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Experimental Evaluation of Ubiquitous Mobile Systems

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Weiser's vision of ubiquitous computing [Wei99] is that of a society where technology has merged with the physical environment, and where systems have become ubiquitous, offering services to users while remaining invisible. This stealthiness implies a number of things. First, it assumes excellent interfaces and a rigorous design. Second, it requires a level of trustworthiness such that users can forget the very presence of the technology, under any conditions and threats. To allow ubiquitous systems to achieve that level of trustworthiness, resilience mechanisms seeking to improve their security, reliability and availability, must be devised.

Mobility has a significant impact on resilience in the framework of ubiquitous computing. Mobility of the physical devices implies an open and highly dynamic environment, stressing usage conditions with multiple interactions and multiple sources of failures. Thus, new risks stem from mobility, along with new threats, both accidental and malicious. Nevertheless, ”positive risks” yielded by mobility ought to be taken into account as well. For instance, heterogeneity of the services available in a ubiquitous system can be regarded as a source of diversity resilience mechanisms can benefit from. One of the objectives of our research is to focus on the study of both positive and negative impacts of mobility over resilience in ubiquitous systems.

In the ubiquitous computing area, evaluation of solutions remains an open problem. In most cases, proposed algorithms are evaluated and validated using wireless network simulators such as NS-2 [NS2], Glomosim [GLO] or JiST/SWANS [BHvR05]. Since simulators use a model of physical components, such as network cards and location systems, this raises concerns as to the representativity of the assumptions that underlie the simulation [CSS02]. Little work concerning the evaluation of algorithms in a realistic environment is available. Of course, this is due to practical reasons: how can one realistically set up a platform allowing the execution of algorithms dealing with mobility and ubiquity?

In this work, we focus on the development of a realistic platform, at the laboratory scale, to evaluate and validate fault-tolerance algorithms (e.g., group membership protocols, replication protocols) targeting systems comprising a large number of mobile devices equipped with various sensors and actuators. Our goal is to have an experimentation platform allowing for reproducible experiments (including movements) that will complement validation through simulation. Our platform must account for issues related to changes of scale so as to emulate as many various systems as possible.

In the context of our platform, we consider a ubiquitous environment comprising both fixed and mobile devices. The mobile device are constituted by programmable mobile hardware able to carry the device itself, a lightweight processing unit equipped with one or several wireless network interfaces and radio-frequency identifiers (RFIDs). The fixed counterpart of the platform should contain the corresponding fixed infrastructure: an indoor positionning system, wireless communication support, an identification system allowing specific devices to be found (RFID readers).

To address a large spectrum of system scales, the location system will need to be precise, otherwise the types of system that can be emulated would be reduced. Two technologies are currently available: motion capture systems and triangularization systems via Ultra-Wide-Band wireless communication (UWB). Again, to address a large spectrum of system scales, it must be possible to parameterize the wireless communication support in such a way that the availability of the service provided by a device can be limited in time or space. This will allow the modeling of mobile ad hoc systems, including frequent connections and disconnections that are typical to such systems.

The targeted system is a “smart environment” akin to ubiquitous systems. We consider a platform set up in a room of approximately 100 square meters where mobile devices can move around. The room should contain services, some of which are available in the whole room while others are limited to specific regions. Mobile devices can also offer services within a limited range and can access the services available in their environment. By changing scales, we plan to emulate systems of different sizes. Hardware modeling of this type of system requires a reduction or increase of scale to be able to conduct experiments within the laboratory. To obtain a realistic environment, all devices must be modified according to the same scale factor. We plan to conduct the following experiments:

- A system of communicating vehicles (VANET) intermittently connecting to a roadway infrastructure.
- A system of nano-robots subject to mobility (as they are carried by the blood stream, for instance) offering services (e.g., delivery of a certain amount of medicine in a specific region of the human body), while interacting with their environment.

For the VANET experiment for instance, the scale reduction factor needs to be at least 50: a 16x6m room will model a 800x300m area. GPS positioning for a moving vehicle is typically 5-20m, indoor will need to be 10-40cm. The 802.11p Wireless Access in the Vehicular Environment (WAVE) standard is still under discussion but it will probably define a communication range of several hundred meters; indoor we thus need to reduce by tuning transmission power of wireless communication devices.

For these reasons, we identified UWB as a potential technology for both communication and positioning and we are currently looking for practical solutions for implementing our platform. Our intention is thus to study the feasibility of the various options and build such a platform. This evaluation platform will then be used to perform experimental evaluation of our research on resilience mechanisms for mobile ubiquitous systems.

References

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