Towards an implementation of the IEEE 802.15.4 time critical MAC extensions over a real-time OS

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CISTER-TR-181130
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*CISTER Research Centre
Polytechnic Institute of Porto (ISEP-IPP)
Rua Dr. António Bernardino de Almeida, 431
4200-072 Porto
Portugal
Tel.: +351.22.8340509, Fax: +351.22.8321159
E-mail:
http://www.cister.isep.ipp.pt

Abstract

Growing at a fast pace, the adoption of embedded computing systems, capable of monitoring and controlling the physical environment around them, is spreading across different environments, from our houses to the industrial setting. This latest trend, induced by recent advancements in the information and communication fields, craves for the new Wireless Sensor Network (WSN) concept, which aims to enable an infrastructure that interconnects the set of widespread intelligent devices, capable of wireless communications, constituting a network of sensor nodes. On an Industrial context, the new Cyber-Physical Systems (CPS), prompted by the Industry 4.0 revolution, aim to correlate the present automated systems to the new information technologies, such as cloud and cognitive computing, to compose a group of collaborative computing systems that enact the smart factory. This new targeted model however, relies on certain time assurances and other QoS (Quality of Service) properties such as scalability, energy efficiency and robustness, which WSN technologies intend to grant. Although a tender paradigm, propositions such as the IEEE std. 802.15.4 protocol ambition to enable the WSN infrastructure and satisfy the QoS requirements. The IEEE std. 802.15.4 protocol provides several MAC (Medium Access control) behaviours to frame the communications stack, each aiming to meet the set of requirements of distinct applications. For deterministic latency, high reliability and scalability QoS requirements, IEEE 802.15.4 standard provides the DSME (Deterministic Synchronous Multichannel Extension) MAC behaviour. Parallel to the phenomenon of the WSN technologies, real-time operating systems (RTOS) are emerging among the IoT (Internet of Things) community to help tackle QoS specifications for determinism and time-critical constraints. The use of a real-time OS in conjunction with a time reliable protocol such as DSME is the key to enable a truly deterministic and time critical WSN. However, besides these settings, QoS at the computing platform must be guaranteed as well if these network infrastructures are to become a reality. Computations must be performed in a predictable way, as to support the QoS demands in terms of latency these networks present. Hence, in this Thesis we propose to rely on the FreeRTOS for a real-time operating system and a well known WSN platform, such as the TelosB to implement the DSME time critical MAC behaviour. To achieve this defined goal, this Thesis presents a port of FreeRTOS to the TelosB platform, which includes an IEEE 802.15.4 compliant radio, as well as an experimental study of the future implementation strategy of the network protocol. Hereby, this Thesis concludes with a successful implementation of the RTOS, FreeRTOS, for the TelosB platform, along with the necessary groundwork and time requirements support for the DSME extension. Additionally, the Thesis provides a suggested model for the protocol stack to fit the FreeRTOS task system.