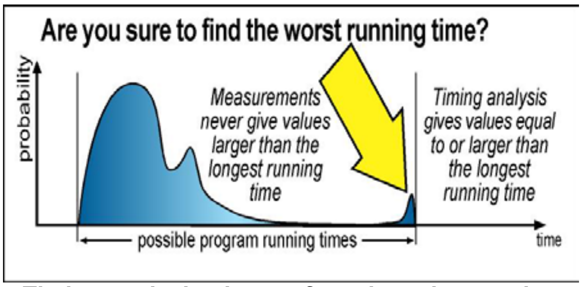
Timing analysis makes computer systems safer

Upper bound for program's running time given without measurements

What is the longest running time of a computer program? Such knowledge is important when constructing computer systems that control safety-critical products like cars, air-planes and nuclear power plants. At Mälardalen Real-Time Research Center (MRTC) methods are researched to automatically find the longest running time of programs.

During the last decade our society has become more and more dependent on computers. This does not only hold for the gray PC-computers situated on our desks, but also the myriad of computer systems found *embedded* in everything from cars and airplanes to microwave ovens, mobile telephones and toys. Did you know that 99 percent of all processors produced today are used in embedded computer systems?

Most embedded computer systems must react with its environment in *real-time*. This means that it is not enough that the calculated result is correct, the *time* when the result is produced is also important. If something goes wrong the costs, both in money and in human life, could be significant. For example, when an airplane pilot moves a control it expects the computer controlled system to change the rudder almost immediately. If the rudder is moved too slowly, or too fast, the plane might become instable and crash.



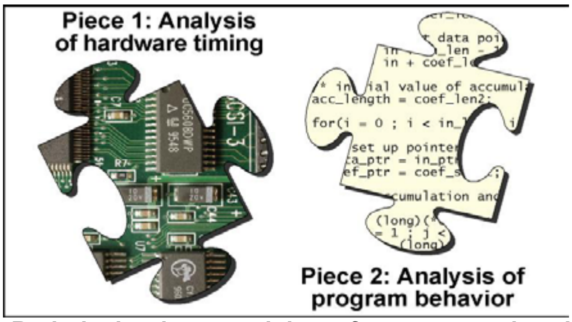
Timing analysis gives safer values than testing

Analysis safer than measurements

To guarantee that a computer system works properly even in the most stressful situations we need to know the *longest* time it takes to run its inherent computer programs. Such a program does not always behave exactly the same way in all types of situations; it might take different amount of time to execute depending on the type of work that should be performed and the type of computer it is run on. Consequently, to derive the longest execution time of a program, both the characteristics of the program code and the computer hardware must be considered.

Today, the industrial practice for determining the longest running time is by measurements. The program is run a number of times with varying inputs which are believed to provoke the longest time. Unfortunately, measurements do not give any guarantees that the longest execution time has been found and is often time consuming and error-prone.

An alternative method to find the longest running time of a program is by *static time analysis*. Such methods work by *analyzing* the program, instead of running it, to derive properties that will hold for all possible program runs. The result is a timing that is guaranteed to be larger than, or equal to, the longest running time of the program. You can compare it to deciding the stability of a bridge by investigating its construction drawings, instead of building the bridge and test if the bridge will hold by running heavy trucks across it.



Both the hardware and the software are analyzed

Research project at MRTC

At Mälardalen Real-Time Research Center (MRTC) in Västerås static time analysis methods are researched. The developed methods derive upper bounds on the possible execution runs of a program, e.g. bounds on how many times a loop can be taken. The methods also derive bounds on how the specific characteristics of the target hardware, such as memory speed and processor construction, can affect the execution time. A prototype tool called SWEET (SWEdish Execution Time tool) has been developed as a result of the performed research.

The usefulness of static time analysis has been shown in a number of industrial case studies, using both SWEET and other commercial state-of-the-art time analysis tools.

Feel welcome to contact us if you are interested in static time analysis and would like to participate in a case study!

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