A Runtime-Model operational framework for Cyber-Physical Systems

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Overview

1. Fast forward 3 years of research to explain the foundations of my current work
2. My research background, explained through our case scenario
3. PrIMoR at a glance
4. The Runtime-Model operational framework

This research 2013 to 2015

IBM and
Personalized Web-Tasking

- Personalized Web-Tasking
  → Web-tasking
  → Tasking
- Self-Adaptive Systems and Context-awareness
- Personalization dimension

Personal goals and situation awareness

Situation-awareness is the capability of the system to not only be aware of contextual changes, but also capable to reason about it as a situation of the context entity, and provide decision-making support [Endsley 1995].

[1] M. R. Endsley. Toward a theory of situation awareness in dynamic systems: Situation awareness. Human factors, 37(1):32-64, 1995

Where is the personal context?

Information, devices, interactions, behaviour, social connections, preferences...

Self-Adaptive Software Systems

Self-adaptive software systems respond to uncertainty by performing changes over itself (structural or behavioural) at runtime, to maintain the relevance of the system with its objectives [Cheng et al. 2009, Müller et al. 2009].

[1] B. H. Cheng, et al. . Software engineering for self-adaptive systems: A research roadmap. Software engineering for self-adaptive systems, LNCS 5525:1-26, 2009.
[2] H. A. Müller, H. M. Kienle, and U. Stege. Autonomic computing: Now you see it, now you don't. Design and evolution of autonomic software systems. Lecture Notes in Computer Science, 5413:32-54, 2009

Runtime Models

Runtime models provide up-to-date information about the system and its environment (i.e., context, users, and requirements) and can be manipulated and adapted at execution time.

Cyber-Physical Systems

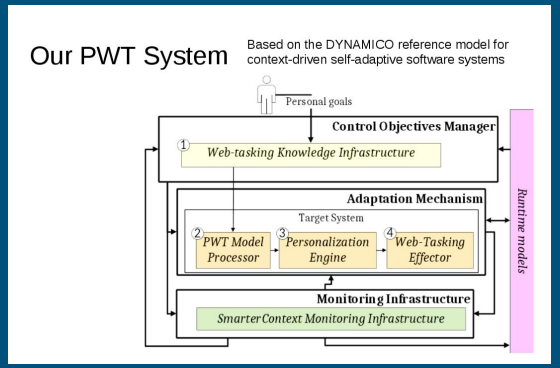
“A cyber-physical system consists of a collection of computing devices communicating with one another and interacting with the physical world via sensors and actuators in a feedback loop.”

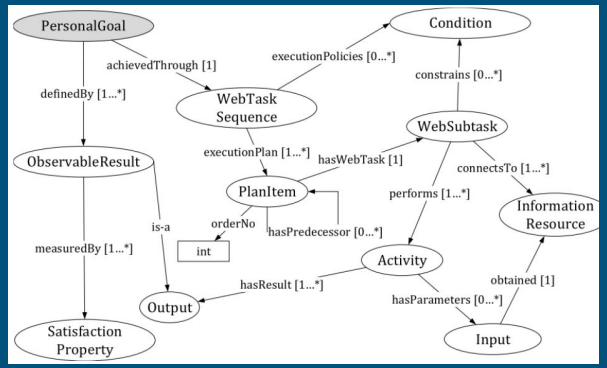
[1] Rajeev Alur. Principles of Cyber-Physical Systems. Computer Science and Intelligent Systems MIT Press, April 2015

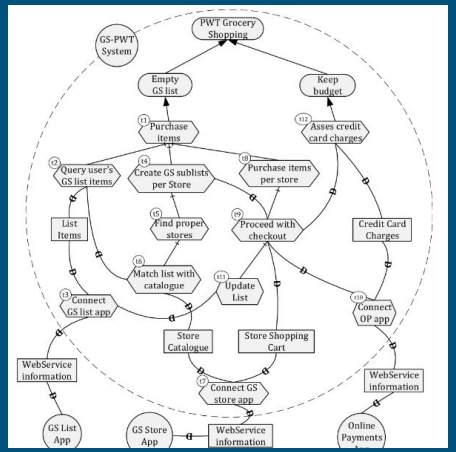
Self-adaptation in Cyber-Physical Systems

The system’s capability to sense and monitor changes in the context, reason upon those changes, and decide and execute required adaptation in order to fulfill the system’s objectives, while the system is in execution.

The PWT project results







SUSGroceries Mobile Application

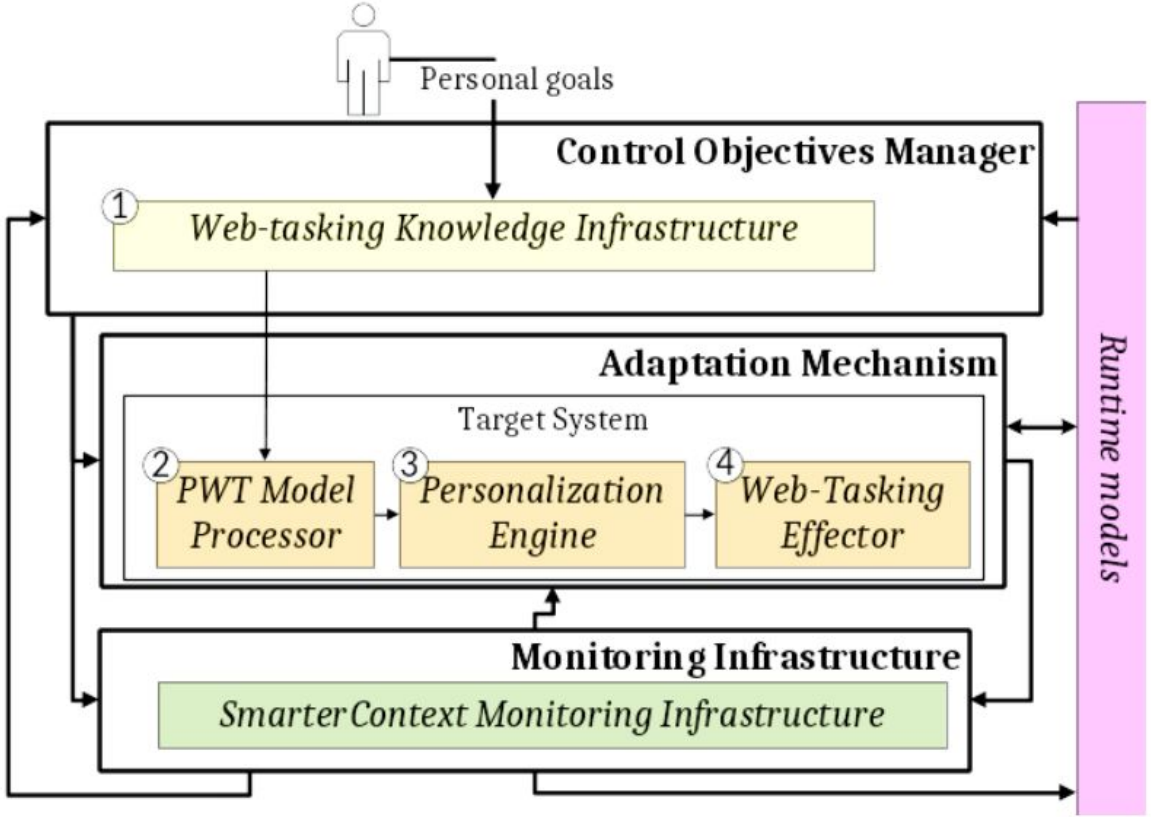
Smart Personalized Web-Tasking application for Grocery Shopping

Fun fact:The word **SUS** in our app name stands for Smart User-Centric System. But "sus" means "your" in Spanish, so technically when you say "SUSGroceries" you are actually saying "Your groceries". Pretty appropriate for a Personalized Web-Tasking application eh?

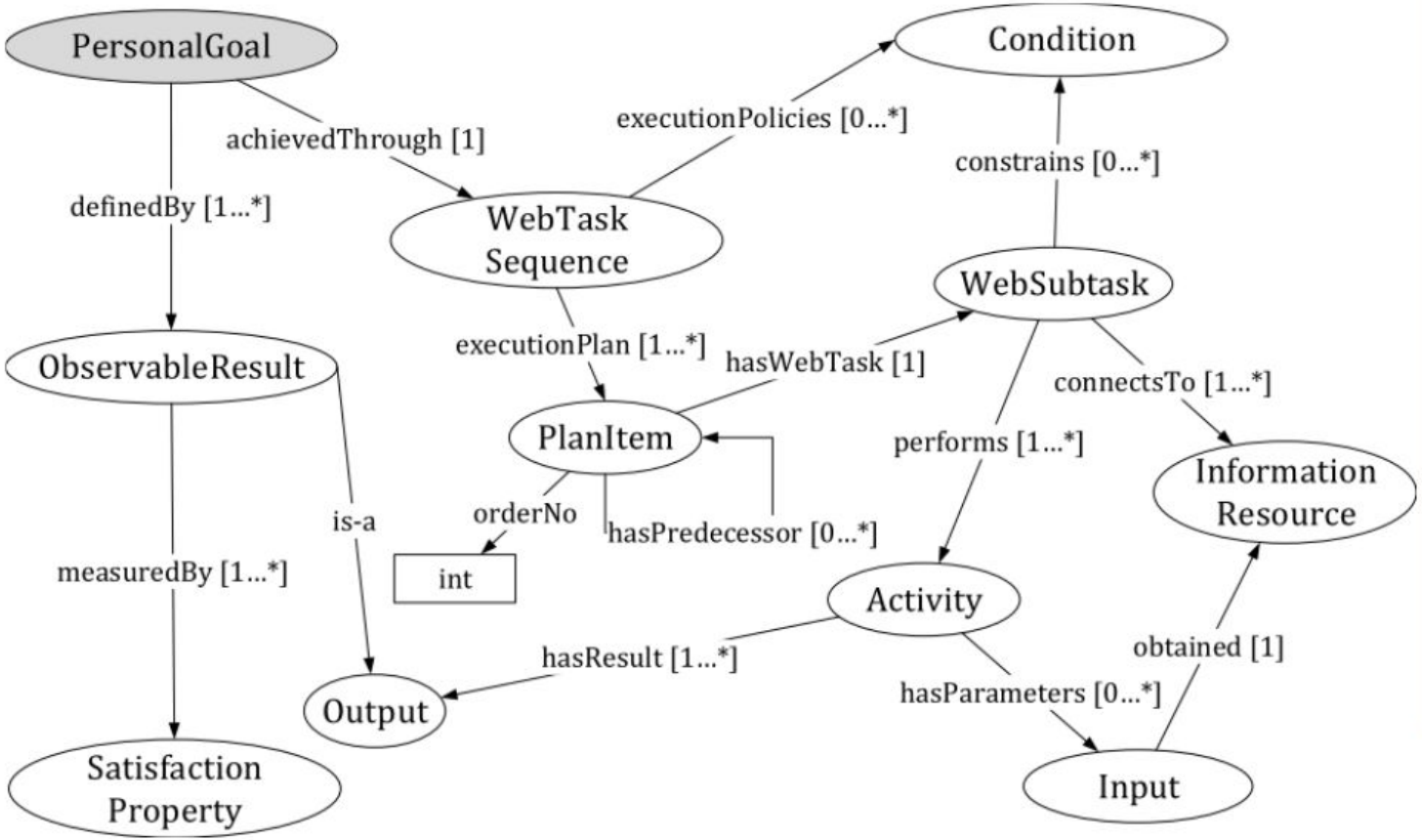
SUSGroceries Video Demo

Our PWT System

Based on the DYNAMICO reference model for context-driven self-adaptive software systems



PWT Ontology Model



Defines the concepts of personalized web tasking

Is available as a runtime model in the form of an OWL2/RDF file

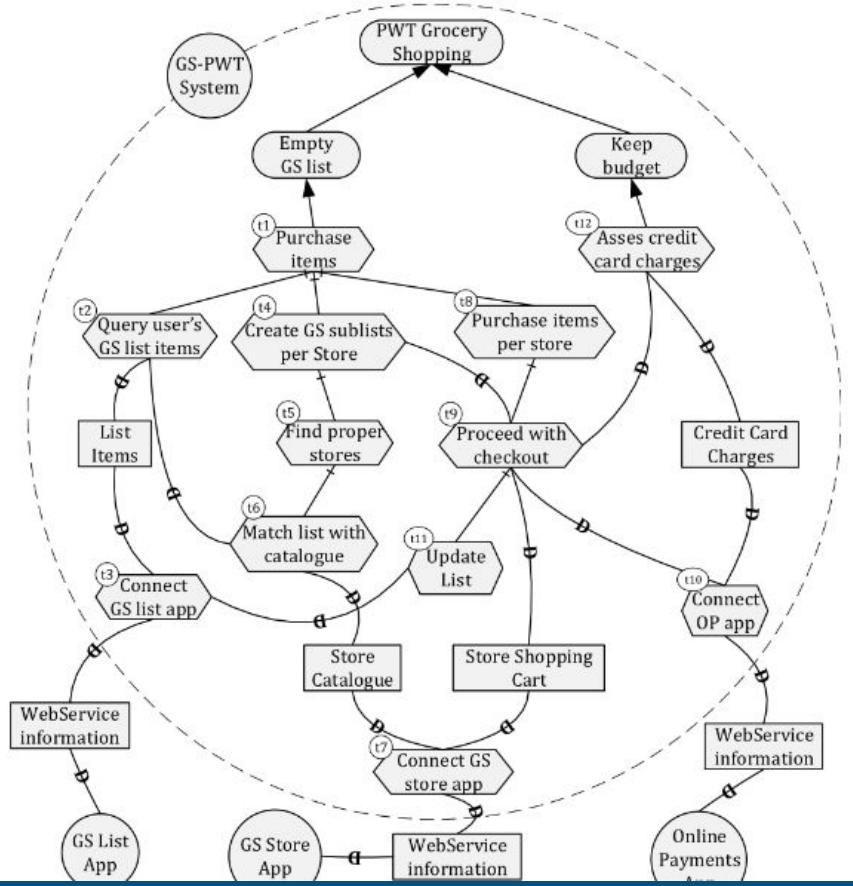
Is applicable in different domains, and can be extended according to the evolution of the web.

Goal-Oriented Context-Sensitive Web-Tasking Model

We extended the iStar atomic notions of actor, goals, task and resources, to support the specification of web-tasking goals, task sequences, tasks and subtasks, as well as the relationships among tasks, subtasks and resources.

Conventions: i* to PWT

Actor	PWT System, External Application (web services)
Goal	User's personal goal, observable results
Task	Web-subtasks
#	Web-task sequence number
Resource	Information Resources



The smart online grocery shopping scenario

Personalization, Automation, and Situation-Awareness

SUSGroceries Mobile Application, CASCON 2014
http://www.rigiresearch.com/research/pwt/susgroceries

Obstacles

SUSGroceries final version?

Instrumentation
Privacy and Security
Standardization
Access to the Personal Context

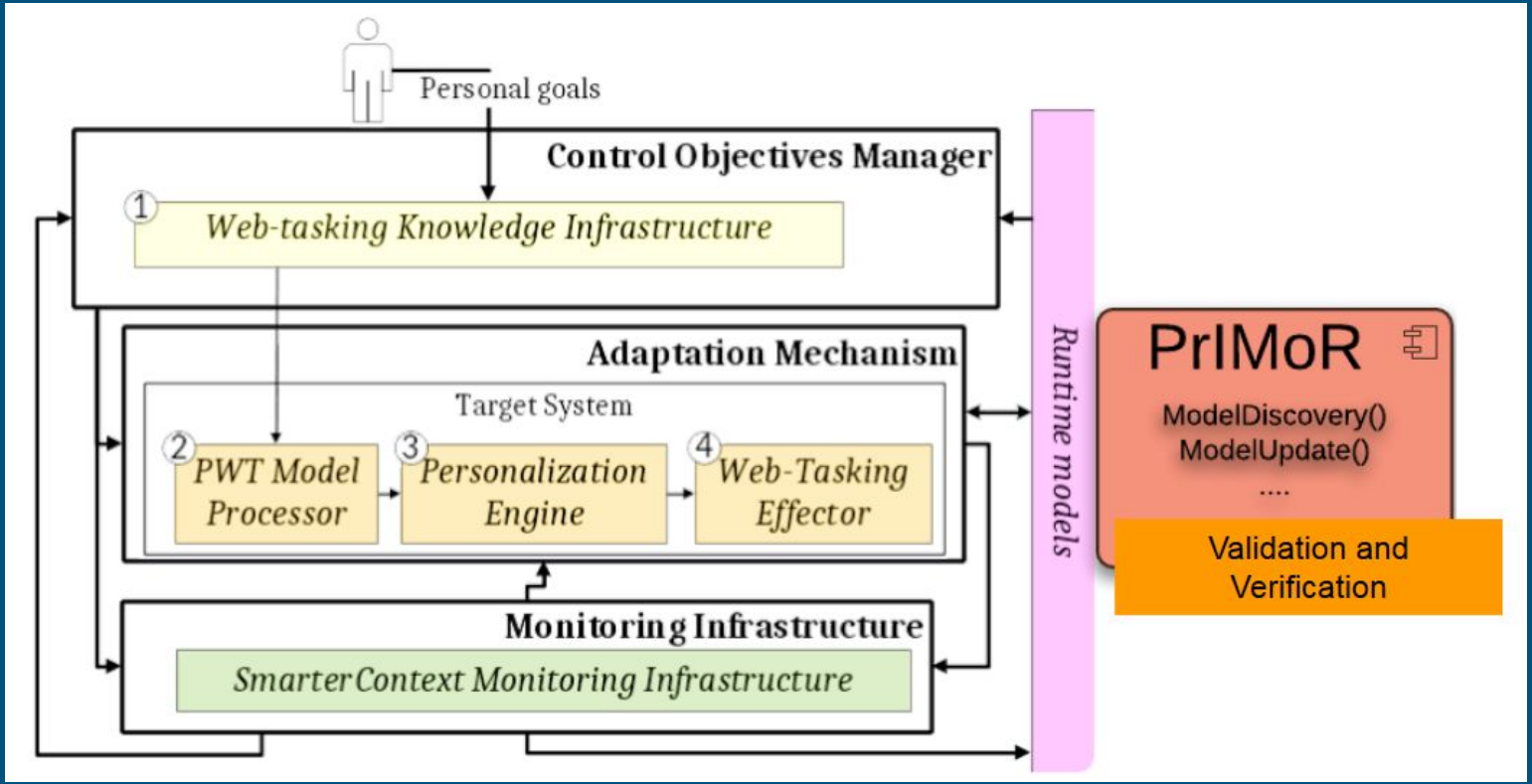
PrIMoR

Processing Infrastructure for Models at Runtime

A component-based processing infrastructure to manage runtime models operations at execution time.

Main services include:

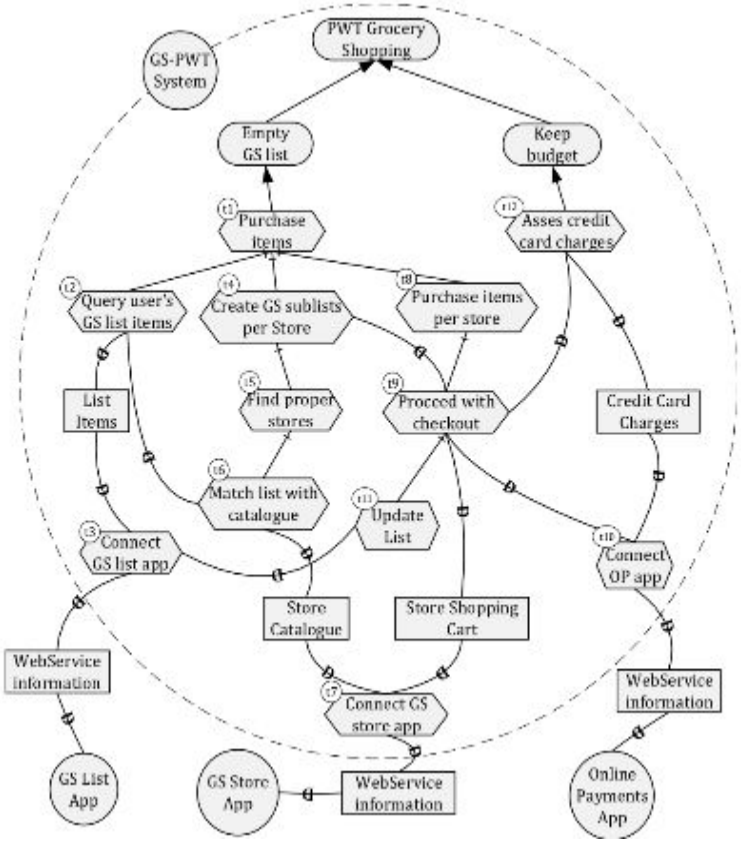
1. Model discovery/monitoring, implies the creation of an abstract representation (i.e., model) of a reality (i.e., system, user, or context)) and further monitoring
2. Model adaptation operations (i.e., add, delete, and modify elements in the model).


Personal goals
Control Objectives Manager
1
Web-tasking Knowledge Infrastructure
Adaptation Mechanism
Target System
2
PWT Model Processor
3
Personalization Engine
4
Web-Tasking Effector
Monitoring Infrastructure
SmarterContext Monitoring Infrastructure
Runtime models
PrIMoR
ModelDiscovery()
ModelUpdate()
....
Validation and Verification

A runtime-model operational framework for cyber-physical systems

1. A hierarchical **library of runtime model operations** (model-generic to model-specific)
2. A library of **selected types of software model** along with their corresponding software artefact realizations, and runtime semantics to support runtime operations

Library of Operations



GCT model representation → Graph (Node, Arc)

General Graph model operations:

- Add Node/Arc
- Remove Node/Arc
- Update Node/Arc

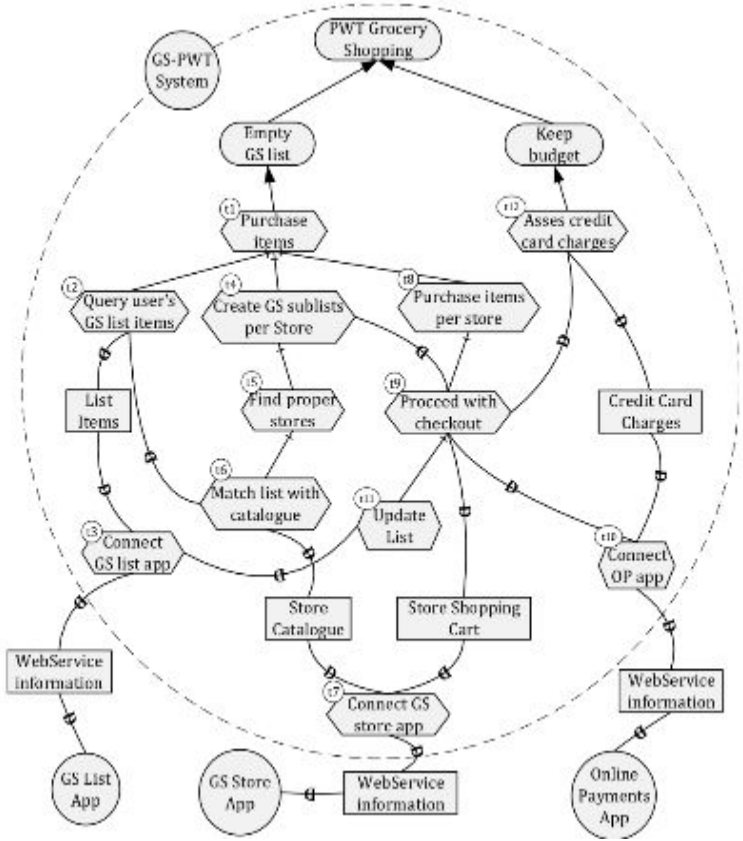
Goal Model Specific Operations:

- Add Goal / Task / Resource / ...
- Remove Goal / Task / Resource / ...
- Update Goal / Task / Resource / ...

GCT model specific operations

- Add Web Task / Personal Goal / …
- Remove Web Task / Personal Goal / …
- Update Web Task / Personal Goal / …

Operations into commands

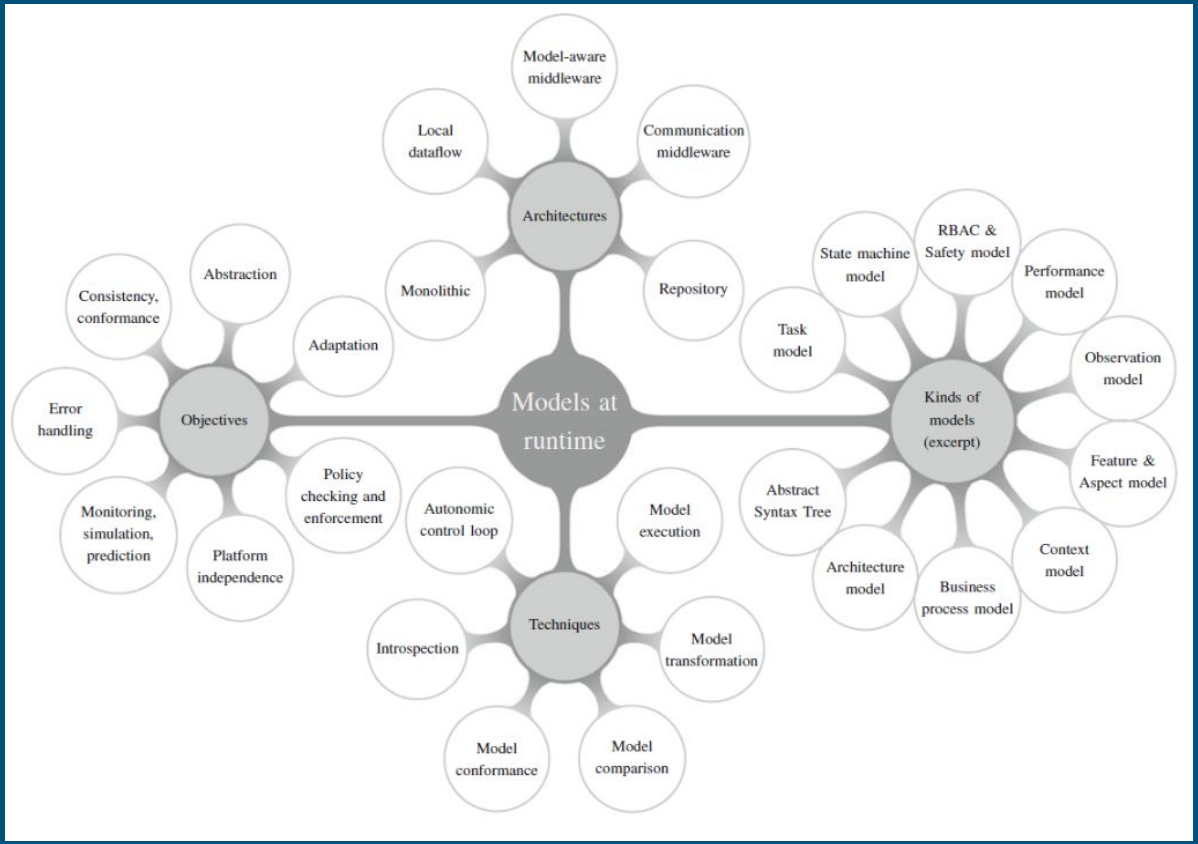



```
AddWebTask(model.GCT <T>, type <T>,
descriptors<T>, preconditions <T>,...)

if (preconditions(type)){
     AddNode(type,descriptors,model.syntax)
          validation(model.structure)
          validation(model.restrictions)
          validation(model)
          ...
     }
```

Current Challenges

- All kinds of runtime models
- What are all possible model realizations?
- What are the runtime semantics?



[1] Michael Szvetits and Uwe Zdun. Systematic literature review of the objectives, techniques, kinds and architectures of models at runtime. (2013)

Thank you