AIS – Autonomous Integrated Systems

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In this article, the AIS cluster research project presents an overview of the results of the 6 R&D partners after three years of work. AIS proposes a new design methodology for MPSoCs for autonomous integrated systems, introducing an autonomous layer. Using this methodology, chips will be designed to react with autonomous characteristics during application. A main focus during the research was to incorporate interfaces between the design tools and the methodologies. As a result, different design methodologies to increase autonomous behaviour are presented. Autonomous elements and functions will be included to monitor and control data-paths, control-paths and communication buses to react at block or system level. The robustness will be optimised by inserting self-optimisation services including an operating system that is able to replicate, monitor and migrate tasks and services. The article will present the highlights of the partners' work and an FPGA-based prototyping platform which shows the interaction of the complementing EDA methodologies of the partners in one design.

Motivation

With the growing complexity of nanoelectronic integrated systems, the importance of non-functional requirements – like robustness or lifetime – are growing. Moreover, the area of application is often unknown or not addressed. As a result, nanoelectronic systems might fail. In classical chip designs, systems are often specified for the worst case. This will lead into over-engineered solutions in most cases. With AIS, we propose a new design methodology to create large nanoelectronic systems including communication buses, memories, computation modules, sensors, and actors besides control and data paths.

To give an example: Instead of designing chip buses – like the AMBA bus from ARM CPUs – for the worst case, future system buses are able to react under harsh environments. The encoding technique will be changed and the robustness of the chip enhanced. As a result, the new encoding technique will reduce the performance of the bus only when it is needed. Moreover, additional power consumption due to stronger encoding techniques can be reduced to a minimum. This example shows the envisioned flexibility of chips with autonomous behaviour.

The characteristics of electronic systems to react autonomously and accommodate flexibly to faults and modifications of the environment as well as the internal state require a new kind of thinking in the design-process. Not only function, area and power consumption are considered to be at the forefront, but also detecting and reacting from systems under defective operative conditions. That means sensors, evaluators and actuators in MPSoCs are going to detect sporadically appearing faults as well as analyse them and initiate actions to guarantee reliable, flawless operation. An autonomous operating system which works on the principle of self-organisation is necessary in addition to error correcting mechanisms, methods of correction and autonomous elements for an MPSoC-platform. The operating system manages hardware resources and allows the usage of the corresponding hardware-architecture by offering a machine-oriented software level (elementary operating system), which provides an API in terms of many services. This software level is going to be self-optimising and self-healing on the principles of self-organisation. For such dynamic self-healing and optimisation it is necessary to have platform data about possible ways of communication, as well as data about processors and their performance characteristics. In this way dynamic optimisation and the self-healing of software will be supported by the hardware platform. Figure 1.02 shows the areas of research done by the partners in the project.

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