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Addressing the Smart Systems design challenge: The SMAC platform

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This article presents the concepts, the organisation, and the preliminary application results of SMAC, a Smart Systems co-design platform. The SMAC platform, which has been developed as Integrated Project (IP) of the 7th ICT Call under the Objective 3.2 "Smart components and Smart Systems integration" addresses the challenges of the integration of heterogeneous and conflicting domains that emerge in the design of Smart Systems. SMAC includes methodologies and EDA tools enabling multi-disciplinary and multi-scale modelling and design, simulation of multi-domain systems, subsystems and components at different levels of abstraction, system integration and exploration for optimization of functional and non-functional metrics. The article presents the preliminary results obtained by adopting the SMAC platform for the design of a limb tracking smart system.

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1. Introduction

The European Technology Platform on Smart Systems Integration (EPoSS) Strategic Research Agenda (SRA) defines Smart Systems as "*intelligent, often miniaturised, technical subsystems with their own and independent functionality evolving from microsystems technology*" [1].

This definition encompasses then a broad class of devices that incorporate functionalities like sensing, actuation, and control, that are usually energy-autonomous and ubiquitously connected. In order to support these functions, they must include sophisticated and heterogeneous components and subsystems such as application-specific sensors and actuators, multiple power sources and/or storage devices, intelligence in the form of power management, baseband computation, digital signal processing, power actuators, and subsystems for various types of wireless connectivity, as conceptually depicted in Fig. 1.

It is evident from this heterogeneity that Smart Systems leverage a variety of different technologies and different materials. As a matter of fact, using the ITRS (International Technology Roadmap for Semiconductor) terminology, Smart Systems can be regarded as the bridge between the two orthogonal dimensions that describe technology evolution: "More Moore" and "More than Moore". The former dimension spans the traditional CMOS scaling for digital devices, whereas the latter one addresses the issue of evolution via "diversification", and refers to devices whose functionalities do not necessarily scale according to Moore's Law but aim at providing additional value in different ways (Fig. 2). The figure exemplifies how merging the capability of maintaining the scaling trend for digital logic and the increased opportunity of diversifying functionality will drive to integrated multiple functionalities on the same silicon support, migrating from system board-level into a System-in-Package (SiP) or System-on-Chip (SoC); in a word, a Smart System.

The challenge in the implementation of Smart Systems goes therefore beyond the design of their individual components (an already difficult task by itself), and rather lies in the co-existence of a multitude of functionalities, technologies, and materials. The widely acknowledged keyword in Smart Systems design is in fact *integration*. There are essentially two dimensions of integration that represent the main obstacle towards mainstream design of

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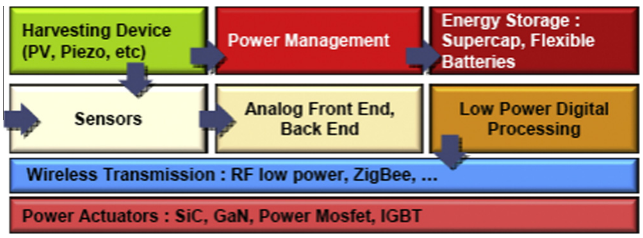

Fig. 1. Typical components of a Smart System.

Smart Systems: Technological and methodological. As already experienced in specific domains (e.g., in digital and analog design), a solution has been found first for the technological issues. Advanced packaging technologies such as System-in-Package (SiP) and chip stacking (3D IC) with through-silicon vias (TSVs) allow today manufacturers to package all this functionality more densely, combining the various domains depicted in the figure above in a single package. SiP technology works nicely because it allows merging components and subsystems with different processes, and mixed technologies using the state-of-the-art advanced IC packaging technologies with minor impact on the design flow. Therefore, to some extent, technological solutions aimed towards integration are available.

Design methodologies, however, are falling behind: Current design approaches for Smart Systems use separate design tools and ad-hoc methods for transferring the non-digital domain to that of IC design and verification tools, which are more consolidated and fully automated. This solution is clearly sub-optimal and cannot respond to challenges such as time-to-market and request of advanced sensing functionalities. A big step towards effective large-scale design of Smart Systems would be that of changing their design process from an expert methodology to a mainstream (i.e., automated, integrated, reliable, and repeatable) design methodology, so that design costs are reduced, time-to-market is shortened, design of the various domains is no longer confined to teams of specialists inside IDMs and system miniaturisation can be achieved with limited risks.

This objective can be reached by defining and implementing a structured design approach that explicitly accounts for integration as a specific constraint, which in the context of the SMAC project consists of a flexible software platform (i.e., the SMAC platform) that includes methodologies and EDA tools enabling multi-disciplinary and multi-scale modelling and design, simulation of multi-domain systems, subsystems and components at all levels of abstraction, system integration and exploration for optimization of functional and non-functional metrics. The key elements of the SMAC platform are:

1. The development of a co-simulation and co-design environment that accounts for the peculiarities of the basic subsystems and components to be integrated.
2. The development of modelling and design techniques, methods and tools that, when added to the platform, will enable multi-domain simulation and optimization at various levels of abstraction and across different technological domains.

SMAC aims at achieving this ambitious objective through a holistic co-design framework, which requires closing several technical and cultural gaps by means of a multidisciplinary approach. In order to do this, the project has required the joint co-operation of research and industry partners, including EDA vendors to ensure the platform usability in realistic, industry-strength design flows and environments, with a direct impact on the industrial exploitation.

Behind the growing interest in Smart Systems, there is a potentially huge and quickly growing market, which is expected to grow in the order of $200B in 2020 [1], inducing an even larger market of non-hardware services involving all the various devices envisioned in the Internet of Things. Such a market is much larger than those of smart- or feature-phones in terms of number of devices. Over 50 billion devices will be connected to the Internet according to Cisco forecasts, and most of these devices will be Smart Systems. Miniaturised Smart Systems find applications in a broader range of key strategic sectors, including automotive, healthcare, ICT, safety & security, and aerospace.

Also, efficient energy management and environment protection are business sectors in which the utilisation of miniaturised Smart Systems may make a difference. The worldwide market for "Monitoring & Control" products and solutions, one of the most important fields of Smart Systems applications, containing solutions for environment, critical infrastructures, manufacturing and process industry, buildings and homes, household appliances, vehicles, logistics & transport or power grids, is around 188B Euro. This value represents 8% of the total ICT expenditures worldwide, and it is identical to the whole semiconductor industry world

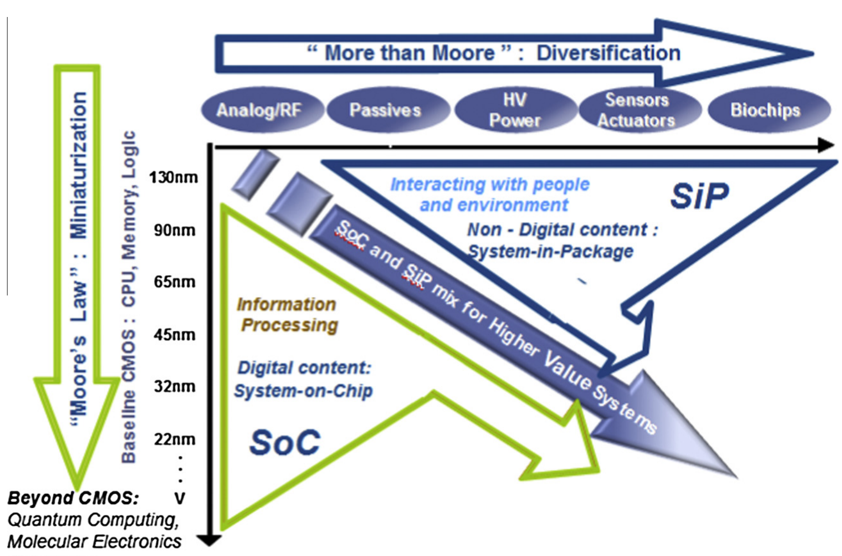

Fig. 2. Smart Systems as a bridge between More Moore and More than Moore.

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