ITEA 4

Project Results

GenerIoT

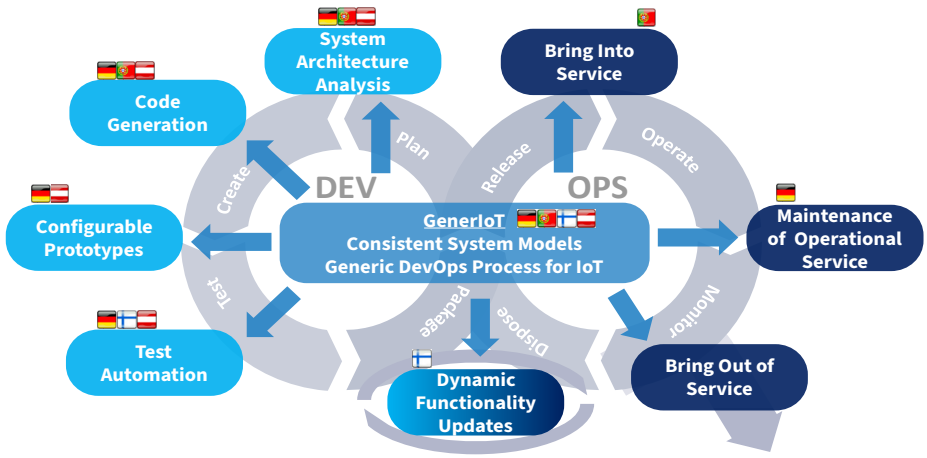
Bringing automated DevOps to the IoT lifecycle

By bridging the gap between the development and operations lifecycles of Internet of Things (IoT) systems, the ITEA project GenerIoT (Generating and Deploying Lightweight, Secure and Zero-overhead Software for Multipurpose IoT Devices) standardised and streamlined the development and management of software for IoT devices.

IoT is 'software-hungry', involving major complexity, costs and security challenges. Connectivity is both an opportunity and a risk: distributed hardware/software systems (often interconnected via the internet) can be adjusted in-field to meet user needs but must be kept up to date, especially when gathering information and influencing the environment. To reap the benefits of IoT, such as for Industry 4.0, processes must be improved from initial conception to end of life so that systems can be dynamically adapted to changing requirements and risks. This demands an efficient development flow that enables short development cycles.

Project developments

GenerIoT aimed to bridge the gap between IoT development and operations by bringing automated DevOps to the IoT lifecycle. This follows a model-based systems engineering (MBSE) approach that ensures consistent system models for software implementation, device hardware and communication channels. Within a continuous integration and development (CI/CD) pipeline – covering the full cycle of planning and implementation, testing, deployment, observation, and feedback collection – the project's system models act as 'glue' to represent structured data and to formalise both the process and design data. These can be refined until they can be transformed into code, with automated code generation forming GenerIoT's key technical innovation. The approach also enables configurable prototypes and environments to test what has been built without running the complete CI/CD pipeline. By these factors combined, significant time and cost savings can be achieved on generation, deployment and field management. All partners contributed to this modelling, collectively deciding on SysML 2.0 as the underlying standard upon which the models are based. GenerIoT also followed established principles for effective collaboration from the outset, including seeking to understand before being understood and thinking in win-win terms. This meant, for instance, a strong focus on joint results rather than deliverables alone, as well as a shared desire to make the most of the support offered by ITEA and the public authorities with a relatively low overhead compared to larger programmes. The partners therefore operated not just as a project consortium but as a dedicated team in which all could contribute in an open and coordinated manner. As a result of these efforts, GenerIoT received the ITEA Award of Excellence for Collaboration.



DevOps cycle GenerIoT

Results so far

With its shared model basis, the next step for GenerIoT was to adapt code automation to different domains. This resulted in eight demonstrators that validated the applicability of the project's results. Some were product-oriented, including detailed data collection as a basis for structural health monitoring and predictive maintenance of a radio tower, a new concept to control the energy consumption of ice hall cooling systems, and a decentralised IoT system for energy monitoring and control in smart homes. Others offer technical support features, such as providing flexible runtimes that can potentially execute code written in various source languages on a single target device. Across the demonstrators, major operational performance enhancements were achieved: CI/CD set-up effort was generally reduced by

around 30% and, in some cases, from days to minutes, while analysis times could be reduced from days to minutes and configuration efforts from hours to seconds. Simulation performance was also increased by anywhere from a factor of 100 to 1000. Crucially, these results have been reached in end-to-end workflows from modelling all the way to deployment and operation.

On the back of strong dissemination (including 27 scientific publications), exploitation activities are now underway. Some partners, such as Razorcat, have already implemented results on the customer side; this is expected to not only increase sales related to avionics certification but to extend their services into automation. Likewise, Nobody Engineering used the project to create software that connects building automation systems to digital services, through which they have reached EUR 800k in contracted annual revenue by offering the service across four countries. Others have developed pre-product prototypes that will be implemented in R&I processes after the project's completion, including Infineon's auto-generation of embedded software code for IoT that can reduce firmware generation efforts by 80% and improve performance by 70% for custom-intrinsic generation. Academic partners have also made results available as open source to maximise their exploitability, such as open-source add-ons to the Kactus2 electronic design automation tool by Tampere University. Finally, Sparx Systems has integrated GenerIoT libraries into its Enterprise Architect visual modelling and design tool, which serves as a foundation for future SysML 2.0 industrial adoption within their userbase.

Results so far

Given the significant efforts needed to bring ideas to the market, the GenerIoT team has committed to further assisting one another on the roll-out of the technology worldwide; discussions are also ongoing about future work to combine their results with generative AI as a hybrid solution. Meanwhile, contributions to SysML 2.0 – such as in working groups – will continue beyond GenerIoT's conclusion. In addition to helping develop an emerging standard, this is a way for the consortium to demonstrate that their work does not end here and that their openness to collaboration extends beyond the project.

Major project outcomes

Dissemination

- 96 papers at conferences and workshops as well as in journals
- Initiated and established the RISC-V and RUST Firmware (**RVF**) **Workshop**

Exploitation (so far)

- **Automated Code Generation** based on MBSE and MDA
  - utilising SysML2.0 and supporting C and RUST
- **Significant time and cost savings** by
  - standardising and streamlining generation, deployment, and field management
- Supporting the **IoT DevOps lifecycle**
  - from system modeling (using e.g. IoT-PML) to secure, in-field updates
- **Highly accurate** software-simulation with close to hardware-accuracy
  - while gaining a **100-1000x speed-up** over classical RTL simulations
- Proof of results with **real live examples** including ice hall facility and structural health monitoring

Standardisation

- Contributions to SysML2.0 standardisation
- IoT-PML is now SysML2.0 aware

ITEA is the Eureka RD&I Cluster on software innovation, enabling a large international 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. ITEA is part of the Eureka Clusters Programme (ECP).

https://itea4.org

GenerIoT

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Partners

Austria

- bee produced GmbH
- Sparx Systems Software GmbH
- XCoorp GmbH

Germany

- embedded ocean GmbH
- FZI Forschungszentrum Informatik
- Infineon Technologies AG
- Razorcat Development GmbH
- ScopeSET
- Technical University of Munich
- University of Rostock

Finland

- Granlund Oy
- Loopshore Oy
- Nobody Engineering
- Suomen Tekojää Oy
- Tampere University
- Tietoevry Finland Oy
- Unikie Oy

Portugal

- Cleanwatts Digital, S.A.
- Instituto Superior de Engenharia do Porto (ISEP)

Project start - end
October 2022 - April 2026

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