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University of Padova

Department of Information Engineering

Bachelor thesis in
Computer Engineering

INSERT TITLE HERE

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Abstract

Inserire abstract. I margini nell'abstract sono stati ridotti di un centimetro. In caso non si volesse questa riduzione rimuovere *changemargin*.

Glossary

GSM Acronym for Global System for Mobile Communications, it's a 2nd generation mobile communication standard, see [2] for more information.

LTE Acronym for Long Term Evolution, it's a 4th generation mobile communication standard, see [3] for more information.

FTP Acronym for File Transfer Protocol, built on top of TCP, see [4] for more information.

VHF Acronym for Very High Frequency, it refers to the radio frequency band between 30 and 300 MHz.

Contents

Chapter 1

Introduction

Place introduction here

Chapter 2

Bacco protocol

The goal of this chapter is to give a detailed description of the *Bacco* protocol and to discuss the implementation choices that were taken in order to deploy it. This is achieved using a top-down ordering for the level of detail, meaning that an overview of the network is to be presented before going into the specifics.

2.1 Overview

The network is built upon 3 fundamental categories of devices:

- Sender node - collects data and sends it to the gateway using LoRa
- Repeater node - listens to the incoming LoRa messages and repeates them
- Gateway node - collects data coming from the sender nodes and sends it to the web server using the FTP protocol over a mobile network such as GSM or LTE [1]. This node has also the role to coordinate the sender nodes that are sending data to it
- Web server - receives data coming from the gateways through FTP, elaborates it and makes it available to consult through a self-hosted web application platform

[1] A gateway can be configured to optionally perform pre-processing operations (e.g. filtering, smoothing, interpolation ...) of the incoming data and can even collect relevant data on-site when needed

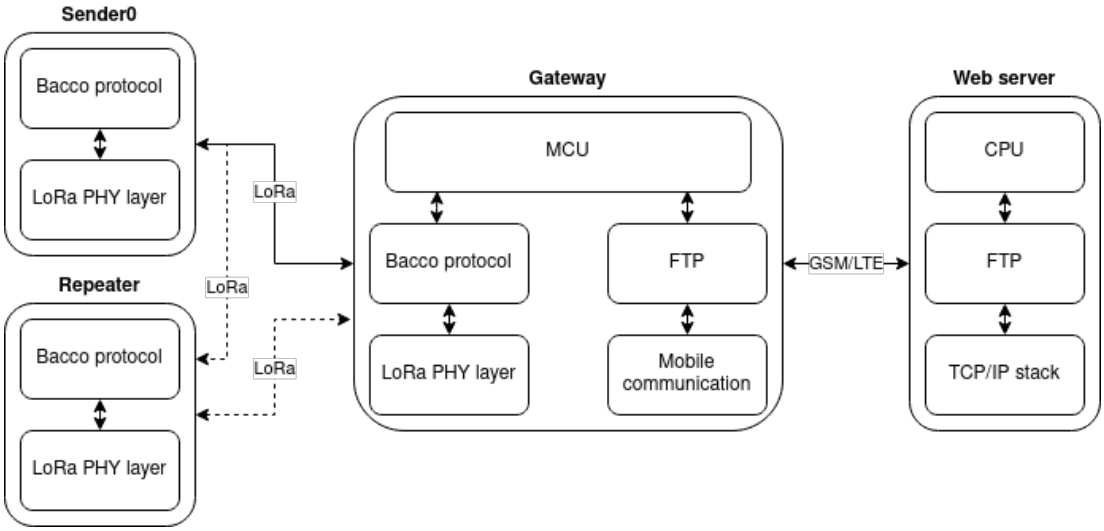

Figure 2.1: Schematic representation of the used protocols

2.2 Topology

The network has a star-of-stars topology, in which the first level is occupied by the Web server and the Gateways, wherease the second level contains the Gateways, the Repeaters and the Senders. [2] Figure 2.2 shows the type of devices that are involved and their communication schema.
The structure is equivalent to a tree, hence we can define a hierarchy of nodes. The root node is the central web server and its children nodes are the gateways. The gateways themselves are parents of either a repeater or a sender node, which correspond to the leaves of the tree.

2.3 Addressing

The addressing scheme follows from the hierarchical structure of the network.
A first description of the addressing algorithm is given in the case where there's a fixed number of nodes connected to the network. Later the procedure will be extended in order to achieve the addition or removal of nodes from the network.

[2]The use of Repeaters where physical obstacles compromise the integrity of the signals is of very high relevance in agricultural contexts, since natural barriers such as hills can easily block VHF radio signals.

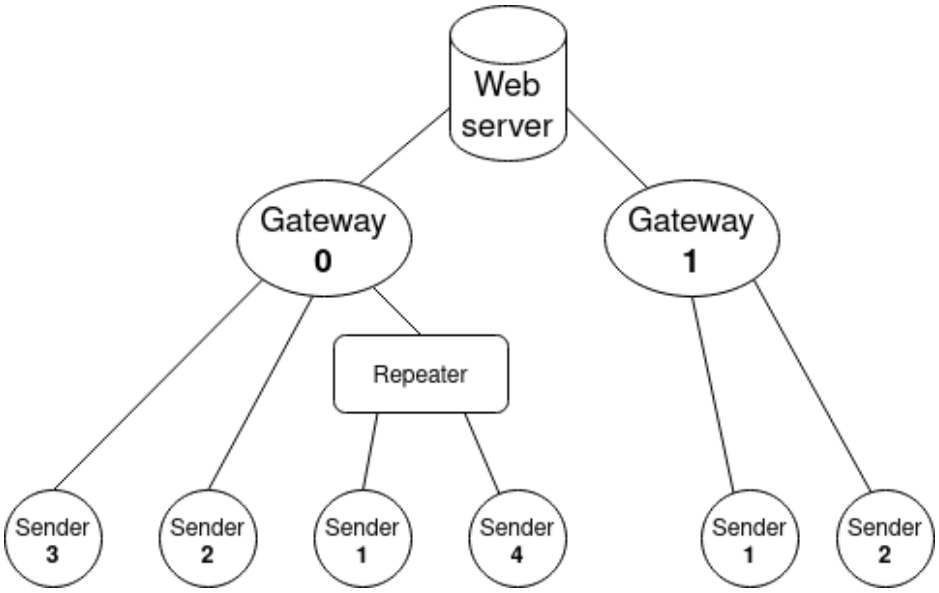

Figure 2.2: Network topology

2.3.1 Static addressing

In order to uniquely identify each node in a static network represented as a tree, we can apply the following procedure:

- May T be a tree and may r be its root node
- May $\{T_i\}$ be a forest of substrees with cardinality of I, where T_i is a subtree rooted in the child node i of r, and I is equal to the degree of r
- For each root node i, assing it an identifier that is unique among the other is. In particular the integers contained in the interval $[1, I]$ will be used to represent each node
- For each T_i apply the same procedure from the first step in a recursive way
- After applying this algorithm to every possible subtree down to the leaves, each node will have a unique identifier among its sibiling nodes
- Now, to get a unique identifier among all the network for every node, we can concatenate the identifiers generated by the algorithm for each ancestors of the node, starting from the root and traversing the tree form parent to child

Since there's only one central Web Server, it is redundant to have an identifier. Each Gateway is manually given a static and unique identifier based on its physical location in the range $[0, 65535]$. On the contrary, addressing of Sender

nodes can be managed dynamically by the corresponding Gateway in order to seamlessly integrate new sensors into the network. The maximun number of Sendr nodes connected to a single Gateway is limited to 128 [3].

- IQ inversion - CAD - OTA operation

[3]This choice is influenced by the Italian regulations on duty cycle (see [**CITAZIONE PARAGRAFO REGOLAMENTAZIONE CHE DEVO ANCORA SCRIVERE**] and [1]) and the fact that most agricultural contexts do not require a huge amount of sensors

Bibliography

[1] "Ministero delle comunicazioni". *"Elenco delle interfacce per gli apparati radioelettrici - Apparati a corto raggio utilizzati per applicazioni generiche (es. telemetria, telecomandi, allarmi e simili)"*. "Band l $\Leftrightarrow 868,0 - 868,6 MHz$". Feb. 2005. URL: https://www.gazzettaufficiale.it/atto/serie_generale/caricaArticolo?art.versione=1&art.idGruppo=0&art.flagTipoArticolo=1&art.codiceRedazionale=05A00705&art.idArticolo=1&art.idSottoArticolo=1&art.idSottoArticolo1=10&art.dataPubblicazioneGazzet 2005-02-12&art.progressivo=0.

[2] Vijay K. Garg and Joseph E. Wilkes. *Principles and Applications of GSM*. Prentice Hall PTR, 1998. ISBN: 0139491244. URL: https://dl.acm.org/doi/abs/10.5555/552293.

[3] Amitava Ghosh et al. "LTE-advanced: next-generation wireless broadband technology [Invited Paper]". In: *IEEE Wireless Communications* 17.3 (2010). DOI: 10.1109/MWC.2010.5490974.

[4] J. Reynolds J. Postel. *File transfer protocol (FTP)*. RFC 959. Network Working Group, 1985. URL: https://datatracker.ietf.org/doc/html/rfc959.