

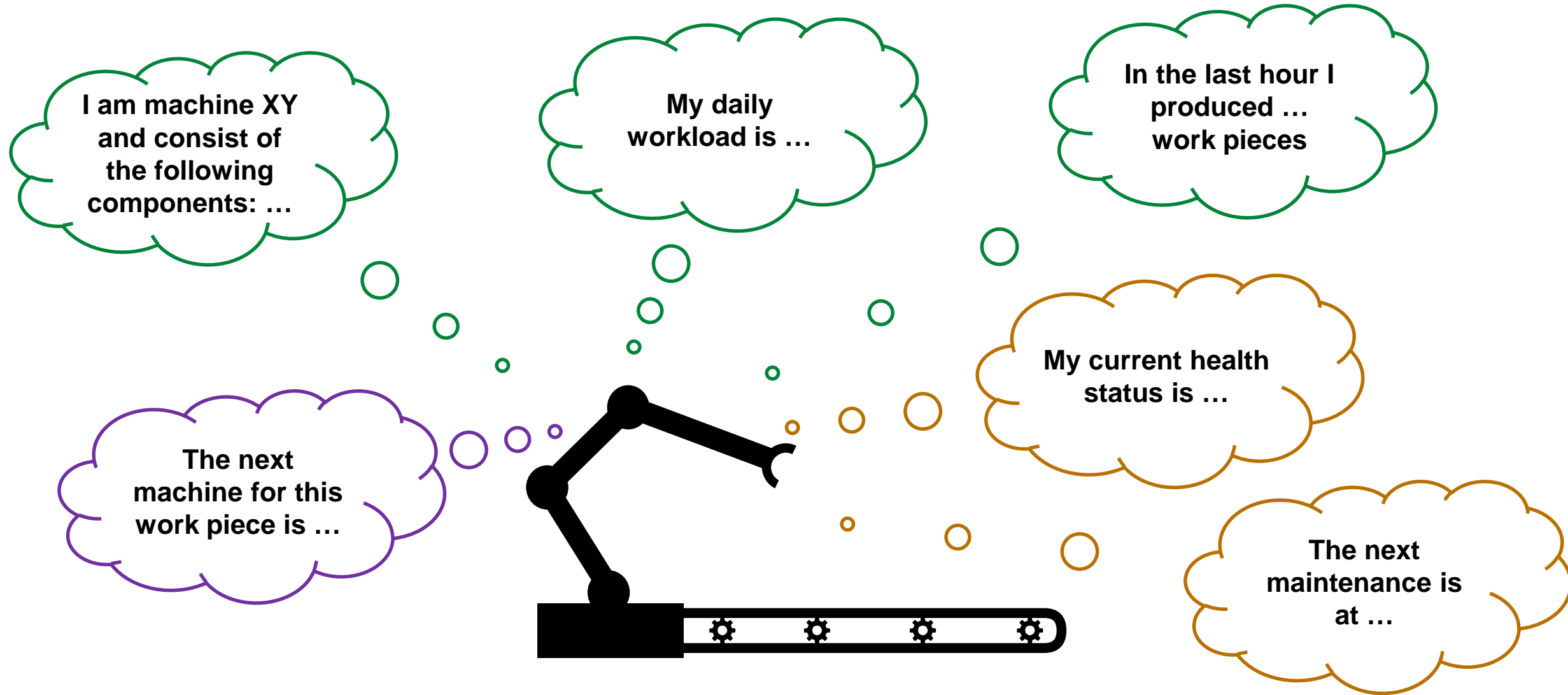
Towards Self-Aware Industry 4.0 using a Layered Meta-Model

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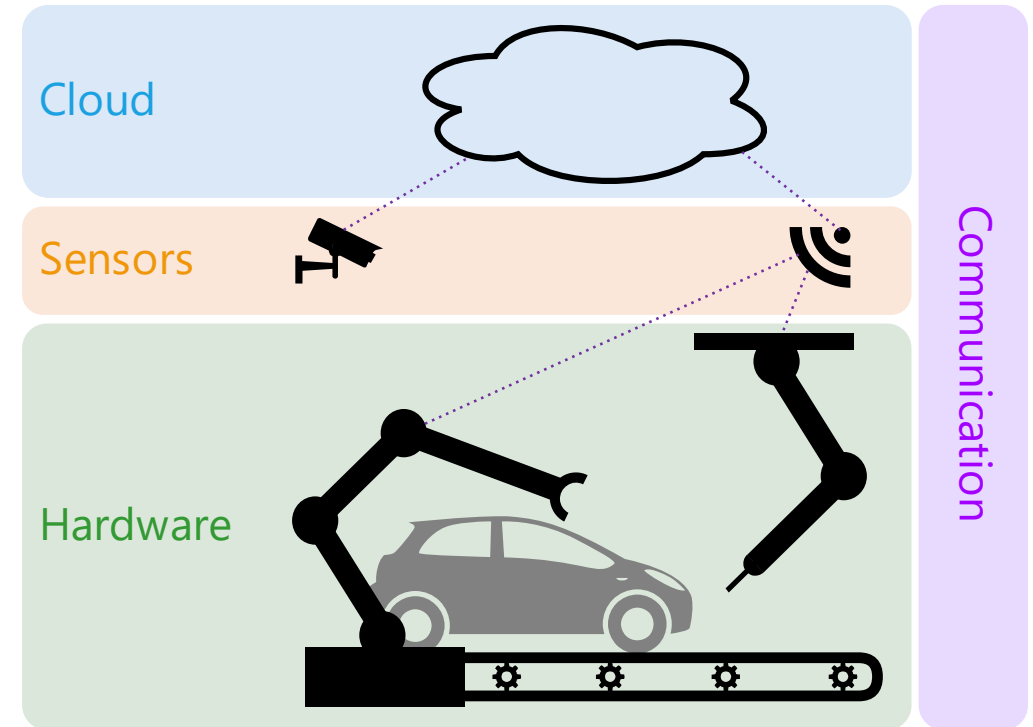
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Self-Aware Cyber Physical Systems



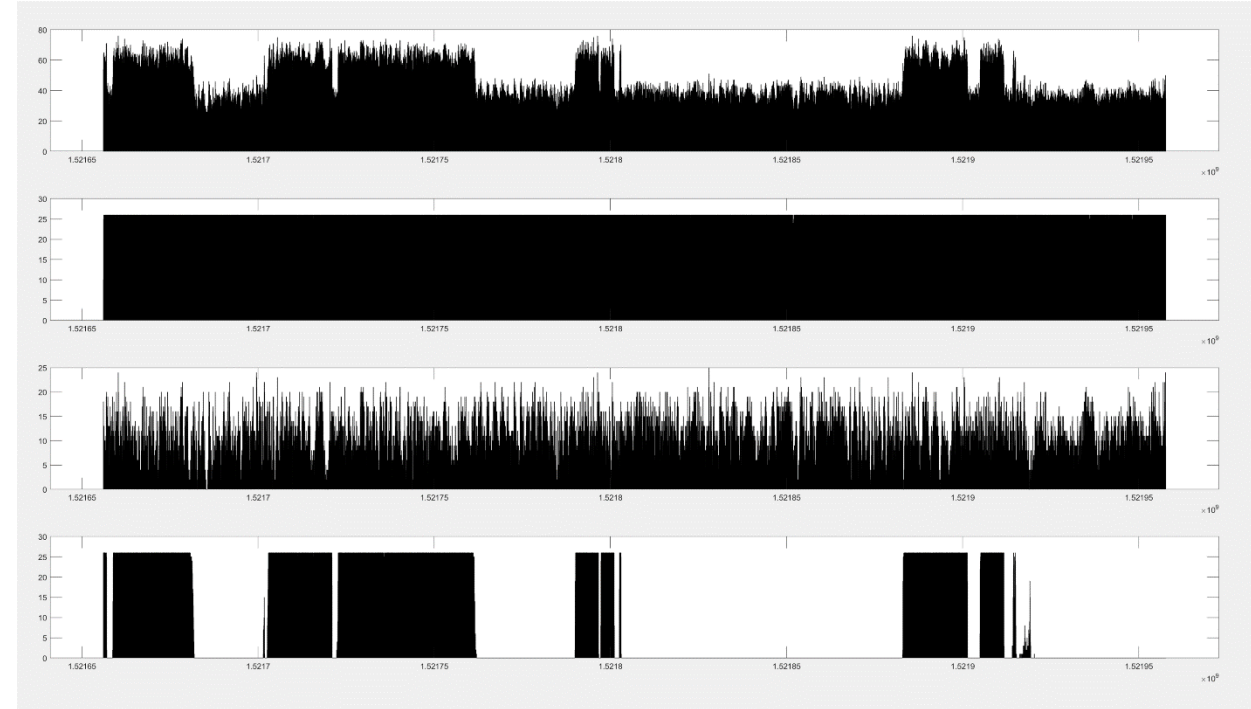
Layered Meta-Model

- Hardware:
 - Cyber physical systems, networked machines
 - Offer degrees of freedom
- Sensors:
 - E.g. cameras, RFID, NFC sensors
 - Offer additional information about production process
- Cloud:
 - Computing resources, assumed as black-box
 - Integration of existing languages: DML [1], Palladio [2]
- Communication:
 - Interaction between hardware, sensors, and cloud
 - Periodic, aperiodic, and event-based



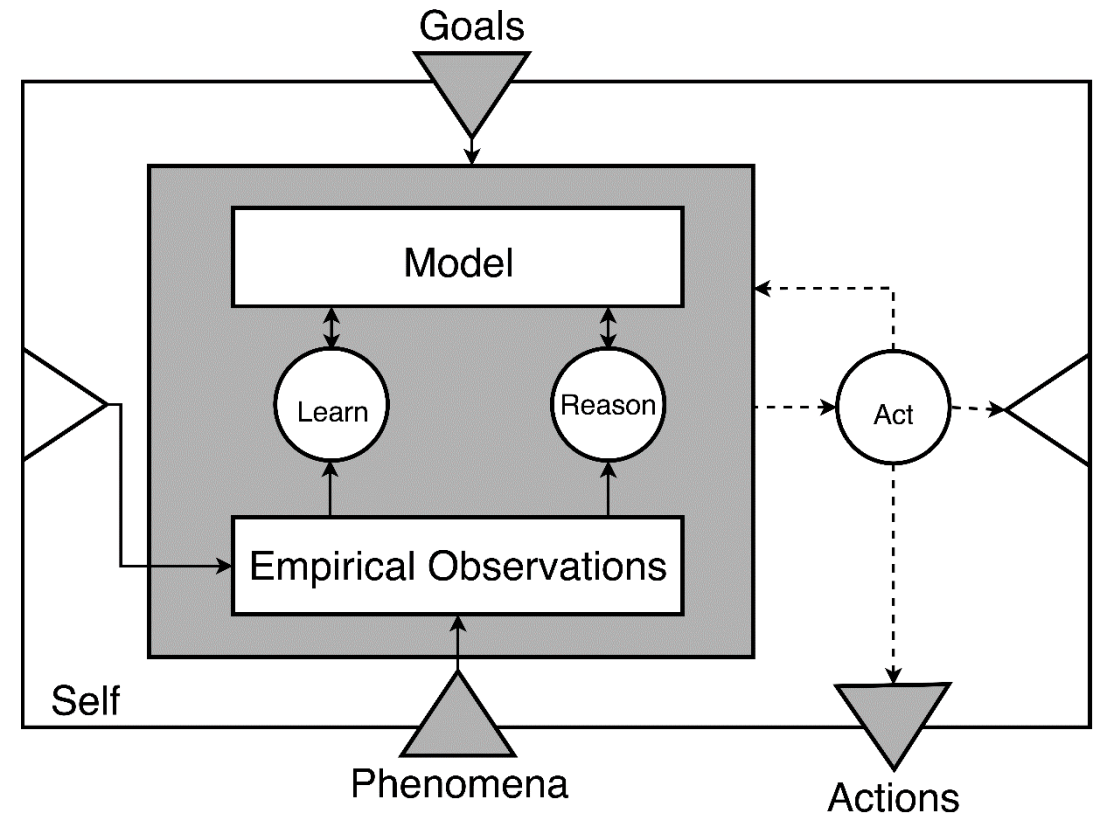
Modeling Sensors using Markovian Agents (MAs) [3]

- Each Sensors modeled as Markovian Agent → Network of nodes with autonomous behavior and interdependences
- Finite state continuous time Markov chain (CTMC)
- Two components:
 - Fixed: local behavior
 - Induced: interaction with other MAs
- Analytical and numerical solution



Envisioned LRA-M Loop Approach

- Self:
 - Driven by external goals and phenomena
- Learn:
 - Observations of production machines
 - Create / update model
- Reason:
 - Evaluate performance using model
 - Generate actions to optimize production system
- Act:
 - Execute events derived by reason phase



Conclusion

Problem

- Cyber physical systems have no knowledge about themselves, environment and process

Idea

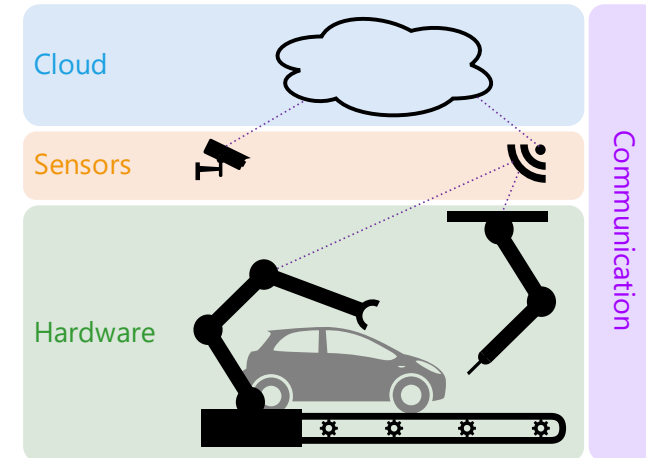
- Design a model that captures this knowledge
- Use this model for optimizations

Approach

- EMF meta-model
- LRA-M loop adaptation

Benefit

- Optimization of the process
- Improved usage of sensor data



Future Work

- Design layered meta-model
- Create LRA-M loop workflow
- Integrate optimization algorithms
- Evaluate model and optimization based on real world data

References

- [1] Samuel Kounev et al. A Model-Based Approach to Designing Self-Aware IT Systems and Infrastructures.
- [2] Steffen Becker et al. The Palladio component model for model-driven performance prediction. *Journal of Systems and Software* 82.
- [3] Andrea Bobbio et al. Markovian Agents: A New Quantitative Analytical Framework for Large-Scale Distributed Interacting Systems.

Thank you for your attention

Slides are available at
<https://descartes.tools/>

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