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Sensible Things that Communicate

PART OF MID SWEDEN UNIVERSITY

Enabling Fully Distributed Global Services on the Internet-of-Things

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Abstract:

The focus of this thesis is the enabling of Internet-of-Things (IoT) applications that exchange sensor and actuator information on a global and ubiquitous scale. The main challenge is to create a common architecture suitable for different types of IoT applications. So far, proprietary and centralized solutions have dominated related work, although an open and distributed approach offers better support for a global IoT. Therefore, the focus in this thesis is on fully distributed middleware approaches and architectures for disseminating information on a global scale between ubiquitously connected entities. In addition to this, there is an impending information overload that needs to be avoided, where the amount of produced sensor information greatly succeeds the usefulness and possible utilization of each individual value. The problem is split into three concrete goals, where the first one surveys the current trends for creating IoT applications. In order to determine their demands on the underlying support and propose an approach for enabling next generation services. The second goal is to implement the proposed approach as a fully functional application platform. Finally, the last goal is to suggest mechanisms to manage resource limitations in order to avoid an information overload. The obtained results include an implemented IoT platform with ubiquitously connected devices that can globally share information between each other in a scalable manner. The platform utilizes a fully distributed architecture and is extended with low cost protocols that only communicate relevant information when it is needed, thus improving the longevity and performance of services based on the IoT. Therefore, the main contribution made by this thesis is that fully distributed architectures outperform other architectures when it comes to global and ubiquitous IoT services. The impact of this work is thus that it highlights the problems associated with poorly scaling architectures, which might be profitable as walled garden solutions but are inferior when it comes to global IoT services.

Based on the results obtained and the experiences learned in the architectural evaluation study, an FPGA-based high-performance wireless sensor platform, the SENTIOF, is designed and developed. In addition to performance, the SETNIOF is designed to enable dynamic optimization of energy consumption. This includes enabling integrated modules to be completely switched off and providing a fast configuration support to the FPGA.

In order to validate the results of the evaluation studies, and to assess the performance and energy consumption of real implementations, both the vibration and image-based industrial monitoring applications are realized using the SENTIOF. In terms of computational performance for both of these applications, the real-time processing goals are achieved. For example, in the case of vibration-based monitoring, real-time processing performance for tri-axes (horizontal, vertical and axial) vibration data are achieved for sampling rates of more than 100 kHz.

With regards to energyconsumption, based on the measured power consumption that also includes the power consumed during the FPGA's configuration process, the operational lifetimes are estimated using a single cell battery (similar to an AA battery in terms of shape and size) with a typical capacity of 2600 mA. In the case of vibration-based condition monitoring, an operational lifetime of more than two years can be achieved for duty-cycle interval of 10 minutes or more. The achievable operational lifetime of image-based monitoring is more than 3 years for a duty-cycle interval of 5 minutes or more.