TECHNISCHE UNIVERSITÄT DRESDEN

Fakultät Informatik | Institut für Software- und Multimediatechnik | Lehrstuhl für Softwaretechnologie

Beyond Objects

From object modeling to role modeling

Forschungslinie - Einführung in die Forschung

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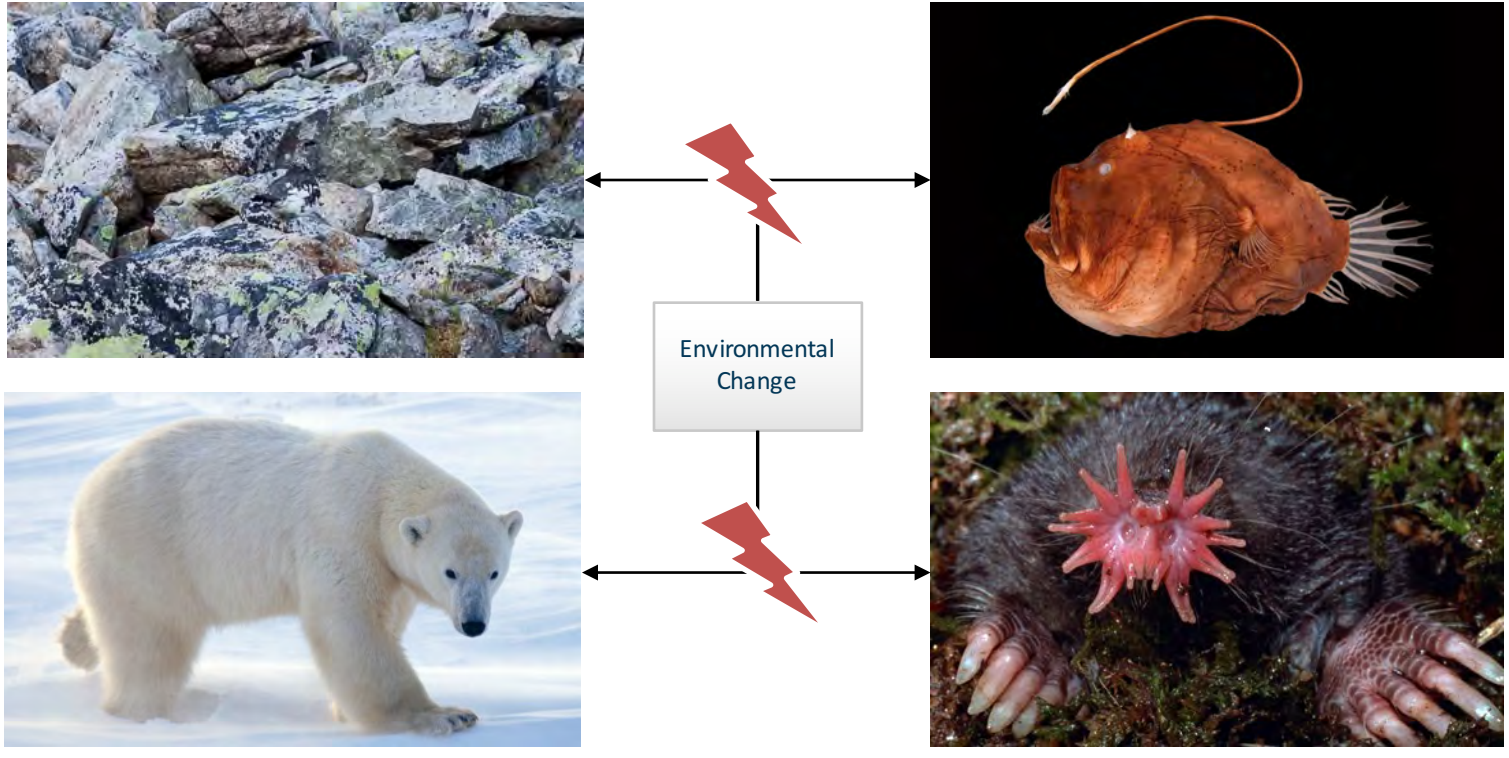
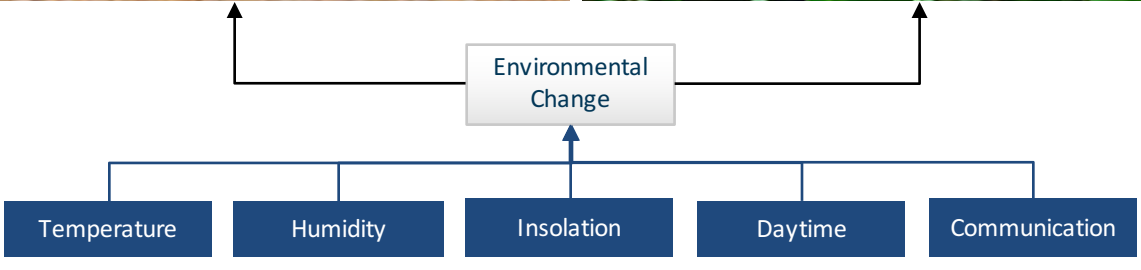
DRESDEN concept
Exzellenz aus Wissenschaft und Kultur

ALPENSCHNEEHUHN

Static Adaptation - Specialization



Dynamic Adaptation



- **Application site**: well known
- **Task**: clearly specified
- **Interaction with humans**: none / sparse
- **Reaction on changes**: plannable

- **Application site**: unknown
- **Task**: varying
- **Interaction with humans**: intensive
- **Reaction on changes**: frequent / partially unplannable

Classic (Model-driven) Software Engineering

- Requirements Analysis
- Design
- Implementation
- Test

Engineering of Self-Adaptive Systems

- Unknown/Changing Stakeholders, Environments, Tasks
- Unknown/Changing Requirements
- Design for change

Static Adaptation - Specialization

Adaptation?

Changing Context = Changing Requirements

Software is Ubiquitous and Indispensable

Ecosystem of Devices

Smart Production

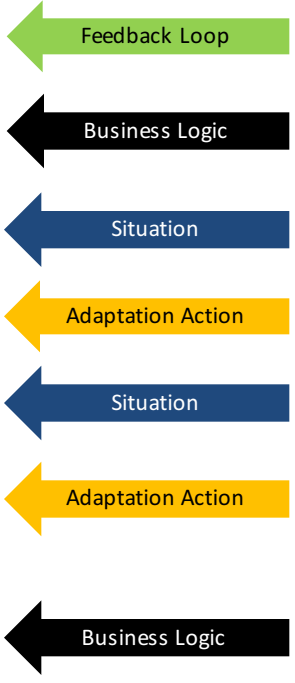
Smart Spaces

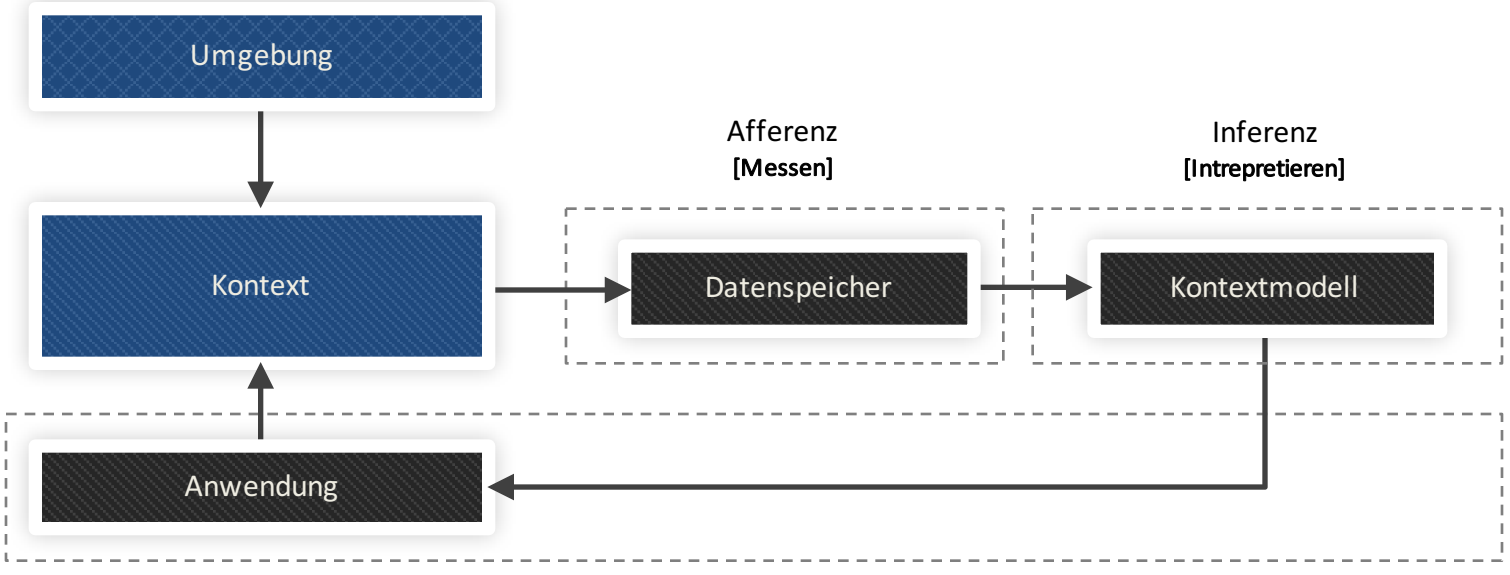
Robots

Application Example – Care-O-bot® 3

```
while(true) {

  Position pos = getNextTargetPosition();

  if (!isCarryingObject()) {
     motion.maxSpeed = 1.5;
     motion.acceleration = 1.0;
  }
  else{
     motion.maxSpeed = 0.5;
     motion.acceleration = 0.1;
  }

  driveToPosition(pos);

}
```

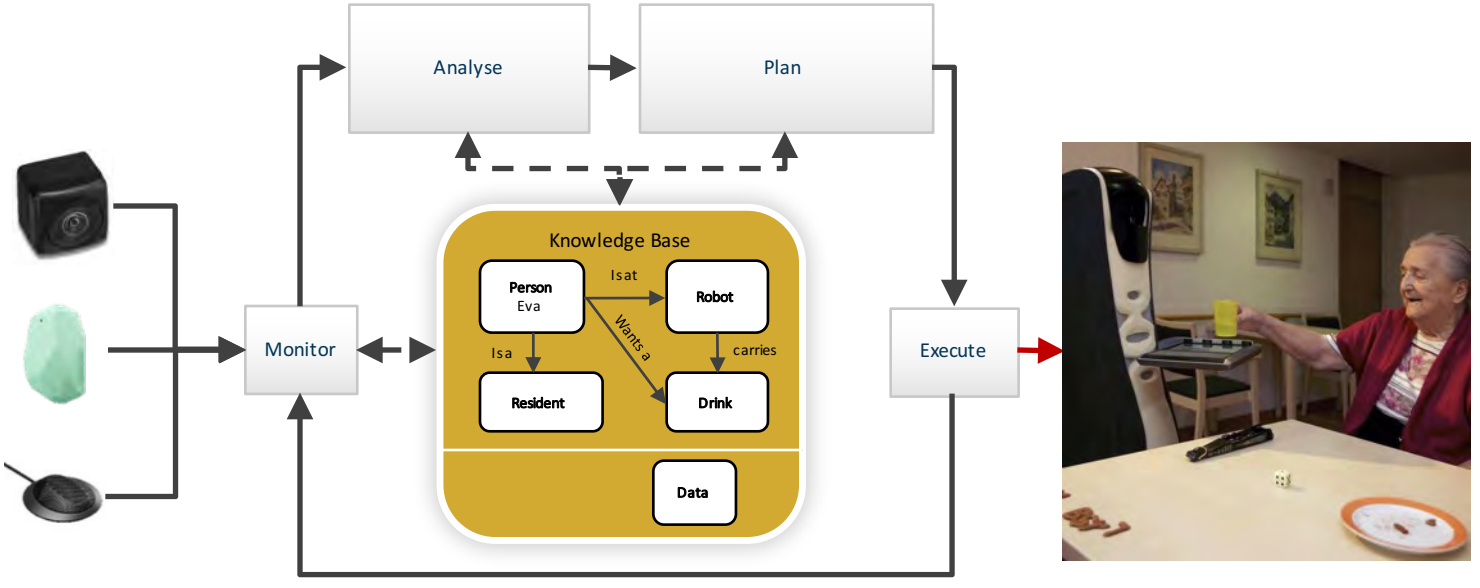
```
while(true) {

  Position pos = getNextTargetPosition();

  if (!isCarryingObject()) {
     motion.maxSpeed = 1.5; //1.5 m/s
     motion.acceleration = 1.0; //1 m/s²
  }
  else {
     motion.maxSpeed = 0.5;
     motion.acceleration = 0.1;
  }

  driveToPosition(pos);
}
```



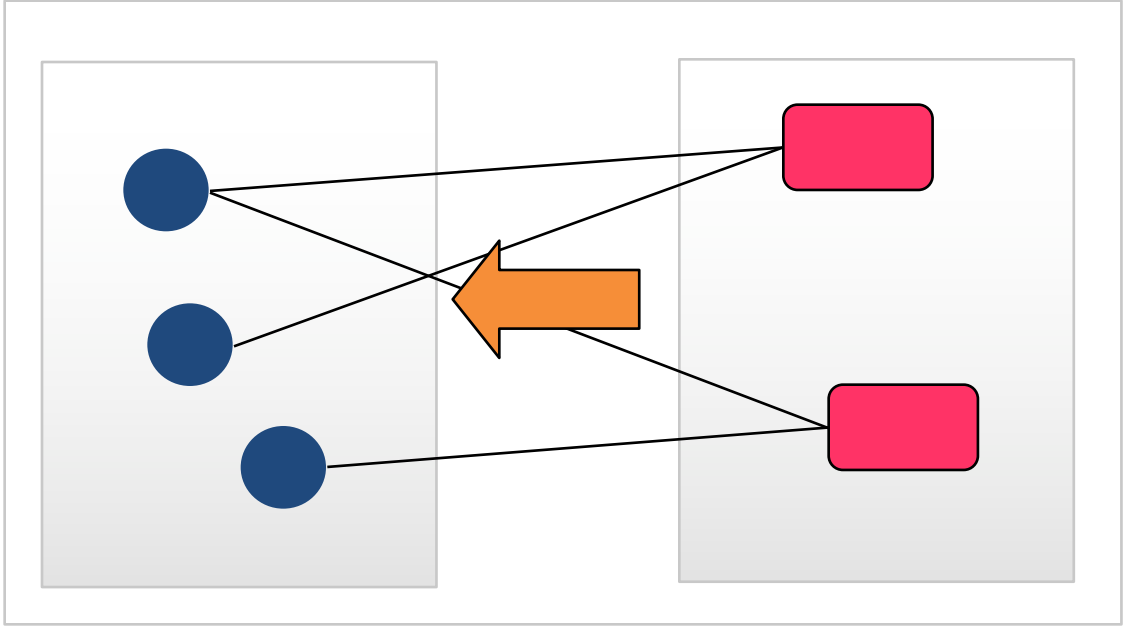

Umgebung
Afferenz
[Messen]
Inferenz
[Intrepretieren]
Kontext
Datenspeicher
Kontextmodell
Anwendung

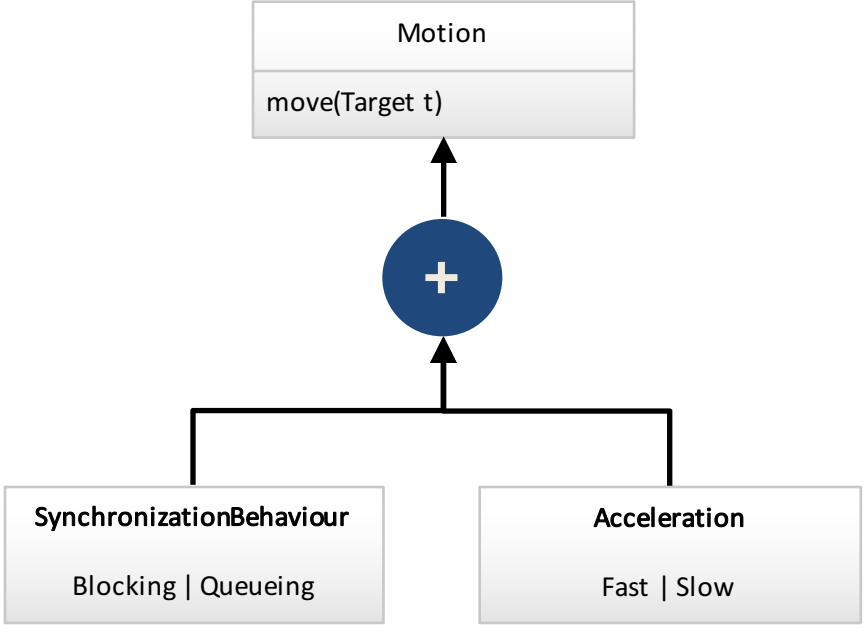
MAPE-K Feedback Loop

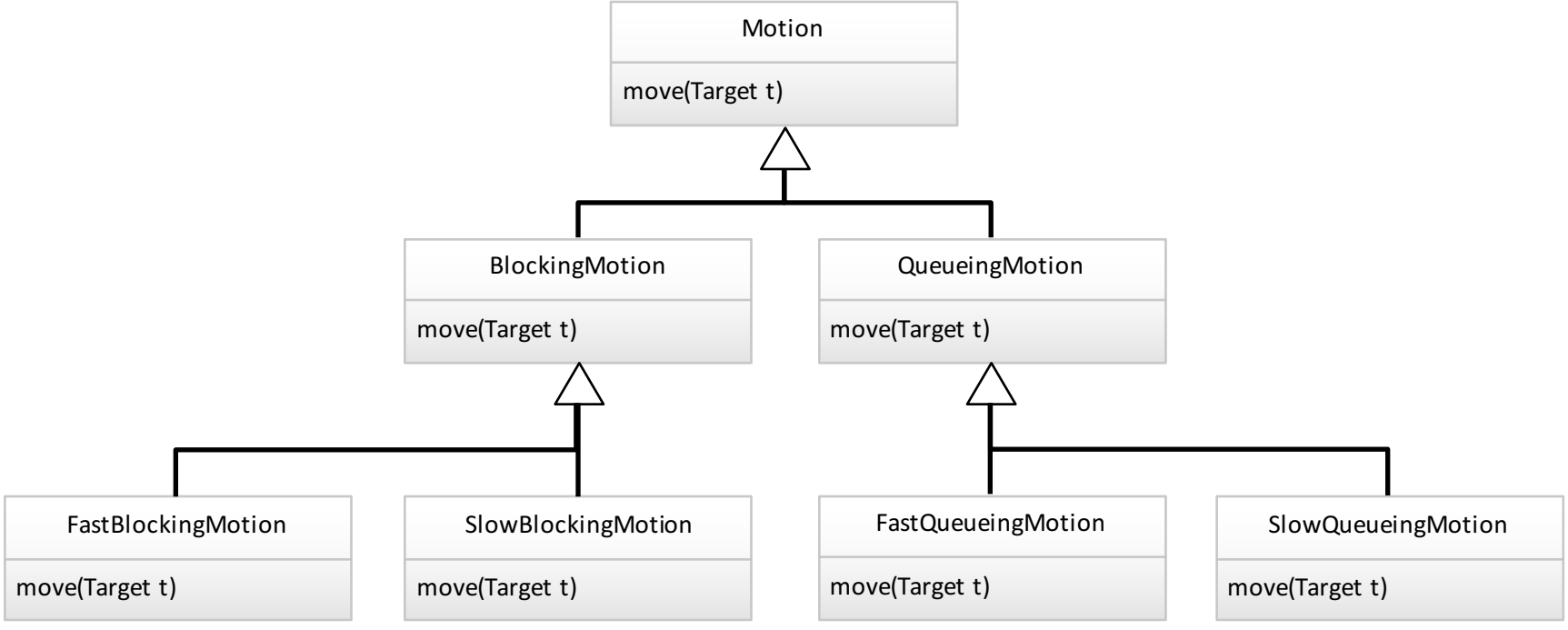
Dobson et al. [DZH+06]



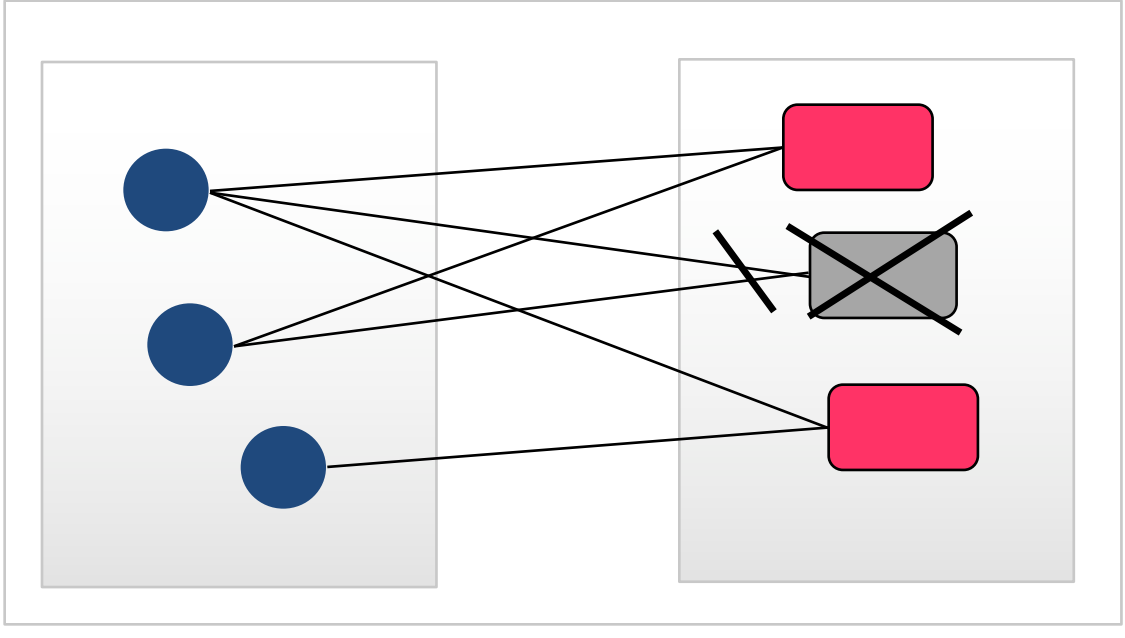
How to extend software(at runtime)?



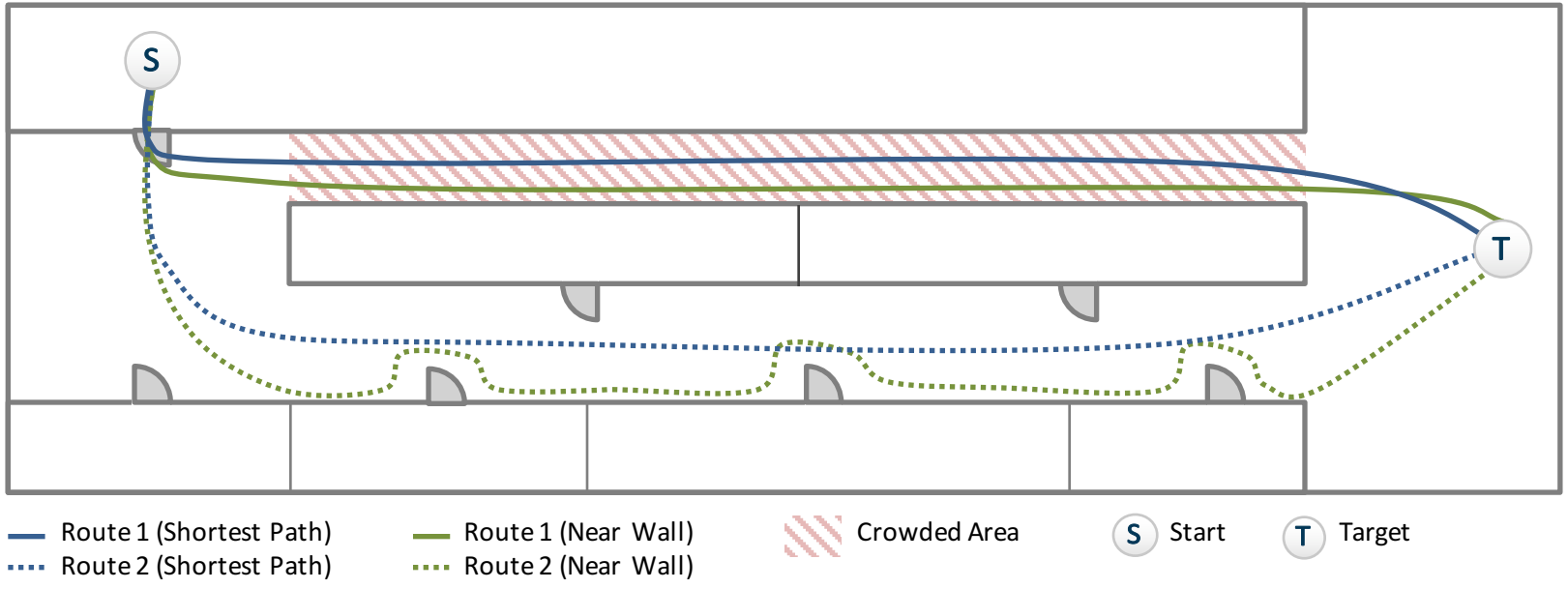

Motion
move(Target t)
+
SynchronizationBehaviour
Blocking | Queueing
Acceleration
Fast | Slow


Motion
move(Target t)
BlockingMotion
move(Target t)
QueueingMotion
move(Target t)
FastBlockingMotion
move(Target t)
SlowBlockingMotion
move(Target t)
FastQueueingMotion
move(Target t)
SlowQueueingMotion
move(Target t)

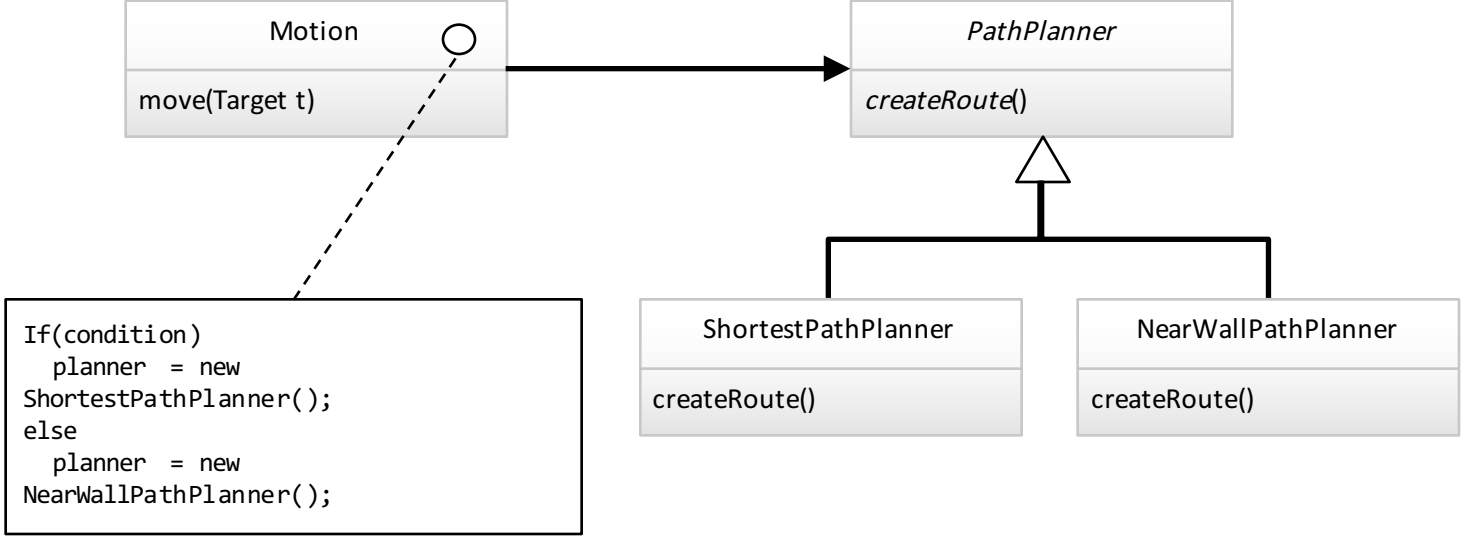
How to substitute components (at runtime)?



Example


S
T
Route 1 (Shortest Path)
Route 2 (Shortest Path)
Route 1 (Near Wall)
Route 2 (Near Wall)
Crowded Area
S Start
T Target

Strategy based Variability

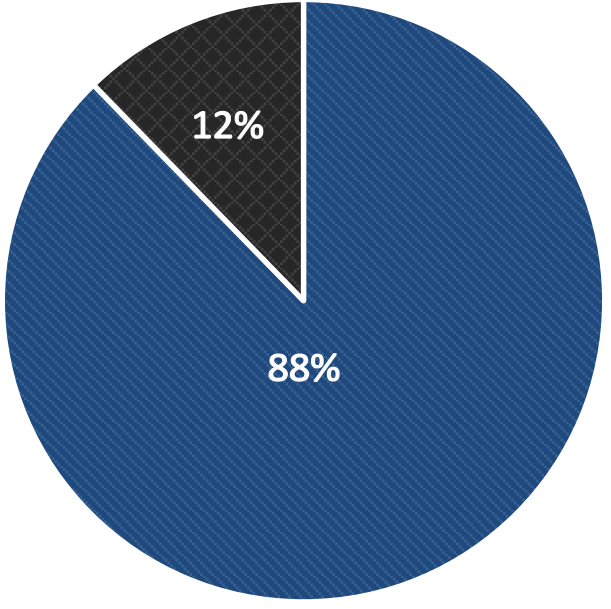


```
if (se instanceof Human) {
  if (hum.isPositionDefined()) {
    if (world.getEntity(hum.getPosition()) instanceof Refuge ||
        world.getEntity(hum.getPosition()) instanceof Road ||
        world.getEntity(hum.getPosition()) instanceof AmbulanceTeam) {
      ...
    } if (!world.getEntity(hum.getPosition()).equals(location())) {
      ...
    }
  }
  if (hum.isHPDefined() && hum.getHP() == 0) {
    ...
  }
  if (se instanceof AmbulanceTeam && hum.isBuriednessDefined() &&
      hum.getBuriedness() == 0) {
    ...
  }

  if (hum.isBuriednessDefined()) {
    if (hum.getBuriedness() == 0 && hum instanceof Civilian) {
      ...
    }
  }
}
```

Lines of Code
31344

Lines of Business Logic
27898

Number of IF-Statements
3427



DiVA – Dynamic Variability in Complex, Adaptive Systems

- European Project 2008-2011 (7th Framework Programme)
- Approach to build and execute Self-Adaptive Systems
- Based on Java

- Separatation of Architectural Models and Adaptation Models
  - Application described using models (components)
  - Adaptation described using aspects (SmartAdapters)
  - Context described as properties with values
  - Rules described as condition → mapping to goals
  - Influence of variants (Aspects) to goals is modelled

	Power Consumption	Network usage	Map Detail	Routing accuracy	Data Latency
Routing (RTG)	true	False	False	true	false
Local Routing (LR)	Low	-	-	Medium	-
Map Based Routing (MBR)	High	-	-	Medium	-
External Routing (ER)	Medium	-	-	High	-
Networking (NET)	true	False	False	False	false
Bluetooth (BT)	High	-	-	-	-
GPRS (GPRS)	Medium	-	-	-	-
Sensors (SEN)	true	False	true	true	false
Camera (CS)	High	-	High	High	-
Infrared (IRS)	Low	-	Medium	Low	-
Ultrasonic (USS)	Low	-	Low	Medium	-
Map Building Strategy (MBS)	true	true	true	false	false
Simple Map (SM)	Low	Low	Low	-	-
Detailed Map (DM)	High	High	High	-	-
Data Transmission (DATA)	true	False	False	false	true
Streaming (STREAM)	High	-	-	-	Low
Buffering (BUFFER)	Low	-	-	-	High

	Name	ID	Guard	Power Consumption	Network usage	Map Detail	Routing accuracy	Data Latency
Rule	IDLE Mode	NM	Mode = IDLE	High	High	Low	Low	N/A
Rule	Exploration mode	PM	Mode = EXPLORE	N/A	N/A	High	Low	Low
Rule	Go to mode	FM	Mode = GOTO	N/A	N/A	Low	High	Medium
Rule	Battery is Low	LB	LowBatt	High	N/A	N/A	N/A	N/A
Rule	Battery is OK	LB	not LowBatt	Low	N/A	N/A	N/A	N/A
Rule	BT available	BT	BTSig	N/A	Low	N/A	N/A	N/A
Rule	no BT	GP	not BTSig	N/A	High	N/A	N/A	N/A

Fleurey and Solberg **[FS09]**

DiVA – SmartAdapters [MBN+09] [LMV+07]

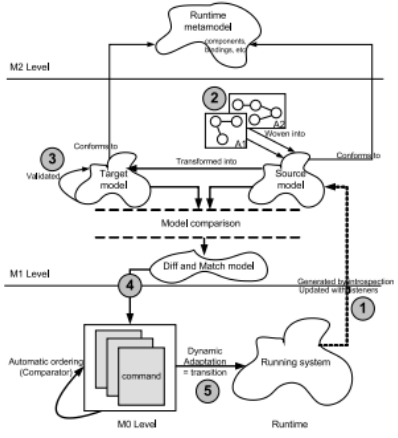
- Application model@runtime
- Introspection to synchronize software and model objects

- Goal is to increase reusability of aspects
  → Description of concerns, adapters, adaptations and adaptation targets

- Pattern matching on model-level to identify targets and apply adapters by executing adaptations

```
01 concern application.phone
02 compose designpattern.observer with application.phone
03 adapter ApplicationPhone extends ObserverAdapter {
04
05    target typeOfValue = Time
06    target subjectClass = application.phone.Clock
07    target observerClass = application.phone.GUI
08    target notifyingMethod = application.phone.Clock.incrementTime()
11
12    adaptation observerUpdate :
13       introduce method public void update (subjectClass s) in observerClass {
14          setTime(time++)
14          displayTime()
15       }
16 }
```

Lahire et al. [LMV+07]

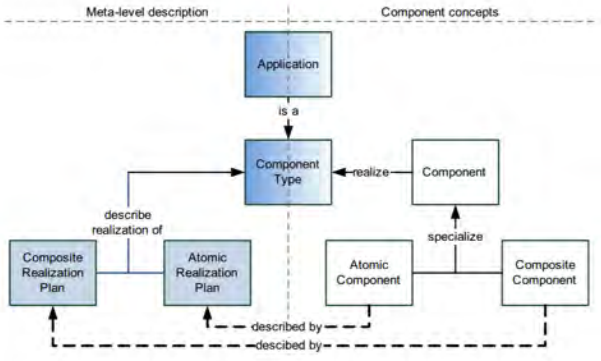


Morin et al. **[MBN+09]**

MUSIC – Self-Adapting Applications for Mobile Users in Ubiquitous Environments [GRW+09]

- European Integrated Project 2006-2010 (6th Framework Programme)
- Design methodology and distributed system architecture
  → for design and implementation of self-adapting systems

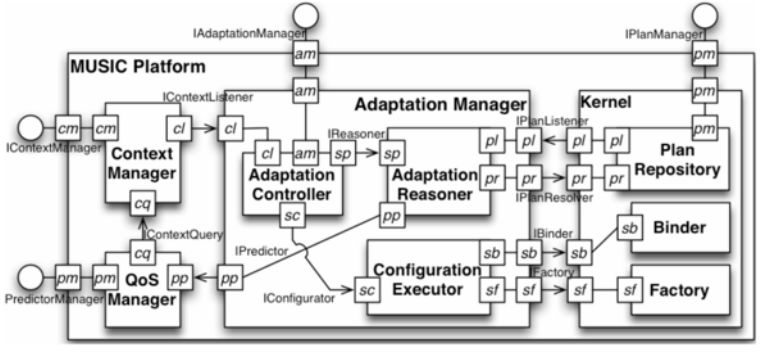
- QoS-Optimization and user preference fulfilment
  - Component-based (hierarchical components with typed ports)
    → Extension to UML-Component Diagrams (UML Profiles)
  - OWL-S for semantic description of QoS-Properties
  - Connectors for collaboration



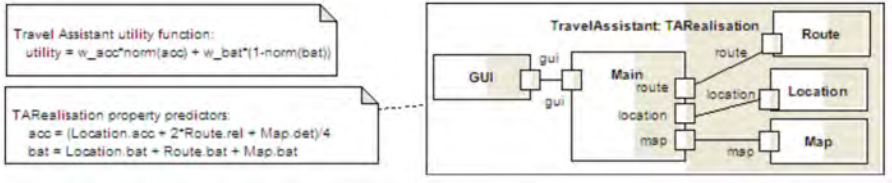
Geihs et al. **[GRW+09]**

MUSIC – Adaptation [RBD+09]

- QoS-Metadata (Utility functions) for component realizations
- Reconfiguration = Combination of the composition operators
  - Create, remove and connect components
  - Context Manager sends events
  - Adaptation Controller coordinates provision
  - Plan reasoner retrieves alternatives (plans)
    → Finding a variant with the best utility
    → Weights provided by user



Property	Description	Value range
acc	Accuracy	1-10
det	Level of detail of map	1-10
rel	Reliability of estimated travel time	1-10
bat	Power consumption of a component or link	0-∞

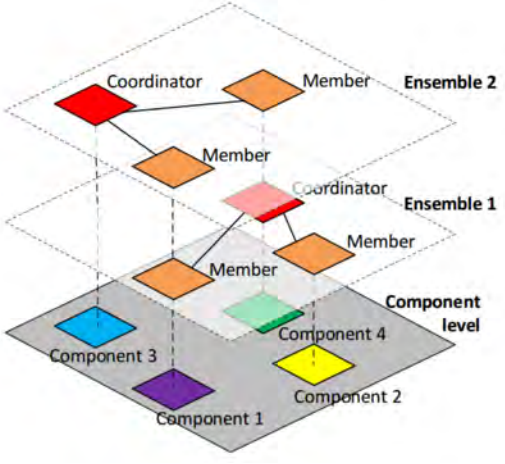


DEECo – Distributed Emergent Ensembles of Components [BGH+13] [KBP+12]

- New class of component systems
  → Ensemble-Based Component Systems (EBCS)
- Combination of Component-Based Systems, Agent-Oriented Systems and Control System Engineering

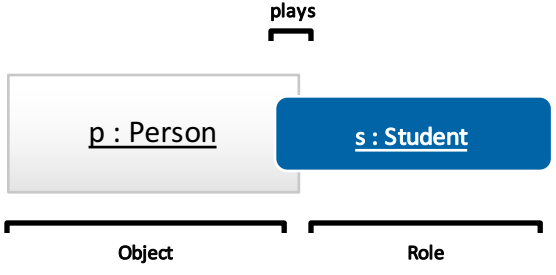
- Explicit component architecture is replaced by ensembles
  - Dynamically varying set of collaborating components
  - Ensembles are formed to collectively achieve a goal

- Components expose knowledge via interfaces and processes
  - Knowledge = State + Available Functionality
  - Processes = Functions
  - Special components for sensors



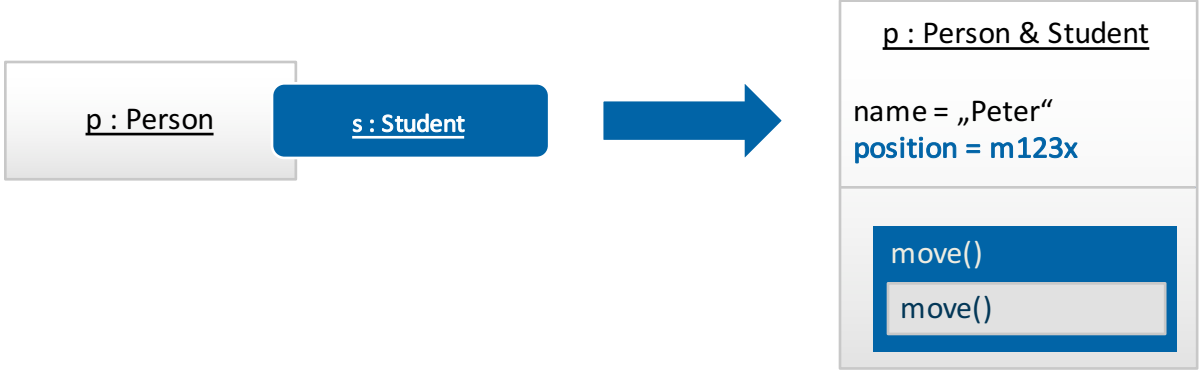
Roles are **dynamic services** of objects

Objects can **play** roles and **discard** them at runtime

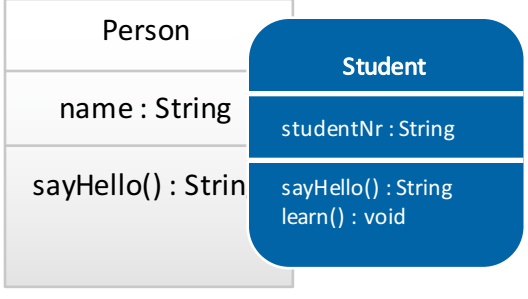


Roles have no own identiy

They are non-rigid

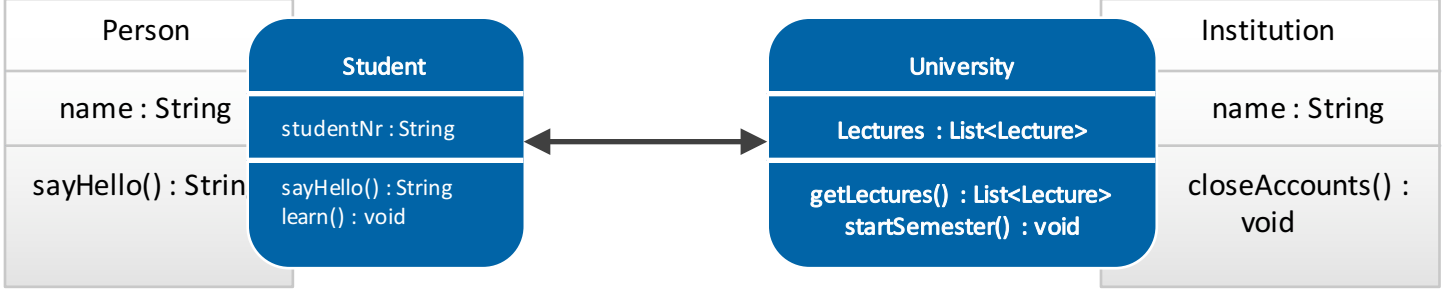


Playing a role changes the **structure** and the **behavior** of an object

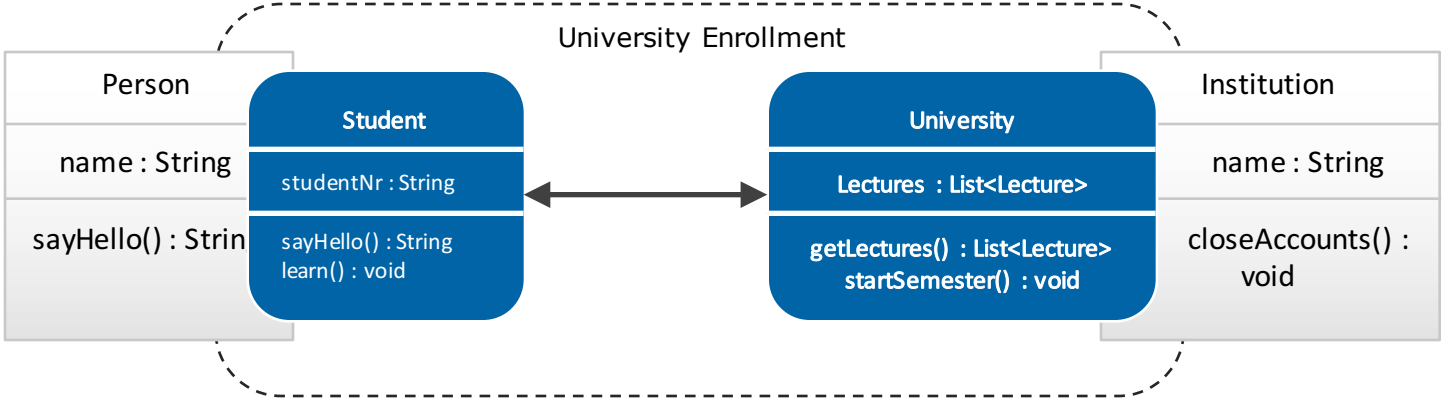


Roles introduce relations to other roles

They are founded

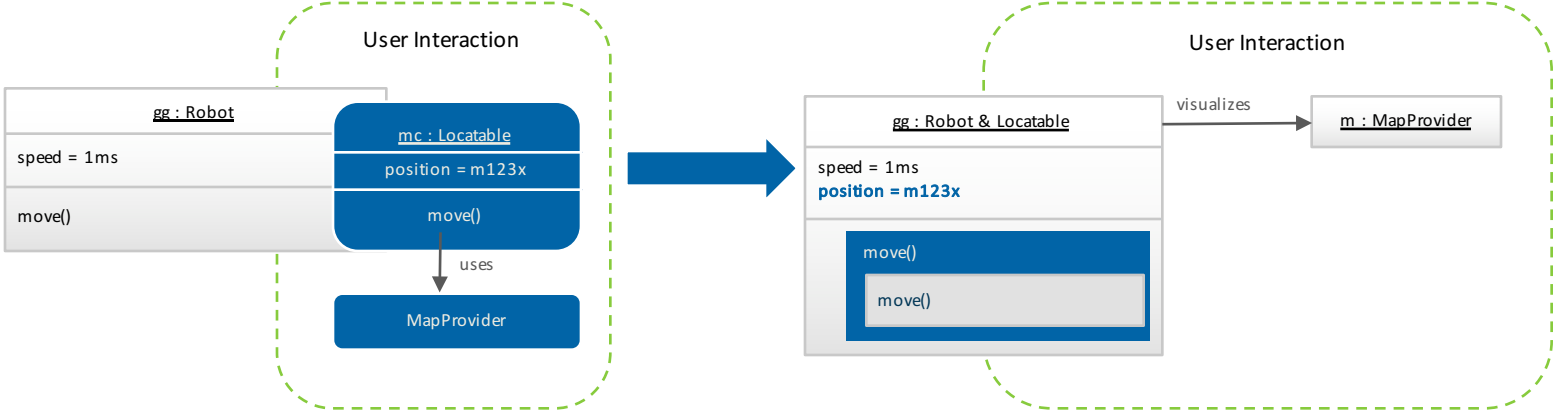


Roles are played in a ~~context~~ **compartment**



A **Role** is a:

- *Dynamic Service* of an object in a given *Context (Compartment)*
- Can be *played and discarded at runtime*

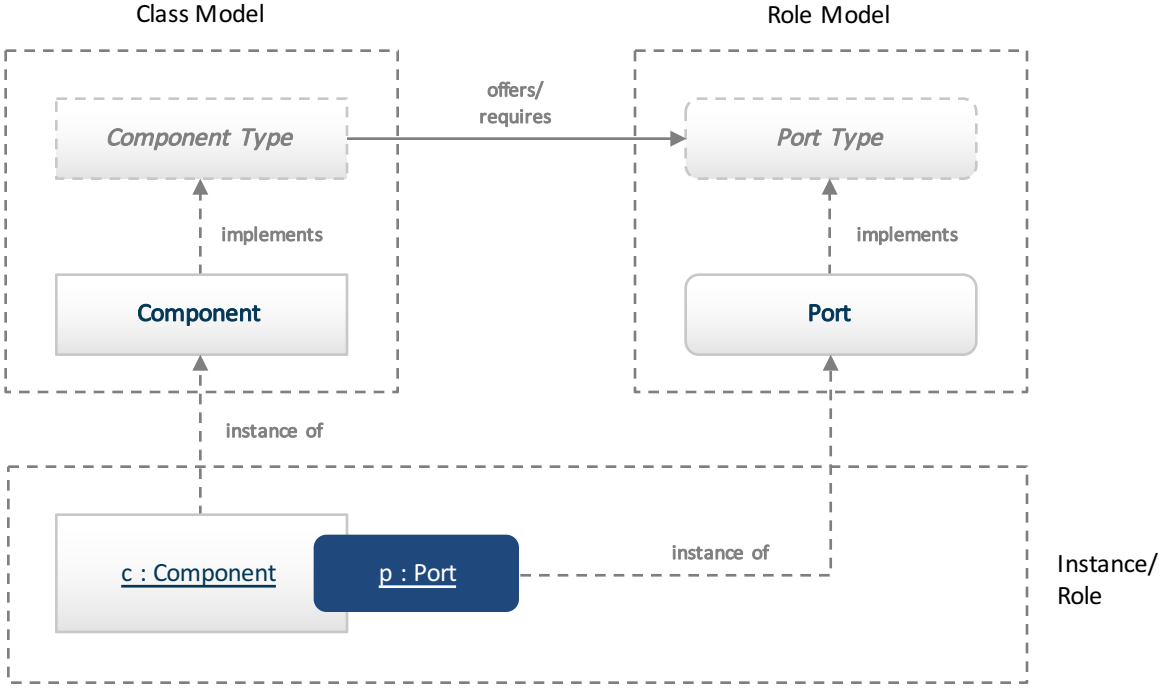


Smart Application Grids is:

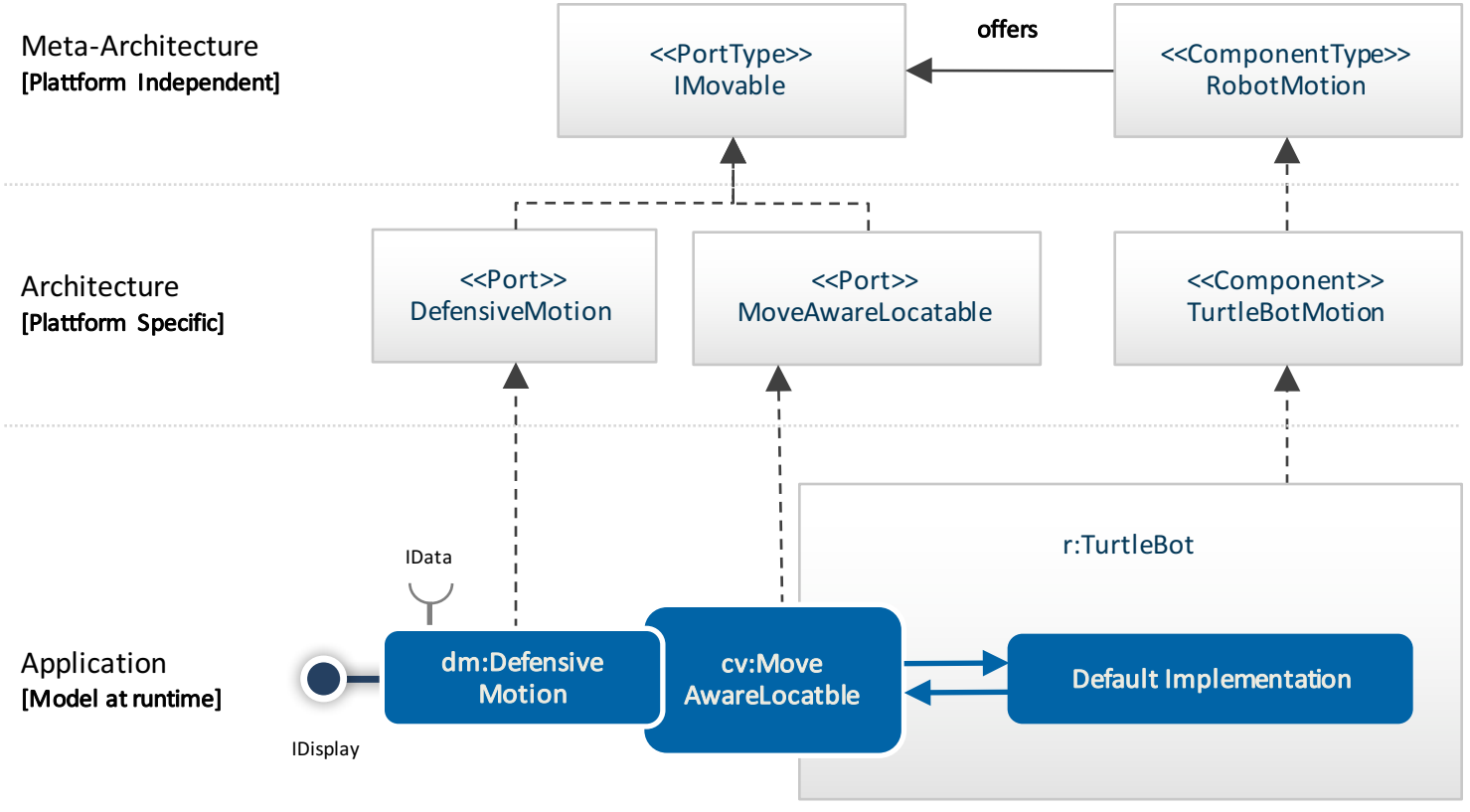
- Model-Driven approach for modeling and developing Self-Adaptive Systems
- Framework for Executing Self-Adaptive Systems

- Based on **Role-Based Design and Programming**
- Based on **Component-Based Design**

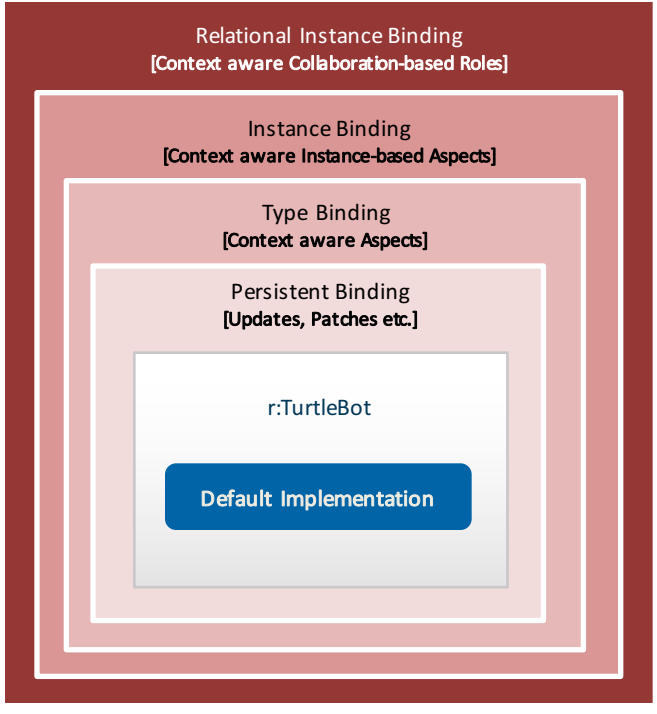
- Dynamic Adaptation
- Meta-Adaptation
- Models@run.time
- Dynamic App Composition (SOA with roles with Service Trader)
- Dynamic verification capabilities


Class Model
Role Model
offers/
requires
Component Type
Port Type
implements
implements
Component
Port
instance of
c : Component
p : Port
instance of
Instance/
Role

SMAGs Component Model - Example

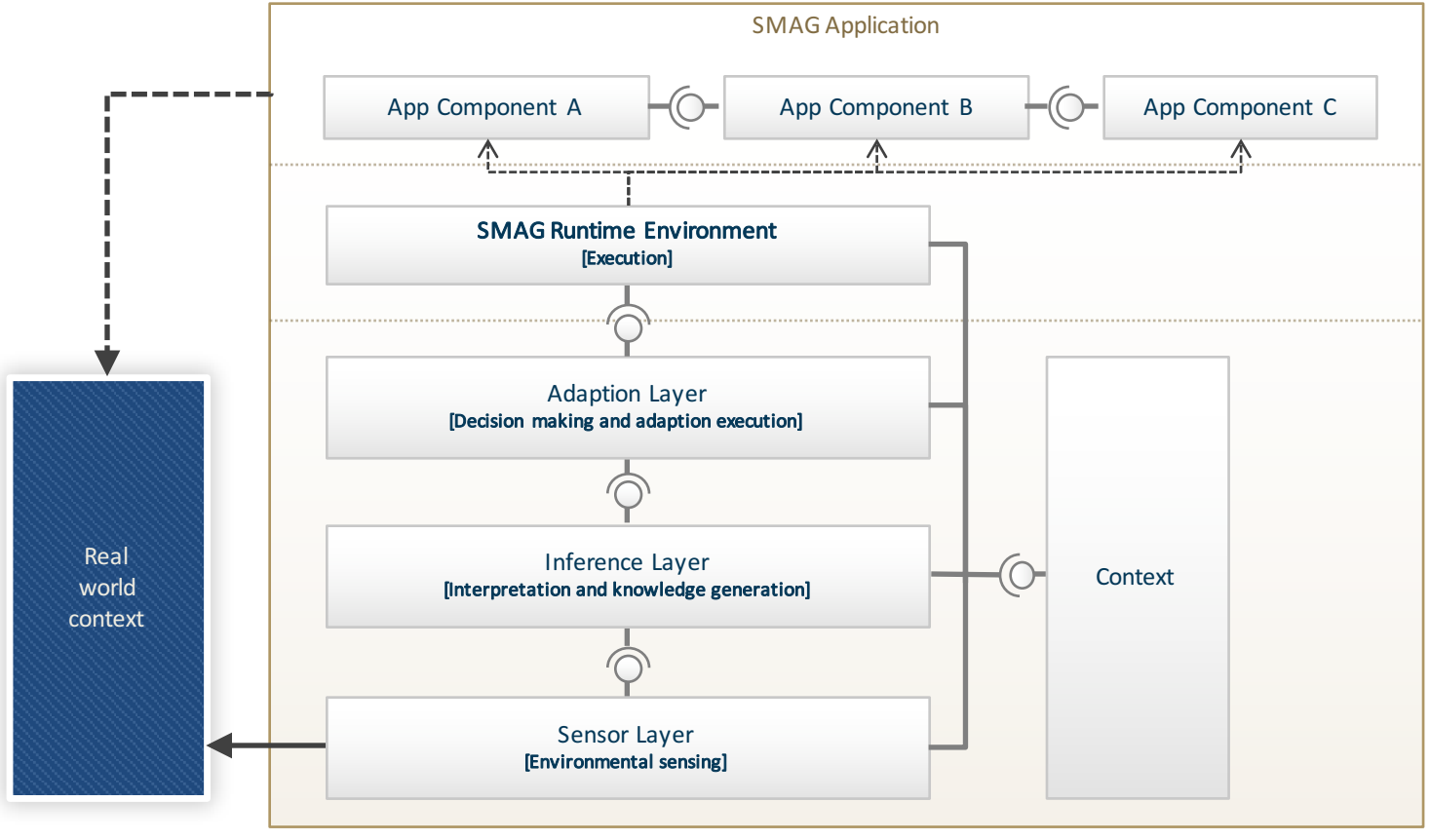


Layered Role-Binding Model

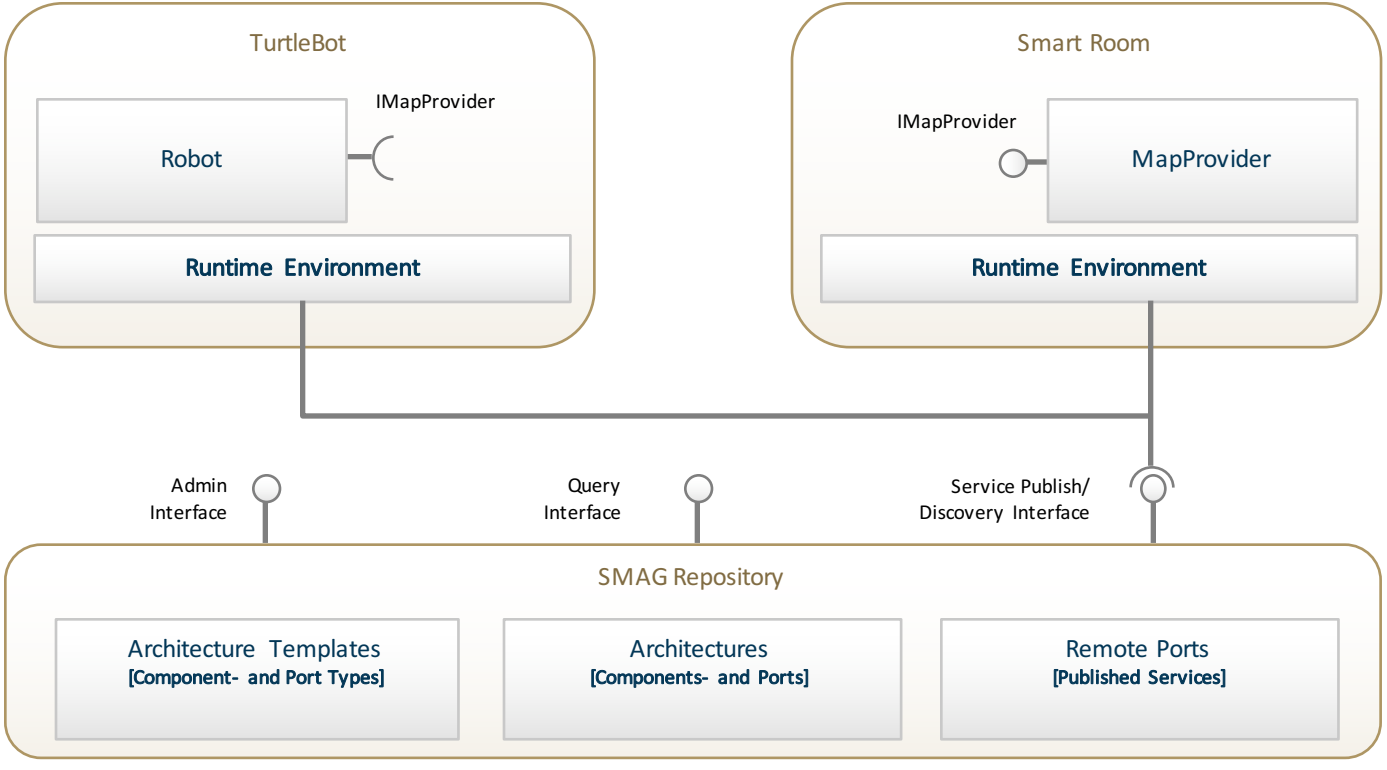


Type	Static	Dynamic	Class	Instance	Colla-boration
Default Impl.	X		X		
Persistent Roles		X	X		
Type Roles		X	X		
Instance Roles		X		X	
Relation-Based Roles		X		X	X

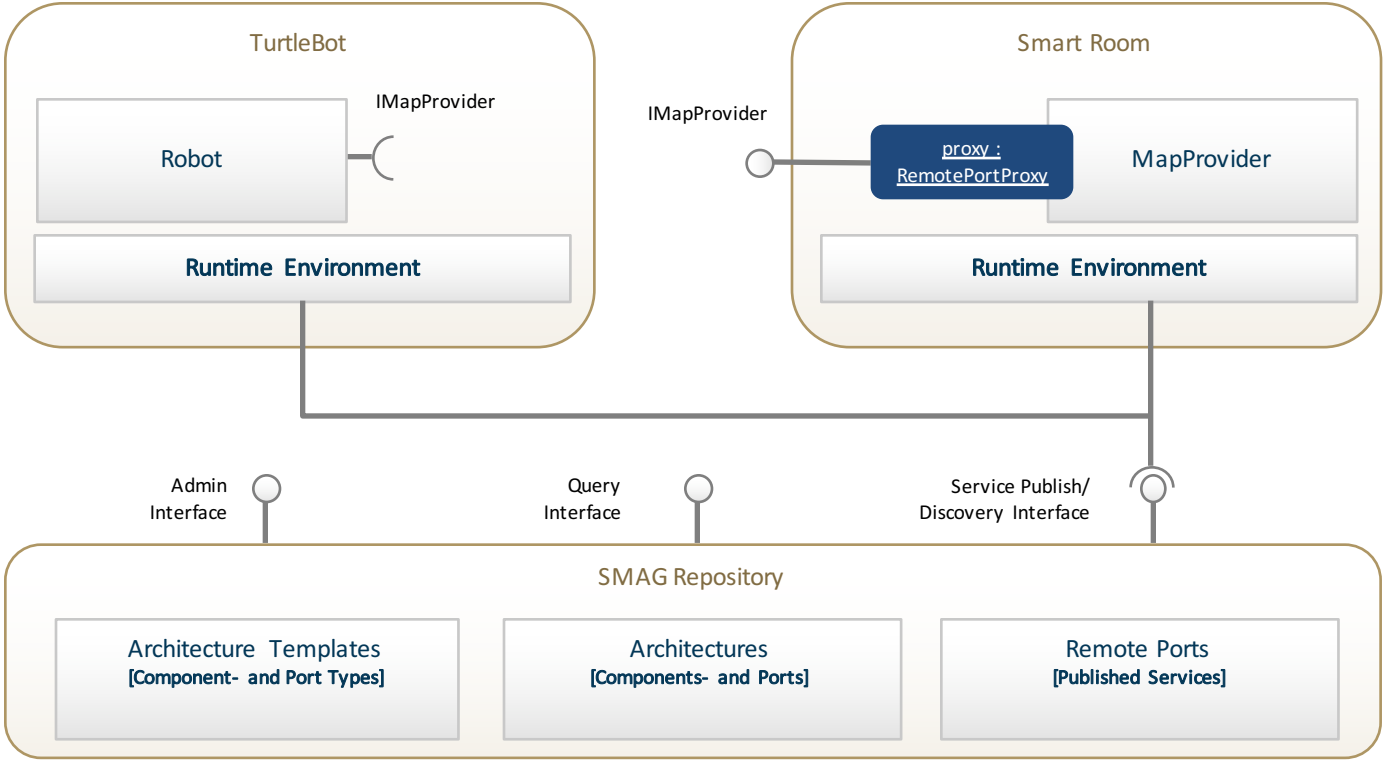
SMAGs Application Architecture



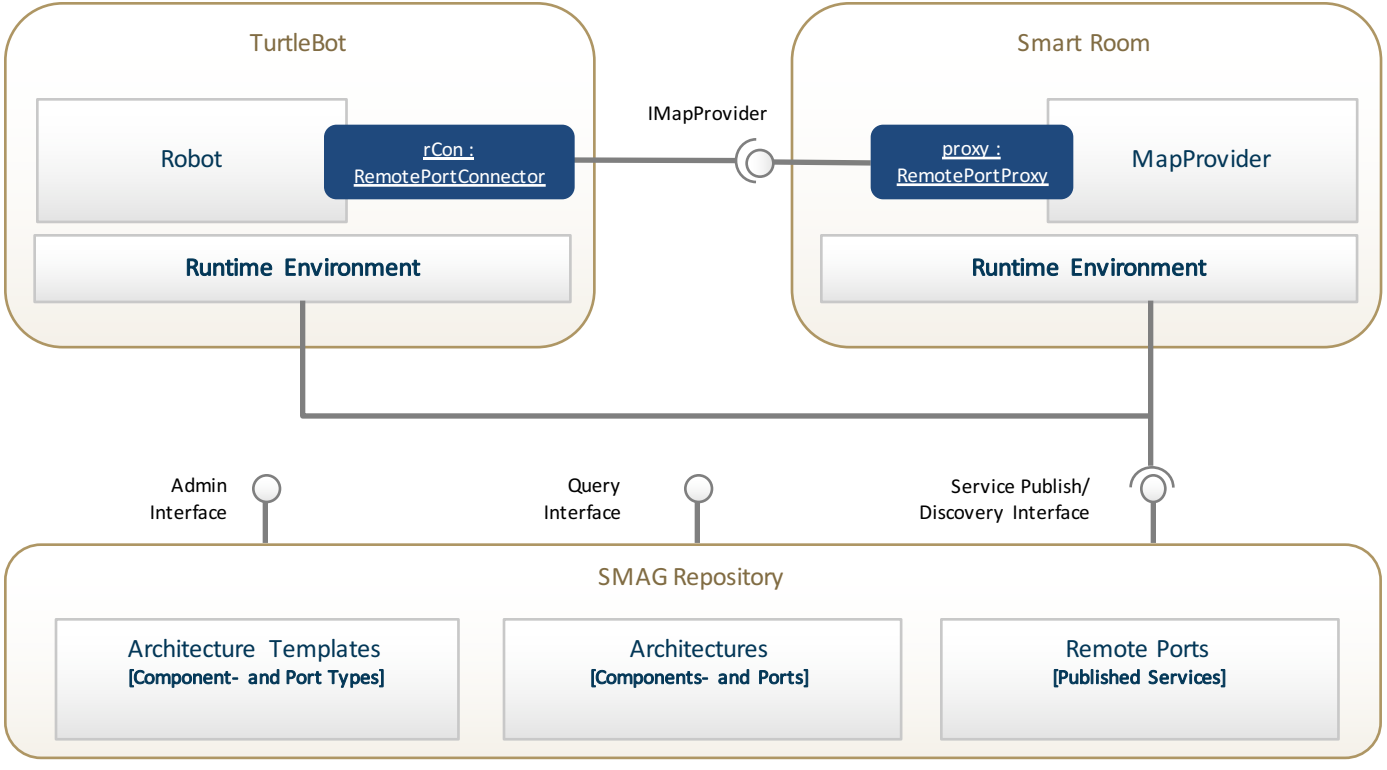
App Composition



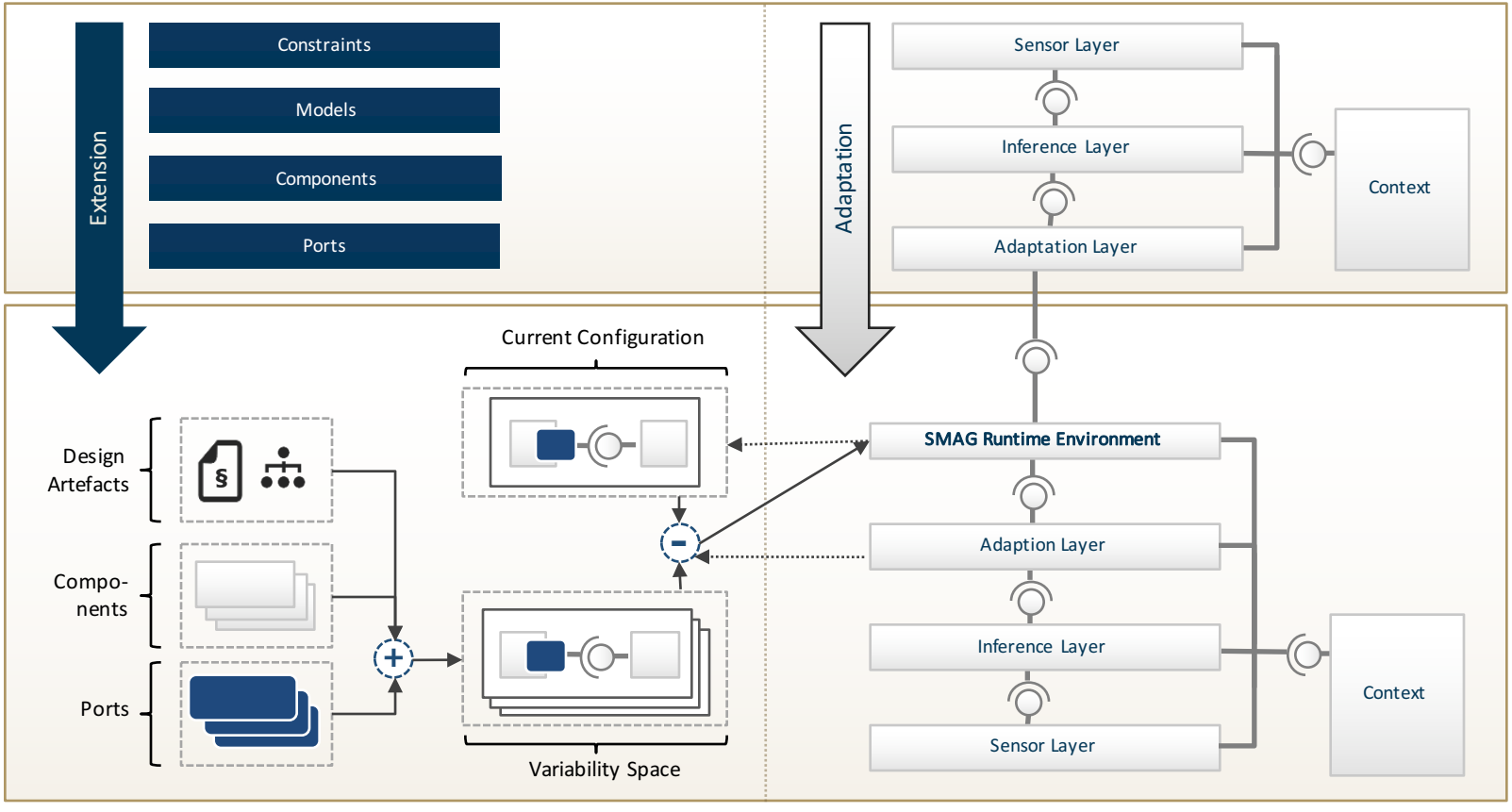
App Composition



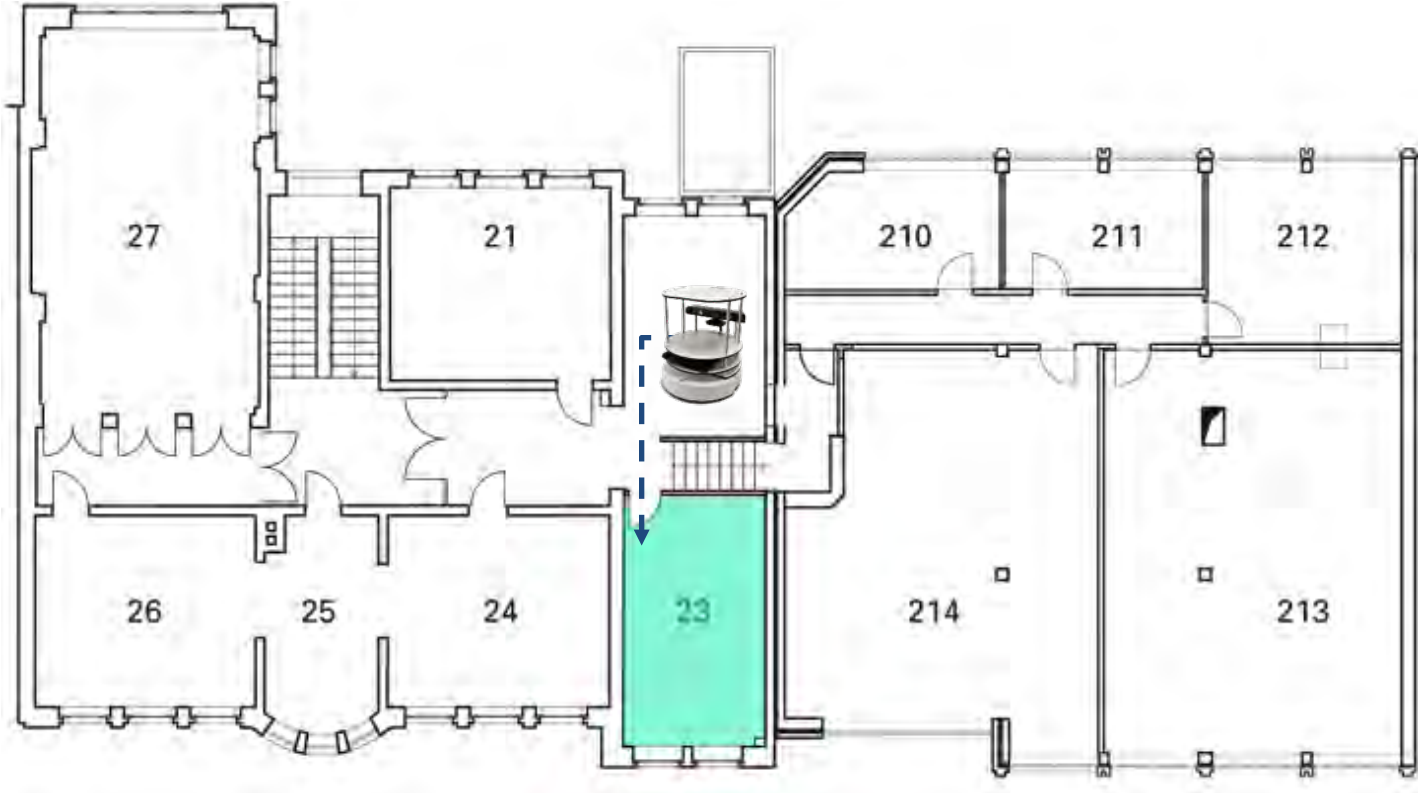
App Composition

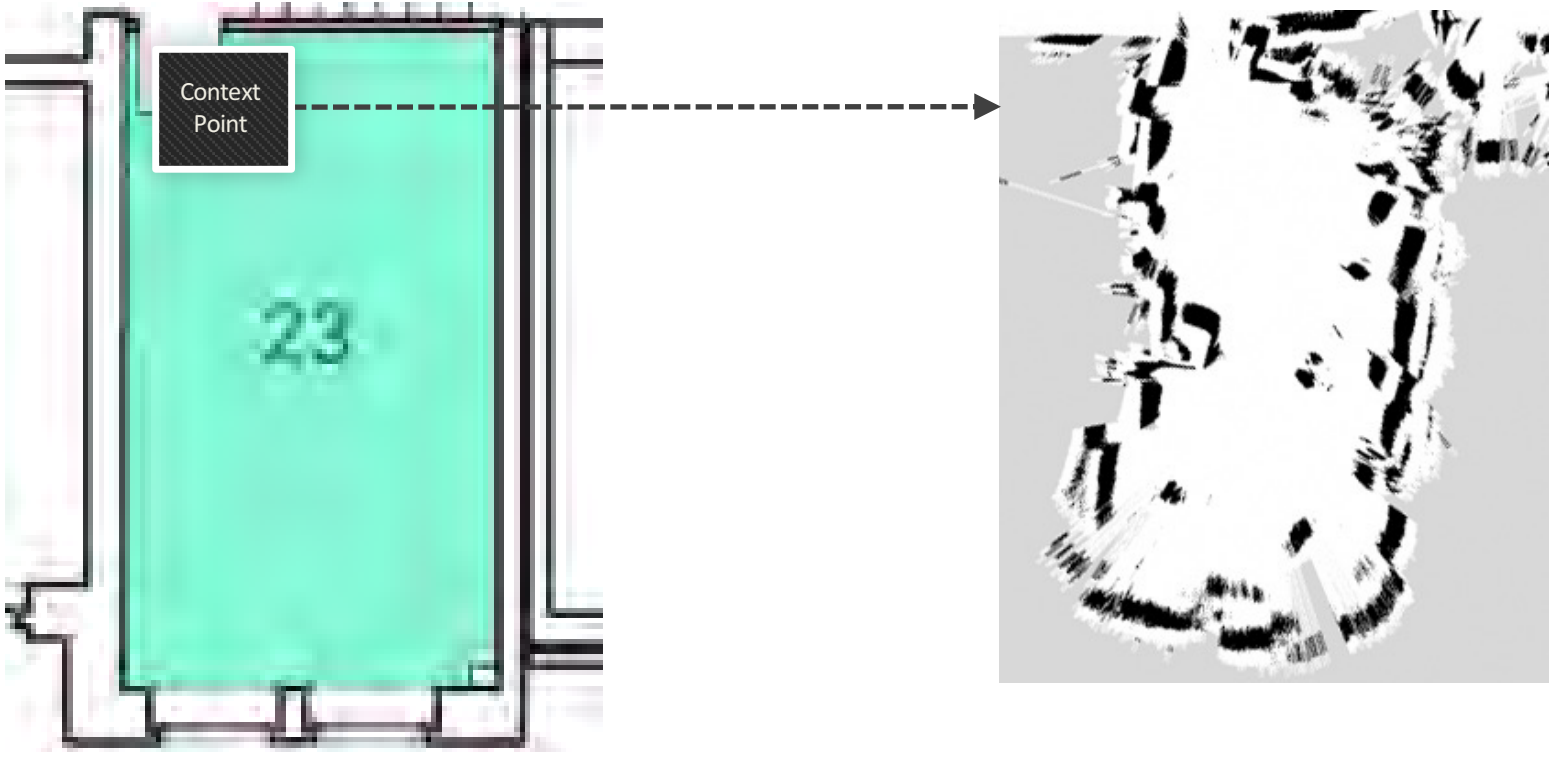


Meta Adaptation

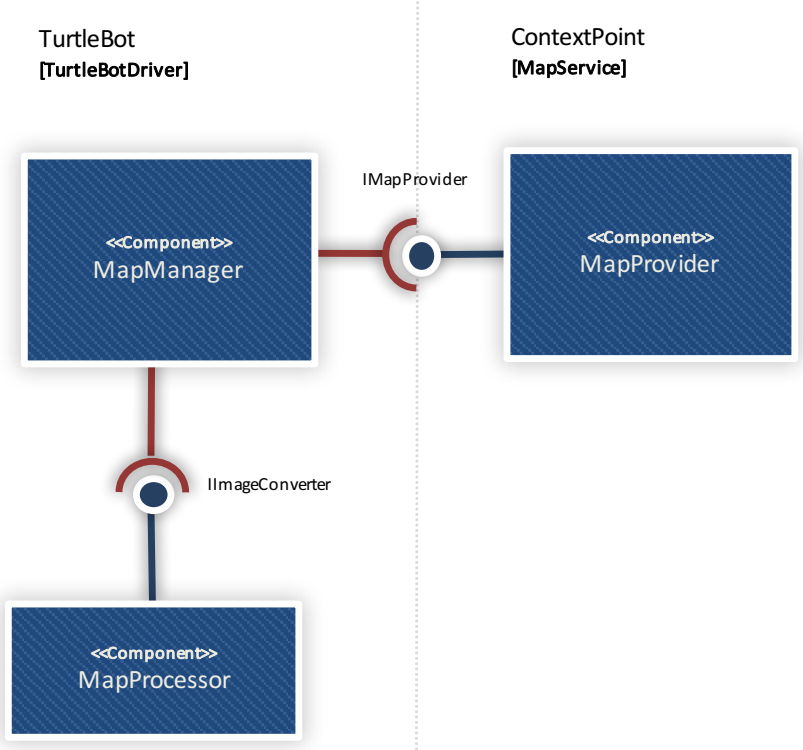


Scenario




Context Point
23

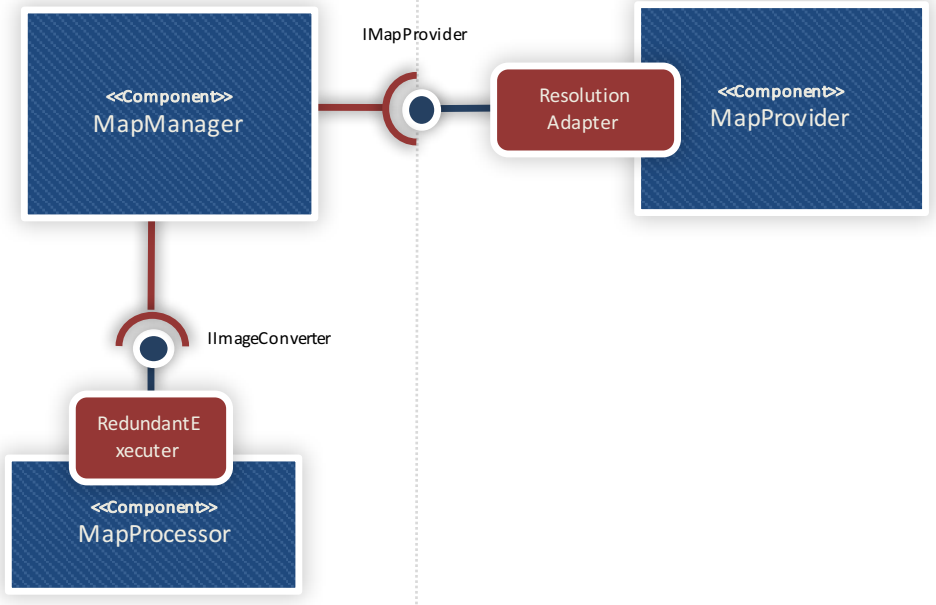
Scenario Demo Application

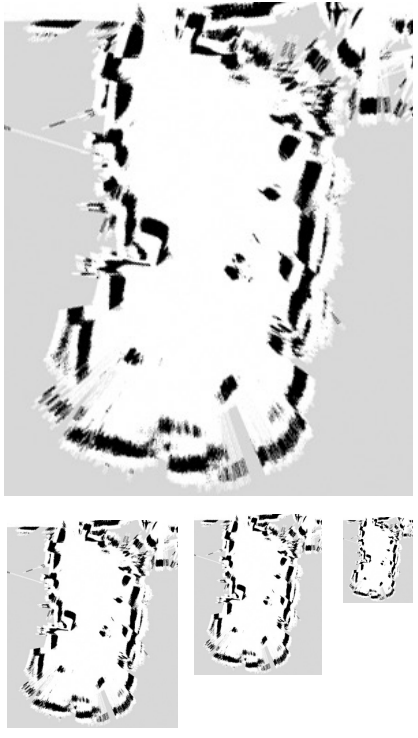


Scenario Demo Application

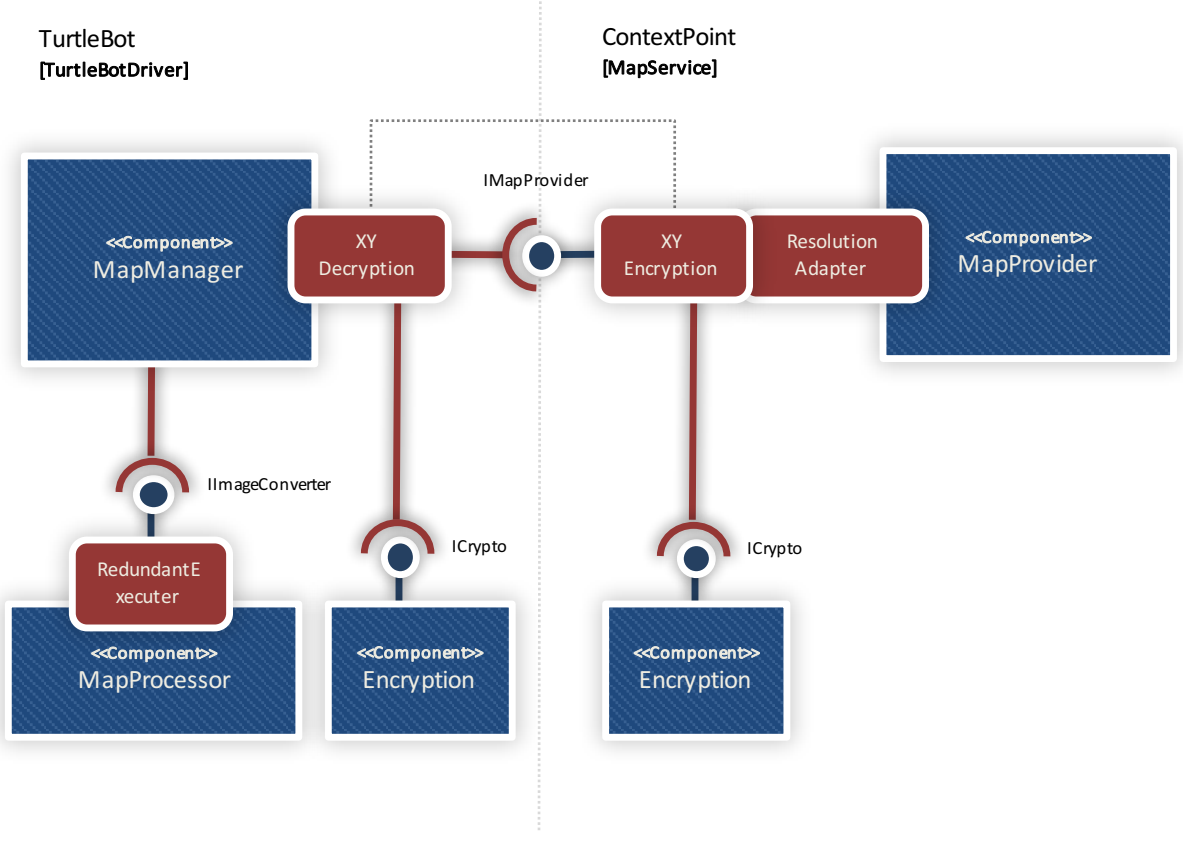
TurtleBot
[TurtleBotDriver]

ContextPoint
[MapService]



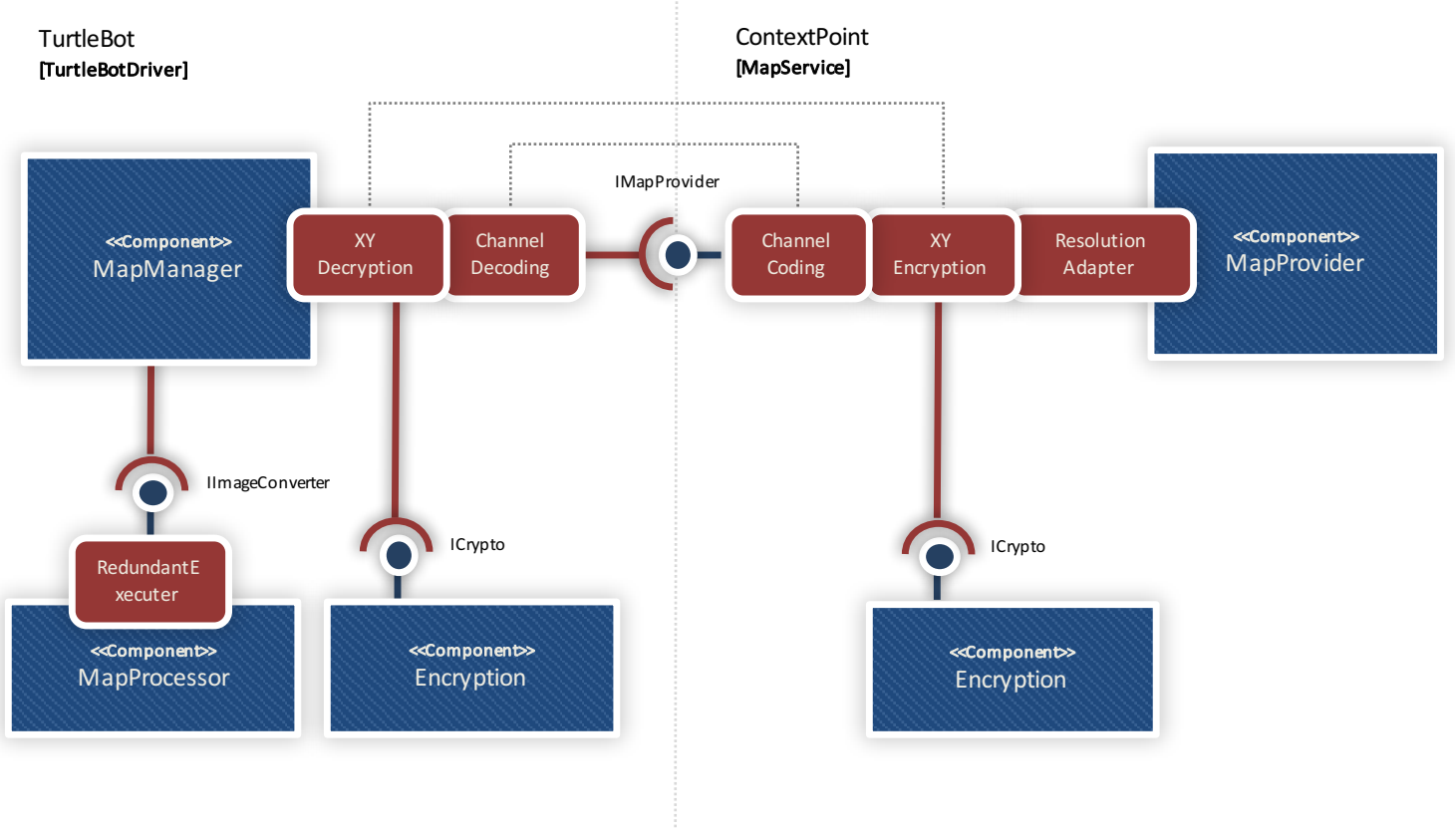


Scenario Demo Application



- AES + CBC + Padding
- AES + CBC + NoPadding
- AES + ECB + Padding
- AES + ECB + NoPadding
- DES + CBC + Padding
- DES + CBC + NoPadding
- DES + ECB + Padding
- DES + ECB + NoPadding
- DESede + CBC + Padding
- DESede + CBC + NoPadding
- DESede+ ECB + Padding
- DESede + ECB + NoPadding

Scenario Demo Application



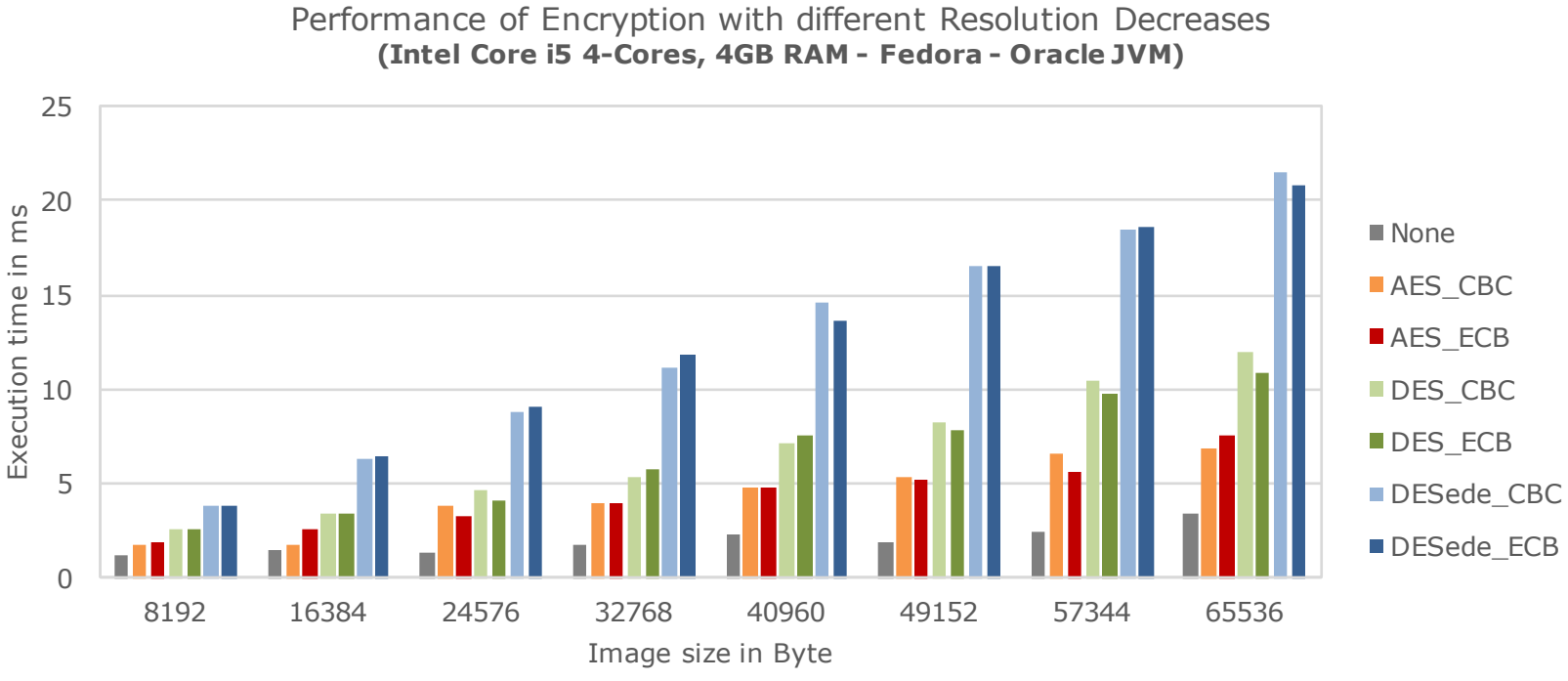
Reed-Solomon

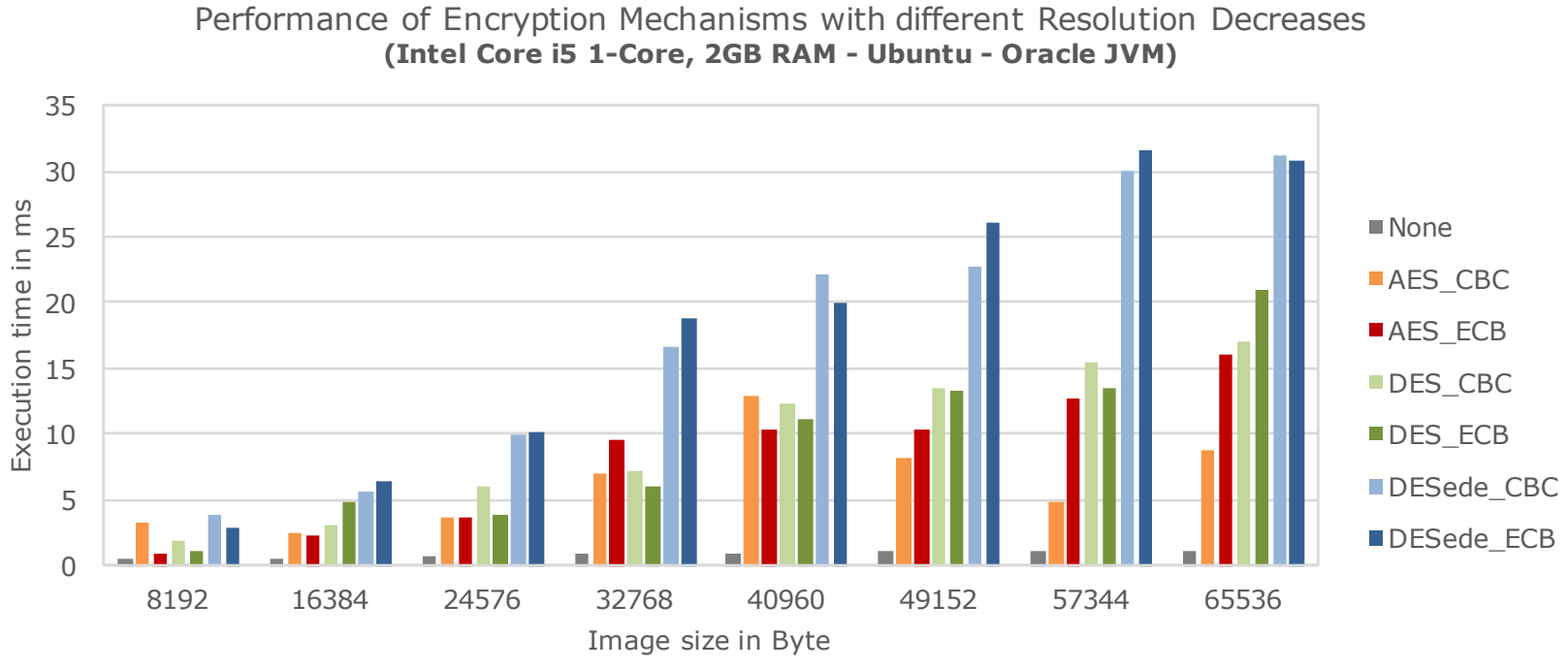
(255B Blocks)

- 5
- 10
- 15

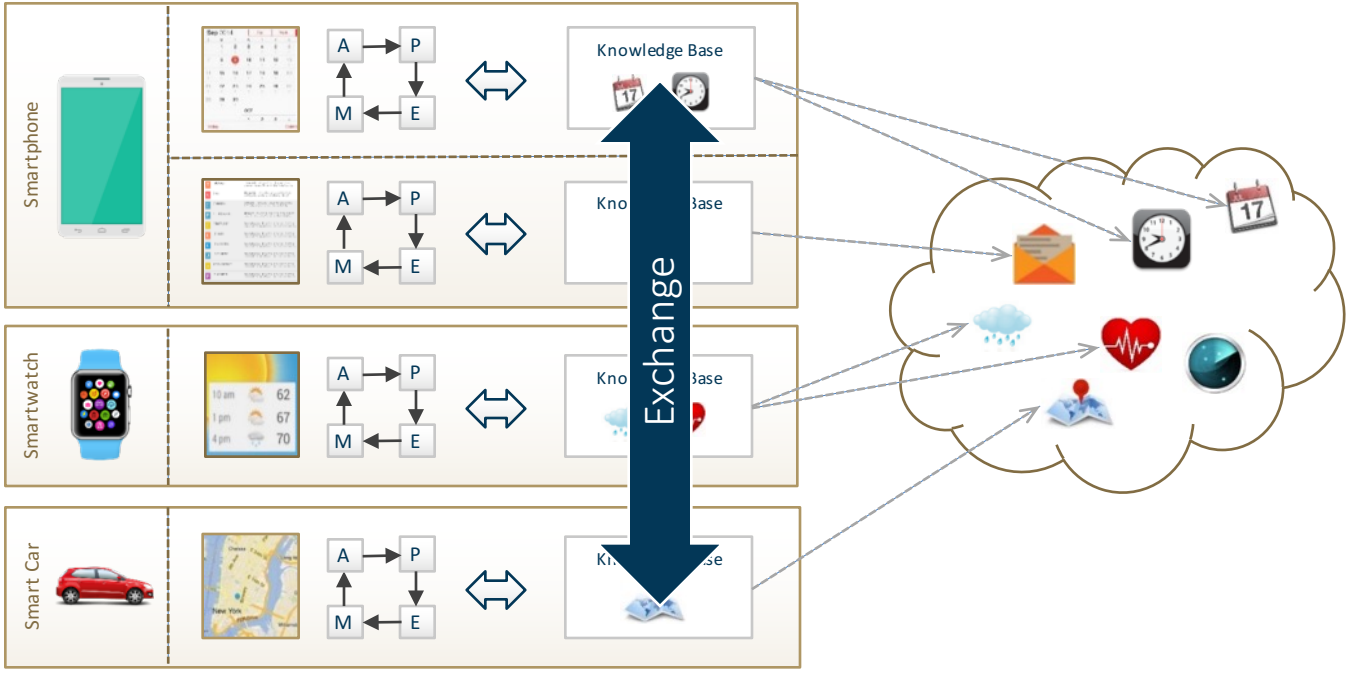
...

- 50


Performance of Encryption with different Resolution Decreases
(Intel Core i5 4-Cores, 4GB RAM - Fedora - Oracle JVM)
Execution time in ms
25
20
15
10
5
0
8192
16384
24576
32768
40960
49152
57344
65536
Image size in Byte
None
AES_CBC
AES_ECB
DES_CBC
DES_ECB
DESede_CBC
DESede_ECB


Performance of Encryption Mechanisms with different Resolution Decreases
(Intel Core i5 1-Core, 2GB RAM - Ubuntu - Oracle JVM)
Execution time in ms
0
5
10
15
20
25
30
35
8192
16384
24576
32768
40960
49152
57344
65536
Image size in Byte
None
AES_CBC
AES_ECB
DES_CBC
DES_ECB
DESede_CBC
DESede_ECB

Meta Adaptation II



Context Model Management Dimension

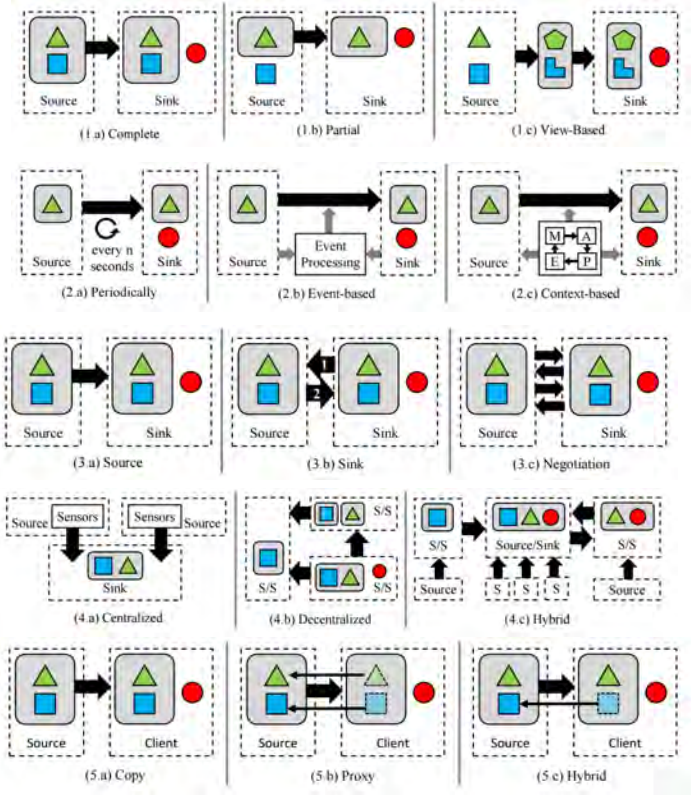
Content (Complete, Partial, View-based)
- What Context Information is accessible?

Timing (Periodically, Event-based, Context-based)
- When is context information updated/queried?

Initiation (Source, Sink, Negotiation)
- Who initiates context model data exchange?

Location (Centralized, Decentralized, Hybrid)
- Where is context information managed?

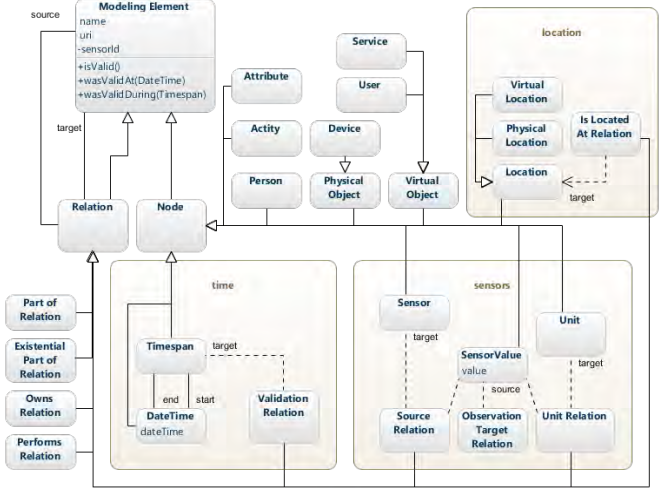
Data Consistency (Copy, Reference, Hybrid)
- How should the consistency of data be managed?



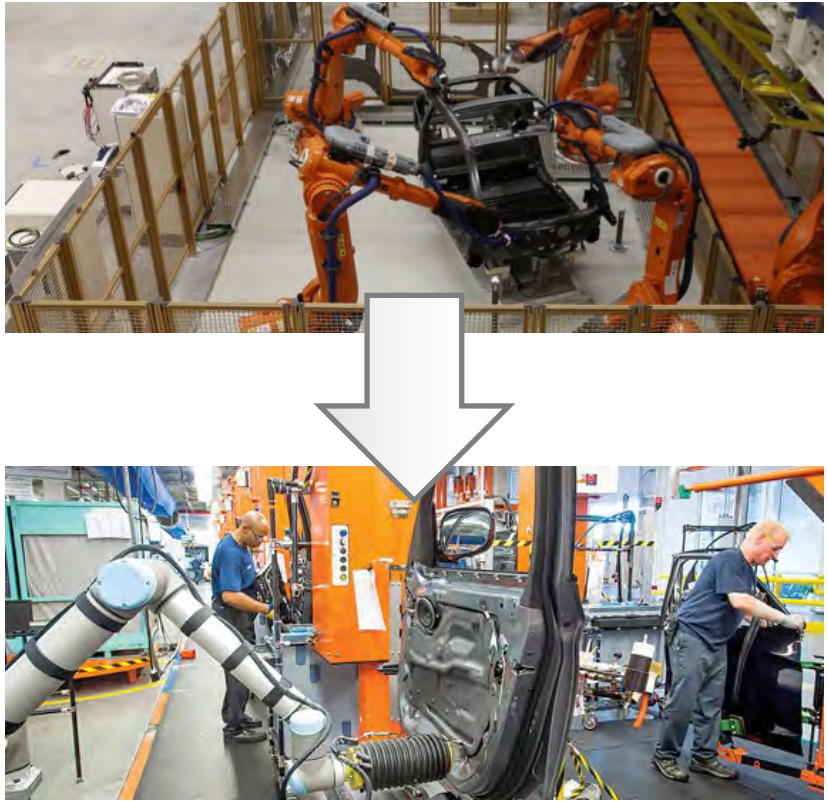
GRoCoMo: Graph- and Role-Based Context Model

- Typed, attributed Graph with complex relationships
- Attributes and Relationships
- Core Model with modeling elements, activities and location
- Time as first-class-citizen
- Context History, History ordering
- Modeling and Query Language

```
1  nodes {
2    node1 : Location [valid within last 5min];
3    node2 : Device [valid within last 5min];
4  }
5
6  relations {
7    rel1 : LocatedAt(node2, node1) [valid within last 5min];
8  }
9
10 where node2.name = "Example Robot";
```

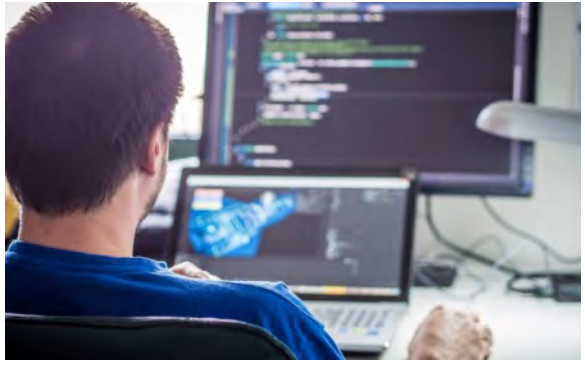


Schnelle Individualisierung?



Mensch\Roboter Co-Working

- Mensch und Roboter arbeiten zusammen
- Arbeitserleichterung durch unterstützen bei schweren Arbeiten
  z.B. Heben von schweren Werkstücken
- Übernehmen von Teilaufgaben die sehr Hohe Präzision und Geschwindigkeit erfordern
- Arm muss sich des Menschen bewusst sein
- Arm muss sich an den Menschen anpassen können



Programmierung

End-User Modellierung

Direct Teaching

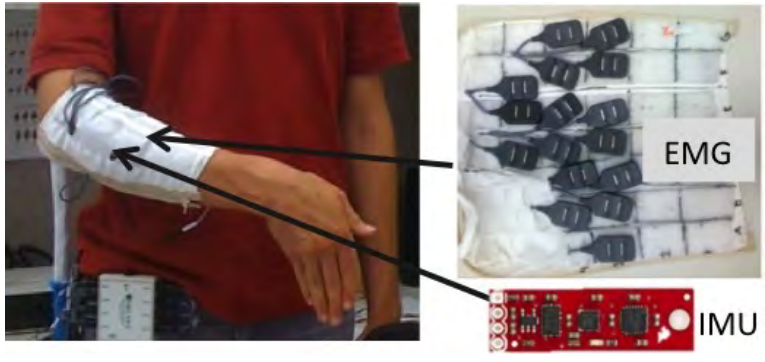
Motion Capturing

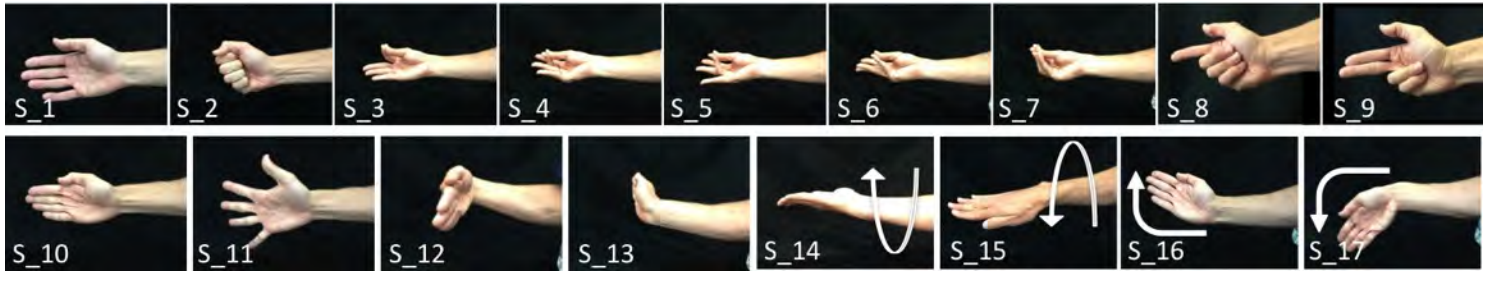
ROY ET AL. 2015 – „Flex sensor based wearable gloves for robotic gripper control“ [RIA+15]

- Wearable-basierter Steuerung eines Roboter-Greifers (virtuell)
- Flexsensoren zur Erkennung der Fingerstellung
- Keine Erkennung der Handstellung/–orientierung
- Keine Erkennung der Position
- Kein taktiles/haptisches Feedback
- Unflexible, starre Softwarearchitektur

WOLF ET AL. 2015 – „ Decoding Static and Dynamic Arm and Hand Gestures from the jpl Biosleeve“ [WAC+15]

- Bandage mit EMG und IMU Sensoren
- Interaktion mit Robotern
- Erkennung von Gesten
- Kein Live-Tracking
- Online Erkennung von statischen Gesten
- Unflexible, starre Softwarearchitektur





Hannover Messe

Mr. T - Mobile World Congress

ST + 5G Lab + Technisches Design

TECHNISCHE UNIVERSITÄT DRESDEN

Fakultät Informatik | Institut für Software- und Multimediatechnik | Lehrstuhl für Softwaretechnologie

Beyond Objects

From object modeling to role modeling to satellite modeling

Forschungslinie - Einführung in die Forschung

Christian Piechnick
Softwaretechnologie
Institut Software- und Multimediatechnik

Vertretung für: Prof. Dr. Uwe Aßmann

DRESDEN concept
Exzellenz aus Wissenschaft und Kultur