Real-World G-Lab: Integrating Wireless Sensor Networks with the Future Internet

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1 Introduction

Based on technologies and algorithms that were developed about 30 years ago, today's Internet is approaching the limits of its legacy architecture. This has spawned a wide range of intensive studies on the future internet, including the German-Lab (G-Lab) initiative.

One of the promising emerging technologies of more recent years are wireless sensor networks (WSNs). The idea is to use sensor-equipped devices such as cellphones and other embedded systems that sense and interact with their environment for obtaining valuable information about the real world. Only a few mature techniques exist to integrate heterogeneous WSNs with the Internet; it is clear that upcoming massive amounts of data widely exceed the capabilities of classical approaches. The goal of *Real-World G-Lab* is to overcome these obstacles by working on the different levels of protocols, services and applications. We will enable developers to write applications that rely on sensor data input, without knowledge of the underlying hardware platform and the network communication algorithms. This implies that sensors are able to participate in the future internet as peer hosts. This enables new fields of applications but likewise opens a set of new challenges in the context of efficient request processing

by WSNs. We will verify our concepts and applications inside the controllable environment of the G-LAB research network, by adding several outdoor WSN deployments to the experimental facility of the G-LAB project.

In summary, Real-World G-LAB will contribute to the integration of resource-constrained (wireless) sensor devices into the future internet by investigating several key challenges, ranging from low-level energy efficiency to improved high-level application development.

2 Integration of Testbeds

Real-World G-Lab will deploy three outdoor and one indoor WSN testbed, as well as one indoor wireless mesh network testbed. To the best of our knowledge, this will be the first federation of sensor and backbone networks that will be permanently available to run experiments on all network layers. By integration of outdoor networks it offers evaluation of realistic applications, e.g. in the fields of environmental and area monitoring including a small mobile network of wireless sensor nodes that is available on demand. A major contribution of the Real-World G-Lab is the extension of the G-Lab experimental facility by a federation of sensor network testbeds as shown in Figure 1.

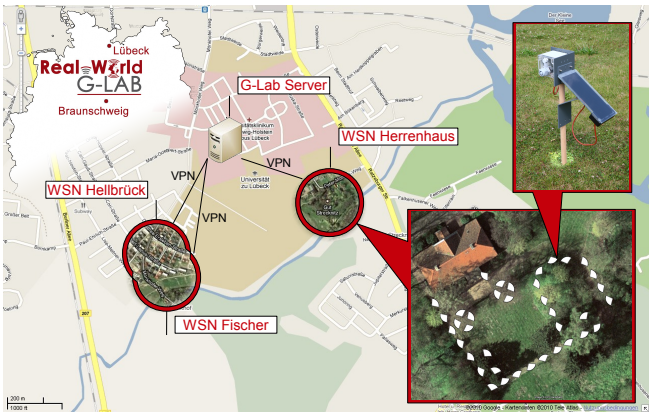

Fig. 1: Integrating WSNs into the G-Lab-Infrastructure

The realization benefits from previous experience and re-usage of components already developed in previous research projects like the WISEBED project that allows for reservation-based utilization of the infrastructure. By that, research results can be evaluated in a large scale on a real world deployment in a fast way. The several testbeds are the base for the experimental real-world evaluation of the research goals described in the next sections.

3 Protocols, Services, and Applications

Protocols: Integrating resource-constrained sensor networks with the Future Internet raises a number of fundamental questions that need to be addressed. One of these deals with the basic communication paradigms, which are currently not sufficiently interoperable. First steps to let sensor nodes participate in Internet communication have already been taken by the research community. Most prominently these are the 6LoWPAN [2] standard and its implementations. However it does not sufficiently address all issues, and there is still a substantial amount of groundwork necessary. We are investigating mechanisms to connect a sensor network to the Future Internet without compromising some crucial mechanisms of the heavily limited nodes, such as keeping energy consumption at the minimum possible level. This is done by allowing nodes to do duty cycling and energy-aware communication. Furthermore we extend the schemes to support dynamic and mobile WSNs. Another approach is the reduction and avoidance of communication wherever possible. This includes work not limited to the low-level communication level (e.g., compression techniques), but includes very high-level algorithmic mechanisms.

Services: Building upon the protocol layer, we will study two key services for a future Real-World Internet: monitoring and management, as well as service discovery. Although these services have already been investigated in other contexts, the specific properties of the Real-World Internet need careful reconsideration.

With respect to monitoring and management we envision a service that allows users to tradeoff the degree of visibility and control of the system state with resource consumption. In particular, the user will be able to specify a resources budget in terms of network bandwidth, memory, CPU cycles, and energy such that our service will offer best possible visibility and control while not exceeding the given budget.

Integrating embedded sensors into the Internet will allow online and real-time access to the state of the real world. We envision a discovery service that allows finding people, places, and objects that exhibit a certain state at a given point in time, utilizing the information gathered by embedded sensors. We will address this problem by using prediction models, by exploiting correlations between sensors, and by applying peer-to-peer strategies [1]. These services will be the base for the application development.

Applications: Real-World G-Lab will contribute to the application development by the simplified evaluation on large scaled, permanently available sensor network. The consortium encourages all other G-Lab partners to contribute their applications or develop further applications. The sensor networks integrated into the testbed are a piece of a larger federation of extensions which will be contributed by the new G-Lab projects. The applications as illustrated in Figure 1 include environmental monitoring, animal observation. The setup will be extended by audio and video signal processing as well as further event detection.

References

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