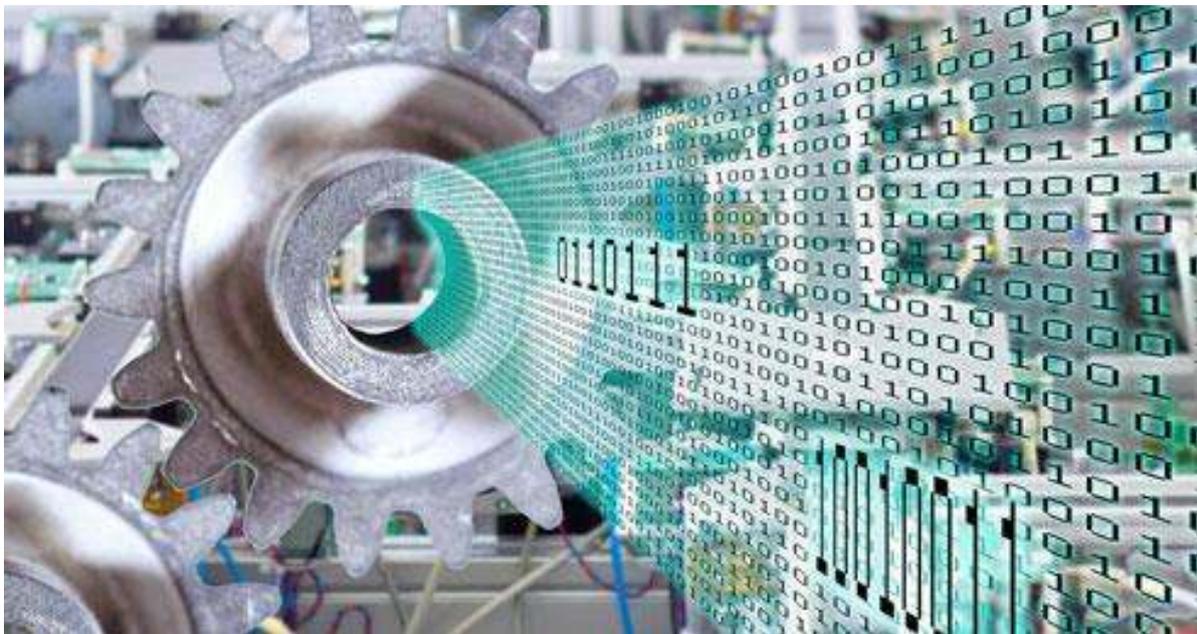


## Cyber-physical Systems: The World is Going Smart

From computer chips triggering an airbag to smart cities: “cyber-physical systems” are changing our world. During CPS-week (April 11 -14. 2016), the international scientific community comes together in Vienna.

One inputs the data, leaves the computer do the calculations, and gets a result back at the end – this is how one used to work with computer programs for a long time. Today however, this is not enough anymore. Computer programs control the airbag in our cars, the temperature in our homes and the beat of our pacemakers. Software and physical components are growing together into integrated systems, and many such systems are getting interconnected, so that as a whole, they are able to solve a common problem. One talks in this case about “cyber-physical systems” (CPS).



Vienna is the Capital of CPS this April

Austria plays an internationally leading role in the CPS arena – both in academic research, and in industrial application. This year, Vienna’s Hofburg hosts the most important scientific event in CPS area worldwide. As many as four important conferences have been co-located within CPS-Week; from 11<sup>th</sup> to 14<sup>th</sup> of April one expects around thousand scientists from all over the world to come. The main organizers of CPS-Week are the Institute of Science and Technology Austria (IST Austria), the Technical University of Vienna (TU Wien), and the Austrian Institute of Technology (AIT).

“Cyber-physical systems are going to completely change our everyday life”, says Professor Radu Grosu (TU Wien). “One estimates that by 2020, there will be more than one thousand electrical systems for each human being.” Many small processors already control our cars. One day, most cars will drive on their own, and will negotiate with each other, which path each one is going to take. Cyber-physical systems in buildings will improve the quality of our life and make it safer. In factories, machines will coordinate with each other in an autonomous fashion – we are talking about an “internet of things” and “Industry 4.0”. Some of these ideas are already being put into practice.

Results in Real Time

These new developments face us with many scientific challenges: “The factor time plays a very different role in cyber-physical systems than it used to play in the computer programs of the past”, says Professor Thomas Henzinger (IST Austria). “Solutions must be found reliably, in real time. When a program on my desktop freezes for a few seconds, or it has to be restarted after an update, this is not a big problem. But if the same thing happens in the control system of an airplane, it can lead to a major catastrophe.” The physical properties of the system determine how much time the software has to find an answer. It does not necessarily have to be the optimal answer. A useful approximation at the right moment is better than the exact solution coming too late. TTTech, founded by Prof. Hermann Kopetz from TU Wien, is a world leading company in this field.

Another characteristic of CPS is their intrinsic uncertainty. “We have to free ourselves from the idea that a computer behaves always the same way, and that we can absolutely predict this behaviour in advance” says Radu Grosu. “We use models of physical processes which are never complete, we deal with sensor data which are always noisy, and we provide approximate solutions that are most often nondeterministic instead of being exact and deterministic.”

In order to deal with uncertainty, new programming techniques have to be developed. “The current state of the art in computer science is very similar to the state of the art of physics, a hundred years ago: Viennese researchers such as Ludwig Boltzmann or Erwin Schrödinger explained how physics can deal with chance and unpredictability. Today, computer scientists have to solve similar problems”, says Radu Grosu. Probabilities or deterministic laws, continuous variables or discrete quantities – when computer code and physical systems are put together, different mathematical approaches have to be reconciled. Scientists such as Thomas Henzinger have been pioneers in developing the model of “hybrid automata”, a model that is used today all over the world.

Useful, reliable, safe

Cyber-physical systems are not being developed in order to replace humans. They are developed in order to become reliable tools for our everyday life. Many of the future challenges that our society will face, will only be solvable if we are going to use digital communication systems. “Information and communication technologies have become the backbone of society. Smart production and the distribution of electricity, intelligent and autonomous traffic systems, modern health care such as telemedicine, support for the elderly, environmental management, public safety and disaster relief, competitive industrial production lines facing global competition, and much more – all these examples show that the ever closer connection between physical world and electronic controls opens up completely new possibilities for social as well as entrepreneurial developments”, says Helmut Leopold, head of the digital safety and security department at AIT.

Eventually, a technological ecosystem will develop, permeating various aspects of life. “We will deal with thousands of computer processors every day, but we will hardly notice them”, says Radu Grosu. Cyber-physical systems will be integrated seamlessly into our modern life, much like earthworms, which improve the quality of the soil in our garden or the trees in the park, filtering dust from the air.

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