COSMOS

DevOps for Complex Cyber-physical Systems

The COSMOS Project has received funding from the European Union's Horizon 2020 Research and Innovation Programme under grant agreement No. 957254.

Fitash UL HAQ
University of Luxembourg

Project Overview

Challenges

- Observability, testability, and predictability of CPS behaviour highly limited with real world consequences

"Self-driving Uber kills Arizona woman in first fatal crash involving pedestrian"

"A simple software update was the direct cause of the fatal crashes of the Boeing 737"

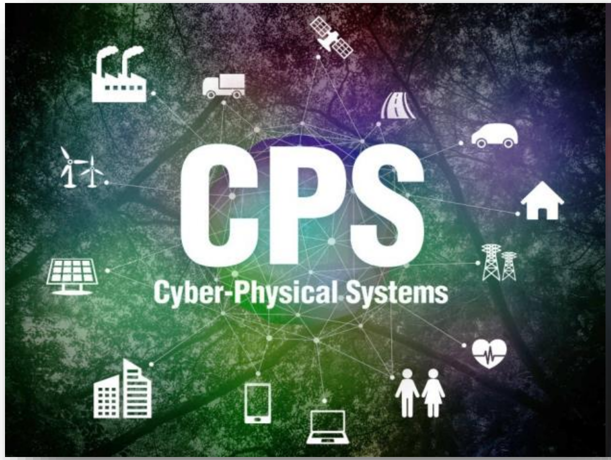
"Swiss Post drone crashes in Zurich - again "

- Contemporary DevOps practices and tools potentially right solution, but currently not developed for CPS domains

Vision

- Develop **novel DevOps tools**, methodologies, and techniques that enable effective, **continuous development and evolution** of CPS

- **Increase** the level of **reliability**, dependability, trustworthiness, and **adaptability** of CPS
- Delivers **proven DevOps advantages** and benefits to Europe's CPS development community



Lessons Learned and Success Stories

- DevOps Pipelines for CPS
  - Catalogue of practices and challenges, toolkit for bad practice identification
  - Generative tools to support the definition of CI/CD pipelines

- V&V and Security Assessment of DevOps pipelines
  - Combining reinforcement learning + metaheuristic search leads to effective detection of safety requirement failures
  - Adoption of a runtime verification framework in industrial settings
  - Metamorphic security testing automates the detection of 100+ vulnerability types

- DevOps Tools for CPS Software Evolution
  - Classification and automated detection of performance antipatterns in CPS via static analysis and data mining techniques
  - Improving cost effectiveness of regression testing for CPS by combining evolutionary intelligence with principal component analysis
  - Real-world maps and Bézier curves to generate test scenarios for self-driving cars

- Self-healing and Self-adaptability Tools for CPS
  - 50% reduction testing costs for CPS via Digital Twins and AI-based regression testing approaches in DevOps pipeline
  - Automated field tests replication as well as change-based prediction/monitoring of critical CPS changes via DevOps pipeline


Automotive


Medical


Avionics


Utilities


Railways

Recommendations for the Future

- Regulatory improvements
  - More dynamic (i.e. Agile and DevOps based) certification techniques and regulations for agile CPS
    - Support for CI/CD pipeline development
    - Testing and runtime verification
    - Maintenance and evolution of CPS
- Education improvements
  - Dedicated CPS curricula (e.g. courses and education material)
  - Prepare future generation of software engineers able to deal with complexity of CPS
- Increased collaboration
  - Academia with open source and private industrial organisations
  - CPS challenges can only be addressed with coordinated effort
  - Multidisciplinary approach required
    - CPS Developers and Researchers
    - Software Engineering Researchers
    - AI and Security Researchers
    - Physics, Human-machine Interaction, etc.
- Focused Research funding
  - Reliability, Security and Safety challenges of collaborative CPS
  - Self-adaptability of CPS to diverse environments, humans, longevity
  - Further challenges for DevOps for CPS
    - AI driven development and devices

ELEGANT

https://www.elegant-h2020.eu/ @elegant_ict

Concertation and Consultation on Computing Continuum:

From Cloud to Edge to IoT

Success Stories

Thanos Stratikopoulos

The University of Manchester

Brussels, Belgium

The context

- Big Data applications process large amounts of data arriving as streams from IoT devices
- Edge processing holds the key for:
  - increased responsiveness
  - better energy efficiency
  - data privacy

The ELEGANT Vision

- Unification of IoT and Big Data programming environments
  - Automatic and easy deployment of existing code from Big Data platforms to IoT devices and backwards; in a self-adaptable way

The ELEGANT Objectives

- Unification of programming environments
- Dynamic Code Motion
- Intelligent resource selection and allocation
- Secure, Reliable, and Dependable code deployment

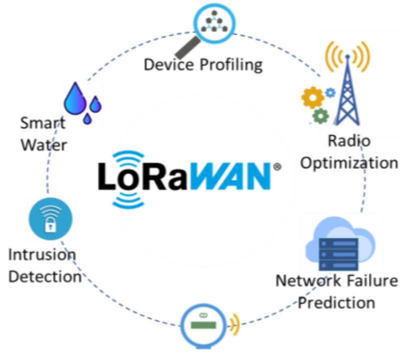
Lessons learnt and success stories

- Challenges
  - ➢ Diversification of the programming models
  - ➢ Lack of interoperability between Big Data and IoT deployments
  - ➢ Lack of dynamic semantic code adaptation
  - ➢ Inability to dynamically orchestrate code
  - ➢ Weakened security features
- ELEGANT Solutions
  - ➢ Unified API for Cloud, Edge, IoT
  - ➢ Elastic Runtime
  - ➢ Intelligent Orchestrator
  - ➢ Acceleration Service
  - ➢ Code Verification Service
  - ➢ Networking Cybersecurity Layer
  - ➢ DevOps tools

ELEGANT Use Cases

Secure Smart Riding (KTM)

Large-Scale Secure Smart Metering (UNIDATA/CNIT)



Video Surveillance (UBITECH/UNISYSTEMS)

Medical Wearables (SPARK WORKS)

Recommendations for the Future

- Performance & Energy efficiency
- Scalability
- Programmer-friendly Tools/Libraries
- Critical Use Case Requirements (e.g. Latency, Privacy)

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FOCETA

Foundations for Continuous Engineering Trustworthy Autonomy

10-11 May The Claridge, Brussels, Belgium

FOCETA Vision and Scientific Pillars

*Introduce a **mixed approach** for engineering trustworthy learning-enabled autonomous systems based on combining the advantages of **data-based** (performance) and **model-based** (guarantees) techniques.*

*Integrate **Learning Enabled Components (LECs) and classical components on the level of** models.*

*Generate **a new paradigm for implementing safety-aware LECs by** fusing learning from examples **and** synthesis from the specification**.***

Transfer** verification technology **for model-driven design to verification of LECs, and conversely, utilize ML to improve testing of models.

Three scientific pillars:

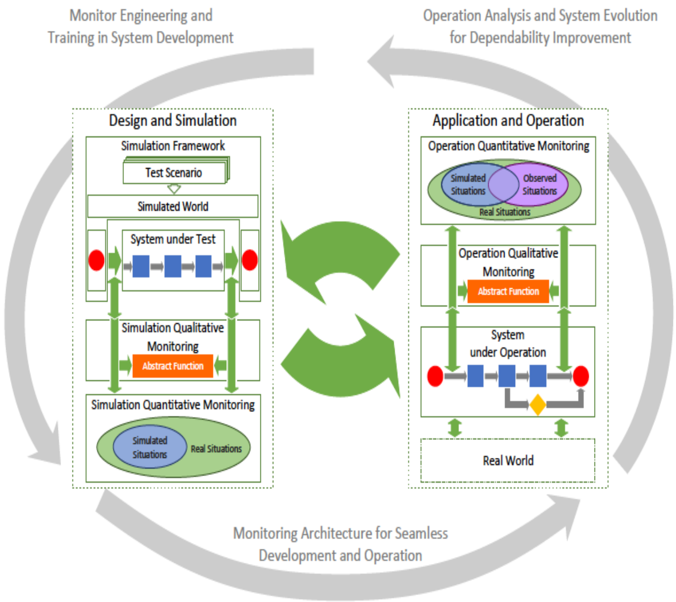
i) ***integration of learning-enabled components*** and ***model-based components*** via a contract-based methodology which allows incremental modification of systems, including threat models for cyber-security,

ii) ***adaptation of verification techniques*** *applied during* ***model-driven design*** *to learning components to enable unbiased decision-making, and finally,*

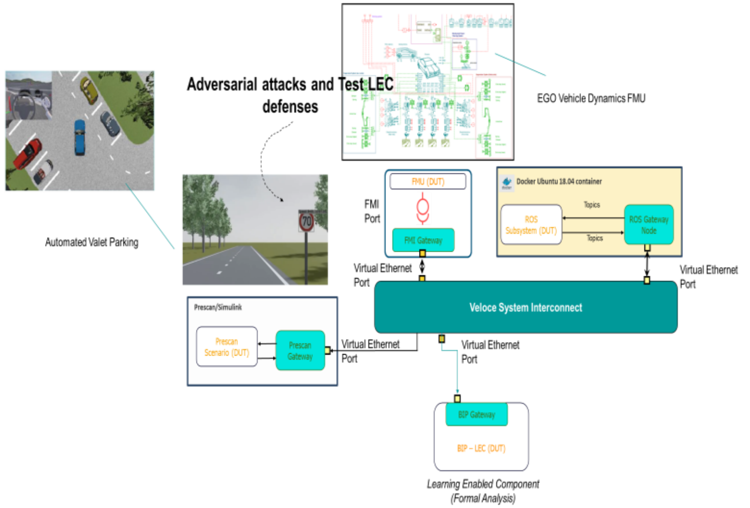
iii) ***Incremental synthesis*** techniques unified the ***enforcement of safety and security-critical properties*** and ***performance optimization***.

FOCETA RESULTS

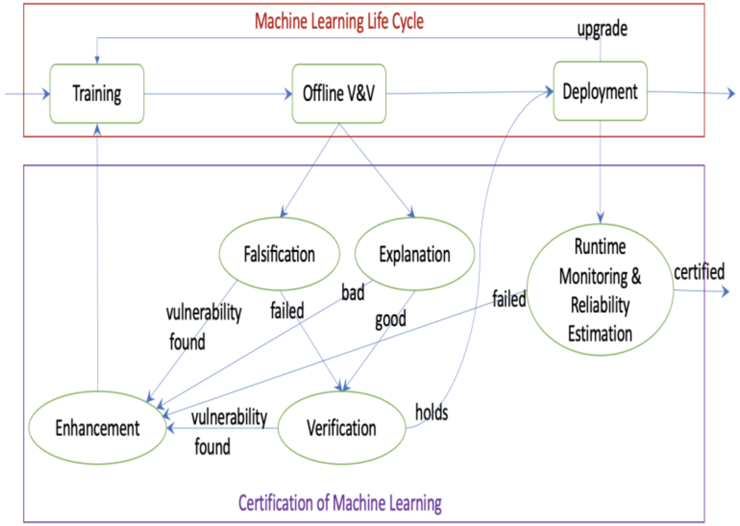
Methology for Continous Updating



Co-simulation Framework



Design Flow for Trustable Learning Components



Lessons Learned

*The role played by **data** in AI-enabled Systems is central*

The collection, cleaning, management, and continuous data update add new tasks.

***Uncertainty** is the dominant characteristic in AI-enabled Systems.*

increased the urgency of making progress on how to model, analyze, and safeguard against the inherent uncertainty of our systems.

***AI specifications** are specifications of problems, **not the behavior** of systems.*

***Verification** challenges are **inevitably exacerbated** in AI-enabled systems, given their **inherent uncertainty**.*

***The continuous update** is a big challenge in AI-enabled systems.*

*We know the challenges of **designing embedded systems** that **rely** on integrating many **disparate SW/HW components**.*

***AI components** developed independently are **another set of subcomponents whose behavior must** be **reliably predicted**.*

Recommendations

*Need for a **multidisciplinary Network of Excellence** with AI, software engineering, critical embedded systems, statistics, formal methods with European industrial actors, CPS and control theory, and SHS (law, ethics).*

*Support EU research that uses more **rigorous, mathematical methods** in dealing with AI.*

*The recommendation of FOCETA naturally is that for LEAS, the **verification at design time only is not sufficient** and **that the combination of design-time verification and runtime assurance** is a **must**.*

Thank you

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PIACERE

Programming trustworthy Infrastructure As Code in a sEcuRE framework [PIACERE]

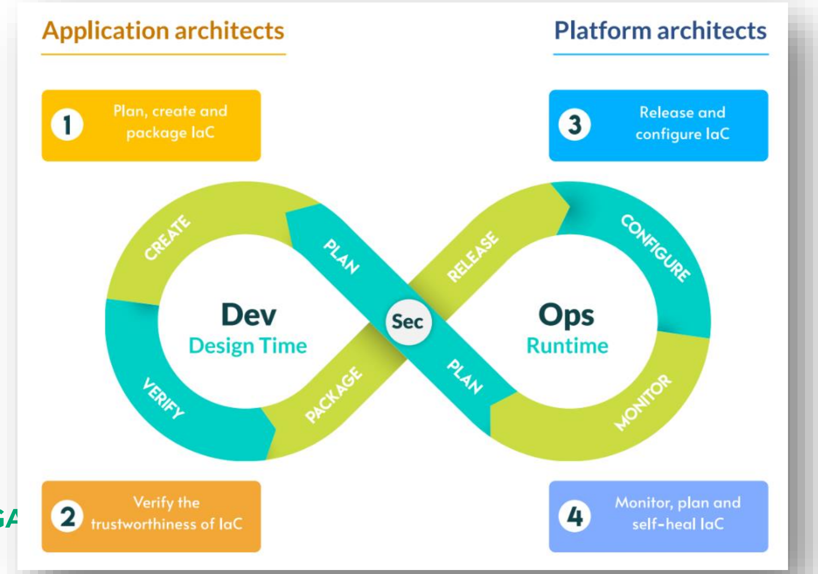
Matija Cankar (XLAB)
Juncal Alonso (Tecnalia)

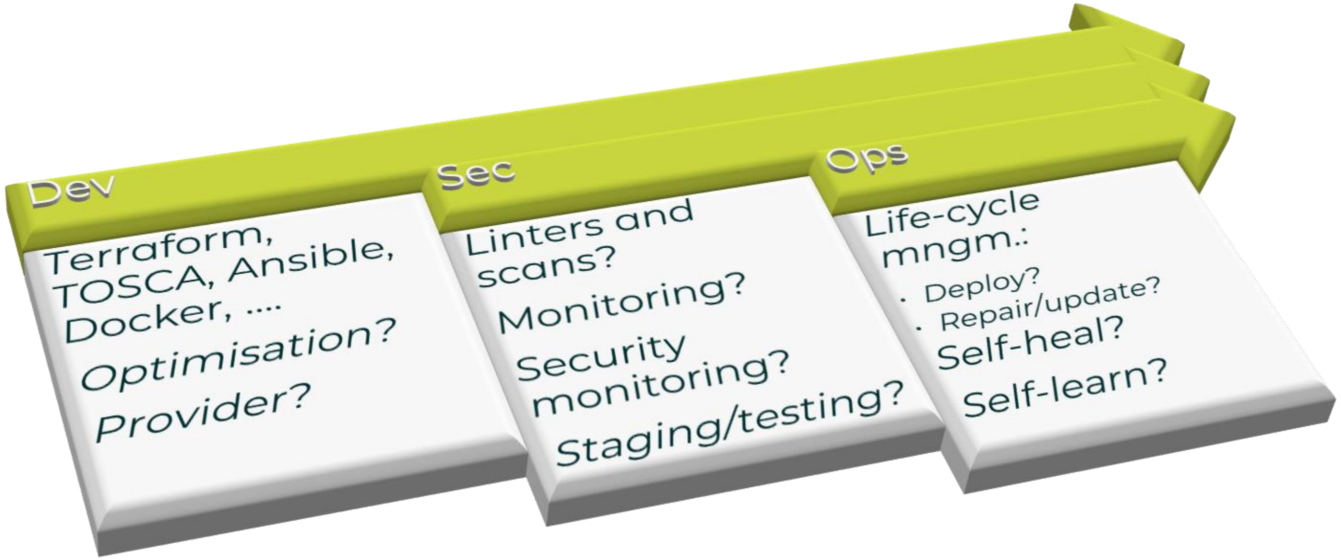
Brussels, 10th of May

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 101000162.

Open PIACERE Framework

- **Vision:** *DevSecOps framework for the **development**, **deployment** and **operation** of **trustworthiness** infrastructure-as-code.*
- **Goal**: Framework with ***tools*** integrated in the IDE.
- **Status**: PoC version already available!





Lessons learned and Success stories

- Refocus a task according to a technology or market change can be very rewarding (Component security checker).
- Design of a language (standard) and implementation have different speeds, and this needs to be considered.

- Great interest from the communities:
  - OS: Eclipse, Linux Europe, Gaia-X, TOSCA
- At least one product from consortium partner exploits PIACERE idea.
- PIACERE addresses a problem currently being faced by SW development companies due to the paradigm shift (from owned resources to outsourcing of the infrastructure management)

images: adapted from Flaticon.com

Recommendation for the Future

- Edge and IoT scope to be incorporated in the IaC paradigm (strategic and opportunistic topic for Europe !!)

- Trustworthiness is newer-ending task and requires constant attention.

image: adapted from Flaticon.com

PIACERE

Thank you!

www.piacere-project.org

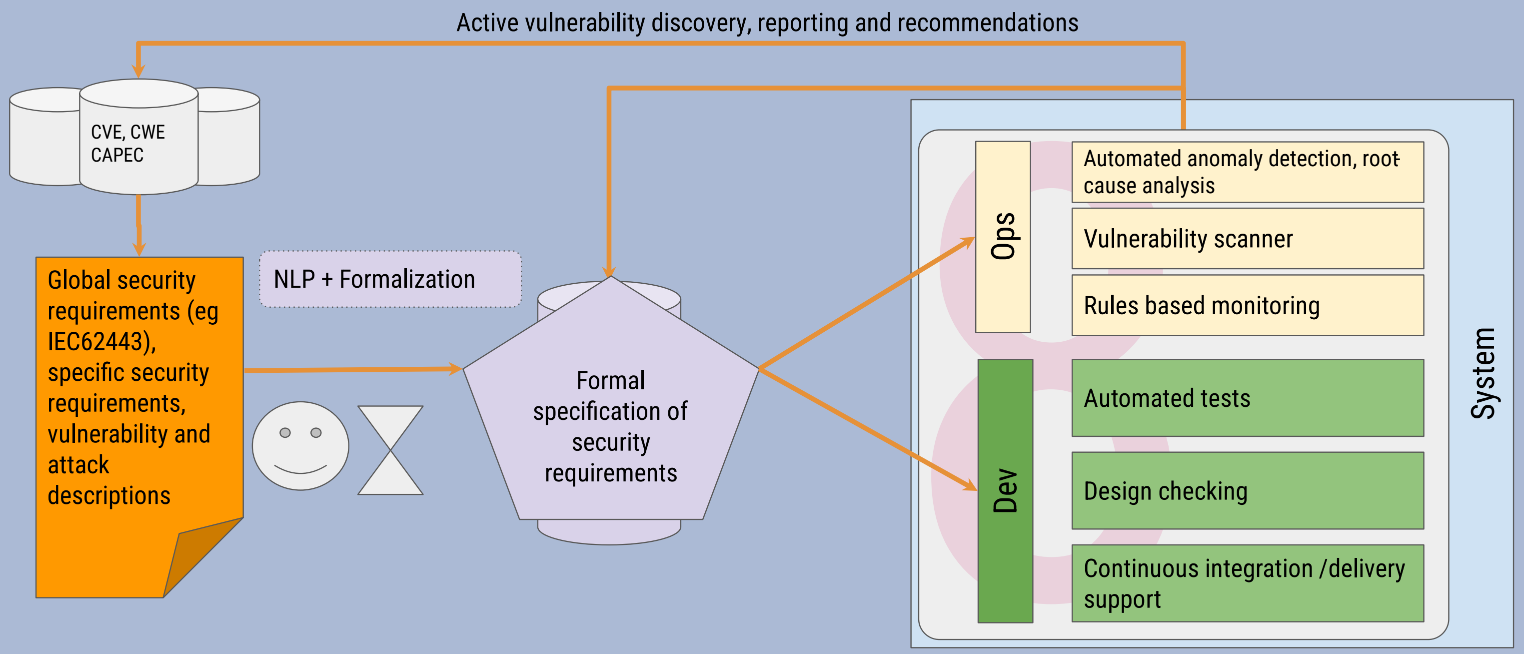
VeriDevOps

Dev Prevent Ops Protect

SOFTEAM UNE MARQUE DE DOCAPOSTE · Åbo Akademi University · montimage · ikerlan · Mälardalen University · ABB · FAGOR ARRASATE

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 957212

Project presentation



Automated Protection and Prevention to Meet Security Requirements in DevOps Environments

Main challenges

- Security vulnerability are omnipresent
- Number of security scenarios explodes
- Vulnerabilities cause losses for end-users
- Security mechanisms has to be built in and reinforced
- Security is difficult to retrofit in design
- Security has to support CI/CD
- Monitoring and traçability is a key property

Lesson learned

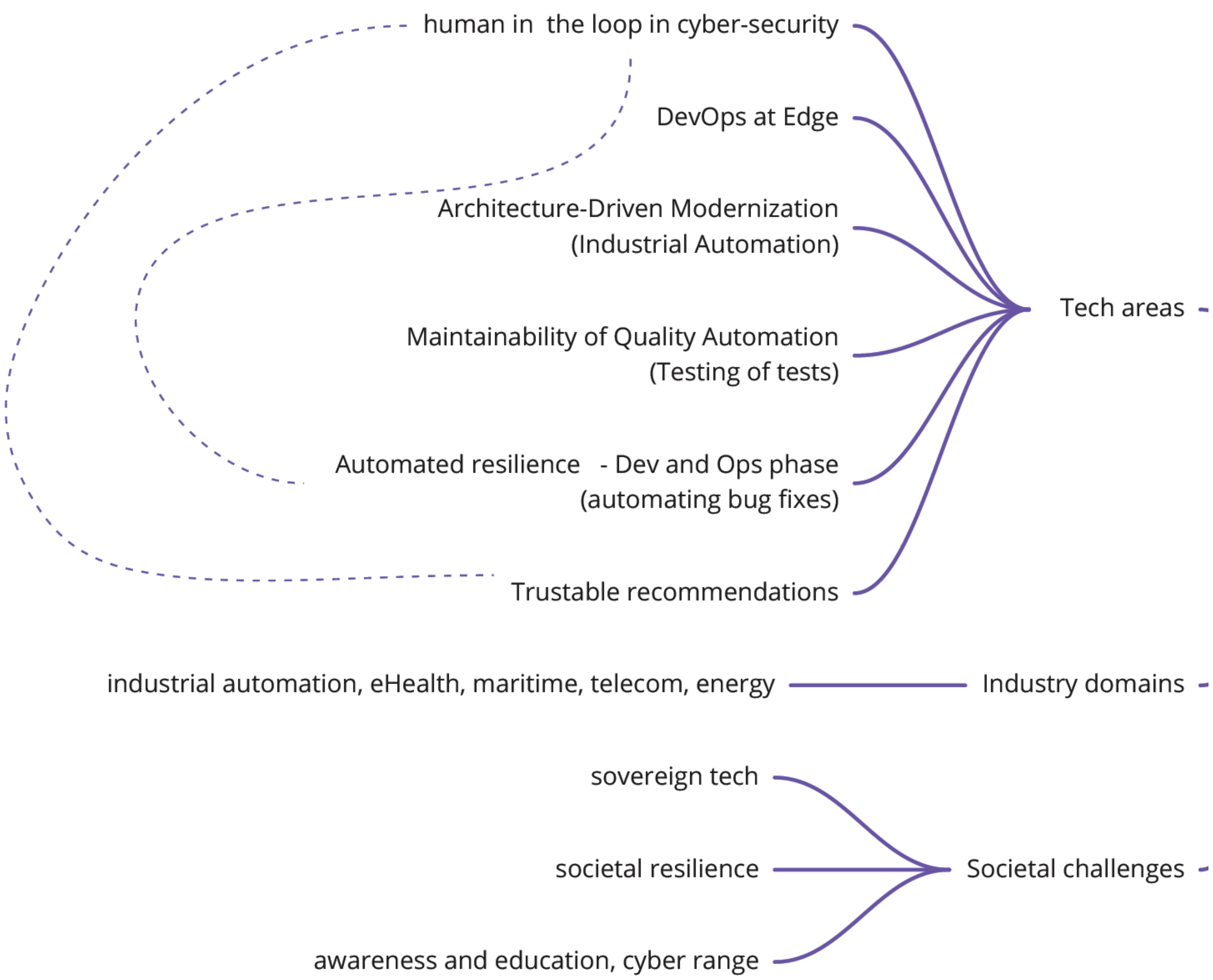
- Close collaboration with case studies
  - Planning all the phases and activities in advance - Frequent replanning
- Still room to enhence automation
- Domain specific / Generalization is not easy
- Prototype -> Product way is difficult and effort consuming
  - Low TRL for many results

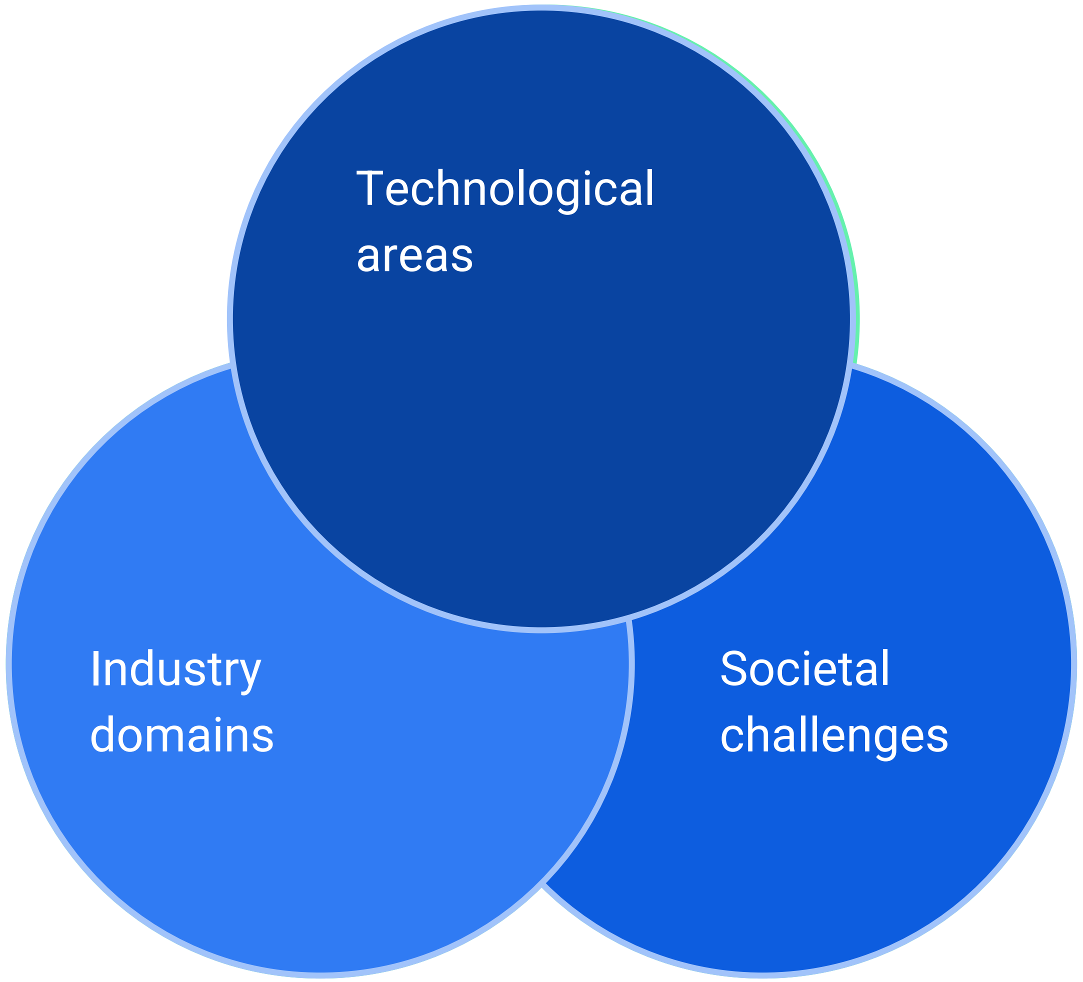
Success story

- NLP datasets and models for Requirements classification and security guidelines mapping.
- ML-based anomaly detection and root cause analysis.
- Metamorphic testing generation as intelligent test generation with automated feedback.
- Vulnerability detection at early stages with scanners.

(More than 30 publications and 15 Key exploitable results)

Recommendations for the future





Thank You

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This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 957212

VeriDevOps

X-by-Construction Design Framework for Engineering Autonomous and Distributed Real-time Embedded Software Systems

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 957210.

Project Overview

Challenges in the design of autonomous embedded systems

Performance requirements met only by centralized multicore processors

Continuous interaction between internal subsystems and with remote entities

Non-functional requirements towards functional safety and cybersecurity

Artificial Intelligence (AI) applied to solve complex tasks in an efficient manner

Project Duration:
01/2021 – 12/2023

Budget:
€ 4.96 million

Project Coordinator:
Prof. Jürgen Becker (KIT)

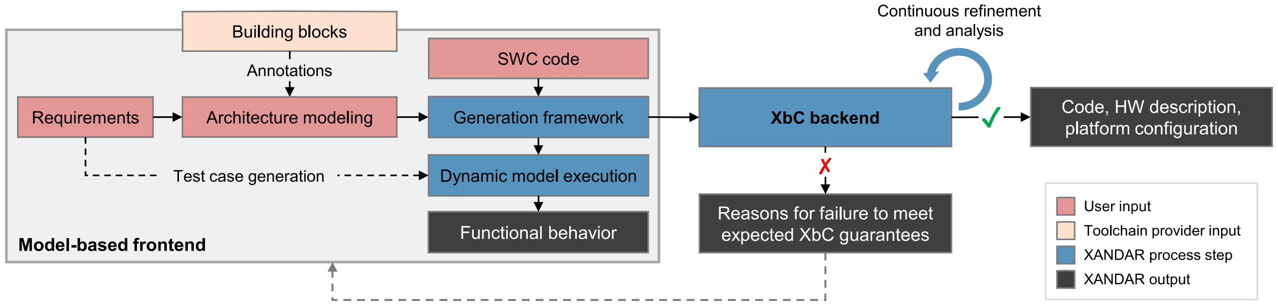
Scientific Coordinator:
Prof. Nikolaos Voros (UoP)

Goal: Deliver a mature software toolchain that applies the X-by-Construction paradigm to auto-generate system implementations with guaranteed properties

KIT Karlsruhe Institute of Technology · University of the Peloponnese · BMW Group · Vector · AVN · Queen's University Belfast · DLR Deutsches Zentrum für Luft- und Raumfahrt German Aerospace Center · fentISS

Success Stories

- ***X-by-Construction (XbC)*** Paradigm realization shown by features such as:
  - ***Pattern library of safety/security mechanisms***
  - Safe integration of ***AI components*** (*ONNX, …*)
  - Timing-aware behaviour specification approach
  - ***Hypervisor-based*** security monitoring



- First **experimental Evaluation** phase successfully completed:
  - Application to SW development of ***safety-critical use cases*** (***DLR*** + ***BMW***)
  - ***Automatic deployment*** to bare-metal *hypervisors* on ***multicore platforms***

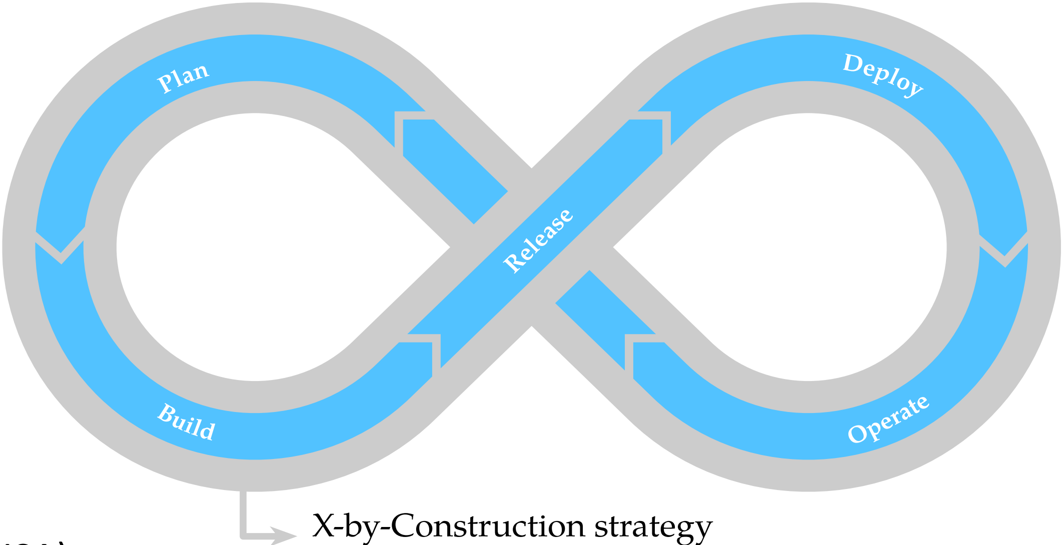
- **Lessons learned** from Development Efforts:
  - Proving the fulfilment of ***non-functional guarantees*** for dynamic/adaptive systems is difficult
  - Many applications have ***static invariants*** that make them compatible with the *XbC paradigm*
  - **Asking designers to specify these invariants is often successful for today's systems**

Recommendations

- ***XANDAR* has shown**: ***XbC*** is applicable to systems with ***Static Invariants***
- **Open question**: *Invariants* to be defined in future *Cloud/Edge Networks*?
  - **Dynamic workloads**
    - multi-tenant use of *distributed AI accelerators*, …
  - **Continuously refined system configurations**
    - *over-the-air* updates, …
  - **Evolving edge nodes**
    - *self-learning AI* algorithms, …

  As ***Enabler*** for reliable ***Cloud/Edge/IoT Networks***, for:

  - **Dynamics:** links to projects such as *Lingua Franca* (*Berkeley*, USA)
  - **Adaptivity:** by integrating ***XbC*** runners into the ***entire DevOps cycle***



X-by-Construction strategy
(*along the entire DevOps cycle*)

- ***Research Challenges***: *How to facilitate* ***dynamic XbC*** *and* ***open HW/SW Architectures****?*
  - *Can* ***time predictability*** *be achieved for* ***multi-tenant accelerators****?*
  - *Is it possible to guarantee* ***data confidentiality*** *in* ***adaptive cloud/edge nodes****?*