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# No dependability, no internet of things

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For the Internet of Things to become a reality the sensor networks which form its backbone must provide dependable real-time information all the time, on time. The RELYonIT project team is working to ensure dependability by testing possible solutions on FIRE's test beds.
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The Internet of Things (IoT) depends on a network of connected sensors and actuators embedded in physical objects, such as appliances and medical devices, providing people, businesses and governments with real-time online access to the state of things and places.

This connectivity will result in a wide range of new services, applications and data, leading to smart cities, electricity grids and healthcare services, for example. To realise these benefits, the sensors and actuators interacting over the wireless networks must be dependable.

However wireless sensors and actuators do not currently offer dependable performance, as they are often affected by the surrounding environment. For example, temperature variations can lead to a loss of synchronisation and a degradation of the quality of the wireless connection. Radio interference from wireless devices and other electrical appliances can also impair low-power communications, reducing speed and leading to high latencies.

How then can developers create smart city solutions if sensors that transmit information on the number of parking spots available or on the concentration of pollutants in the air are not operating as expected during the hottest times of the day or in the presence of radio interference?

The dependability of embedded wireless networks cannot yet be taken for granted, and there is hence a need to increase understanding of the performance of these devices under a wide range of environmental conditions. Only in this way can the promise of the future internet become a reality.

## KEY RESULTS

To obtain a deep understanding of performance in relation to environmental conditions and to provide dependable solutions, the RELYonIT team has extended existing FIRE facilities to enable the repeatable playback of pre-recorded environmental conditions.

In particular, the team has successfully created low-cost extensions for wireless sensor networks test beds that allow researchers to:

- study the impact of temperature with few hardware overheads (TempLab)
- create realistic and repeatable interference patterns without hardware overhead (JamLab).

These test bed extensions play a crucial role in the investigation of network performance by allowing researchers to rerun experiments under identical environmental conditions.

For example, TempLab can accurately reproduce temperature traces recorded in outdoor environments with an average error of only 0.1 °C. Preliminary experiments using TempLab have revealed that high temperature can drastically change the topology of a network and lead to partitions, significantly reduce the performance of MAC protocols, and increase the processing delay over the network.

JamLab provides simple models to emulate the interference patterns generated by typical appliances, as well as a playback capability to regenerate recorded interference patterns. Through a simple software up-load, JamLab automatically selects the portion of the test bed nodes that reproduce interference. RELYonIT used these test beds to devise accurate models capturing the impact of the environment on IoT hardware and protocols, and to develop protocols that can be automatically configured to meet application-specific dependability requirements.

## MORE DEPENDABILITY, MORE BUSINESS

The solutions developed by RELYonIT will find wide application in the market. Industrial partners in the consortium are developing a new line of dependable real-world applications involving different types of sensors and actuators.

These applications focus on highly demanding monitoring scenarios such as smart parking systems and geological subsoil imaging for oil and gas infrastructures. At the same time, the academic partners will exploit the acquired know-how to train the next generation of engineers and researchers.

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