STRESZCZENIE

The research project concerns the specification of the control part of a cyber-physical system (CPS) by the interpreted Petri net. The CPS is an integration of computation with physical processes, whose behaviour is defined by cyber and physical parts of the system. The design methodology of CPSs includes the joint dynamics of computers, software, networks and physical processes. The physical part refers to the real world and is prone to environmental influences, while the cyber part controls the objects and makes decisions. It should be pointed out that this project focuses on the specification aspects of the control part of the system (including formal analysis and decomposition methods), thus other aspects (e.g., modelling techniques of the physical part of the CPS) beyond the scope of the project.

The research objective of the project is to develop novel modelling methods for the control part of a CPS with the use of an interpreted Petri net. The main emphasis is placed on the specification, which is then analysed and formally verified, and, if needed, decomposed into smaller independent modules. Such an approach allows the modelling of either an integrated control system (realized within a single device), or a distributed one (consisting of various devices, that cooperate with each other). In the project it is planned to apply Petri net theory to specify the control part of the CPS. A Petri net is a formal mathematical apparatus that allows for graphical representation of the control system. Its main advantage lies in the natural reflection of the concurrency relations in the modelled system. Furthermore, an interpreted Petri net additionally takes into account input and output signals that allow for bidirectional communication with the physical world. Such signals are usually applied to control the other (physical) components of the system. Unfortunately, the most popular analysis and decomposition methods of systems described by Petri nets have a serious limitation related to exponential computational complexity, which means that a solution may not be found within the assumed time.
The main scientific aim of the project is to develop novel efficient and effective methods for analysis and decomposition of the control part of a CPS specified by an interpreted Petri net. An additional research objective of the project is to investigate the usefulness and limitations in the modelling of a cyber-physical system specified by an interpreted Petri net. Most of the currently used techniques of CPS specification are mainly based on sequential algorithms that are usually dedicated to microcontrollers, or programmable logic controllers (PLCs). In the project it is planned to use an interpreted Petri net to specify the control part of the CPS. Such an approach allows modelling concurrency, which is essential in designing a system to run on digital circuits, such as Field Programmable Gate Array (FPGA) devices. In particular, it is planned to focus on the determinism and timing aspects (logical time, physical time). It should be underlined that this subject has already been initiated within the research project “Miniatura 2” that is currently being brought to fruition by Remigiusz Wiśniewski (the project is financed by Polish National Science Centre under Grant No. 2018/02/X/ST6/01861).

New analysis and decomposition methods for the control part of a CPS specified by an interpreted Petri net will be developed. The methods will be experimentally verified (for efficiency and effectiveness) and compared with the existing ones. The project results will be disseminated within the developed Hippo-CPS web system, and published in prestigious JCR journals of the highest scientific rank.