This research project concerns the specification of the control part of a cyber-physical system (CPS) with 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. A CPS is used in a variety of domains, such as, vehicular and transportation systems, medical and health-care systems, smart homes and buildings, social networks and gaming, power and thermal management systems, electric power grids or networking systems. The *physical* part refers to the real world and is prone to environmental influences, while the *cyber* part controls the objects and makes decisions.

The main 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. Petri nets, widely used in many domains as a graphical modelling formalism, enjoy popular support for analysis and verification. They are easy to use, as the main elements involve only places, transitions, and arcs connecting them with each other. Their main advantage lies in the natural reflection of the concurrency relations in the modelled system. Petri nets allow the modelling of independent processes and can be decomposed into smaller parts, each one to be then implemented in a separate device. 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.

The underlying motivation for research in modelling of the CPS control part is that the most popular analysis and decomposition methods described by Petri nets have a serious limitation related to the exponential computational complexity, which means that the solution may not be found within the assumed time. The main 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. There are also various other aspects related to such a specification that have to be carefully investigated, such as the ones regarding determinism or perception of time.

To satisfy the main project objective the following tasks will be performed:

1. *Analysis of the usefulness and limitations in a modelling of a CPS specified by an interpreted Petri net (determinism, specification of logical and physical time).* In this task, we plan to investigate whether the interpreted Petri nets can be useful in the design of a CPS where determinism and time (logical and physical) play an important role.
2. *Development of analysis and decomposition methods for the control part of a CPS specified by an interpreted Petri net*. This is the most important task, where efficient and effective methods for analysis and decomposition of the control part of the CPS will be developed. The task involves elaboration of algorithms, theorems and proofs. It is planned to use integer algebra (computation of place and transition invariants), undirected graph (including perfect graphs) and hypergraph theories.
3. *Development of a set of test modules (benchmarks) for the control part of a CPS specified by an interpreted Petri net for the purposes of experimental research*. Since the methods developed in task 2 above ought to be verified experimentally, it is planned to prepare a set of benchmarks (including real examples, taken from world-wide literature, as well as hypothetical test modules).
4. *Development and realization of the Hippo-CPS system in order to perform the experimental verification of the designed analysis and decomposition methods, and to disseminate the project's outcomes.* The verification process of the developed methods should be automated and performed in an effective way. Therefore the dedicated Hippo-CPS system has to be developed. Moreover, the system will be publicly available to any scientist anywhere in the world.
5. *Experimental verification of the efficiency and effectiveness of developed methods with the application of developed benchmarks and Hippo-CPS.* This task relates to the thorough experimental verification of the efficiency and effectiveness of the developed methods. Since the verification process needs large computing resources we plan to split the verification task into concurrent subtasks and apply multitasking supported by a specialised computation server.

The expected project results will be mainly related to the new analysis and decomposition methods of the control part of a CPS specified by an interpreted Petri net. 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 the top JCR journals of the highest scientific rank.