Towards a Monitoring System for a LoRa Mesh Network

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***Abstract*—LoRa is a popular communication technology used in Internet of Things (IoT) applications. Typically, in the LoRaWAN architecture, an end node periodically sends a LoRaWAN message to a gateway connected to the Internet. Recent works, however, showed the possibility of LoRa mesh networks where LoRa nodes communicate with each other. In this paper we present a monitoring system as a tool for observing the traffic and the operation of such LoRa mesh networks. The client side is implemented at the LoRa nodes which periodically send to a server detailed information about the nodes' in-and outgoing LoRa packets. The server visualizes the information through a dashboard. Thus the monitoring tool allows network administrators to further analyze such LoRa mesh networks.**

***Index Terms*—IoT, LoRa, Mesh networks.**

I. Introduction

LoRa is a communication technology for the Internet of Things (IoT). It is typically used to send a small payload of data from a sensor device to a gateway. LoRa provide links of several km between devices, low power consumption and is designed for applications with low data rates [1].

Most LoRa IoT applications apply the LoRaWAN architecture[1]. In terms of networking, LoRaWAN uses a star topology with a single hop between the end nodes and the gateway. There is no direct communication between LoRa nodes.

In recent research the LoRaWAN architecture has been challenged by proposing multi-hop [2], mesh and routing protocols [3]. In such proposals the LoRa node is either used as repeater that broadcasts traffic to other LoRa nodes to finally reach a gateway, or the LoRa nodes perform even as tiny routers [4]. Real field deployments of such multi-hop LoRa networks have already been made, such as in Ebi et al. [5], who proposed a synchronous LoRa mesh network. Another prominent example is Meshtastic [6], a real operational application which only communicates within a LoRa mesh network without any gateway to the Internet.

Considering that LoRa mesh networks are now becoming piloted in real life deployments, it is timely for network administrators and researchers to have a tool that allows to deeper analyze practical aspects of such networks. For distributed computing such LoRa mesh networks can enable novel IoT applications that run on a new computing layer formed by tiny compute nodes. Given the resource constraints of these distributed tiny devices, there will be new challenges for the community to optimize protocols and algorithms.

In this paper we introduce a monitoring system which we have developed as a first step for studying the traffic in such LoRa mesh networks. We first give an overview about the design and then show with an initial dashboard the usability of the monitoring system.

II. System Design and deployment

LoRa IoT devices are typically embedded system which contain a microcontroller board with LoRa radio and sensors. The more powerful boards can be programmed leveraging a Real-Time Operating System (RTOS) framework, which enables task management within the code at the node.

For our work we use as LoRa node the TTGO T-Beam ESP32 board. This device is based on the ESP32 System on a Chip (SoC) and feature an SX1276 LoRa transceiver (Fig. 1). Furthermore, it has BLE and Wifi networking interfaces. This board is also one of the suggested hardware of the previously mentioned Meshtastic [6] application.

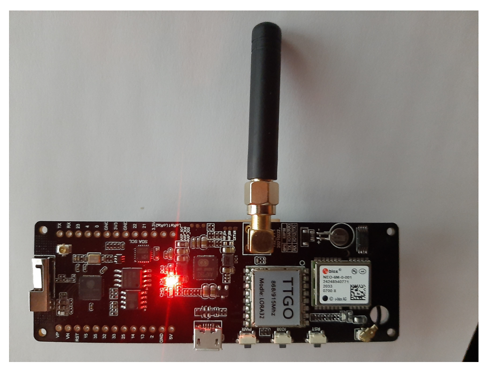

Figure 1. T-Beam board with LoRa radio used for the experimentation.

To do LoRa mesh networking with the TTGO T-Beam, we use the LoRaMesher library [2], which we have developed and which implements the routing protocol for LoRa mesh networks proposed in [4].

In order to monitor traffic in the LoRa mesh network, our approach is to take data at the LoRa node and sending it to a remote server using one of the device's networking interfaces. The choice was to use the Wifi interface of the TTGO T-Beam.

[1]LoRa alliance https://lora-alliance.org/

[2]https://github.com/LoRaMesher/LoRaMesher

 DOI 10.1109/ICDCS54860.2022.00139

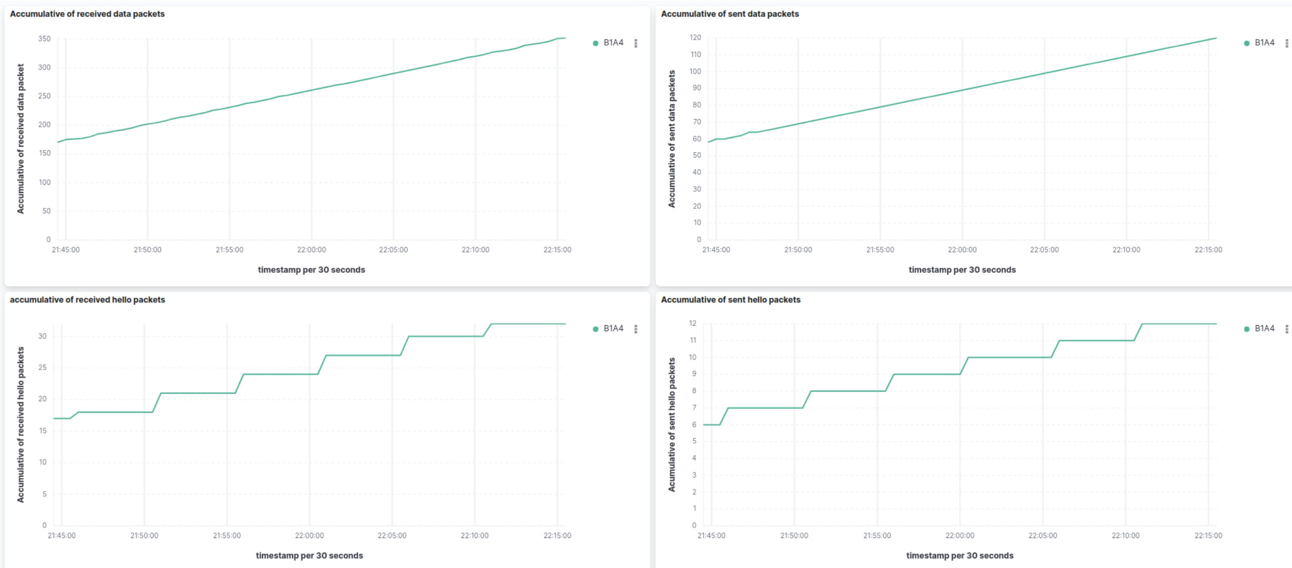

Figure 2. Monitoring system dashboard with selected traffic indicators.

The monitoring system is conceived as a client-server applications which communicates over HTTP. For this the client needs to run in a TTGO T-Beam node which has Wifi connectivity. The server can be hosted remotely at any PC or VM in the cloud with has a routable IP address.

In order to integrate the HTTP client into the LoRaMesher code, we create a new RTOS task with a routine to enable the Wifi connection, read counters containing traffic data and send the information to the server. The new task is set to low priority to maintain the priority of the other tasks. By default the task is scheduled by the RTOS to send every 30s a monitoring message to the server.

The server side of the monitoring system is built with node.js, ElasticSearch and Kibana. The node.js server receives URL encoded monitoring data from the clients. The Javascript client of ElasticSearch is used to establish the data flow between the node server and the ElasticSearch engine. Kibana is used to create the user interface through a dashboard.

We deploy the monitoring system at a server with public IP address[3]. For the LoRa mesh network we create a controlled scenario in order to show the usability. We flash four LoRa nodes with the code consisting of the LoRaMesher library and the extension of the monitoring system. The topology formed is a network where each node is one hop from each other. The nodes were configured to send LoRa routing messages every 5 minutes and data packets period every 30 seconds. Each node sends data packets to the other nodes in alternating order.

Figure 2 shows the dashboard of the monitoring system after 30 minutes of execution with a view on the traffic at the node 0xB1A4. In the top left corner we can see the accumulated number of the *total* received data packets for this node at certain time interval. The slightly nonlinear increase that can be observed points to collisions in LoRa packets. The dashboard also allows to chose other counters, such as the data packets received with this node as destination. The right side shows the number of sent data packets, which according to the experimental setup corresponds to a third of the received data packets. At the bottom left side we see the number of received routing packets and at the bottom right side, the cumulative of the sent routing packets.

[3]http://84.88.85.2:5601/

III. Concluding Remarks and Outlook

We introduced a monitoring system to enable studying and analyzing in detail the traffic and operations of LoRa mesh networks. We hope that this tool will be of help for the community to design and evaluate new protocols and algorithms for these resource-constraint distributed systems.

Acknowledgment

This work was partially supported by the Spanish Government under contracts PID2019-106774RB-C21, PCI2019-111851-2 (LeadingEdge CHIST-ERA), PCI2019-111850-2 (DiPET CHIST-ERA).

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