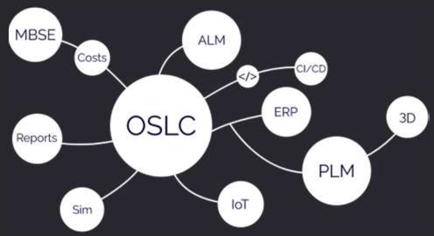

OSLC FEST 2022
Virtual Conference

17 November 2022

OSLC for Cognitive Cross-Checking of System Models

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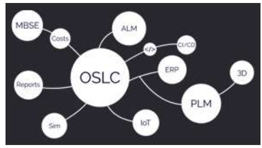
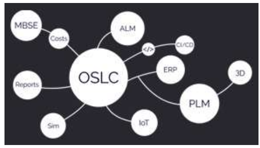


IEEE Senior Member, HEA Fellow

- US-funded(DoD), UK-funded(MoD) and EU-funded projects
  - US research project in collaboration with the AFRL.
  - UK research projects in collaboration with BAE Systems, Atlas Elektonik, and seabyte.
  - EU research projects in collaboration with Airbus, Eurocopter, Goodrich, Autoflug, ASG, and Secondo Mona.
- Autonomy-based projects
  - Autonomously cross-checked models from multidisciplinary design teams of high-integrity systems.
  - Autonomous decision-making support for avionics analytics.
  - Remote integration of capabilities from autonomous ground vehicles for defence.
  - Automation of distributed aircraft fuel management systems tested in lab and real-scale rigs.
  - Intelligent control architecture for autonomous maritime vehicles.
  - Autonomous reconfiguration of production lines.
- Over 100 publications, including a book and 5 book chapters.

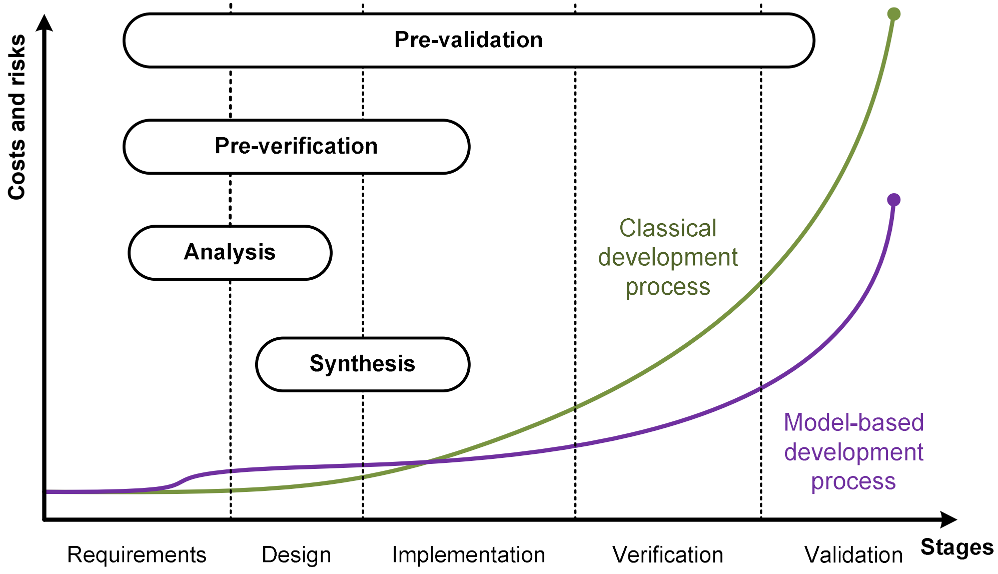
Contents

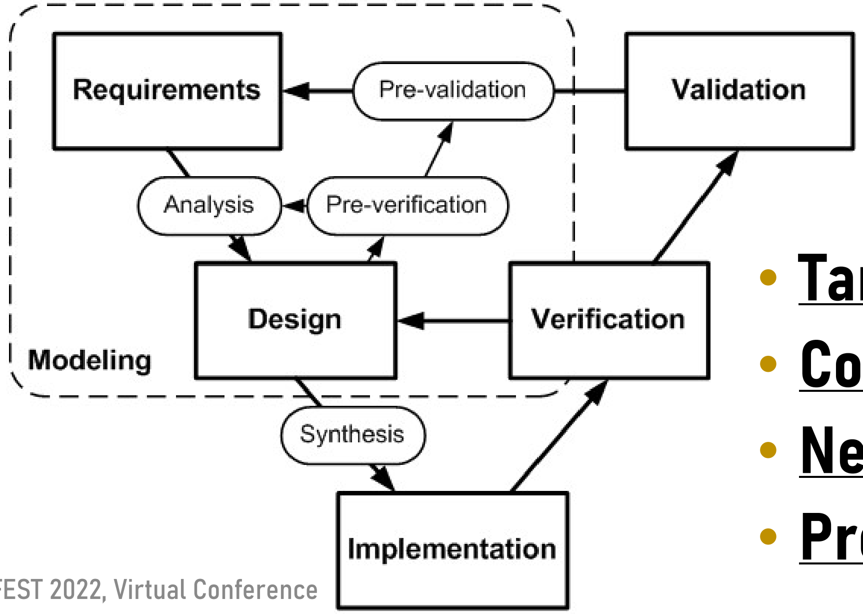


- Introduction
- Background
- Example
- Approach
- Reflection

Early Efforts to Reduce Costs and Risk

- **Focus:** Dependable Cyber-Physical Systems
- **Feature:** High-integrity; safety, security, etc.
- **Challenge:** SDLC risks & costs increasing
- **Trend:** Pre-verification & pre-validation

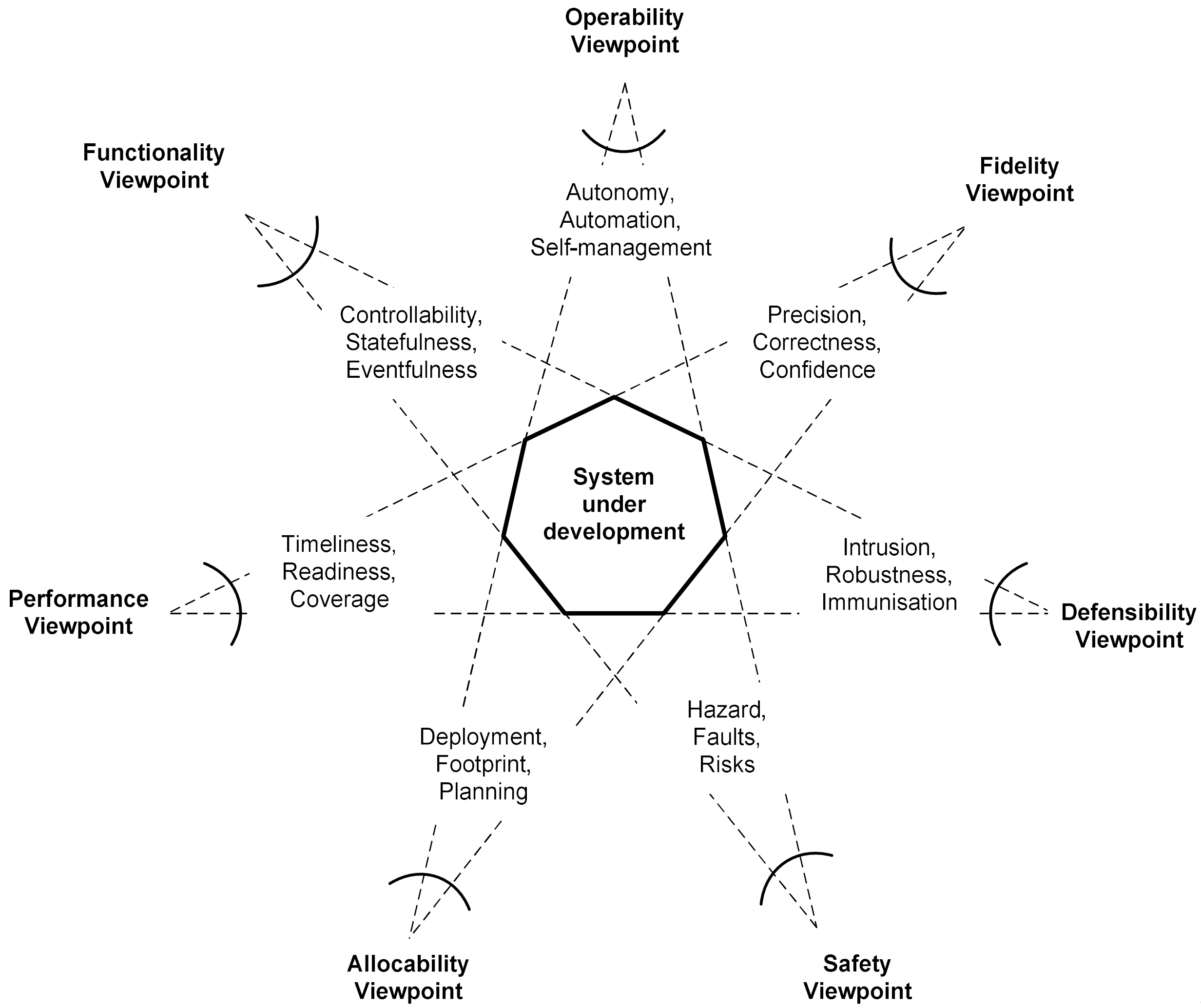




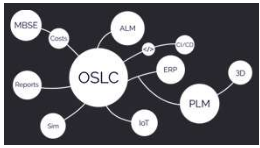
- **Target:** Functional & non-functional requirements
- **Constrain:** Multiple models and teams
- **Need:** Agile model cross-checking
- **Problem:** Deadlocks between development Teams

Different Views/Models of the Same System

- One single (unified) system model is impossible
- But it could be a notation-unified system model
- The approach is to merge notation from different domain-specific representations
- To check the impact of each representation on others can quickly be reflected.

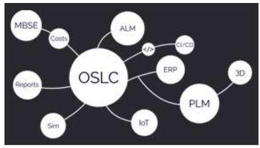


Related Existing Technologies



- Integration of Models
  - Cyber-Physical Modelling [1]
  - OSLC
  - MIC (Model-Integrated Computing) [2]
  - CIF (Compositional Interchange Format) [3]
- Multi-View Tools
  - Modelica (control) [4], 20sim (mechatronics) [5]
  - MIC, MVM [6]
- Single-View Tools
  - AADL [7], MARTE [8]
  - SysML, UML
  - COMPASS [9], CRYSTAL [10]
  - ISO/IEC/IEEE 42010 standard [11]

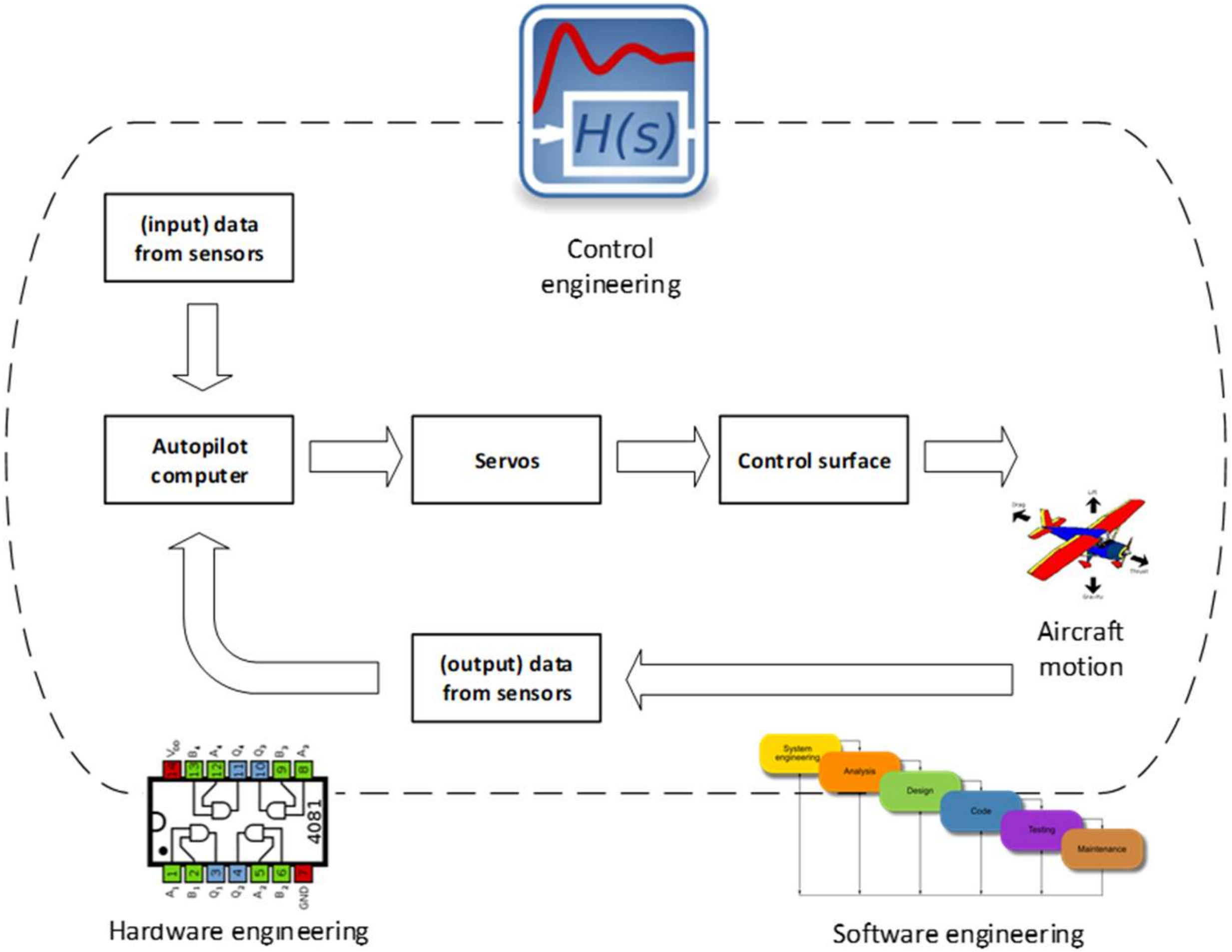
Application Example



- An automatic Flight Control System (AFCS).
- Three distinct models (views) from different engineering disciplines are considered to design the above AFCS:
  - a control engineering model,
  - a software application model
  - a hardware platform model.
- They have different description languages to model the AFCS, e.g. block diagrams, UML diagrams, and AADL diagrams.
- Three application scenarios:
  - a software application model connected to a hardware platform model and a control engineering model.
  - a hardware platform model connected to a software application model and a control engineering model.
  - A control engineering model connected to a hardware platform model and a software application model.

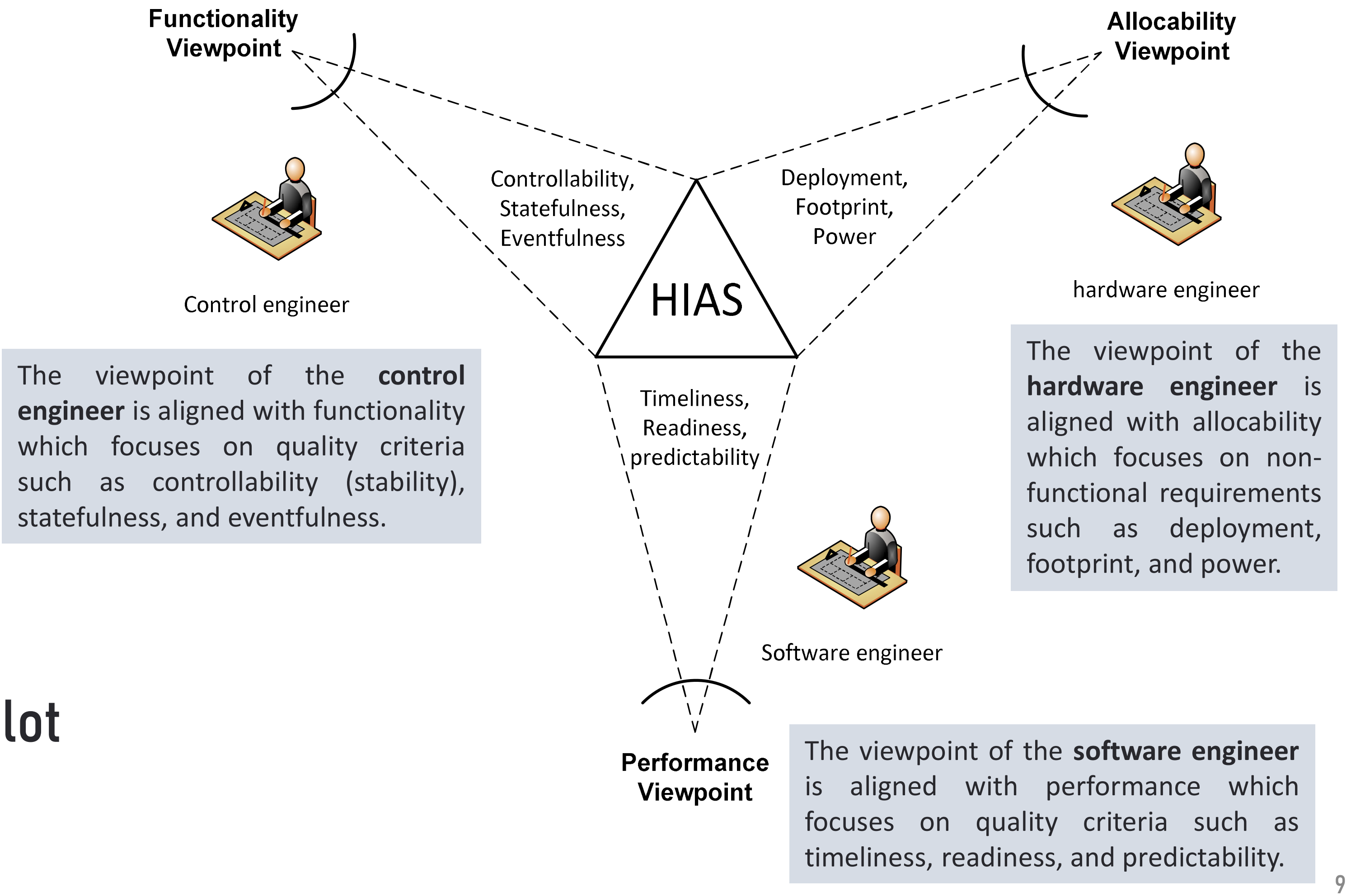
Simplified Example of Aircraft Autopilot

- Simple example but enough to show the idea
- Three disciplines
  - Control engineering
  - Hardware engineering
  - Software engineering
- Stakeholders from each discipline



Multiple Stakeholder Viewpoints

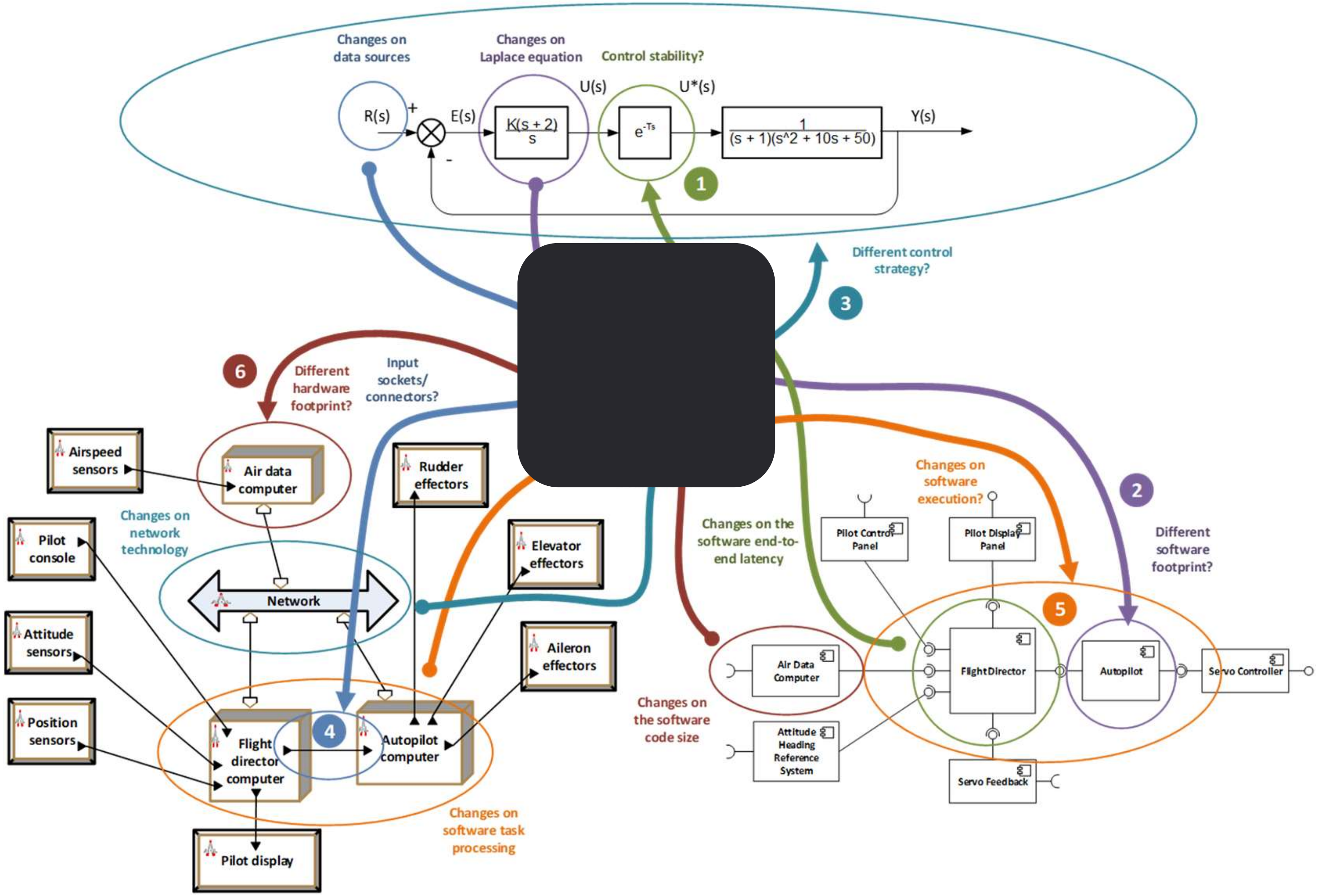
- Three stakeholders
  - Control engineer
  - Hardware engineer
  - Software engineer



- HIAS: AFCS or autopilot

Simplified Example of Aircraft Autopilot

1) SW-CW:
   Latency ⇒ Stability
2) CW-SW:
   Modelling ⇒ Footprint
3) HW-CW:
   Architecture ⇒ Strategy
4) CW-HW:
   Data ⇒ Socket
5) HW-SW:
   Processing ⇒ Execution
6) SW-HW:
   Coding ⇒ Footprint



Software Impact on Hardware and Control

Software Model Updates	Hardware Model Effects	Control Model Effects
End-to-end latency (QM)	SP: Execution SE: Task SC: Processing QF: Efficiency QC: Schedulability QM: Scheduling time	SP: Delay SE: Controller SC: Feedback control QF: Dependability QC: Responsiveness QM: Time response
	SP: Transmission SE: Packet SC: Communication QF: Efficiency QC: Responsiveness QM: Network latency	
Code size (QM)	SP: Footprint SE: Memory SC: Computation QF: Efficiency QC: Allocability QM: Hardware use	SP: Control parameter SE: Controller SC: Feedback control QF: Dependability QC: Stability QM: Root Locus, Bode margins
Data size (QM)	SP: Storage SE: Memory SC: Information QF: Efficiency QC: Mem Allocability QM: Mem use	
	SP: Bandwith SE: Network SC: Information QF: Efficiency QC: Network Usability QM: Network use	

Computation

Communication

SP: System Property
SE: System Element
SC: System Capability
QF: Quality Factor
QC: Quality Criteria
QM: Quality Metric

Model Analytics

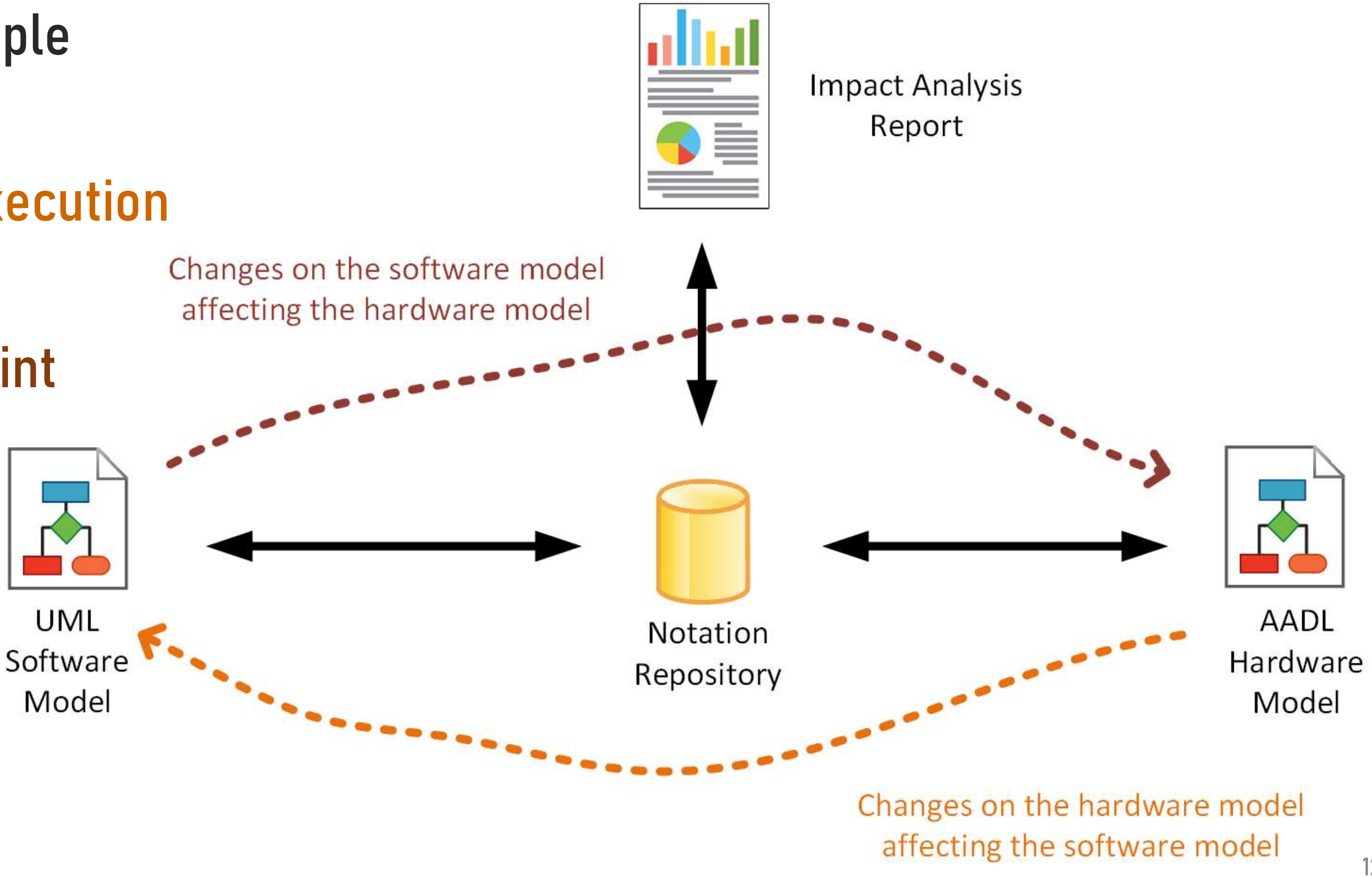
- HW-SW-HW Example

5) HW-SW:

   Processing ⇒ Execution

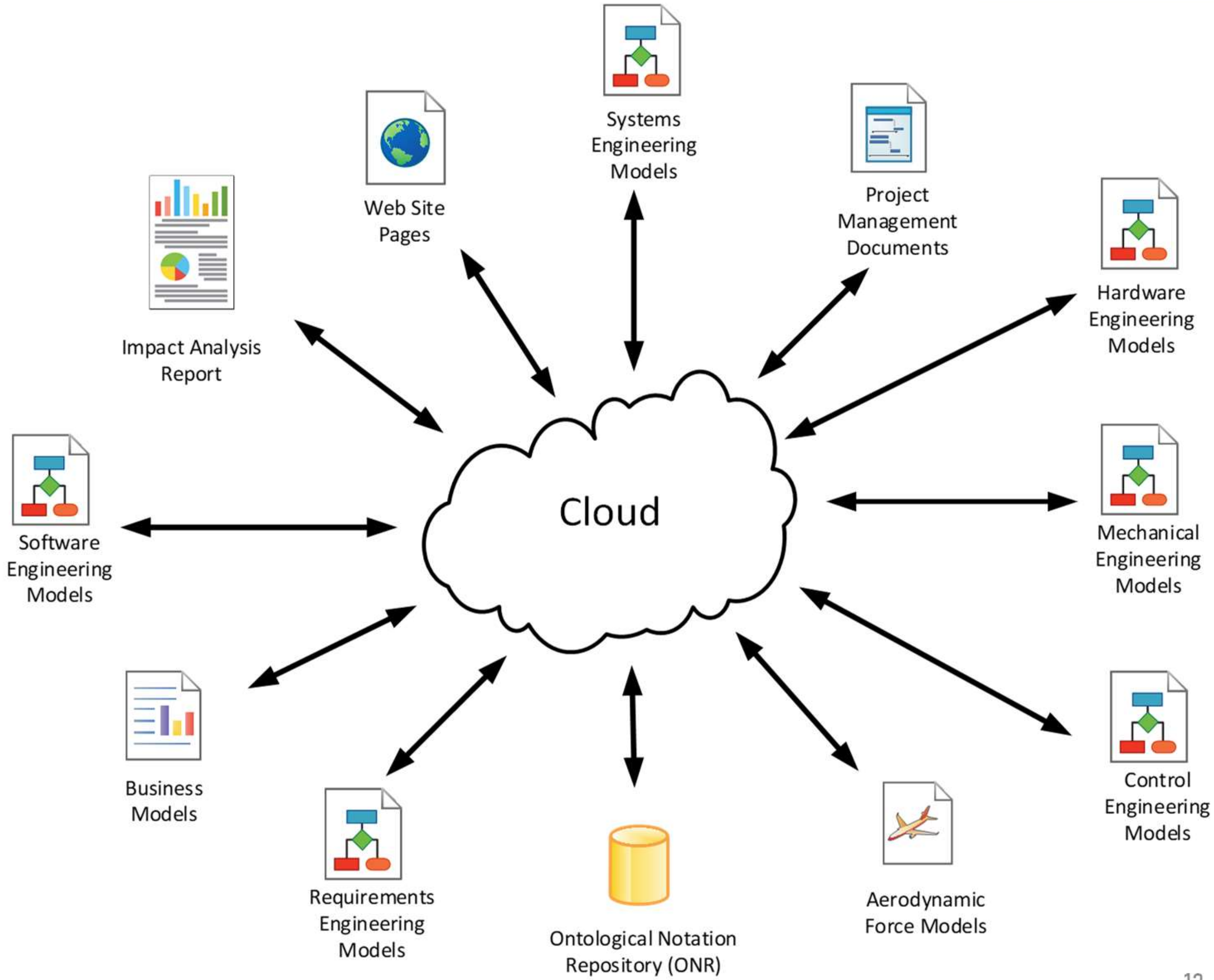
6) SW-HW:

   Coding ⇒ Footprint



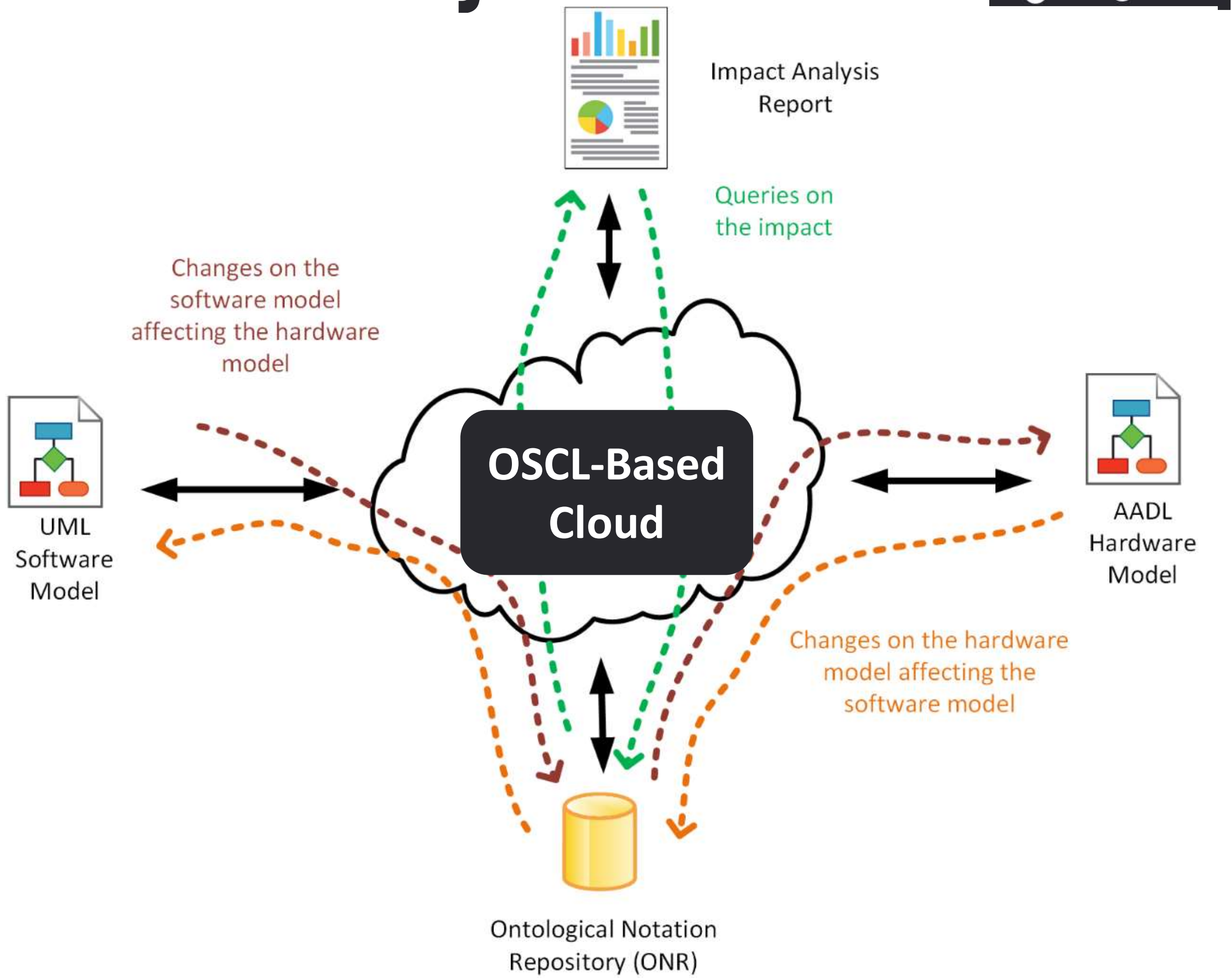
Cloud-Based Framework

- Implementing a cloud-based approach for the framework
- Merging the model notation (parameters) into a single repository for analysis
- Modelling notation includes the functional and non-functional requirements and constraints from different engineering disciplines.



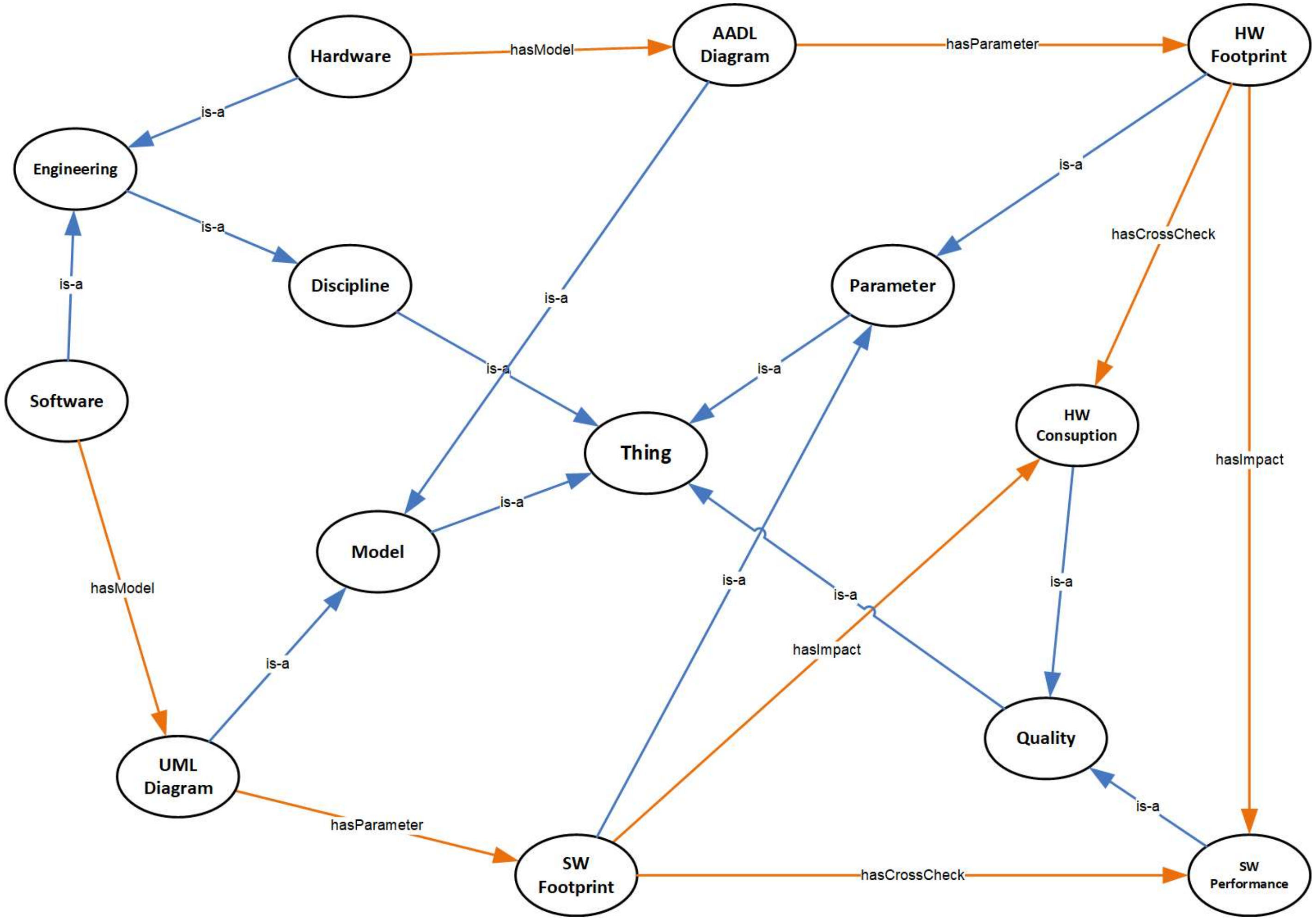
OSCL Cloud-Based Model Analytics

- Relating models
- Cross-checked modelling
- OSCL-based cloud to interconnect models



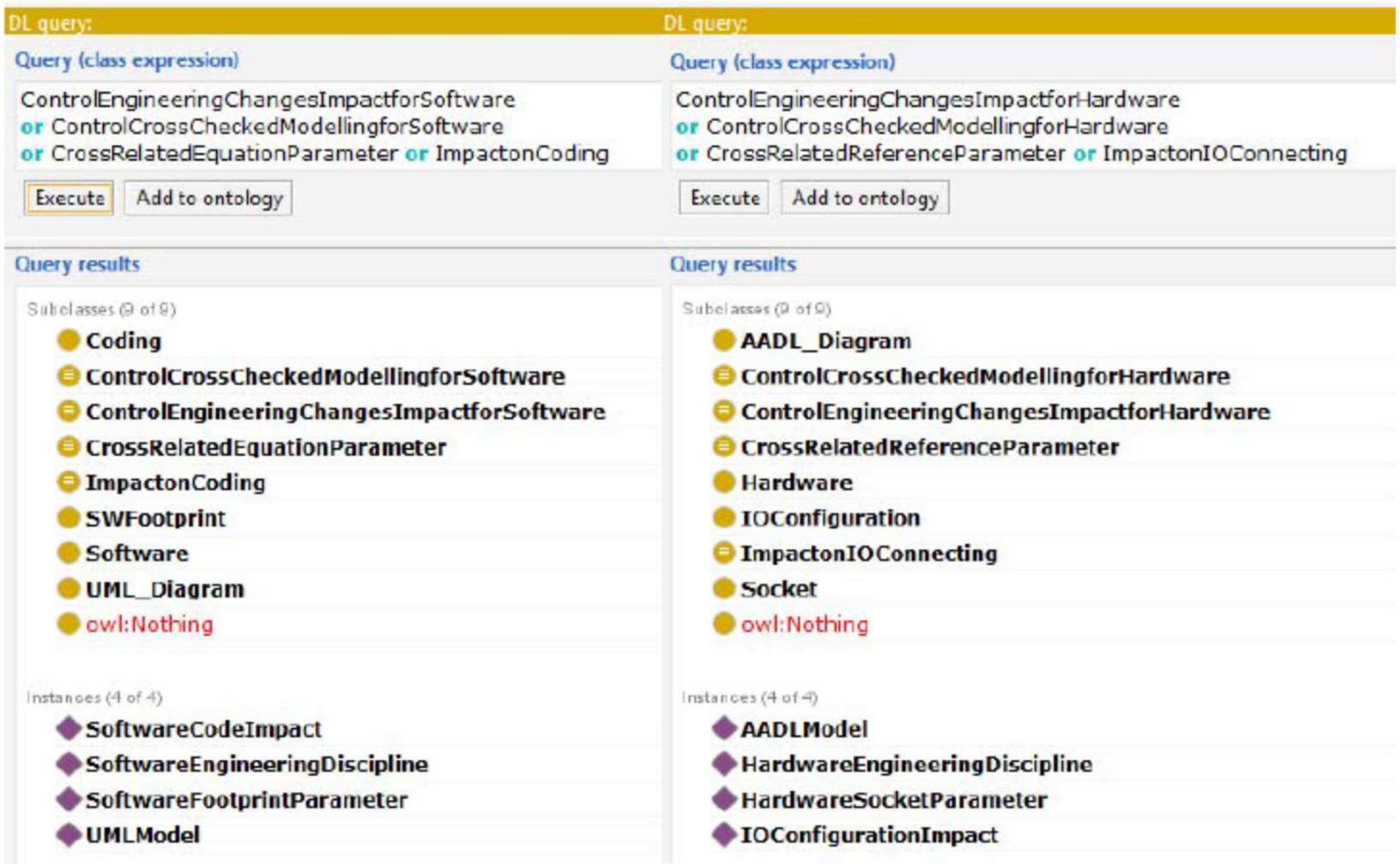
Ontological Notation Repository

- Ontologies make use of **semantic diagrams** to easily realize concepts the ontology and the connections between concepts.



Ontological Proof of Concept

- Protégé user interface for the ontology (ONR)
- Relating models and cross-checked modelling
- OSCL-based cloud to interconnect models



Software Model Service

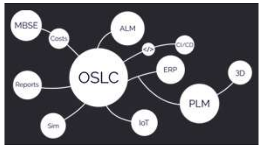
- Application scenario:
  - Software impacts on Hardware

- Software model on the Autonomous Model Analytics (AMA) application

- OSLC service interface for the software model
  - Creation of service
  - Resource shape
  - Query capability
    - Query resource

```
<oslc:service>
  <oslc:Service>
    <oslc:domain rdf:resource="http://open-services.net/ns/am#"/>
      <oslc:creationFactory>
        <oslc:CreationFactory>
          <dcterms:tittle>Creation of Software Model Service</dcterms:tittle>
          <!-- Creation of new resource (the software model)>
          <oslc:creation rdf:resource="http://host/creation/swmodelnotation"/>
          <!-- Metadata of the XML resource>
          <oslc:resourceShape rdf:resource="http://host/shapes/swnotationshape"/>
          <oslc:usage rdf:resource="http://open-services/ns/core#default"/>
          <oslc:resourceType rdf:resource="http://open-services/ns/am#Resource"/>
        </oslc:CreationFactory>
      </oslc:creationFactory>
      <oslc:queryCapability>
        <oslc:QueryCapability>
          <oslc:queryBase rdf:resource="http://host/query"/>
          <oslc:resourceShape rdf:resource="http://host/shapes/ swhwlinkqueryshape "/>
        </oslc:QueryCapability>
      <oslc:queryCapability>
   </oslc:Serice>
</oslc:service>
```

Software Model Resource Shape



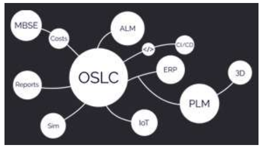

```xml
<?xml version="1.0" encoding="UTF-8"?>
<rdf:RDF xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
         xmlns:dcterms="http://purl.org/dc/terms/"
         xmlns:foaf="http://xmlns.com/foaf/0.1/"
         xmlns:oslc="http://open-services.net/ns/core#">

<oslc:ResourceShape rdf:about="http://host/shapes/swnotationshape">
  <dcterms:title>Shape for the software model notation</dcterms:title>
  <oslc:name>SWNotation</oslc:name>
  <oslc:describes rdf:resource="http://host/services/swm#Notation"/>

  <!–Resource shape for the software footprint parameter>
  <oslc:property>
    <oslc:Property>
      <oslc:name>SWF</oslc:name>
      <dcterms:title>Software Footprint</dcterm:title>
      <oslc:propertyDefinition rdf:resource="http://host/services/swm#SWF"/>
      <oslc:valueType rdf:resource="http://www.w3.org/2001/XMLSchema#integer"/>
      <oslc:occurs rdf:resource="http://open-services.net/ns/core#Zero-or-one"/>
      <dcterms:description>Use of hardware based on the software size</dcterms:description>
    </oslc:Property>
  </oslc:property>
```

```xml
    <!–Resource shape for the software performance quality>
  <oslc:property>
    <oslc:Property>
      <oslc:name>SWP</oslc:name>
      <dcterms:title>Software Performance</dcterm:title>
      <oslc:propertyDefinition rdf:resource="http://host/services/swm#SWP"/>
      <oslc:valueType rdf:resource="http://www.w3.org/2001/XMLSchema#integer"/>
      <oslc:occurs rdf:resource="http://open-services.net/ns/core#Zero-or-one"/>
      <dcterms:description>Software performance based on hardware 
capacity</dcterms:description>
    </oslc:Property>
  </oslc:property>
</oslc:ResoruceShape>
</rdf:RDF>
```

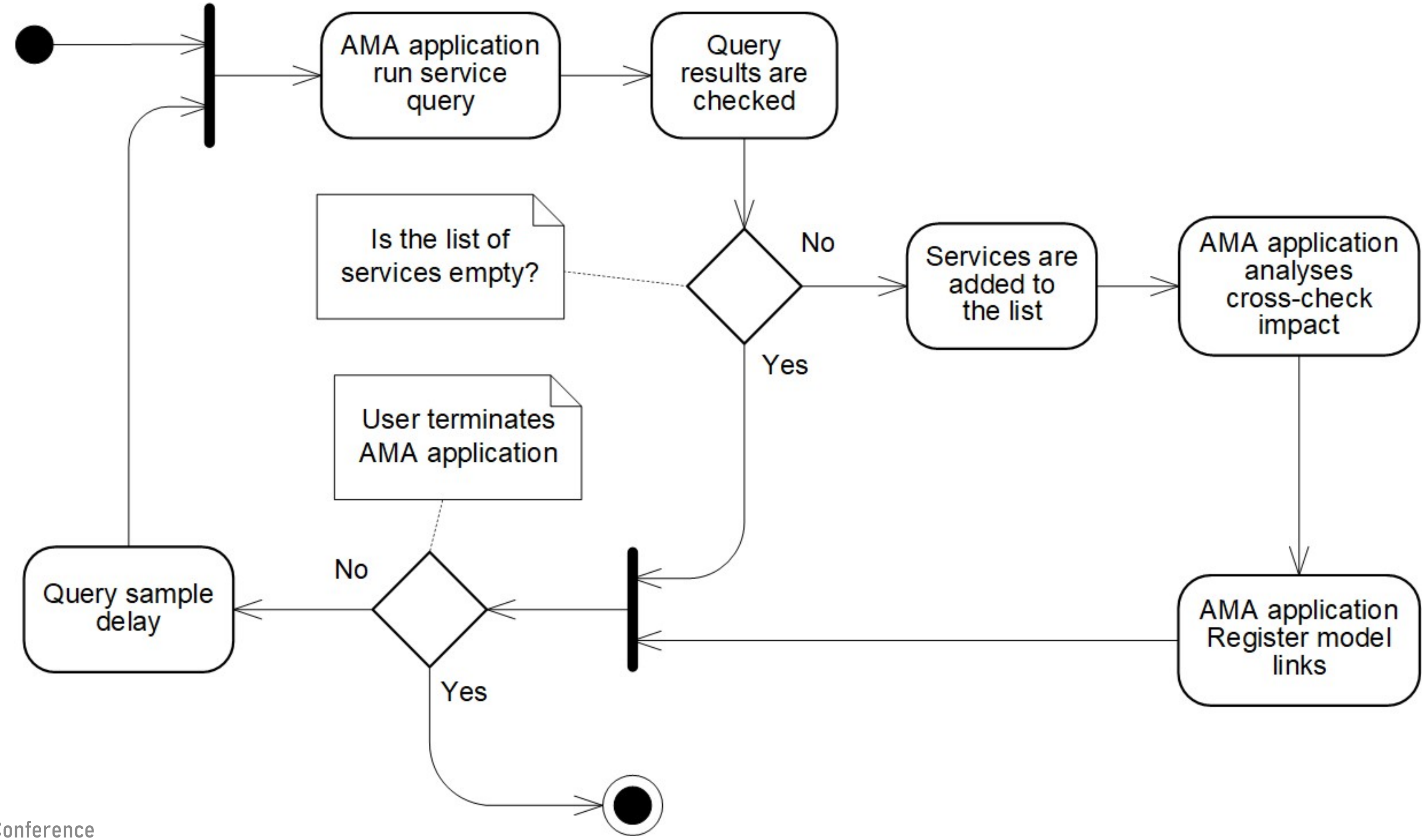
Software Model Query



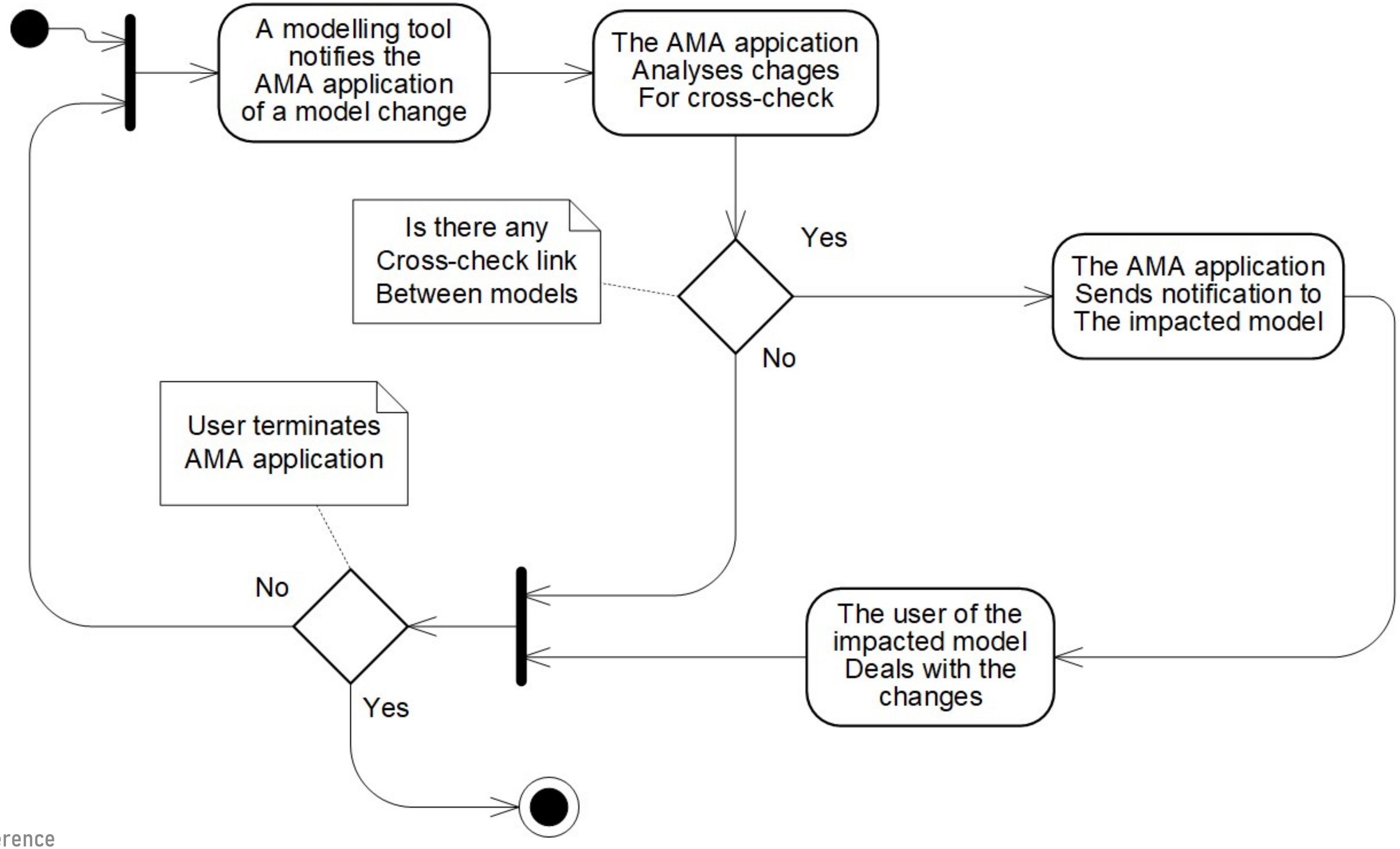

```xml
<?xml version=”1.0” encoding=”UTF-8”>
<rdf:RDF xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
         xmlns:dcterms="http://purl.org/dc/terms/"
         xmlns:oslc="http://open-services.net/ns/core#">
<oslc:ResourceShape rdf:about="http://host/shapes/swhwlinkqueryshape">
  <dcterms:title>Shape for the software-hardware link</dcterms:title>
  <oslc:type rdf:resource="http://open-services.net/ns/core#ResourceShape"/>
  <oslc:name>SwHwLinkQuery</oslc:name>
  <oslc:describes rdf:resource="http://open-services.net/ns/swm#"/>

  <!–Resource shape for the software-hardware link query>
  <oslc:property>
    <oslc:Property>
      <oslc:name>SWNotation</oslc:name>
      <oslc:occurs rdf:resource="http://open-services.net/ns/core#Zero-or-many"/>
      <oslc:valueShape rdf:resource="http://host/shapes/swnotationshape"/>
      <oslc:propertyDefinition rdf:resource="http://host/services/swm#Notation"/>
      <oslc:isMemberProperty>true</oslc:isMemberProperty>
    </oslc:Property>
  </oslc:property>
</oslc:ResourceShape>
</rdf:RDF>
```

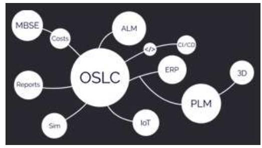
Discovery & Retrieve of Service Info



Analysis of Model Information



Reflective Remarks



- Impacts from model updates on other models cannot necessarily to implement in real time
- Benefits from the model cross-checking framework but is complex by nature; toward process automation
- Model impacts can be also used for performance assessment
- OSCL is a good driver for the framework. However, it will add some complexity to the framework.
- OSCL facilities the model interconnections for cross-checking impact but a lot of work on producing the XML files
- Need for an automated process for the generation of OSLC interfaces for the framework
- Future work: development of framework prototype

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