

Towards Integrated IoT Languages

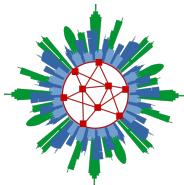
SuMoCoS Workshop, Ulaanbaatar, Mongolia

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- *What* have to be done to *introduce* IoT systems? (Process)
- *What* should IoT systems *do*? (Runtime)



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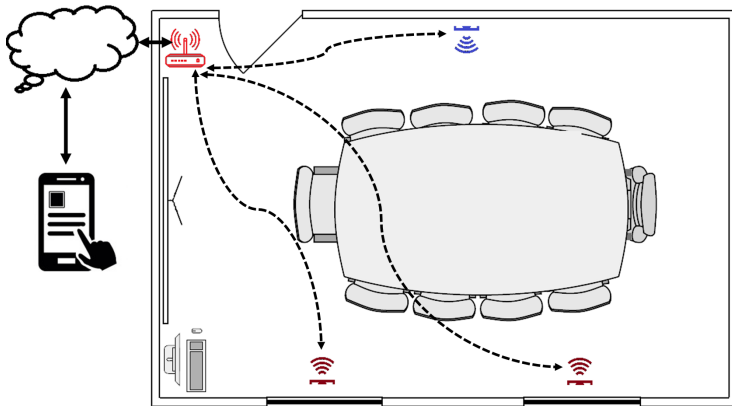
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- Integration is required

ongoing IoT example: very simple SmartOffice with two modes:

- 1 Presentation: close blinds, switch off bulbs
- 2 Discussion: open blinds, switch on bulbs if not sufficient light





Required IoT Languages:

- *Things* in the SmartOffice with Sensors and Actuators
- *Rules* controlling of Actuators depending on Sensors
- *Communication* of Things with each other

Integration Challenges:

- select Things to fulfill the scenario
- specify Rules for the scenario using states of Things
- create Network depending on Rules and Things

Everything has to fit to each other!



- different parts of IoT systems:
 - Hardware / Things: sensors, actuators, gateways, ...
 - Software: operating systems, drivers, libraries, application software including rules, ...
 - Network: protocols, topologies, ...
- Initial development and ongoing maintenance / evolution
- different stakeholder, development tools, data, ...

Everything has to fit to each other!



There are lots of IoT Projects to develop and evolve:

- various Data / Artifacts
- various Consistency issues
- various Traceability information

General Problem:

- high Heterogeneity requires different IoT languages
- IoT Artifacts are separated by tools, but interrelated contentwise
- IoT project-specific Consistency rules have to be fulfilled

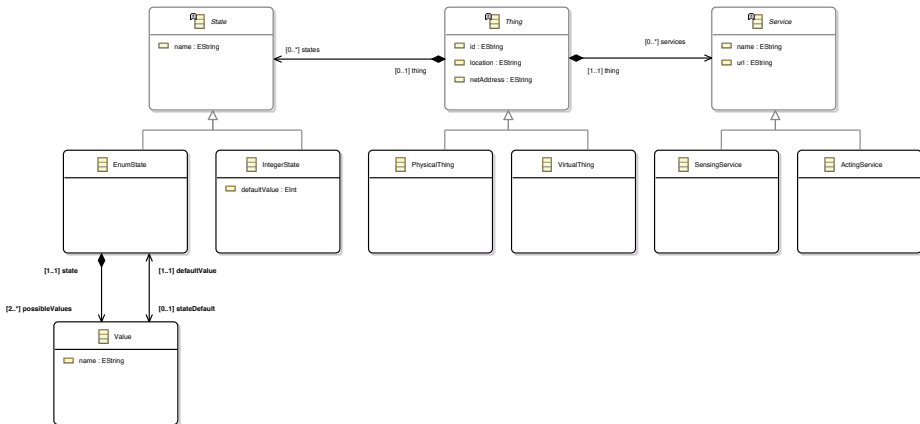
Problems of interrelated Artifacts

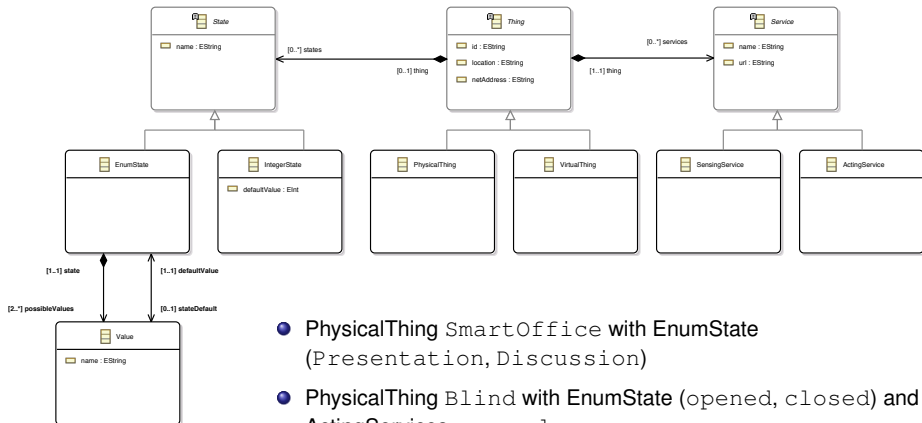
- Interrelations introduce Redundancies and Dependencies, which lead to Inconsistencies
- manual or unstructured Consistency Preservation requires high effort and is error-prone



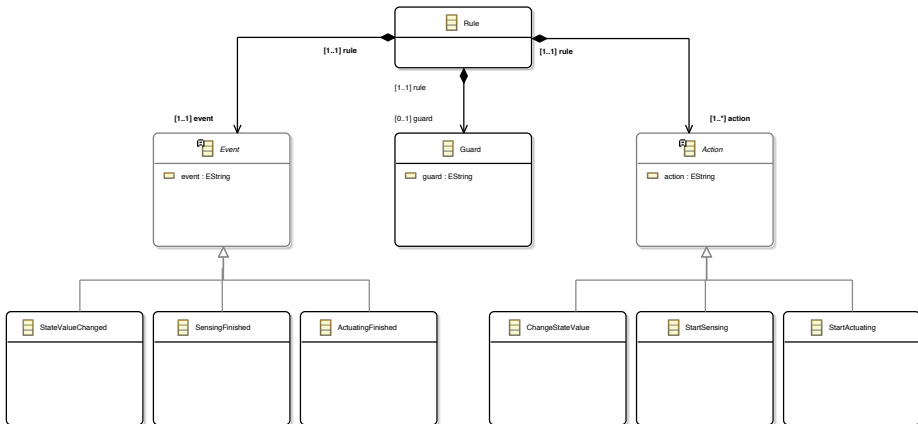
- Use Model-Driven Engineering (MDE) to ...
 - deal with complexity by using multiple Views
 - develop IoT languages
 - generate code and configurations for development and deployment
- Describe all Data as Views conforming to Viewpoints (structural formalization [Chechik, Nejati, and Sabetzadeh, 2012])
- Reuse approach for Consistency in Multi-View-Environments [Meier, Klare, Tunjic, Atkinson, Burger, Reussner, and Winter, 2019]

→ Integration of IoT Languages



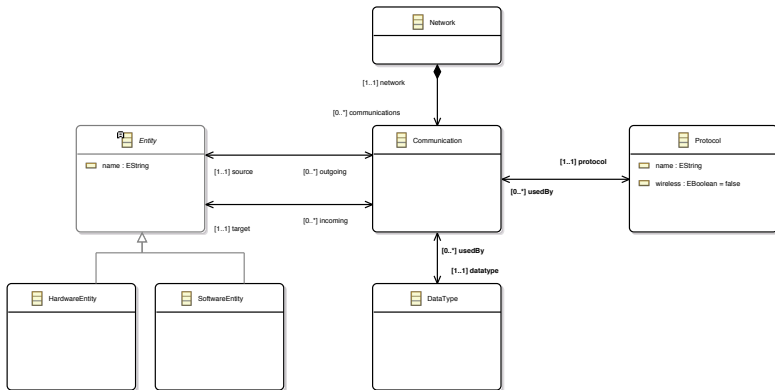


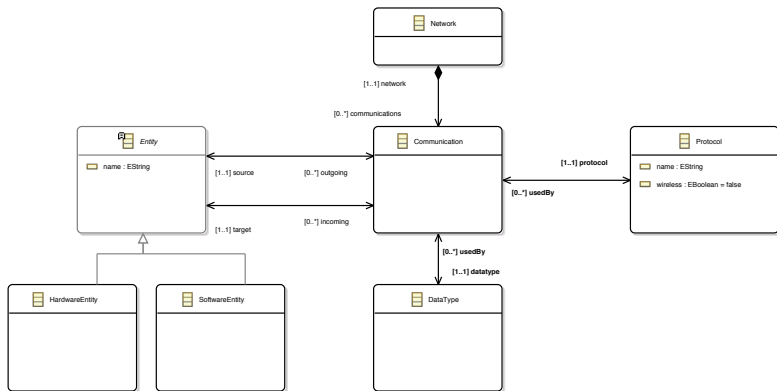
- **PhysicalThing SmartOffice** with **EnumState** (Presentation, Discussion)
- **PhysicalThing Blind** with **EnumState** (opened, closed) and **ActingServices** open, close
- **PhysicalThing Bulb** with **EnumState** (on, off) and **ActingServices** switchOn, switchOff
- **PhysicalThing LightSensor** with **IntegerState** light and with **SensingService** measureLight





- **When** value of `SmartOffice` changed to `Presentation` **than** execute `Blind.close` **and** execute `Bulb.switchOff`
- **When** value of `SmartOffice` changed to `Discussion` **than** execute `Blind.open`
- **When** value of `SmartOffice` changed to `Discussion` **if** `LightSensor.light < 42` **than** execute `Bulb.switchOn`





Rules require (indirect) Communication between ...

- SmartOffice → Blind
- SmartOffice → Bulb
- SmartOffice → LightSensor
- ? LightSensor → Bulb ?



- Model *one* IoT system, not several *independent* artifacts
- Ensure contentwise *consistency* between Things, Rules and Communication
- Enable different stakeholder to *work together*
- Enable analyses *across* different artifacts



- 1 Ensure Consistency between Views automatically
- 2 Support initial View(point)s
- 3 Integrated (Meta)Model

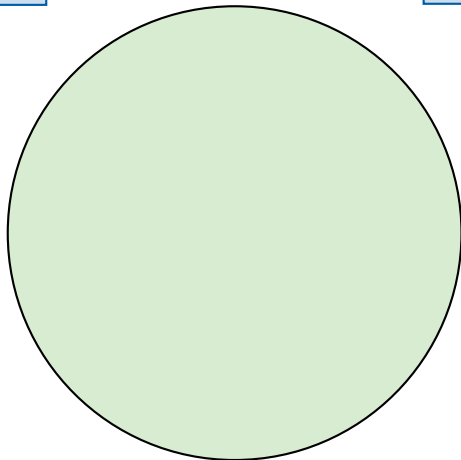


- 1 Idea: treat IoT languages as projectional viewpoints onto the whole system
- 2 Single Underlying (Meta)Model, SUM(M) [Atkinson, Stoll, and Bostan, 2009]
- 3 Reuse approach for ensuring Consistency in Multi-View-Environments [Meier, Klare, Tunjic, Atkinson, Burger, Reussner, and Winter, 2019]
 - Requirements: reuse existing artifacts, explicit SUM(M)
 - → MoCONSEMI



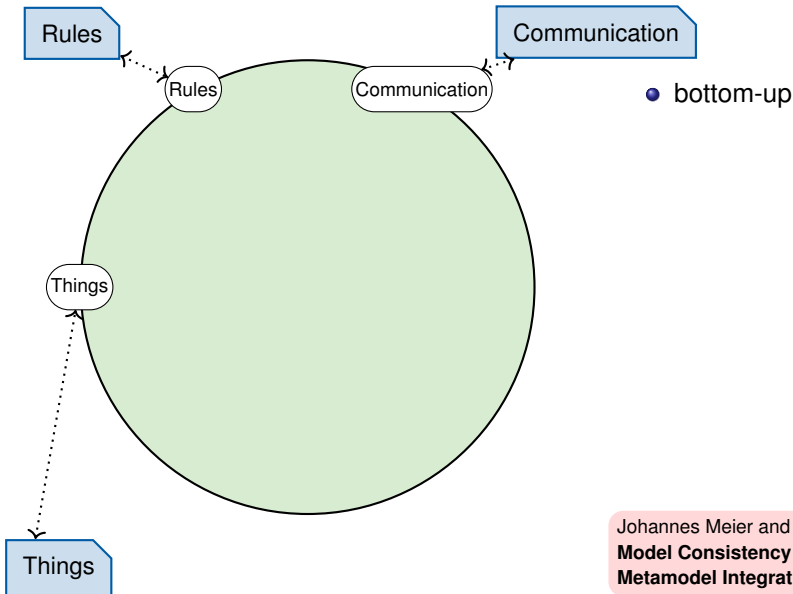
Rules

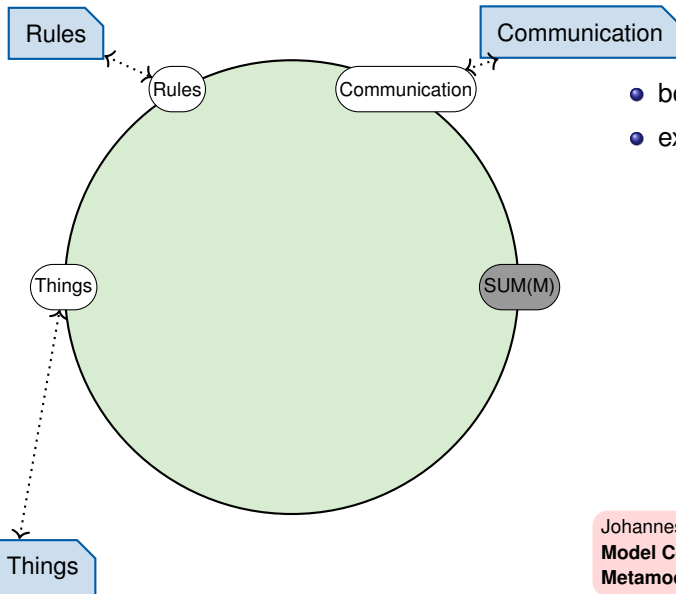
Communication



Things

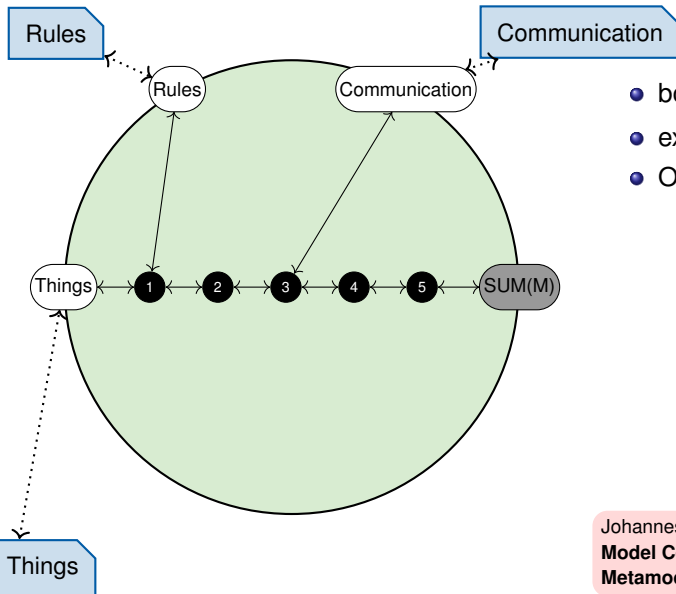
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**Model Consistency ensured by
Metamodel Integration** (2018)





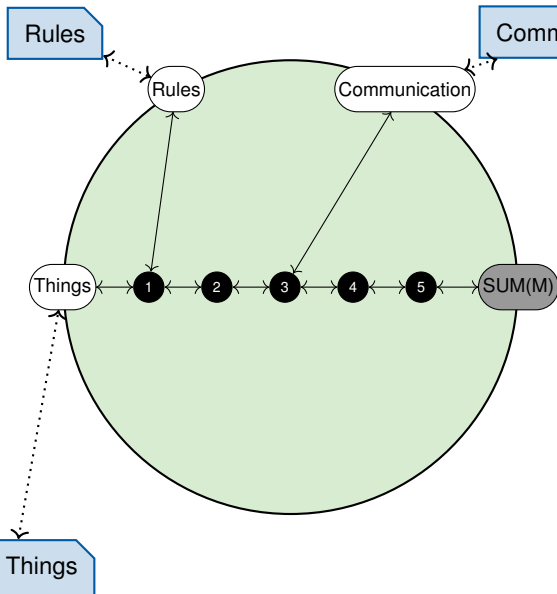
- bottom-up
- explicit SUM(M)

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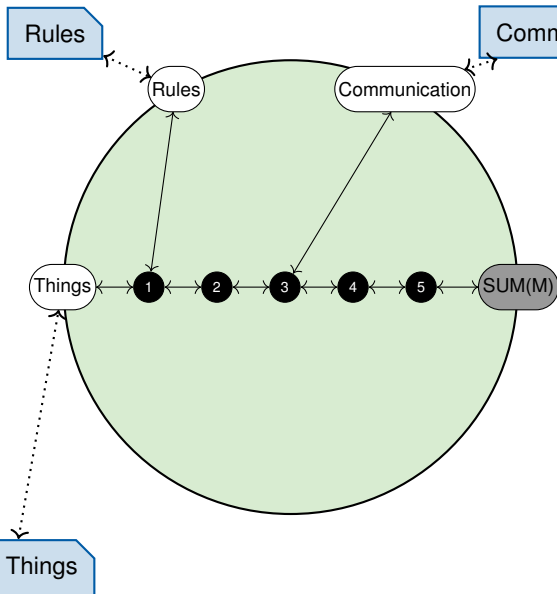
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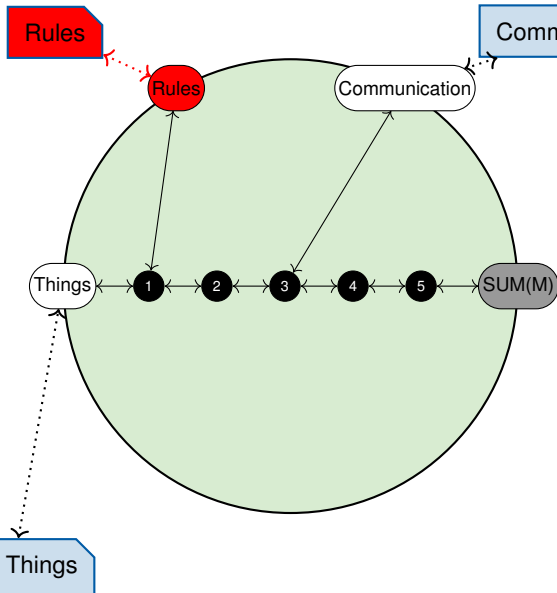
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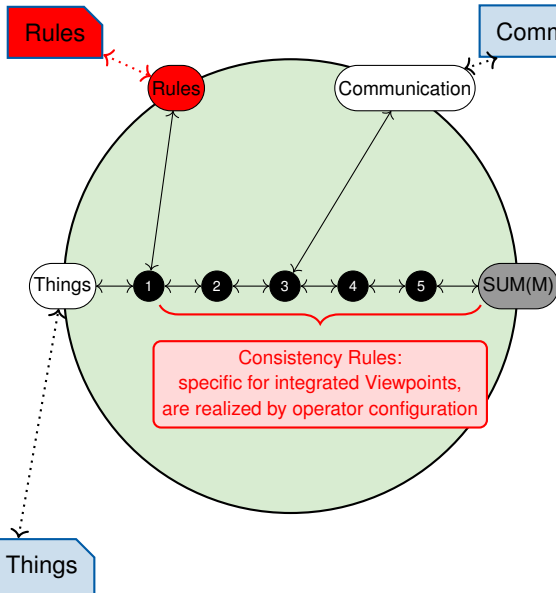
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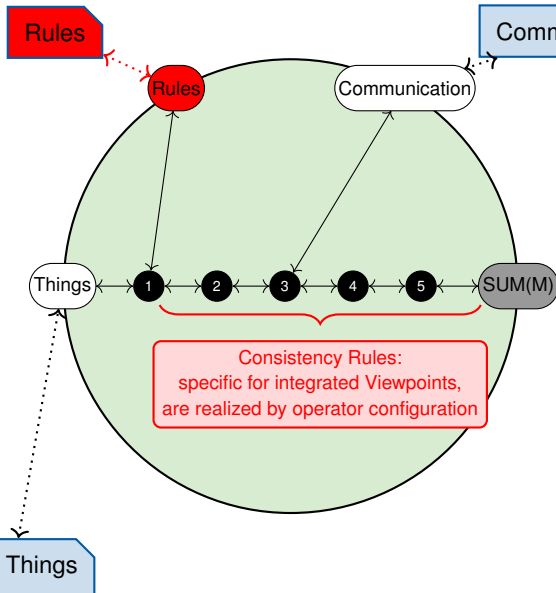
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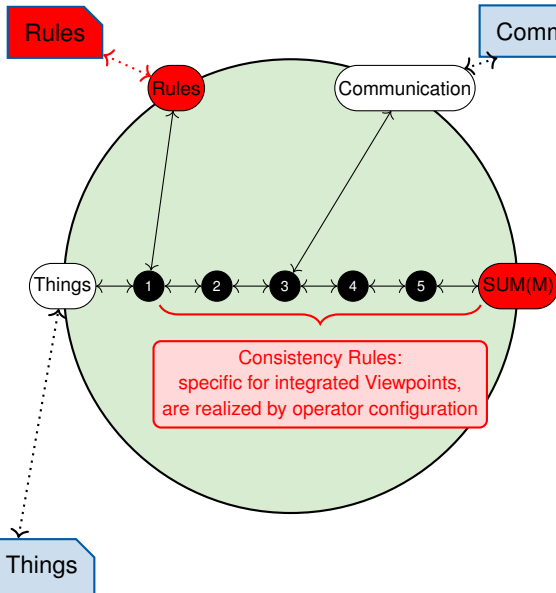
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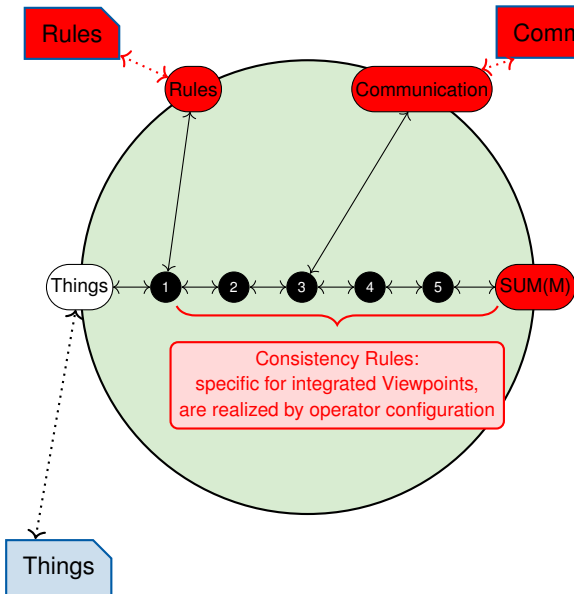
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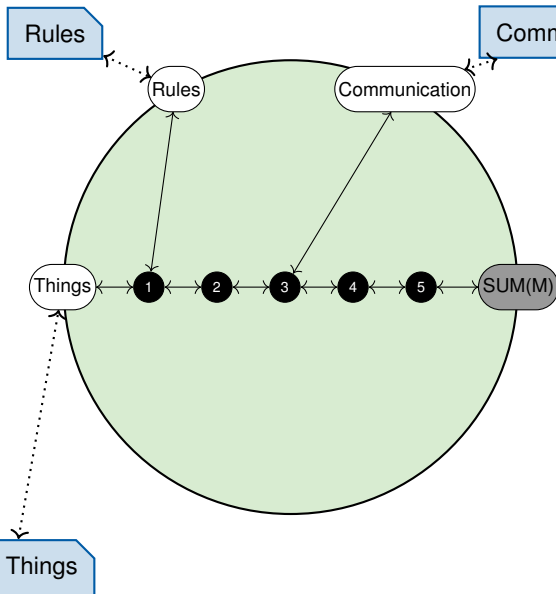
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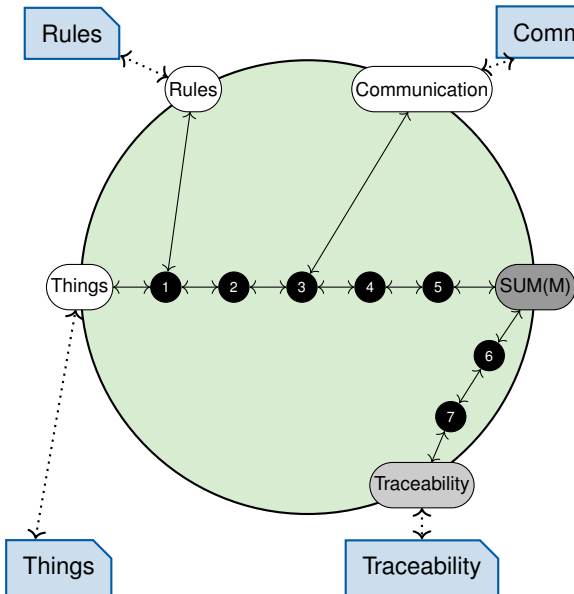
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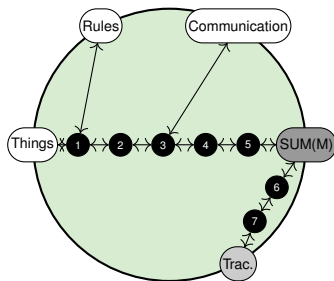


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- new View(Point)s

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Challenges for Transformations:

- 1 transform whole Models and Metamodels
- 2 support both Directions
- 3 propagate Changes to all Models
- 4 provide Changes inside the same Model
- 5 prevent Information Loss
- 6 generic / flexible: arbitrary (Meta)Models and Consistency Rules
- 7 reusable in different IoT Projects → Granularity



Design Decision “Operators as Transformations”:

- reusable Units for the IoT Expert
- created once and provided as Library by MOCONSEMI
- understandable: intermediate steps for debugging, visualizations

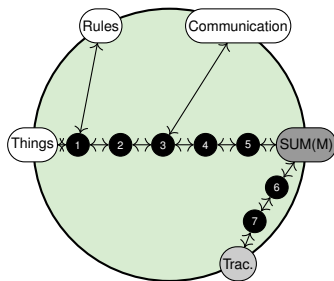
Consistency Rules ...

- specify the impact of User Changes
- fulfilled by configured chain of operators

Things

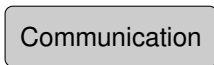
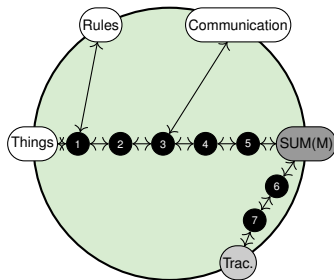
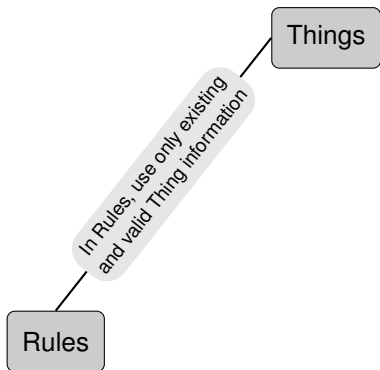
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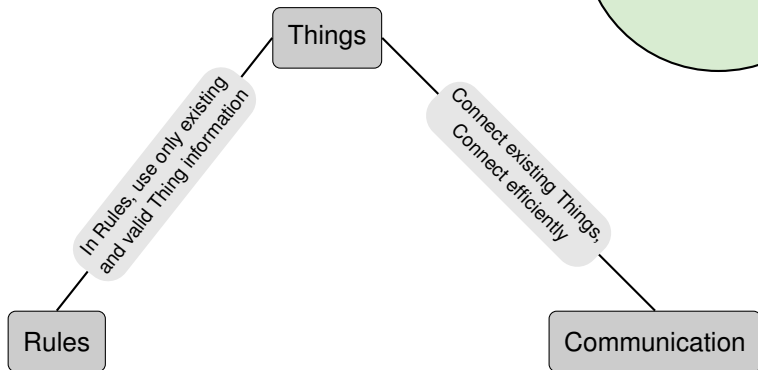
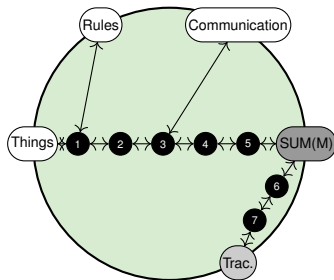
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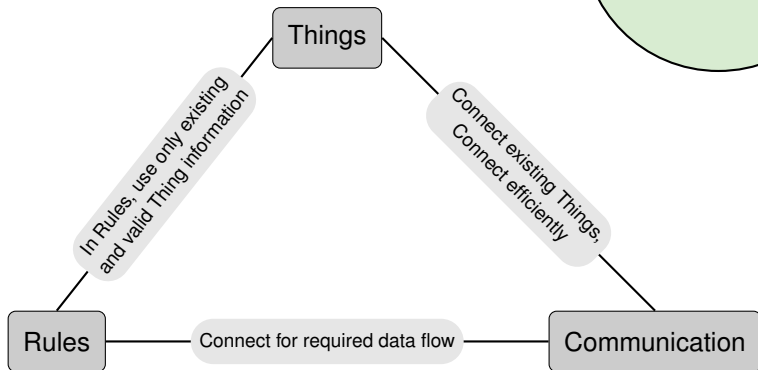
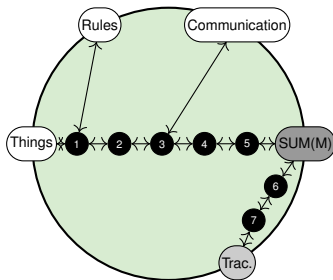
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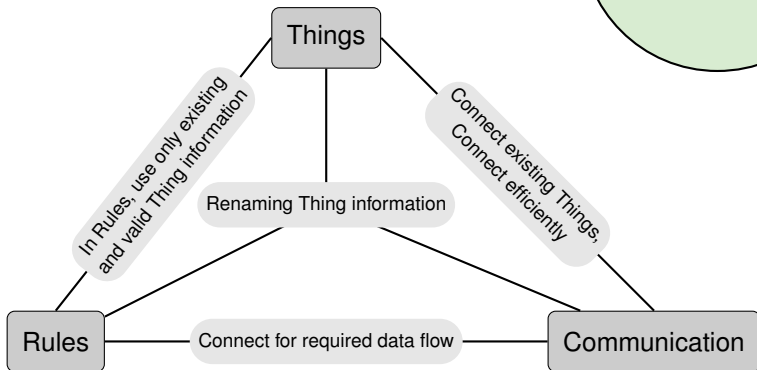
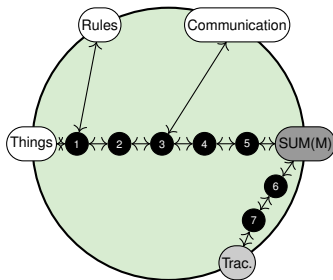
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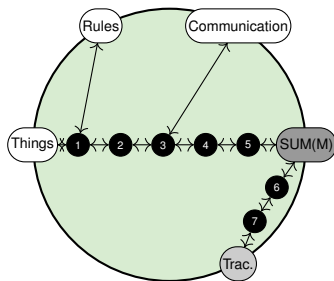


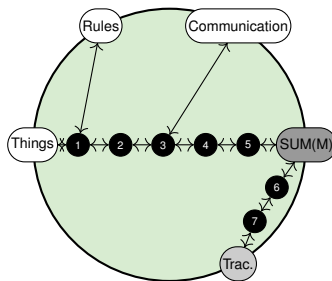
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- Use tailored IoT Languages to ...
 - describe single aspects of IoT systems
 - to manage complexity by separation of concerns
- Integrate IoT Languages explicitly to ...
 - ensure Consistency automatically
 - enable cross-analyses
- sketched examples:
 - SmartOffice example
 - 3 IoT Languages
 - Integration





- Improve and extend the sketched IoT Languages, e.g. States, Guards
- Identify and develop more IoT Languages, e.g. Data
- Extend the integration of IoT Languages
- Apply the integrated IoT Languages for a big Application, e.g. SmartHome



- Colin Atkinson, Dietmar Stoll, and Philipp Bostan. Supporting View-Based Development through Orthographic Software Modeling. Evaluation of Novel Approaches to Software Engineering (ENASE), pages 71–86, 2009.
- Marsha Chechik, Shiva Nejati, and Mehrdad Sabetzadeh. A Relationship-Based Approach to Model Integration. Innovations Syst Softw Eng, 8(123):3–18, 2012. doi: 10.1007/s11334-011-0155-2.
- Johannes Meier and Andreas Winter. Model Consistency ensured by Metamodel Integration. 6th International Workshop on The Globalization of Modeling Languages, co-located with MODELS 2018, 2018.
- Johannes Meier, Heiko Klare, Christian Tunjic, Colin Atkinson, Erik Burger, Ralf Reussner, and Andreas Winter. Single Underlying Models for Projectional, Multi-View Environments. In Slimane Hammoudi, Luis Ferreira Pires, and Bran Selic, editors, Proceedings of the 7th International Conference on Model-Driven Engineering and Software Development, pages 119–130. SCITEPRESS - Science and Technology Publications, 2019. ISBN 978-989-758-358-2. doi: 10.5220/0007396401190130. URL <http://www.scitepress.org/DigitalLibrary/Link.aspx?doi=10.5220/0007396401190130>.