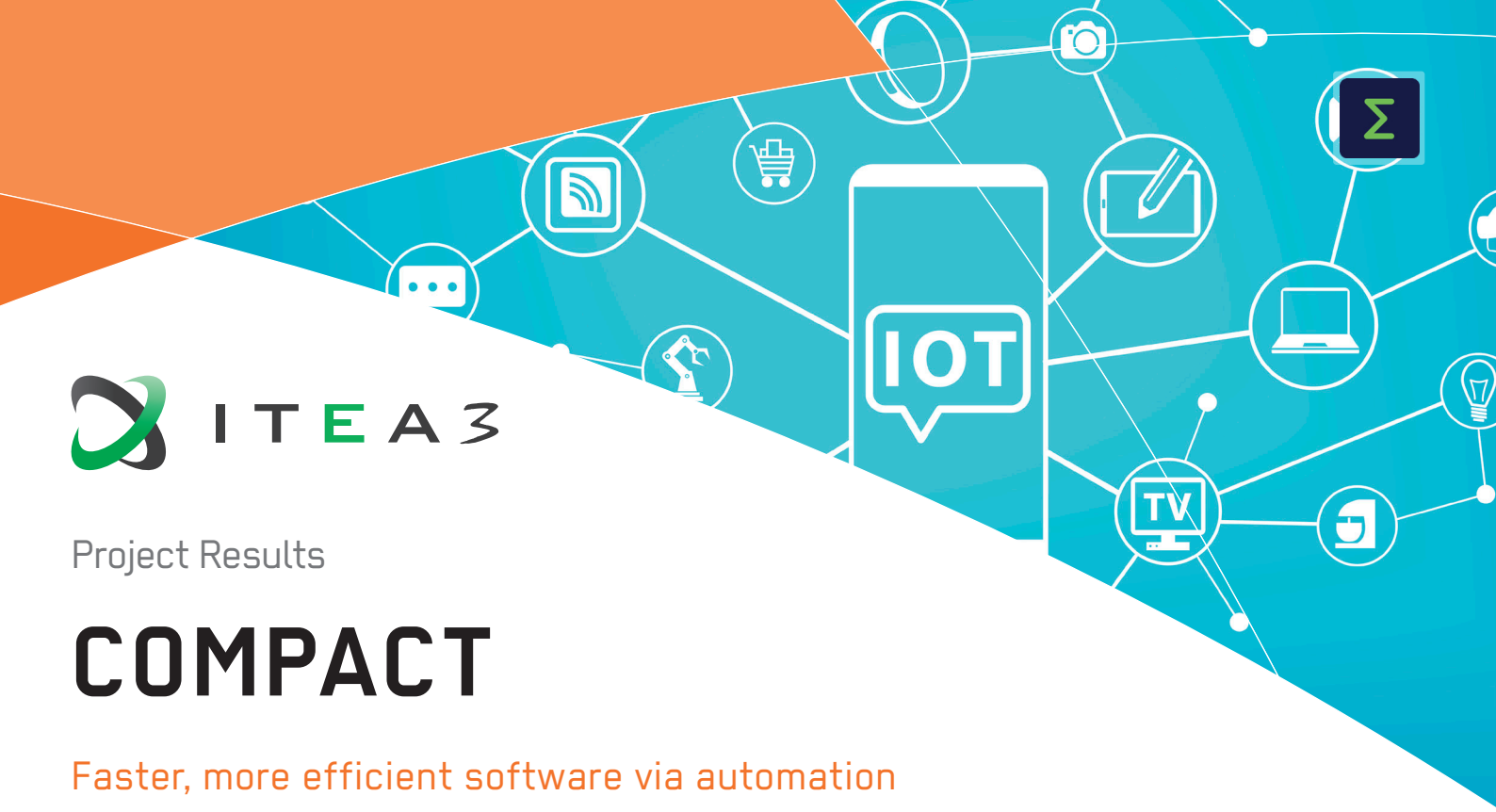

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Project Results

COMPACT

Faster, more efficient software via automation

EXECUTIVE SUMMARY

COMPACT (Cost-Efficient Smart System Software Synthesis) targeted a model-based methodology and tools for Internet of Things (IoT) software generation in order to significantly increase quality, maintainability and time to market.

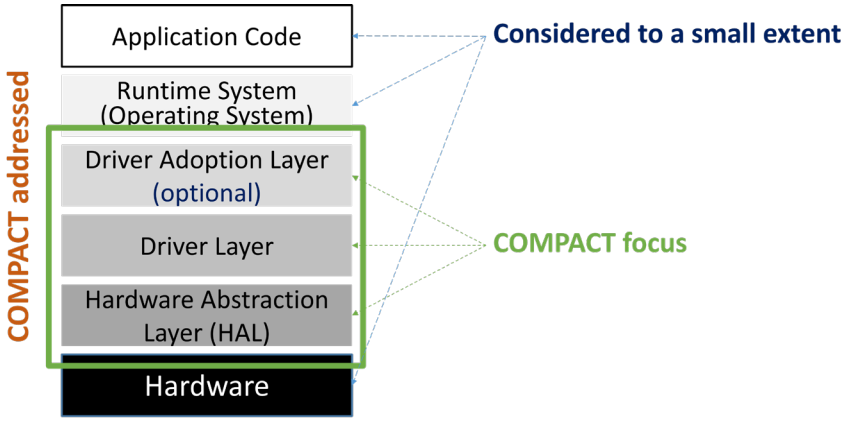
PROJECT ORIGINS

From industrial automation to healthcare, IoT has impacted every aspect of our lives. However, the cost pressure of making IoT devices as smart, cheap and energy efficient as possible affects both manufacturing and design costs, with software design accounting for around 45% of the overall System-on-Chip (SoC) development effort. Fast and efficient software development is thus a key enabler of future growth within the IoT domain.

The ITEA project COMPACT aimed to increase software productivity by addressing a substantial part of the non-recurring engineering cost: low-level software. With an approach based around the automation of software production, productivity has been increased by generating code from abstract models while manufacturing cost and product performance penalties have been avoided by optimising the software code generated. The system vision is addressed by selecting the best variant from multiple generated solutions, thereby reducing the limiting cost factor of embedded software when creating a semiconductor-based product.

TECHNOLOGY APPLIED

COMPACT's technological scope focuses on tiny IoT edge nodes of the Arduino class and low-level software in driver adoption layers, driver layers and hardware abstraction layers (HAL). Application code, runtime systems and hardware have also been considered to a limited extent. The software itself concerns small devices for which the affordable die size constrains the hardware.



COMPACT has sought to create a connection between how a device is modelled and how its software is developed. The solution is automatic software generation based on models, for which a complete chain of tools has been developed.

Based on requirements, concepts and use-cases from industrial partners, the project has achieved major innovations in modelling, tooling & automation and analysis & optimisation. An IoT Platform Modelling Language (IoT-PML) defines the overall modelling approach and features various meta-models for non-functional properties, specific functional behaviour and firmware configuration. This combines previously isolated modelling approaches and provides a foundation for the structuring and formalisation of the domain. For automatic code generation, various generators, libraries, plugins and tools for highly automated IoT software development have been created and integrated into a framework. Static and dynamic methods then analyse software properties (such as timing, power and memory footprint) and optimisation methods and plugins enable software transformation to ensure that the generation overhead remains within an acceptable range.

Three demonstrators have also been developed to illustrate the project's relevance to multiple applications: smart sensors (model-based code generation workflow and virtual prototype-based software analysis), vehicle detection (use of

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IoT-PML in the Enterprise Architect tool) and an IoT sensor device (model creation and support for system architecture and functional interface refinement). As a contribution to standardisation, a COMPACT extension to the IP-XACT standard has been finalised in Accellera and submitted to the Institute of Electrical and Electronics Engineers (IEEE).

MAKING THE DIFFERENCE

In terms of results, COMPACT has exceeded expectations by generating highly efficient software, up to 90% of which is faster and more compact than human-written code. This results in less memory usage, less energy consumption and lower latency. Depending on the degree of generation, a 20-70% reduction in software development costs can be expected without any performance loss or memory footprint of the software code. As designers can produce around 2,000 lines of code per year and a person-year costs roughly EUR 150,000, COMPACT predicts that each line of generated code will have a value of EUR 75. Generators for a new device family therefore pay off with their first use.

As the project has adopted an open software implementation for better dissemination, one of its key strengths has been broad exploitation by various channels. SME software tool companies have been able to create new tools while large semiconductor companies and system houses have created software more efficiently. This enables them to retain or expand their positions within the IoT for semiconductors market, expected to grow from USD 20 billion in 2017 (the start of COMPACT) to over USD 61 billion by 2024. SSCE, for instance, has built the base for cybersecurity modelling which is now part of the core product, enabling access to the aviation and space industry. Similarly, KAOS is offering its new COMPACT Crypto API (CCAPI) to several customers in the automotive and home automation domains and has trained two junior engineers to further extend platform support. Finally, VISY's demonstrator of a vehicle model classifier and license plate recogniser is in use at four customer sites and they expect orders worth EUR 1.8 million for systems with technologies developed in COMPACT.

As for the future, the project has shown that automated model-based code generation works efficiently in HAL and drivers, which will encourage work to bring model-based code generation to the next abstraction levels (such as runtime systems and DSP-centric applications). COMPACT has also demonstrated the power of using AI for software optimisation in combination with code generation and compiler configuration. Through 46 publications and 31 conferences, universities and research organisations have widened their scope with a new base for further research. By opening up new markets and paths of research, the project will therefore help keep Europe in a leading position in the embedded software domain, in turn opening up new uses for IoT to benefit our daily lives.

MAJOR PROJECT OUTCOMES

Dissemination

- 46 Publications (incl. 1 invited talk, 1 Best Paper) in 9 Countries (AT, CN, CZ, DE, ES, FI, GR, IT, UK, US) at 31 conferences and workshops and in 2 journals/magazines
- Highlight: Workshop on RISC-V Activities 2020 with 230 registrations (including 69 participants from 9 COMPACT partners)

Exploitation (so far)

- SSCE built the base of Cyber Security Modelling, which is now a part of the core product. This enabled SSCE access to the aviation and space industry because of SSCE's dramatic increase of knowledge gained in COMPACT.
- KAOS offers the library COMPACT Crypto API (CCAPI) to several customers in the automotive and home automation areas.
- VISY's developed technology for the COMPACT demonstrator of a vehicle model classifier and license plate recognizer on an embedded platform is in productive use now; both on embedded hardware and on server platforms at several customer sites.
- And further internal and external exploitation of the results by all partners.

Standardisation

- COMPACT's IoT-PML extension to the IP-XACT standard has been finalised in Accellera and submitted to the Institute of Electrical and Electronics Engineers (IEEE).

ITEA is a transnational and industry-driven R&D&I programme in the domain of software innovation. ITEA is a EUREKA Cluster programme, enabling a global and knowledgeable community of large industry, SMEs, start-ups, academia and customer organisations, to collaborate in funded projects that turn innovative ideas into new businesses, jobs, economic growth and benefits for society.

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Partners

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ABIX GmbH
SparxSystems Software GmbH

Finland

Comatec Automation Oy
Minima Processor
Noiseless Imaging Oy
Tampere University
Visy Oy

Germany

Eberhard Karls Universität Tübingen
FZI Research Center for Information Technology
Infineon Technologies AG
Kasper & Oswald GmbH
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Project end
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