Demo: 'Funkdebugger' - A Failure Analysis Framework for Industrial Wireless Communication Systems

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Abstract

Today's efforts towards more productive and efficient industrial automation systems strongly demand more flexible, intelligent and low-cost Machine-to-Machine (M2M) interactions. In many application areas, the collaborative nature of industrial wireless systems offer several advantages over traditional wired networks. The development and deployment of reliable, predictable and safe industrial communication systems inevitably require specific setup and maintenance procedures. Furthermore, user-friendly and fast failure analysis systems are indispensable for broad application of wireless networks in today's industry.
This demonstration presents a failure analysis framework for wireless communication systems with a strong focus on coexistence analysis.

Categories and Subject Descriptors

B.8.2 [**Performance and reliability**]: Performance Analysis and Design Aids

General Terms

Measurement, Performance, Reliability, Design.

Keywords

Factory automation systems, Wireless communication systems, Link quality, Failure analysis, Coexistence analysis

1 Introduction and Motivation

Wireless communication systems have emerged to an inherent part of today's dynamic industrial manufacturing market. They enable the deployment of unique manufacturing systems in application fields such as interconnection of movable and mobile machine parts as well as network infrastructure in difficult or dangerous environments.

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Communication systems like Siemens IWLAN, WirelessHART, ISA 100.11a or upcoming products based on the WSAN-FA standard [2] address the requirements [1] of wireless communication in industrial automation. The increasing use of these technologies led to the development of installation and maintenance guidelines [6, 4, 3] to avoid expensive system failures due to coexisting and thus competing wireless links. As a result of the limited availability of application specific failure analysis tools, these guidelines cover static failure scenarios predominantly caused by misconfiguration. Beyond, sophisticated failures caused by short term interference, sporadic packet collisions or coexisting communication systems strongly require scientific measurement tools and a high degree of technical knowledge.

The current dissemination of wireless technologies requires the development of application-specific failure analysis systems for increased reliability, predictability and safety. An application-specific hardware/software framework constitutes the main prerequisite for such profound cross-domain systems.

2 Demo description

This demonstration presents the architecture of the 'Funkdebugger' – a passive failure analysis framework for industrial wireless communication systems. We will demonstrate the architectural concepts of the adaptive hardware/software system in two parts. Firstly, the two most basic implementations of the hardware concept are introduced. A portable and battery powered monitoring system for temporary, on sight troubleshooting tasks as well as a distributed, more permanently system including multiple monitoring nodes. Secondly, the analysis and software architecture of the 'Funkdebugger' framework are demonstrated. Therefore, an initial set of analysis algorithms are utilized for a black box analysis of the local IEEE 802.11 network topology and identification of some error-prone wireless links in the conference network.

Analysis architecture

A detailed failure analysis of coexisting communication systems is based on a combination of multiple information sources e.g. spectral data, network traffic of multiple wireless standards, time and position information. To process this extensive amount of data on systems with limited memory

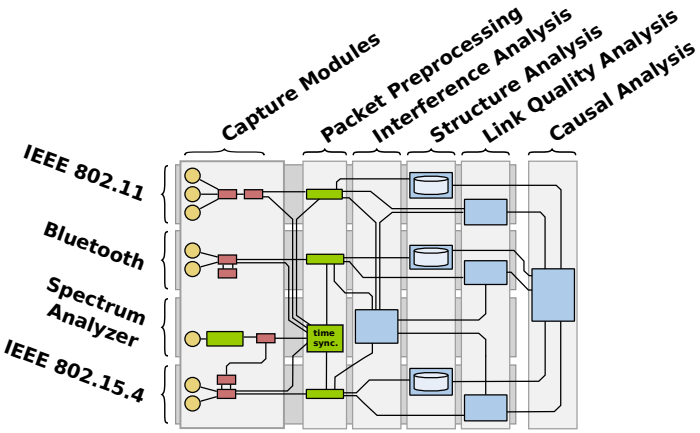

Figure 1. Simplified software architecture for distributed failure analysis

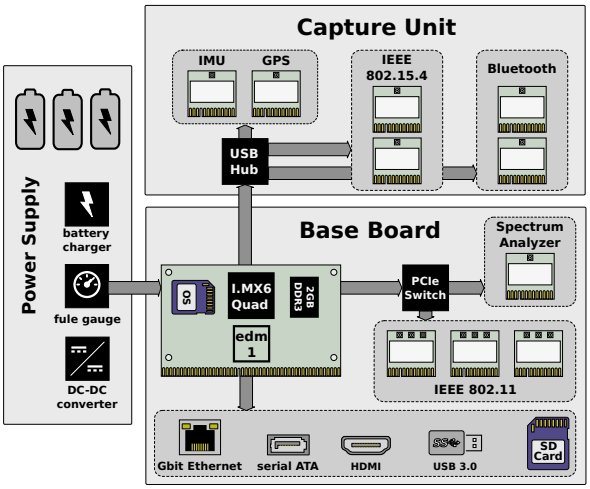

Figure 2. Concept of the modular hardware structure

and processing resources, we have implemented a multistage stream based information processing system (Fig. 1). The first two layers built from communication standard-specific capture and preprocessing modules include an early data reduction, time synchronization as well as blocks for the creation of uniform and tidy data structures [5]. By processing the cleaned up data each subsequent failure analysis layer amplifies the degree of abstraction up to a direct indication for the original failure.

Software architecture

The underlying software framework of the 'Funkdebugger' is tailored towards a performant implementation of the analysis architecture. In addition to the block based software structure we introduced a flexible local or networked interconnection system.

That way it is possible to use the 'Funkdebugger' software framework to setup a distributed failure analysis system, where multiple monitoring and computation nodes collaborate within one analysis task. The interface towards the interconnection systems is available in different programming languages to simplify the development of highly optimized information filters as well as the prototyping of abstract algorithms.

Hardware architecture

The hardware requirements are predetermined by the main purpose of the system - the passive monitoring of multiple wireless communication systems.

Because of the variety of wireless standards and the rapid development of new communication systems the hardware must be expandable and adaptable for special use cases. Therefore, we designed a modular, robust and hand-held hardware platform (Fig. 2) customized towards the operation in industrial environments. The modular concept is based on affordable standard components and supports multiple transceiver modules.

The functional interaction between the modular software and hardware structure of the 'Funkdebugger' enables the implementation of mobile battery powered failure analysis instruments as well as permanent observation systems.

3 Future work

Currently, the 'Funkdebugger' software framework just left the prototype stage where many parts of the system are still written in R and Python. Refactoring critical parts in C oder C++ will improve the performance on the embedded hardware platform.

Besides the analysis of IEEE 802.11-based networks we implemented an initial set of bluetooth analysis algorithms. To complete the 'Funkdebugger' we will intensify our work on bluetooth and IEEE 802.15.4-based systems.

4 Conclusions

In this demonstration, we have shown a failure analysis system specifically tailored towards wireless communication standards. Based on an initial IEEE 802.11 analysis we illustrated that an failure analysis specific hardware/software framework will accelerate the process of troubleshooting and therefore enable the development, installation and maintenance of reliable, predictable and safe industrial wireless networks.

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