

Better Performance, Less Energy Consumption

Today it is standard for computers on the PC market to have two or more processor cores on a single chip. With this arrangement they can deliver better performance while consuming less energy. The trend in industry is also toward “dual-core” and “multi-core” computers that can run programs on two or more processors in parallel. But unlike office computers, automation control system programs running on industrial computers must be executed with precision at predetermined time intervals lasting only a few microseconds. Previously it was not possible to guarantee this level of performance for distributed computation using dual-core processors. Dr. René Graf has developed a process that acts as a kind of lock keeper and guarantees that time-critical program segments are executed with precise timing.

The nominal peak performance available from the processor cores in a dual-core or multi-core processor is not utilized, in order to minimize waste heat. Instead, each core operates at a slightly reduced level of performance. For example, each one will run at two gigahertz even though it would be possible for it to run at three. Because this arrangement generates less heat, energy consumption is reduced by up to 50 percent compared to a single-core processor running at four gigahertz. “There is better performance with less heat generation,” says Graf.

But there are also some drawbacks. There is only one main memory, and when both processors try to access it at the same time there is a conflict. For complex processes that require large amounts of computing power, the nominal performance cannot be called upon ad hoc. An individual processor core executes its tasks at a reduced performance level, and this may take longer than it would on a higher-performance, single-core processor. “For office software that doesn’t matter, because the tasks aren’t time-critical,” explains Graf. But the situation is very different when it comes to industrial applications. The control of an aircraft’s mechanical components and the signal processing in a magnetic resonance tomograph operate with command sequences that are timed in the realm of microseconds; in other words, the sequences are executed within the blink of an eye.

Industrial automation computers must also execute their tasks in accordance with precisely defined time intervals in order to ensure that the command sequences are conveyed correctly and the robots and machines execute their tasks at exactly the right moment. If there is only one processor core, this isn’t a problem. This processor simply executes the program according to the different tasks’ priorities. “This makes it possible to guarantee that timing requirements are complied with,” says Graf, a physicist, who has worked at Siemens Industry since 2001. In 2008 he started working in advanced development and since then he has focused his efforts on the development of automation systems. During this time he has registered 51 inventions. Many of these are protected in 35 IPR families by the 14 patents that have been granted so far.

Graf was motivated to work on automation programs that run on multi-core processors by his conversations with specialists in the automobile industry. “There is a desire to use multi-core

processors in that sector as well, but they would have to be able to meet the specifications for closely and precisely timed operations,” explains Graf. Usually a computer assigns the outstanding tasks to particular processor cores at random. Therefore it isn’t possible to anticipate exactly when a specific process step will be completed. “Because it isn’t possible to know which processor core will complete a task and when it will do so, a longer timeframe has to be planned for that task than would be necessary for a single core computer. Of course this wouldn’t be acceptable,” says Graf.

Consequently, he developed a process that works like a sort of “lock keeper”. “First, a program has to be divided into time-critical and less time-critical segments,” explains Graf. In the time-critical phases, the processor core that is executing the task receives unhindered access to the main memory and the network card. The other core is blocked during this phase. According to Graf, this solution is particularly appropriate for programs whose time-critical segments are not too long; otherwise the advantages of the multi-core processor — better performance using less power — are lost. “Here in Nuremberg we are operating a pilot facility that uses my solution, and we can demonstrate that it works,” says Graf. For this accomplishment he has been awarded the Siemens’ internal inventor prize for the Industry Sector.

He is convinced that one day the automation sector too will no longer rely on decentralized control units connected to the machines in a plant to calculate the factory’s processes. “Instead, I can imagine a sort of ‘cloud’ in which all of the computing power for the automation system is provided centrally,” says Graf. “The only elements that will continue to be decentralized and located at the individual machines will be peripheral devices for signal conversion. These units will communicate with the cloud through field buses.” The advantage for production operations is that the computing power is scalable and can be increased or reduced as needed. “For example, if a new production step is introduced that requires ten new control commands, more processor capacity will simply be made available — this capacity was already there, but it just wasn’t activated. Until then, this extra computing power won’t cost anything,” explains Graf. “Pay per use” is the operative phrase. Of course these are all daydreams of the future at this point.

Graf is a self-confessed nerd — in other words, a person who lives mostly in the world of his computers. But that’s only when he’s at work. He devotes his free time to his family. Moreover, he is in excellent physical condition. Since his time at the Karlsruhe Institute of Technology Graf has been a member of a group of jugglers and acrobats, and he has continued to pursue these sports in Nuremberg. “Acrobatics is like weight training; the only difference is that instead of weights, you train with people whose company you can enjoy,” he says with a grin.