Power-management strategies boost mobile performance

Energy optimisation extends the autonomy of mobile embedded devices and communicating networks

Mobile devices are hugely dependent on their ability to manage limited battery capacities to reach reasonable autonomy. The ITEA 2 GEODES project addressed power consumption in complex distributed communications systems from a global and coherent point of view, covering internal nodes in a device and the network environment in which it has to function. The results are being applied in several areas, and the power-management strategy has been summarised in a freely available handbook.

Mobile embedded devices now offer more functionalities than ever with even greater connectivity. Power optimisation is no longer confined to the device itself but also needs to take into account its environment through the networks it accesses. The challenge is similar in large sensor networks, involving groups of communicating nodes with heterogeneous capabilities – central processing unit, memory, etc.

MINIMISING ENERGY CONSUMPTION

GEODES focused on minimising energy consumption for two reasons: consumer awareness of the need to focus on energy use for environmental concerns; and device autonomy which requires products to use less energy despite implementing many more functions and with feature set as an important selling point.

While new hardware architectures are barely able to keep up with performance demands, battery technology is not evolving fast enough to address energy problems. Energy efficiency is becoming a differentiating factor and motivating the design of low power embedded systems with energy management to cut power consumption, maximise battery life and decrease thermal dissipation.

The slow evolution of battery technology has put the autonomy of embedded devices under pressure. In recent years, embedded processors have gone through an amazing evolution, demanding even better battery performance. Many attempts have been made to reduce the growing gap; the most common involves tailoring power consumption to performance.

SERIES OF MECHANISMS

GEODES investigated mechanisms for reducing power consumption, focusing on two:

1. Those on the level of individual nodes such as stand-by mechanisms, where nodes are switched to standby to reduce energy consumption; and
2. Those on the network level, such as transmit power control, where correct power levels need to be assigned to nodes to minimise total power consumption while keeping the whole network connected.

Major innovations included:
- Power-aware applications;
- Power-aware components at operating-system level;
- Energy-efficient techniques for the network (new MAC protocols, new routing algorithms);
- Middleware for quality of service (QoS) handling and node interoperability; and
- SystemC simulator for power estimation.
OVERCOMING THE POWER/PERFORMANCE GAP

Project results will help overcome the power/performance gap for next-generation devices. Applying systems/software awareness to power issues is key to bridge opposing evolution towards greater performance requirements and longer device autonomy. Coupling this awareness with a well-balanced offline/inline power optimisation can bring major energy savings and be considered an enabling technology.

There is massive potential for energy-efficient wireless-sensor networks (WSNs) and embedded systems in the Internet of Things (IoT) with machine-to-machine (M2M) connections. GEODES techniques can help facilitate deployment of M2M IoT systems with efficient energy management and communications solutions for extended operation.

Markets where GEODES techniques can be applied include:
- Wireless M2M connectivity through SIM-equipped devices;
- Protection of critical infrastructure such as perimeter protection of oil-pumping stations;
- Environmental monitoring and fire-fighter protection; and
- Airport security with vast IP-based video-surveillance networks.

OUTCOMES ALREADY EXPLOITED

GEODES results and outcomes have already been implemented. The power-management strategy is summarised in a freely available two-part handbook (http://geodes.ict.tuwien.ac.at/PowerSavingHandbook/). The approach is being applied internally by project partners to improve the autonomy of existing devices and as part of the design approach for new products.

Key outcomes include orders-of-magnitude energy savings such as doubling the autonomy of video-surveillance applications and lifetime extensions such as a 100% improvement in WSN lifetime verified on multiple prototype demonstrators across diverse domains. And up to 11% total energy consumption reduction has been achieved for TV set-top boxes – in a 10 million unit market, this would save some 62 GW of power a year.

Major project outcomes

DISSEMINATION
- More than 50 publications (e.g. FDL, DSD, DATE, DAC, INDI, ISWCs, EURASIP, …)
- 4 public workshops (WUPS, ERCIM, RMTH) & 3 public tutorials (DATE, WUPS)
- Numerous presentations at other events (e.g. GDR SoC/SiP, WWIC, RESCOM, PERCOM)
- 1 public handbook viewable online: http://geodes.ict.tuwien.ac.at/PowerSavingHandbook/

EXPLOITATION
- 2 open source software:
  - Powwow framework from IRISA, available at http://powwow.gforge.inria.fr/
  - TUV SystemC ISS for node power estimation
- 6 new products with new features being released:
  - Sensaris Senspack & Rempods, Philips wireless products for lifetime area, Technicolor Set Top Box, WMC Figo system, ENEA OSE RTOS new services
- Other products with new features expected in 1-3 years:
  - Thales personal communication system MOOVE, supervision & surveillance, EOLANE video surveillance equipment

STANDARDisATION
- 3 contributions to standardisation bodies (SystemC AMS, Zigbee, IETF 6LoWPAN)
- 2 supports to other standard bodies:
  - EU Code of Conduct on power saving modes in Set Top Boxes,
  - Multicore Association standard for the APIs

PATENTS
- Method and SW architecture to develop Power-Aware applications,
  - Thales Communications & Security, patentee registered and applied in FR & PCT
- Modular Wireless Physiological Monitoring and Communication System
  - Sensaris, in progress in US
- Method and apparatus to configure a WSN
  - Thales Communications & Security, registered