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REMIS

August 2010 NO.7 ~ ARTEMIS Strategic Research Agenda

Mobile and cloud power enabling massive scalability and opportunities for growth

# WHAT THE FUTURE HOLDS ..



What does Neelie Kroes think about ARTEMIS?



Rolf Ernst states embedded systems to be the nervous system of society.

## SRA 2010 - THE NEW ORDER

The Strategic Research Agenda (SRA) 2006 generated an overall perspective of the embedded systems evolution in which ARTEMIS as the first Joint Technology Initiative (JTI) would bring European leadership in this area. The JTIs are an industry driven form of the PPP (public-private partnership). As part of this initiative, opportunity is given to the stakeholders to allocate major public and private resources to address the major challenges and define new rules of business in the sector.

IMPACT AND PARADIGM CHANGE ~ "The revolutionary impact and paradigm change in the ARTEMIS programme have to do with implementing and spreading embedded systems to seed the ambient intelligence of the future," explains Tatu Koljonen, co-chair of SRA WG. In the past few years, ARTEMIS has made good progress in implementing the main goals and objectives the SRA and is now attracting new and significanty interest in many fields and applications. Therefore, growing importance for including the grand societal challenges has prompted the new version of the SRA.

An expert group comprising best European minds from academia and industry and coordinated by Laila Gide and Tatu Koljonen has engaged in recalibrating the SRA, as it were, to provide scientific and technical input that will depict how embedded systems can help to solve grand societal challenges. This will strengthen the interplay between ARTEMIS and the other initiatives, and so foster the intellectual prominence of Europe in posing the relevant questions for embedded systems in this new world order.

CENTRALITY OF EMBEDDED SYSTEMS

~ Embedded systems are essential to the

digitisation of everyday life - more and more they permeate all aspects of life, from personalised healthcare to increasingly burning and important issues such as citizen empowerment and the affordability of various services. They boost technical capability, mobility, quality of life as well as business and added-value creation. It is vital to link the grand societal challenges to the technical challenges faced by embedded systems, such as energy awareness and limited power consumption for systems, ease of use, the 'always connected' mode and safety and security (the very essential aspect of 'trust'). Europe has to build on its leading position, for example in the field of automotive and machinery equipment, and invest in more and better embedded systems in areas in which it is lagging behind. If Europe is investing in more in embedded systems, it will better answer application needs. Embedded systems form the interface between physical and virtual world and give competitive advantages that can be gained by introducing them to other technical areas and business domains.

**REFOCUSING** ~ Laila Gide points out that the ARTEMIS SRA describes the strategic baseline of ARTEMIS. The strategic direction of European R&D is aligned with the needs of our society. As one major advancement in comparison to the SRA 2006, the new SRA 2010 will make stronger links between societal challenges, applications areas and R&D topics more visible and point out their connection.

The SRA 2006 Strategy matrix contained 'horizontal' components (Reference Design and Architecture, Seamless Connectivity and Interoperability, and Design Methods and Tools) and 'vertical' application contexts. Given the regulatory, research and industrial evolutions that are occurring with overlapping agendas, a redefinition of the ARTEMIS agenda is essential. While the matrix approach of the SRA (2006) is still generally valid, the explicit addition of the grand societal challenges dimension (fig. 2) does mean that the agenda requires redefinition the role and position of ARTEMIS and Europe.

Tatu Koljonen adds: "Key points of reference in the redefinition process are: FP7, Eureka and national programmes as well as the ENIAC JTI, the new emerging PPPs – Factory of the Future, Energy-efficient Buildings, Green Cars and Future Internet – as well as other ETPs, such as EPOSS, and also the EIT ICT labs. "A JTI aims to evoke a systemic, comprehensive change involving a number of sectors whereas the ITEA projects are complementary to improving the existing value chain and FP7 is more research oriented. The EIT ICT Labs are needed to incorporate the changed paradigm into the curricula of students."

FIVE KEY CHALLENGES ~ In brief, the new version of the SRA identifies five key challenges as candidates in the pursuit of the right questions. The main focus on a 'system of systems' (already adopted by the European Commission for the coming calls) sees a shift from syntax (form and structure) to semantics (meaning) in which ontology engineering can offer a direction towards solving the interoperability of devices, systems, and services. With different systems for systems comes the need to cope with mixed criticalities in order to provide the required level of dependability and security, for example. This prompts the question of certification - how can this be done in a modular, incremental way? These systems will have to be adaptive or self-organising since the system lifecycles will differ. The final callenge lies in data management.

MAIN MESSAGE ~ Laila Gide: "The big advantage of ARTEMIS is the opportunity it gives for building a consistent SRA.



Laila Gide and Tatu Koljonen, Co-chairs of the Working Group ARTEMIS Strategic Research Agenda and members of the Steering Board of ARTEMIS Industry Association.

ARTEMIS provides the means to involve all key stakeholders of the embedded systems domain and to combine their power. This includes large industries, SMEs, research institutes and universities as well as public institutions. In addition, the ARTEMIS SRA not only identifies relevant research topics but also outline the way to implement and foster innovation." This implementation includes establishing innovation environments and tool platforms, as well as facilitating cooperation with Centers of Innovation Excellence (CoIE), education and training. It also deals with questions of standardization, the involvement of SMEs and investigating new business models. ARTEMIS touches those essential elements that are essential in creating balanced eco-systems that favor excellence and nurture innovation.

Tatu Koljonen concludes that "Better communication and dissemination to a global audience are two of the essential tools that will help to underline the opportunities and societal relevance of embedded systems solutions. By refining the questions the ARTEMIS strategy should ask in the light of the knowledge and insight that has been gained and in respect of current and future trends, ARTEMIS will be able to build on a new cross-domain approach to support a variety of applications, services and solutions for the grand societal challenges (bubbles) and to achieve a paradigm change, with big impact and quick to market."

Thank you Laila Gide and Tatu Koljonen 🛛 🔳



## ARTEMIS – DERIVING RESEARCH PROBLEMS FROM COMPLEX SOCIETAL CHALLENGES

The ARTEMIS Summer Camp 2010 included a keynote talk by Rolf Ernst, Technische Universität Braunschweig, Germany. The keynote was motivated by the 2010 Update of the SRA, the ARTEMIS Strategic Research Agenda.

The huge success and omnipresence of embedded systems have effectively made it the central nervous system of society.



2006: RESHAPING EMBEDDED SYSTEMS

~ In creating the first SRA in 2006, the focus was individual application contexts: Industrial (including automotive and aerospace), Nomadic Environment, Private Space and Public Infrastructure. Across these applications, three research domains that form a second dimension of major research challenges were identified: Reference Designs and Architectures, Seamless Connectivity and Middleware, and System Design Methods and Tools. Furthermore, networked embedded systems were regarded as a key future trend in reshaping the world of embedded systems from a collection of independent or locally connected computers to large interconnected systems. 2010: REVIEWING THE CURRENT SITUATION

~ While this prediction has proven correct, its impact goes far beyond the SRA 2006. If we look at the current situation, we see that several important changes have taken place. Many emerging embedded applications share the same networks and components. The networks form hierarchies, which do often not correspond to the respective application structures (examples are given below). Open networks of embedded systems combine multiple application domains giving rise to another level of system complexity. The emerging use of the Internet for embedded system networking provides new opportunities. Not only can embedded systems exploit the emerging ubiquitous network topology for communication, they also gain access to the knowledge of Internet-based information systems. In turn, information systems can utilise embedded systems as source of information enabling an Internet of Things.

#### SOCIETY'S CENTRAL NERVOUS SYSTEM ~

Therefore, embedded systems technology should no longer be considered in isolated application contexts only but also in relation to larger societal challenges. This is even more appropriate as, today, dealing with societal challenges depends largely on technological support which, in turn, depends on embedded systems technology. The huge success and omnipresence of embedded systems have effectively made it the central nervous system of society.

So, the SRA 2010 introduces societal challenges as an overarching concept with several applications and research domains. A few key challenges were selected: Smart Buildings and Cities of the Future, Green, safe and supportive transportation, Personal Healthcare and Energy in a Sustainable Environment.

#### DERIVING TECHNOLOGICAL CHALLENGES

~ A three-step approach helps to derive technological challenges. First, the stage is set by identifying the embedded systems and their networks are that are expected to play a role in the context of the respective societal challenge. This step reveals an enormous global system complexity with numerous component and application dependencies that are in dire need of structure to identify common technical goals. For that purpose, the second step draws the connection to the societal challenges using scenarios that serve as concrete aspects of an abstract societal challenge. The scenarios are selected such that they 1) are visionary and reflect societal trends such as ageing society or the need for a sustainable environment, 2) show the importance of embedded systems even to a layman and 3) can serve to motivate and derive novel embedded systems research challenges that are not obvious in an individual application context. The third step, then, formulates the new research challenges as a basis for future programmes.

#### STEP 1: IDENTIFYING EMBEDDED SYSTEMS

~ To illustrate step 1, we will start with two examples that show how networked embedded systems are about to outgrow individual application contexts. Cars today contain sophisticated on-board networks including different bus protocols and up to 100 embedded processors. In the future wireless car-to-car and car-to-infrastructure communication will create another network layer that will be open rather than controlled by an individual automotive OEM. That layer will improve automotive functions, e.g. enable advanced driver assistance systems (ADAS) that use other cars' sensors as well as connect the car to the traffic control system, a typically public infrastructure application. This connection will enable feedback for adaptive vehicle speed and traffic control to optimise traffic flow or reduced energy consumption as well as catering to individual needs, for example by giving senior citizens or children more time and space, or adapting the speed. This shift becomes even more evident if we change perspective and look at the role of a future networked car. Besides being connected to the traffic infrastructure, the vehicle will have access to information systems, personal communication and entertainment - all nomadic environment applications - and thus be able to run an online networked diagnosis of its performance (industrial) and the driver (private space application) and, if it has electric drive, can be connected to the smart grid. So, effectively, a single car becomes part of all SRA 2006 application contexts combining many services with different providers and responsibilities.

Smart buildings and smart cities are a second example of step 1 (see figure). Home networks, currently associated with controlling appliances and entertainment, will support more functions, one of which will be ambulant healthcare. While currently not interoperable, home networks will most likely be connected to facility management, building security and office networks as well as the local smart energy grid. Smart buildings will be connected to the smart city infrastructure that includes public services like the police and healthcare, traffic and mobility management, industry, and the utilities supply network (like water and energy). In turn, cities are part of a global network of communication and energy or water supply. Many of the network components in the figure already exist; the novelty lies in the quality of the connection of different networks, enabled by the future Internet

**STEP 2: CONNECTING TO SOCIETAL** CHALLENGES USING SCENARIOS ~ The introduction of societal challenges in step 2 is a major extension over the SRA 2006. Personalised Healthcare is a challenge that comes with the dramatic shift in demographics towards an ageing population. As a consequence, there will be an increased number of patients with age-specific, chronic and degenerative diseases, such as cancer, diabetes, cardiac, Alzheimer's or Parkinson's diseases. OECD data suggest an increase in spending on health related services from 9% to 15% of the GDP in developed countries while acute care in hospitals has dropped by 30% in the last 15 years. There is an emerging trend towards ambulant care, but keeping and surveying the patient at home can only be the first step.

Scenario 1 "Care Everywhere" assumes that diagnosis and treatment will be extended seamlessly to wherever the patient goes, enabled by wireless multi-parametric biosensors which are attached to telemonitoring networks. New "e-health" hospitals will cut healthcare costs and, at the same ... embedded systems technology should no longer be considered in isolated application contexts only but also in relation to larger societal challenges.



Figure Smart Building and Cities - Embedded Network Interdependencies

time, increase a patient's mobility and comfort.

Scenario 2, "Early Diagnosis and Prevention" addresses one of the main goals of public healthcare, which is to reduce the impact and cost of diseases by early diagnosis and prevention. Networked embedded systems controlling "in vivo" monitoring of biological samples ("the doctor in your pocket") and improved imaging systems using embedded system technology will support that goal.

These two scenarios have a significant impact on embedded systems with the shift in (safety critical) healthcare from the hospital to the embedded systems network. More precisely, ambulant care at home must be connected to the healthcare services and thus to a safety critical communication path (figure) from the home all the way to the "e-health" public service. Patient monitoring must be maintained not only when the patient is in the car but the car itself might need to adapt to the driver's health condition and age, thereby defining new safety-enhancing needs for autonomous driver functions.

**SOCIETAL CHALLENGE** ~ Smart Buildings and Cities of the Future is an overarching societal challenge combining many infrastructure service aspects. Only some of the potential benefits of the platform (figure) have been sketched.

Scenario 1, Mobility for Everyone, addresses an important individual need. Today, many people suffer from limited mobility due to navigational and traffic participation challenges, exceptional health circumstances or handicap. Here, the embedded systems networks can assist, adapting elevators and doors, supporting navigation and preventing injury by -adapting traffic, alerting others and increasing security. As in the case of personal healthcare, the application must follow the person, from home to work, through the building, in traffic, at work or recreation. This requires seamless interaction within safety and real-time constraints. Again,

### WHAT THE **FUTURE** HOLDS ...

the adapted car or public transportation must be hooked up to databases and future mobility assistance services.

Scenario 2, City Energy Control, shifts the focus from the individual to public economics. Today, more than 40% of the total energy consumption is spent on buildings, with a further large amount on traffic. Unconnected building control systems, private devices and transportation systems limit the potential optimisation. Widely distributed local energy production (solar panels, thermal power stations) and local energy storage (e.g. car batteries) challenge power grid control. New capabilities are required, such as decentralised control, the use of integrated home, office and facility networks, integrated buildings and traffic energy management along with new billing schemes. Unfortunately, the technologies developed for facilities and industry do not easily scale down to small units such as family homes, neither by cost nor energy consumption.

Scenario 3, Security, is of both individual and public interest. Depending on the definition, security is a concern in many contexts. Personal security, prevention of terrorism and crime, health emergencies or catastrophic situations (earthquake, fire) all require robust, real-time functions with fast and seamless interaction that integrate sensors, information systems and embedded networks affecting almost the whole network illustrated in the figure. On the other hand, open networks also challenge information security as embedded networks collect large amounts of sensitive personal and public data. Controlling information access will become one of the key challenges.

### STEP 3:... DERIVE NOVEL EMBEDDED SYSTEMS RESEARCH CHALLENGES ~

The societal challenges outlined here are sufficient for the third step, the derivation of

research challenges. Several consequences for embedded systems research can be identified. The change from local networks with local designer responsibility to open networks of embedded systems sees single system ownership shift to multiple design processes and responsibilities involving many parties with conflicting objectives. There is a change from static networked embedded systems to systems-of-systems, which are highly dynamic, evolving and are never down. The convergence of applications on open networks introduces component and network safety requirements, availability and real-time behaviour in areas where such requirements have not been an issue, such as in home networks and car-to-infrastructure communication. This has been demonstrated in several of the scenarios.

The Future Internet will extend its role from a backbone of information society to a communication and integration vehicle for a rapidly growing world of embedded systems, soon far outnumbering the people using the Internet. The Internet will become part of the seamless integration challenge already found in the SRA2006 and, therefore, must be enabled to safely and reliably handle many different embedded applications. The Internet will not replace the current embedded system networks but will connect such networks, as shown in the figure. Because Internet communication cannot be expected to reach the same quality as provided by current embedded system networks, embedded systems must be made robust to compensate for lower real-time and reliability guarantees, and must be able to operate in the event of temporary network failures. These conflicting quality requirements are addressed by the new Cyber Physical Systems research area.

Many new scientific challenges require collaborative research as well as robust

networked systems that can handle high system dynamics and limited reliability. The individual embedded system must be able to adapt to changing application contexts and network environments without having to test every possible configuration in the lab. This requires (partially) autonomous systems that should have self-optimisation, self-healing and self-protection capabilities to work in unreliable network environments. New design processes are needed for such systems whereby part of the design process is moved from the lab to the field.

Last but not least, mixed criticality networks and components are needed to efficiently support several levels of safety, real-time and energy requirements as well as the mobility of critical embedded system functions as outlined in the personal healthcare scenarios. While this list is incomplete, it does highlight some of the urgent research needs requiring collaborative research across several application contexts and industries.

In conclusion, open networks have added a new level of complexity to embedded systems. The new area of embedded systemsof-systems is driven by comprehensive societal challenges rather than by individual application domains. The Future Internet will become a key embedded systems communication backbone and must meet the corresponding requirements. Embedded system robustness, mixed criticality networks and components, and autonomous systems requiring new design processes have been identified as resulting scientific challenges.