Code generation in CPPS platforms

overview and insights

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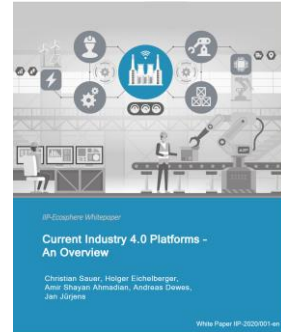University of Hildesheim

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CPPS Platform???

- Often: Wide notion
- Here:
  - Coherent software basis
  - Support/execute user-defined applications
  - Domain: CPPS
  - May but must not be in cloud

Overview (1)

Driven by BMWI IIP-Ecosphere

- 14 dimensions, including
  - protocols, edge, digital twin / AAS
  - AI
  - configurability / model-driven approaches
- Analysis of 21 industrial platforms, including
  Mindsphere, ThingWorx, Leonardo, MS Azure IoT, AWS IoT, …
- SLR on ~2000 publications
  47 scientific platforms

Eichelberger, Sauer, Ahmadian, Kröher, Industry 4.0/IIoT platforms for manufacturing systems –
A systematic review contrasting the scientific and the industrial side, IST journal, 179, January 2025, 107650
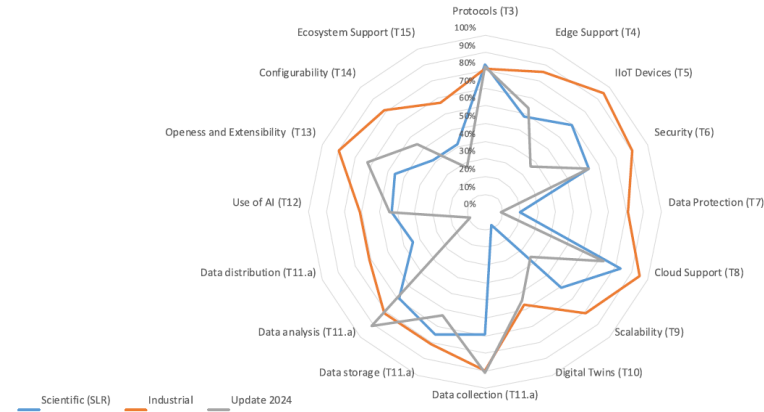
Overview (2)

"Just" the DT/configurability dimensions

- Industrial (2021):
  - Digital Twins (DT): 61%
  - AAS (5%), „Things modeling" 38%
- Scientific: data processing [KRS19], native/process DSLs [JGM+21], algorithms [XZH+24], components [CHS+24], 3D DT UI [SCM+24]

[JGM+21] John, Ghosal, Margaria, Pesch, DSLs and Middleware Platforms in a Model-Driven Devel …, 10.1007/978-3-030-89159-6_10
[KRS19] Keflakis, Roukounaki, Soldatos, Configurable Distributed Data Management for the Internet of the Things, 10.3390/info10120360
[XZH+24] Xiao, Zhou, Hu, Liu, Design and implementation of an interactive networked condition …, j.eswa.2024.124376
[CHS+24] Cuadra, Hurtado, Sarachaga, et al, Enabling DevOps for Fog Applications in the Smart …, 10.1016/j.future.2024.03.053
[SCM+24] Simoes, Carretero, Martinez, et al, Implementing Digital Twins via micro-frontends, …, 10.1016/j.cag.2024.103946

Insights (1)

- oktoflow platform
  - Originating from IIP-Ecosphere
  - Transitioning into DatiPilot ReGaP
- Massive code generation > 75% of the apps

Insights (2)

Some generation issues

- – Variant API parameters (from IDTA submodel generation)
- – Text vs. Structural Code Parts (from services/connectors)
- – Repated Tasks, e.g., imports (from datatypes)
- – Complex but reusable textual templates

Approach: Artifact model(s)
- T-LOC ↓ ~21%
- Complexity ↓ ~9%
- Exec time ↓ x6
- Mixing both sides???

- Eichelberger, Weber, Model-Driven Realization of IDTA Submodel Specifications: The Good, the Bad, the Incompatible?, ETFA'24
- Weber, Hillebrand, Eichelberger, ADS Performance Revisited, Symposium on Software Performance (SSP'24)
- Nikolajew, Eichelberger, Industry 4.0 Connectors – A Performance Experiment with ADS (SSP'24)

Outlook

- oktoflow is still there ;)

- Community: Energy applications/reduction
  - New requirements
  - More user interaction
  - AI/Machine colleagues must touch oktoflow

https://regap.de

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