Adaptation of Service-based Systems

Jun.-Prof. Dr. Dimka Karastoyanova
IAAS, University of Stuttgart
karastoyanova@iaas.uni-stuttgart.de

Universitätsstr. 38
70178 Stuttgart
Germany
Office: **1.361**
Phone: **+49 (0)711 7816 476**

Topics

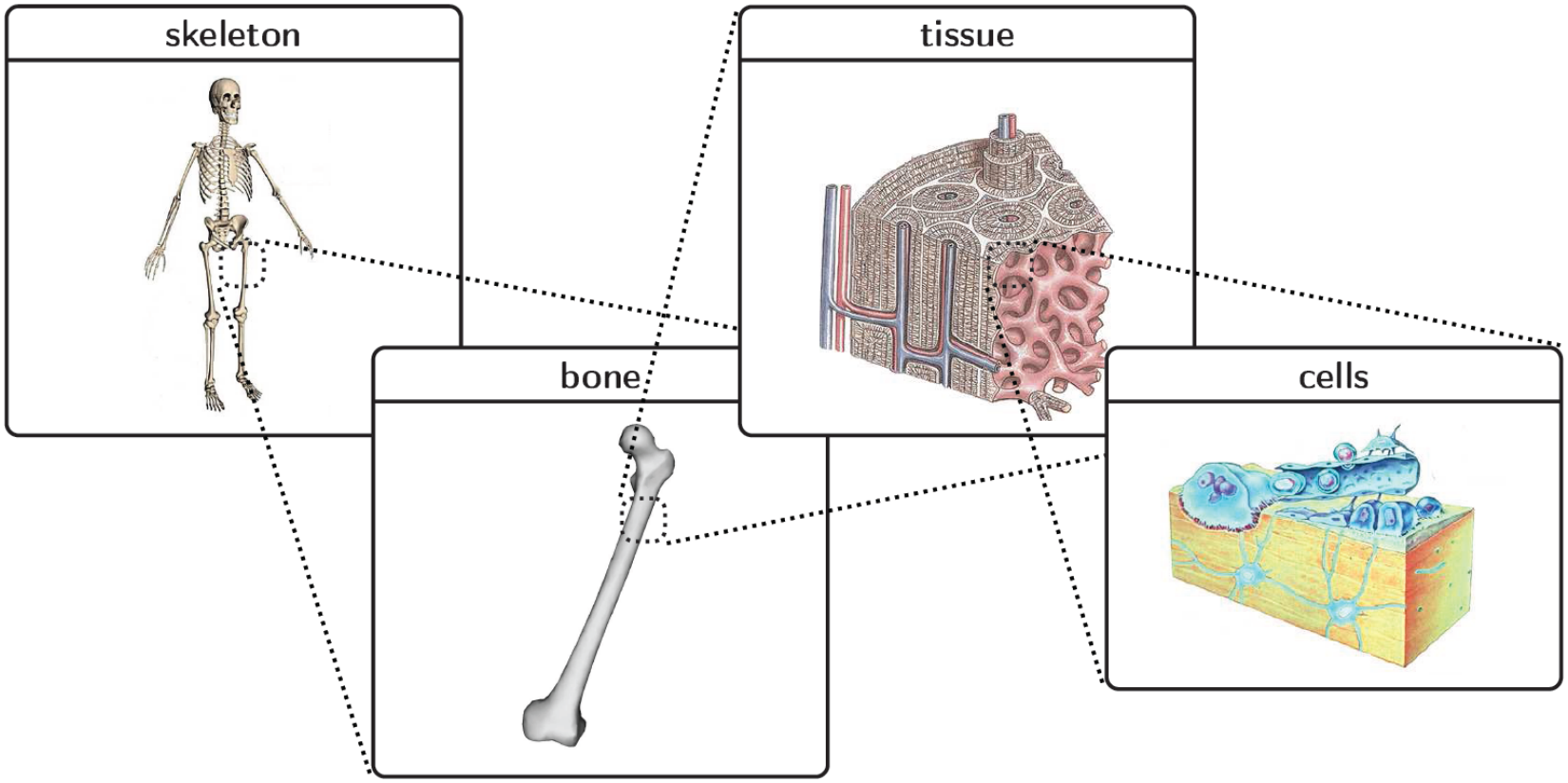
- Service-based Systems
- Adaptation
  - Classification of Triggers and Approaches
- Adaptation Approaches from our Research
- Summary/Conclusion

The Famous Travel Agency Process

- Choreography of several applications/compositions

Multi-Scale Human Skeleton Simulation

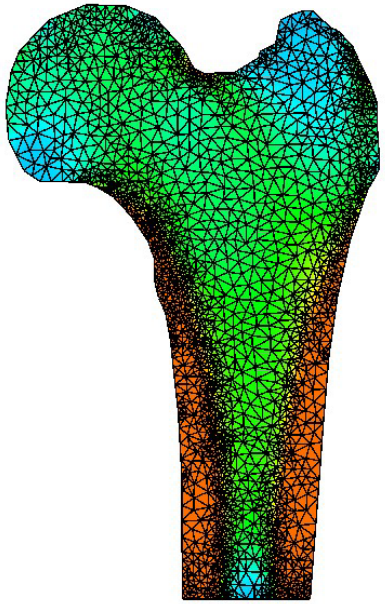
- Choreography of simulations of skeleton, bone, tissue, and cell scale

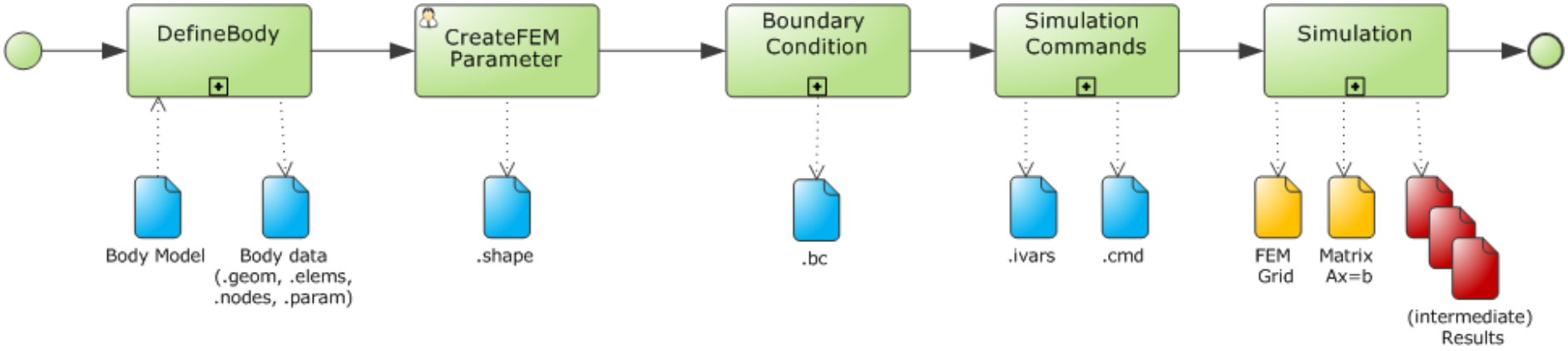


Picture adopted from www.anatomium.com, www.med-ed.virgina.edu and R. Bartl University München

Bone Growth Simulation

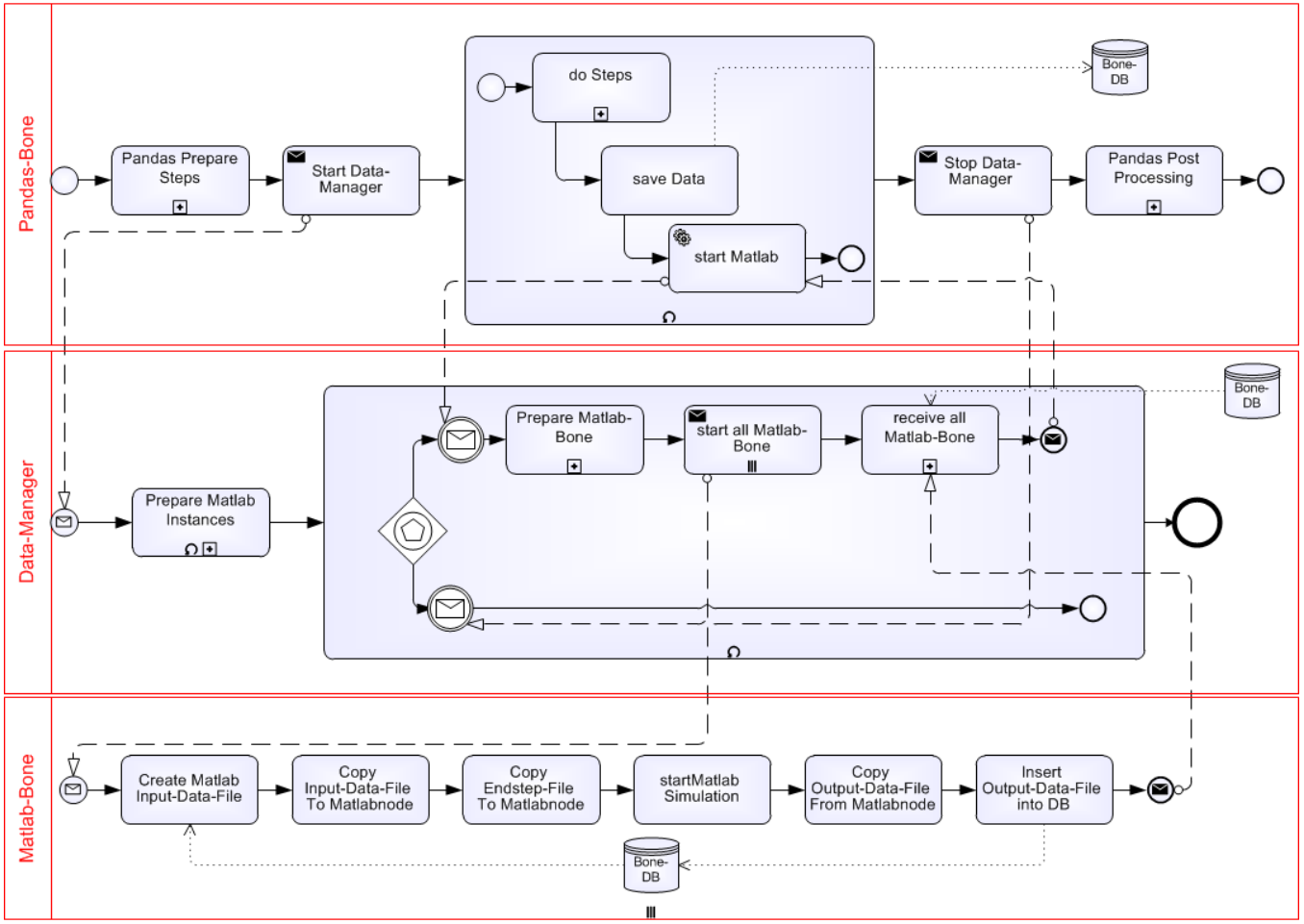
- Orchestration to simulate bone growth depending on load, exercise, etc.
  - Understand diseases, e.g. fractures
- Based on the Finite Element Method (FEM)
  - Initial and boundary condition
  - Simulation is solved via a PDE as a matrix equation (Ax=b)





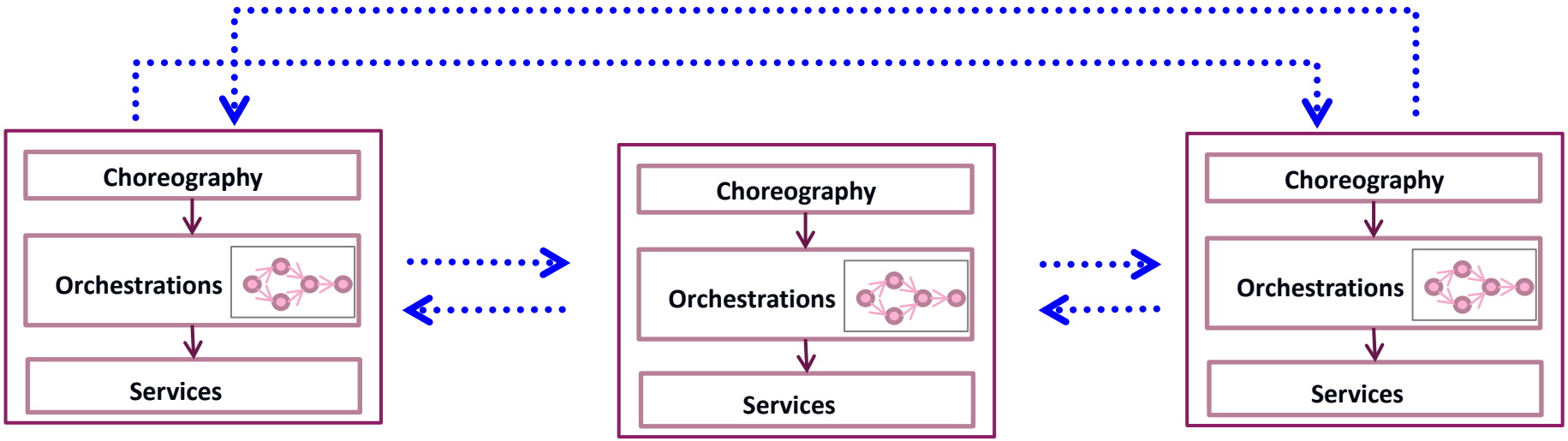
Bone Growth Simulation

- Modeled and realized as a choreography



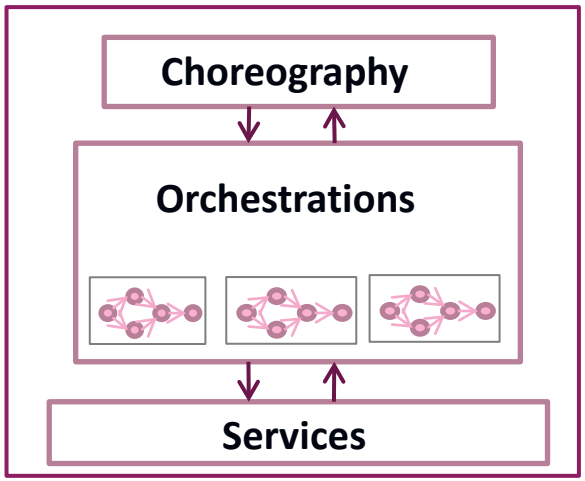
Service-Based Systems

- Service-Based Systems:
  - Choreographies of complex services/service-based applications (SBAs)
  - Services may be choreographies or orchestrations themselves

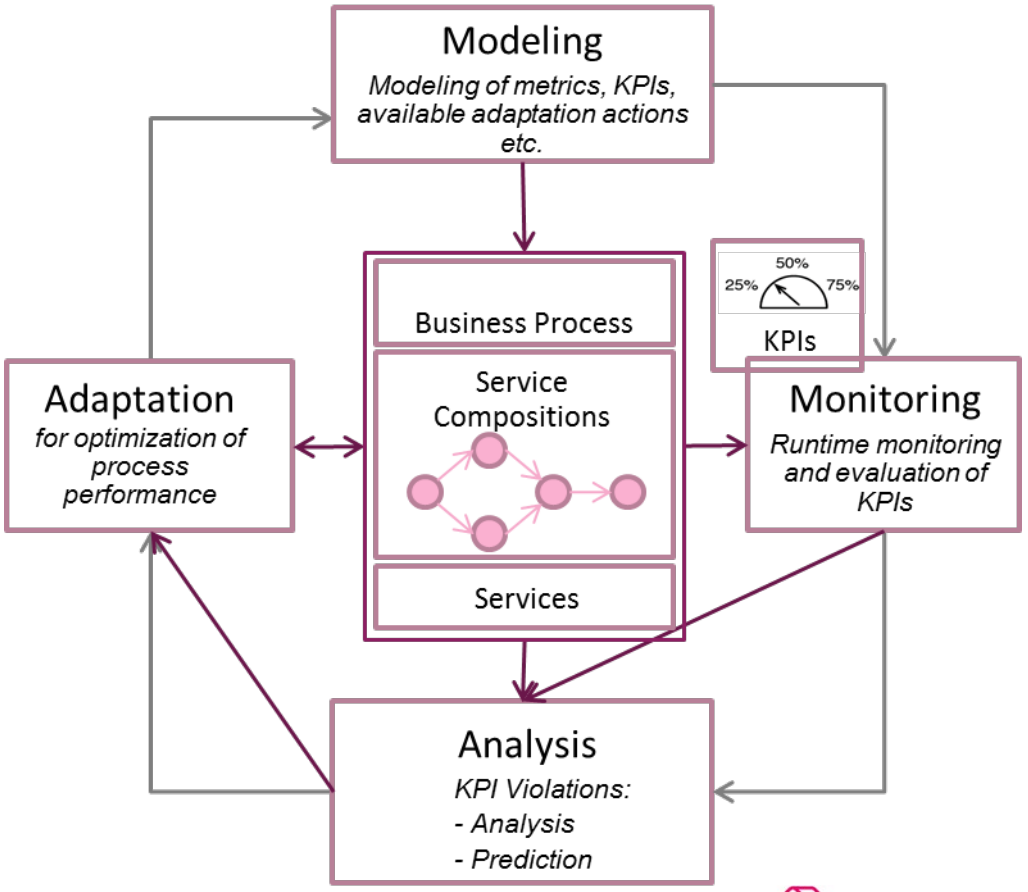


Service-Based Applications

- SBA model:
  - Three layers
  - Current research focus:
    - Model, execute, monitor and adapt on all three levels coherently



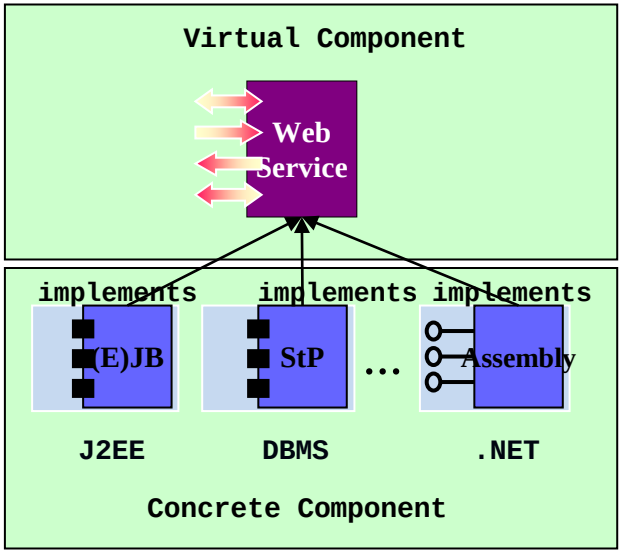
- SBA Life cycle → includes adaptation
- Framework for QoS aware, adaptable SBAs



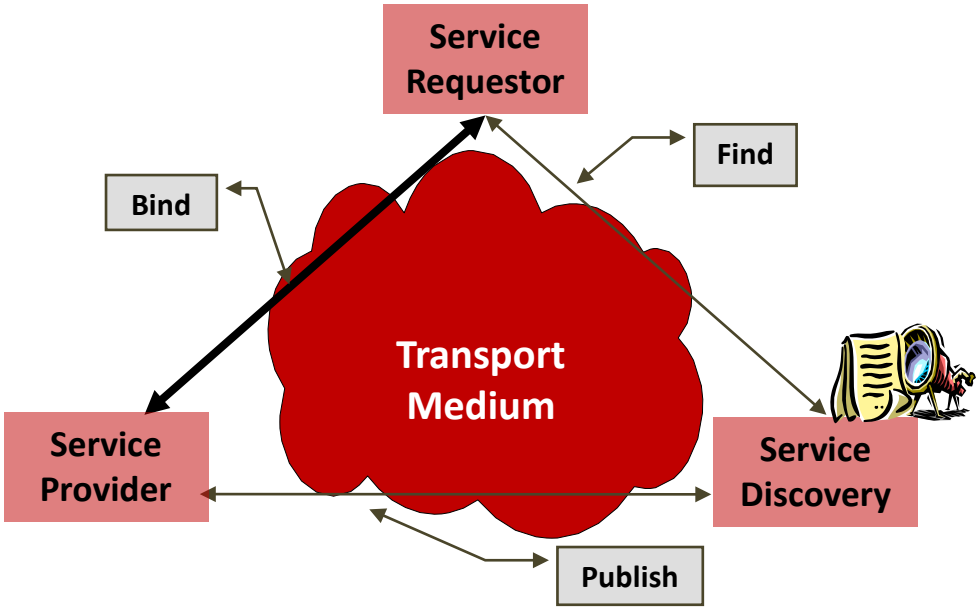
S-CUBE

Service-Based Applications (SBAs)

- **Services**:
  - Are units of functionality
  - Described using a unified IDL
  - Independent of implementation technology
  - Self-contained stable service interfaces
  - Virtualization of components

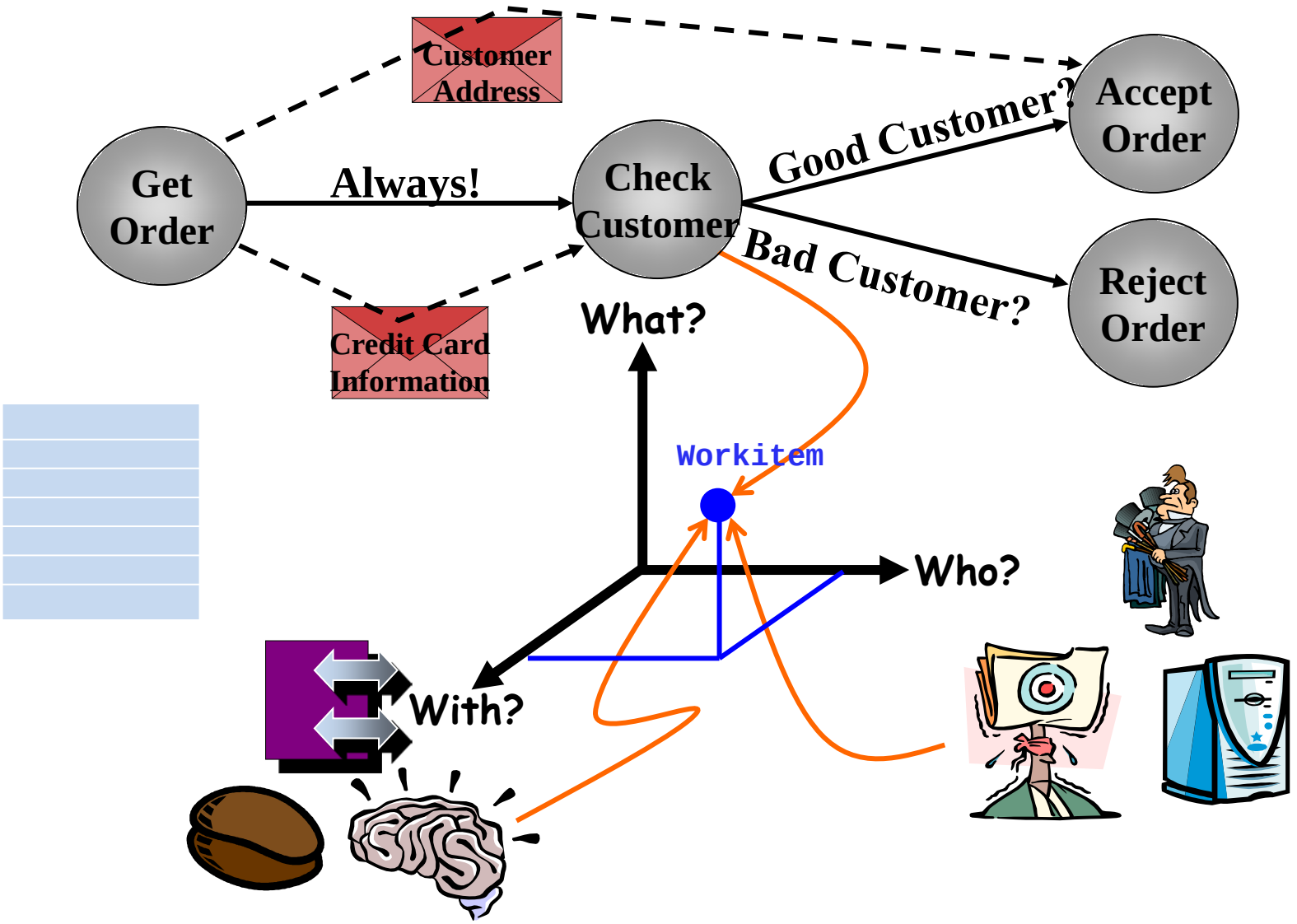


- **SBAs** comprise services
- And follow the principles of the Service Oriented Architecture (SOA) style
- The SOA roles and operations:



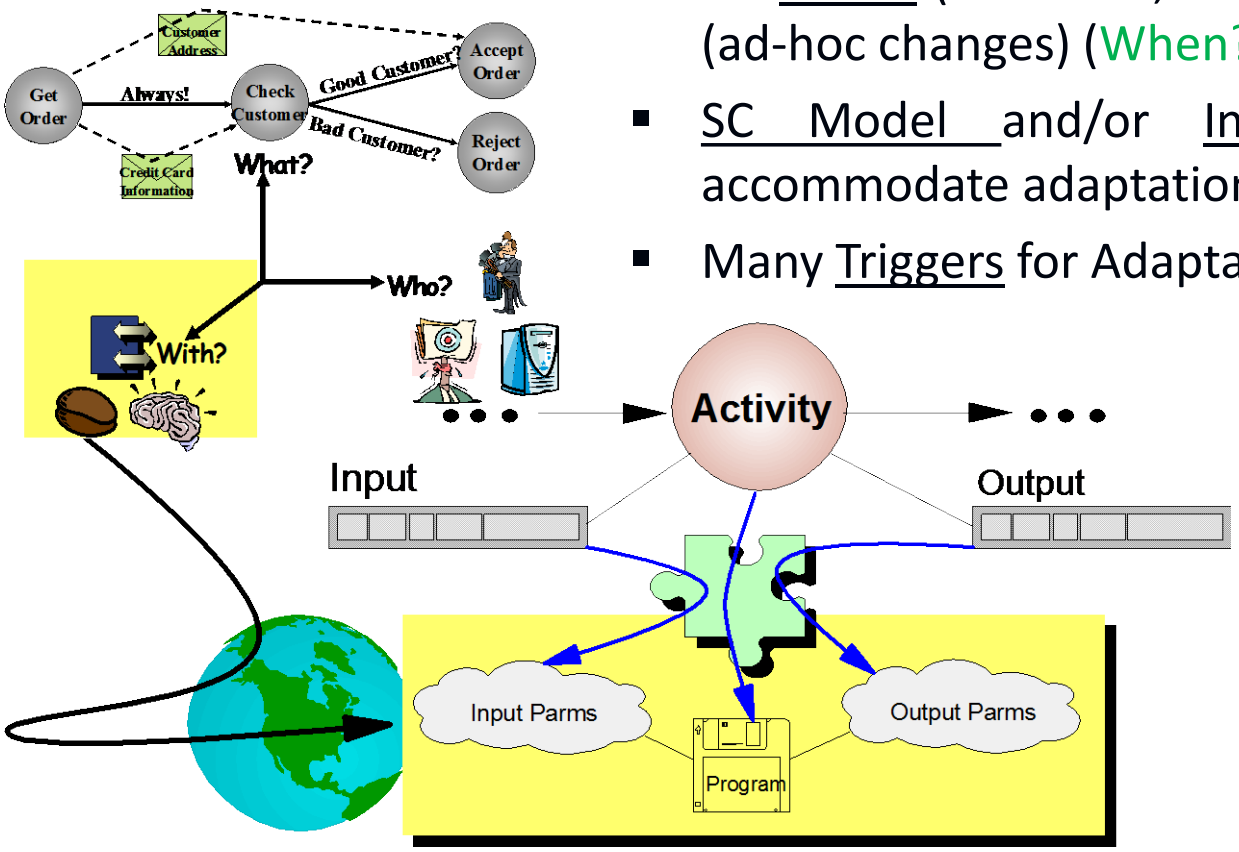
- Technology for implementing SBAs is workflows

Service Compositions



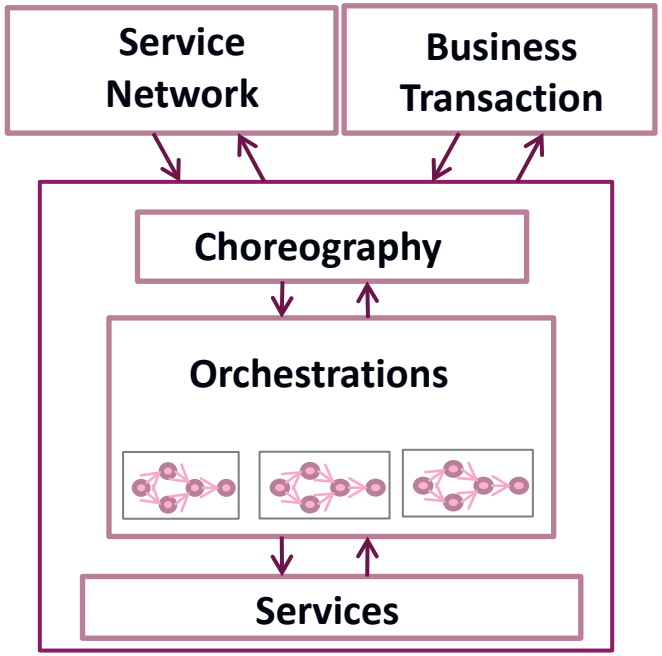
Adaptation of Service Compositions (How?)

- Adaptation on all dimensions
  - Control flow changes
  - Functions changes
  - Exchange human participants
- On model (evolution, versioning) and instance level (ad-hoc changes) (When?)
- SC Model and/or Infrastructure changes to accommodate adaptation (What realization?)
- Many Triggers for Adaptation (Why?)



Adaptation Triggers (Why?)

- Triggers can be generated on each level of an SBA
  - Value for participants - Service Networks
  - QoS and nfp violations, KPIs – SCs and BPs
  - SLAs violations – all layers
  - Compliance violations – all layers
  - Changes in policies – mostly BPs
  - Unavailable services – Service Infrastructure + SCs
  - Context change – all layers
  - Organizational restructuring – mostly business related
  - Law – mostly the BP layer
  - …



Next:

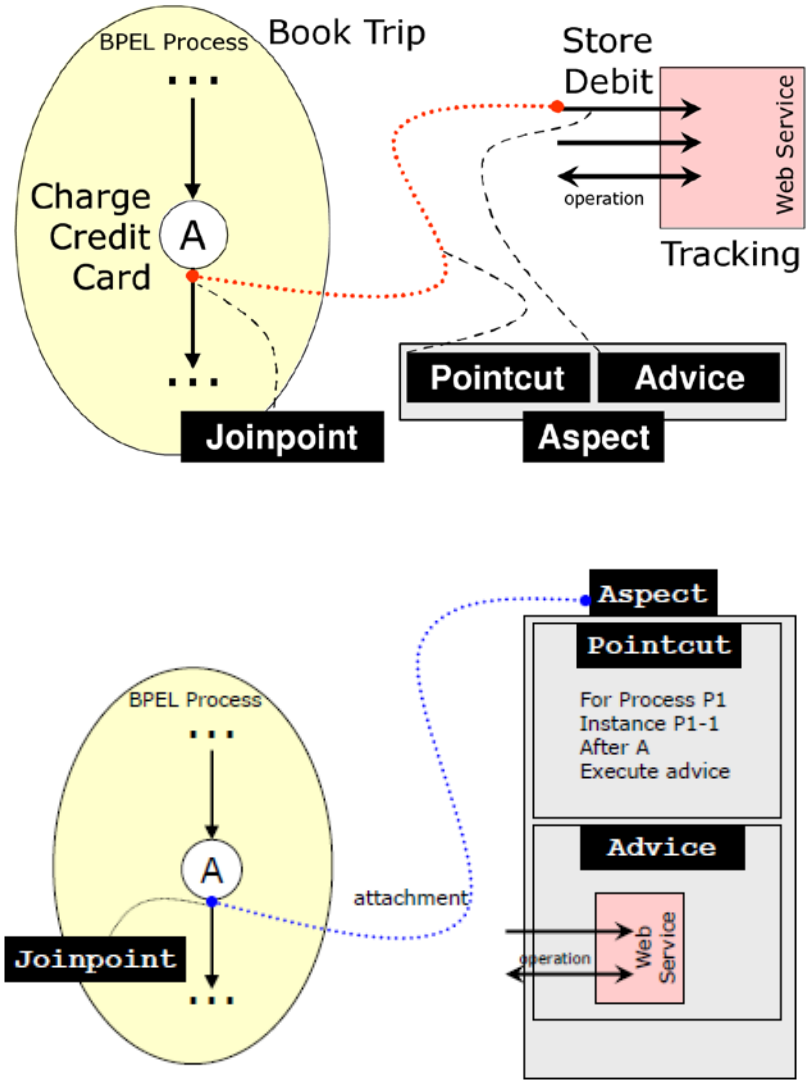
- Adaptation of SCs: BPEL'n'Aspects
- SBA Adaptation: KPI Violation prediction and Adaptation
- Process Outsourcing – Fragmentation and Coordination
- Flexible Scientific Workflows

BPEL'n'Aspects

- Adaptation of SCs
- Control flow change
- Reaction to any kind of trigger
- Standard-based
- Engine extensions needed

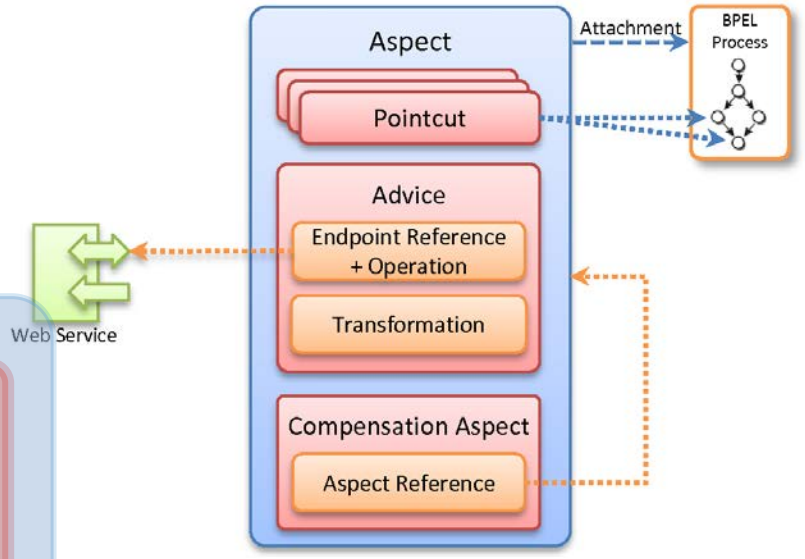
BPEL'n'Aspects

- Use of the **AOP** paradigm
- Insert **WSs (aspect)** into an **SC (program)** as a **reaction to event**
- Aspects are attached to processes
- WS invocation before, instead or after activities
  - i.e. **control flow changes**
- Engine publishes process execution events
- The **dynamic weaving** of the activities/WSs is triggered by these events



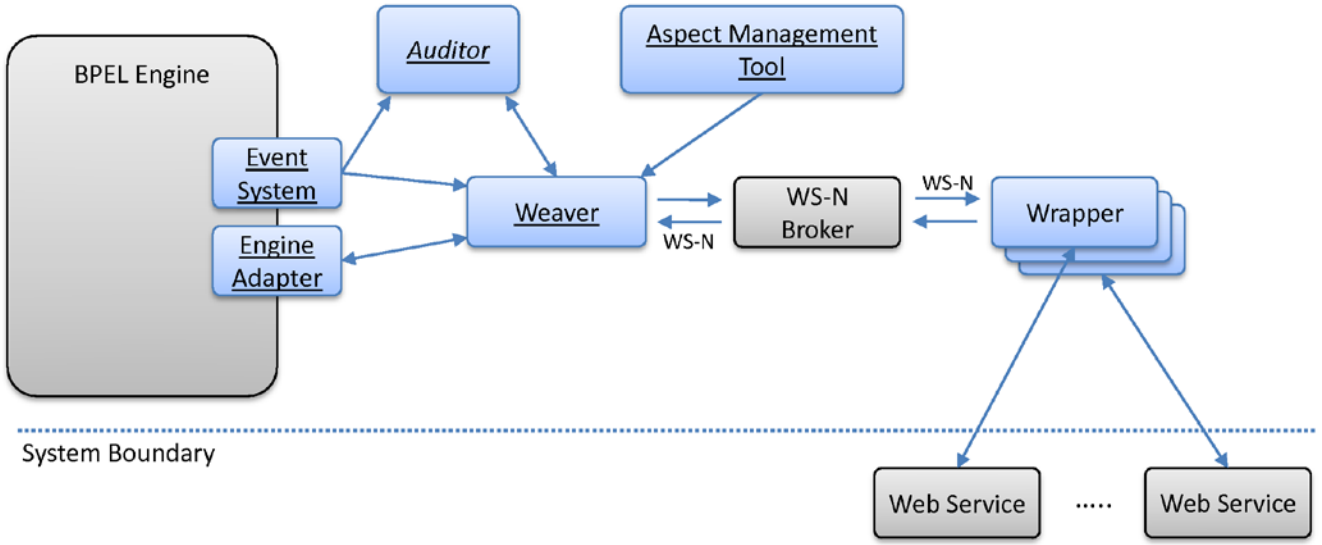
Aspect as a WS-Policy

```
<ws:Policy  ...>
 <wsp:All>
  <a4b:Aspect id="...">*
   <a4b:Advice name="..."
          compensating="true | false"
          alwaysCompensate="true | false"?>
    <wsa:EndpointReference>...
          </wsa:EndpointReference>
          ...
   </a4b:Advice>
   <a4b:CompensationAspect aspectId="..."/>?
   <a4b:Pointcut>...
          <a4b:ProcessArtifact type="activity
          |transitionCondition |..." identifier="..."/>
          <a4b:When type= "before | instead | after"/>
   </a4b:Pointcut>?
  </a4b:Aspect>
 </wsp:All> </ws:Policy>
```




```
<wsp:PolicyAttachment>
 <wsp:AppliesTo>
          <DomainExpression/>+
 </wsp:AppliesTo>
  (<wsp:Policy>...</wsp:Policy>
  | <wsp:PolicyReference>...
   </wsp:PolicyReference>)+
</wsp:PolicyAttachment>
```

Architecture and Prototype



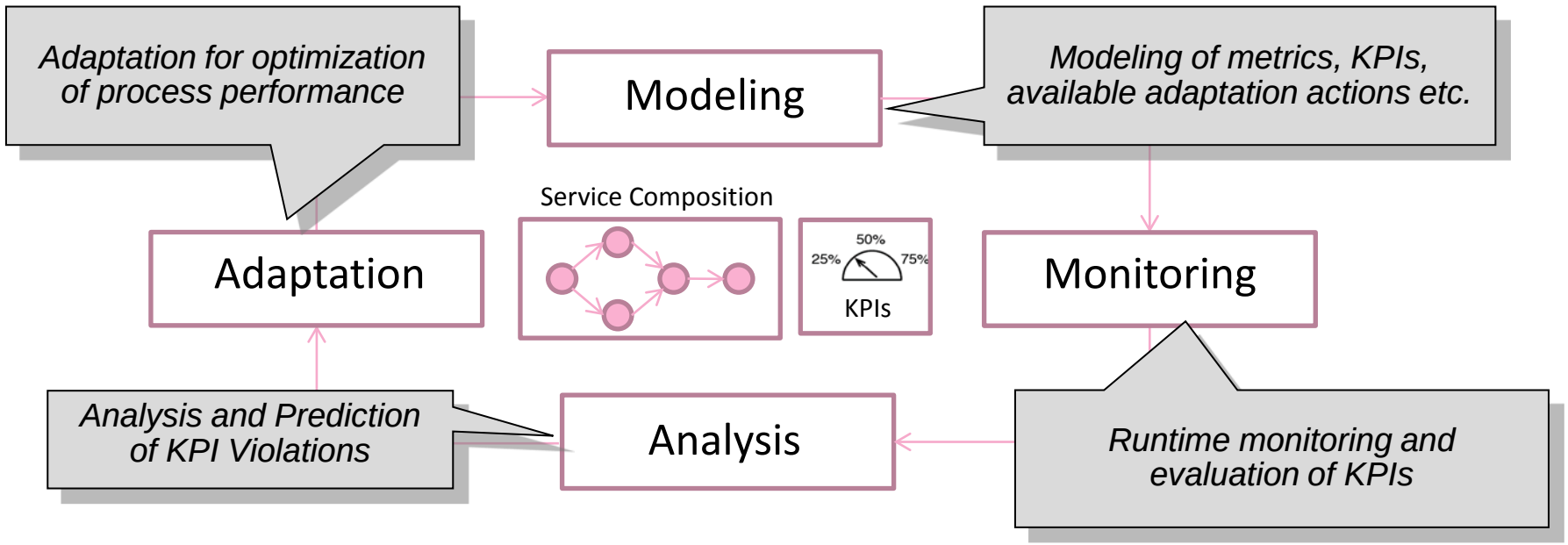
- BPEL Engine
  - Publishes relevant events:
    - activity status,
    - variable modification,
    - execution of implicit and explicit CHs
- Aspect Management Tool:
  - specify and deploy aspects
- Weaver
  - Weaves in aspects
- Audit component
  - Stores execution events published by the engine
  - Stores variable values at aspect weaving time needed for later compensation

Preventing Violations of KPIs

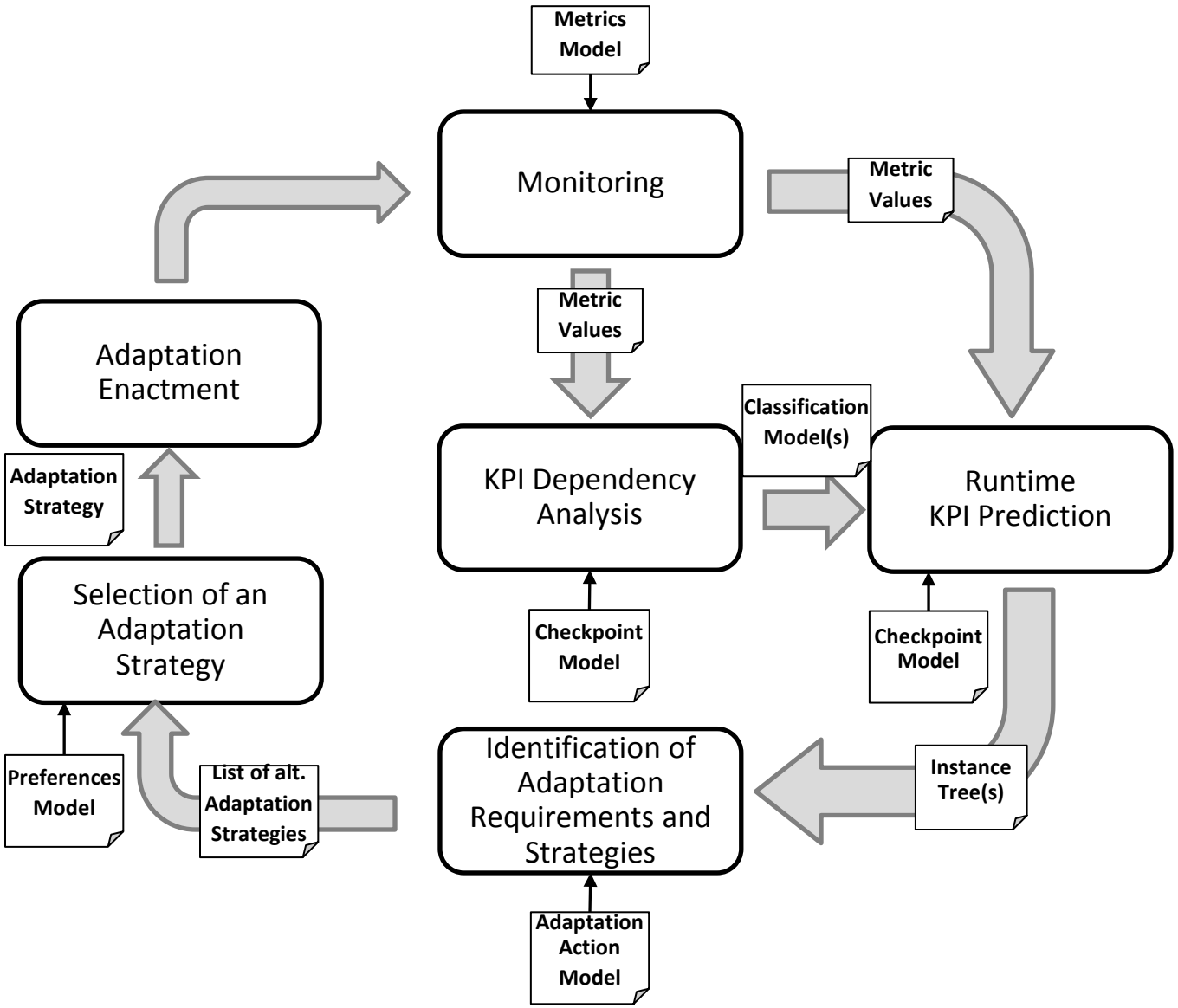
- Adaptation approach: any
- Adaptation trigger: KPI violations
- Engine extensions needed
- Run time approach

Adaptable and QoS-Aware Service Compositions

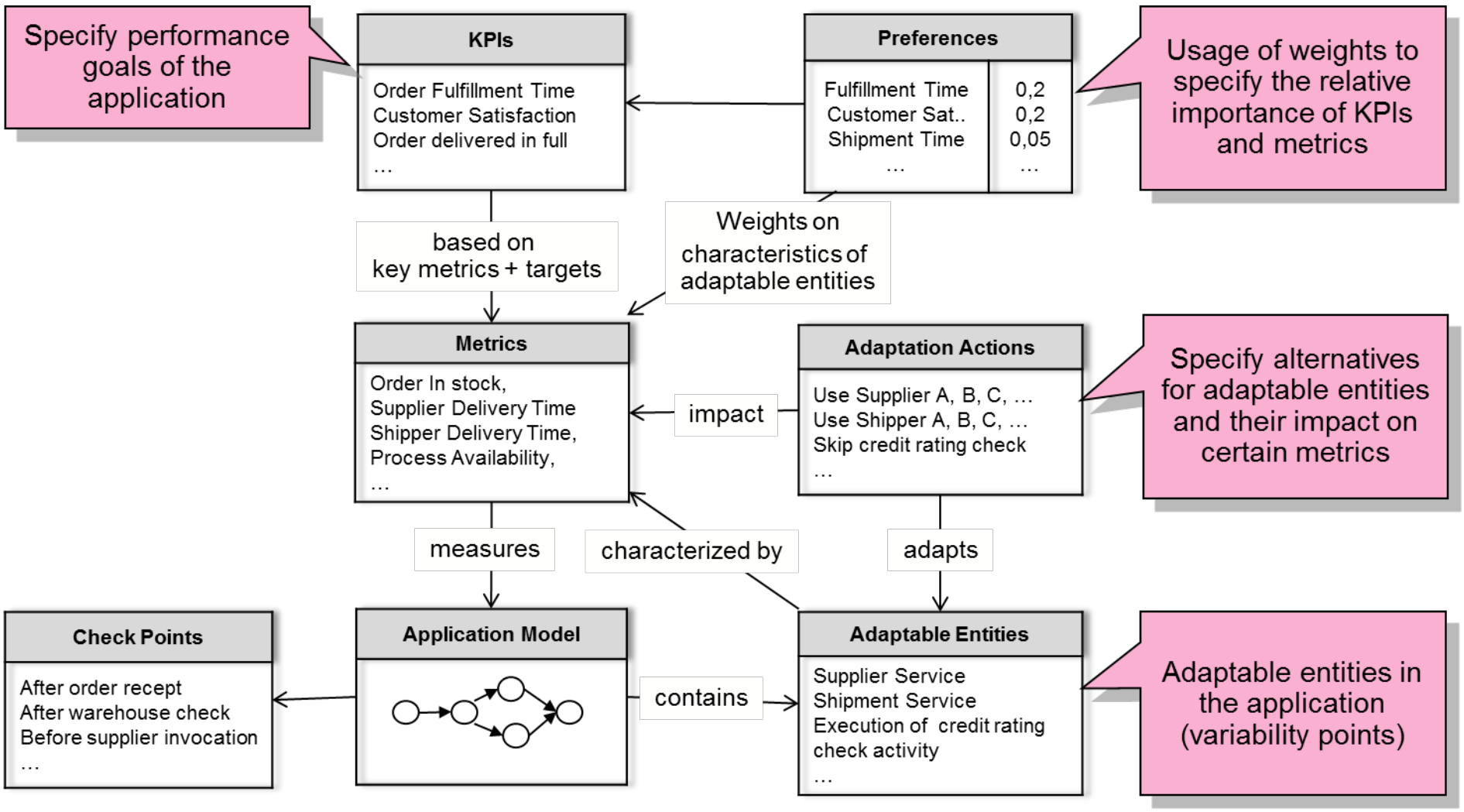
- For service compositions implementing business processes:
  - Use adaptation as reaction to the changes in QoS parameters of a Service-Based Application
  - Adaptation trigger: KPI targets are not reached
  - Approach: Analyze the reason for the KPI violation (influential factors) and optimize through adaptation



Runtime

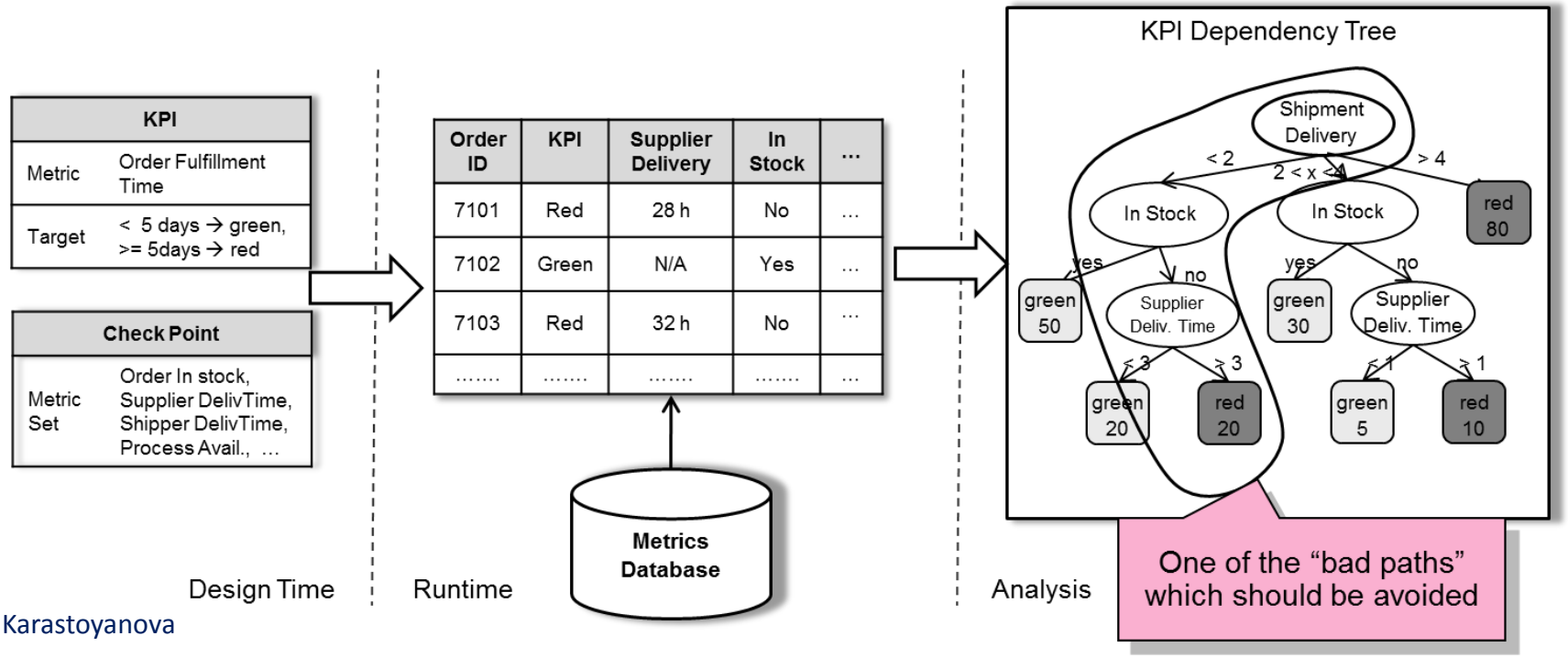


Modeling



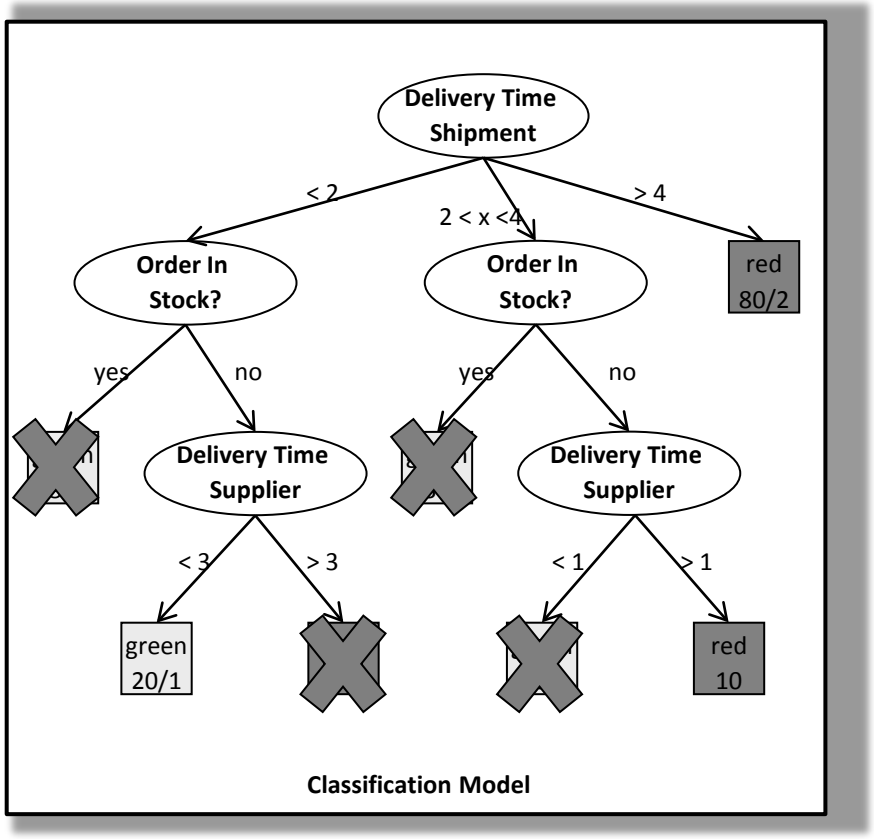
Analysis and Prediction

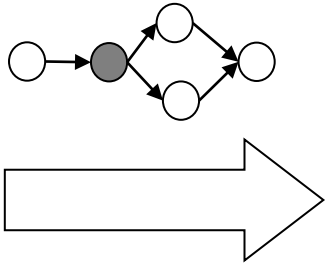
- Analyze the influential factors and
- explain the KPI target violations *(why?)*:
  - Explanation model is created using decision tree techniques (machine learning) based on historical process instances (monitoring)
- Result is a KPI dependency tree explaining
  - which metrics (combinations) and
  - which value ranges of those metrics lead to good or bad KPI values



Analysis and Prediction

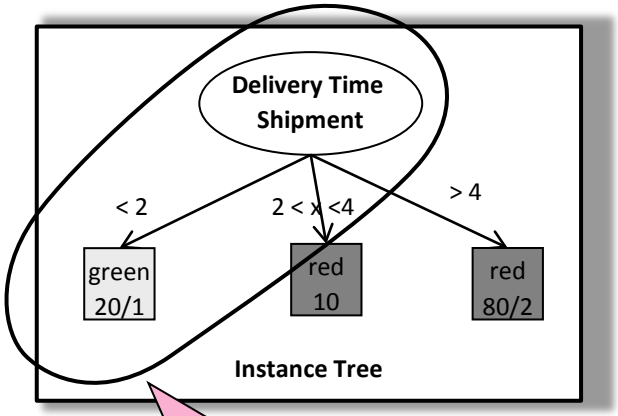
- Predict the KPI class while the process instance is still running
- Using the prediction model (dependency tree) and runtime information /measured metrics
- Result: an instance tree showing the KPI classes in relation to characterizing metrics of adaptable entities → shows which adaptation actions are needed





Order in Stock = No

Delivery Supplier = 2,0



We want to achieve this path

→ Try to ensure that "shipment delivery time" < 2 days

Identify Adaptation Actions

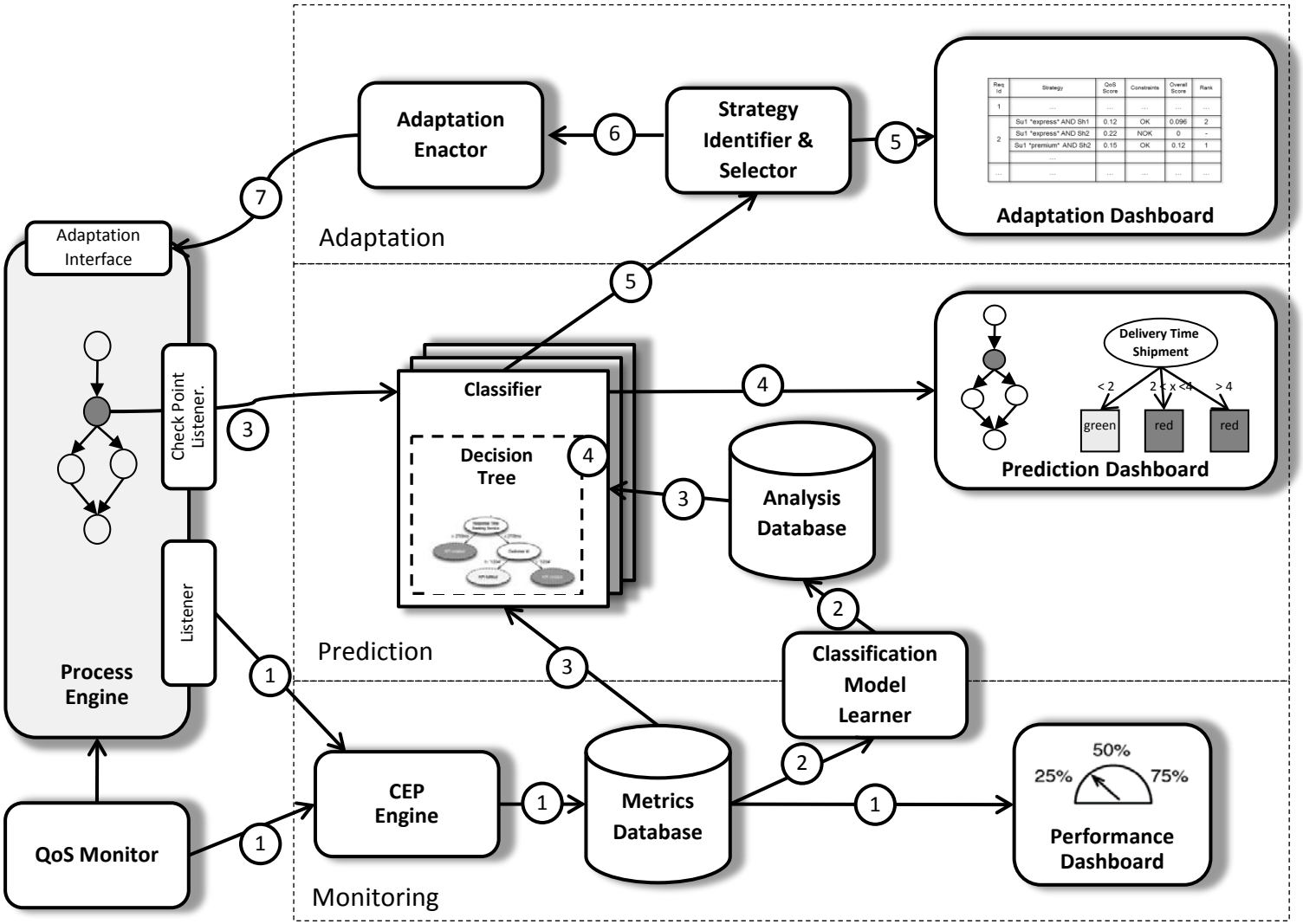
Adaptation Action	
Type:	Service Substitution
Subject:	Purchase Order Process: Supplier Service
Service:	Supplier A *express*
Impact Model:	max del time <= 4 days delivery cost = 10€ availability WS > 0,99 reliability = 0.5

Choose and combine adaptation actions which address adaptation requirements according to their impact model

Id	Adaptation Requirement	Predicted KPI Classes
1	SuTime<4,5 AND ShTime<3 AND Su=A	Green AND very good
2	SuTime<4,5 AND ShTime<2 AND Su=B	Green AND good
3	SuTime<7,5 AND ShTime<2 AND Su=A	Green AND very good
4	SuTime<7,5 AND ShTime<2 AND Su=B	Green AND good
…	…	…

Req Id	Adaptation Strategy
1	Supplier A *express* AND Shipper 1
	Supplier A *express* AND Shipper 2
	Supplier A *premium* AND Shipper 2
	…
…	…

Architecture of the Prototype

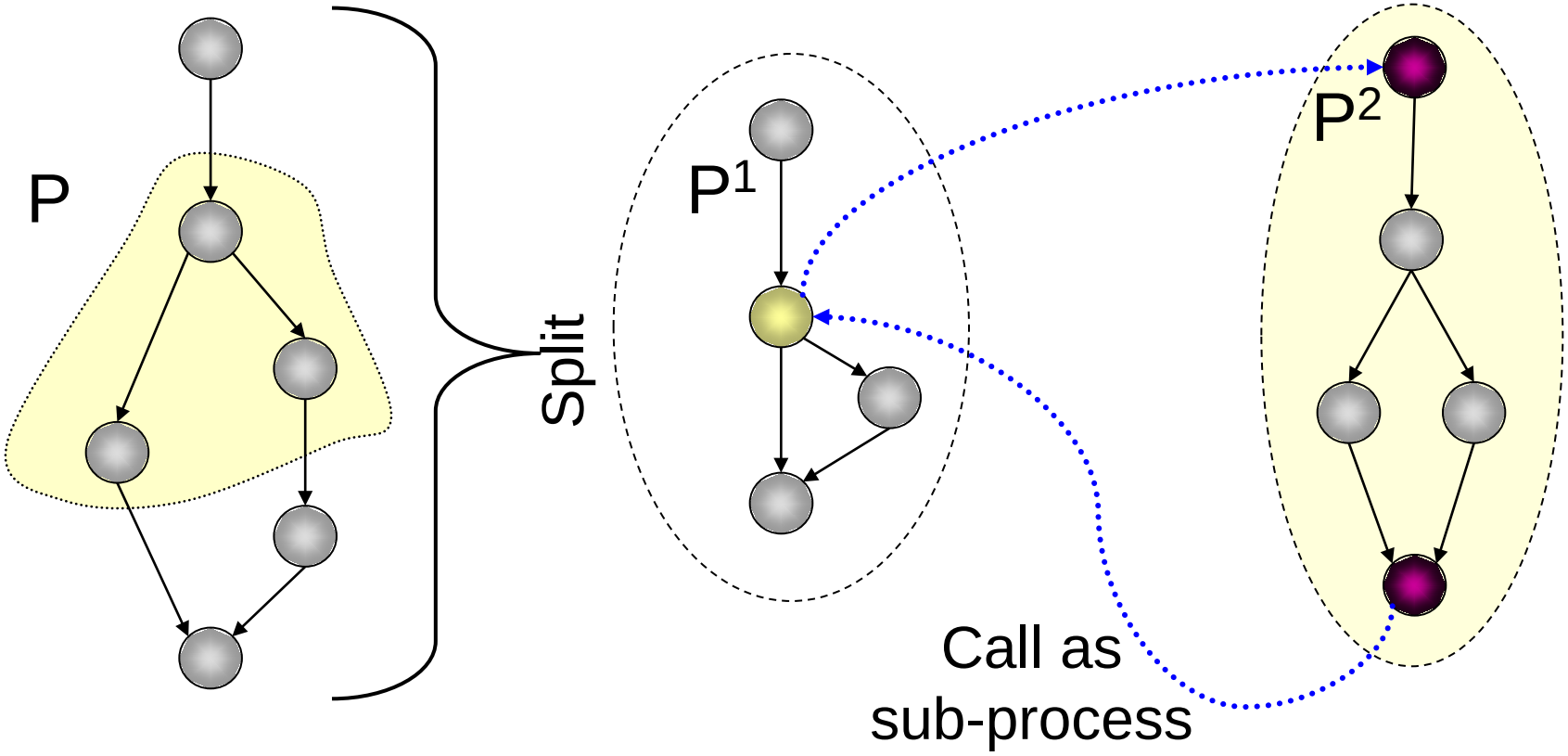


Outsourcing Processes:

- Adaptation of SCs
- Control flow adaptation, split into fragments
- Trigger: Organizational Adaptation
- Design time (and Run time)
- Language extension
- Engine extension, Coordination Infrastructure
- Standard-based

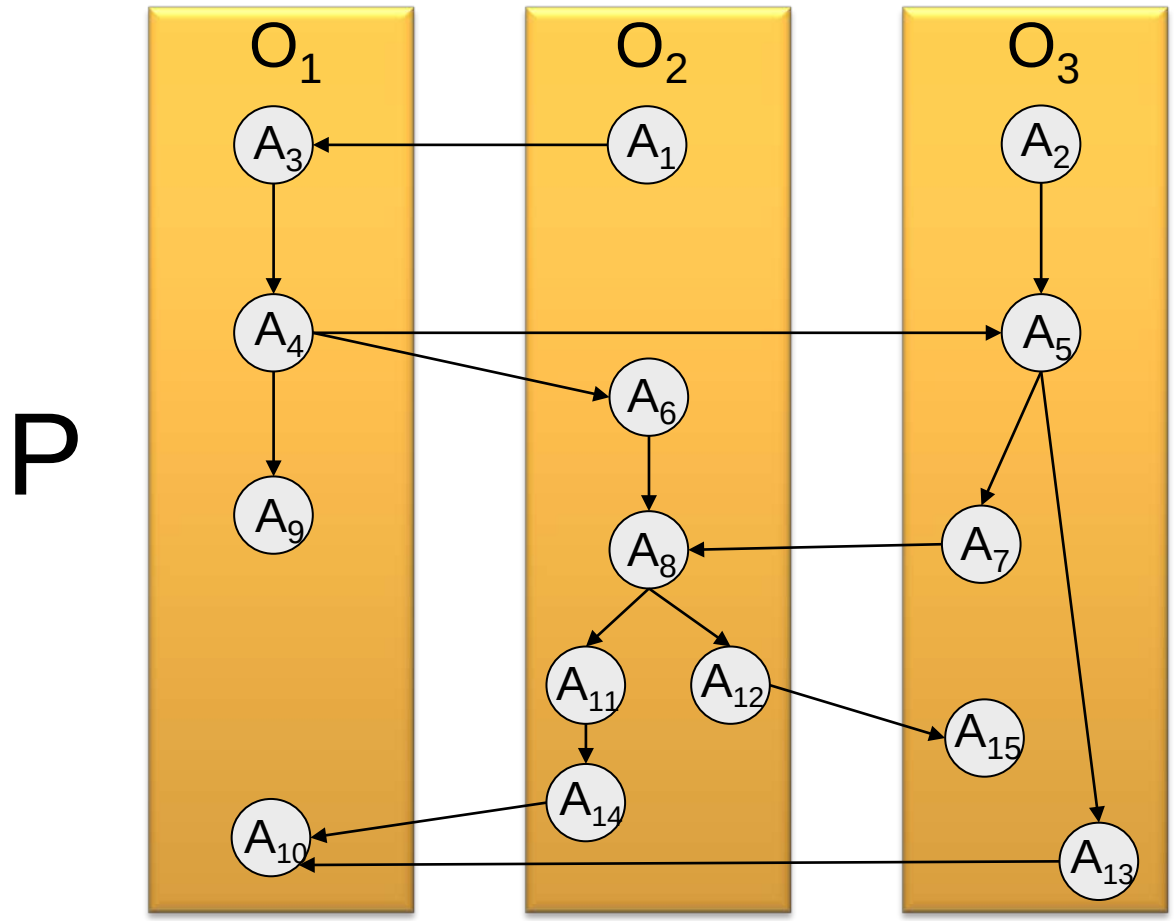
Outsourcing: Splitting Processes

- Outsourcing part of a process using the concept of sub-processes
  - Autonomy of sub-processes



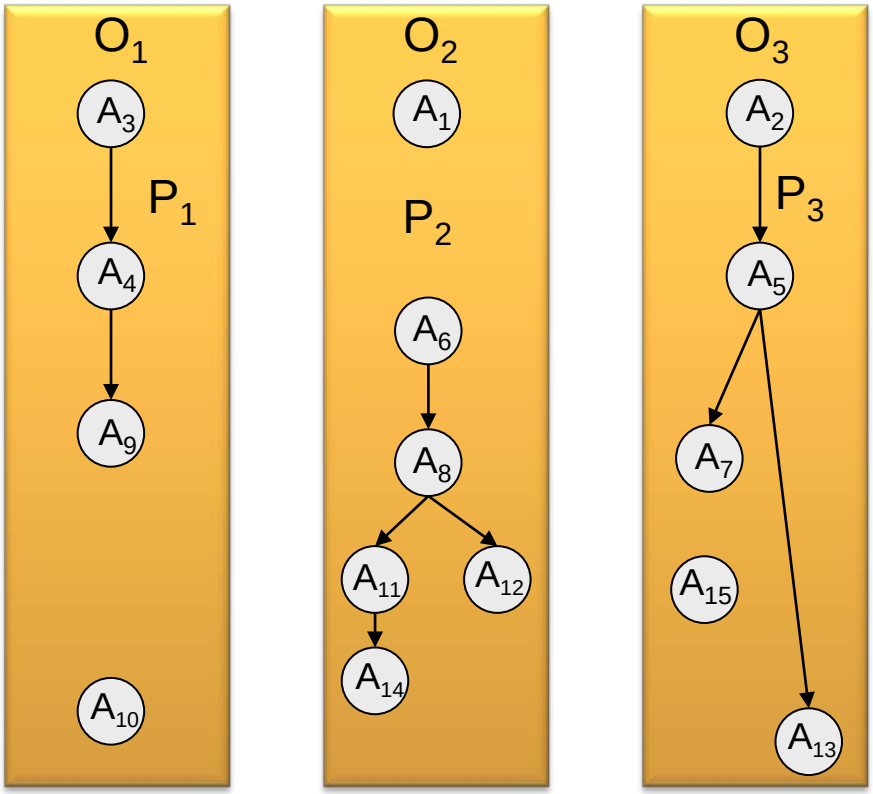
Splitting a Process to Multiple Organizations

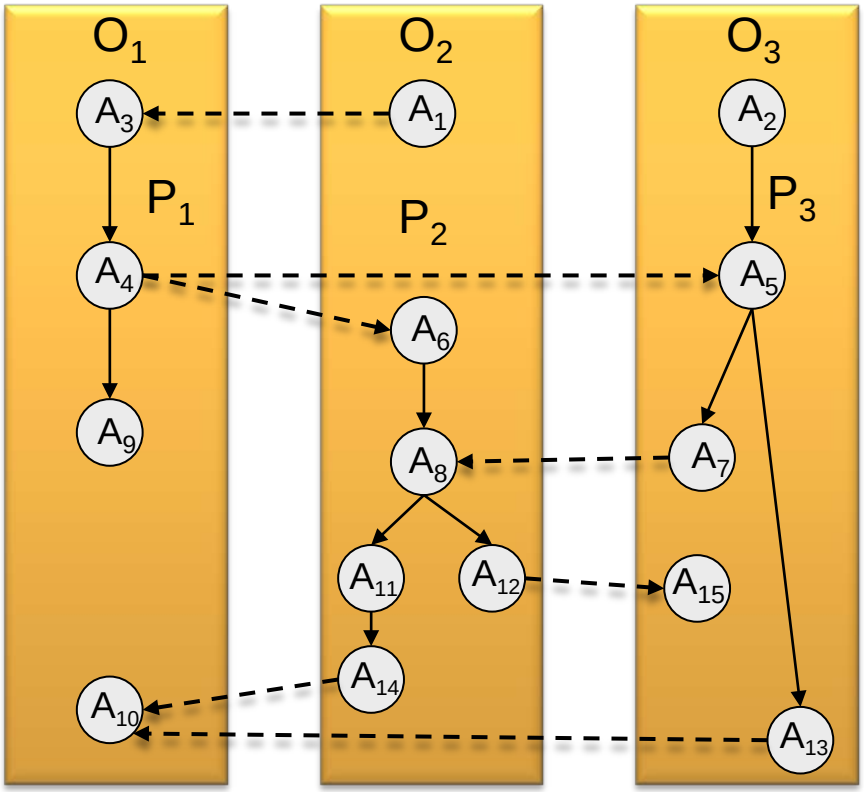
- Alternatively:
  - process fragment/partition is outsourced to an organization,
  - each process is performed autonomously



Projecting Onto Organizations

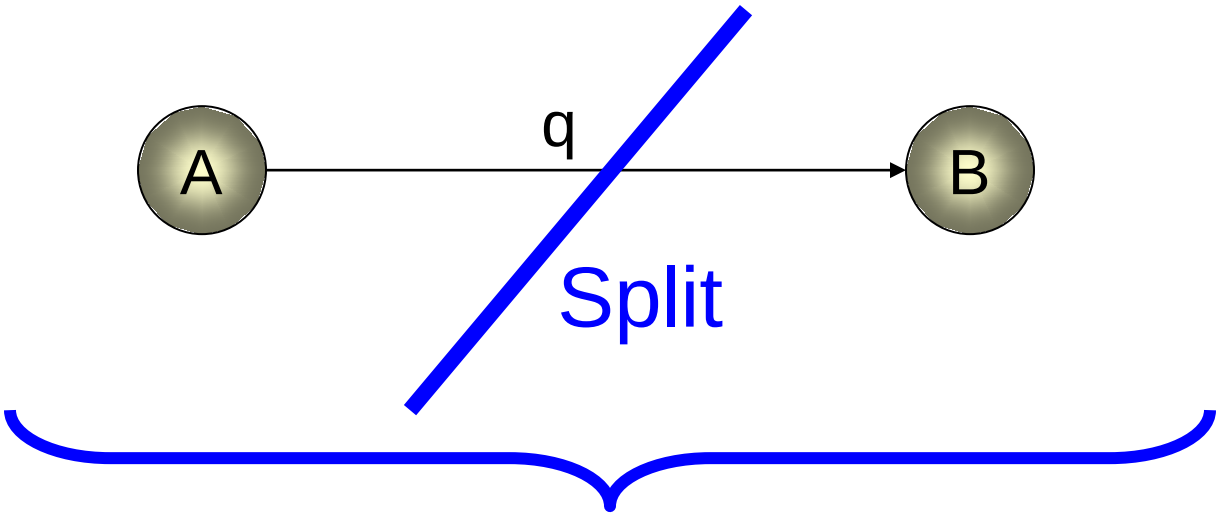
- **Step 1**: Project process onto organizations
  - Define partitions/fragments
  - Split control connectors
- **Step 2**: Wire/connect the processes to model original business logic

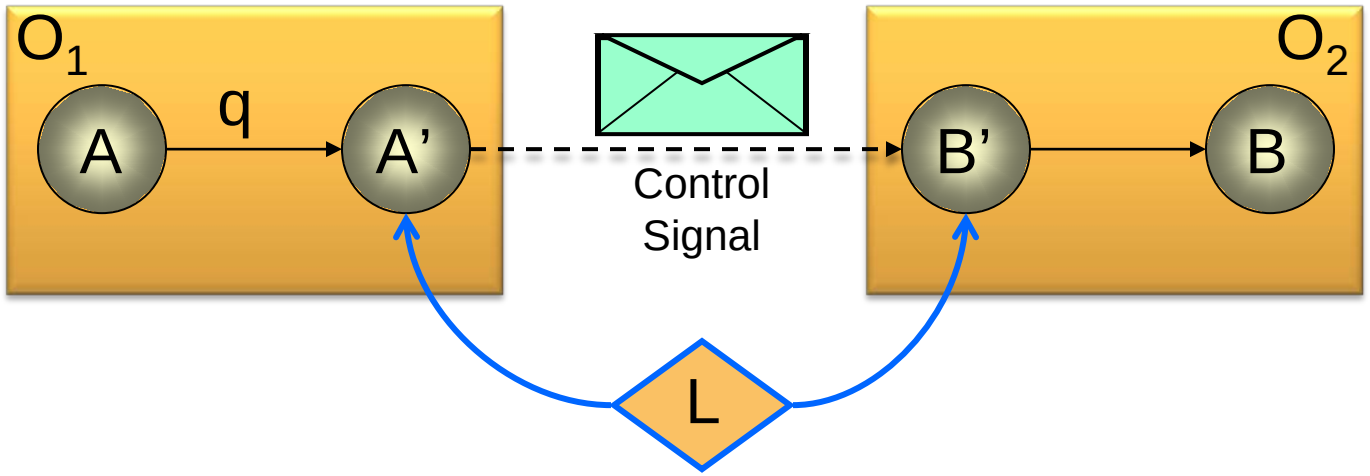




Step 1: Deriving the Wiring

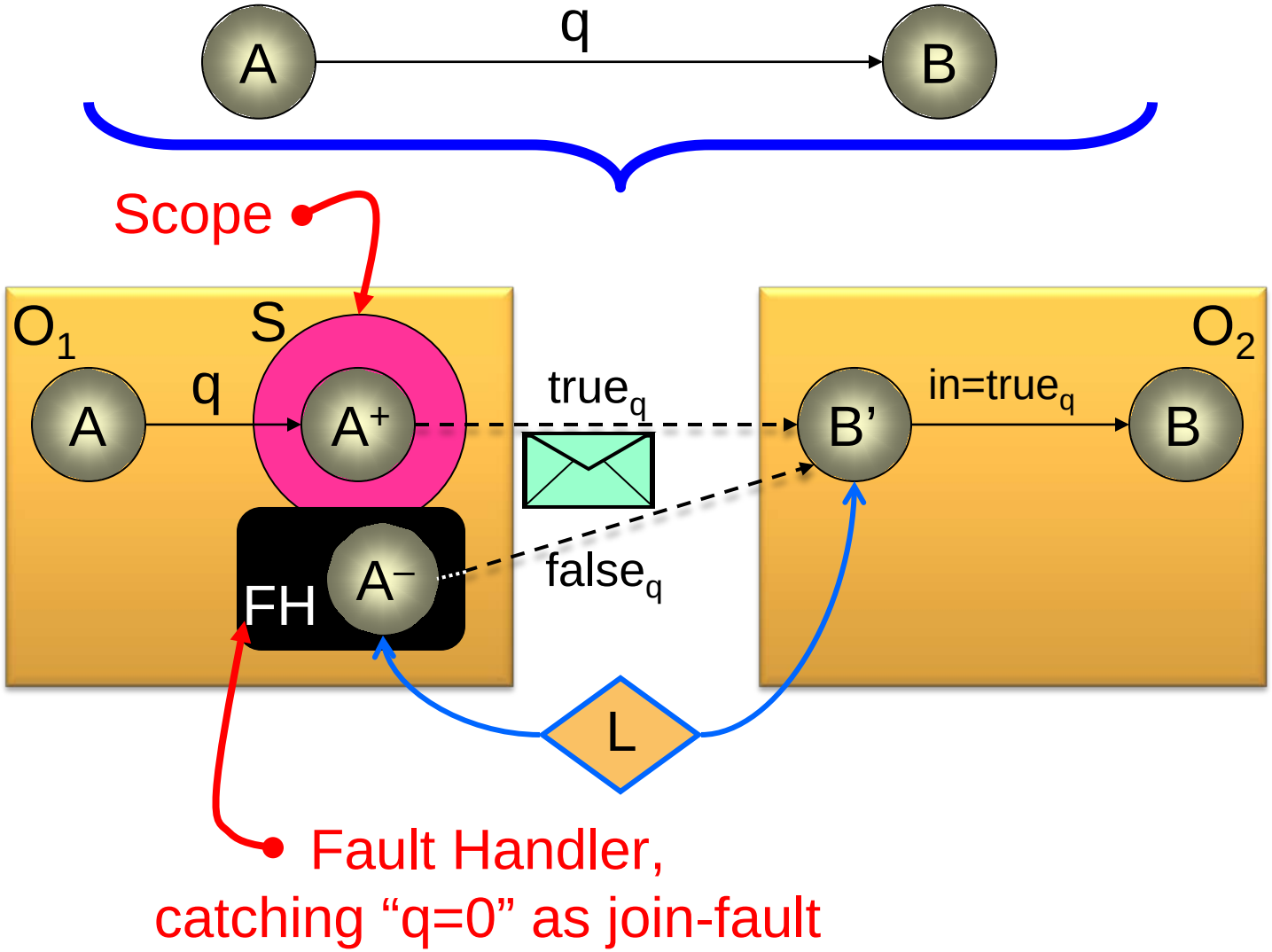
- Splitting Control Links





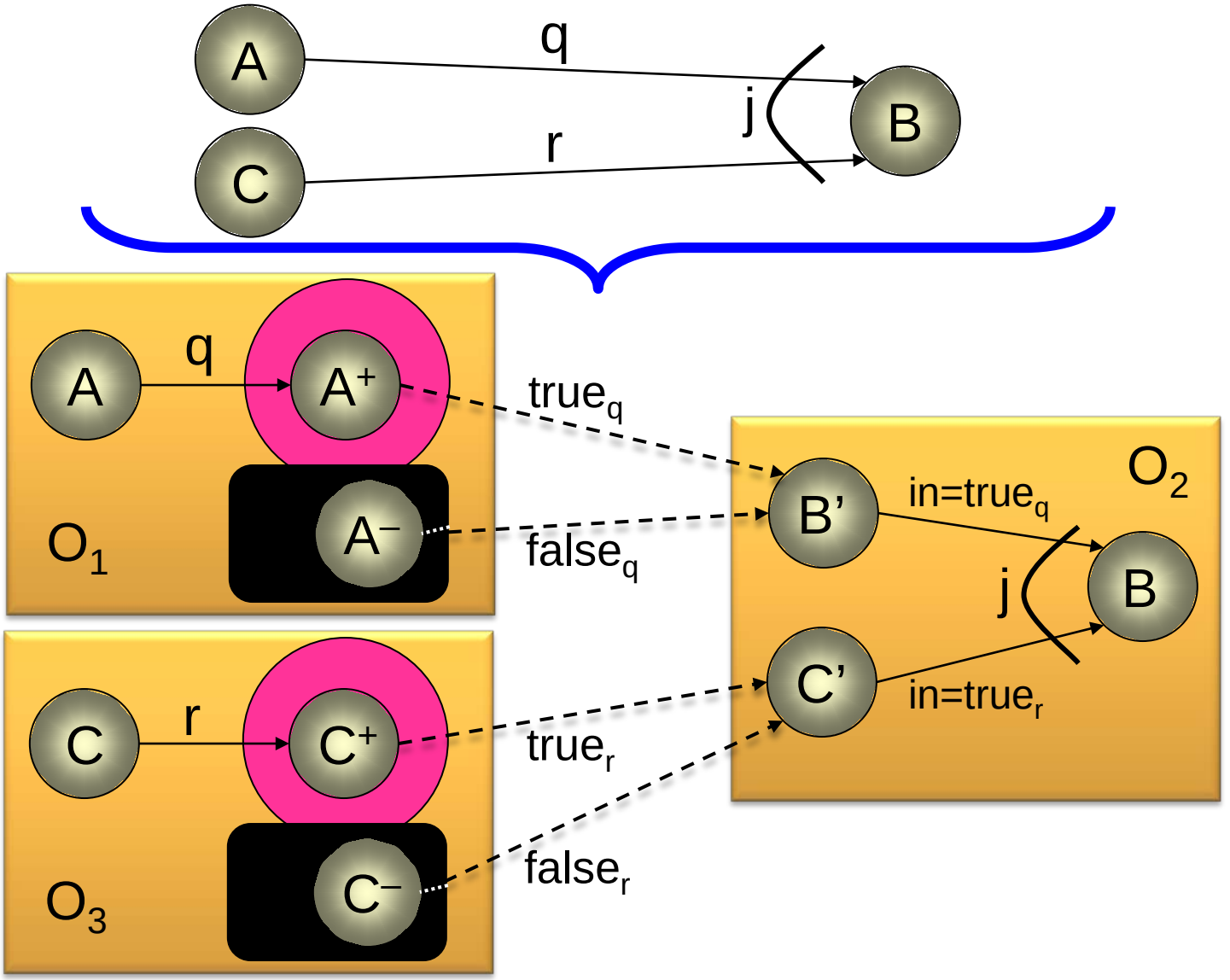
Deriving the Wiring (2)

- Splitting Control Links



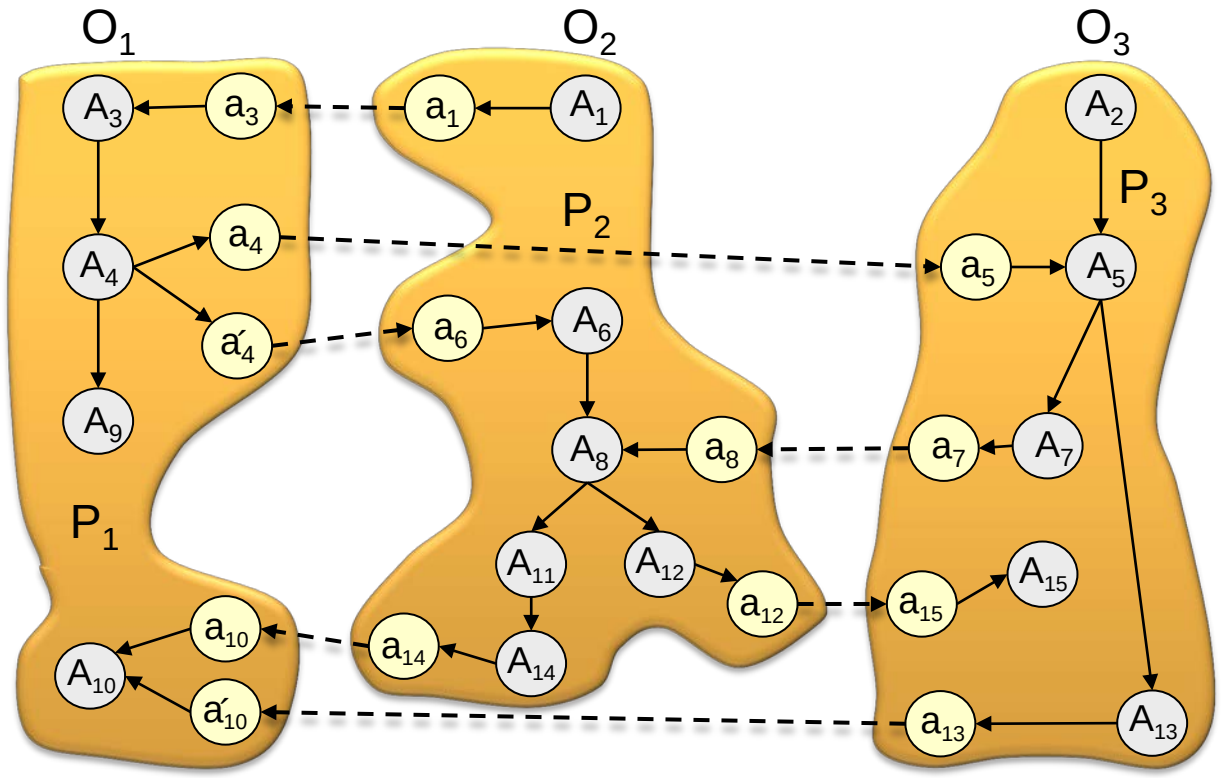
Join Nodes

- Splitting Control Links leading to join nodes

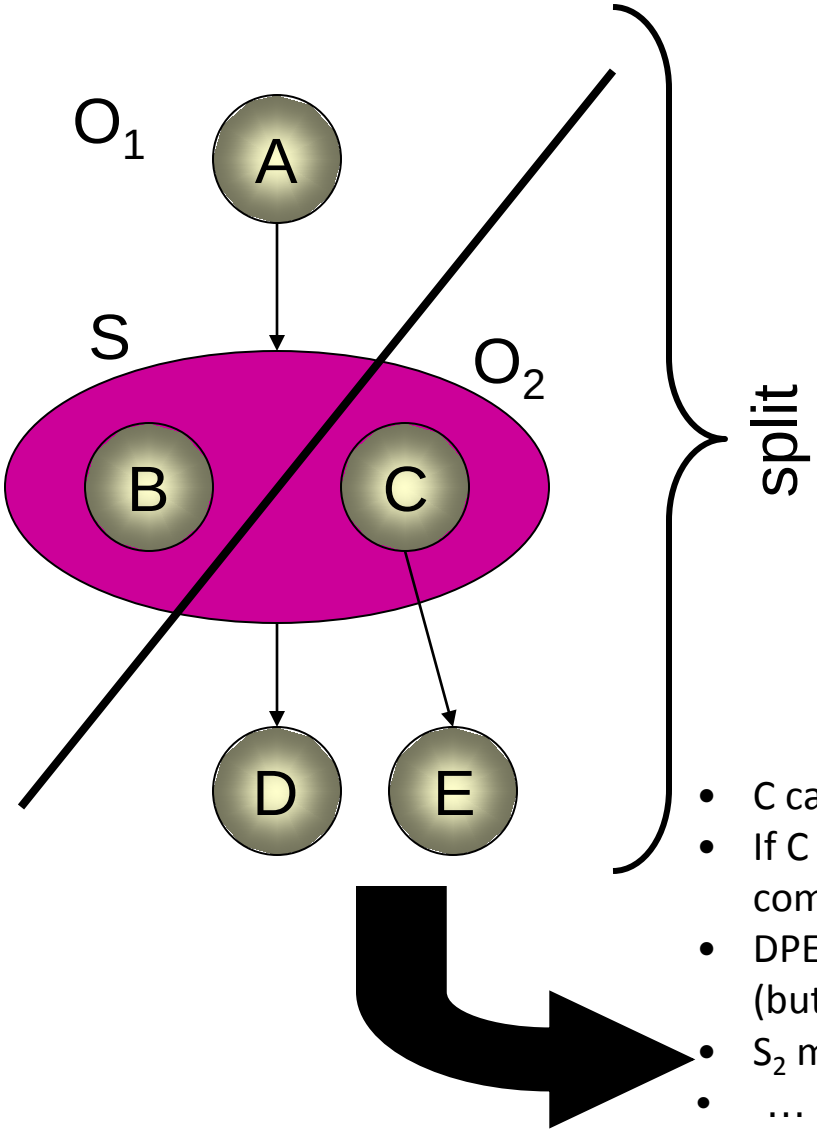


Projecting Onto Organizations

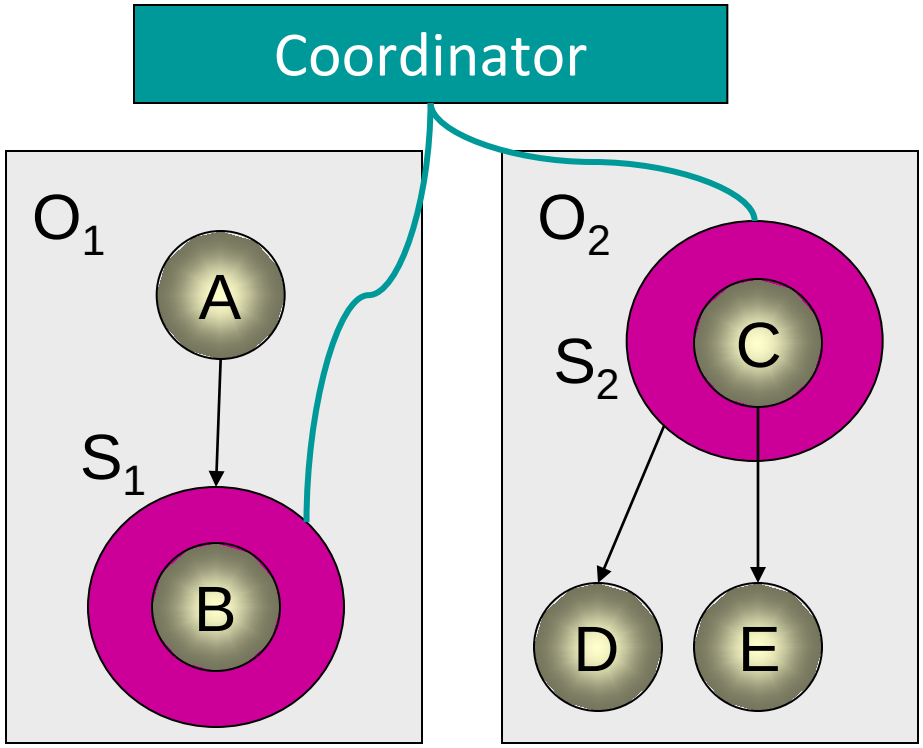
- **Step 3**: Deploy partitions onto infrastructures
  - Wires are split control connectors
  - No changes in standards necessary if no structured activities are split



Splitting a Scope



split



- C can only start if A completed successfully
- If C completed successfully D may only run after S_1 completed successfully
- DPE: Link CE may be set to false in case S_1 detects a fault (but S_2 did not)
- S_2 may get compensated although no fault occurred at S_2
- …

➔ Coordination required

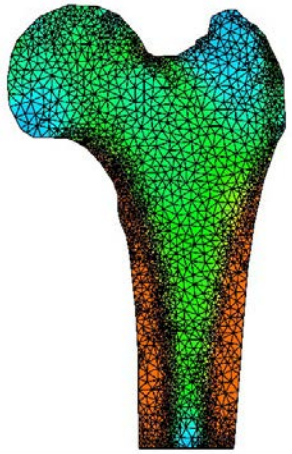
Flexible Scientific Workflows

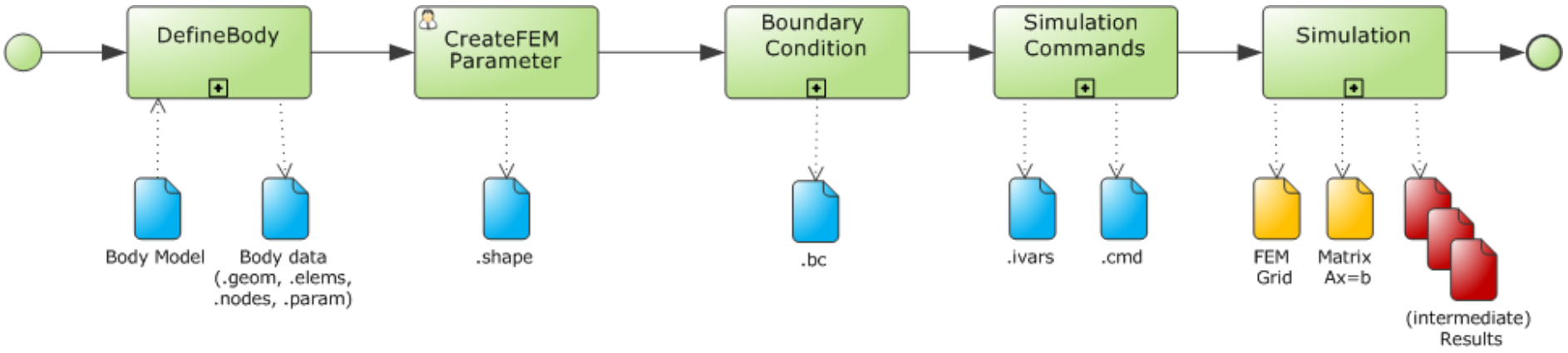
- Adaptation of SCs
- Control flow change; any available approach
- Reaction to change in simulation workflow model
- Standard-based
- Engine extensions needed

Scientific Workflows

- Scientific Workflows
  - Scientific experiments/computations/ simulations modeled and executed as workflows
- Characteristics:
  - deal with huge amounts of **data**,
  - are often **long-running**,
  - usually data driven,
  - can integrate **multiple data sources** (i.e. sensors, data bases, file systems, etc.)

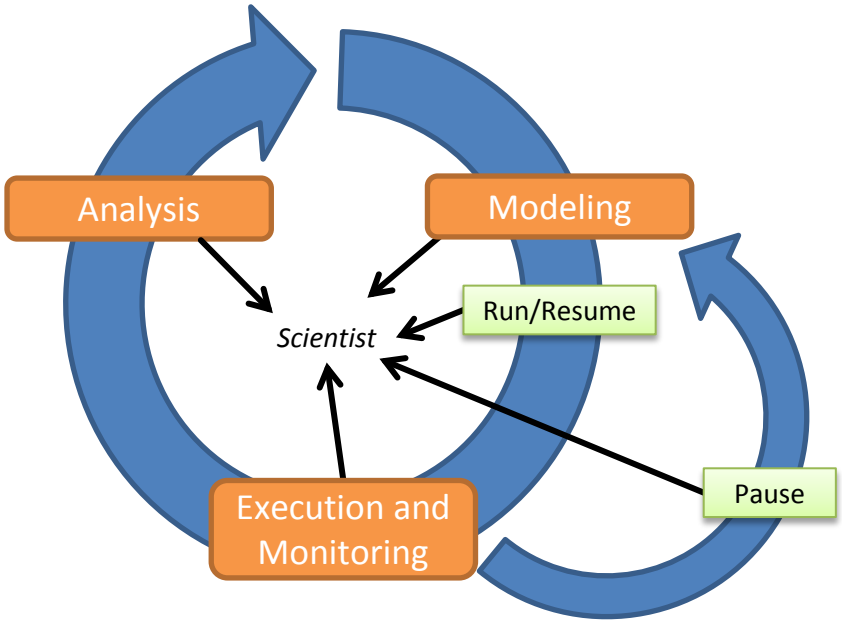
- Bone Growth Simulation:

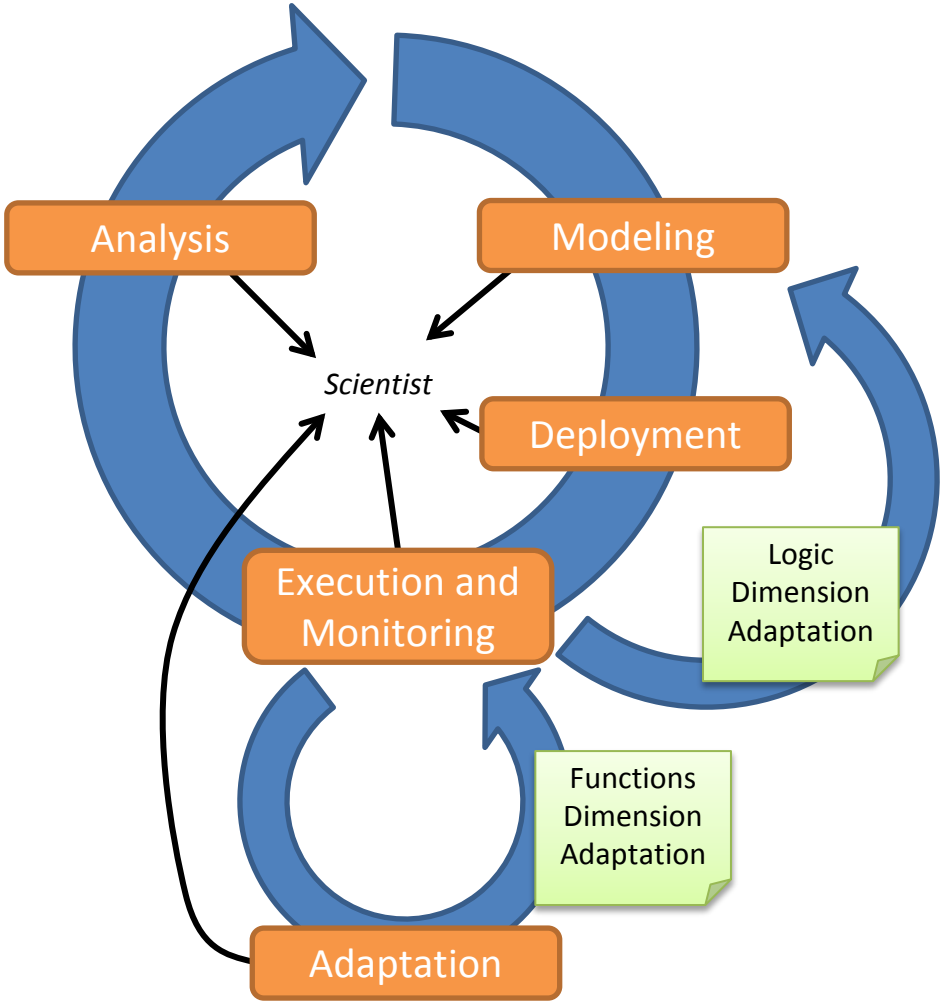


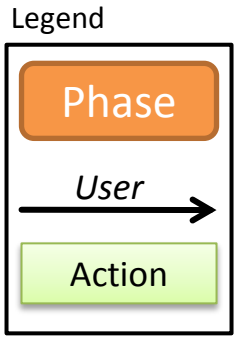


SimTech

- Differences in life cycles: scientific workflows vs. service compositions
- Goal: enable scientific workflows using the life cycle of SCs

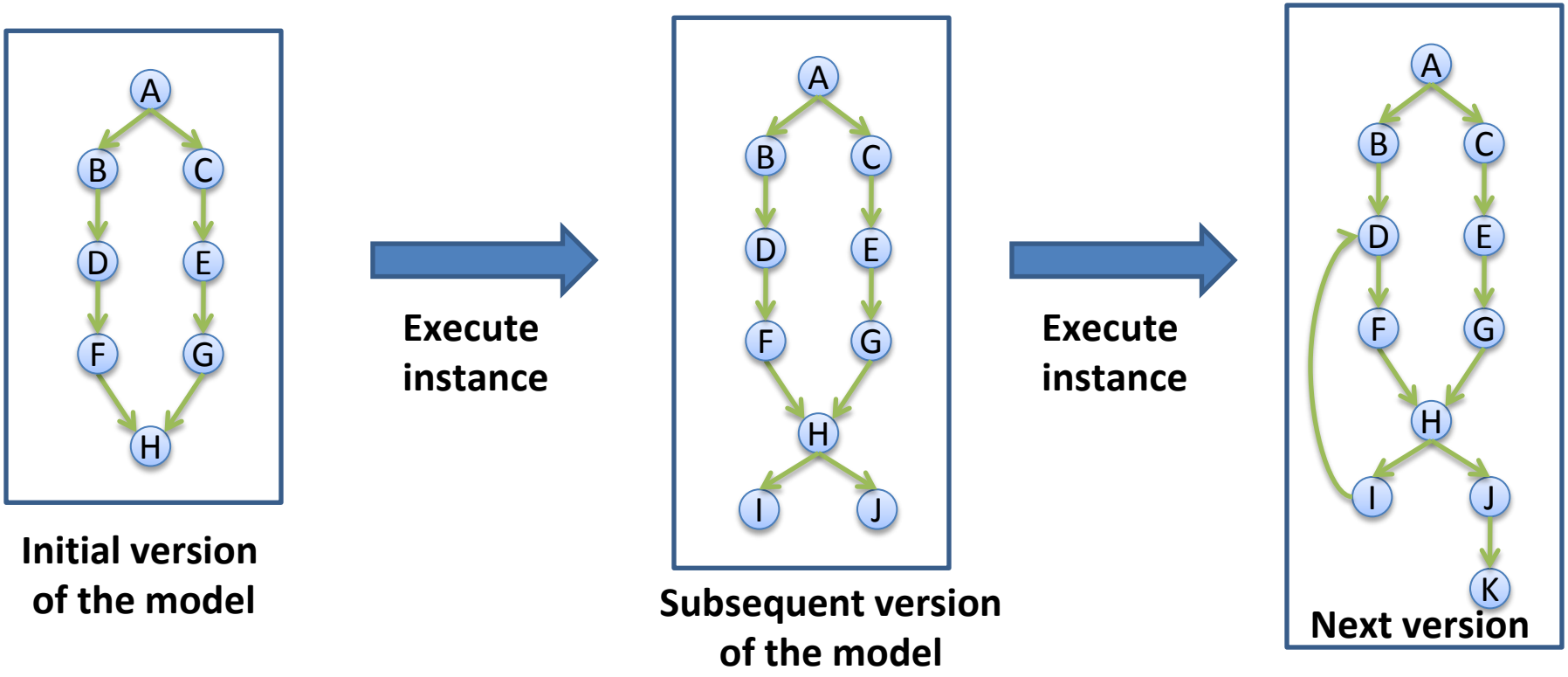






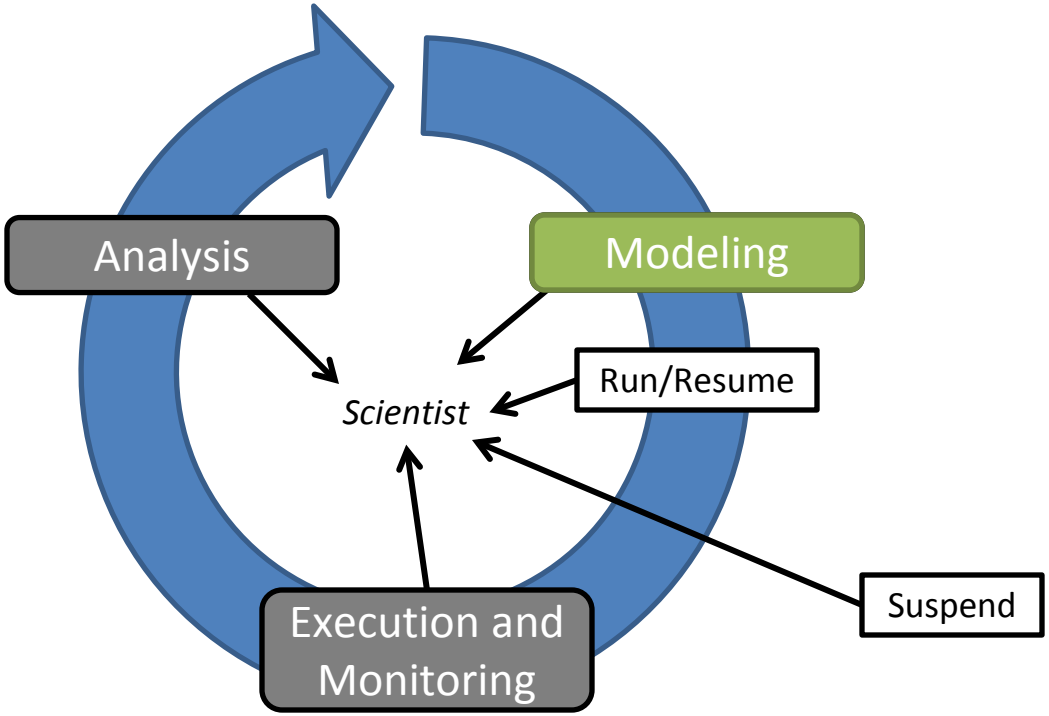
Execution of Partially Specified Processes?

- Execution of process instances is based on process model
- The model is considered to be complete by the execution engine
  - i.e. the instances are terminated after the last activity



Our Approach: Model-as-you-go

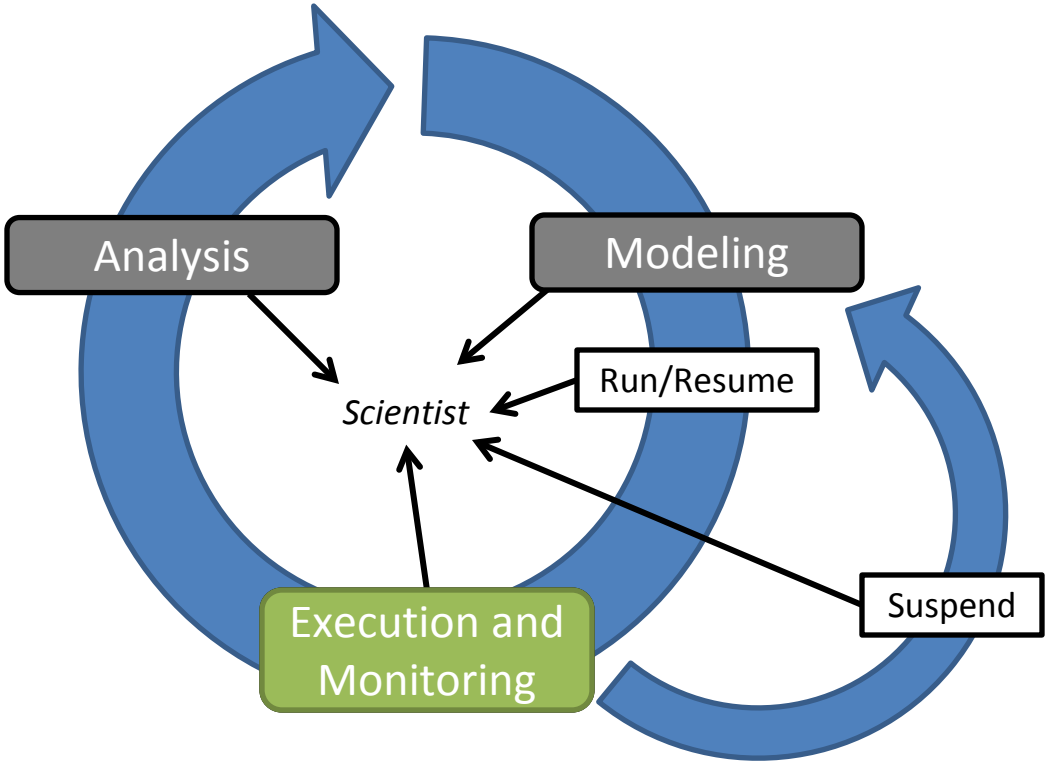
In what workflow life cycle phase we are …



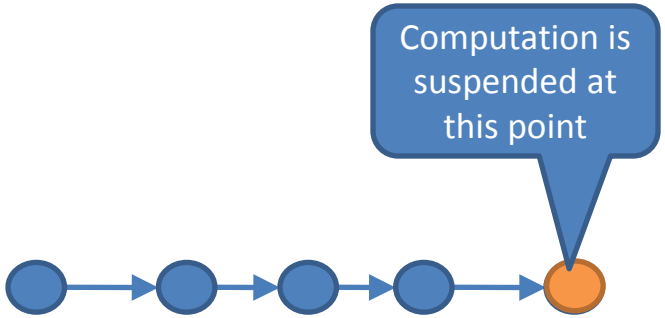
What the scientist experiences …

Model-as-you-go

In what workflow life cycle phase we are …

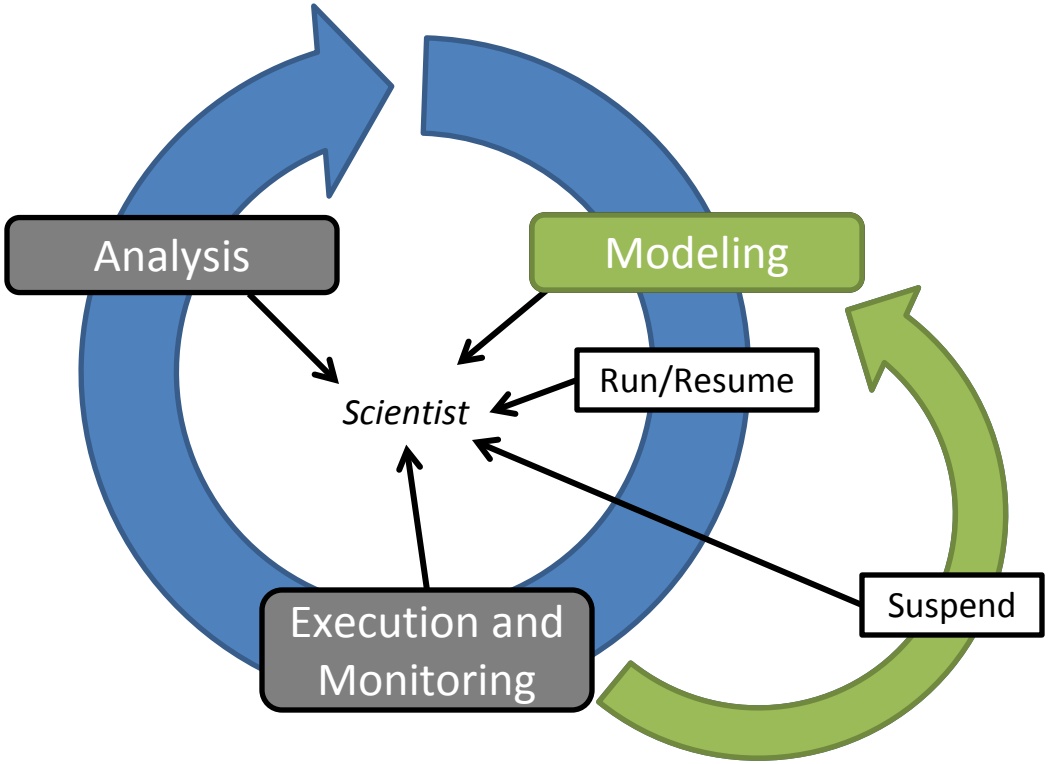


What the scientist experiences …

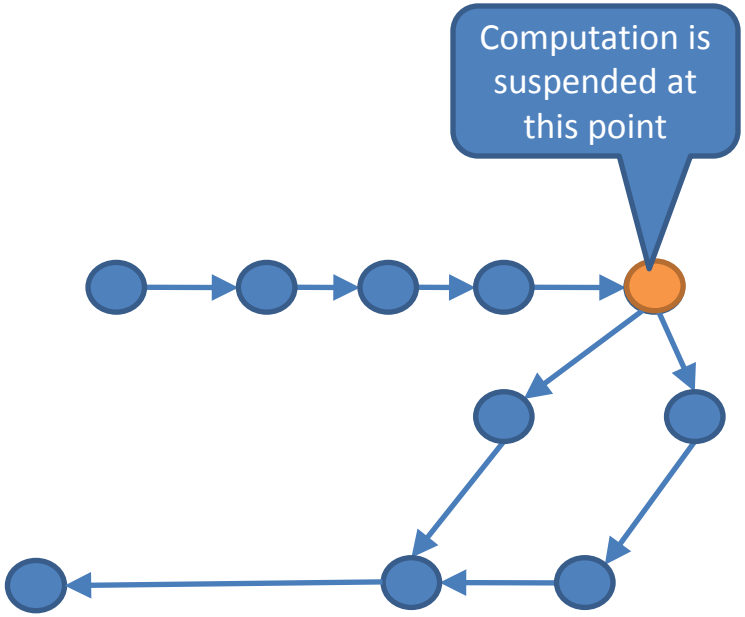


Model-as-you-go

In what workflow life cycle phase we are …

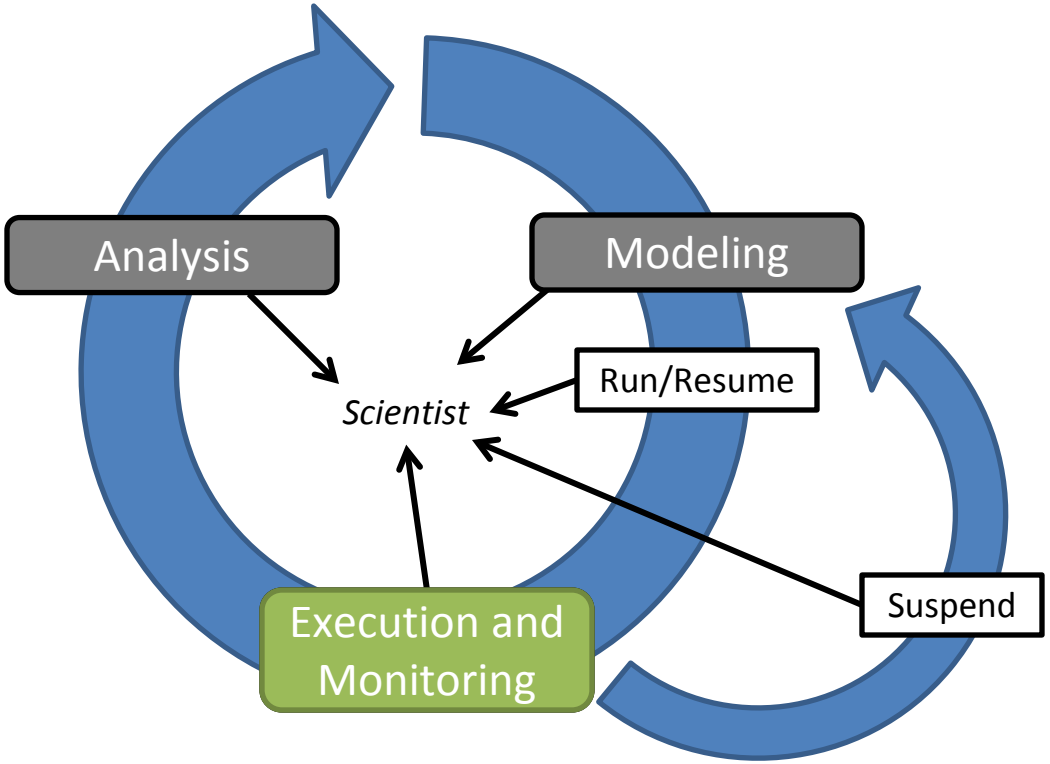


What the scientist experiences …

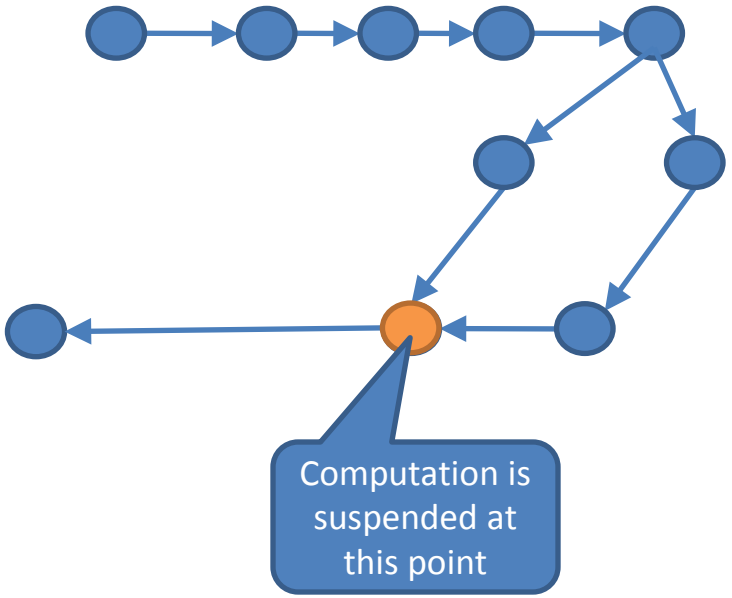


Model-as-you-go

In what workflow life cycle phase we are …

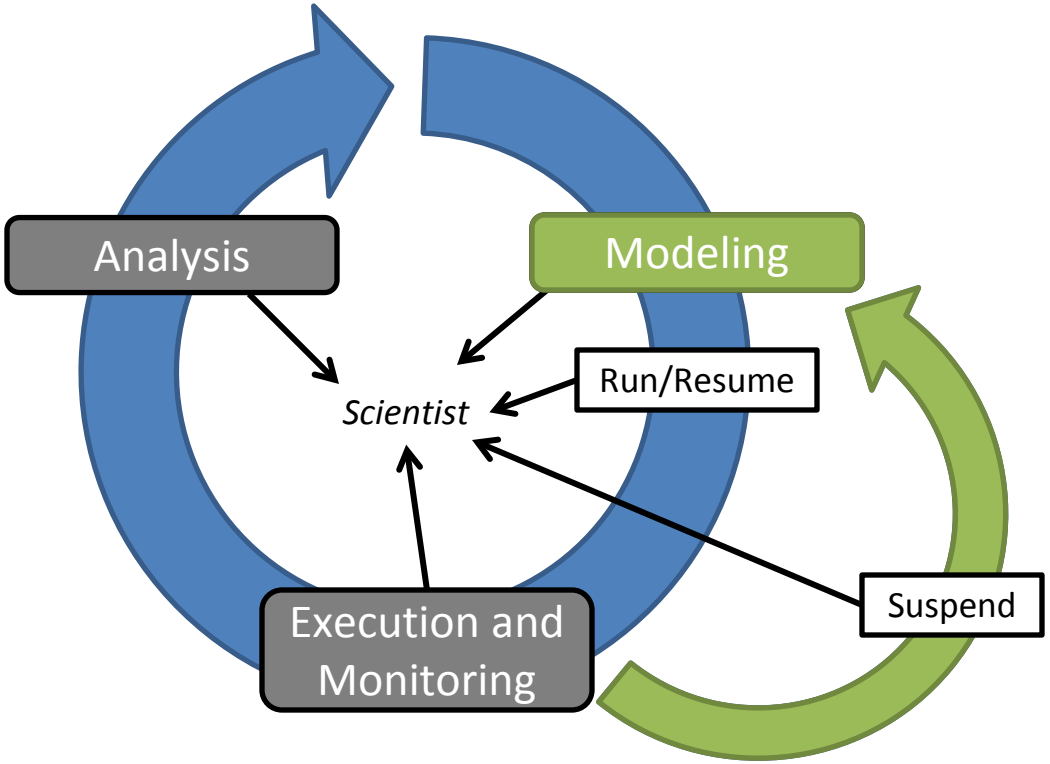


What the scientist experiences …

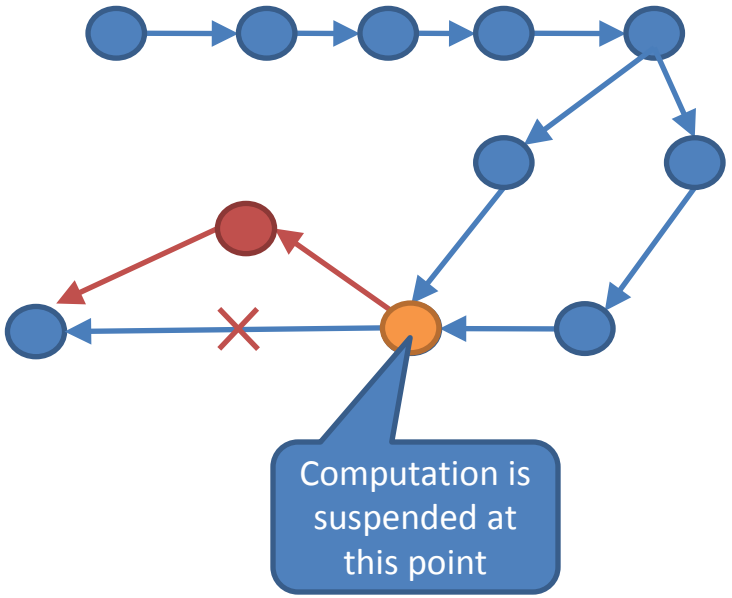


Model-as-you-go

In what workflow life cycle phase we are …

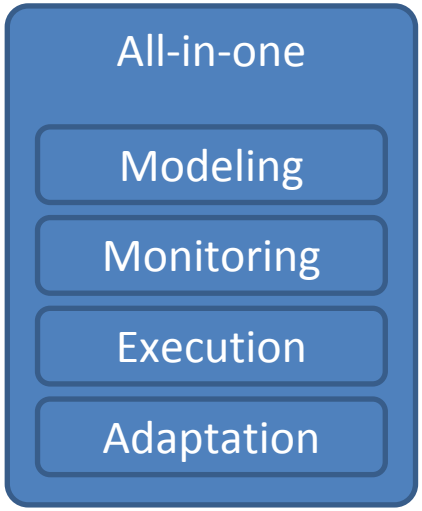


What the scientist experiences …



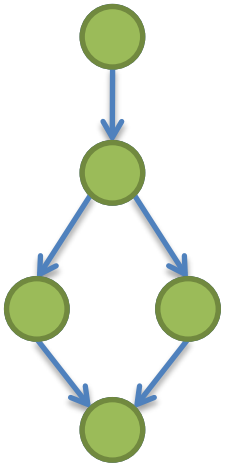
Model-as-you-go – Major Extensions

1)

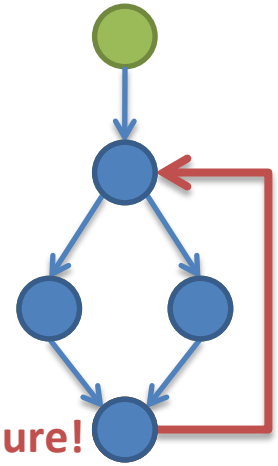


2) Execution control

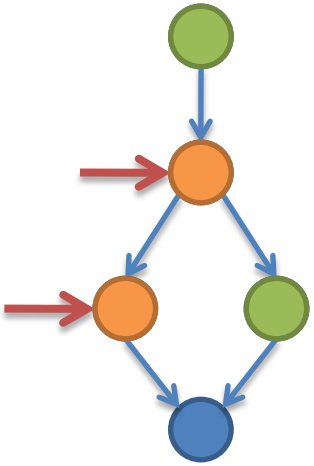
3) Adaptation as modeling experience



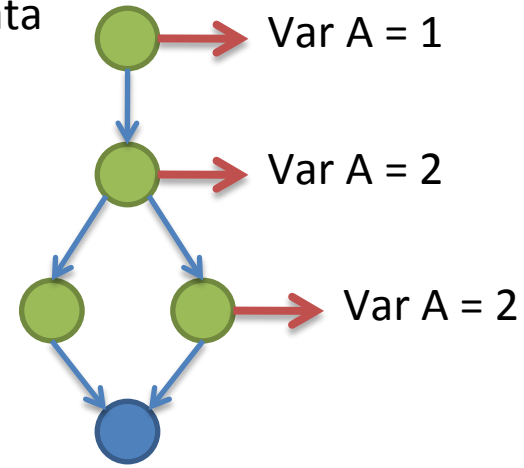
4) Iteration

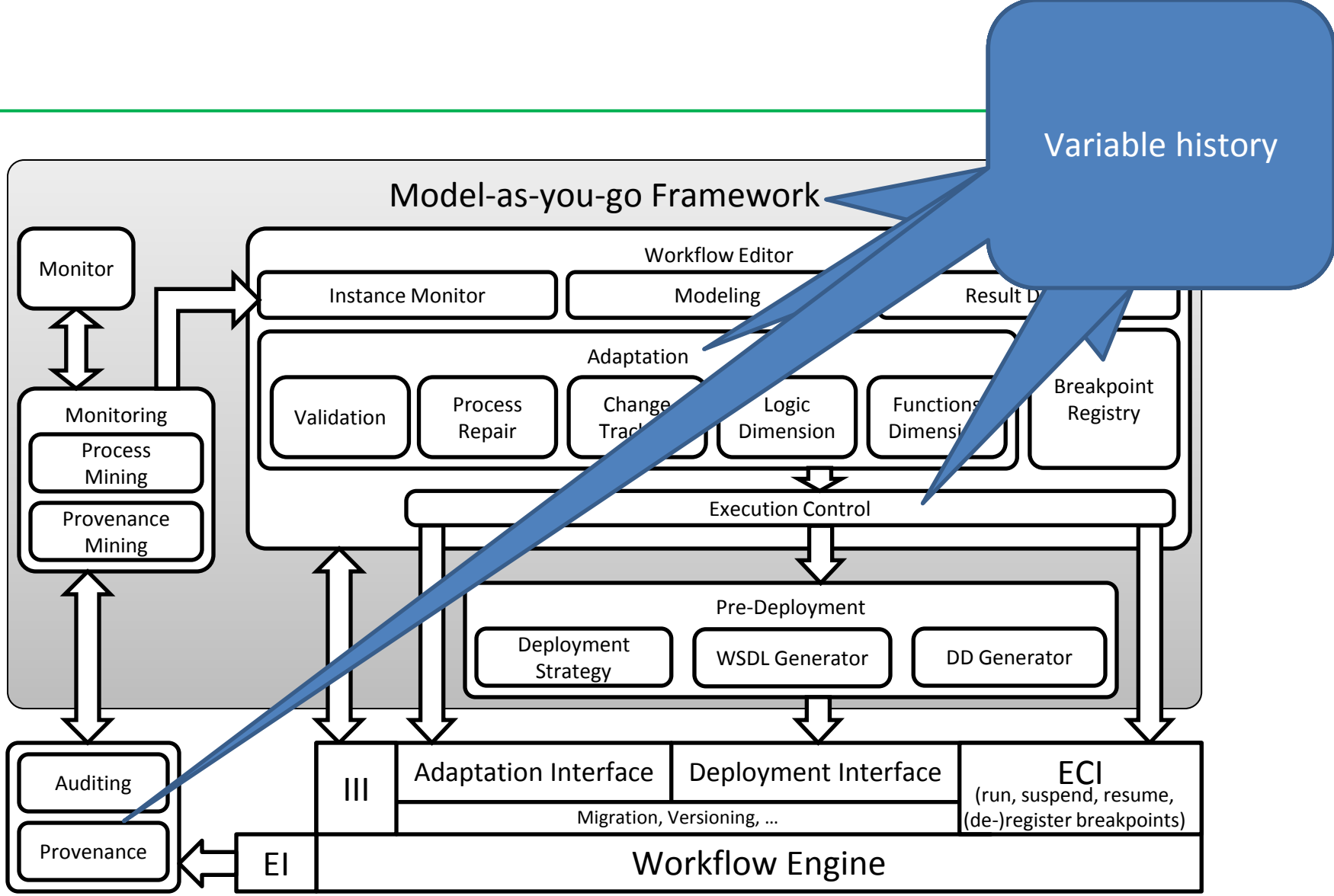


5) Breakpoints



6) History of variable data





Summary

- Adaptation of Service Based Systems and Applications:
  - Relevant for many application domains
  - Can be carried out
    - on one or more layers of an application / system and
    - across organizational boundaries
  - Is complex - consider dependencies to other aspects – data, domain, SBA architecture, triggers, etc.
  - Still a lot to be done
- Future:
  - Coherent cross-layer adaptation
  - Coherent approach to select adaptation action(s) for a trigger
  - Choreography adaptation, Cross organizational adaptation, split and merge
  - Views for different user types (Business Transactions, Service Networks) and their use for adaptation

References

- NoE **S-Cube:** http://www.s-cube-network.eu/
- Excellence Cluster **SimTech**: http://www.simtech.uni-stuttgart.de/
- IAAS at the University of Stuttgart: http://www.iaas.uni-stuttgart.de/
- Wetzstein, Branimir; Zengin, Asli; Kazhamiakin, Raman; Marconi, Annapaoloa; Pistore, Marco; Karastoyanova, Dimka; Leymann, Frank: Preventing KPI Violations in Business Processes based on Decision Tree Learning and Proactive Runtime Adaptation. In: Journal of Systems Integration, January, 2012.
- Guinea, Sam; Kecskemeti, Gabor; Marconi, Annapaola; Wetzstein, Branimir: Multi-layered Monitoring and Adaptation. In Proceedings of ICSOC 2011.
- Khalaf, Rania; Leymann, Frank: Coordination for Fragmented Loops and Scopes in a Distributed Business Process. In Proceedings of BPM 2010.
- Sonntag, Mirko; Karastoyanova, Dimka: Next Generation Interactive Scientific Experimenting Based On The Workflow Technology. In International Conference on Modelling and Simulation (MS 2010).
- Sonntag, Mirko; Karastoyanova, Dimka: Compensation of Adapted Service Orchestration Logic in BPEL'n'Aspects. In Proceedings of BPM 2011.