LoRa for Internet of Things applications: LoRaWAN and LoRa-based protocols to support real-time communications

keywords: LoRa, LoRaWAN, Low-Power Wide-Area networks, Medium Access Control protocols, Listen Before Talk, ALOHA, Internet of Things, Industrial IoT.

The presentation will overview the research activities and scientific results obtained by the Real-time systems and Networks group of the University of Catania in the area of communications for Industrial Internet of Things (IIoT) applications. In particular, the presentation will address the combination of the LoRa technology with both the MAC protocols standardized by LoRaWAN [1] and a novel medium access strategy that, differently from LoRaWAN, is able to provide time guarantees to real-time flows.

Many legacy wireless systems use frequency shifting keying (FSK) modulation at the Physical layer as it is a very efficient modulation for achieving low-power operation. LoRa is based on the chirp spread spectrum modulation, which maintains the same low-power characteristics as the FSK modulation, but significantly increases the communication range. Although chirp spread spectrum modulation has been used in military and space communications for decades, thanks to the long communication distances that can be covered and the robustness to interference, LoRa is the first low-cost implementation for commercial usage. As a result, the LoRa Physical layer enables long-range communication links, while LoRaWAN defines the communication protocol and the network architecture. In fact, the LoRaWAN specifications define a Low Power Wide Area Network (LPWAN) protocol stack to wirelessly interconnect battery-operated nodes and target key Internet of Things (IoT) requirements, such as bi-directional communications, end-to-end security, mobility, and localization services.

The LoRaWAN network architecture is deployed in a star-of-stars topology in which gateways relay messages between the end-devices and a central network server. The gateways are connected to the network server via standard IP connections and act as a transparent bridge. LoRa technology offers long-range capabilities that allow for a single-hop link between the end-device and one or multiple gateways. A single gateway can therefore cover entire cities or hundreds of square kilometers. The range highly depends on the environment or obstructions in a given location, but it is greater than any other standardized communication technology.

LoRaWAN is one of the most successful LPWANs and is emerging as an appealing solution for several IoT applications, such as environmental monitoring and smart metering. To comply with the ETSI regulations [2,3], LoRaWAN can adopt at the Medium Access Control (MAC) layer either a pure ALOHA approach with duty-cycle limitations or a polite spectrum access technique, such as Listen Before Talk (LBT). The two approaches differ in various aspects and have their pros and cons that will be carefully discussed in the presentation. Moreover, we will present a comparative performance assessment of the two protocols obtained through simulations in realistic scenarios under different workload conditions.

The LoRa technology is also promising for IIoT scenarios that require temporal guarantees for real-time flows, a common requirement in industrial applications. However, its adoption for industrial IoT is impaired by the limitations of the relevant MAC protocols standardized by LoRaWAN, as they do not provide for bounded latency. For this reason, the presentation will discuss an alternative medium access strategy built on top of LoRa that provides support for real-time communications, thus enabling the implementation of LoRa-based LPWAN for industrial applications. We will present the detailed design of two novel MAC protocols, i.e., RT-LoRa and Industrial LoRa, and the results of performance assessments obtained through simulations in realistic IIoT scenarios.

[1] LoRa Alliance Technical Committee. LoRaWAN™1.0.3 Specification; LoRa Alliance: Beaverton, OR, USA, 2018.
[2] ETSI. Short Range Devices (SRD) Operating in the Frequency Range 25 MHz to 1 000 MHz; Part 1: Technical Characteristics and Methods of Measurement; ETSI: Sophia Antipolis Cedex, France, 2017.
[3] ETSI. Short Range Devices (SRD) Operating in the Frequency Range 25 MHz to 1 000 MHz; Part 2: Harmonised Standard for Access to Radio Spectrum for Non Specific Radio Equipment; ETSI: Sophia Antipolis Cedex, France, 2018.