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Business Processes and Smart Devices: a marriage of convenience?

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ESOCC OSLO NORWAY 2017

Acknowledgements








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Customizable predictions

CCCC says that, by YYYY, over XX billion connected things will be in use in DDDD producing ZZ zetabytes of data every FFFF

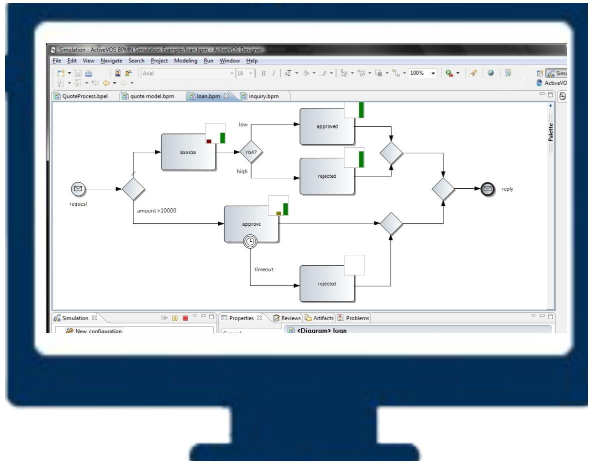
- CCCC = [Gartner, Cisco, colleague, granma, Web, …]
- YYYY in [2020, 2050]
- XX in [20, 100]
- DDDD in [Industry, Smart cities, Healthcare]
- ZZ (think about a huge number then double it)
- FFFF in [year, week, minute, second]

Regardless of predictions

- IoT is now real, pervasive, and relevant
- Initially was only a matter of connectivity
- Now things need to be:
  - Smarter
  - More precise
  - Context-aware
  - …
- These are all requirements of applications which use these data provided by smart devices

IoT and applications

From application to PAIS



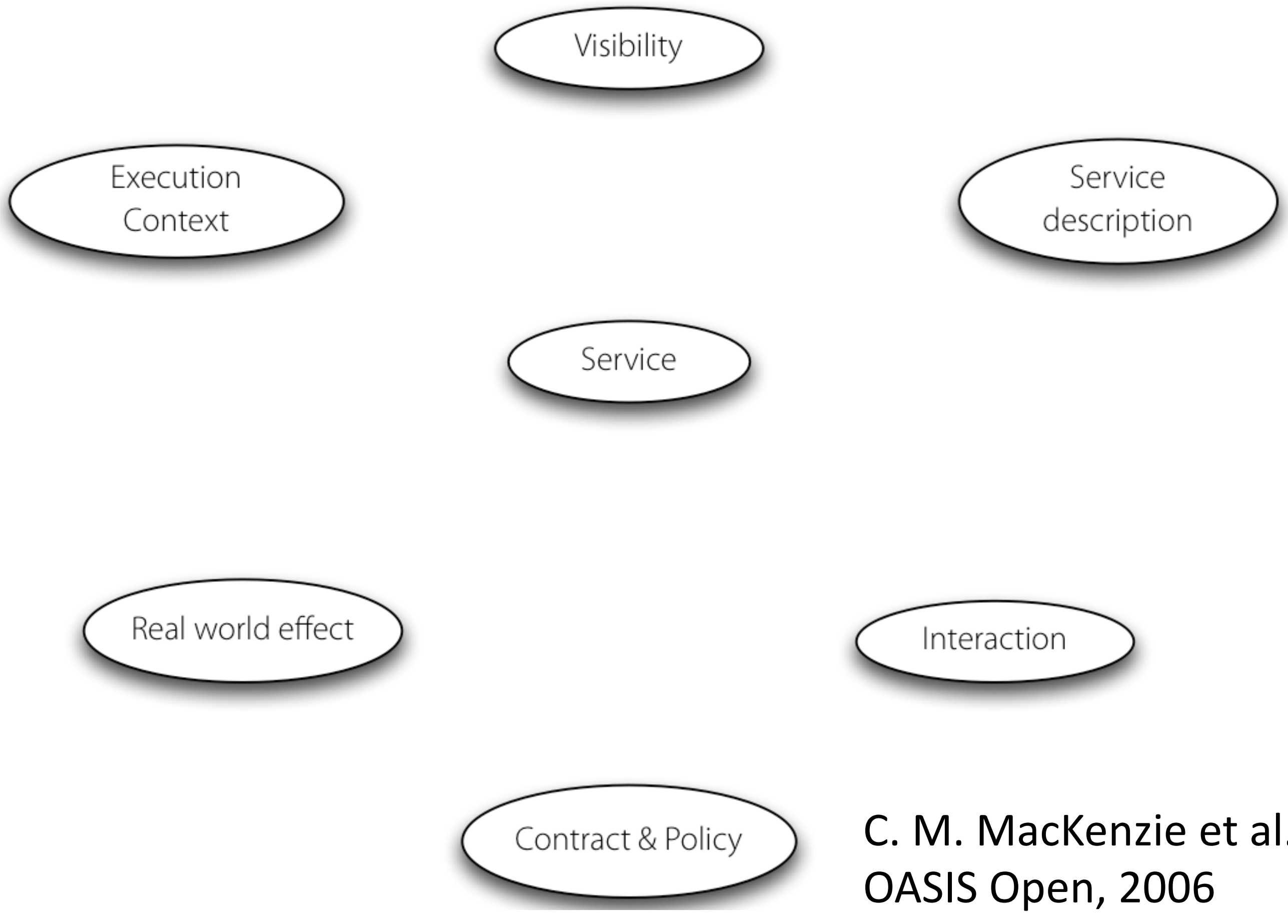
- Provide data which drive decisions
- Inform about the status of the process
- Execute tasks

PAIS and SOA

“In a Service Oriented Architecture (SOA) the information system is seen as a set of connected services. A PAIS can be realized using such an architecture and in fact it is very natural to see processes as the “**glue**” connecting services. The fit between SOA and PAIS is illustrated by emerging standards such as BPEL and BPMN”

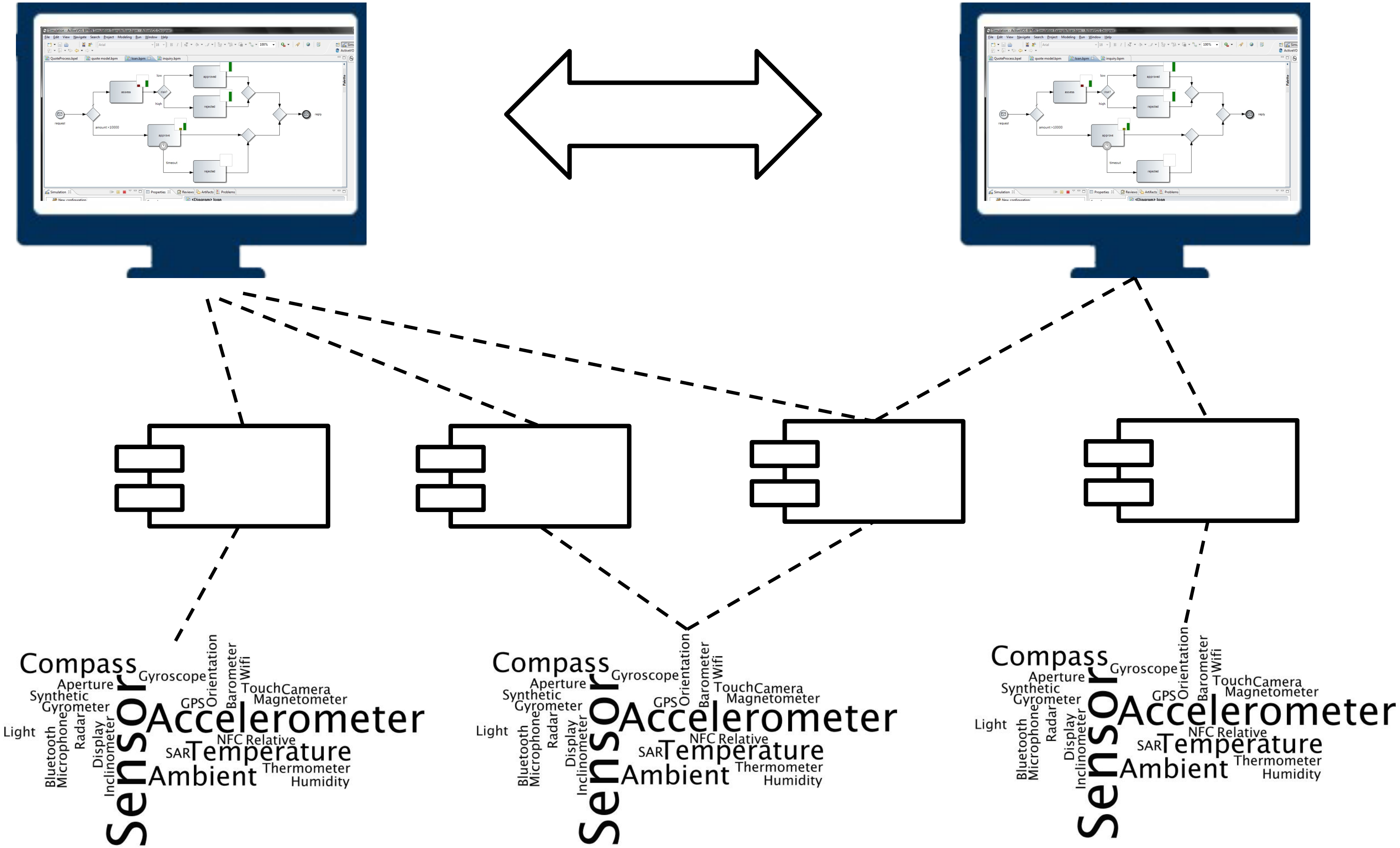
van der Aalst W.M.P. (2009)
Process-Aware Information Systems: Lessons to Be Learned from Process Mining.
In: Jensen K., van der Aalst W.M.P. (eds) Transactions on Petri Nets and Other Models of Concurrency II.
Lecture Notes in Computer Science, vol 5460. Springer, Berlin, Heidelberg

Sensors and SOA



C. M. MacKenzie et al., Reference Model for Service Oriented Architecture 1.0., OASIS Open, 2006
https://www.oasis-open.org/committees/download.php/19679/soa-rm-cs.pdf

Inter-organizational scenario



The manifesto

The Internet-of-Things Meets Business Process Management: Mutual Benefits and Challenges

Christian Janiesch[1], Agnes Koschmider[2], Massimo Mecella[3*], Barbara Weber[4], Andrea Burattin[4], Claudio Di Ciccio[5], Avigdor Gal[6], Udo Kannengiesser[7], Felix Mannhardt[8], Jan Mendling[5], Andreas Oberweis[2], Manfred Reichert[9], Stefanie Rinderle-Ma[10], WenZhan Song[11], Jianwen Su[12], Victoria Torres[13], Matthias Weidlich[14], Liang Zhang[15]

Abstract
The Internet of Things (IoT) refers to a network of connected devices collecting and exchanging data over the Internet. These things can be artificial or natural, and interact as autonomous agents forming a complex system of interactions. Business Process Management (BPM) was established to identify, discover, analyze, design, implement, and monitor collaborative business processes within a single and across multiple organizations. Whereas the IoT and BPM have been so far regarded as separate topics in research and practice, we argue that there are multiple links to be explored. In this paper, we pose the question to what extent these two paradigms can be combined and we detail the challenges of the mutual combination. As a conclusion, this paper suggests areas for future research.

Keywords
IoT (Internet-of-Things) — BPM (Business Process Management) — Challenges — Manifesto

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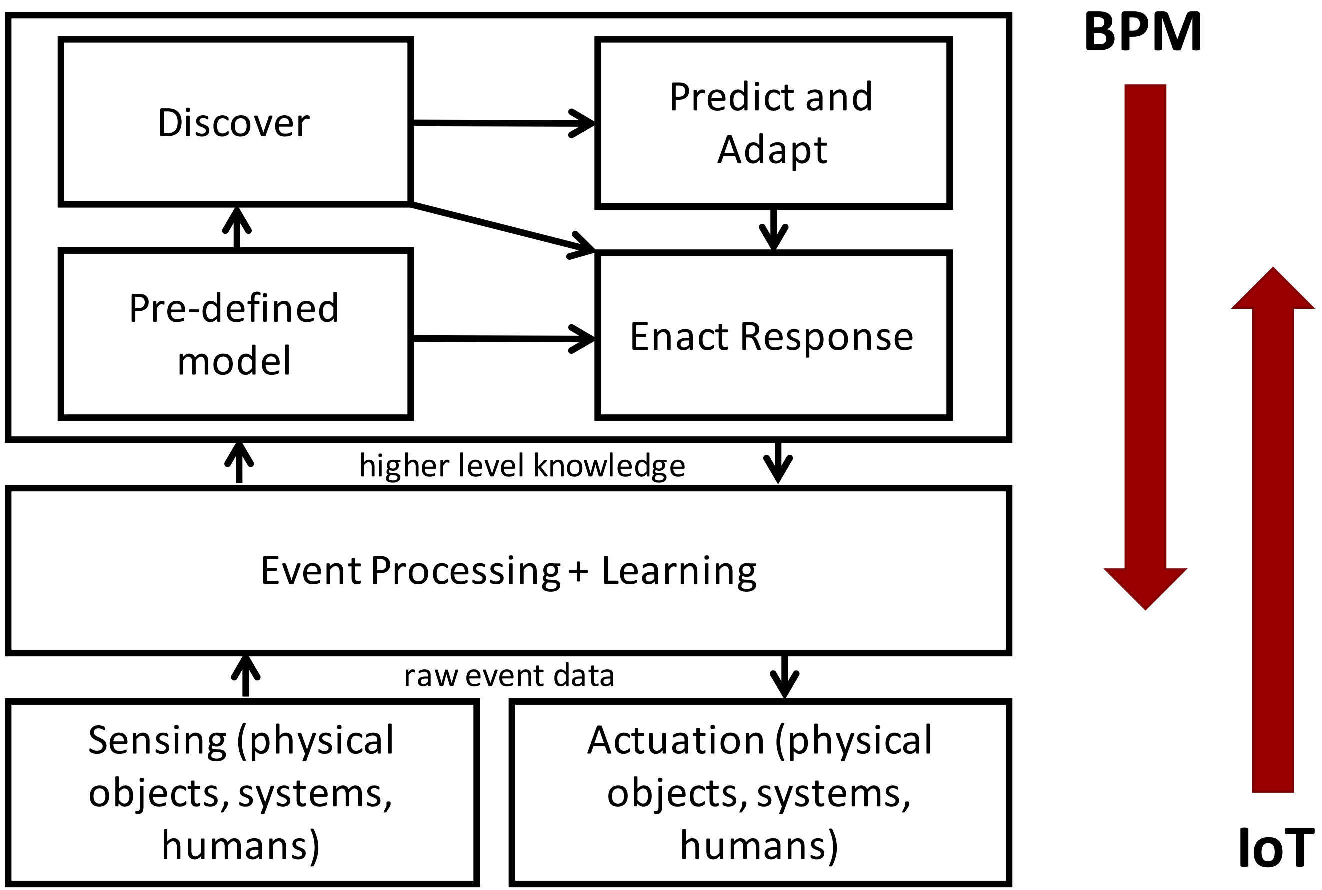
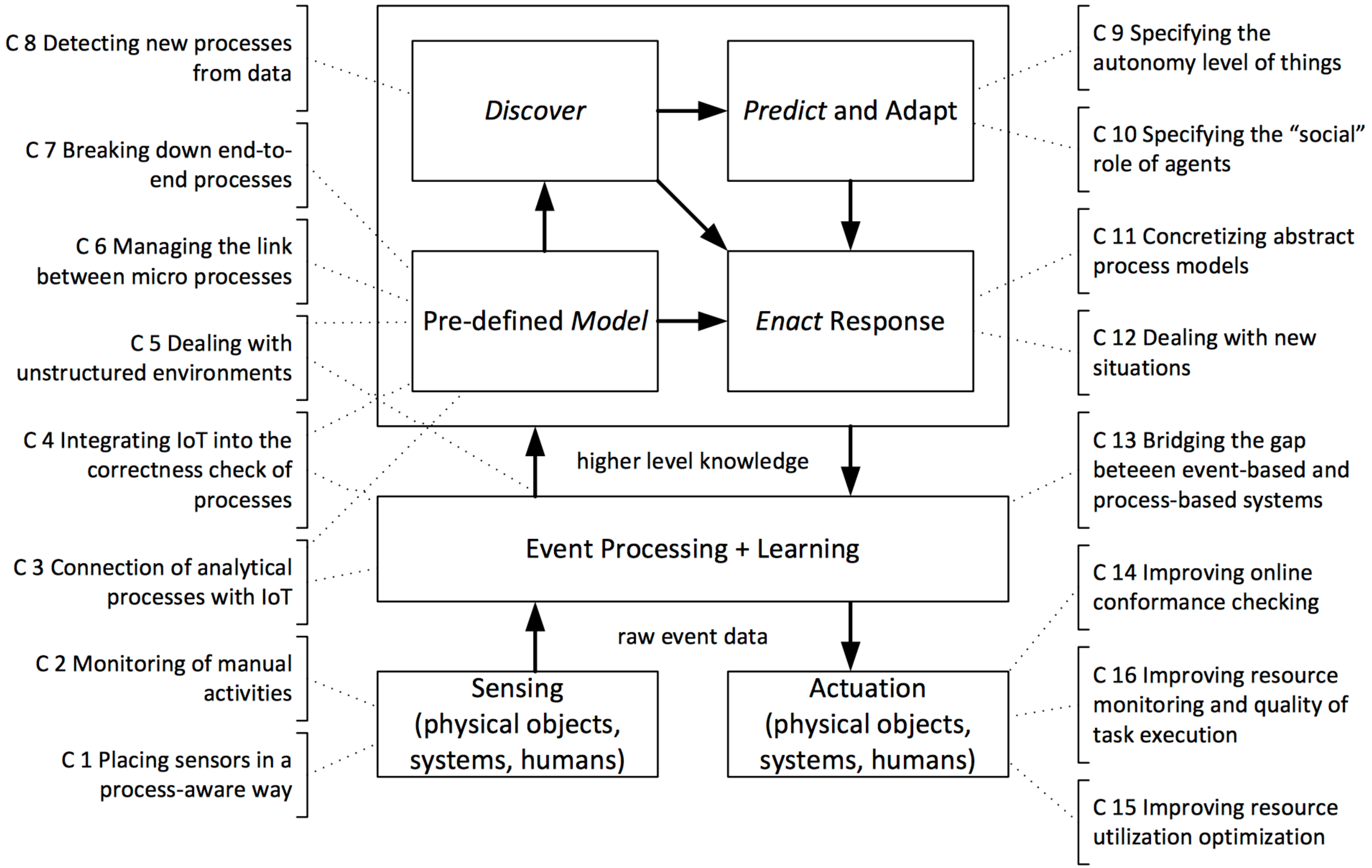
https://arxiv.org/pdf/1709.03628.pdf

BPM and IoT: interaction



Source: B. Weber, “BPM Meets IoT: a Dream Team?”, 1° Int’l Workshop BPM Meets IoT, BPM 2017

BPM and IoT: challenges



C. Janiesch et al, “The Internet-of-Things Meets Business Process Management: Mutual Benefits and Challenges, 2017

Critical issues: from the BPM perspective

- Data deluge
  - Do I really need all the produced data?
- Data movement
  - Where should I store data?
- Availability
  - What if the device stops working?
- Reliability
  - Are the sensed data correct?
- Visibility
  - Data are sensed but not (immediately) visible

Critical issues: from the smart device perspective

- Process segmentation
  - Smart devices knows only a portion of the process
- Process obligation
  - Modeling processes with imperative language force the smart device behavior

Case Management

structured process	case	ad hoc process
• structured process flow • activites known in advance • many repetitive elements • no degree of freedom for people wrt process flow	• process flow can partly be structured • activites partly known in advance • some repetitive elements • some degree of freedom for people wrt process flow	• process flow cannot be structured – new tasks on the fly • activites partly known in advance • few repetitive elements • very high degree of freedom for people wrt process flow
← can be modelled →		← cannot be modelled →

Source: K. Hinkelmann "Case Management Modeling and Decision-aware BP", NEMO 2015

BPM vs (A)CM

- BPM
  - Focus on activities
  - All possible paths are defined
  - As an activity occurs the state of the process changes
- (A)CM
  - Focuses on events and outcomes
  - Activities to reach completion cannot be predetermined completely
  - At the start, when an event occurs, a case file is opened
  - Evens, content and context determine activities
  - The state depepnds on the content of the case file

Source: K. Hinkelmann “Case Management Modeling and Decision-aware BP”, NEMO 2015

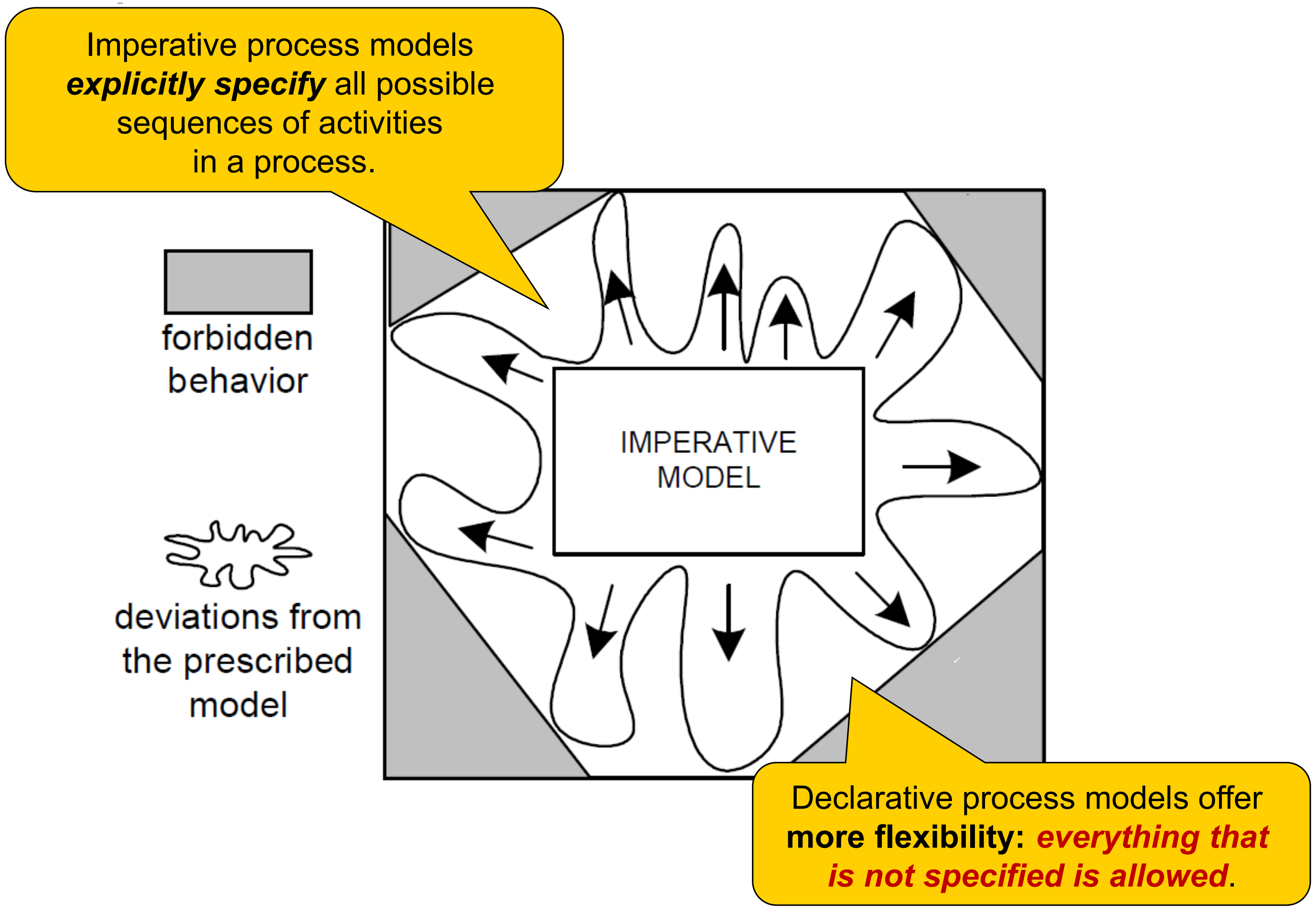
BPM vs (A)CM

- BPM
  - Deterministic
  - Task-centric
  - State-driven
  - Structured
- The function of BPM is to provide transactional thread across multiple systems of record
- Based on “standard procedures, practices, and policies”

- (A)CM
  - Non-deterministic
  - Content-centric
  - User-driven
  - Unstructured
  - Collaborative
- In ACM the case folder and the case itself is a system of record
- Based on “what needs to be done to resolve this case”

Source: K. Hinkelmann “Case Management Modeling and Decision-aware BP”, NEMO 2015

Imperative vs Declarative process modeling

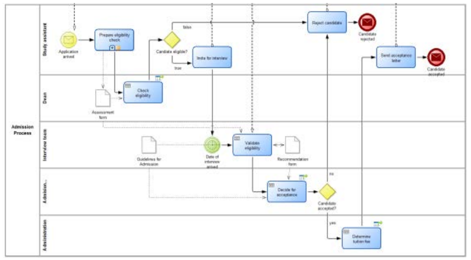


Courtesy of M. Mecella and A. Marrella from Università di Roma ”La Sapienza”

From BPMN to CMMN

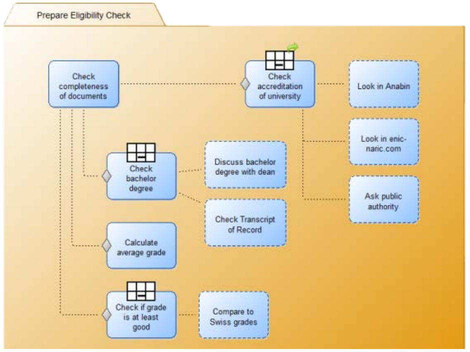
structured process

BPMN



case

CMMN



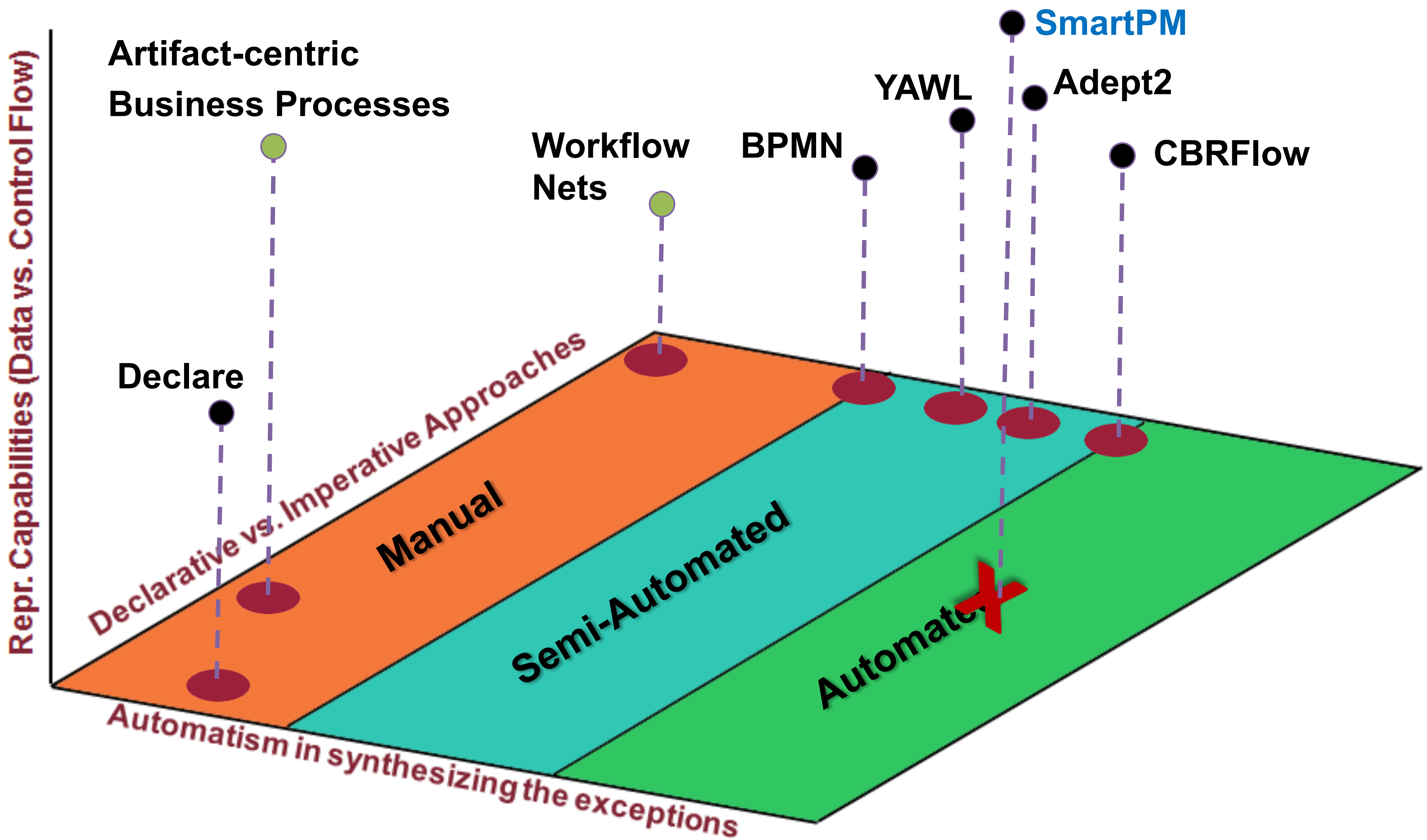
ad hoc process

- process flow cannot be structured – new tasks on the fly
- few repetitive elements
- very high degrees of freedom for people

← can be modelled →

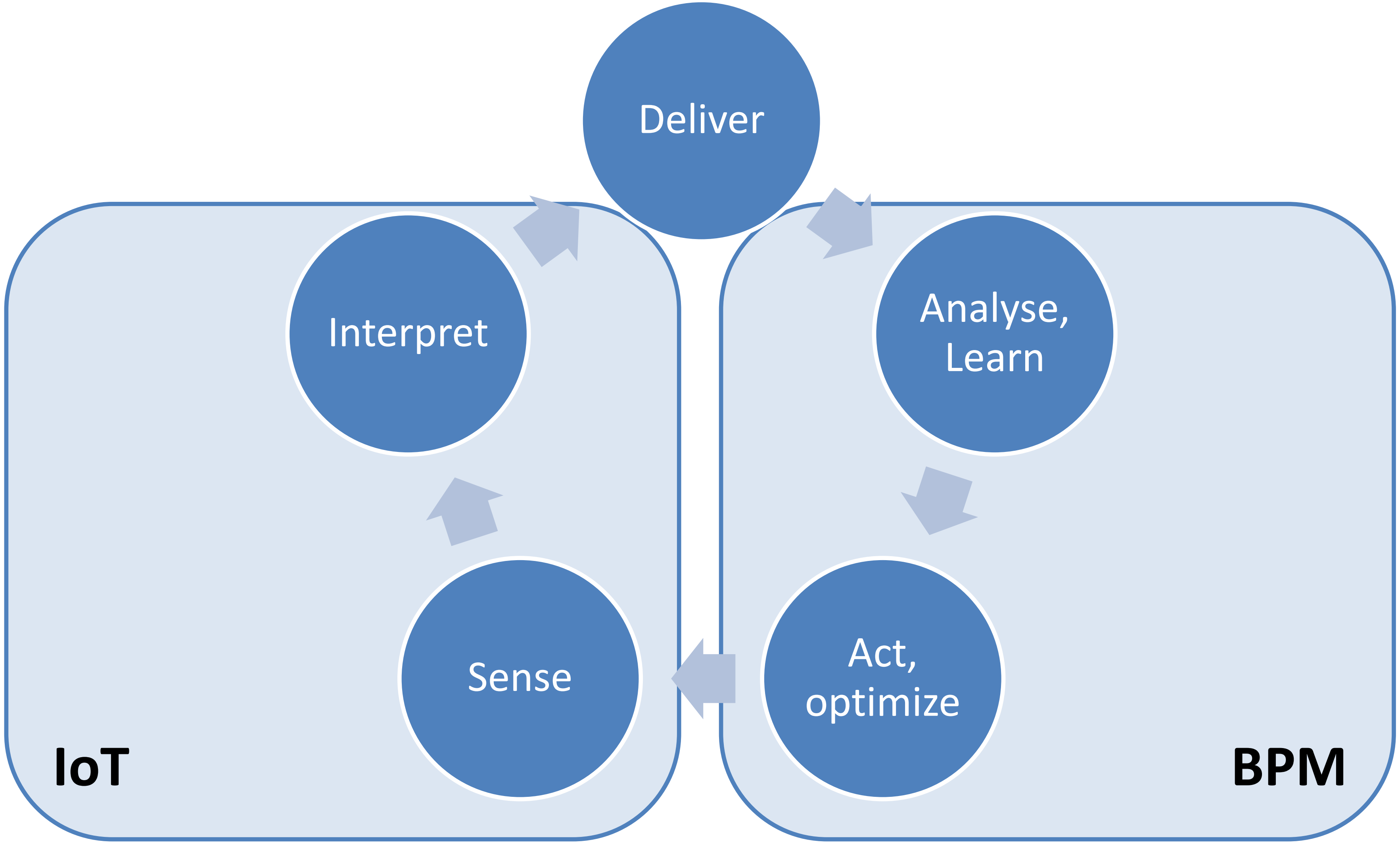
← cannot be modelled →

Why moving to a declarative approach

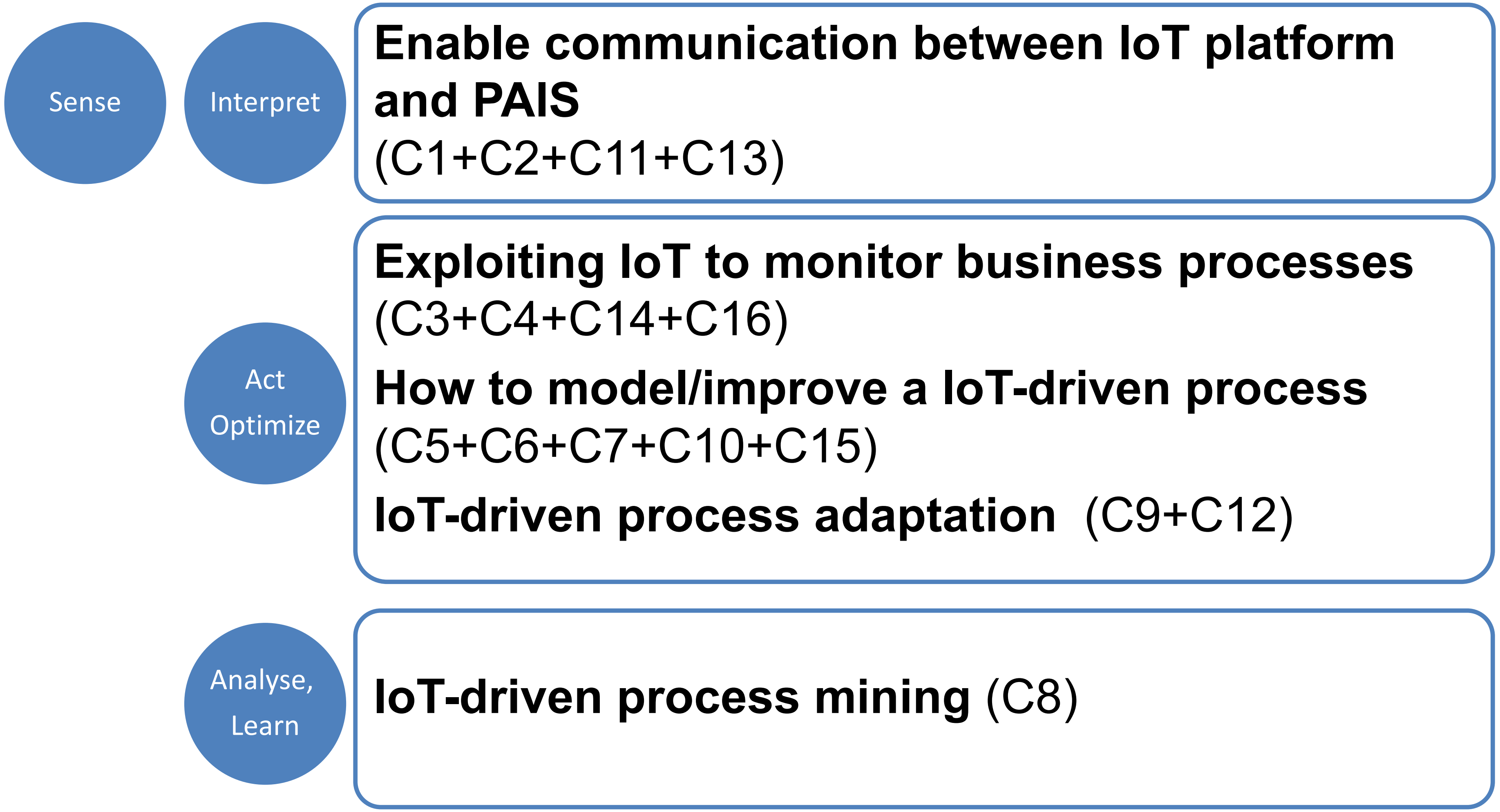


Marrella, A., Mecella, M., Sardina, S.: Intelligent Process Adaptation in the SmartPM System. ACM TIST 8(2), (2017)

BPM and IoT: interaction



Challenges re-classification



Challenges re-classification

Sense

Interpret

Enable communication between IoT platform and PAIS
(C1+C2+C11+C13)

Act

Optimize

Exploiting IoT to monitor business processes
(C3+C4+C14+C16)

How to model/improve a IoT-driven process
(C5+C6+C7+C10+C15)

IoT-driven process adaptation (C9+C12)

Analyse,

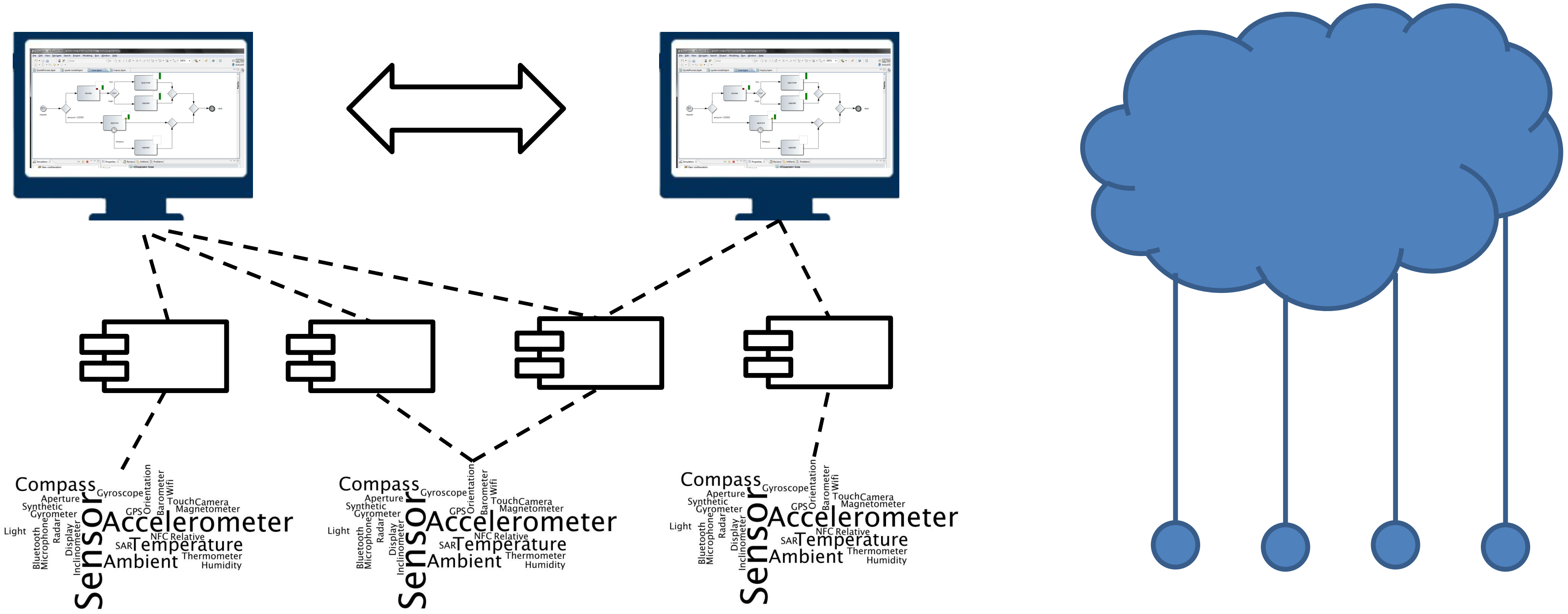
Learn

IoT-driven process mining (C8)

Sense

Interpret

Information logistics between processes and sensors



Enabling the information logistics

DITAS

Data-intensive applications Improvement by moving daTA and computation in mixed cloud/fog environmentS

DITAS receives funding from the European Union's Horizon 2020 research and innovation programme under grant agreement RIA 687584

http://www.ditas-project.eu

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IBM (ISRAEL)

OSPEDALE SAN RAFFAELE (ITALY)

Cloud Computing

- No need to explain …

Edge Computing

"[…] technologies allowing the computation to be performed at the edge of the network, on downstream data on behalf of cloud services and upstream data on behalf of IoT services"

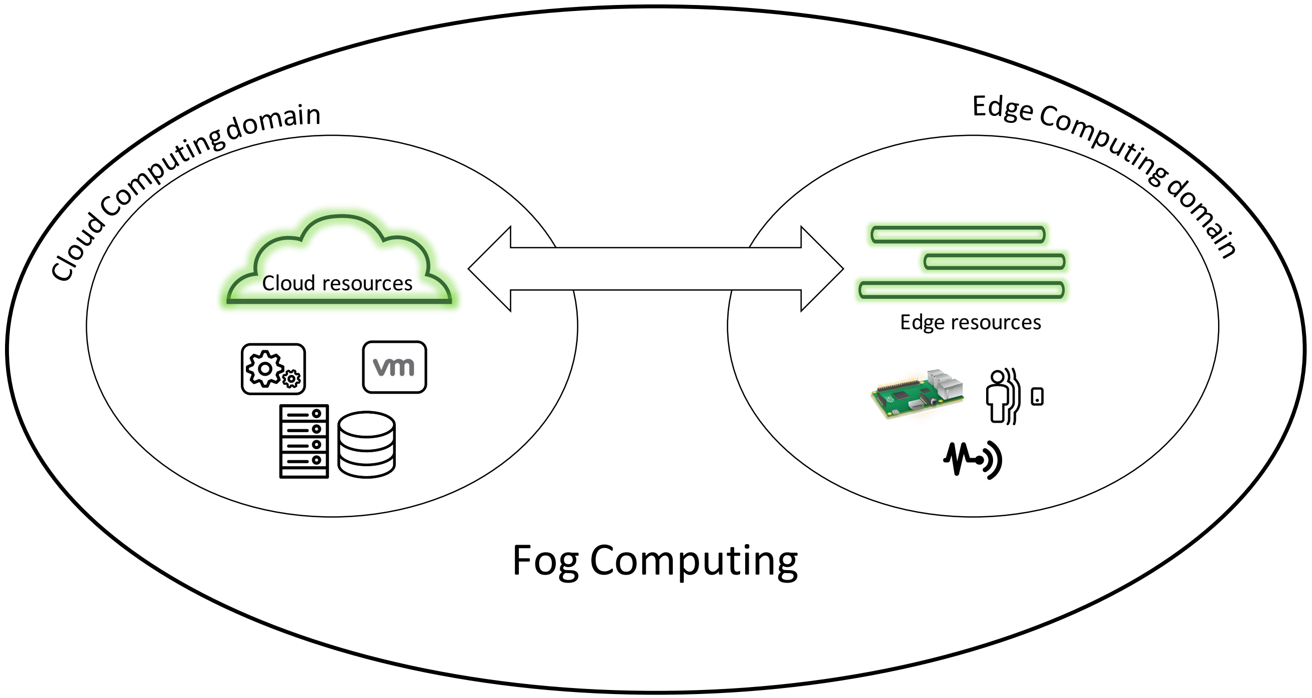
Shi, W., Cao, J., Zhang, Q., Li, Y., Xu, L.: Edge computing: Vision and challenges. IEEE Internet of Things Journal 3(5), 637–646 (Oct 2016)

Fog Computing (from the telco)

“to provide compute, storage, and networking services between Cloud data centers and devices at the edge of the network”

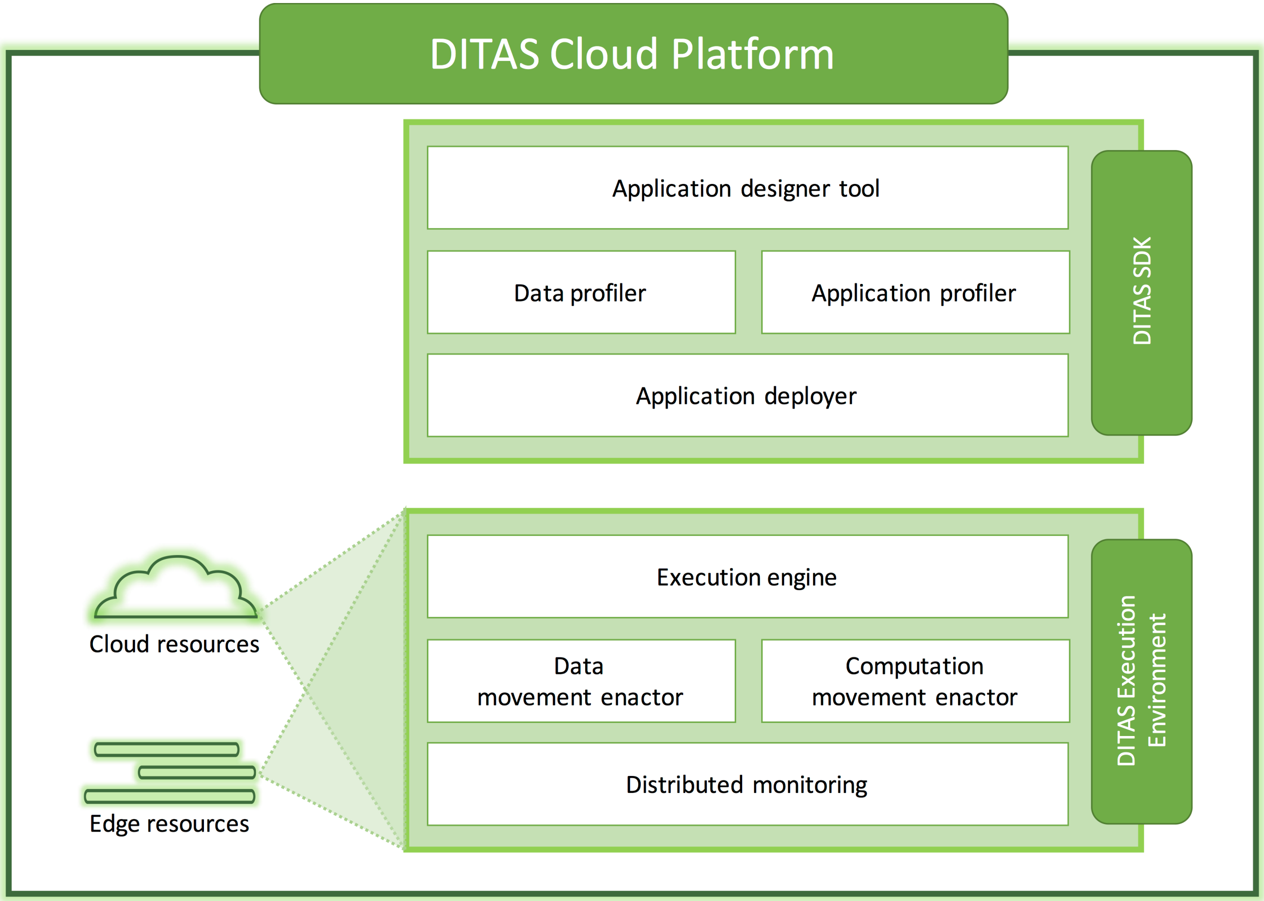
Bonomi, F., Milito, R., Zhu, J., Addepalli, S.:
Fog computing and its role in the internet of things.
In: Proceedings of the First Edition of the MCC Workshop
on Mobile Cloud Computing. pp. 13–16. MCC ’12 (2012)

Fog Computing (for us)



OpenFog Consortium Architecture Working Group: OpenFog Architecture Overview (February 2016), http://www.openfogconsortium.org/ra

DITAS architecture



F. D'Andria et al, Data Movement in the Internet of Things domain, ESOCC WiP Track 2015.
P. Plebani et al, Information Logistics and Fog Computing: the DITAS approach, CAiSE Forum 2017

Challenges re-classification

Sense

Interpret

Enable communication between IoT platform and PAIS
(C1+C2+C11+C13)

Act
Optimize

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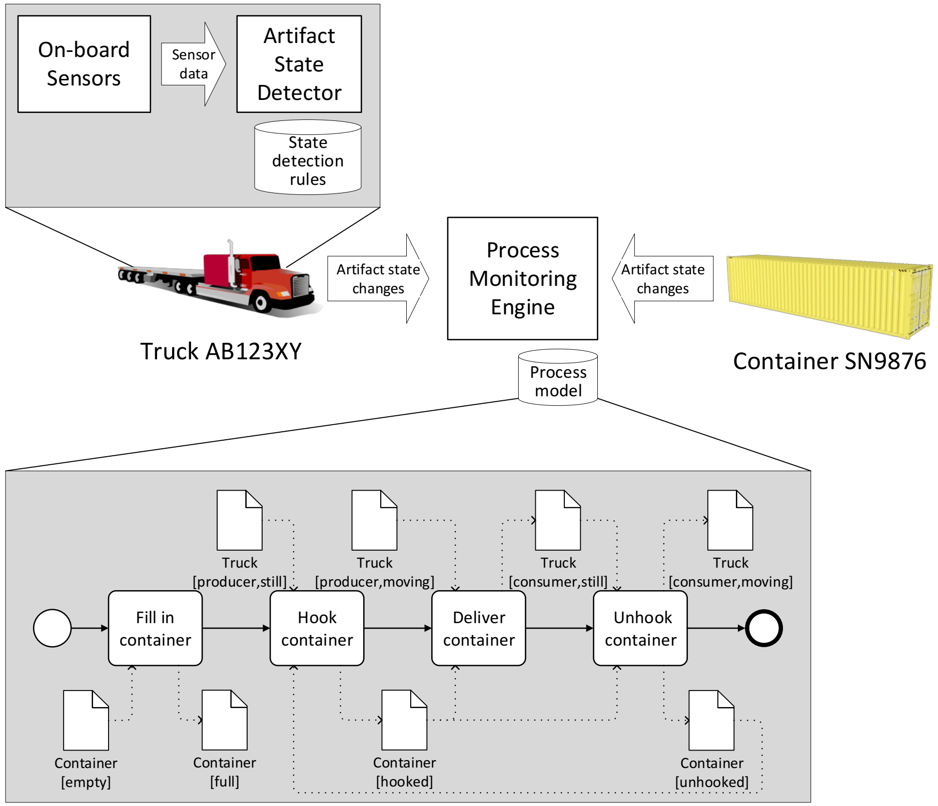
Analyse,
Learn

IoT-driven process mining (C8)

Act

Optimize

Process monitoring



- Domain:
  - multi-modal logistics
- Monitoring:
  - Each party monitor its portion (distributed vs centralized)
  - The artifact owner could not see the entire process
- Compliance checking:
  - The model used to define the process is the same used to configure the monitoring system

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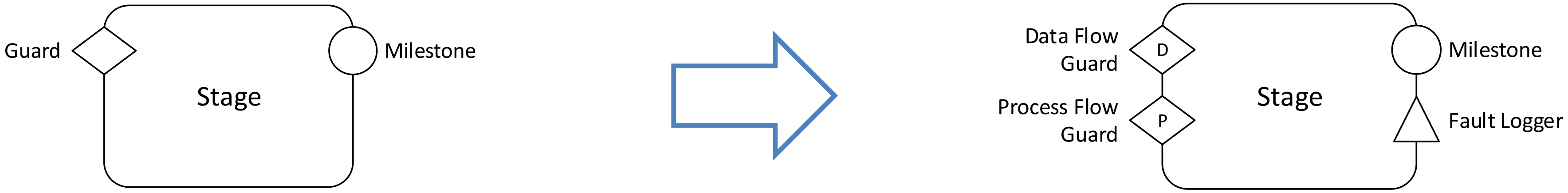
From sensors to smart devices

- Usually transportation units or vehicles (artifacts) are equipped with sensors
  - Sensors are configured to send data that are managed by the PAIS (*)
- Moving to smart devices:
  - Artifacts can autonomously infer their own state and forward it to the monitoring platform
- Challenge: How to configure the smart devices?
  - Get inspired by artifact-centric modeling language
  - Use an imperative language to model the process and a declarative to monitor

(*) A. Baumgraß, N. Herzberg, A. Meyer, M. Weske, BPMN extension for business process monitoring, EMISA 2014,

Extending GSM (E-GSM)

GSM (Guard Stage Milestone) | **E- GSM**



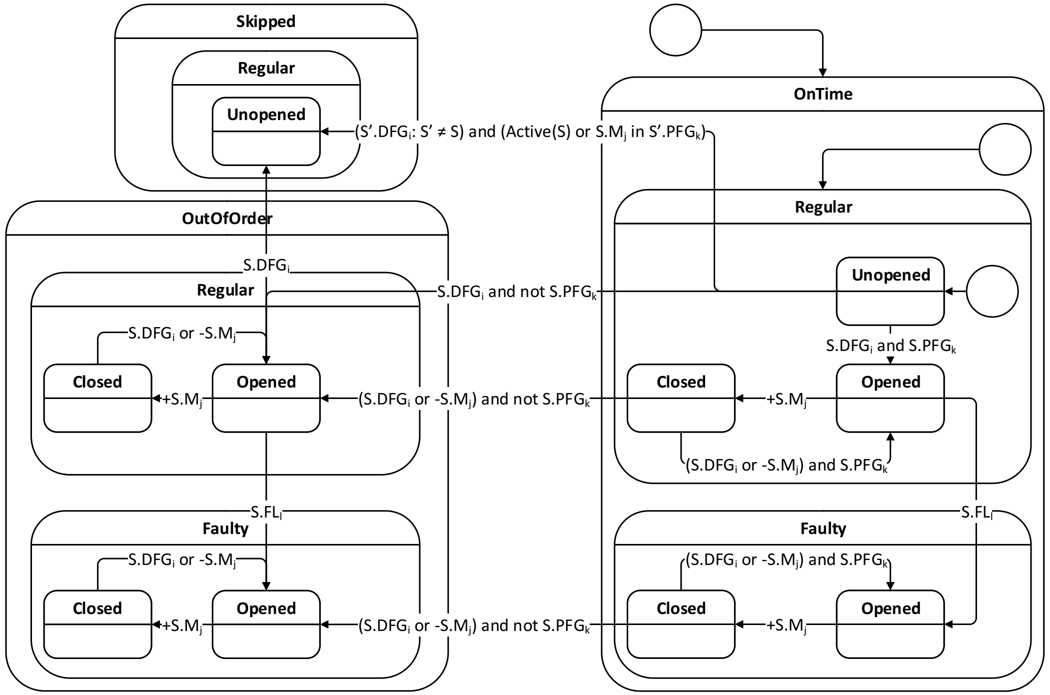
- Guard (G) determines the start of each task based on events
- Milestone (M) determines the end of each task based on events
- Events can be internal or external, involving conditions on sensor data, explicit messages, etc.

- Guard distinguished in Data Flow Guard and Process Flow Guard:
  - Data Flow Guard (DFG) task activation
  - Process Flow Guard (PFG) expected process flow
- Fault Logger (FL) annotation introduced:
  - When task constraints are violated

L. Baresi, G. Meroni, P. Plebani “Using the Guard-Stage-Milestone Notation for Monitoring BPMN-based Processes”, Proceedings of BPMDS’2016 Working Conference, 2016.

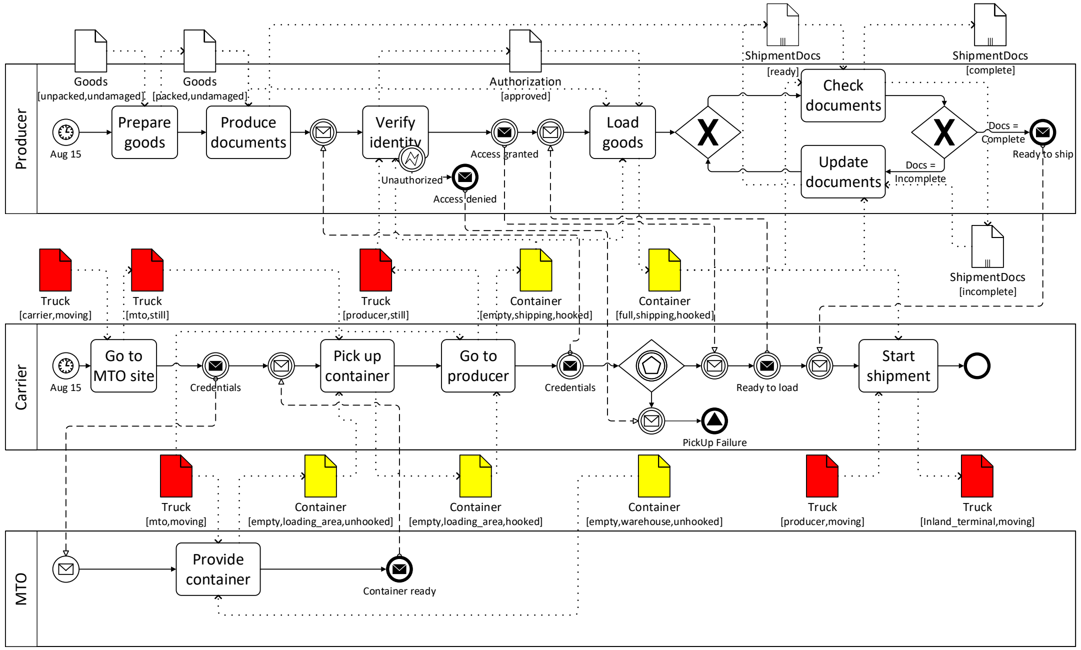
E-GSM Stage lifecycle

- E-GSM allows to monitor processes with respect to three orthogonal dimensions:
  - Execution state:
    - unopened
    - opened
    - closed
  - Execution status:
    - regular
    - faulty
  - Execution compliance:
    - on time
    - out of order
    - skipped

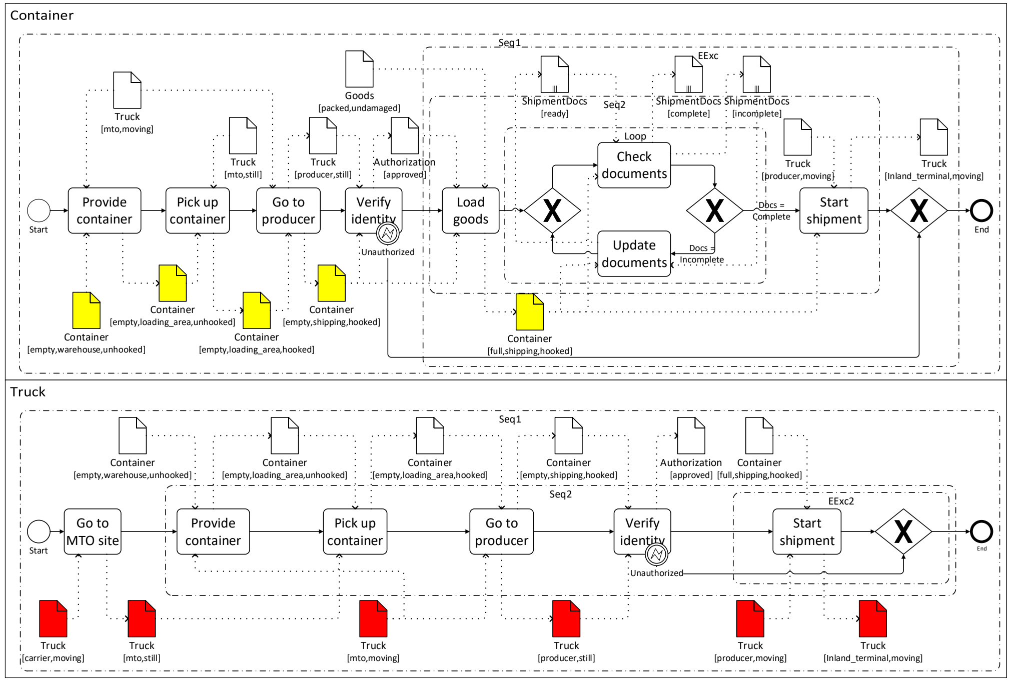


Approach 1/3

From a multi-party business process modeled with BPMN where artifacts are exchanged



To sets of tasks associated to artifacts

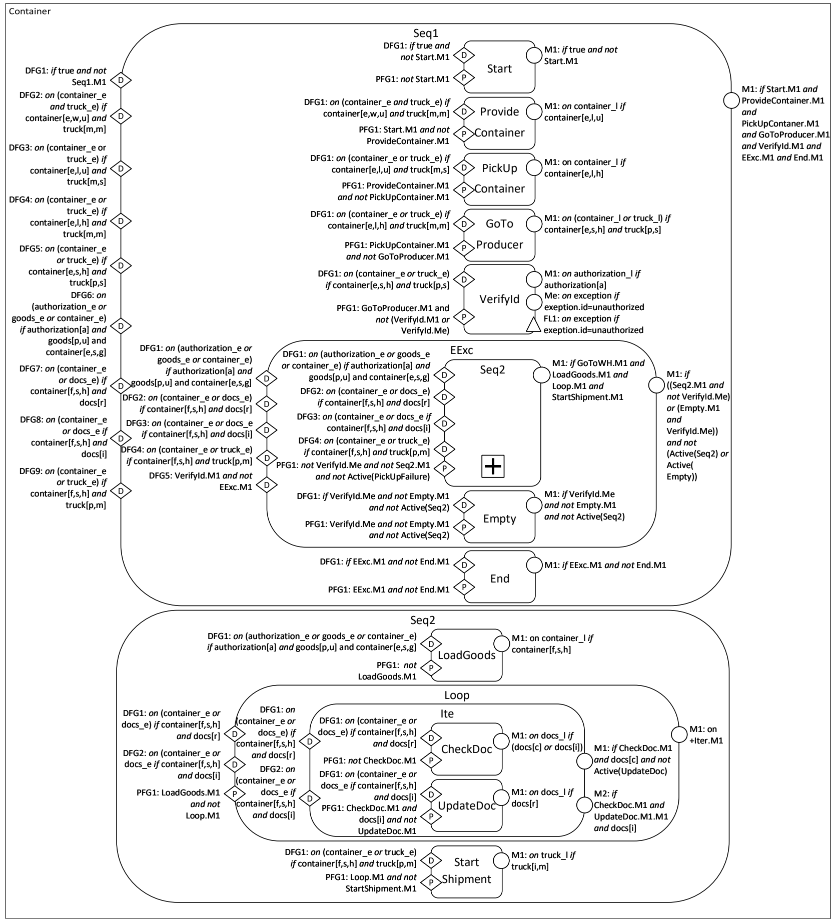


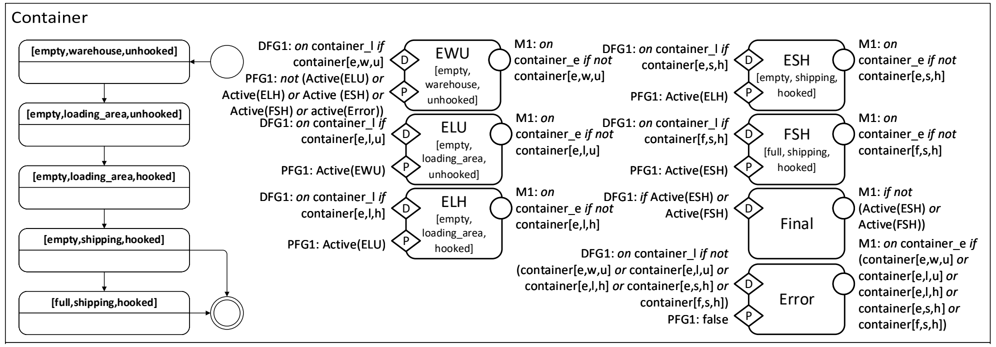
Approach 2/3

- Each artifact is associated to a smart device which is in charge of monitoring
  - The process state (does the process evolving correctly?)
  - The artifact state (is the artifact managed properly?)
- We need to analyse the co-evolution of both life-cycles
- E.g., cold-chain in transportation
  - Process monitoring check if the goods move from A to B
  - Artifact monitoring check if the temperature is below T during the tranportation
  - Co-evolution ensure that the goods arrives at destination in good conditions

Approach 3/3

Life-cycles are defined with E-GSM automatically generated from the extracted BPMN





Act

Optimize

Process monitorability

- How many activities in a process can be monitored by smart objects?
  - Smart objects may lack sensors to determine one state
  - Smart objects may lack rules to derive one state from sensor data
  - If one state cannot be determined, activities that require or produce that state cannot be monitored

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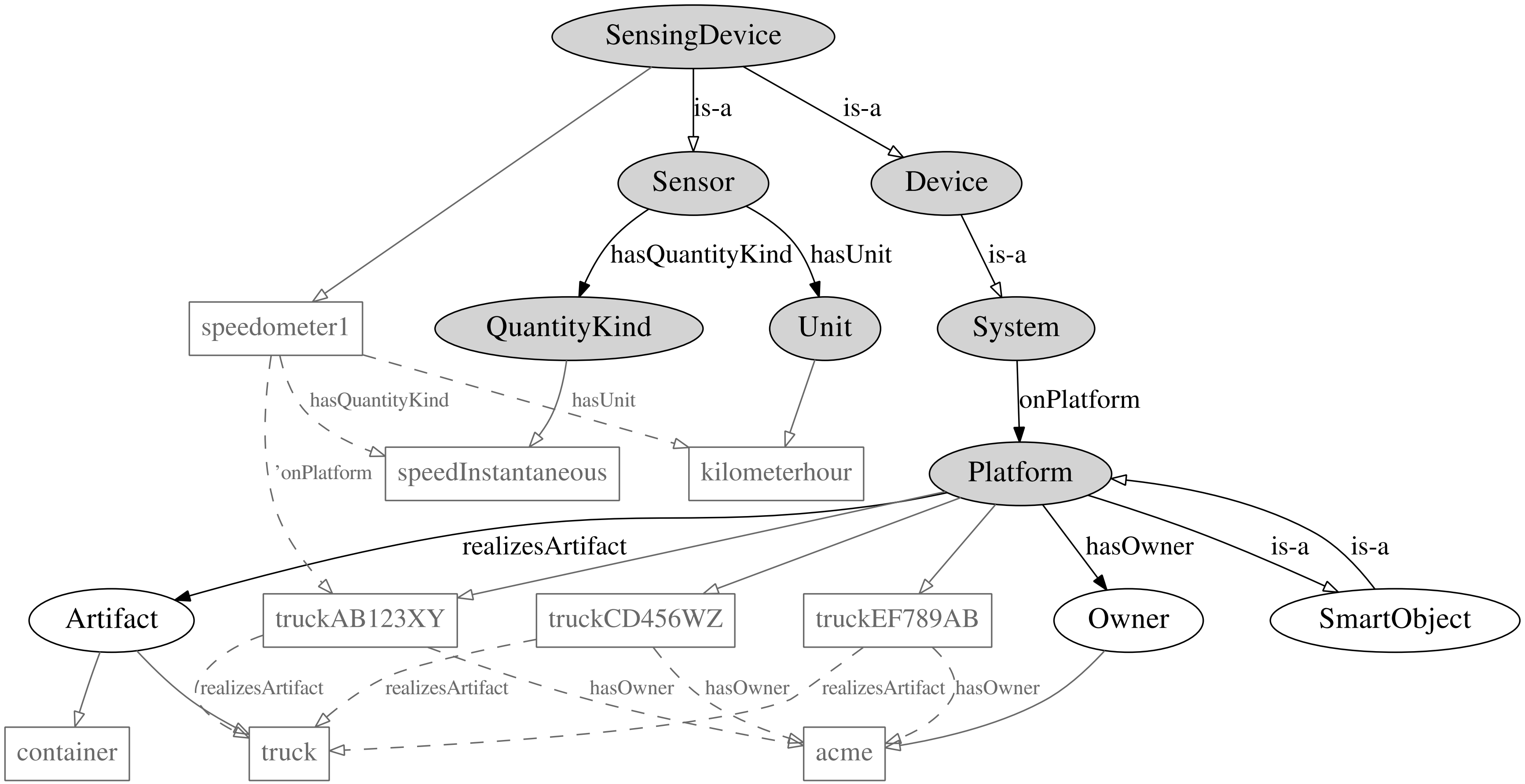
Contribution

- Ontology-based approach to:
  - Formalize the capabilities of smart objects
  - Estimate the monitorability
  - Provide suggestions to improve the monitorability

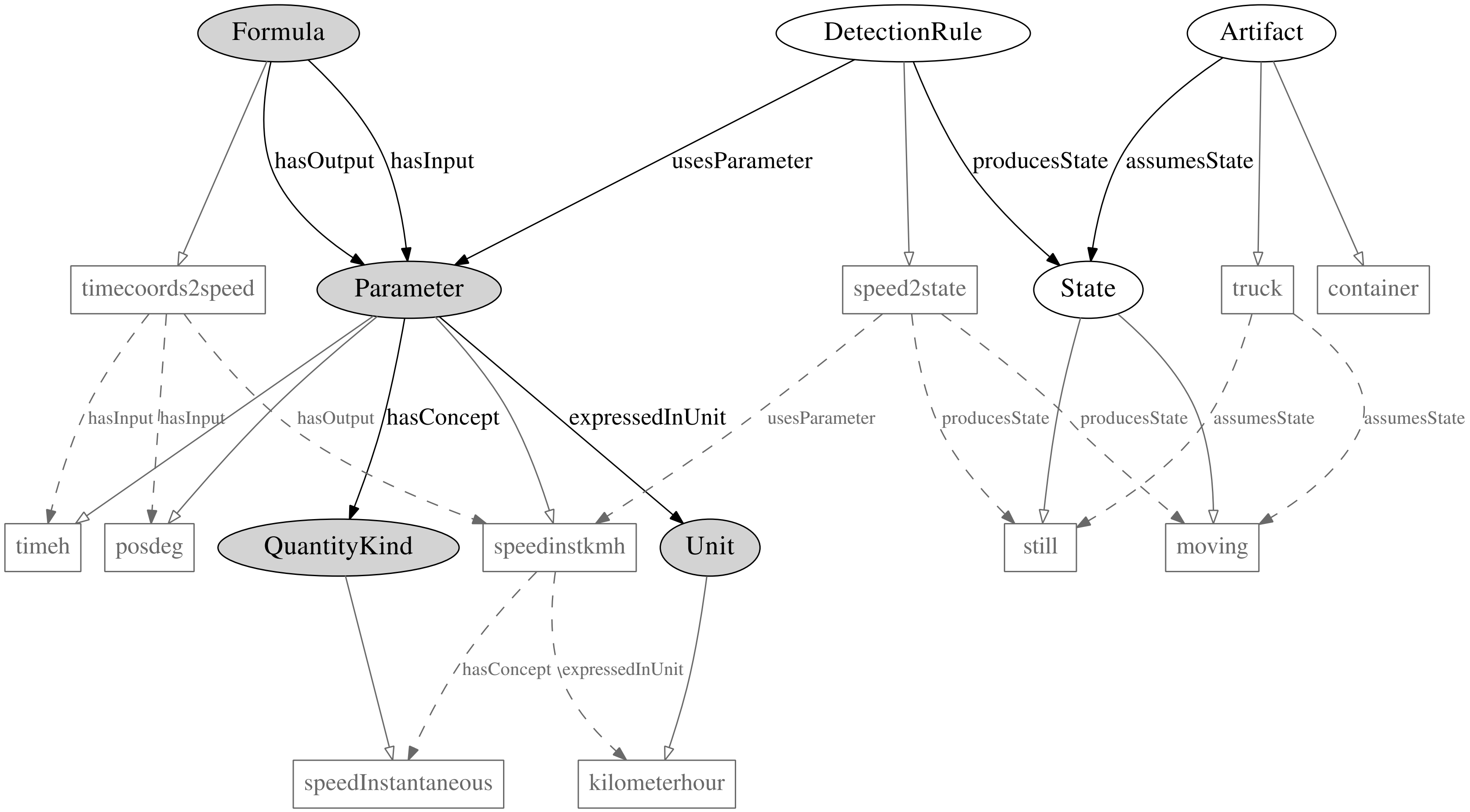
G. Meroni, P. Plebani "Artifact-Driven Monitoring for Human-Centric Business Processes with Smart Devices: Assessment and Improvement", Proceedings of BPM Forum 2017, Barcelona, Spain, September 10-15, 2017

Extending FIESTA-IoT



R. Agarwal et al., Unified IoT ontology to enable interoperability and federation of testbeds. In: WF-IoT 2016, pp. 70–75. IEEE Computer Society

Extending Physic Domain Ontology



Hachem, S., Teixeira, T., Issarny, V.: Ontologies for the internet of things. In: MDS ’11, pp. 3:1–3:6. ACM (2011)

Act

Optimize

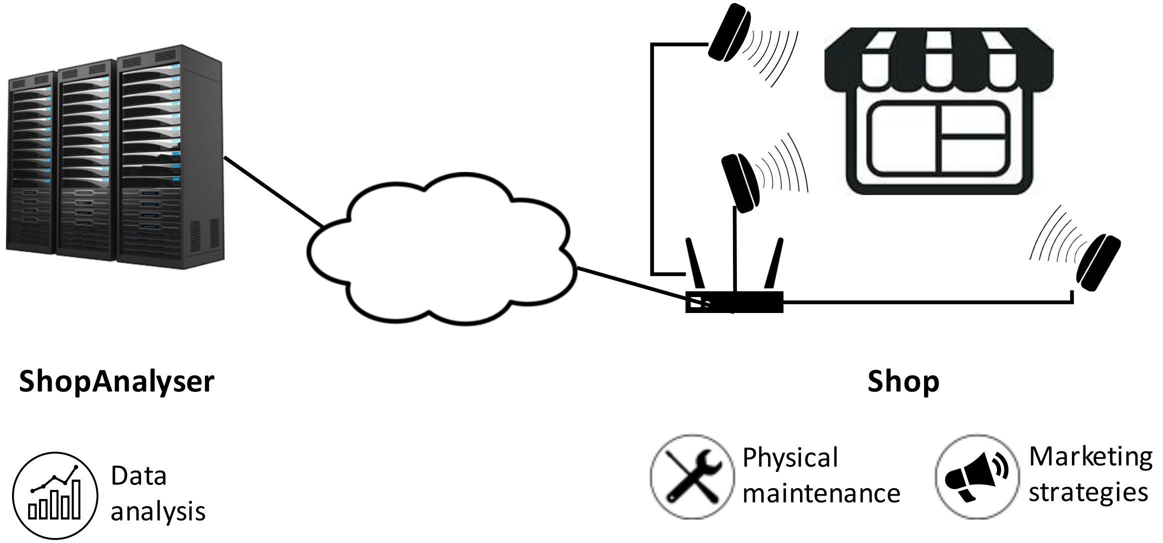
Process modeling: resilience

- Data-centric approach
  - Lack (or low quality) of data is the main source of failures
- Resilience maturity model
  - Paves the road to increase the awareness w.r.t. the resilience issues
  - Set of levels of resilience
- CMMN extension supporting the resilience by-design
  - To propose a tool able to model a resilient multi-party business compliant with our maturity model

P. Plebani, A. Marrella, M. Mecella, B. Pernici, Multi-Party Business Process Resilience By-Design: A Data-Centric Perspective, CAiSE 2017 (Best paper)

Multi-party business process resilience

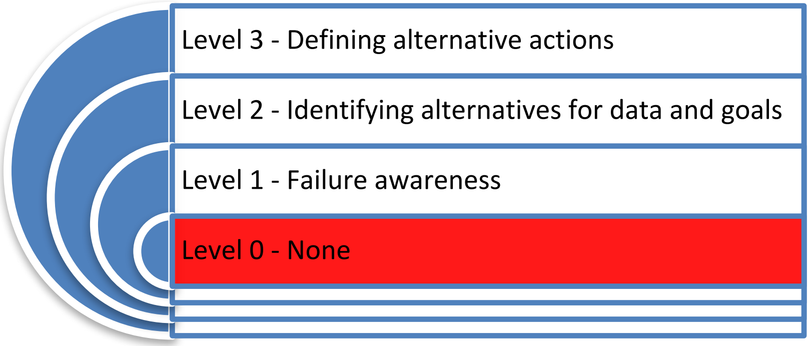
- Parties
  - The have their own independence
- Tasks
  - We are interested only on tasks that produces/consumes data produced/consumed by other parties
- Data
  - Used to define the state or to drive the system evolution

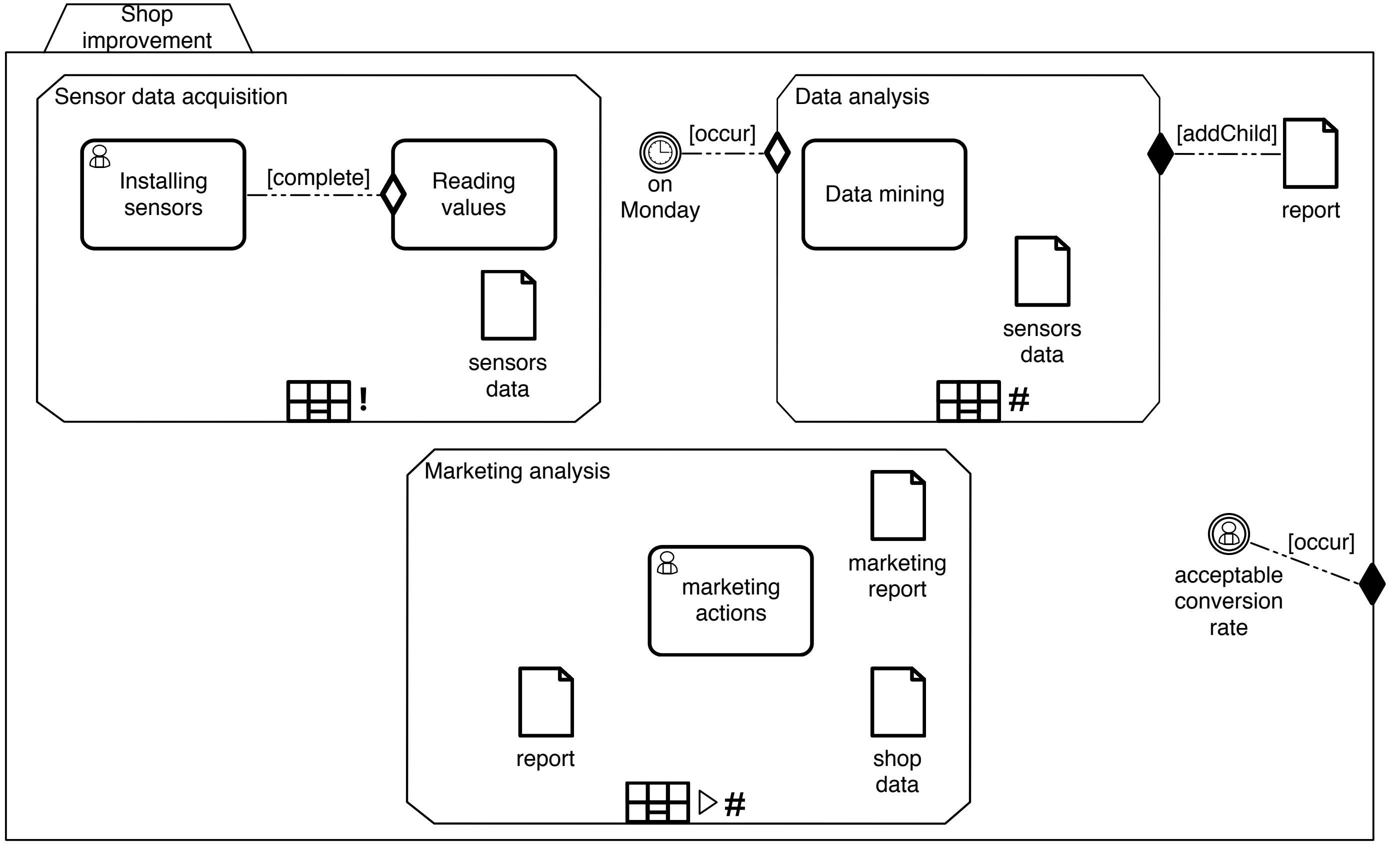


Levels of resilience

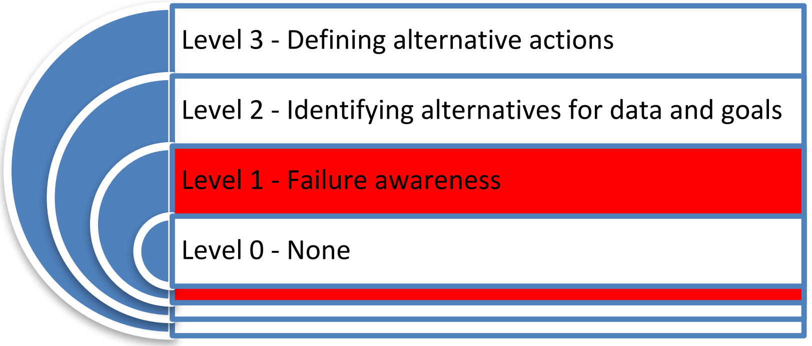
- Level 3 - Defining alternative actions
- Level 2 - Identifying alternatives for data and goals
- Level 1 - Failure awareness
- Level 0 - None

Level 0 - None


Level 3 - Defining alternative actions
Level 2 - Identifying alternatives for data and goals
Level 1 - Failure awareness
Level 0 - None

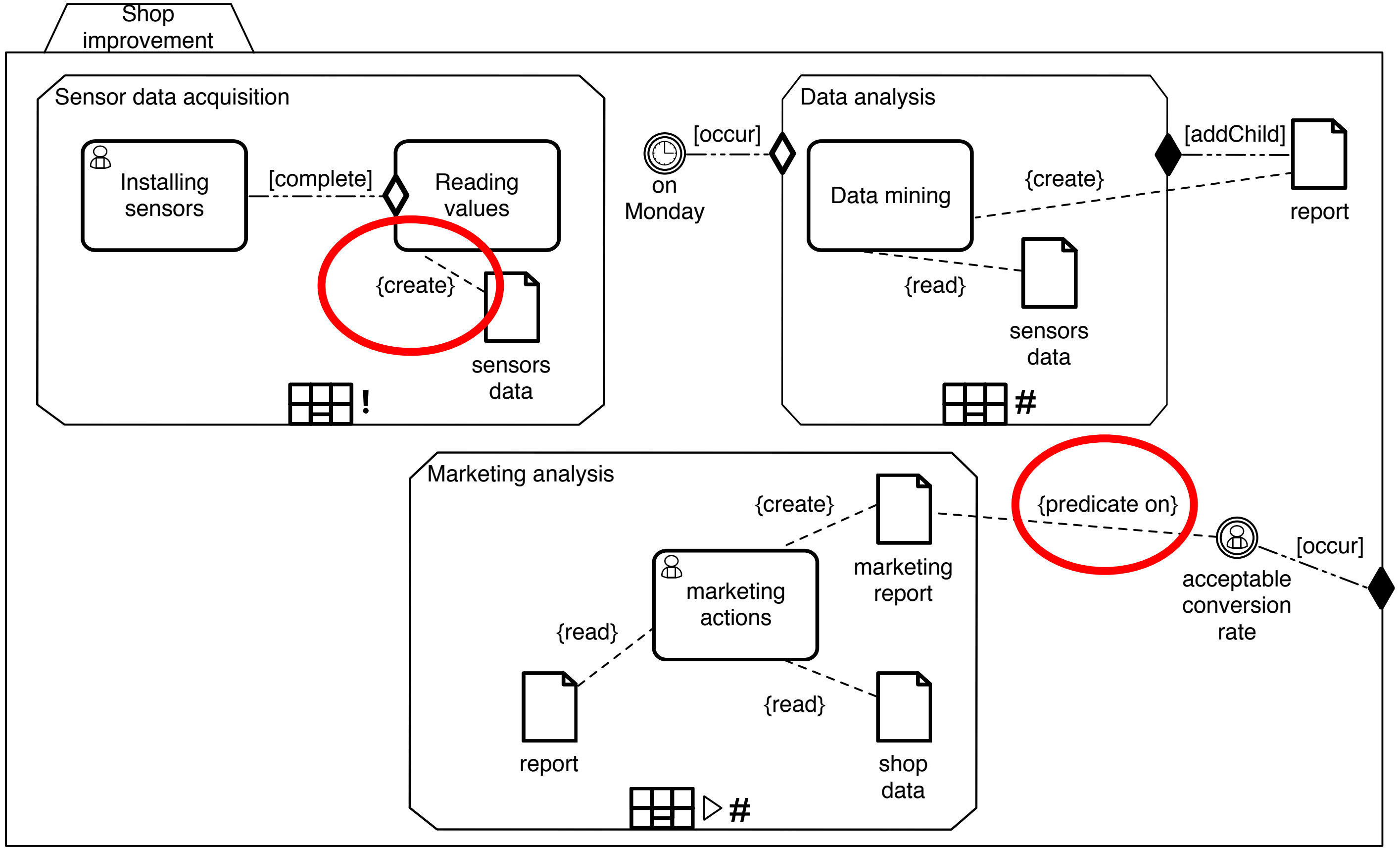

Shop improvement
Sensor data acquisition
Installing sensors
[complete]
Reading values
sensors data
!
[occur]
on Monday
Data analysis
Data mining
sensors data
#
[addChild]
report
Marketing analysis
marketing actions
marketing report
report
shop data
#
[occur]
acceptable conversion rate

Level 1 – Failure awareness

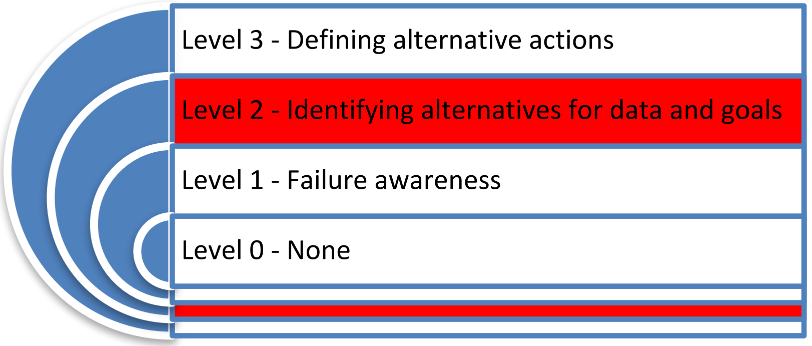


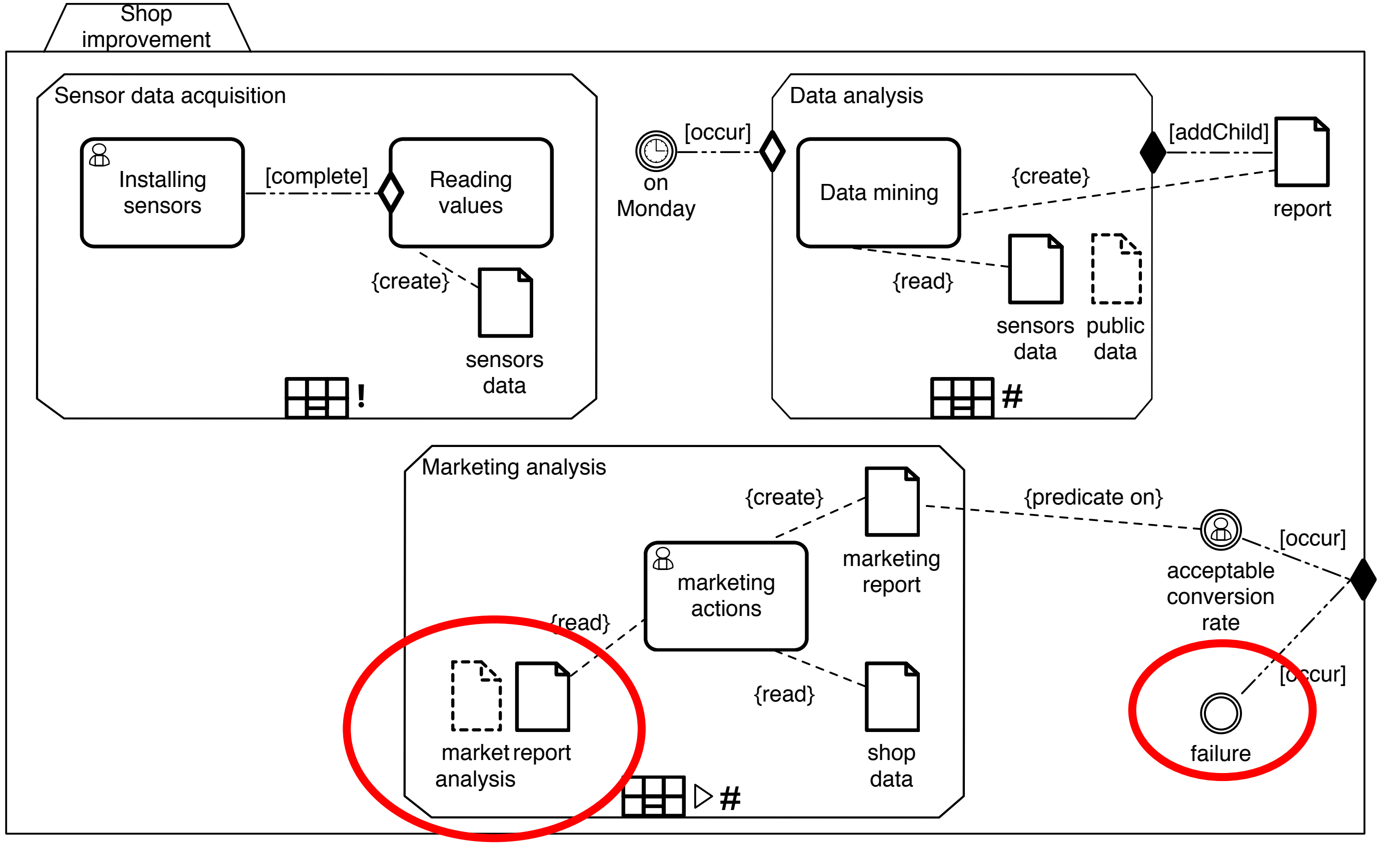
Improving the data semantics

- Relationship between data and tasks
- Relationship between data and events
- Specification of the operations made on data



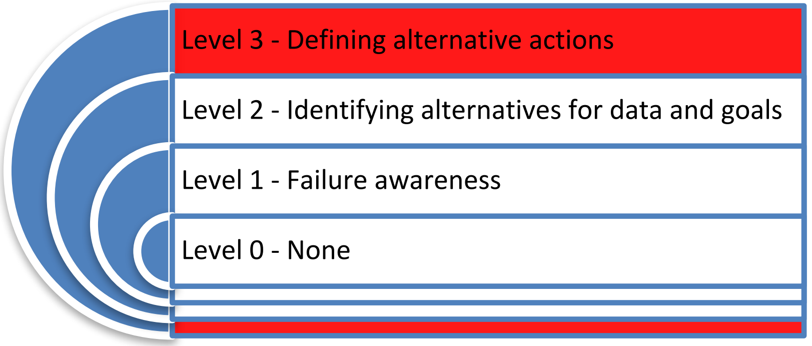
Level 2 – Defining alternatives for data and goals

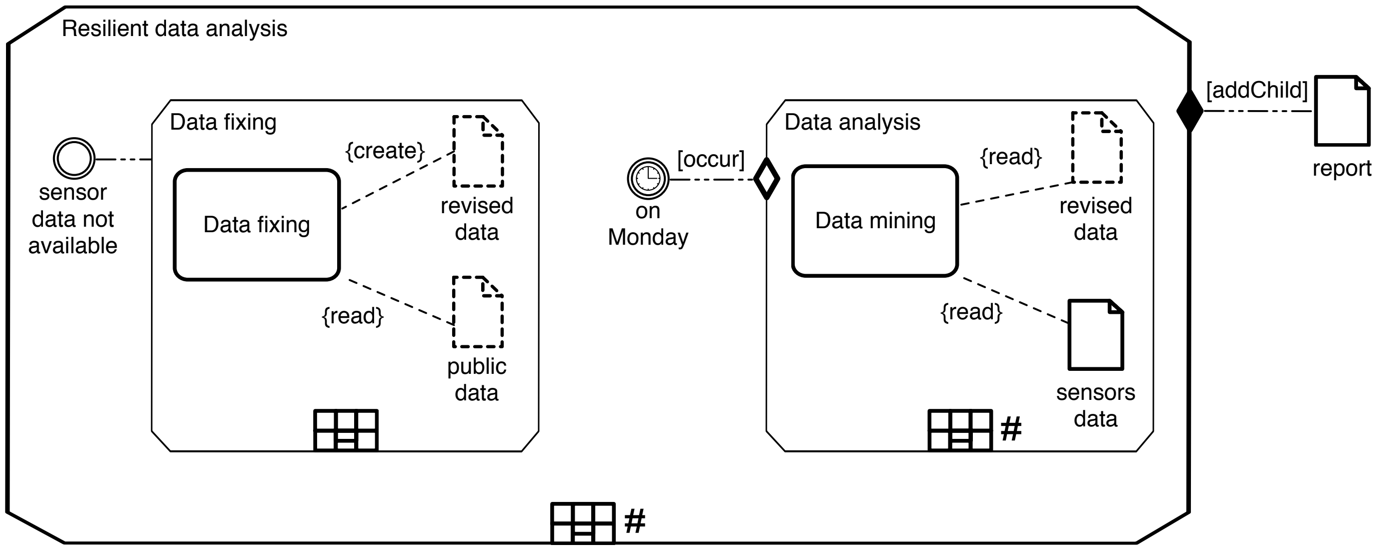




- Introduce discretionary data to specify alternative data
- Goal alternatives can be specified using the standard CMMN

Level 3 – Defining alternative actions





Add new tasks (i.e., case plan fragments) to achieve the planned goal

- No additional CMMN elements are required
- Usually operates on alternative data

Act
Optimize

Process modeling: commitments

- Enriching the choreography model with commitments
- Commitments will drive the smart devices which can monitor the execution

IoT-based Compliance Checking of Multi-party Business Processes modeled with Commitments

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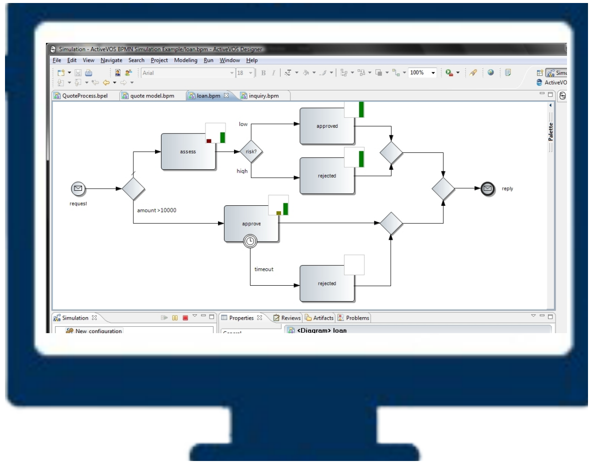
Abstract. In a multi-party business process, the choreography defines the conversational protocol among the parties, so that the visibility of the parties' private processes is limited to the set of operations required to respect such a protocol. Especially in scenarios where physical resources are exchanged, knowing how a resource owned by a party is managed in the premises of another party is not possible. Thus, possible misalignments can be detected too late. At the same time, IoT is increasingly adopted to enact business processes in many domains: e.g., logistics, manufacturing, healthcare. As, with IoT, smart devices can physically flow through the different parties involved in a process, their sensing capabilities can be exploited to improve the process compliance checking. With this work we propose an approach for compliance checking that mixes commitments and smart devices. Commitments, declaratively defining mutual contractual relationships between parties, drive the configuration of smart devices that, flowing along with the process flow, check their satisfaction and, in case of misalignment, timely inform the involved parties.

Keywords: Multi-party process compliance, Timed Commitments, BPMN Choreography Model, IoT

Concluding remarks



Focus on data

- Able to cope with different scenarios of usage

Focus on activities data

- Activity-based approaches could have a lot of limitations
- Artifact-centric approaches give you more freedom

We need to make both of them more usable for developers/process managers/users

Business Processes and Smart Devices: a marriage of convenience?

- In some sense yes:
  - They evolve independently
  - Both take inspiration from the other to evolve
- In some sense no:
  - They will need each other more and more
  - Both could start from the assumption that the other is always there

Concluding remarks