SkiROS2

Skill-based robot control system for ROS V.2

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SkiROS

Software platform for the coordination industrial robots

Main features

- Skill-based robot control architecture
- Behavior trees execution system, for reactive behavior in dynamic environments
- Hardware-abstracted task description
- Semantic database server
- Integrated with PDDL task planner

ROS - enabled

This project has received funding from the European Union's Horizon 2020 research and innovation programme under the Grant Agreement N° 723658

SkiROS - A brief introduction

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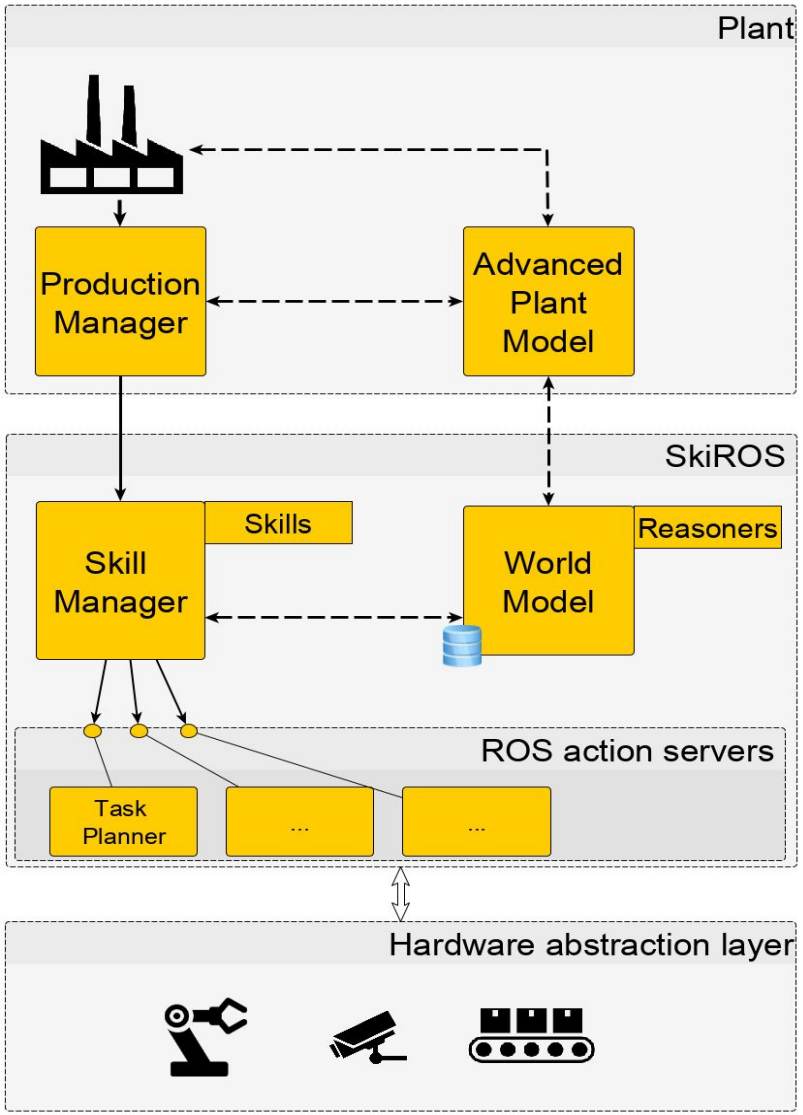
SkiROS in Scalable

High-level
Integration and synchronization with PM/APM

SkiROS
Task design and execution on robot

Low-level
Integration of hardware through HAL



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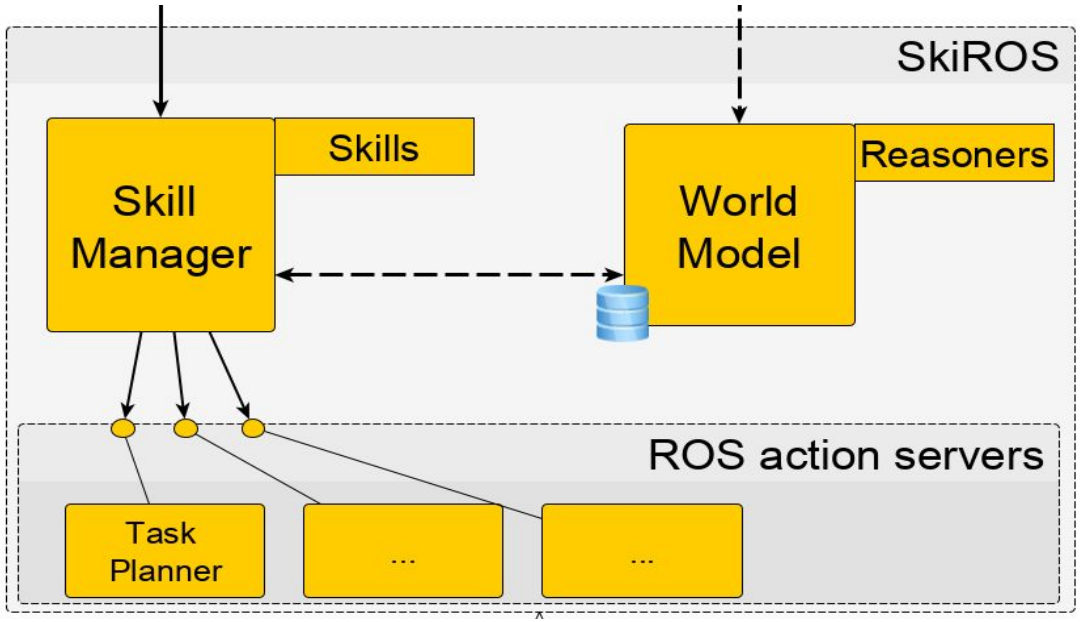
SkiROS architecture

World model
The semantic database, manages task data and offers services to modify it and reason on it

Skill manager
The execution engine, manages information about available skills and offers services to execute and monitoring

Skills
Complex primitive skills can be exposed as ROS actions



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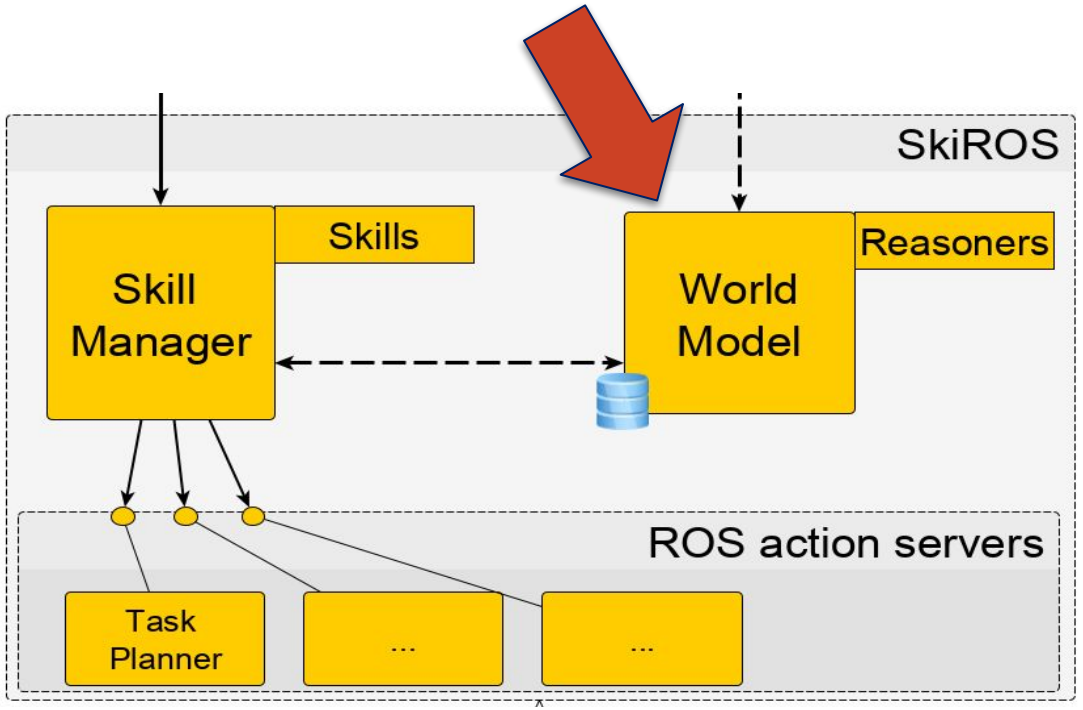

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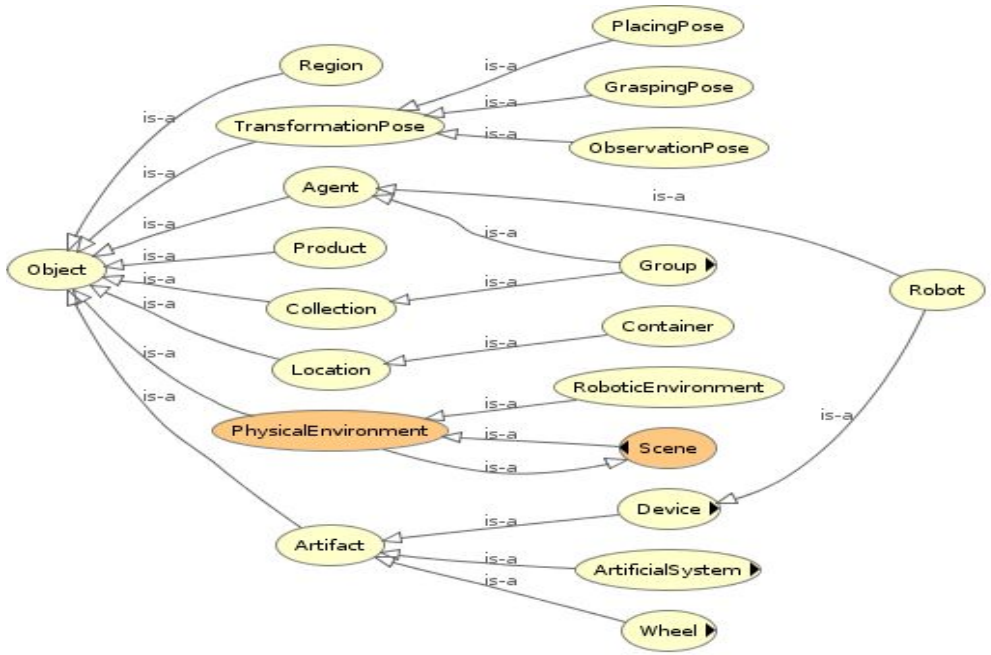
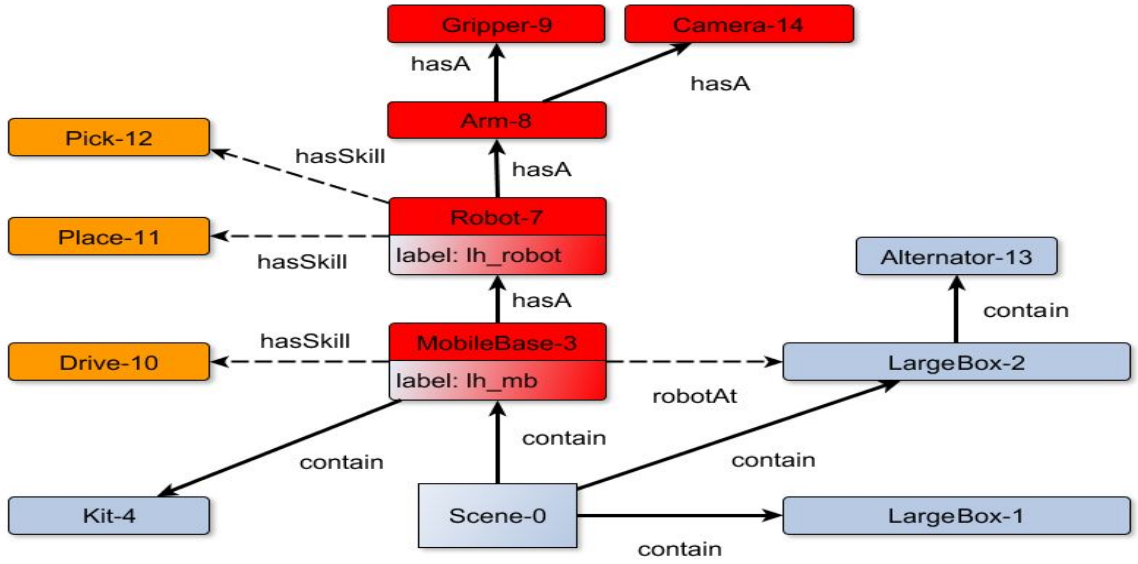
World model

Ontology
Semantic definition of concepts, data structures and relations of objects in the domain



Scene graph
Model of the current world state for reasoning, planning and execution



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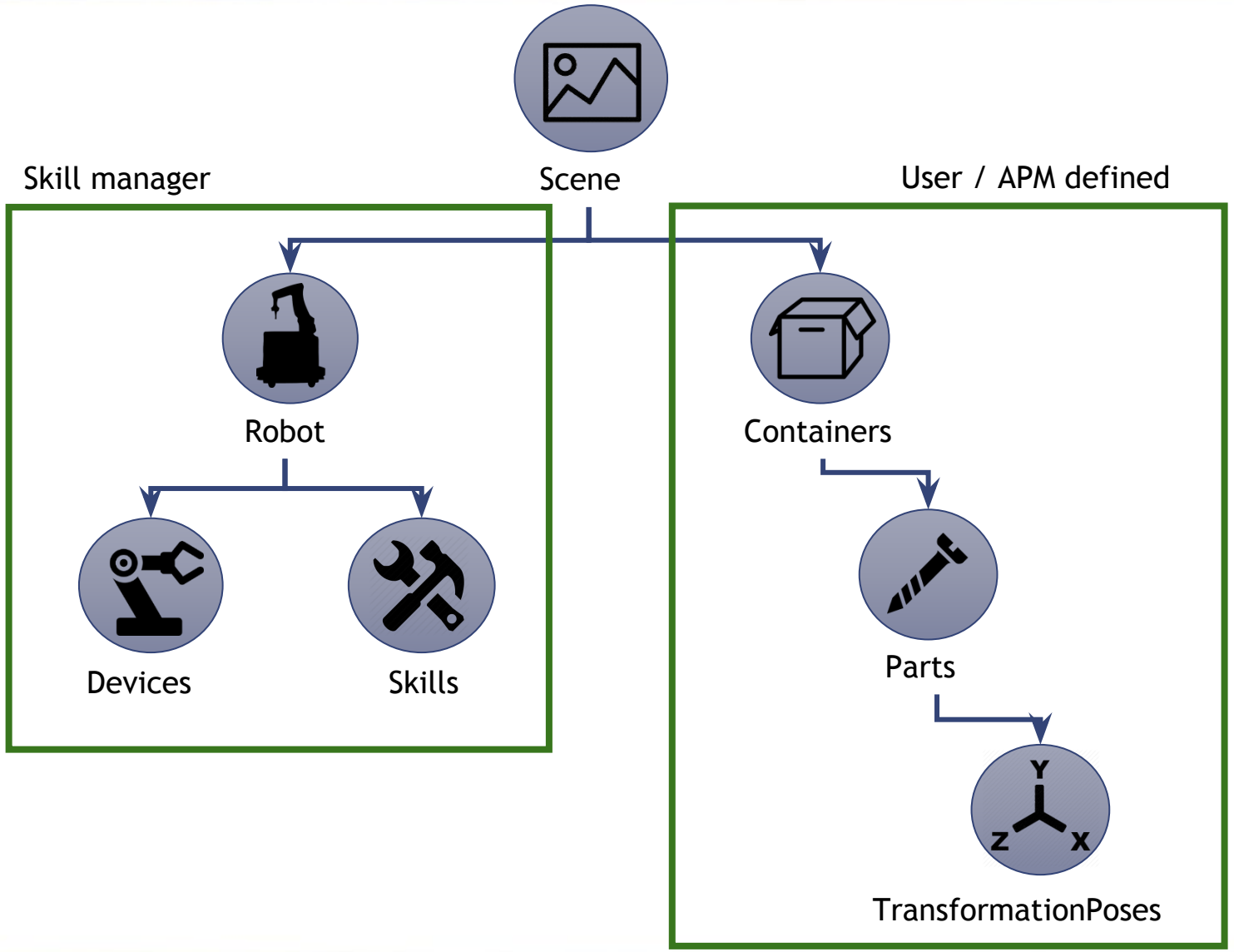
Scene graph



Automatic synchronization with TF

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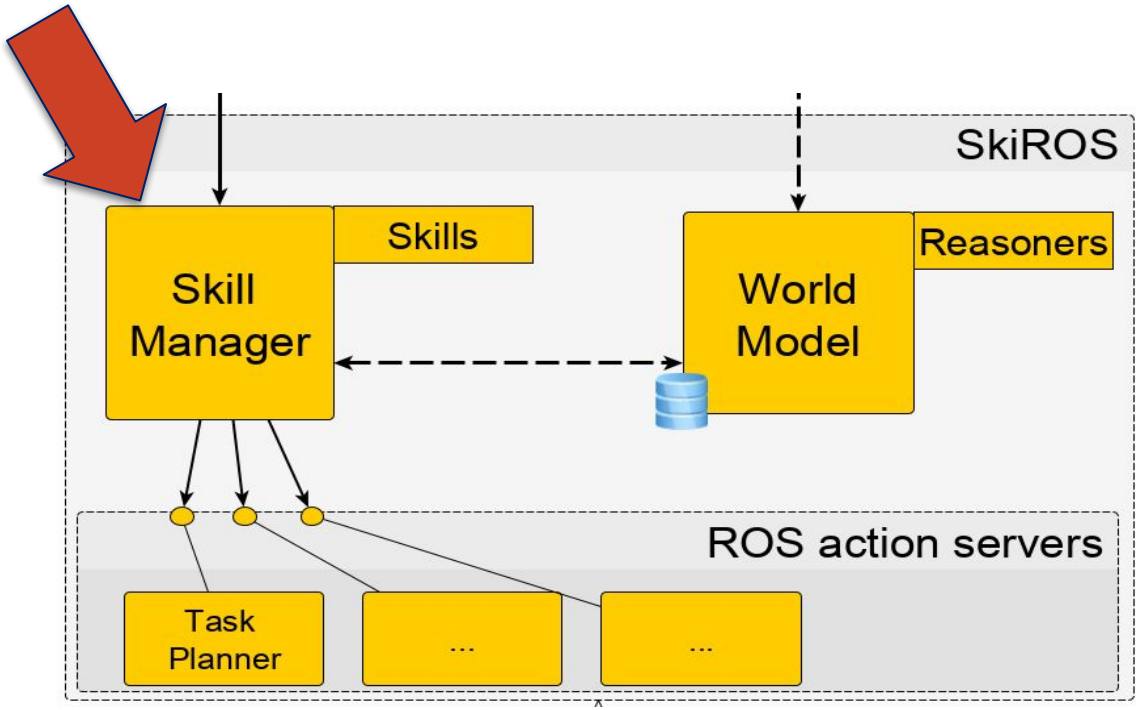

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Skill manager

Skill manager node

World model sync

Uploads robot description and available skills on world model

Execution services

<robot_name>/get_skills service: return the list of available skills
<robot_name>/command service: start/stop a skill execution
<robot_name>/monitor publisher: output feedback from skills

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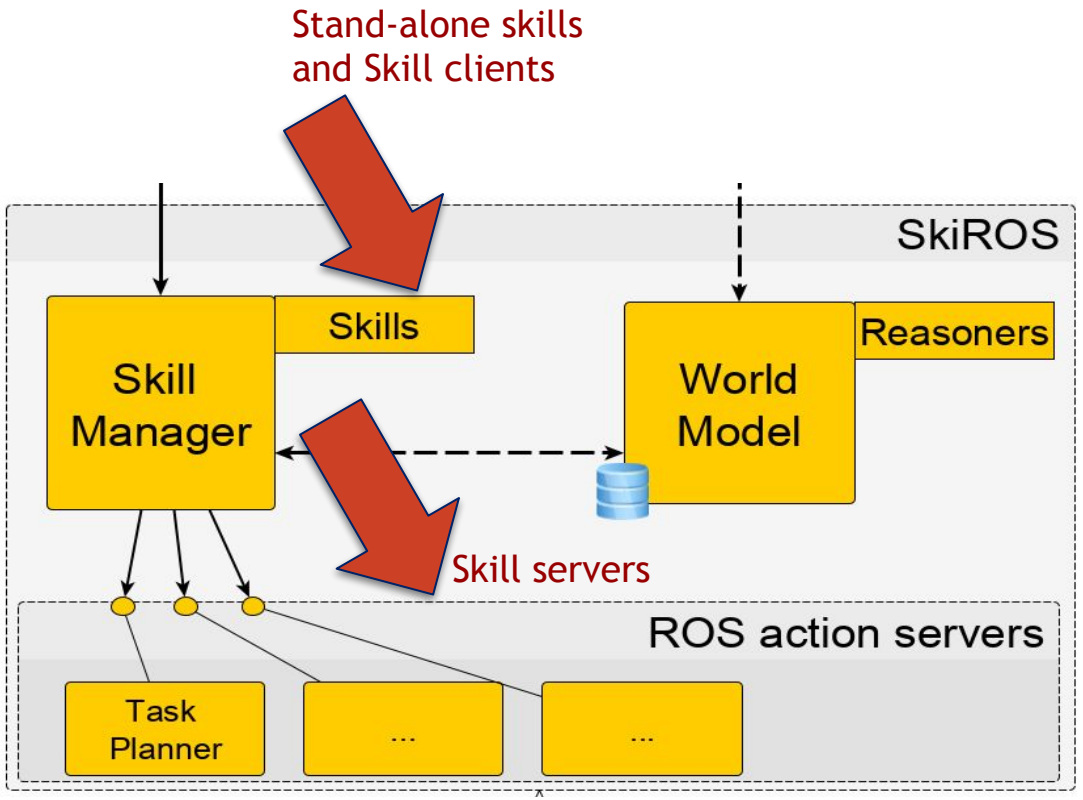

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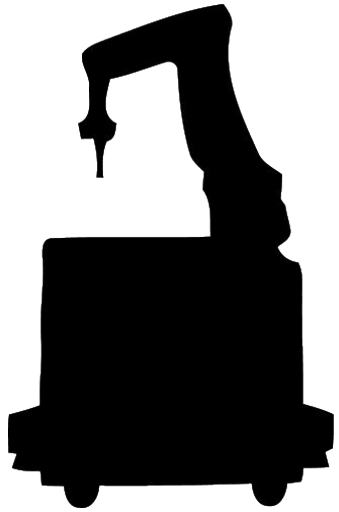
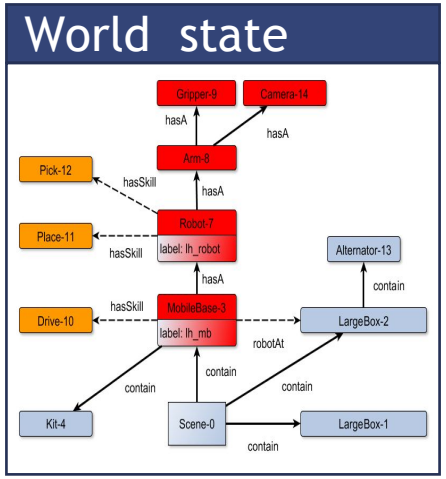
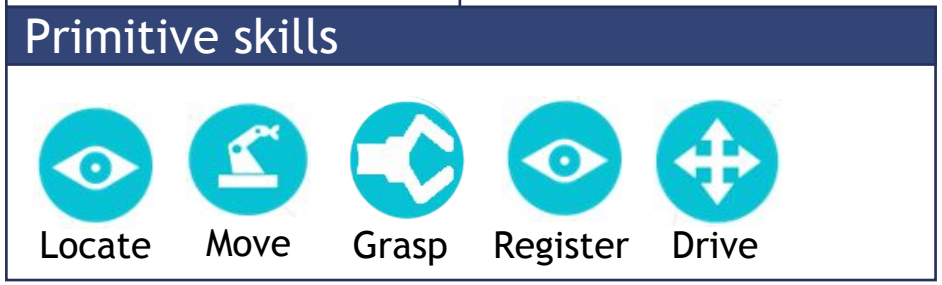
Skill concept revisited

Skill	A process that can change the state of the robot and its environment.
Primitive skill	A command that resides at the lowest level of the hierarchy and can be directly executed by the robot platform
Compound skill	A hierarchically organized collection of skills.
World state	Contains the current state of the world known by the robot







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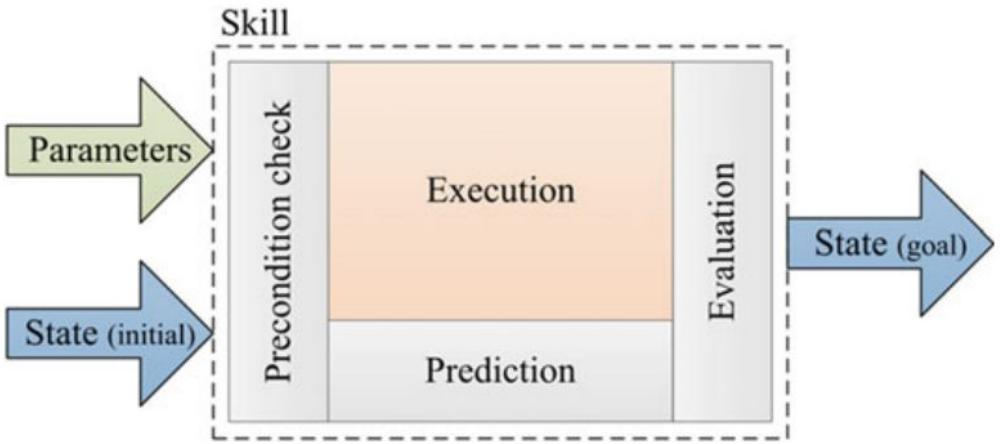
Skills

Definition:
A skill allows to transition from one world state to another, if its preconditions are met



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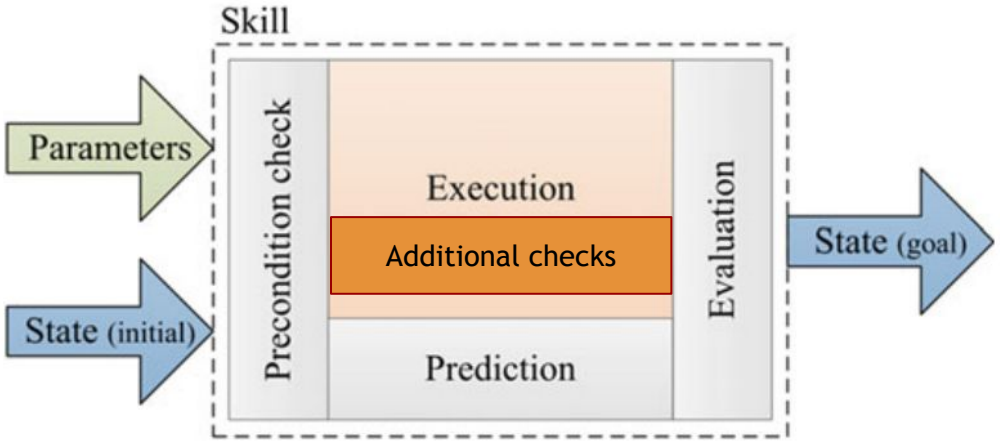
Skills

Problem:
A skill might be an action with a long duration. The system is **not reactive** during its execution. Complementary checks have to be encoded within the skill



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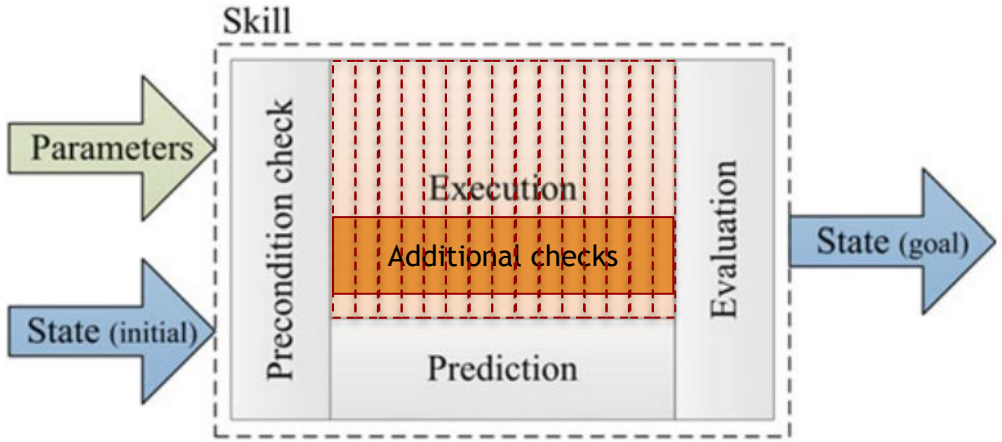
Skills

Idea:

Time slicing of a skill into n steps.

A skill becomes a Markov chain that is interruptible at each step.



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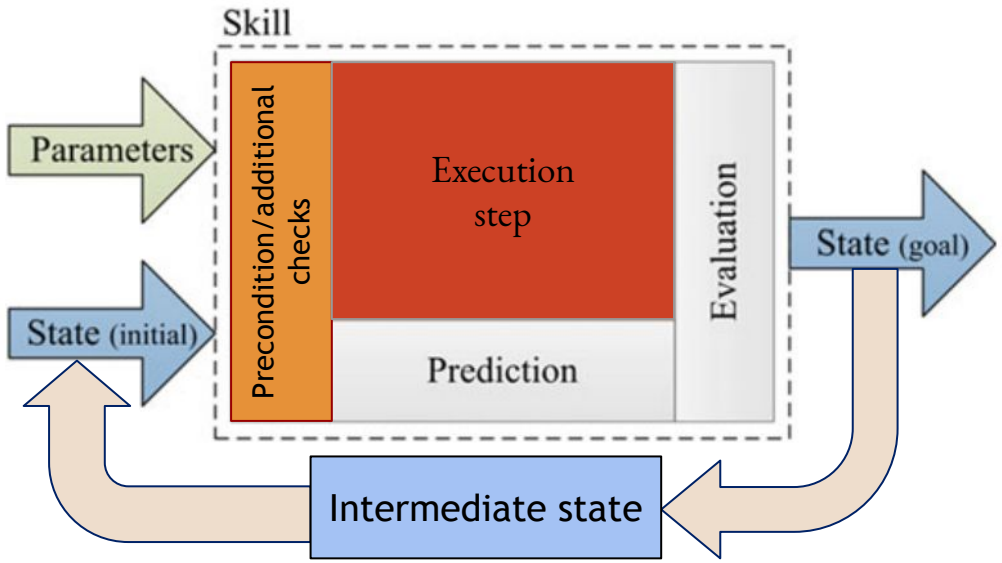
Skills

Solution:

With the right design, a skill can be expressed in terms of an iterative function system

$s(x) = s_n(s_{n-1}(s_{n-2}(\ldots(s_1(x))\ldots)))$



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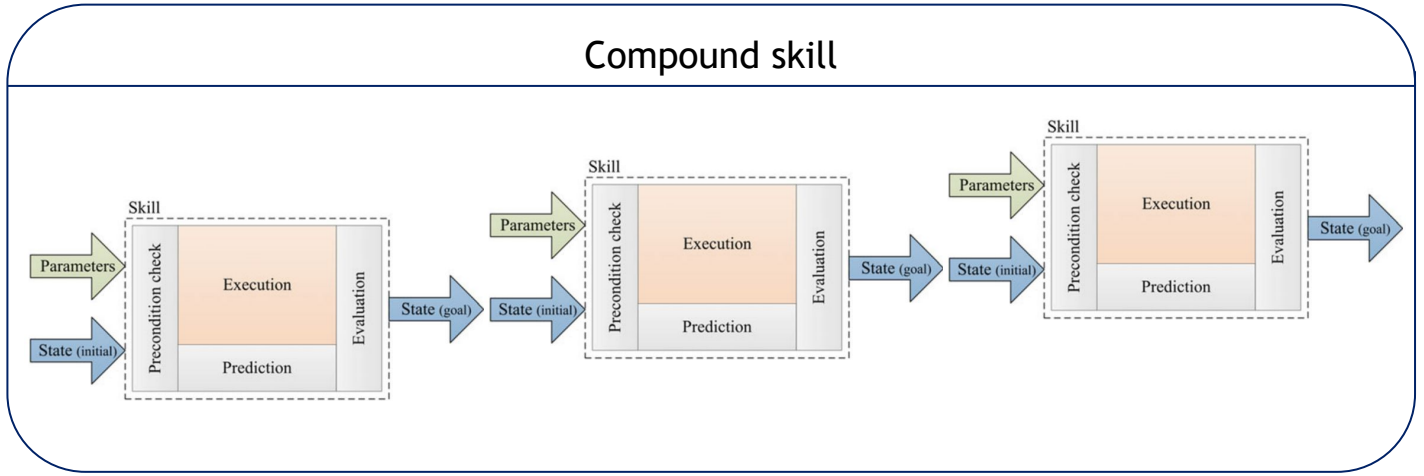
Compound skills

Hierarchical structure of set of skills

Often only used as sequences

- Compound Skill
  - do Skill A
  - do Skill B
  - if condition
    - true: do Skill C
    - false: do Skill D



Sequences are not flexible enough!

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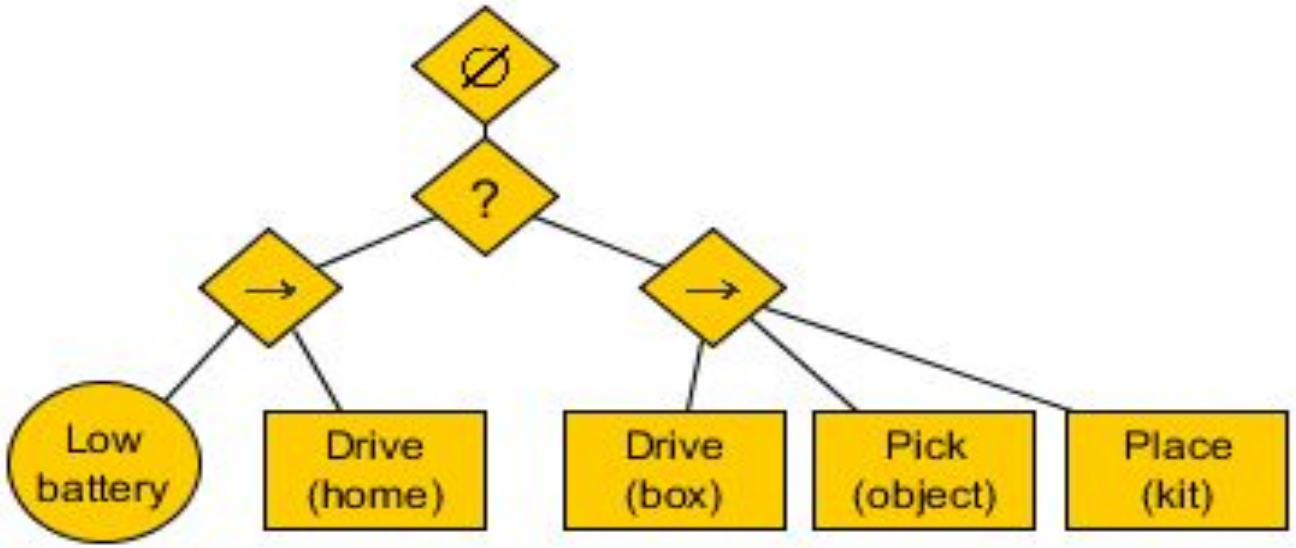
Behavior trees

Intuitive way of representing and coordinating iterative skills are behavior trees

- Tree where leaves are actions to execute and nodes define the execution sequence
- Actions can return 3 states: Success, Failure or Running
- Execution is divided into discrete ticks, which propagate from the root node
- Allows change of execution at each tick

Node type	Symb.	Execution
Root	∅	return tick(child(0))
Sequence	→	tick ch. sequentially. stop with F if one ch. F
Parallel	‖	tick ch. in parallel. stop with F if one ch. F
Selector	?	tick ch. sequentially. stop with S if one ch. S
Decorator	δname	varies
Action	□	return S, F or R
Condition	○	if condition=True return S else return F



SkiROS extends this concept!

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SkiROS - Reactive assembly

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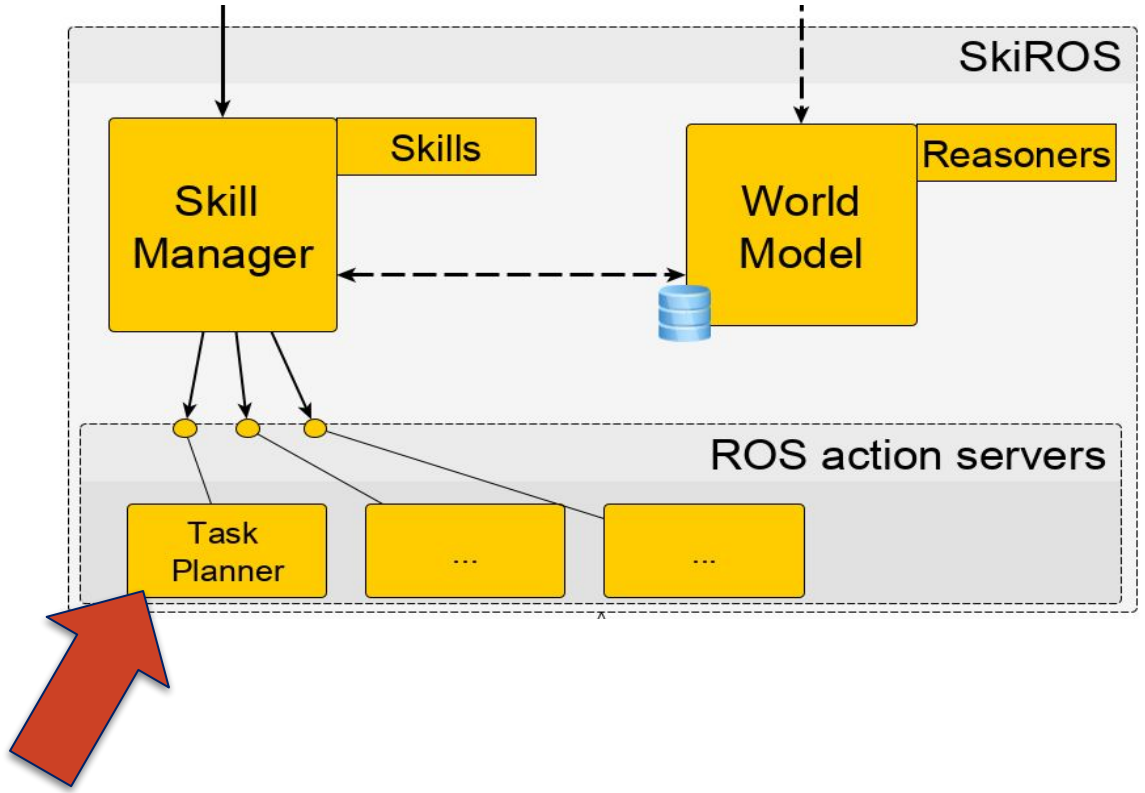

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Task planning skill

Process flow
Task description

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Task planning skill

Process flow

Task description → Define PDDL goal

InKit(Alternator, Kit)

at(robot, Station-1)

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Task planning skill

Process flow

Task description → Define PDDL goal → Generated PDDL plan

InKit(Alternator, Kit)

at(robot, Station-1)

drive(LargeBox-25)

pick(Alternator)

place(Kit-7)

drive(Station-1)

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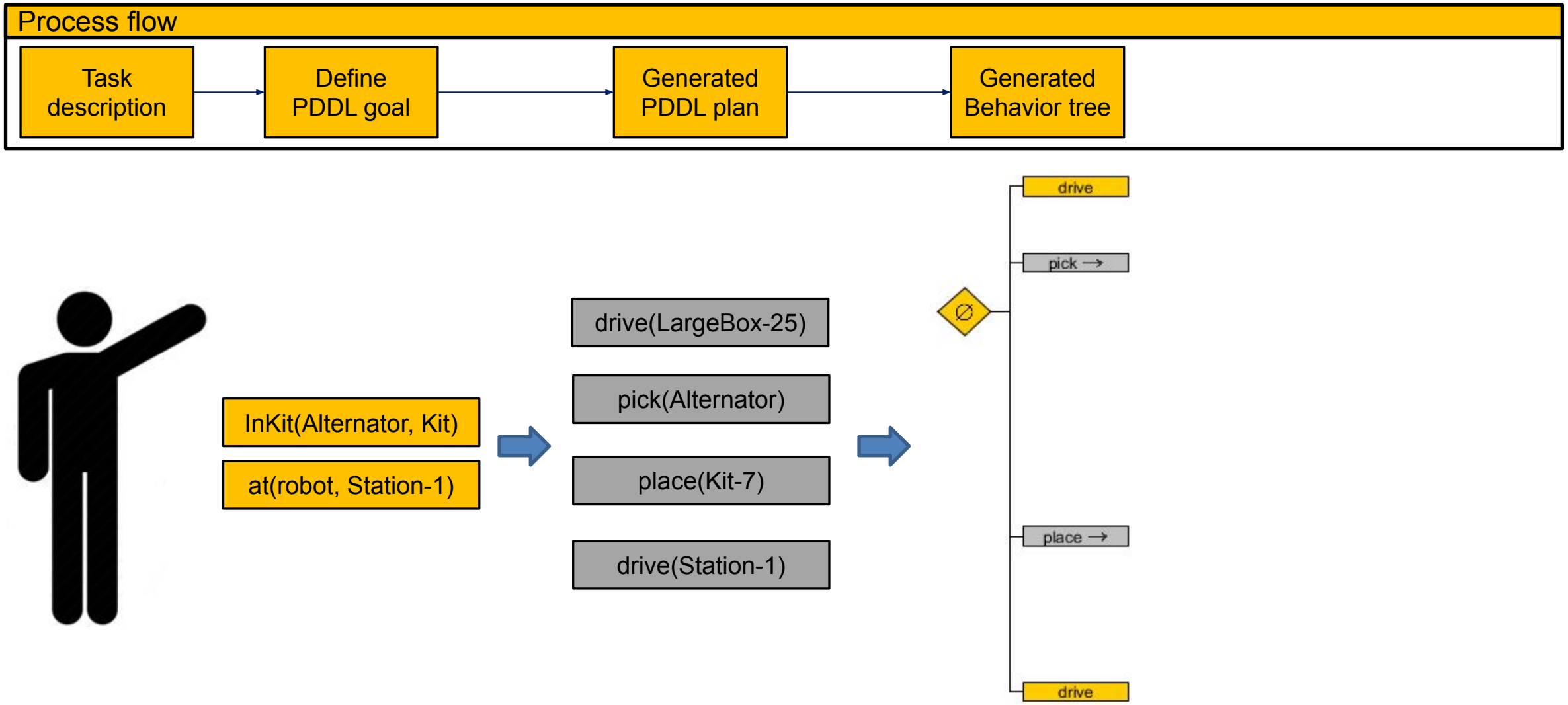
Task planning skill



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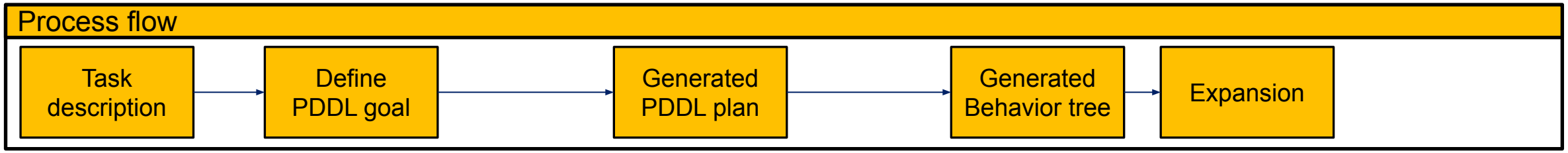

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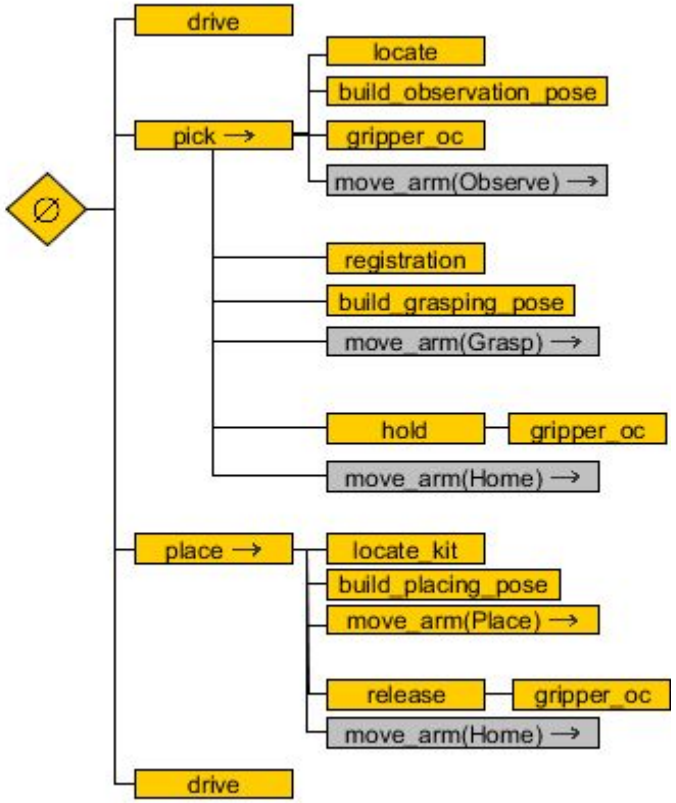

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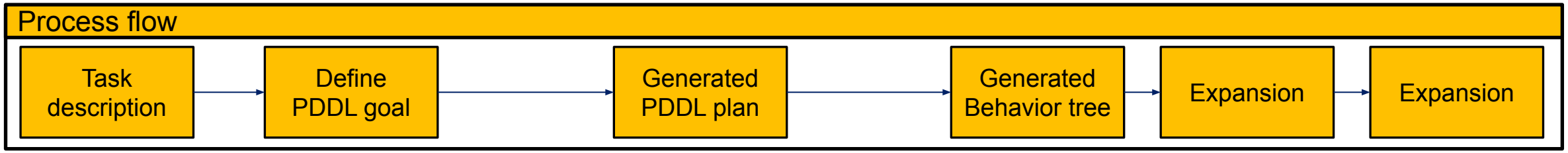
Task planning skill



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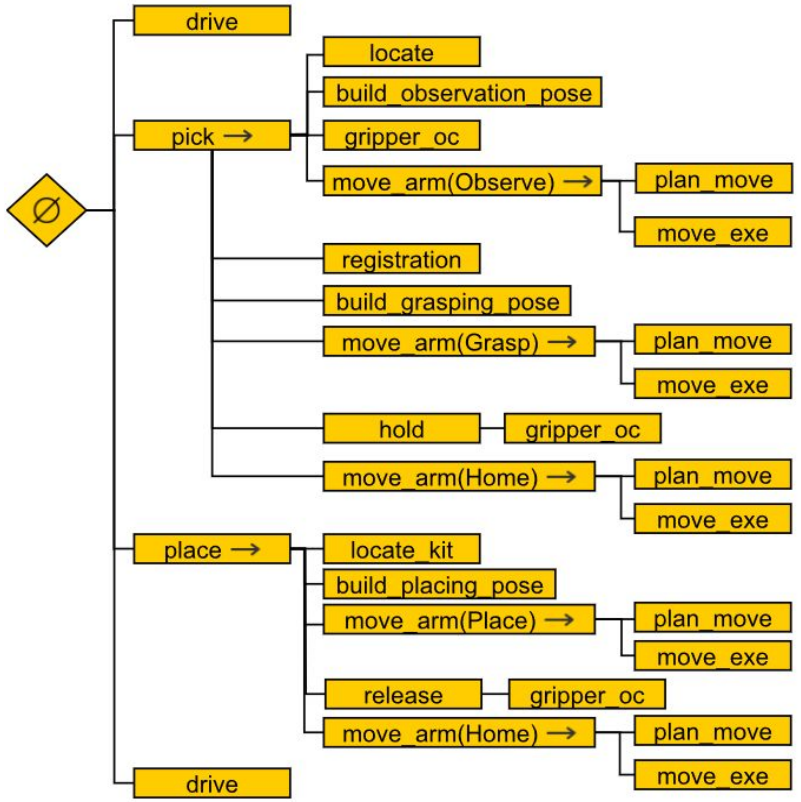

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SkiROS - Kit planning

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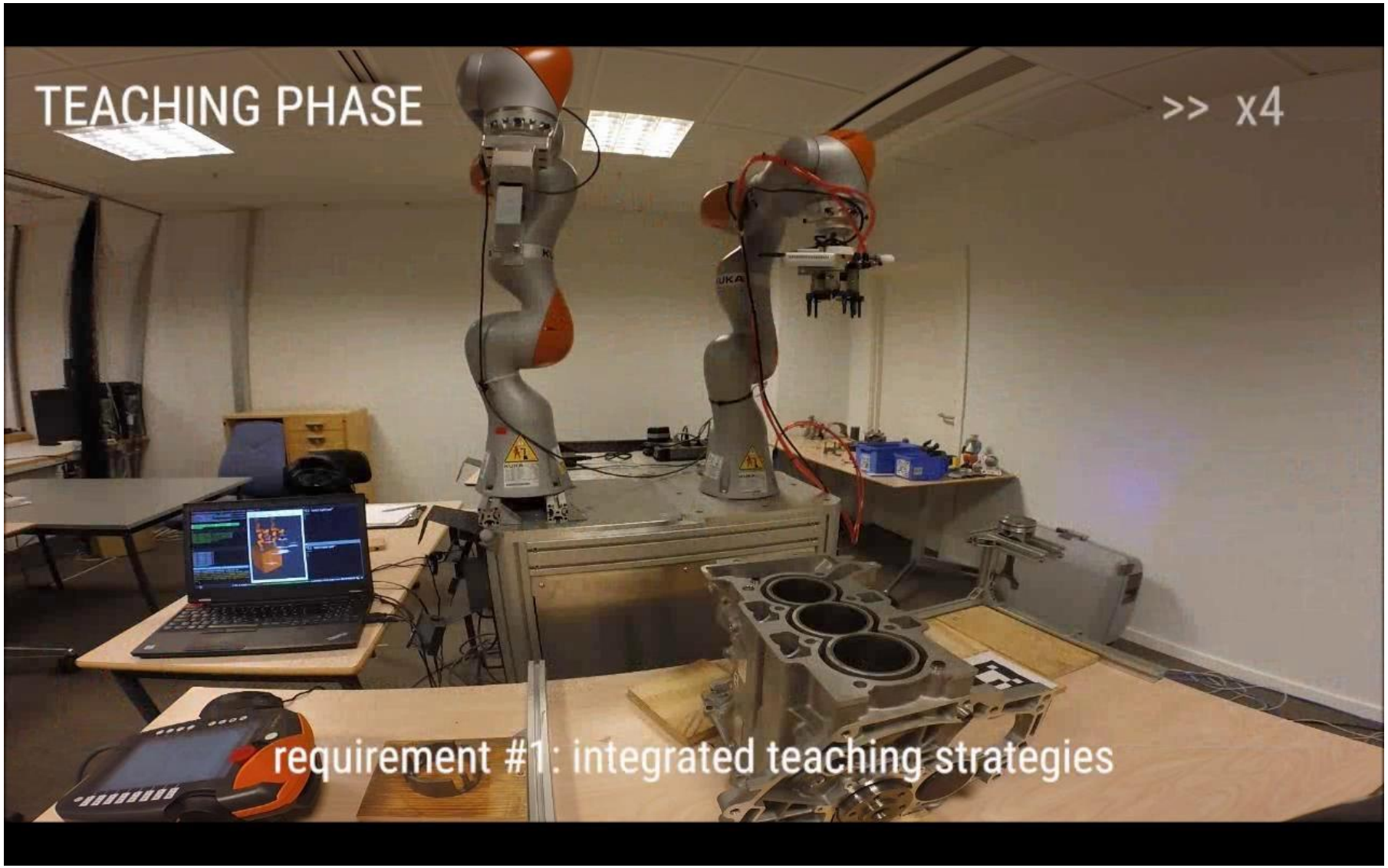
SkiROS - Kinesthetic teaching



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Future of SkiROS

Source code publicly available (soon)

Founded RiACT as spin-off from Scalable

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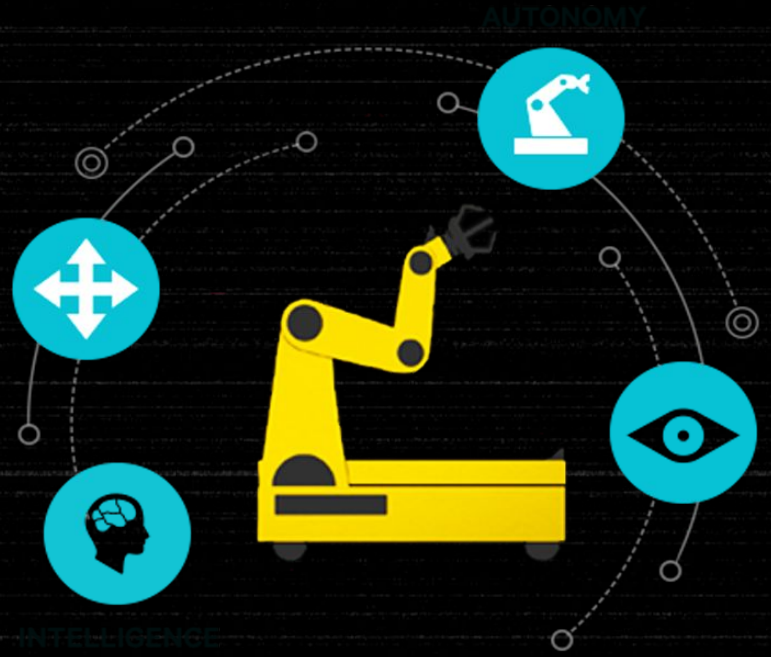

RACT

Robots in Action

The RiACTivists

Magnus Philip Ritzau
Master /
Business developer

Bjarne Grossmann
Post Doc /
Software engineer

Francesco Rovida
Post Doc /
Control engineer

Volker Krueger
Professor /
Advisor

Hands-on!
Let’s program some turtles

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```
git clone https://github.com/Bjarne-AAU/skiros-demo.git
cd skiros-demo
./scripts/install-skiros-repo.sh .

roslaunch demo_skills main.launch
```


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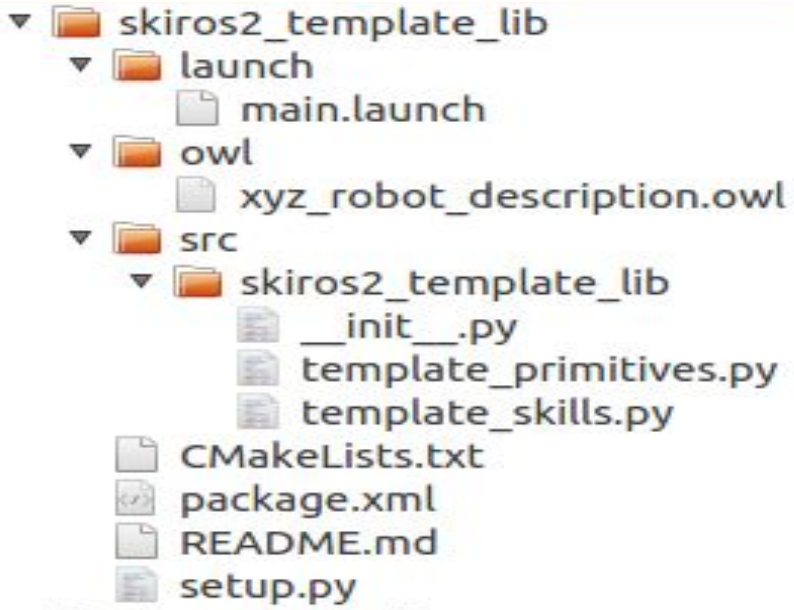

The development process can be summarized in the following steps:

- Create a new OWL file with a new robot description, including hardware and other relevant properties.
- Develop necessary plug-ins:
  - Primitive skills
  - Compound skills
- Create a new ROS launch file running a skill manager with the new robot description and skills

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