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SMART CITIES

MAGICIaN

Low-power cellular network technology for mission-critical IoT applications

The Internet of Things (IoT) market today relies on Low Power Wide Area Network (LPWAN) technologies for connectivity, which transmit in unlicensed frequency bands (e.g., LoRa, Sigfox). As a result, they don't scale well and cannot guarantee reliability and latency due to potential interference from other nearby networks. The recently released NarrowBand IoT (NB-IoT) standard is the first LPWAN technology to use licensed frequency bands. This avoids interference, resulting in more predictable behavior. Moreover, it is easy to deploy as it relies on existing Long Term Evolution (LTE) infrastructure, supports deep indoor coverage, and promises a battery lifetime up to 10 years. These advanced features make NB-IoT a promising candidate to provide reliable connectivity to mission-critical IoT applications, such as real-time remote control of appliances, alarming applications, or emergency monitoring. Such applications require guarantees in terms of reliability and latency, in addition to a long battery life. However, NB-IoT has a wide range of configuration parameters that affect the trade-off between latency and battery lifetime. As such, there is a need for management solutions, that support automated and remote reconfiguration of device and network parameters based on the requirements of specific mission-critical applications.

The goal of the MAGICIaN project was to develop an end-to-end network and device management system to optimize and manage NB-IoT for mission-critical IoT applications. The system should be able to automatically reconfigure device and network parameters that optimize the trade-off between downlink latency and battery lifetime that is inherent to NB-IoT, based on the application requirements. Moreover, it should support GPS-less localization, seamless handovers to other technologies, header compression, and brief voice communication. On top of the management system, three mission-critical IoT applications are implemented: (i) a real-time demand-response system for residential appliances, (ii) an alarming wearable for the elderly, and (iii) a monitoring system for emergency services.

THE OUTCOMES

1. Insights into and optimization of NB-IoT latency and battery lifetime

NB-IoT includes several novel (configurable) features to achieve the promised 10-year battery lifetime, such as Power Saving Mode (PSM) and Extended Discontinuous Reception (eDRX). Depending on the configuration of PSM and eDRX parameters, the trade-off between latency and energy consumption can be configured. The behaviour of NB-IoT was thoroughly characterized using analytical models and real-life experiments, and in turn used to optimize the parameters based on application requirements. On one extreme, the end-to-end NB-IoT system was shown to support latencies as low as 50ms, while on the other extreme, 10 years of battery life can be reached with a typical IoT battery.

2. GPS-less and GPS-assisted localization methods for NB-IoT

Satellite-based localization systems such as GPS consume too much power to locate an NB-IoT end device that needs to last for several years on a small battery. On average, it takes 30 seconds to get a valid GPS fix. Therefore, Assisted GPS (A-GPS) tries to reduce the Time to First Fix (TTFF) by providing assistance data. We investigated and implemented three algorithms that, based on the signal strength to NB-IoT base stations, estimate the position of a transmitting device to augment A-GPS. These algorithms result in a median accuracy between 300 and 130 meters. Moreover, they can be used to provide an indoor location estimate, in contrast to GPS. Using this rough location estimate, the average TTFF of GPS was reduced from 30 to less than 4 seconds.

3. End-to-end NB-IoT network management and data exchange platform

The LwM2M/CoAP protocol stack was analyzed for the enablement of both end-to-end device management, including communication and localization settings, and the exchange of data. Here, both support for the Internet Protocol (IP) and non-IP delivery modes of NB-IoT was considered as well as device-initiated data exchanges. Moreover, the LwM2M specification was extended with voice streaming capabilities, including a northbound interface to the VoIP ecosystem. The feasibility of voice streaming over good quality NB-IoT links was demonstrated. Lastly, both the end device logic and the LwM2M management back-end were extended to support multi-modal NB-IoT solutions, combining NB-IoT with a fallback technology such as BLE or Wi-Fi.

NEXT STEPS

Orange plans to valorize on 4 streams : (1) NB-IoT connectivity with security and Service Level Agreement (SLA) Quality of Service (QoS); (2) an NB-IoT platform to manage large amounts of devices and System Integration Maps (SIMs) and providing Application Programming Interfaces (APIs) for integration with other management systems; (3) an NB-IoT device framework to identify, test and validate new NB-IoT devices, transparent plug & play commissioning of NB-IoT devices, including user authentication, QoS negotiation, network association, and cloud backend connectivity; and (4) NB-IoT consultancy towards customers.

Televic will further investigate to productize a wearable for outdoor alarming and localization with voice capabilities for the care sector achieving the most optimal battery lifetime vs. performance trade-off on the market. It will extend the AQURA portfolio offering indoor and outdoor solutions seamlessly.

REstore continues its innovation in residential demand response. The gained expertise on NB-IoT from MAGICIaN will be leveraged for choosing the right IoT connectivity solutions for this application.

Citymesh will continue to work on an NB-IoT based safety gateway appliance for mission critical communications. The main focus will be to continue to meet the everlasting demand of rescue workers to improve their - and possible surrounding casualties - situational awareness and general safety.

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FACTS

NAME	MAGICIaN
OBJECTIVE	End-to-end NB-IoT network management for mission-critical IoT applications
TECHNOLOGIES USED	Low-power wide area networks (LPWANs), NB-IoT, LwM2M, Static Context Header Compression (SCHC), Constrained Application Protocol (CoAP)
TYPE	imec.icon project
DURATION	01/10/2017 – 30/09/2019
PROJECT LEAD	Tom Sorgeloos, Orange Belgium
RESEARCH LEAD	Jeroen Famaey, IDLab, an imec research group at the University of Antwerp
BUDGET	2,319,768 euro
PROJECT PARTNERS	Citymesh, Orange Belgium, REstore, Televic Healthcare
RESEARCH GROUPS	IDLab, an imec research group at the University of Antwerp; IDLab, an imec research group at Ghent University

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The imec.icon research program equals demand-driven, cooperative research. The driving force behind imec.icon projects are multidisciplinary teams of imec researchers, industry partners and/or social-profit organizations. Together, they lay the foundation of digital solutions which find their way into the product portfolios of the participating partners.

MAGICIaN project partners:

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