SE SOFTWARE ENGINEERING

RWTH AACHEN UNIVERSITY

Executing Robot Task Models in Dynamic Environments

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http://www.se-rwth.de/

Motivation

- Research project iserveU [1]
- Support hospital caregiver tasks:
  - delivering items
  - following persons
  - guiding persons
- Easily integrate new task types
- Enable technically unaware staff to operate robot
- Support arbitrary robots

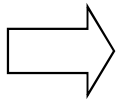
[1] http://www.se-rwth.de/materials/iserveu/

Research Statement

- Service robotics is a challenging domain:
  - involves many different roles
  - dynamic environment
  - heterogeneous robot tasks
- Use models:
  - reduce complexity
  - increase reuse
  - enable platform-independence
  - ➢ reduce costs
- Execution of tasks

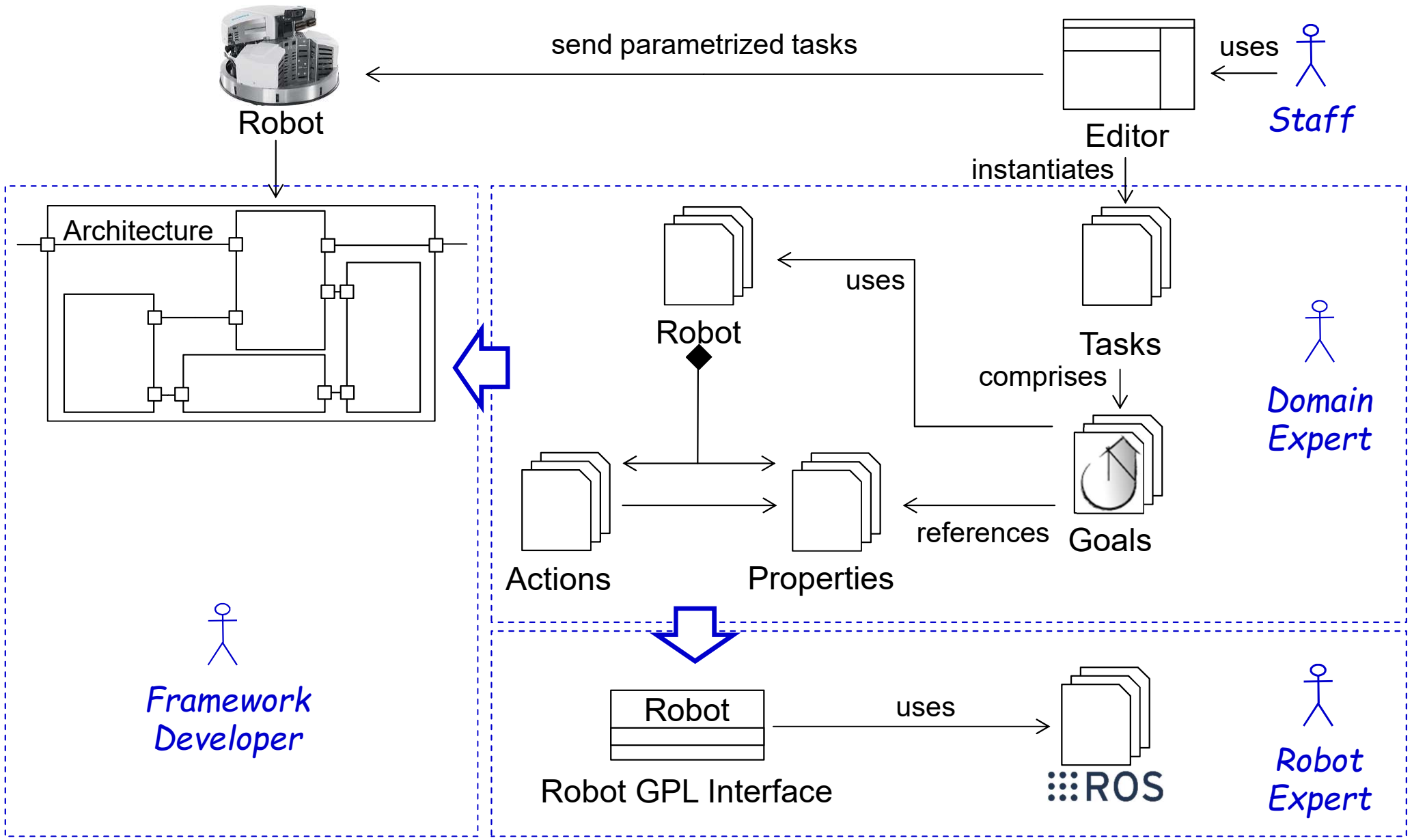
⇨ How to model this? How do the models interplay?

Outline

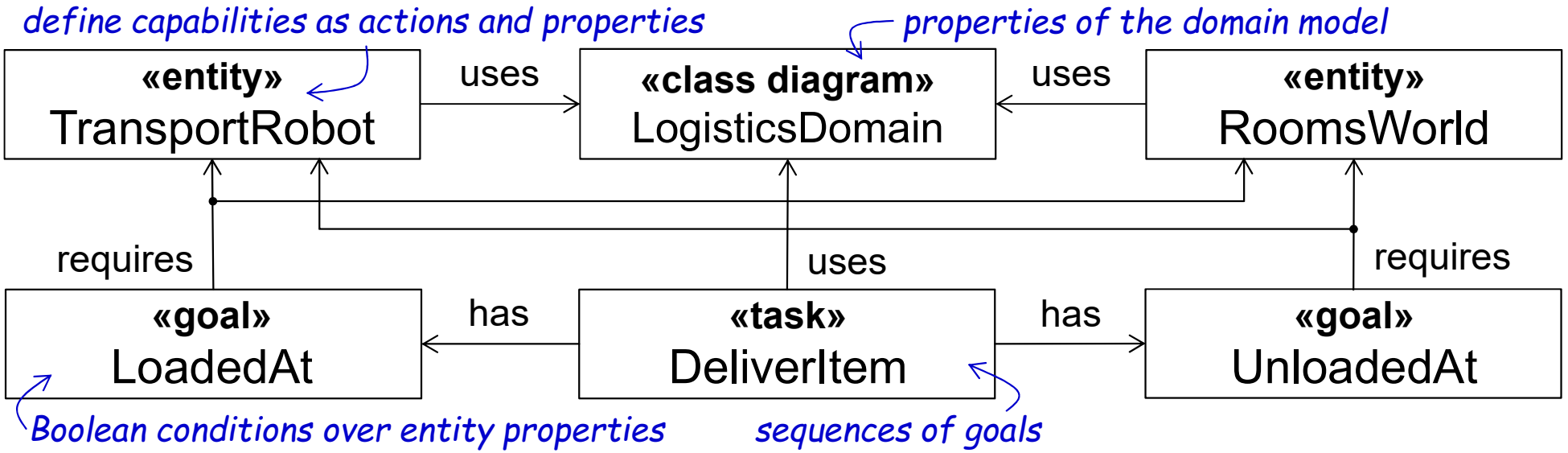


1. Introduction & Research Statement
2. iserveU DSLs & Software Architecture
3. Executing Task Models
4. Conclusion

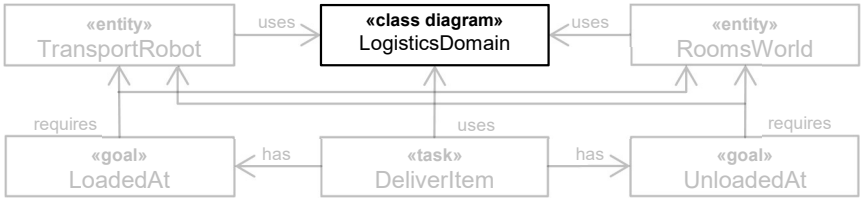
Overview

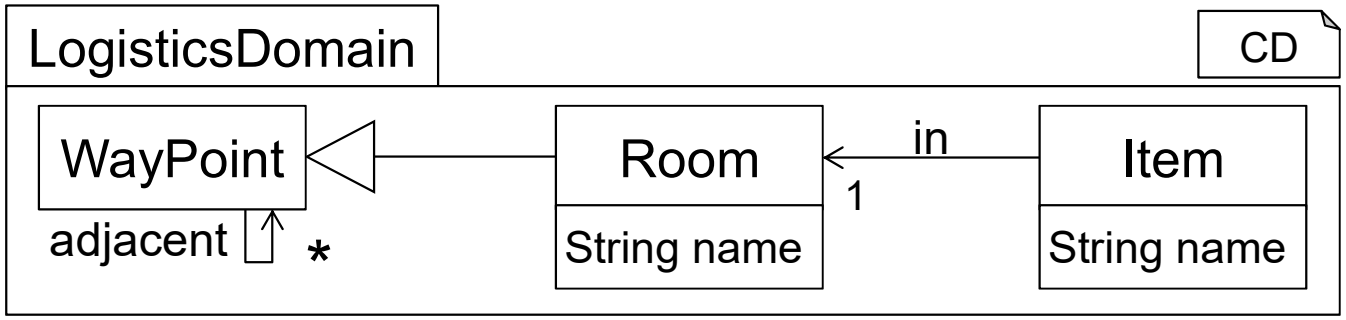

Robot
send parametrized tasks
Editor
uses
Staff
instantiates
Architecture
Robot
uses
Tasks
comprises
Domain Expert
Actions
Properties
references
Goals
Framework Developer
Robot
uses
ROS
Robot GPL Interface
Robot Expert

Example: iserveU Models

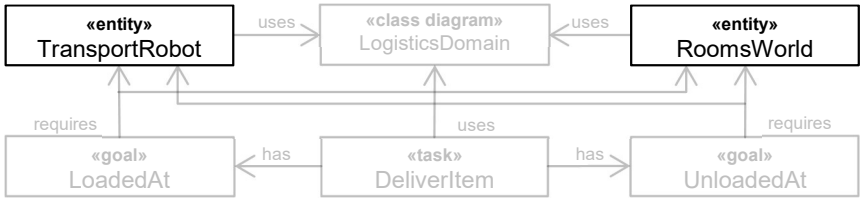


Example: Domain





Example: Entities

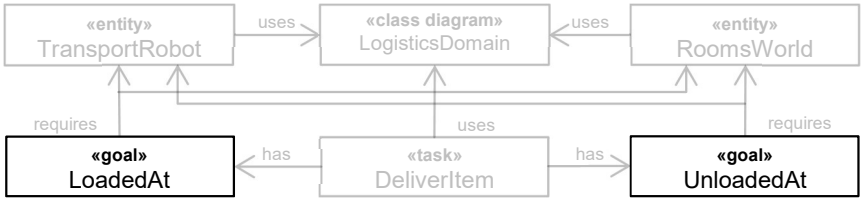


references other entity and domain

Entity

```
01 domain LogisticsDomain;
02 world RoomsWorld rw;
03
04 robot TransportRobot {
05  property Waypoint robotLoc();
06  property Boolean hasLoaded(Item item);
07
08  action pickUp(Item item, Room room) {
09   pre:  robotLoc() == room && rw.itemLoc(item, room);
10   post: hasLoaded(item)    && !rw.itemLoc(item, room);
11  }
12
13  action move(Waypoint from, Waypoint to) { /* .. */ }
14 }
```

Example: Goals



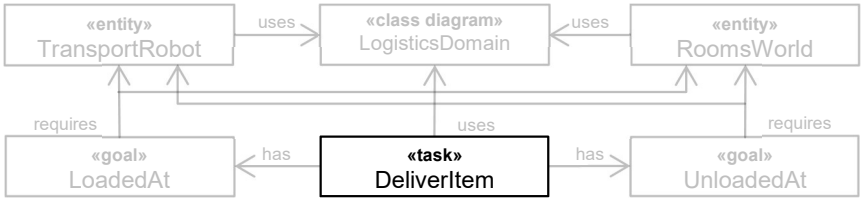

```
01 robot TransportRobot rob;
02 goal LoadedAt(Room room, Item item) {
03   (rob.robotLoc() == room) && (rob.hasLoaded(item))
04 }
```

Goal

Boolean property

references entity properties

Example: Tasks



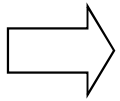

```
01 domain LogisticsDomain;
02 task DeliverItem(Room src, Item i, Room dst) {
03   LoadedAt(src,i);
04   UnloadedAt(dst,i);
05 }
```

Task

ordered list of goals

How are tasks executed?

Outline



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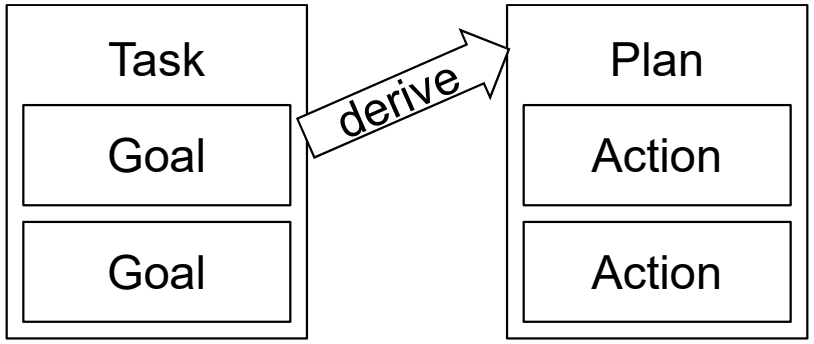
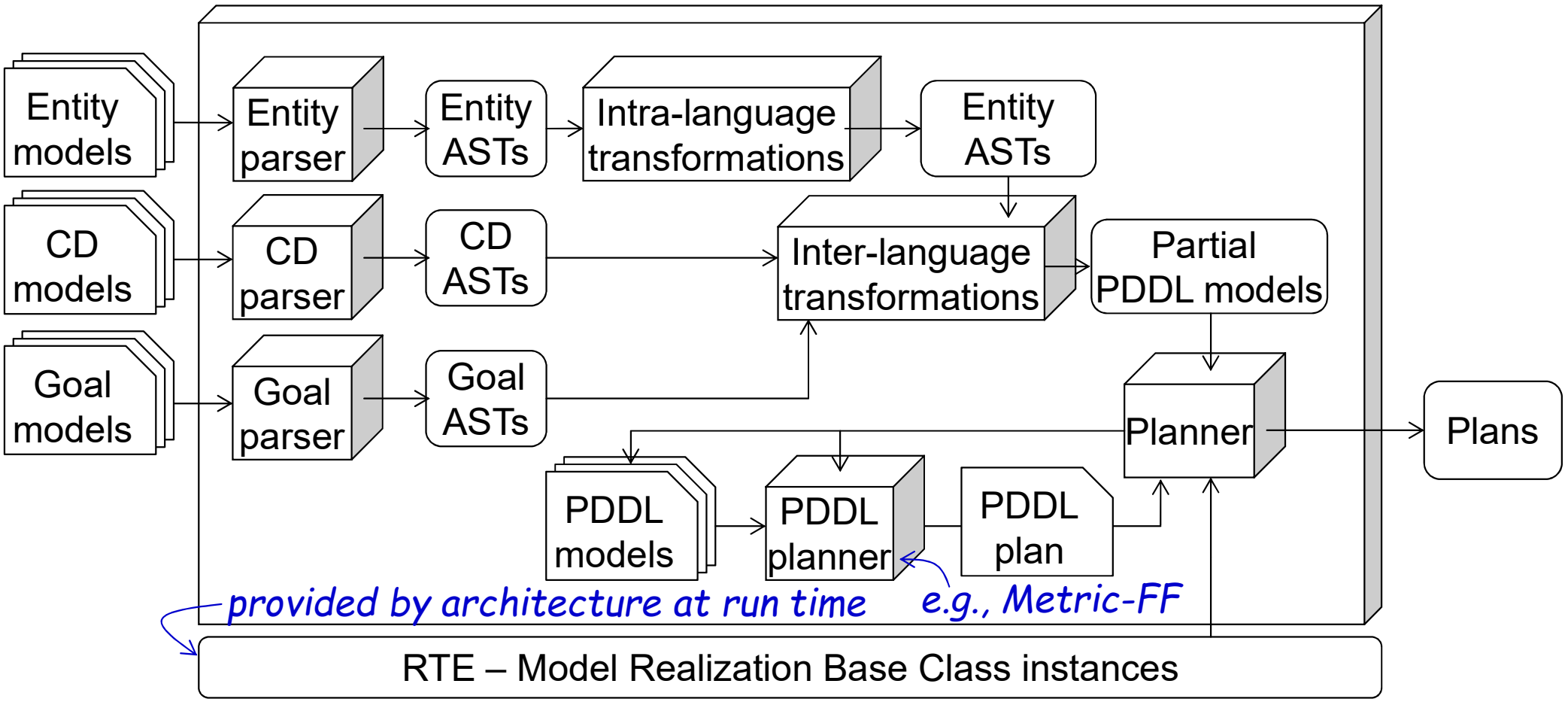
Task Execution

- Dynamic domain: deterministic, fixed plans will fail
- Use PDDL[1] planner to execute tasks:
  - reach goals in order (i.e., fulfill condition)
  - fulfill goal through action execution
- Action:
  - can be executed if precondition is fulfilled
  - after fulfilling: effect manipulates environment
- Planning data: CD types, entity model, goal models
- Derive a plan through model transformations at run-time

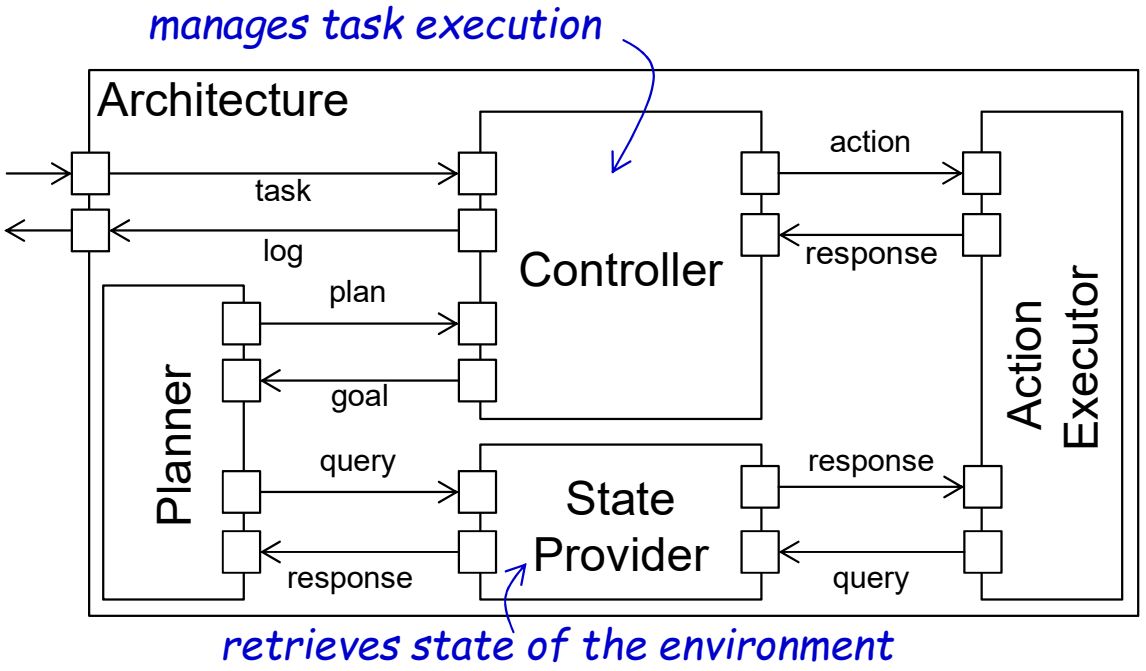


[1] Drew McDermott, Malik Ghallab, Adele Howe, Craig Knoblock, Ashwin Ram, Manuela Veloso, Daniel Weld, and David Wilkins. *PDDL-The Planning Domain Denition Language*. Tech report: 1998

Process


Entity models
Entity parser
Entity ASTs
Intra-language transformations
Entity ASTs
CD models
CD parser
CD ASTs
Inter-language transformations
Partial PDDL models
Goal models
Goal parser
Goal ASTs
Planner
Plans
PDDL models
PDDL planner
PDDL plan
provided by architecture at run time
e.g., Metric-FF
RTE – Model Realization Base Class instances

Effects on Architecture



- Implementation of `ActionExecutor` generated
  - action types depend on entity models
- Implementation of `StateProvider` generated
  - properties depend on entity models & domain types

Conclusion

- Controller orchestrates robot task execution
- Planner calculates how to achieve goals
- Action executor delegates to middleware

- Evaluated in a German hospital

- Operate in dynamic environment

- Separation of concerns

- Good extensibility & reusability

Thank you for your attention