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By Elias Hazou

AFTER a hard day's work at the office, you're back home eager to hit the sofa. You step inside the elevator, push '2' on the control panel and give it no more thought. That's because you take it for granted that, when the doors open, you'll have arrived at the second floor.

There are, of course, exceptions to any rule. For example, in my apartment block the darn thing occasionally goes psycho and 'decides' to climb to whatever floor it wants to.

The chances of a lift's computer chip going all screwy are extremely remote, but they do exist nonetheless. It's an almost inevitable problem inherent in embedded systems, of which elevators are a proud member.

What's an embedded system? In layman's terms, it's a special-purpose computer system designed to perform one or a few dedicated functions, often with real-time computing constraints. It is usually *embedded* as part of a complete device including hardware and mechanical parts. In contrast, a general-purpose computer, such as a personal computer, can do many different tasks depending on programming. Embedded systems control many of the common devices in use today.

Physically, embedded systems range from portable devices such as digital watches and MP4 players, to large stationary installations like traffic lights, factory controllers, or the systems controlling nuclear power plants. Complexity varies from low, with a single microcontroller chip, to very high with multiple units, peripherals and networks mounted inside a large chassis or enclosure.

Joseph Sifakis, a Greek computer scientist, has developed a method aimed at cutting machine errors down to a minimum - or wipe them out completely. And we're not just talking elevators here. Think big, like flight controller panels on commercial airliners.

A co-laureate of the 2007 Turing Award - think of it as the Nobel Prize for Computer Science - for his pioneering work on model checking, Sifakis was in Nicosia this week at the invitation of the Cyprus Institute for a lecture on "Embedded Systems – New scientific challenges for computer science."

"When it comes to predicting how systems interact with the outside environment, we're still in the Middle Ages," he tells the *Sunday Mail.*

In the absence of such a theory, computer scientists have to apply verification methods, a sequence of instructions or commands that are run to test an embedded system.

Before you start writing code on a project, you face the chronic problem of software development: flawed design requirements. It makes sense to find flaws up front because flawed requirements breed bugs that you have to get rid of later, often at a high cost to the project.

Explains Sifakis: "A verification method executes commands of a system and sees what happens - is the response the correct one? It explores what we call the state-space of the verified system - all the possible states of the system. The problem is that you need to explore an astronomical amount of states; so the key challenge is how to make this exploration efficient and accurate."

Some of the algorithms developed by Sifakis have served as the basis for verification tools (software) used by Microsoft and Google.

Model checking circumvents the problem of undecidability, a theorem developed by the mathematical genius Kurt Gödel in 1936. In a nutshell, the theorem says that there exist problems for which we cannot provide a correct answer YES or NO.

The crux of Sifakis' work lies in developing techniques to obtain under some conditions YES or NO answers.

The Albert Einstein approximate lookalike says there an estimated 200 billion embedded-system devices in the world today.

"Take the average modern car: it has about 50 embedded systems, each with a specific job, be it automatic braking, collision-detection systems and so forth. The challenge is to make these as failsafe as possible."

Sifakis' work hides enormous potential for the future - known as the Internet of Things.

The Internet of Things refers to a network of objects, such as household appliances. The idea is as simple as its application is difficult. If all cans, books, shoes or parts of cars are fitted with minuscule identifying devices, daily life on our planet would undergo a transformation. Things like running out of stock or wasted products will no longer exist as we will know exactly what is being consumed on the other side of the globe. Theft will be a thing of the past as we will know where a product is at all times.

One way of integrating the billions of devices would be through the Internet. Say all your household appliances are plugged in, software will determine how much power each of the devices is using at any time. If the washing machine has finished its cycle and is on idle, still consuming electricity, the Internet of Things will detect that and switch it off. It's all very *Minority Report*-like - but it's coming.

Says Sifakis: "Imagine medical appliances that would monitor disabled people and transmitting data on their condition. That in turn raises security concerns, and you'd need anti-hacking tools to prevent the personal data from being stolen. And that's where verification tools can come in handy."

Born in Heraklion, Crete, Sifakis is a CNRS (Centre national de la recherche scientifique) researcher and the founder of Verimag Laboratory, in Grenoble, France. Verimag is a leading research laboratory in the area of critical embedded systems.