Generalised Platform for Sensor Data Processing

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Abstract

A flexible processing platform for sensor/actuator related applications is developed. Beside Hardware/Software design a system level approach is included. Functionality is shown in a demonstrator.

1. Introduction

In co-operation with small and medium-sized enterprises (SME) the Chemnitz University of Technology develops a generalised platform for sensor data processing. The project comprises the development of a central, compact and flexible processing unit for sensor data, a flexible interface to connect enhanced sensors, a generalised software interface and a system level design methodology. The project is funded by the German Ministry for Education and Research (BMBF) within the "InnoProfile - Unternehmen Region" framework. Seven scientists are working on the research project that has been started in April 2006.

2. Project Concept

One focal element of the project is the flexible unit for sensor data processing, called GPS-Box. It offers a large number of interfaces for connecting sensors/actuators and for communication with other units. The box centrally records, stores and rehashes sensor data. Applications may easily and fast access the data using an unitary, hardware independent interface. Figure 1 depicts the overall system.

Second focal point is the refinement of the sensor/actuator intelligence to support the use of both new and existing sensors in different applications. This aims on finding a solution to easily and cheap equip the units with many different communication interfaces. Sensors and actuators may also be able to process data directly, e.g. to reduce the amount of transmitted data for energy-saving reasons. Intelligence at the sensor site allows features like the location aware collection of data in smart networks [1].

Within the project application specific hardware will be used together with micro-controller technology to combine the processing power of specialised hardware with the flexibility of software. Furthermore the technique of reconfigurable hardware is evaluated to enhance the flexibility.

One example for the use of reconfiguration is the *flexible interface* shown in Figure 1. It is intended to easily and cost-efficiently adapt the central platform and the sensors/actuators to various usecases. It will be adjustable to multiple versions of lower communication protocol layers. Adaptation of the physical interfaces will be achieved by using a modular sensor design. Dynamic reconfiguration may enhance the flexibility [2]. The pre-processing of the sensor data can be altered appropriate to runtime demands, e.g. altering the algorithm of automotive related image processing depending on the surrounding daylight.

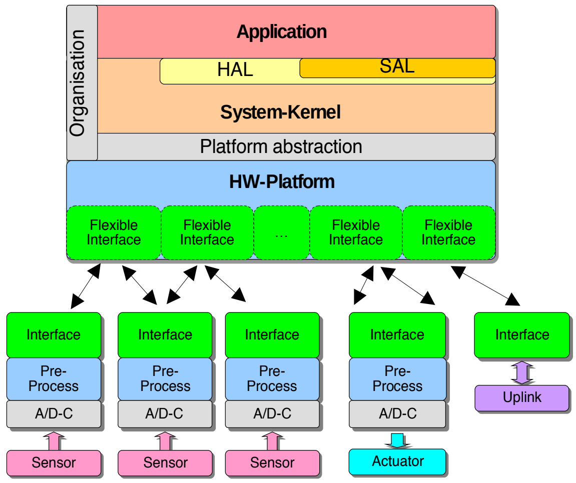

Fig 1: Overall system view

A platform abstraction layer separates the operating system from specific hardware. Further abstraction mechanisms in the operating system (hardware abstraction layer, sensor abstraction layer) hide sensor specific facts, e.g. the underlying connection type (wired or wireless) and the used communication protocol. Thus the flexibility of the communication interfaces is utilized by the applications without additional effort. In combination with embedded database technology the collected sensor data may be provided to local and remote applications.

To apply the generalised platform on dedicates usecases, three design stages (specification, implementation/design and test) have to be accomplished. As shown in Figure 2. a library of high level models of system components, hardware and software parts as well as communication channels is used for checks during the specification process. They ensure that constrains imposed by specified requirements can be meet by the platform. From these functional models an abstract system model is derived which will be mapped on real resources of sensors, electronic controller units (ECU) and communication links during the design phase. A simulation based verification approach is given at hand to support the refinement of the system. Utilising cross-level simulators such as omnet++[1] or COOJA [2] on network, operating system and instruction level allow the detailed analysis of the system.

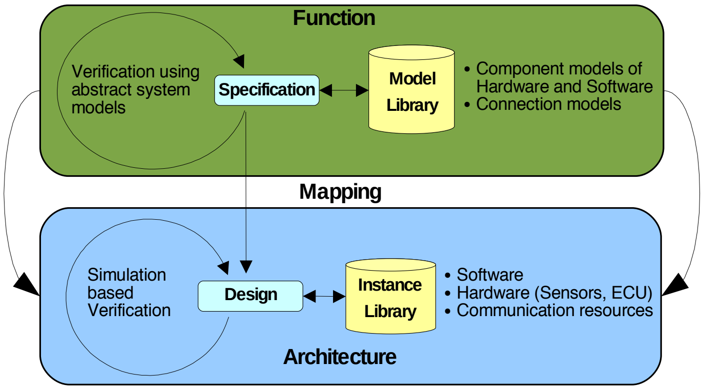

Fig 2: System level design methodology

3. Current work

Utilizing wireless networking technology allows sensors to be deployed as mobile devices. Wireless transmission on 0.8, 2.4 or 5 GHz provides different features in terms of bandwidth, scope and security. A power efficient radio transmission can be achieved by the IEEE 802.15.4 standard. This allows the deployment of very tiny and intelligent sensor devices in a network of an a priori unknown topology.

AdHoc-Networking-Algorithms are applied in combination with a smart power management to connect nodes to the central platform. Abstraction layers provide to applications a transparent view to the sensors. Applications acquire sensor data independently of the under laying network, connectivity or sensor position. A power aware communication requires smart route discovery algorithms based on geographic position or simpler nearest neighbour principles. A longer lifetime of an energy autarchic device is reached, when the actual energy status is taken into account for the routing decision. Advanced simulations are carried out in the project for communication protocols in combination with a model of sensors, A/D converters, micro-controllers and transceivers.

One demonstrator project deals with localisation of wireless sensor nodes without relying on external infrastructure. This is essential as sensor data is often useless without the knowledge about the position where it was taken. Based on a set of anchor nodes (i.e. sensor nodes with a priori known positions) the location of the remaining nodes is determined by evaluating the distances between directly connected nodes. The distances can be derived from measurements of time-of-flight (TOF) or received signal strength (RSS). Finally a sensor location is calculated that suites the set of measured distances with minimum error.

A second usecase focuses on wireless communication between vehicles and infrastructure. The generalised platform is used to collect vehicle internal data as an on-board unit. After processing the data the gathered information is exchanged with fixed units at the roadside. They are connected to an infrastructure which forwards the information for analysis purposes to the central traffic management system. The management system returns information about the road or traffic situation (e.g. the actual speed limit), which is send back to the vehicles. Major attention has been paid to build the system independent of the underlying communication layer. This is required as international effort in research and development of a common standard for automotive communication has not been finalized.

4. Conclusion

This paper summarises the results of the current work and also depicts the ongoing development. As stated before, the project started in April 2006. By combining a Xilinx-FPGA-Development board, a wireless communication module, a 12”-TFT-Display and embedded Linux a first demonstrator has been realized. Based on it, the ideas of the overall system are estimated and further developed. In cooperation with project partners and other interested parties usecases for the GPS-platform are evaluated, rated and realized by the means of hard- and software demonstrations. At present the box could be used in automotive applications (e. g. car communication), spread sensor applications and applications for ageing and disabled people.

5. References

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