Many of our everyday decisions are made, at least to some extent, based on various rankings resulting from comparative research, also known as *benchmarking*. When buying a new phone, we analyze independent rankings available on the Internet that compare the performance of competing models. Deciding to purchase a car, we check its positions in rankings of reliability, fuel consumption, and crash test results. Choosing a university, we make use of rankings taking into account, among others, scientific potential, prospects for graduates in the labor market, and international collaboration.

Being able to perform benchmarking is also crucial for scientists and engineers working on innovative solutions. Therefore, for the development of a given field, it is extremely important to devise a methodology for conducting such comparative studies. In many branches of Computer Science, especially those concerned with creating and improving complex systems, one of the basic mechanisms adopted to this end is *computer simulation*. For example, assessing the efficiency of new algorithms that manage data packet traffic in the Internet is not done by simply installing software implementing these algorithms on target network devices, which would incur high costs and pose a huge risk of failures, but is instead preceded by months or even years of simulations, repeated in various configurations and scenarios.

However, for computer simulation to be possible, it is necessary to develop *models* of the simulated objects. The task of an individual model is to recreate during simulation those aspects of the behavior of the corresponding object that are relevant to a particular research problem. Studies of a complex system are thus done by simulating the models of the objects comprising it and the interactions between these models. In particular, in our previous example regarding network traffic, one would need models for devices managing the traffic, communication links between them through which the traffic flows, and users who generate the traffic.

A fundamental constraint when modeling objects for simulation purposes is a *trade-off between accuracy and efficiency*. On the one hand, the more accurate a model is, that is, the more features of the corresponding object it takes into account, the more faithful a simulation, and hence the more reliable its results. On the other hand, taking into account too many features may make a simulation inefficient, which means that completing it will not be possible in reasonable time and with acceptable computing resources. A key problem is thus to identify an appropriate level of fidelity at which a given object or system should be modeled, so as to ensure the most suitable balance between accuracy and efficiency.

The main theme of this project is thus *exploration of the accuracy-efficiency trade-off* in order to develop models that would enable computer simulation of modern low-power wireless micro-devices that are one of the key technologies for realizing the so-called *Internet of Things* vision.[1] Such devices are embedded into surrounding physical objects—things—and integrate hardware components used for processing, radio communication, and sensing or actuating the objects, so as to allow them to autonomously make our lives easier. To this end, however, the micro-devices must be coordinated, which is the task of software that implements existing and emerging dedicated algorithms, so-called network protocols. In this light, simulation is a crucial mechanism that enables benchmarking the developed protocols, even in networks of thousands of devices, potentially with minimal initial investments in real hardware, which significantly reduces the overall costs of research on Internet of Things solutions. The motivation behind the project is the fact that there are currently no suitable models for the dominant modern hardware architectures adopted in low-power wireless micro-devices.

We plan to develop such models, among others, by analyzing technical documentation of the architectures as well as experimenting with them, following an approach referred to as reverse engineering. In addition, we want to experiment with modern network protocols themselves to get more insight into their requirements with respect to the necessary fidelity of simulation. For the devised models, we plan to build prototype implementations in a leading network protocol simulator and experimentally confirm their efficiency and accuracy through comparisons with real hardware. In this way, apart from scientific publications, we want to give the low-power wireless networking community a prototype of an actual scientific instrument that can be readily used for protocol benchmarking and developed further.

[1] http://www.deltami.edu.pl/temat/informatyka/internet/2018/05/15/Internet_Rzeczy/ (in Polish)