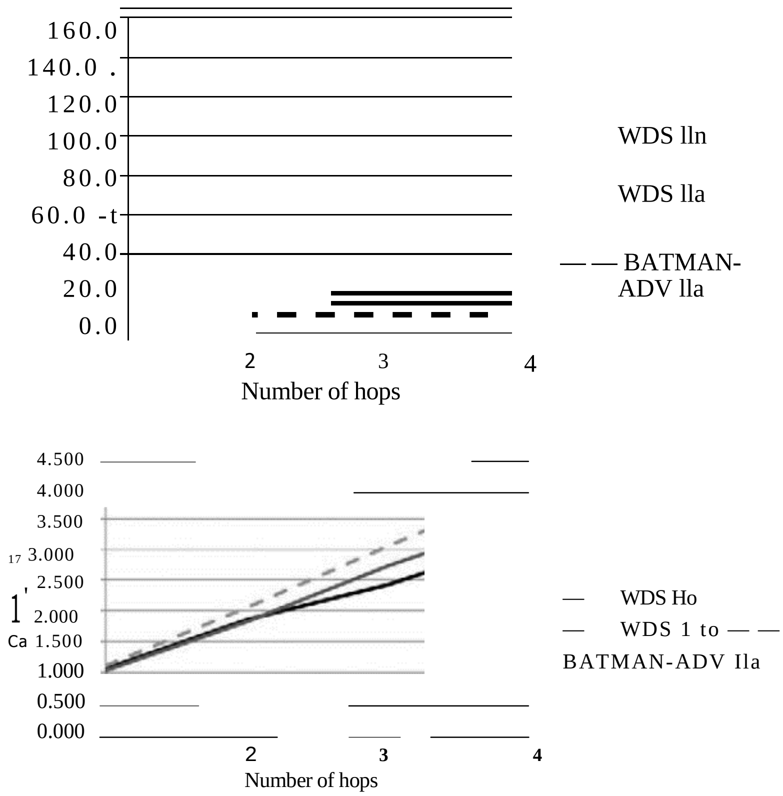


**Fig. 3.** Throughputs and delays in a linear topology

## 4 Analyses of the Results

In both results WDS shows better performances than BATMAN-ADV. We think the improvement for the throughput is achieved because the WDS delivery mechanism is much simpler than BATMAN-ADV in that WDS knows which AP has the destination station at the beginning so it simply deliver the frame to the neighbor AP until it reaches the targeted AP. We also think that less routing control traffic such as RREQ (route request) or RREP (route reply) flood the network which leaves more resource for the user traffic. WDS algo gives a smaller RTT delay than BATMAN-ADV. We think it is because WDS have streamlined the delivery process so there are less processes required than BATMAN-ADV. For example in BATMAN-ADV it encapsulates every user frame to get them to its destination. So we think as long as the mesh topology is tree-shaped, WDS works better than any other routing protocols.

## 5 Conclusions

BATMAN-ADV is a publically available L2 mesh routing protocol. WDS is a frame delivery mechanism between APs standardized in IEEE 802.11. Sometimes the mesh network may simply form a linear topology to provide a service coverage to a line-shaped area. It would be also beneficial in that a linear topology can be built without any routing protocol involved, where WDS can be applied. It is worth comparing two routing protocols and a built-in delivery mechanism. An experimental comparison shows that WDS performs better in the throughput and RTT delay. This is because WDS does not rely on the routing control frames to maintain its forwarding table as BATMAN-ADV does.

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