Delay/Disruption Tolerant Mesh Network Using LibreMesh and IBR-DTN

Virgínia Tavares, Moacir Neto, Francisco Müller and Aldebaro Klautau

***Abstract*— The Wireless Mesh Network (WMN) allows communication between wireless devices with the aid of multihop wireless mesh routers, while they are within range of the radios, under penalty of data loss. But, long distances, delays, disruptions or disconnections between nodes are a challenge to Wireless Mesh Network. The DTN (Delay / Disruption Tolerant Networking) technology allows the transfer of continuous and quality data in a network, this technology has a data delivery guaranteed by its Store-and-Forward mechanism. This article presents a low-cost and easy implementation of a Delay/Disruption Tolerant Wireless Mesh Network, through WMN associate with DTN. For the easy and low-cost implementation, we use the tools LibreMesh and IBR-DTN, because they are free and have low complexity. The validation of the implementation was through an analysis of Packet Loss and Round Trip Time (RTT) between the Mesh Network with and without the DTN association.**

***Keywords*— Wireless Mesh Network, DTN, IBR-DTN**

I. Introduction

Wireless Mesh Networks (WMNs) [1] comprises two or more routers working together to share routing protocols and creating an interconnected RF pathway. These routers are, in most cases, equipped with only one IEEE 802.11 radio [2]. Each router acts as a forwarding node to transfer the data, and the forwarding of data is possible only to the neighboring node. WMNs results in a simple, easy and self-repairing structure, with good reliability and scalability. However, scenarios with delay/disruption in nodes connectivity are a problem, because when the network link is low, the Wireless Mesh Network has a bad performance. A WMNs association with store-and-forward technology can easily solve this problem. The DTN (Delay/Disruption Tolerant Networking) is a store-and-forward technology because it bundles together the application data and stored at each node and then forwarded to the next node when access is available. This technology allows transmission of data where there may be no end-to-end connection between source and destination. It is based on designed protocols that deal with the unusual communication conditions, such as transmission delays of minutes or hours, intermittent connectivity, and low reliability [3]. This paper presents a Delay/Disruption Tolerant Mesh Network implementation. For this, associating WMNS to DTN technology. And also, produces a validation of this system through an analysis of Packet Loss and Round Trip Time (RTT), with and without the DTN association. The used tools will present in the following topic.

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II. Used Tools

There are several open-source software and hardware solutions for WMNs implementation. In our scenario, we used the Libre-Mesh platform [4], because it is a low complexity solution for the easy creation of self-configuring wireless networks. It is based on the routing protocols: BATMAN-ADV, BMX, and OSLR. The installation includes replacing the original firmware of the routers with Libre-Mesh firmware, which is specific to each router model. The Libre-Mesh firmware is based on OpenWRT, an extensible GNU/Linux distribution for embedded devices (typically wireless routers). Therefore, routers in the implementation should follow the requirements for OpenWRT support.

The standard communication protocol in DTNs is the Bundle Protocol (RFC 5050), as it mainly provides the ability to cope with intermittent connectivity and the ability to take advantage of scheduled and opportunistic connectivity (besides 'always up' connectivity). Forming the store-and-forward network. Bundle Protocol has several implementations for various platforms available, research as [5][6][7] have shown that the free software IBR-DTN [8] is an efficient implementation of the Bundle Protocol for embedded systems. In IBR-DTN, the exchange of information by the nodes occurs using the Wi-Fi module of the devices capable of receiving its installation. This tool is available in the form of a free app available for Android distribution, starting from Version 2.3. The IBR-DTN app enables the exchange of voice and text messages. IBR-DTN is also compatible with Linux operating systems, including OpenWRT. This software has features, such as DTNping that allow testing the connection between two IBR-DTN devices. And also, DTNsend and DTNrecv features that make files transmission between DTN nodes.

III. Performance Evaluation

Two Wireless Access Point (AP) containing the LibreMesh firmware composes our setup, we use the TP-Link-CPE510 300 Mbps with Memory 64MB DDR2 RAM and 8MB Flash Memory. The devices that were used to install the IBR-DTN was a Raspberry Pi 3 Model B, and a computer with a Core i5-7500 and WiFi module. Both configured with Linux as Operating System. In each AP has one device with IBR-DTN connected via LAN. Thus, to facilitate understanding, these pairs will be referred to as node A and node B throughout this paper. Figure 1 illustrates the setup.

To test our setup with delay/disruption, Node B was moved away from Node A and connection tests were performed on each distance increase of 5-meter. In the 20 meters distance,

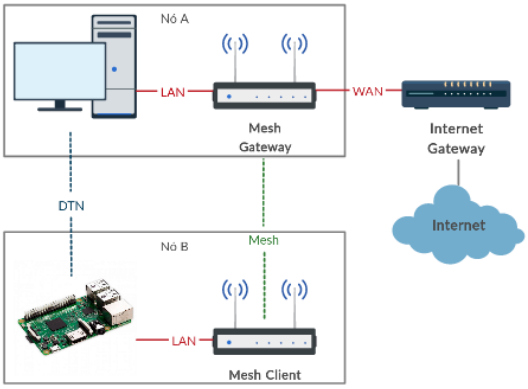

Fig. 1. Our Delay/Disruption Tolerant Mesh Network setup. The node A and B are composed, each, of a router with LibreMesh firmware and a device with IBR-DTN installed.

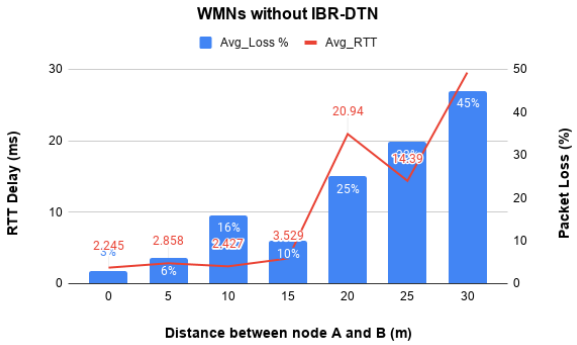

Fig. 2. RTT and packet loss due to nodes distance in our scenario without IBR-DTN

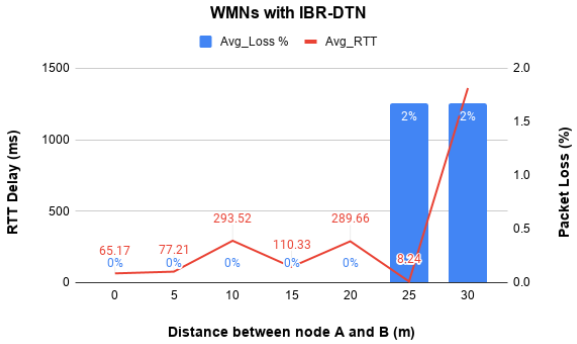

Fig. 3. RTT and packet loss due to nodes distance in our scenario with IBR-DTN

the Node B left the room and went to another, causing interference on the link. Every connectivity test was specified with a send of 60 packets of 64-byte and a 15 seconds disruption between nodes. In the scenario without IBR-DTN installed, we performed TCP Ping. And in the one with IBR-DTN installed, the DTNping was performed. It is important to bounce that we separately used DTNping and TCP Ping so that there is no interference with each other. The maximum distance tested between the nodes was 30 meters.

We analyze our network through the parameters: average Packet Loss Rate (percentage of transmitted packets arriving at their destination) and average Round Trip Time (time required for a packet to travel from the source to the destination and back again). The network without the DTN protocol has a large rate of package loss, Figure 2 shows it. WMN without IBR-DTN continues to send the packets even in network disruption, and when reestablished connection it loses packets. In Figure 3 the resilience of the DTN is seen regardless of distance and delay, because the DTN itself holds bundles until the connection is reestablished. Thus increasing the delay-time, but decreasing the packet loss. Figures 2 and 3 have large a Round Trip Time (RTT) variation, because in a wireless network RTT is affected by several factors, e.g, physical distance between the nodes, mobility and presence of interference in the circuit [9]. From the RTT parameter is possible to determine the accomplishment of connection with and without IBR-DTN. However, without enough precision to be an absolute measure of performance.

IV. Conclusion

Through this work was possible to confirm that Wireless Mesh Network with an association with DTN technology provides a Delay/Disruption Tolerant Mesh Network. And that an implementation of this network can be realized using LibreMesh and IBR-DTN because they provided a good and simple environment. By all counts, and with proven results of the connectivity tests in a scenario with disruption and varied distance between nodes, we confirm that our network worked as we expected. As plans for the future, it is desired to test communication disruption for a long period and use a third DTN node as a Data Mule (packet carrier).

Acknowledgments

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