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Zastosowanie wielozadaniowości do poprawy parametrów czasowych wykonania aplikacji w węźle rozproszonego systemu czasu rzeczywistego

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Abstract

In computer systems, interrupts are used to improve system response times compared to sequential execution of applications. Inter-node communications in a distributed system can also benefit from asynchronous processing with interrupts. However, interrupts interfere with normal processing. To bind that interference, interrupt service routines are typically designed to execute extremely fast.

Hard real-time systems must be analyzed to verify that strict time constraints are met. For typical hard real-time systems, interrupts are either avoided or assumed to be serviced in negligible time and completely ignored in analysis of time constraints.

The thesis investigates hard real-time systems where interrupt service times are not negligible. The whole interrupt system is modelled as a priority-based, pre-emptive scheduling algorithm and each interrupt service routine is modelled as a hard real-time task. Such approach enables the use of real-time scheduling theory to determine whether specified time constraints are met.

The research is stimulated by the fact that interrupts are supported by modern Programmable Logic Controllers (PLC) that is widely used computational devices, designed for industrial automation and control applications. Classic PLCs are based on a simple, well-known programming model: a single† task executing a never-ending program loop. Each iteration of the loop – a sweep – consists of distinct, synchronous phases of acquisition of inputs, execution of application program, actualization of outputs and inter-node communication. The synchronous approach simplifies analysis of time constraints.

The PLC runtime does not support multiple tasks, thus all interrupt service routines must execute the whole processing at once using reasonable amount of execution time. Keeping interrupt service time negligible posses hard limits on functionality of interrupt service routine. Such systems would strongly benefit from long-running interrupt service routines that can be analyzed using methods investigated within the thesis. While PLCs are hardware platform used through the thesis, obtained results can be directly applied to other real-time systems, such as embedded systems, whose designers tend to keep more control over hardware and software than PLC application designers.

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† PLCs that are fully compatible with IEC 61131-3 do support preemptive multitasking, however the exact behaviour is vendor-dependent. Such PLCs are not covered within the thesis.