Safe Concurrent Abstractions for WSNs

1 Project Description

Wireless sensor networks (WSNs) are composed of a large number of tiny devices (known as "motes") capable of sensing the environment and communicating among them. WSNs are usually employed to continuously monitor physical phenomena in large or unreachable areas, such as wildfire in forests and air temperature in buildings.

Software for WSNs is usually developed in the C programming language, and the addition of a real-time operating system may extend it with preemptive and/or cooperative multithreading. However, concurrency in C requires a low-level exercise related to scheduling, synchronizing, and the life cycle of activities (i.e. creating and destroying threads).

Concurrency in C also lacks safety warranties, given that they are susceptible to unbounded execution, race conditions and deadlocks. Nonetheless, safety is an important aspect in WSNs, as motes have scarce resources, are deployed in remote locations, and must run for long periods without human intervention.

The programming language Céu is being developed as part of the proponent's PhD research in PUC–Rio and is targeted at highly constrained embedded systems (such as WSNs), incorporating features found in dataflow and imperative reactive languages.

Céu supports concurrent lines of execution that run in time steps and are allowed to share variables. However, the synchronous and static nature of Céu enables a compile time analysis that can enforce deterministic and memory-safe programs, offering a high-level and safe alternative to the predominating C based multithreaded systems. The Céu compiler generates code comparable to handcrafted C programs in terms of size and portability.

The main objective of our research during the sandwich period in Chalmers is to evaluate the applicability of Céu in the context of Wireless Sensor Networks and secure communications. The evaluation involves quantitative measures (e.g. memory usage) and qualitative measures (e.g. ease of programming).

We believe that Wireless Sensor Networks are an ideal scenario to employ the Céu programming language, given it is targeted at highly constrained embedded systems, offering fine-grained concurrency, low memory overhead, and safety warranties.

2 Researcher

Francisco Sant'Anna is a fourth year Ph.D. student in the Computer Science department at PUC-Rio. He earned his BSc (2003) and MSc (2007) degrees also in the Computer Science department at PUC-Rio.

The current title of his PhD thesis is "Céu: Embedded, Safe, and Reactive Programming", which is expected to be concluded in September 2013. His advisors are Prof. Roberto Ierusalimschy and Prof. Noemi Rodriguez, which actuate, respectively, in the field of programming languages and distributed systems.