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## Foreword

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Internet-of Things (IoT) technology is not new. We can see examples of telemetry applications used for tracking trucks in the United States dating all the way back to the 1980s. Since then several enabling technologies have been developed and used, applications implemented, and even the name of this area has changed a lot, but IoT has not really reached the point where we can claim there are billions of connected devices serving us to improve our lives and increase productivity. The ultimate type of IoT, the so-called *Massive IoT*, which immerses us into full digitalization of our physical world has been elusive.

The Massive IoT market has numerous applications that realize the digital transformation of existing processes. The economic gain of such transformation reflects better sensing capability that drives reduction of losses, limitation of risks, and optimization of resource usage. The sensing and data communication parts of these transformation projects need to be very simple and highly scalable. Unlocking Massive IoT requires a wireless connectivity technology that needs to support the following unique qualifications in addition to being secure, reliable, and manageable:

- Low-power, so the IoT devices can operate on batteries for a long time (10+ years) to ensure full autonomy.
- Long-range, in the order of 10s of kilometers, to ease the deployment by not requiring dense deployment of radio gateways, which creates practical issues (e.g., where to place a base station, how to provide power and backhaul to it), and increases the infrastructure cost.

- Low-cost, not only on the IoT device side (i.e., sensors) but also the infrastructure side. Deployments not being limited to large nationwide carriers, but also cost-effectively available to the enterprises and even consumers at home is important.
- Low-touch, with little or no manual interaction with the devices during the deployment and maintenance.
- Easily accessible to anyone, through open standards, open source implementations, and allowing use of unlicensed radio frequencies.
- Supported by an open and large ecosystem. End-to-end IoT applications require integration of several components on the end-device (processor, sensor, radio transceiver, and application), the infrastructure (radio network, core network), and the cloud (data platforms and applications). Applications are numerous, and each one demands its own unique combination of components. It's clear that no company can deliver the promise of IoT single-handedly. Such a scene is only addressable by a large and well-integrated ecosystem.

LoRaWAN (Long Range Wide Area Network) technology emerged to deliver a LPWAN (Low-Power Wide-Area Network) connectivity solution that meets the challenging set of criteria required by the Massive IoT scene. Since its debut in the market around 2015, it has been nurtured by the LoRa Alliance, for developing the standard, certification, and the market for this technology. What started as a single specification for the link-layer to provide over-the-air transport has grown into a full end-to-end architecture spanning both the front-end and the back-end protocols for multiple network element types, added advanced transport features such as multicast and fragmentation, support for all major RF regions in the world, and adaptation of popular application stacks.

In this issue of Journal of ICT Standardization authors present the technical details of the core set of features forming the LoRaWAN connectivity: the transport (link-layer), security, RF regional parameters, certification, and firmware update over-the-air.

LoRaWAN has been seeing wide adoption across the globe. As of this publication there are more than 160 national operators that deployed LoRaWAN for public access, and countless many private networks in almost every corner of the world for private use. We are seeing acceleration in deployments and movement towards an inflection point (i.e., the elbow of hockey stick).

LoRaWAN is emerging as a strong power behind the IoT, which is the 3rd technology wave shaping the Internet and our lives. Being in the early days of this new era we invite the readers to get familiar with the LoRaWAN technology and join this exciting journey.

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