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POLITECNICO DI MILANO





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A GSM-BASED APPROACH FOR MONITORING CROSS-ORGANIZATION BUSINESS PROCESSES USING SMART OBJECTS

Context

- Exchange of goods among organizations does not imply a change of ownership
  - I.e. shipping companies handle goods belonging to other stakeholders
- Owners want to know the status of their goods during shipping
  - Usually SLAs are established among the parties
  - The service provider has to put in place tools to comply with the SLA

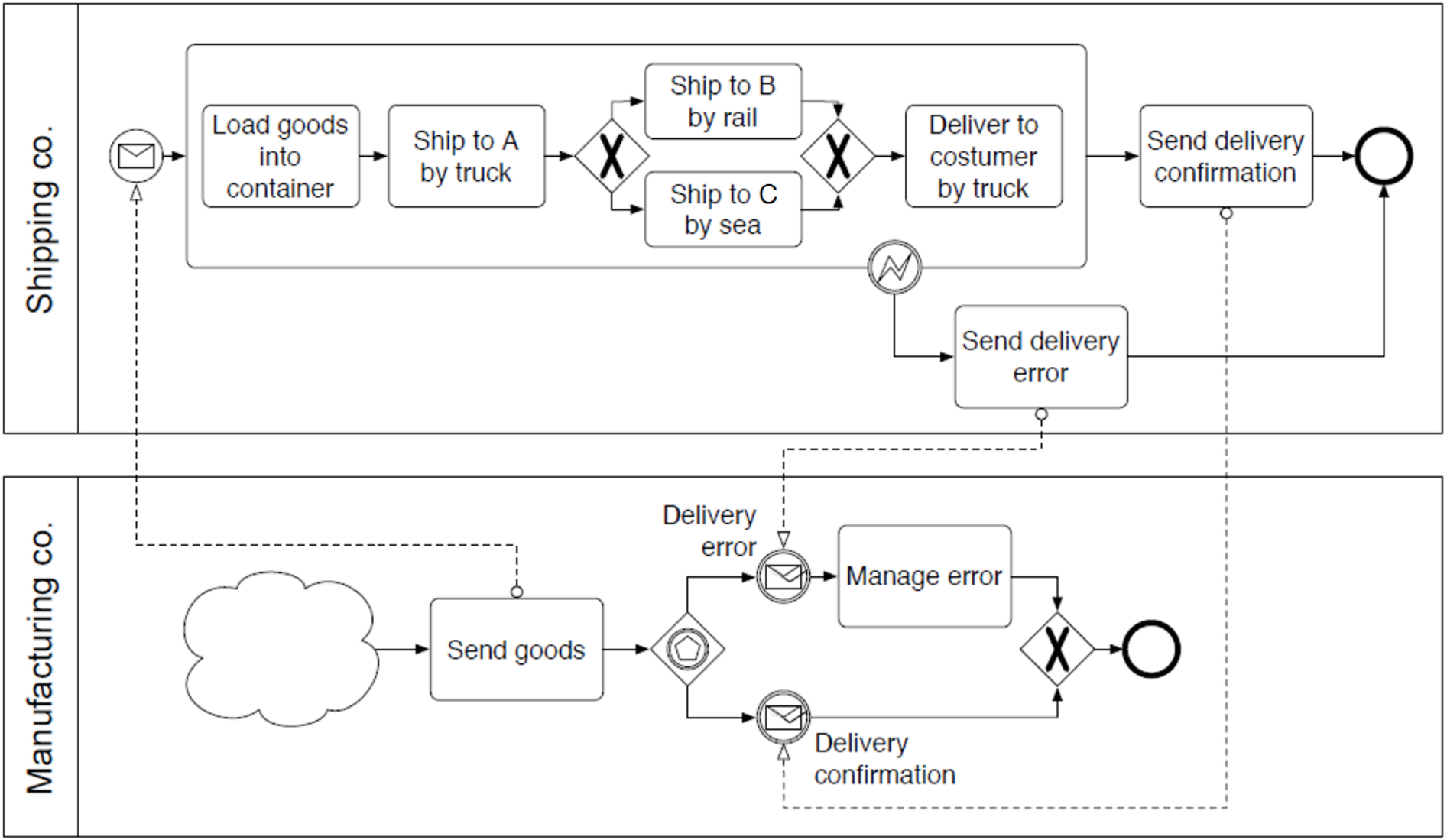
Problem statement

- The adoption of SLAs is not straightforward:
  - SLAs are time consuming
    - Both parties need to agree on quality of services, terms, conditions
  - SLAs lack flexibility
    - Agreements are valid for a specific provider, they must be redefined when the service provider is changed
  - Information hiding occurs
    - Monitored data depend on the service provider's capabilities
  - Activity status hiding
    - The service provider's internal processes are not visible to the consumer
- Basically, consumers must rely on the service provider's infrastructure to monitor their goods

Main objective

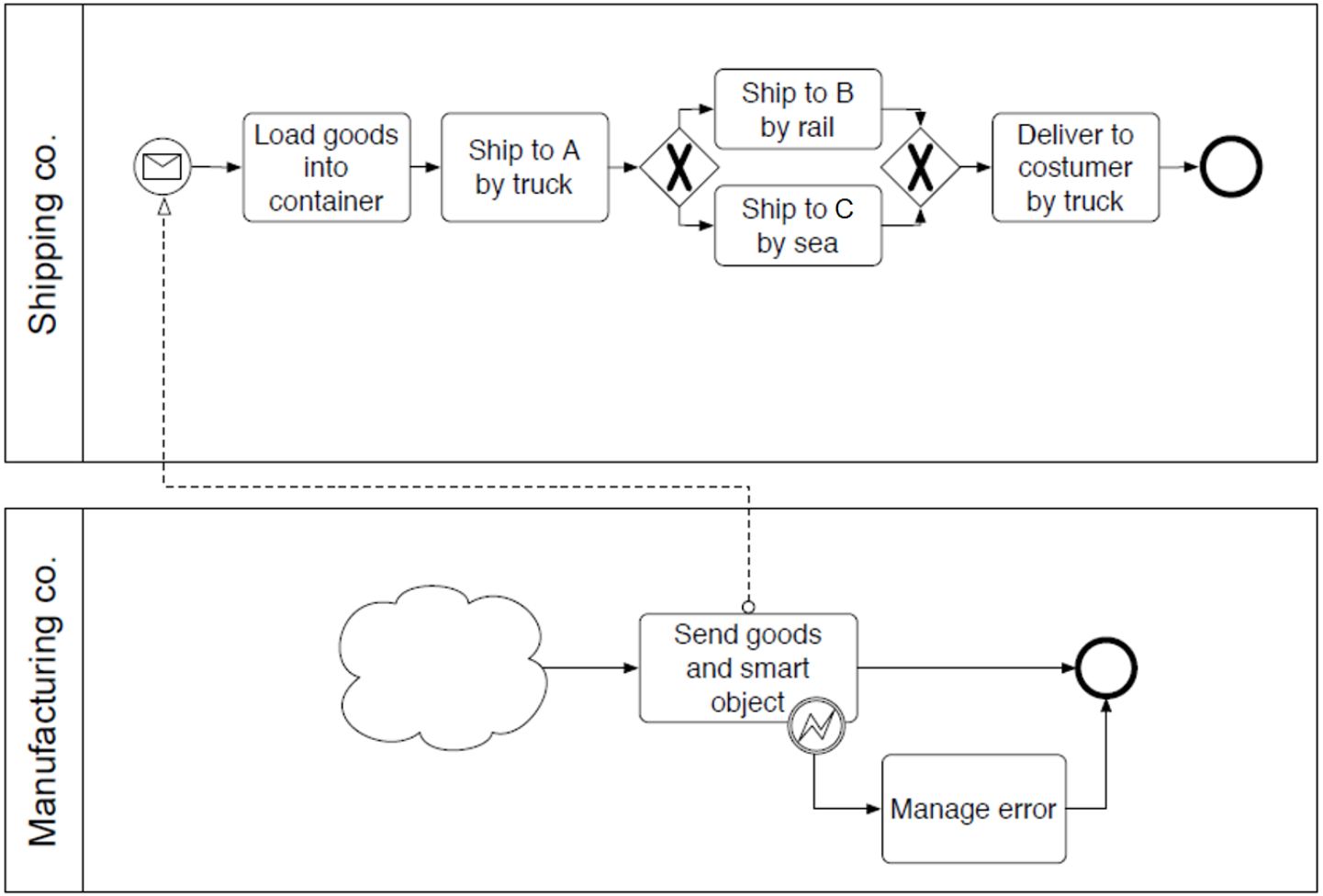
- Perform monitoring tasks directly onto exchanged goods
- Exploit the Internet of Things paradigm by employing Smart Objects
- Instruct Smart Objects to be aware of cross-organization processes:
  - Keep track of currently running activities
  - Identify violations in the execution order
  - Identify incorrectly executed activities

The current scenario



Vision

- Use Smart Objects to monitor portions of a complex process choreography (i.e. the process within a pool)

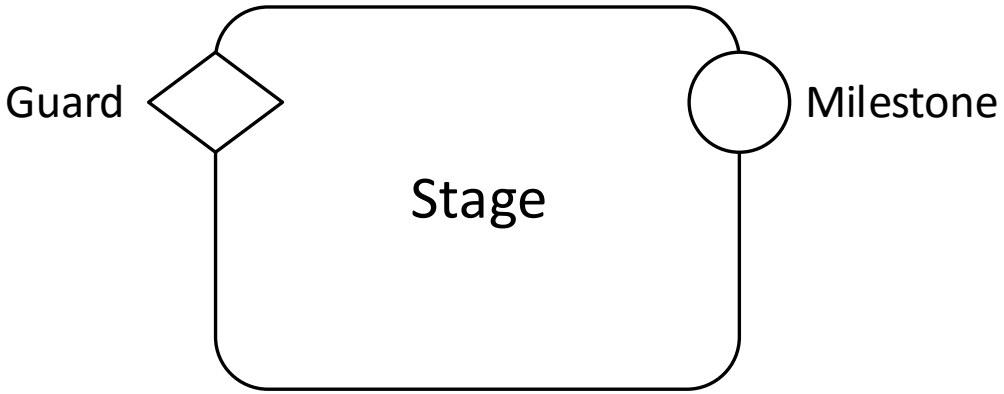


Control-flow languages limitations

- Control-flow languages are unsuited to instruct Smart Objects about the monitored process:
  - They require the execution order of activities to strictly adhere to the process definition
    - If activities do not respect their execution order, an exception is raised and the rest of the process cannot be monitored
  - They rely on an orchestrator that explicitly starts or ends activities
    - The Smart Object has no control on the execution of activities, it must autonomously identify which activities starts or ends
  - They lack constructs to define conditions that mark activities as incorrectly executed
    - It is not always possible or necessary to terminate or replay an incorrectly executed activity
- Declarative languages overcome these limitations

Adopting GSM

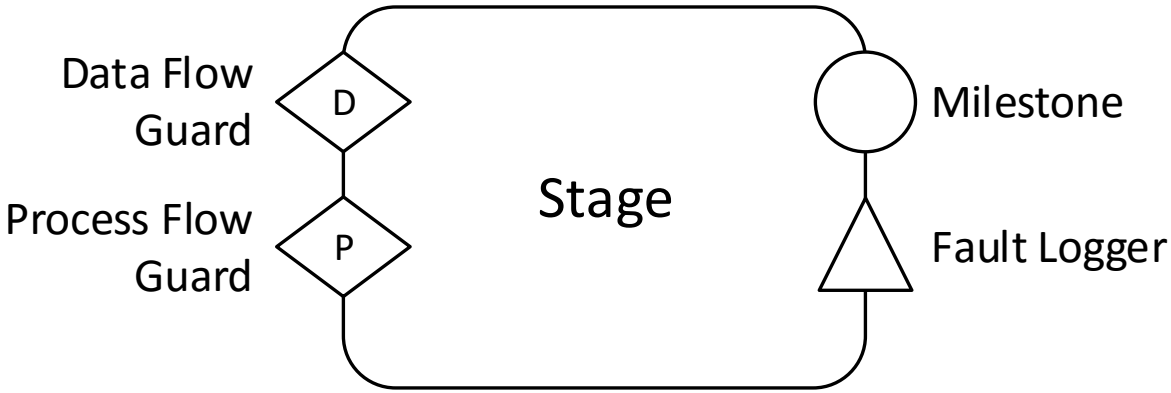
- The Guard-Stage-Milestone (GSM) notation [1] is the ideal candidate for modeling processes on Smart Objects:
  - Guards determine the start of each task based on events
  - Milestones determine the end of each task based on events
  - Events can be internal or external, involving conditions on sensor data



[1] Hull et al.: Introducing the guard-stage-milestone approach for specifying business entity lifecycles.

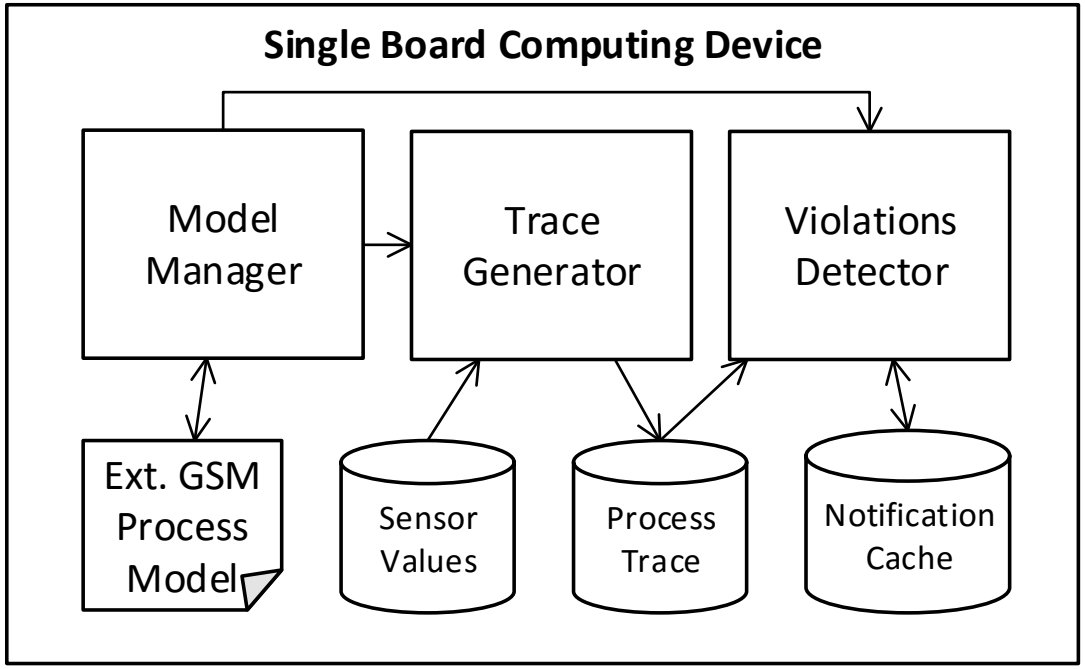
Extending GSM

- We extend GSM by introducing the following changes:
  - Guards distinguished in Data Flow Guards and Process Flow Guards:
    - Data Flow Guards determine task activation based on external events
    - Process Flow Guards define the expected process flow
  - Fault Loggers annotations are introduced:
    - Conditions on sensor data that determine violation of the task's constraints and invalidate it
    - If a task is invalidated, it is not terminated



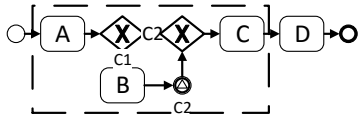
Architectural solution

- Smart Objects equipped with sensors, a Single Board Computing device and communication interface
- Model Manager
  - Downloads process definitions and definitions updates
  - Notifies process model changes to other components
- Trace Generator
  - CEP engine
  - Infers events based on sensor data
  - Identifies currently running activities
  - Generates the process trace
- Violations Detector
  - Verifies process and data constraints
  - Reports violations

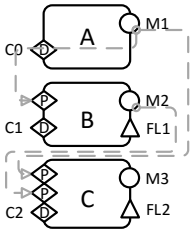


Using GSM

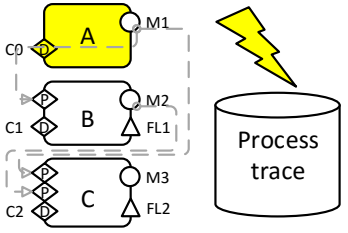
- Integration methodology among processes and Smart Objects made of three phases:
  - Identification of activities:
    - Starting form BPMN process model, activities that will run on the Smart Object are selected
  - Generation of extended GSM definition
    - The portion of the process model that includes the selected activities is converted in extended GSM
  - Execution and monitoring
    - The extended GSM definition is loaded onto the Smart Object and executed
    - A process trace is generated and compliance assessed at runtime
    - Notifications are sent whenever violations are detected



Identification of activities

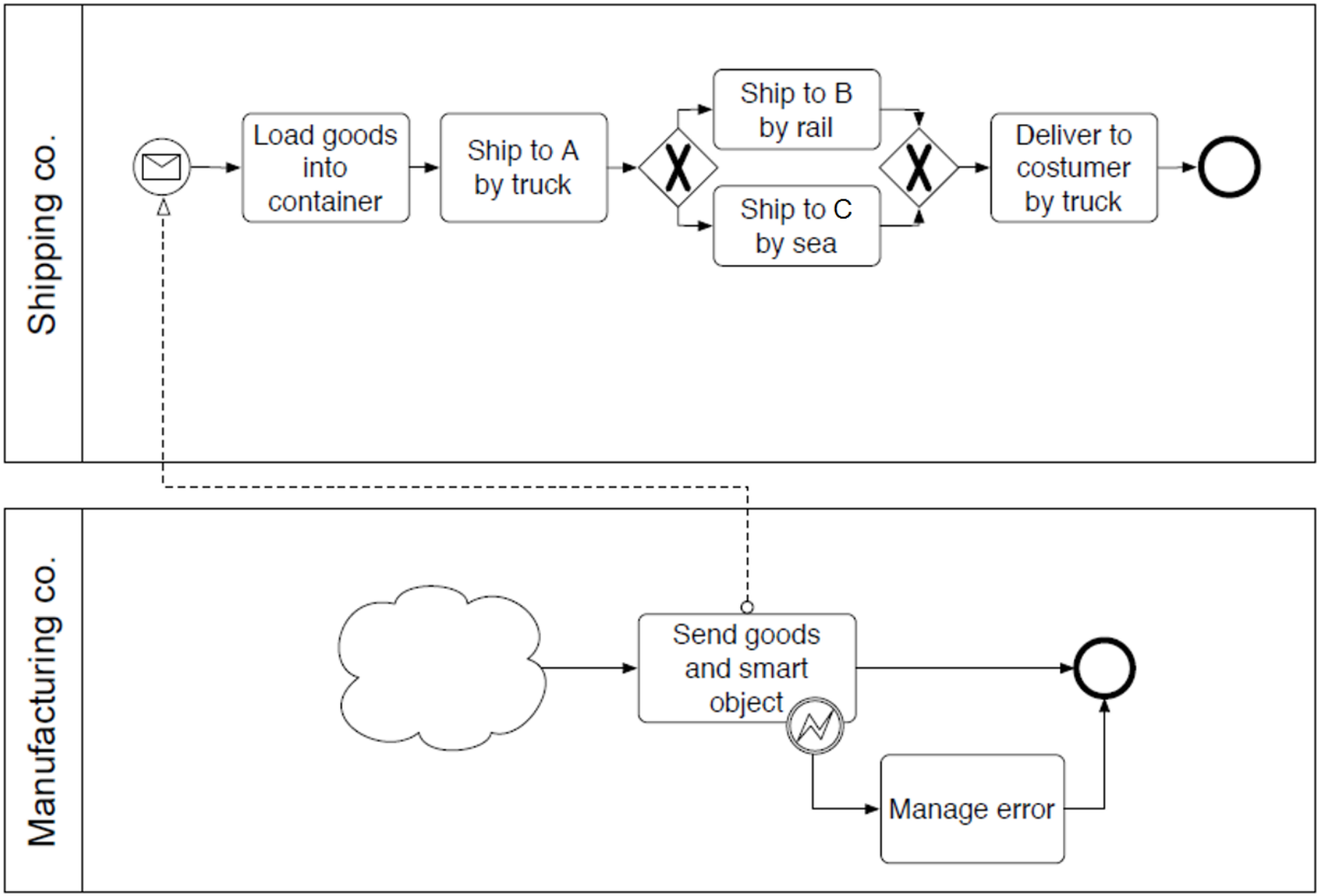


Generation of extended GSM definition



Monitoring of goods

Validation
A simple shipping process in BPMN



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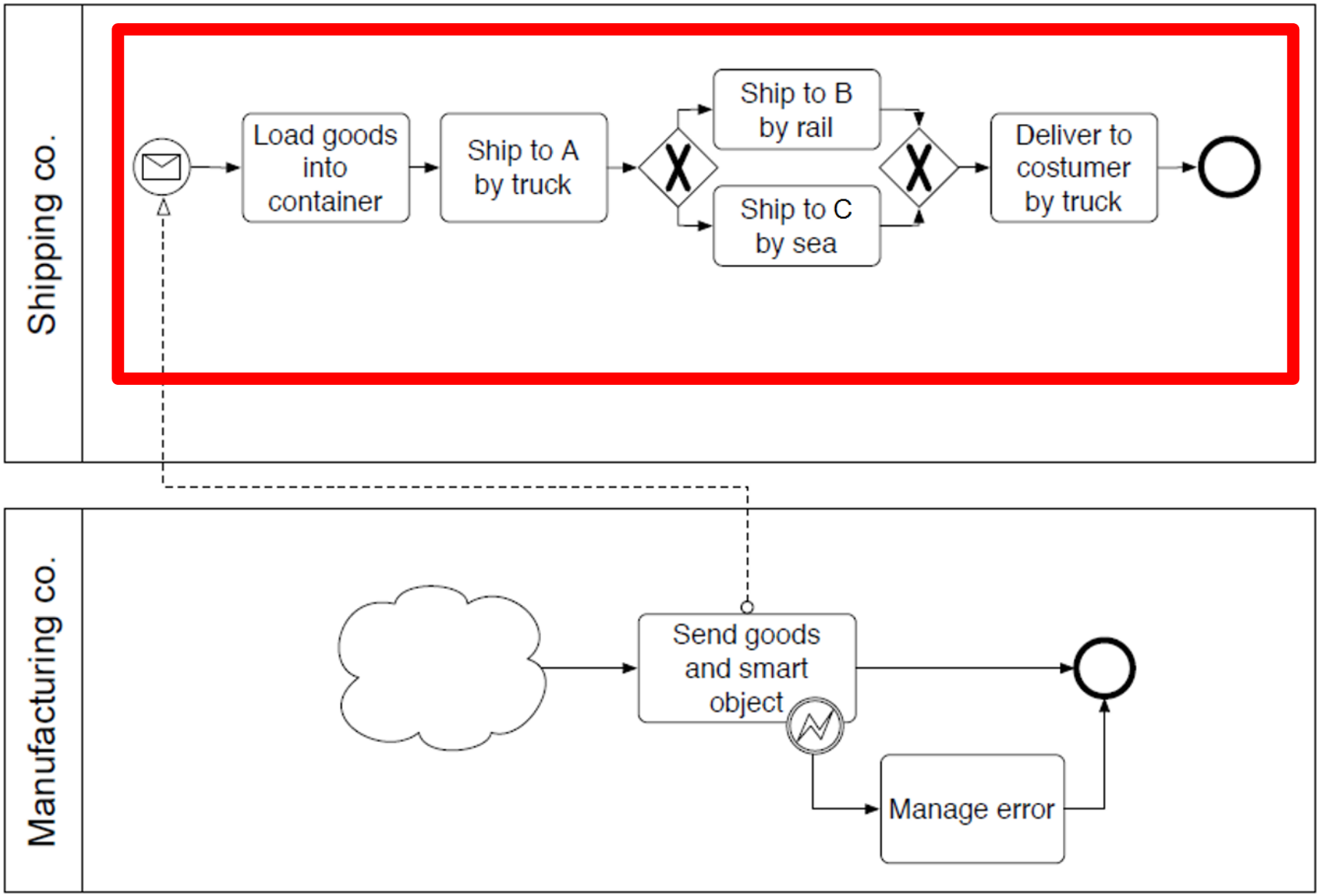
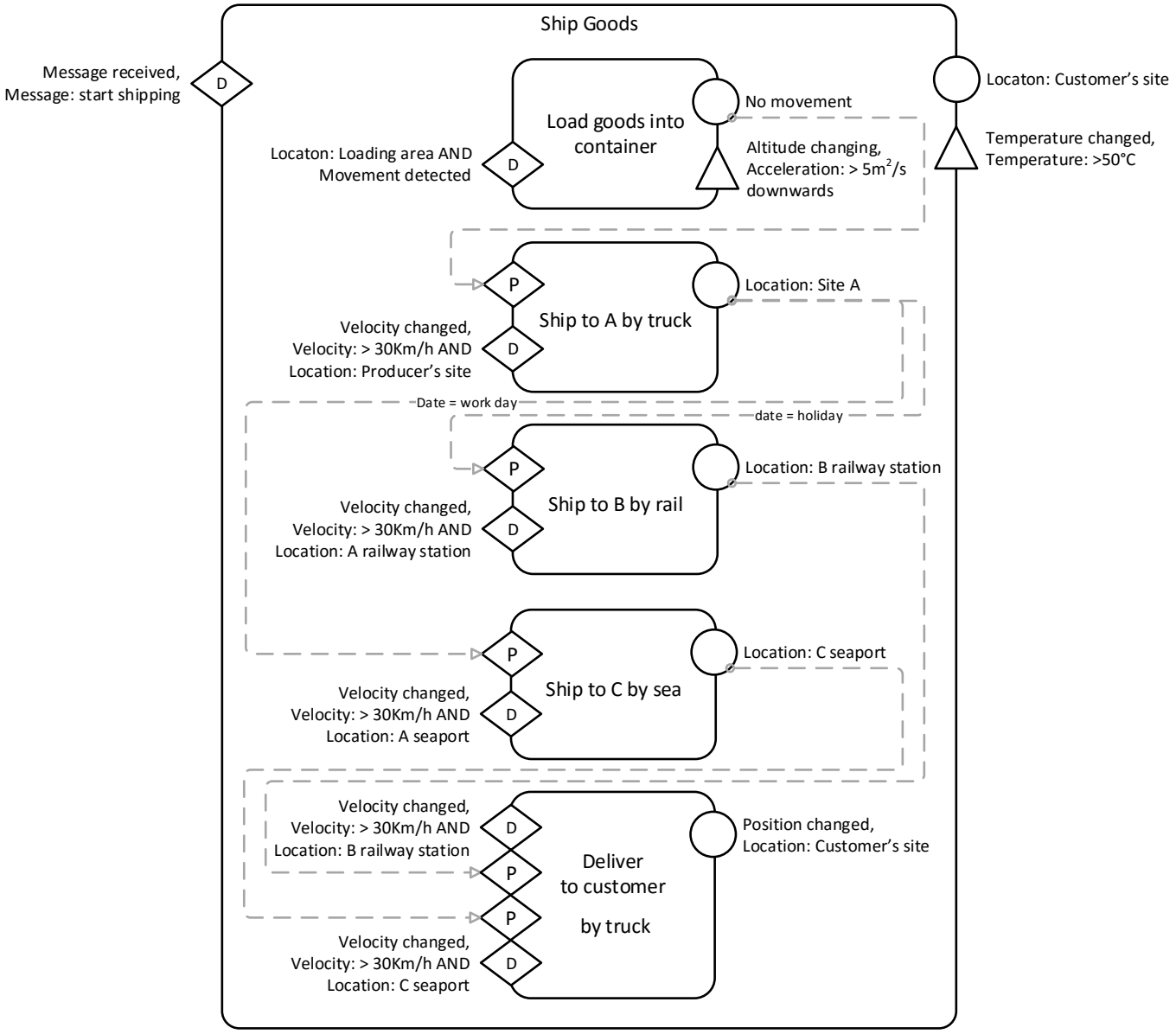
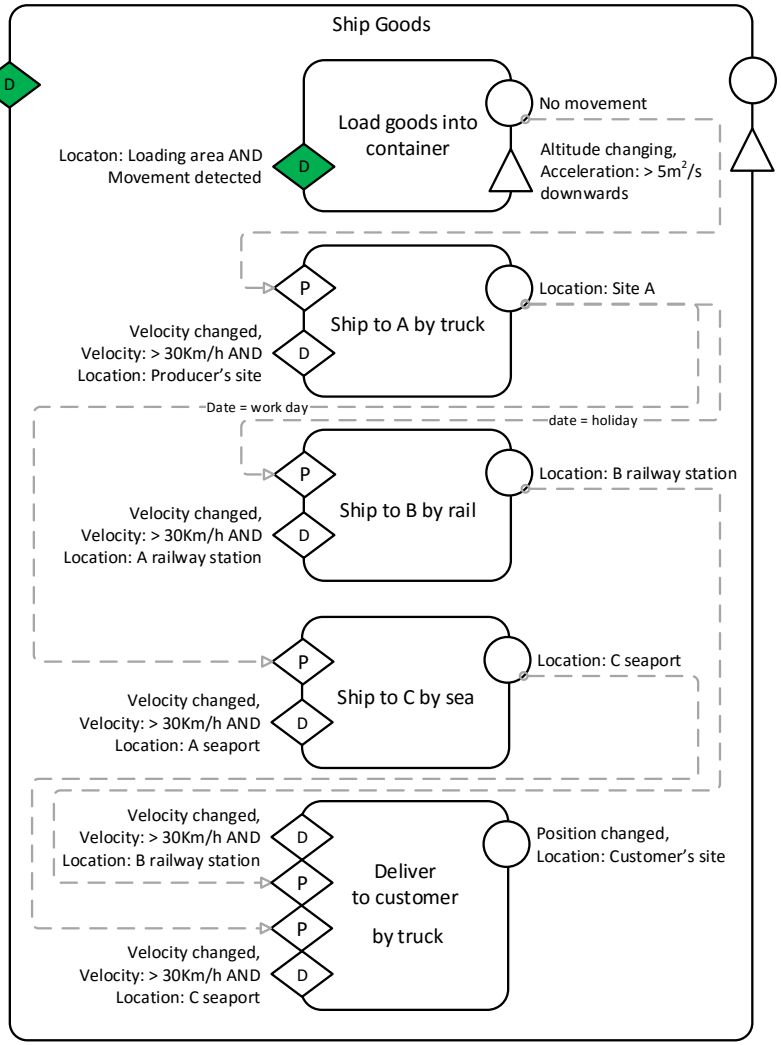
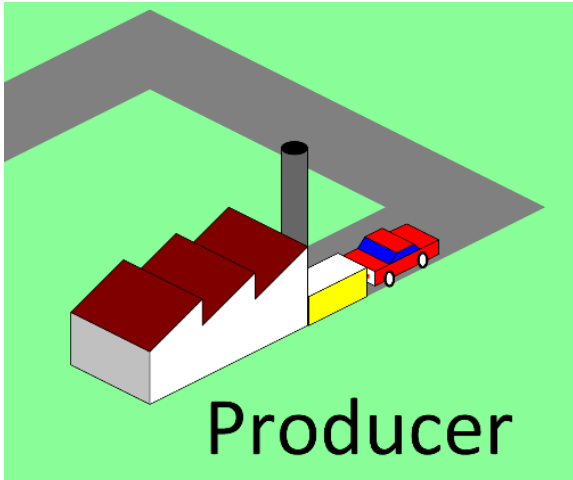


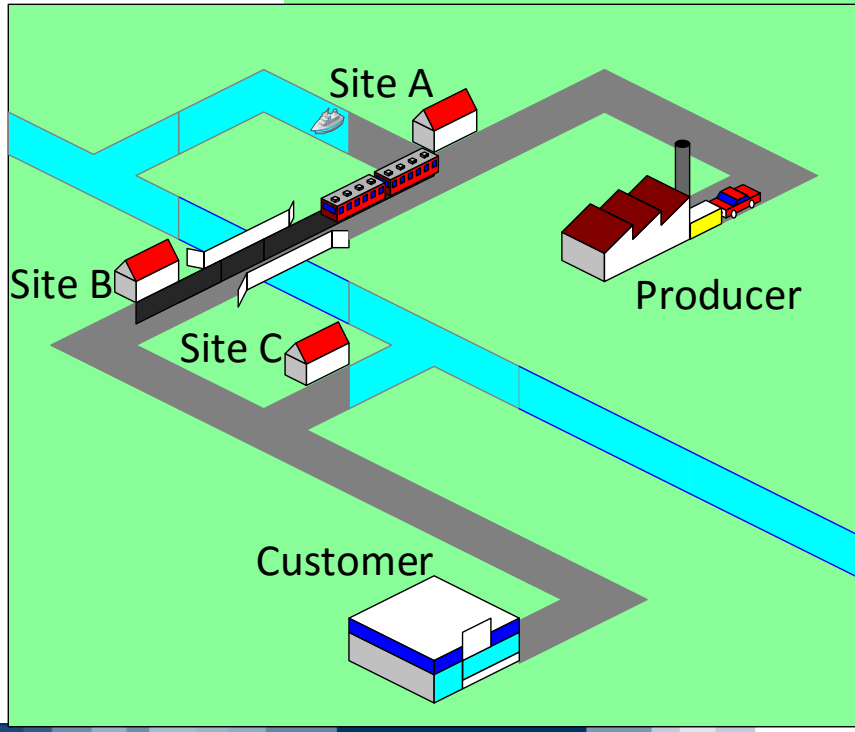
Validation
The same process in extended GSM



Validation
Detecting compliance violations







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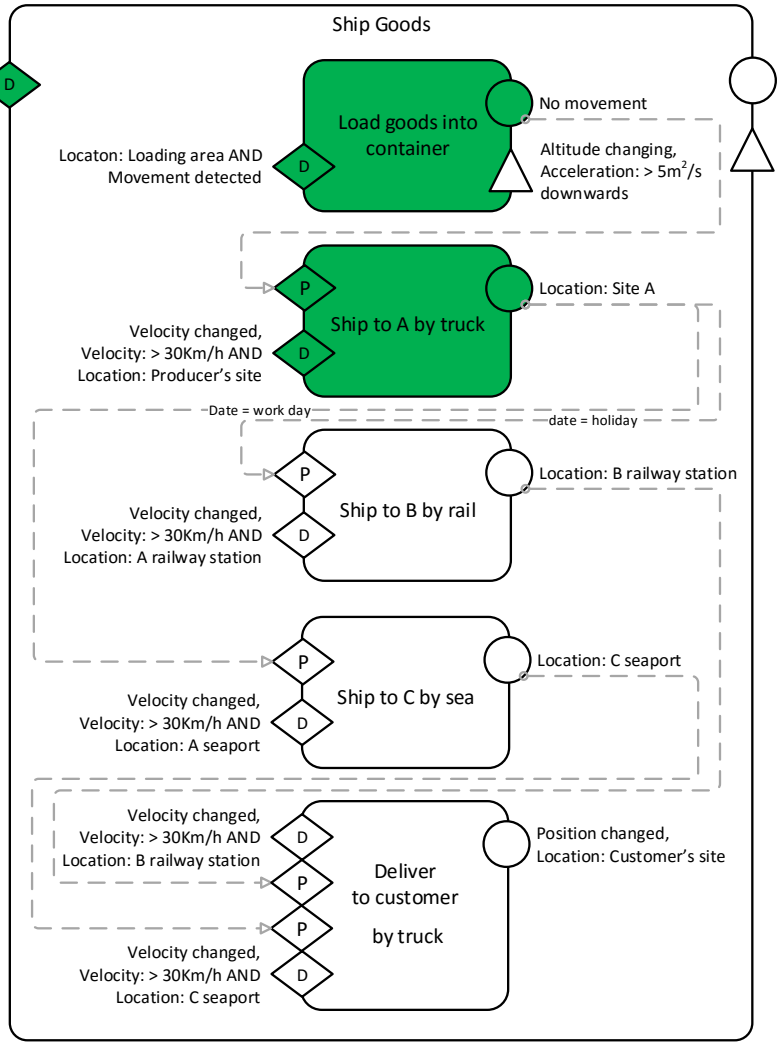

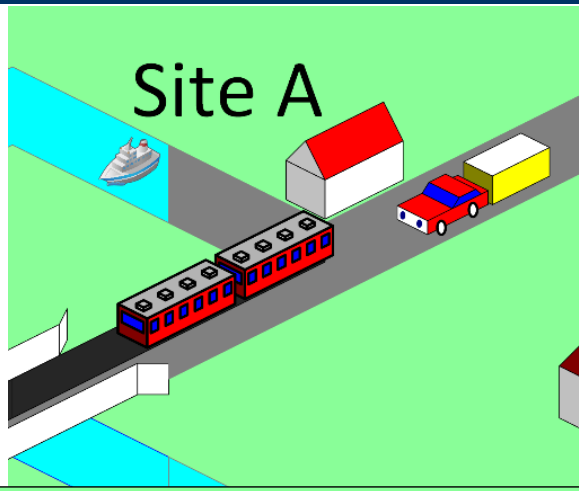

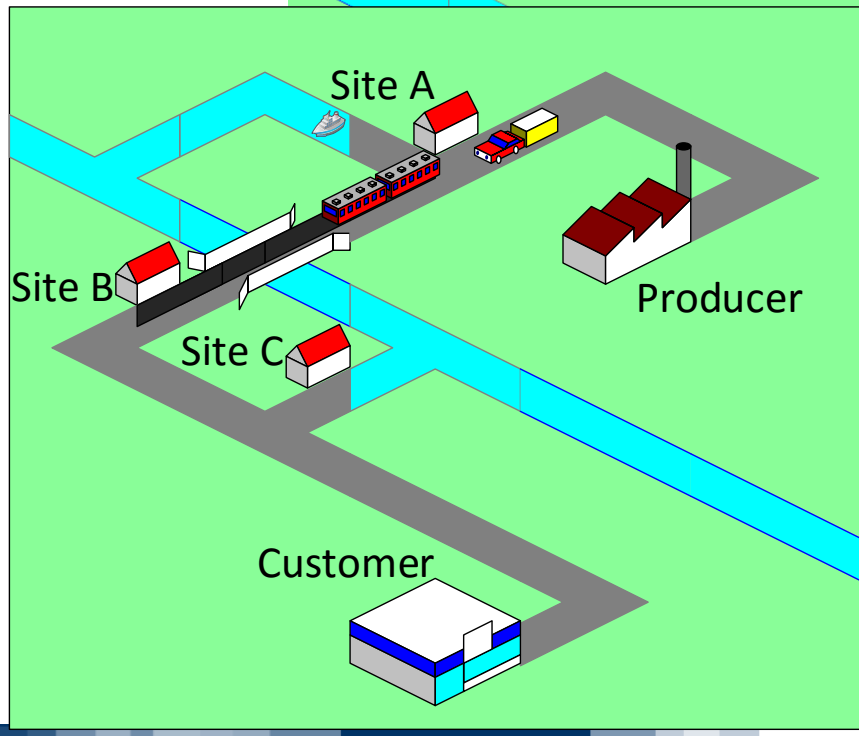

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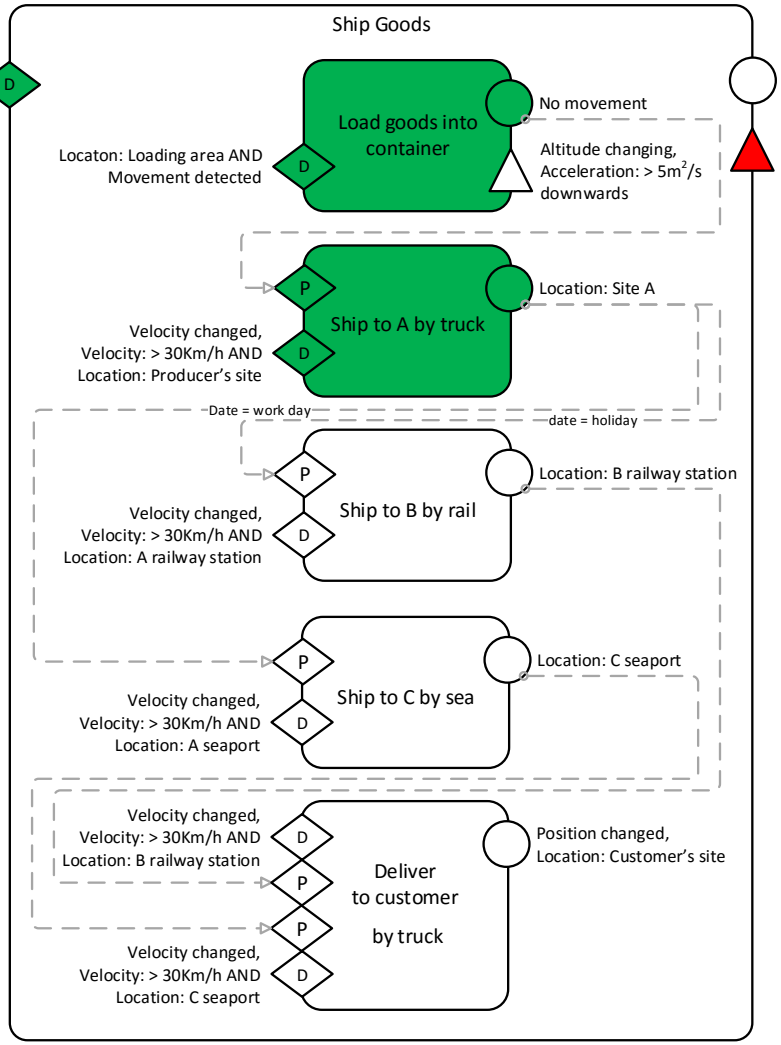

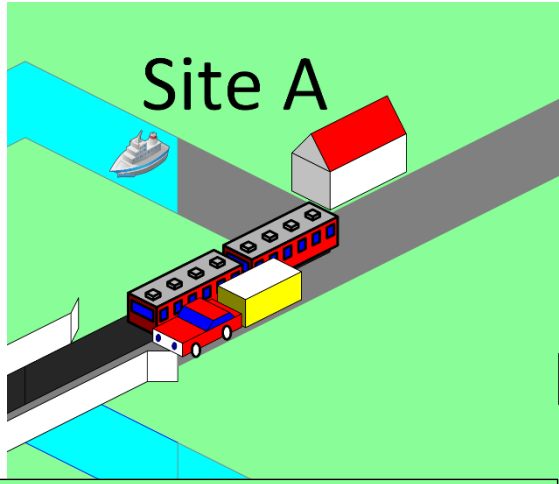

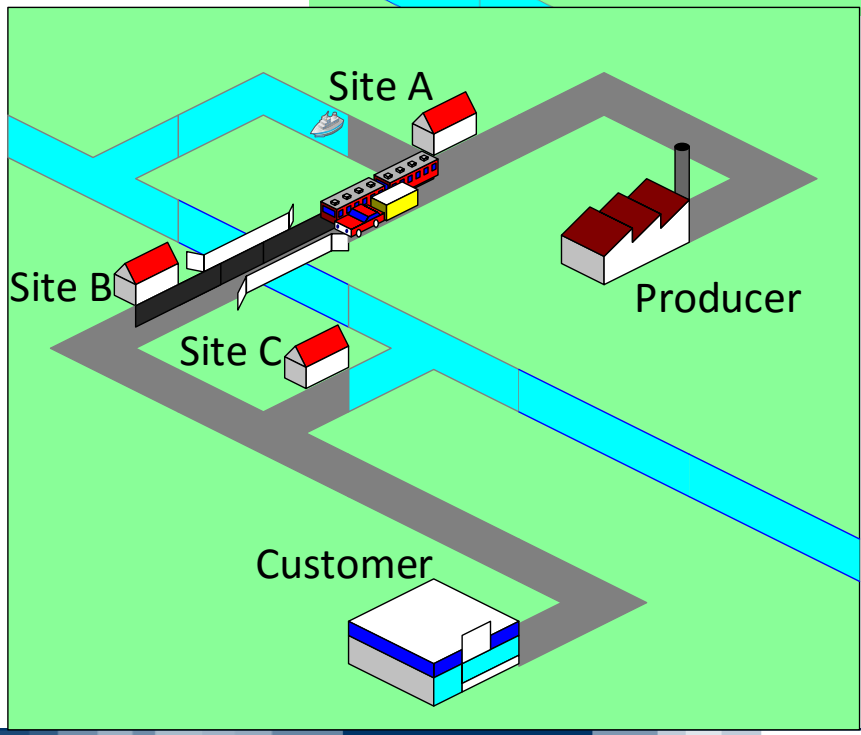

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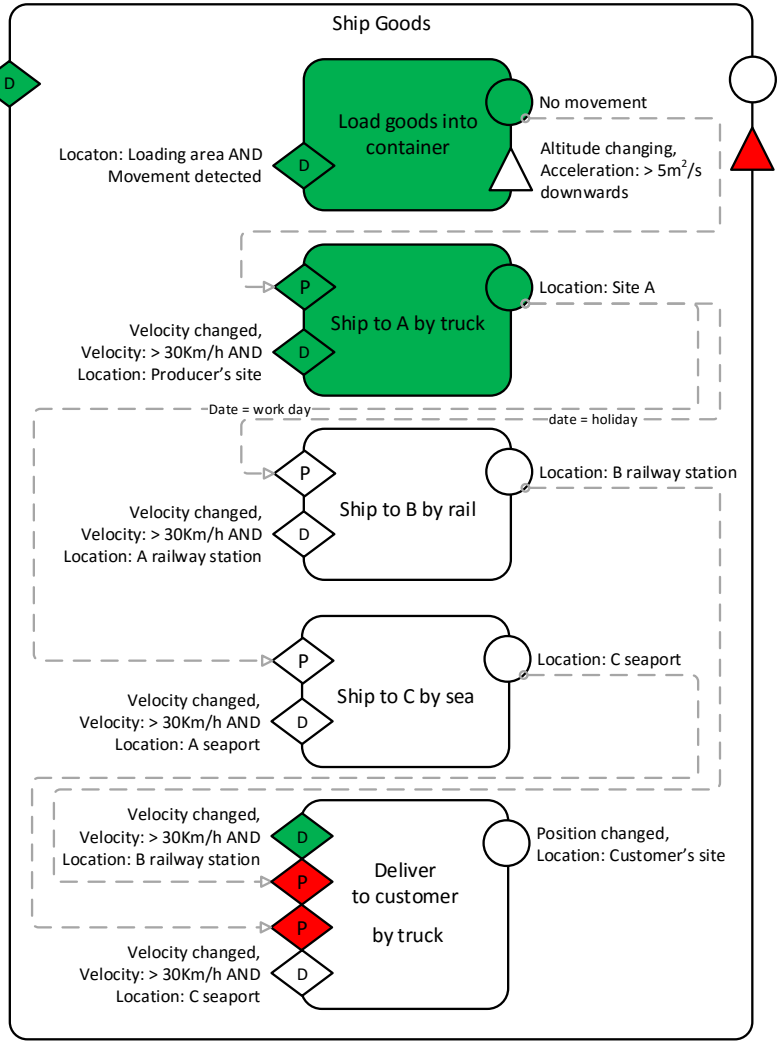

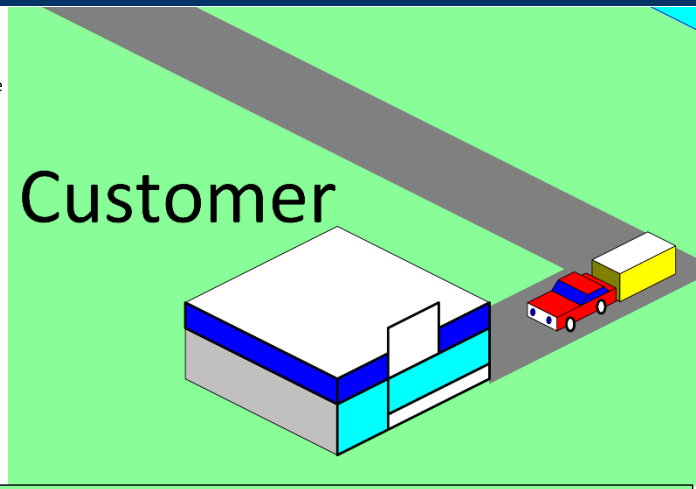

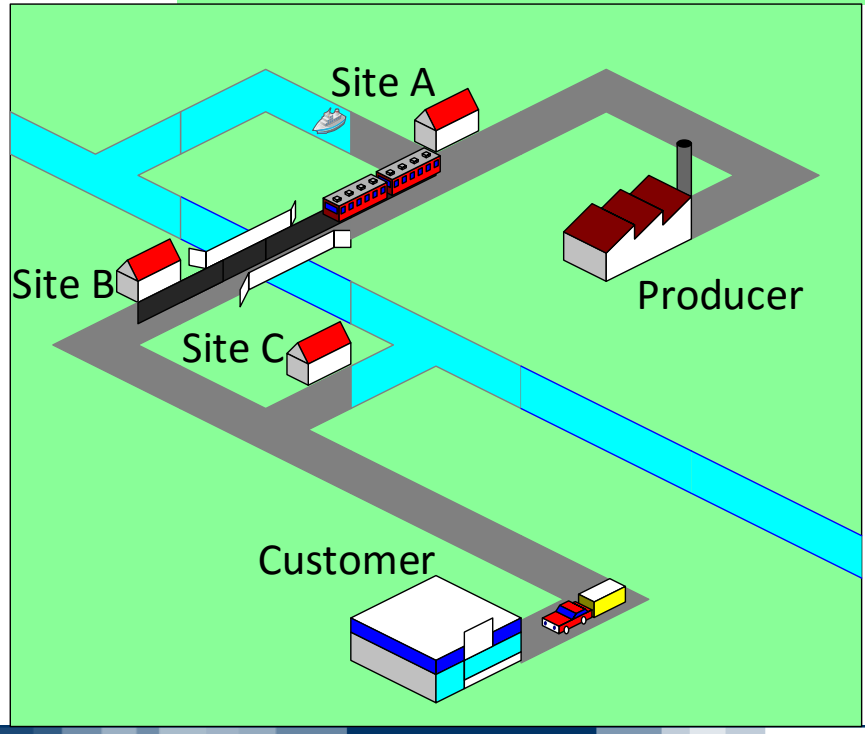

State of the Art

- BPMN 2.0 extensions to model Smart Objects interactions [2] [3]
  - Process knowledge outside Smart Objects
  - Data uncertainty and requirements not dealt
- Translators from BPMN to executable code for sensor network configuration [4]
  - Process model used only at design time
  - Process cannot be changed easily at runtime
- BPM-based frameworks relying on events by Smart Objects with data quality mechanisms [5]
  - Process knowledge centralized
  - No process compliance mechanisms at runtime

[2] Meyer et al.: Internet of things-aware process modeling: integrating iot devices as business process resources

[3] Thoma et al.: On iot-services: Survey, classication and enterprise integration

[4] Tranquillini et al.: Process-based design and integration of wireless sensor network applications

[5] Schief et al.: Enabling business process integration of iot-events to the benet of sustainable logistics

Future work

- Develop a semi-automatic translator from BPMN to extended GSM
  - If BPMN is sufficiently annotated the translation is completely automatic
  - Else the extended GSM definition must be manually enriched
- Develop a prototype of the process-aware Smart Object
- Delegate portions of the monitoring process to other Smart Objects
  - Distribute the extended GSM definition among different Smart Objects

Thanks for your attention

Any question?

Integrating IoT with BPM
References

1. Hull, R., Damaggio, E., Fournier, F., Gupta, M., Heath, Fenno(Terry), I., Hobson, S., Linehan, M., Maradugu, S., Nigam, A., Sukaviriya, P., Vaculin, R.: Introducing the guard-stage-milestone approach for specifying business entity lifecycles. In Bravetti, M., Bultan, T., eds.: Web Services and Formal Methods. Volume 6551 of Lecture Notes in Computer Science. Springer Berlin Heidelberg (2011) 1-24
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4. Tranquillini, S., Spiess, P., Daniel, F., Karnouskos, S., Casati, F., Oertel, N., Mottola, L., Oppermann, F., Picco, G., Römer, K., Voigt, T.: Process-based design and integration of wireless sensor network applications. In: Proc. BPM 2012, Berlin, Heidelberg, Springer-Verlag (2012) 134-149
5. Schief, M., Kuhn, C., Rsch, P., Stoitsev, T.: Enabling business process integration of iot-events to the benet of sustainable logistics. Technical report, Darmstadt Technical University (2011)