Polymorphic Ubiquitous Network Testbed RUBIQ

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Abstract. In this paper we present RUBIQ, a polymorphic ubiquitous network testbed. RUBIQ works on StarBED, which is a network testbed consisting of hundreds of PCs connected to each other. RUBIQ consists of a set of subcomponents such as RUNE and QOMET that make it possible to simulate ubiquitous network systems in huge scale that can hardly ever be experimented in the real world. We illustrate the structure of the testbed, how it functions, and the results of some of ubiquitous network system simulations. We show some results demonstrating that the testbed achieved an accurate simulation of a pedestrian tracking system by using appropriate modules, such as a wireless communication emulator and processor emulator.

Keywords: ubiquitous networks; wireless network; distributed testbed; supporting software; simulation; emulation.

1 RUBIQ

In this paper we present RUBIQ, a polymorphic ubiquitous network testbed implemented on StarBED, and a couple of its subcomponents such as RUNE and QOMET. RUBIQ enables to perform various kinds of simulation environments with the available simulation modules.

StarBED [1] is a network testbed which consists of over 1,000 PCs connected to each other. StarBED provides a simulation supporting software, SpringOS, to implement an easy-to-use simulation environment with which the users can write simulation scenarios that can be executed automatically.

In order to be able to use StarBED for simulation we developed a set of subcomponents, called RUBIQ. The major components of RUBIQ are the simulation support software RUNE (Real-time Ubiquitous Network Emulation environment) [2] and the wireless network emulator QOMET (Quality Observation and Mobility Experiment Tools) [3] described in the following part.

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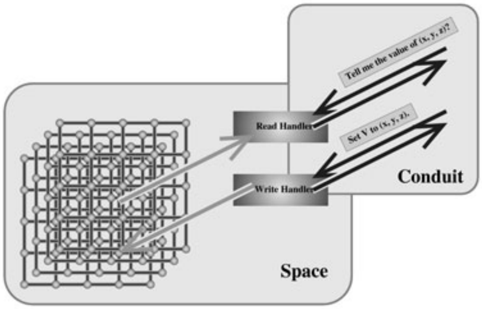

Fig. 1. Space and Conduit

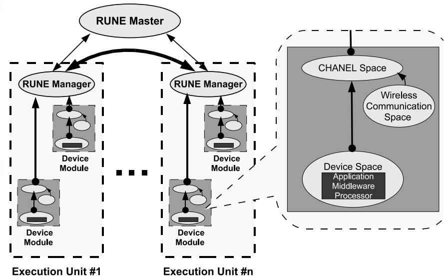

Fig. 2. RUBIQ based simulation

The simulation-support software RUNE is used to effectively run and manage the simulation. The basic elements of the logical structure of a RUNE-driven simulation are the *space* and *conduit* shown in Fig. 1. A *space* is an entity that behaves as one of the simulated elements. *Spaces* can simulate: (i) nodes, i.e., physical devices, (ii) environments, such as the thermal field; (iii) networks. *Spaces* are connected with each other by elements called *conduits*. Their role is to create an abstract error-free communication channel between two *spaces*.

One of the most important elements when using simulation for studying ubiquitous network systems is to be able to recreate with sufficient realism the communication. QOMET emulates several wireless communication technologies such as WLAN, ZigBee, Active tag by using a scenario-driven architecture. QOMET calculates a network quality degradation (ΔQ) description from a scenario representation. The ΔQ description represents the varying effects of the network.

RUBIQ also provides other supporting software modules belonging to different layers of emulation, such as processor emulation and middleware emulation. The major processor and middleware emulation modules provided by RUBIQ can emulate PIC 16F series processor, OpenRISC OR1200 processor, and ZigBee protocol stack. The users can choose those modules accordingly and combine them to implement the simulation they want to carry out as shown in Fig. 2.

2 Simulations Carried Out on RUBIQ

So far we took advantage of RUBIQ to evaluate a number of ubiquitous network systems such as an in-home sensing system, a motion planning robot system and an active tag based pedestrian tracking system [4] by leveraging hundreds of StarBED nodes.

As a representative example, we describe the simulation of the active tag based pedestrian tracking system shown in Fig 3. In the simulation, we started by reproducing a real-world 16 pedestrian experiment carried out with the prototype and eventually simulated the system with over one hundred pedestrians. In order to simulate the system, we utilized QOMET, a PIC 16F processor emulator and the firmware for the real system. The results showed a good agreement between the real-world experiment and the simulation. Moreover, we obtained

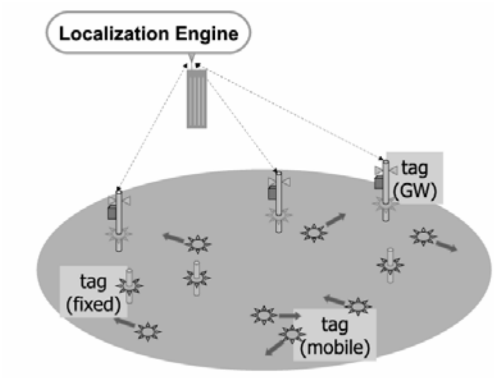

Fig. 3. Pedestrian tracking system

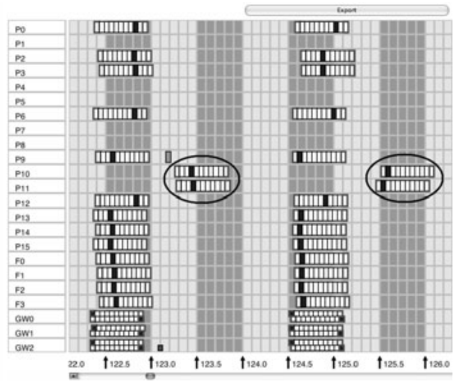

Fig. 4. Firmware issues

a significant achievement by finding some implementation issues. These issues, the quality of the random number generator and accuracy of the time synchronization protocol shown in Fig. 4, were fixed in the next version.

3 Conclusion

In this paper we presented RUBIQ, a polymorphic ubiquitous network testbed, and showed some results obtained by executing simulations. RUBIQ allows the accurate simulations of ubiquitous network systems by using its subcomponents.

So far we simulated a number of ubiquitous network systems with up to a few hundred entities, and the scale of simulations could be extended up to thousands by fully using the abilities of StarBED.

References

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