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Flexible and Modular Low Power Wireless Networks

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Abstract

Driven by falling prices, continuous miniaturization and increasing functionality, low power wireless networks tap into new application areas. But an efficient utilization of embedded systems is hindered by lacks in interoperability and flexibility, because they are proprietary. In this paper, an approach for an abstraction layer in the area of embedded systems with respect to low power wireless networks is presented. This layer is used to harmonize interfaces between network-node and application functionality like sensors. The overall goal is to design a dedicated modular low power wireless network with a flexible structure and topology.

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1. Introduction

Most of the available low power wireless networks are following a dedicated purpose, but do not have unified hardware or software interfaces. Therefore, they lack in the flexible adaptation to new application areas, because they have company-specific characteristics. To adapt sensor networks in different areas, experts are needed and sometimes reverse engineering on the level of the OSI model is necessary.[1] This hinders the efficient, flexible dissemination and adaptation of such networks. To overcome this problem, an unification of the used interfaces is needed.

Driven by falling prices and continuous miniaturization, topics like real time data, machine-to-machine or cyber-physical systems are discussed in a bunch of areas like logistics or agriculture. The linkage of smallest sensors is getting more important to measure the environment and analyze this data in order to combine data from the real with the virtual world. By doing so, it is possible to enrich data with a multitude of context information to provide a better database for decision-making processes.

The used flexible, modular, low power wireless networks are characterized by a flexible structure and topology, a modular separation of network and application functionality (e.g. sensors) and unified interfaces. They are related to embedded systems and the most commonly used interfaces are SPI, I^2C, RS485, UART or CAN-Bus.

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2. Technical Foundation

2.1. Overview

In the area of low power wireless networks, there is a very diverse landscape regarding to the interfaces (e.g. SPI) and to structured unified communication and control, defined by the sensor vendor. This can be solved by using an abstraction layer in order to unify the communication. It is necessary to expand a sensor with a low power microcontroller (MCU) so that the controller can implement the homogenized (dedicated) interface. In contrast to proprietary low power networks, which have a pre-defined functionality, the presented approach should be flexible enough to be easily and fast adopted to new application areas. A good example to outline these challenges is Ethernet, which abstracts from the underlying layers of the OSI-model. Therefore, the technical details are hidden for the accessing services and applications.

To realize the integration of these local networks to higher systems (e.g. information systems), technologies like GSM or WLAN are used. A gateway describes the interface between WAN (e.g. internet) and the local networks and provides an unified interface. Bi-directional data streams between network nodes are important for the self-organization of the network (e.g. mesh network). In addition, the architecture should have functionally equivalent network nodes.

But this flexibility leads to an increasing routing effort in mesh networks and is affected by the number of network nodes. Thereby, the needed time to detect a topology is very important for the communication, whereby a node should support poll (to gain access) and push communication (to send data).

2.2. Approach and Topologies

For the use of wireless networks in application areas characterized by monitoring large-areas, different structures and topologies can be applied. Fig. 1 outlines the possible flexible network structures and topologies.

The first topology is called star-topology[3]. This topology can be easily extended and has only minimal requirements regarding to the complexity of the used network, but a direct connection is needed for each sensor to the gateway.

The second is a point-to-point topology (from each network node to the event cloud).[3] Like the last topology, this one is easily extensible and interference-proof. The big disadvantage is, that this topology is very cost-intensive, because every network node needs a module (like GSM) to communicate with the event cloud.

In the third part, a multi-sensor board (e.g. Embedded System) with an integrated gateway node is used to communicate with the event cloud.

The last topology is a mesh-network. Here, the nodes can interchange data with each other and it is possible to organize the whole network at run-time. This dynamical organization can be realized by the underlying wireless technology or software layer. The big benefit is, that each node does not have to communicate directly with the gateway. From this it follows that the energy consumption is lower, because the distance between sender and receiver is minimized.

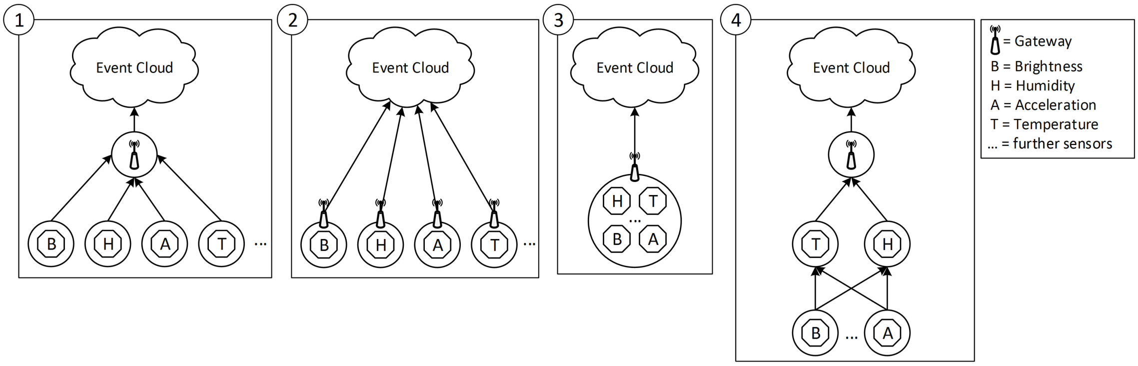

Fig. 1. Topology overview