Proposal Book [- G-ICT - CHIST-ERA Eligibility - YES]

Proposal Data

Acronym	E-CROPS
Full name	Energy harvesting Communication netwoRks: OPtimization and demonStration
Duration	36
Topic	G-ICT
Keywords	microelectronic systems, micro-mechanical systems, energy efficiency, energy harvesting, sensor networks, scheduling, power management, trade-off between power and chip performance, energy storage, information theoretic limits
Ranking	0

Coordinator contact point for the proposal

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Consortium Partners

C/P	Institution	Contact	Other	Country	Legal Status	
C	Centre Tecnològic de Telecomunicacions de Catalunya (CTTC)	Deniz Gunduz	Bertrand Devillers	Spain	Public research organisation	**Ind.Eff.:**78 **Ind.Cost:**407,250 **Ind.Bud.:**168,000
P	Middle East Technical University / Electrical and Electronics Engineering Department	Elif Uysal-Biyikoglu	Haluk Kulah	Turkey	Public research organisation	**Ind.Eff.:**104 **Ind.Cost:**352,209 **Ind.Bud.:**145,240
P	Imperial College, Electrical and Electronics Engineering Department	Erol Gelenbe	Omer Abdelrahman, Ricardo Lent	United Kingdom	Public research organisation	**Ind.Eff.:**54 **Ind.Cost:**619,398 **Ind.Bud.:**495,519
P	EURECOM / Mobile Communications Department	David Gesbert	Petros Elia, Laura Cottatellucci	France	Public research organisation	**Ind.Eff.:**36 **Ind.Cost:**421,179 **Ind.Bud.:**210,588

Abstract:

“Anytime, anywhere, anything” has been the recent catch-phrase used by technology evangelists promising untethered wireless data flow not only among people, but also among devices of any imaginable sort. Trillions of autonomous devices are foreseen in this promise. While wireless sensor networks solve the wiring problem, we would still need to recharge or replace hundreds of batteries every day or supply the network infrastructure (e.g. base stations in the cellular world) with an ever increasing amount of power. Harvesting available ambient energy, such as solar, thermal or electromagnetic, to power wireless devices is the only viable solution to realize this promise in a sustainable manner. Building upon this requirement, in E-CROPS we study the design, optimization and implementation of a wireless network in which, nodes can harvest renewable energy and store the extra energy in their batteries, be it at the terminal or the network infrastructure side. In our theoretical study, we aim to formulate a mathematical theory of communication for energy harvesting networks, considering the communication network jointly with the energy network consisting of the harvesters and the storage units. We propose to design the protocols enabling the adaption of the physical and network layer design to the temporal changes in the available energy as well as to the distribution of the energy within the network. In parallel, we will study novel vibration and thermal energy harvesters as well as the appropriate storage units, and integrate these devices into a wireless sensor network application as a proof of concept for our scientific results. Bringing together researchers from theoretical and experimental backgrounds, we expect that both sides will benefit significantly from this interaction: 1) The design of the harvesting and storage units will be adapted to the needs of the specific communication scenarios; 2) Practical energy and data profiles will be used to design and compare our algorithms, and finally 3) A proof-of-concept sensor network application will be implemented to test the practicality of our ideas in real world.

Relevance:

The project call highlights contributions reducing the energy consumption of communication and computation systems both on the component level through information theoretic analysis and with a system level approach through intelligent architectures. Our proposal involves both levels of study through a holistic approach: we propose a theoretical framework for a cross-layer optimization between the communication network and the underlying energy supply and storage network in the presence of time-varying energy. This constitutes the foundational aspect of our project with a long-term scientific impact by developing a mathematical theory of energy-harvesting (EH) communication networks. E-CROPS will also study the design of vibration- and thermal-based EH devices based on the needs of the communication network. The algorithms resulting from our theoretical study will be tested on a sensor network whose nodes are supplied from the designed EH devices. This is ICT-relevant as the most promising applications for the future communication networks, such as Internet of Things and Machine-to-Machine communications will be based on devices with alternative and renewable energy resources. Our approach is multidisciplinary in the sense that we are bringing together high quality researchers from various layers of the communication network (communication theory, network theory, and energy storage) as well as a well-known research group on the design of energy harvesting devices.

Proposal Book [- G-ICT - CHIST-ERA Eligibility - YES]

Proposal Data

Acronym	GEMSCLAIM
Full name	GreenEr Mobile Systems by Cross LAyer Integrated energy Management
Duration	36
Topic	G-ICT
Keywords	Green IT, energy optimization, energy-efficient operating system, customizable HW, energy-aware compiler
Ranking	0

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Consortium Partners

C/P	Institution	Contact	Other	Country	Legal Status	
C	University of Innsbruck/Institute of Computer Science	Thomas Fahringer	Radu Prodan	Austria	Public research organisation	**Ind.Eff.:**93 **Ind.Cost:**392,028 **Ind.Bud.:**392,028
P	Queens University of Belfast/High Performance and Distributed Computing	Dimitrios Nikolopoulos		United Kingdom	Public research organisation	**Ind.Eff.:**48 **Ind.Cost:**690,331 **Ind.Bud.:**578,772
P	RWTH Aachen University/Institute for Communication Technologies and Embedded Sysems	Rainer Leupers	Anupam Chattopadhyay	Germany	Public research organisation	**Ind.Eff.:**108 **Ind.Cost:**621,000 **Ind.Bud.:**621,000
P	Politehnica University of Timisoara/Faculty of Automation and Computer Engineering	Marius Marcu	Sebastian Fuicu. Alexandru Amaricai-Boncalo, Razvan Bogdan, Oana Amaricai-Boncalo, Andrei Stancovici	Romania	Public research organisation	**Ind.Eff.:**72 **Ind.Cost:**184,888 **Ind.Bud.:**184,888

Abstract:

Personal computing currently faces a rapid trend from desktop machines towards mobile services, accessed via tablets, smartphones and similar terminal devices. With respect to computing power, today´s handheld devices are similar to Cray-2 supercomputers from the 1980s. Due to higher computational load (e.g. via multimedia apps) and the variety of radio interfaces (such as WiFi, 3G, and LTE), modern terminals are getting increasingly energy hungry. For instance, a single UMTS upload or a video recording process on today´s smartphones may consume as much as 1.5 Watts, i.e. roughly 50% of the maximal device power. In the near future, higher data rates and traffic, advanced media codecs, and graphics applications will ask for even more energy than the battery can deliver. At the same time, the power density limit might lead to a significant share of “Dark Silicon” at 22nm CMOS and below. Obviously, disruptive energy optimizations are required that go well beyond traditional technologies like DVFS (dynamic voltage and frequency scaling) and power-down of temporarily unused components. The GEMSCLAIM project aims at introducing novel approaches for reducing this “greed for energy”, thereby improving the user experience and enabling new opportunities for mobile computing. The focus is on three novel approaches: (1) cross layer energy optimization, ranging from the compiler over the operating system down to the target HW platform, (2) efficient programming support for energy-optimized heterogeneous Multicore platforms based on energy-aware service level agreements (SLAs) and energy-sensitive tunable parameters, and (3) introducing energy awareness into Virtual Platforms for the purpose of dynamically customizing the HW architecture for energy optimization and online energy monitoring and accounting. GEMSCLAIM will provide new methodologies and tools in these domains and will quantify the potential energy savings via benchmarks and a HW platform prototype.

Relevance:

Mobile terminals and consumer devices are among the fastest growing markets in computing, and Europe has a strong position, both academically and industrially, in delivering key HW and SW technologies and components. In the long term, further growth is endangered (besides by other issues like complexity) by the “power/energy wall”. Maximum power density and battery capacity do not scale anymore with Moore´s Law. While low power/low energy techniques in use today are mostly based on horizontal techniques (e.g. clock gating at the logic level or DVFS at the operating system level), the purpose of GEMSCLAIM is to explore new avenues in energy optimization via an interdisciplinary vertical approach: Leveraging the complementary expertise of its partners, a novel combined optimization across the major HW/SW system layers (compiler/OS/HW platform) will be investigated. The consortium´s vision is to enable an additional 30% energy saving for the digital HW platform of mobile terminals.

Proposal Book [- G-ICT - CHIST-ERA Eligibility - YES]

Proposal Data

Acronym	SMARTER
Full name	Smart Multifunctional ARchitecture & Technology for Energy-aware wireless sensoR
Duration	36
Topic	G-ICT
Keywords	energy harvesting, battery-free, low-power electronics, multifunctional transducer, micro-ultracapacitor, IR-UWB, Structural Health Monitoring
Ranking	0

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Consortium Partners

C/P	Institution	Contact	Other	Country	Legal Status	
C	LAAS-CNRS	Jean-Marie DLIHAC	Marise Bafleur, Magali Brunet, Daniela Dragomirescu	France	Public research organisation	**Ind.Eff.:**109 **Ind.Cost:**702,111 **Ind.Bud.:**437,760
P	Cranfield University	Meiling Zhu	Paul Kirby, A. Giulano Durazo-Cardenas, R.V. Wright, V. Marsic	United Kingdom	Public research organisation	**Ind.Eff.:**66 **Ind.Cost:**608,162 **Ind.Bud.:**456,123
P	University of Barcelona	Pere Miribel	Jordi Colomer, Jaime Lopez, Beatriz del Moral, Jaime Punter	Spain	Public research organisation	**Ind.Eff.:**68 **Ind.Cost:**199,200 **Ind.Bud.:**199,200

Abstract:

The overall vision of the project is to develop comprehensive knowledge and an innovative methodology in the areas of energy autonomous wireless systems from a global system perspective, enabling self-powered, battery-free wireless sensing nodes to meet a wide range of structural health monitoring (SHM) applications. The research is multi-disciplinary, and designed to enable the emergence of innovative energy technologies suitable for transfer from laboratories to industries. The research vision builds on the project partners' complementary skills and strengths in the area of 'towards zero-power ICT' with the potential to lead to multiple scientific and technical breakthroughs.. The first breakthrough is to make use of the SHM sensing device itself to implement a single

multifunctional device providing both structural health data and electrical energy harvested from mechanical vibrations. Another breakthrough will be to store the harvested energy in a fully integrated smart storage device, which adapts its storage capacity, according to the available energy in the environment and to the power consumption of the load. This adaptability will provide a constantly optimized matching between storage device and energy harvester to foster energy transfer. The energy storage itself will be a micro-ultracapacitor, so will have the desirable features of high specific energy, short time response, long lifetime and safe operation. This micro-ultracapacitor will be implemented in a silicon compatible technology so as to facilitate co-integration with other functions. A final innovation will be the co-location of the different devices (harvesting, sensing, storage, processing, data transmission) on the same flexible substrate, in order to enable conformal attachment of the device, a characteristic highly desirable in a SHM context where the surfaces to be monitored are seldom planar. Additionally, by this means the issue of the anisotropy of vibration harvesters is settled, the harvester being, by nature, properly oriented. More globally, the project aims at producing a device in which co-integration, co-location of functions, versatility of applications and energy autonomy are pushed to a maximum.

Relevance:

The project is relevant to the topic “Green ICT, towards zero power ICT” of the call in that it: - deals with the design of an autonomous system scavenging its own energy from the environment that will offer the possibility of deploying new zero power ICT functions. - addresses the issue of energy consumption in sensing and communication - includes an embedded energy management system to minimize energy consumption - is based on a context aware architecture: what power is likely to be harvested? What energy is being stored? Is it useful to activate sensing? Is it wise to communicate? - provides a fully heterogeneous integration of the system onto a single flexible substrate with adaptive strategies and low power design approaches (e.g. dark silicon for the communication block) - produces a demonstrator - considers an application domain where it will be possible to compare it with state of the art - proposes an alternative green technology to batteries via energy harvesting and storage on micro-ultracapacitors.

Proposal Book [- G-ICT - CHIST-ERA Eligibility - YES]

Proposal Data

Acronym	STAR
Full name	SwiTching And tRansmission
Duration	36
Topic	G-ICT
Keywords	Telecommunication energy efficiency, photonic switching, energy efficient network design, green networks
Ranking	0

Coordinator contact point for the proposal

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Consortium Partners

C/P	Institution	Contact	Other	Country	Legal Status	
C	University of Leeds, UK	Prof. Jaafar Elmirghani		United Kingdom	Public research organisation	**Ind.Eff.:**42 **Ind.Cost:**552,054 **Ind.Bud.:**441,642
P	University of Cambridge	Prof. Richard Penty	Prof. Ian White	United Kingdom	Public research organisation	**Ind.Eff.:**40 **Ind.Cost:**454,466 **Ind.Bud.:**363,573
P	INRIA	Dr Laurent Lefevre	Dr Olivier Gluck	France	Public research organisation	**Ind.Eff.:**60 **Ind.Cost:**602,681 **Ind.Bud.:**222,663
P	AGH University of Science and Technology, Department of Telecommunications	Dr Piotr Cholda	Prof. Andrzej Jajszczyk, Dr Artur Lason, Dr Andrzej Szymanski	Poland	Public research organisation	**Ind.Eff.:**54 **Ind.Cost:**344,960 **Ind.Bud.:**344,960

Abstract:

In this project we adopt the Core Switching and Routing GreenTouch energy saving target of 100 and believe this ambitious target is achievable. A key observation in core networks is that most of the power is consumed in the IP layer while optical transmission and optical switching are power efficient in comparison, hence the inspiration for this project. Therefore we will introduce energy efficient optimum physical network toplogies that encourage optical transmission and optical switching at the expense of IP routing whenever possible. Inititial studies by the applicants

show that physical topology choices in networks have the potential to reduce the power consumption by a factor of at least 20, however network optimization and the consideration of traffic and the opportunities afforded by large, low power photonic switch architectures will lead to further power savings. We will investigate a large photonic switch architecture in this project, minimize its power consumption and determine optimum network physical topologies that exploit this switch to minimize power consumption. We believe that a power saving by a factor of at least 10 in the photonic switch power consumption is possible through our new designs. We will design new large photonic switch fabrics, based on hybrid semiconductor optical amplifiers (SOA) / Mach Zehnder interferometers as gating elements to minimise the switching energy per bit, and plan to optimize the network architecture making use of these new switch architectures and introduce on chip (photonic switch) power monitoring to inform higher layer decisions. Networks are typically 3 to 5 times over provisioned at present to maintain quality of service. We will study optimum resource allocation to reduce the overprovisioning factor while maintaining the quality of service. Here power savings by a factor of at least 3 are possible. Protection is currently provided in networks through the allocation of redudent paths and resources, and for full protection there is a protection route for every working route. We will optimize our networks to minimize power wastage due to protection and will consider for the first time in core networks the impact of embodied energy (energy used to manufacture the network components) to reduce the overall carbon footprint of the network. The power savings due to optimum physical topology design, optimum resource allocation, power saving due to optical switching instead of IP routing and more efficient photonic switches and the power savings due to energy efficient protection can be combined and therefore the investigators and their industrial collaborators BT, Alcatel Lucent and Telekomunikacja Polska, believe that an ambitious factor of 100 power saving in core networks can be realised through this project with significant potential for impact.

Relevance:

The project addresses one of the two targeted areas in the call, namely “Green ICT, towards zero power ICT (G-ICT)”. It focuses on “the decrease of energy consumption.. for communication” introducing emerging technologies at the component (SOA), system (photonic switch) and network levels for global power minimization in communication networks. Specifically at the component and system levels it introduces photonic integration with the Cambridge photonic switch holding the world record for the number of optical components integrated (>1000), and introduces new system architectures, for example real time power monitoring in the switches. At the network level it optimizes the physical topology for energy saving, it introduces intelligence to reduce the over provisioning, intelligence for optimum power minimized routing and power minimized protection. It therefore addresses the “New flexible and intelligent architectures based on energy consumption minimization (context aware architecture …)” call target.