



A precise overview of work packages, documents and publications can be found on the GINSENG website:

<http://www.ict-ginseng.eu/>

The GINSENG consortium consists of the following eight institutions:

SAP has grown to become the world's leading provider of enterprise software solutions. As an integral part of SAP's R&D activities, SAP Research is responsible for identifying, researching, understanding, developing and evaluating new and emerging technologies, processes and e-business solutions that strategically influence the future of SAP business applications. With the focus on applied research, SAP Research bridges the gap between open, collaborative research with external partners and exploitation into new or existing SAP product lines through SAP's development groups. Especially, the **Research Center Dresden**, Germany, is a main driver behind SAP's global research activities in the fields of Business Intelligence and Future Manufacturing.



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Swedish Institute of Computer Science (SICS) is a leading research institute for applied computer science in Sweden. SICS is a non-profit organization. Our mission is to contribute to the competitive strength of industry by conducting advanced research in strategic areas of computer science, and to actively promote the use of new research ideas and results in industry and in society at large. SICS collaborates closely with the international research community and with both large and small companies, in Sweden and internationally. Our main office is situated in Kista outside Stockholm. SICS employs approximately 110 researchers, including more than 50 PhDs, plus approximately 20 students working on their Master Thesis.

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The **University of Coimbra**, Portugal, comprises eight Faculties, more than 2000 teachers and 22000 students. Founded in the year 1290, the University of Coimbra is the oldest in Portugal and one of the oldest in the World. The University of Coimbra develops high added-value activities in partnership with over one thousand national and international organizations. It is an institution dedicated to creation, transmission, critique and dissemination of culture, science and technology. The University of Coimbra's international prestige is the result of a set of multiple factors, which includes the cosmopolitan character of its academy (with over 70 nationalities). **Contact:** Jorge Sá Silva, sasilva@dei.uc.pt

Founded in 1989, the **University of Cyprus** is one of the youngest universities in Europe. It is the premier organization of higher education in Cyprus and has been recognized for its teaching quality and the level of research work it creates, both locally and internationally. It comprises 7 schools, 21 departments, and 7 research centers. The **Networks Research Laboratory**, part of the **Department of Computer Science, School of Pure and Applied Sciences** attaches great significance to research and teaching. The Lab undertakes research in mobile and wireless networks, with focus on mobility management, QoS provision, and security. **Contact:** Vasos Vassiliou, vasosv@cs.ucy.ac.cy



Founded in 1845, **University College Cork (UCC)** currently has 19,000 students in four colleges: Arts, Celtic Studies and Social Sciences, Business and Law, Medicine and Health, and Science, Engineering and Food Science. UCC has an established international profile for its research activity, currently with the highest level of peer-reviewed research income amongst Irish universities, and ranking 184th in the recent QS world ranking of universities. Within the **Department of Computer Science**, the **Mobile & Internet Systems Laboratory** leads several research projects on mobile and multimedia networking, including several on wireless sensor and embedded networks. UCC is the lead partner in the FP7 GINSENG project. **Contact:** Cormac Sreenan, cjs@cs.ucc.ie

Sines refinery began operating in 1978. Covering 320 hectares area, Sines refinery has a storage capacity of three million m³, of which 1.5 million m³ is crude oil, and the rest is final and intermediate products such as gas, gasoline and diesel. The refinery comprises 27 process units. With a distilling capacity of 10.8 million tons a year, or 220,000 barrels a day, Sines refinery is one of the largest in Europe. Sines refinery produces Gasoline, Diesel, LPG, Fuel oil, Naphtha, Jet fuel, Bitumen, and Sulphur. **Contact:** Luís Pedro Silva; luis.pedro.silva@galpenergia.com



Now approaching its 50th year, **Lancaster University** is a world-class centre for teaching and research and is located on a beautiful campus in the North West of England. Lancaster University is committed to pursuing international research at the highest level. As a leading research-led university, we have students from over 100 countries studying at our UK campus and teaching and research partnerships across the globe. We have over 12,000 students across one of the safest campuses in the UK. 92% of Lancaster University graduates go into work or further study we have a community of over 100,000 alumni in 138 countries. Our research and teaching also has a significant impact on society and the economy through our work with business and other organizations. **Contact:** Utz Roedig, u.roedig@lancaster.ac.uk

Founded in 1745, the **Technische Universität Braunschweig** has the longest tradition among Germany's technical universities. Our core disciplines are engineering and natural sciences which are closely linked to our other disciplines of humanities and economic, social, and educational sciences. The **Institute of Operating Systems and Computer Networking** performs research on distributed systems and corresponding networking and communication systems, architectures and protocols. Mobility issues and wireless networks have been playing a major role in our recent research on Vehicular Networks, Wireless Sensor Networks, and Delay Tolerant Networks. **Contact:** Lars Wolf, wolf@ibr.cs.tu-bs.de



GINSENG

Performance Control in Wireless Sensor Networks



Key Achievements

- A wireless sensor network that offers performance control for message delivery delay and reliability.
- A set of technology innovations that offer an exploitation opportunity for European companies.
- Evaluation in a real-world deployment at an oil refinery.

Key Innovation

Research on wireless sensor networks (WSNs) has mainly been focused on protocols and architectures for applications in which network performance assurances are not considered essential, such as agriculture and environmental monitoring. However, for many important areas, such as plant automation and health monitoring, performance assurances are crucial, especially for metrics such as delay and reliability. The GINSENG project is a significant advance beyond the state-of-the-art by developing a novel performance controlled WSN that is targeted for use in a range of industrial environments. In such environments, WSN technology can result in significant savings in deployment and maintenance costs, and offers easy reconfiguration in adapting to changing business needs. The overall goal of GINSENG is a wireless sensor network that meets application-specific performance targets, and that is proven in a real industry setting where performance is critical.



The GINSENG middleware enables the easy integration of (wireless) sensor data in real-world industrial environments. It closes the gap between wireless nodes in the sensor network and existing monitoring and visualization tools for the plant control room personnel, but also high-level information management applications in the backend such as ERP systems, data warehouses or advanced business intelligence systems.

Technical Approach

GINSENG involves several innovations and a fresh approach to wireless sensor network research. First, GINSENG adopts a planned approach for sensor node deployment to enable performance control. The second basis of GINSENG is software components with assured performance, including operating systems and protocols for radio medium access. The third basis of GINSENG is a set of algorithms that ensure control with respect to network topology and traffic. These three components enable the possibility to deploy sensor networks with assured performance. Recognizing the inherent uncertainties of the real-world, GINSENG also provides mechanisms and tools to perform performance debugging of deployed systems.

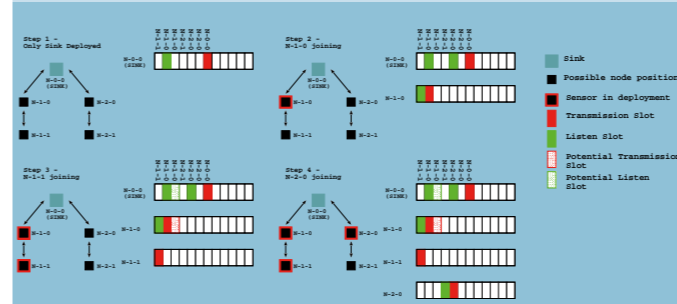
To encourage exploitation of the research outputs, GINSENG integrates with existing industry IT systems through a distributed middleware. The applicability of the technology developed in GINSENG is proven in a performance-critical real-world application: in the context of the GALP oil refinery in Sines, Portugal, the end-to-end solution is used to monitor and control industrial processes. The GINSENG solution comprises sensor network software that executes on wireless sensor nodes, and middleware/backend software that is hosted on Internet-attached computers. The sensor nodes run the Contiki embedded operating system with real-time extensions, together with the GINSENG TDMA-based medium access control protocol (GinMAC), dynamic topology control algorithm, overload control code, node mobility, and performance debugging support. The distributed middleware provides stream processing and other capabilities to a variety of backend applications, currently for plant control room personnel, for network configuration, and for plant life-cycle management.

← Harsh industrial environment: The huge amount of steel inside the refinery is challenging for every kind of radio communication.



Demonstration & Use

The GINSENG solution is implemented and has been evaluated both in laboratory testbeds and a real-world deployment at the GALP refinery in southern Portugal. At the refinery, a 26-node experimental network is being used to monitor tank levels, pipe pressures and flow, and to actuate pressure release valves. The ability of GINSENG to offer performance control for sensing and actuating within ambitious message delivery delay and reliability bounds has been proven in this network. Ongoing research is to monitor its longer-term performance and operation.



Scientific, Economic and Societal Impact

GINSENG has enabled the academic partners to work on state-of-the-art research problems that have yielded innovative solutions and experimental software. For example, extensions to the Contiki system, the GinMAC protocol, dynamic topology control, and performance debugging. This has led to peer-reviewed publications and open-source software. Industry partner SAP will use middleware developed in the GINSENG project in their “Real-World Integration Platform”. Industry partner Petrogal is evaluating GINSENG as a cost-effective and complementary technology to their conventional wired network of 35,000 sensors at the Sines refinery, and will use the demonstration system to impress upon their equipment suppliers their expectations for performance-control in future product offerings.

By enabling the use of WSNs in industrial applications, GINSENG will allow European technology companies to exploit the project outcomes to introduce products that advance the

state-of-the-art. Once productized, this has the potential to significantly reduce the operating costs of European industry, thus improving their global competitiveness. More generally, GINSENG can extend beyond industrial scenarios to other application domains where performance-control is required, such as health informatics, worker safety and emergency response, thus offering to improve human work and living environments.

Facts

Project coordinator:	Cormac Sreenan
Contract number:	224282
Project start date:	1 September 2008
Duration:	42 months
Community contribution:	3,099,416 Euro

← GINSENG utilizes a TDMA medium access protocol with exclusive slots dimensioned offline to match application requirements. Sufficient retransmission slots are provisioned for reliable operation in the deployment environment.



Exploitation

The GINSENG project has created significant knowledge in the areas of wireless sensor networks and industrial monitoring and control. This intellectual property is available for exploitation by hardware and software developers in the form of license agreement or commercial agreement with technical assistance.