

AMIGO's software architecture: performing a RoboCup Challenge

J.J.M. Lunenburg

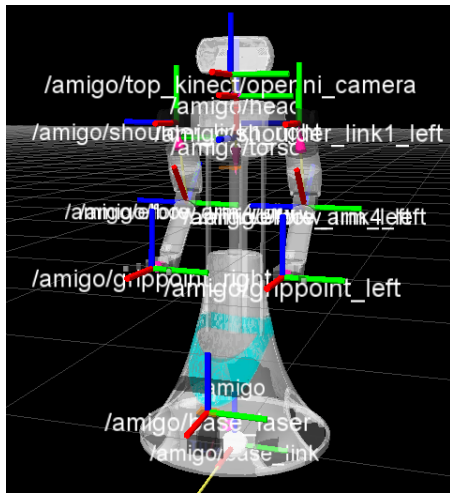
October 8, 2013

TU / **e** Technische Universiteit
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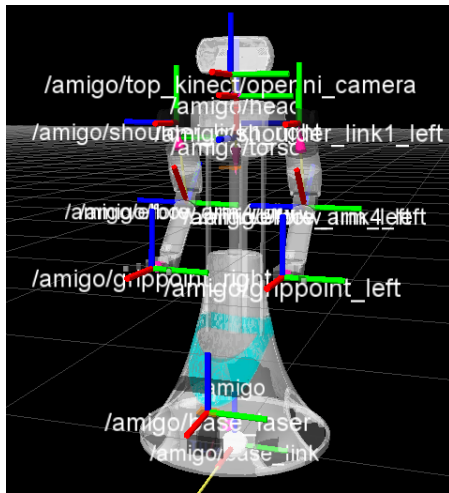
Where innovation starts

- ▶ roscore

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- ▶ Robot state publisher
 - Subscribes to joint angles
 - Uses URDF model
 - Publishes poses of robot links
 - Used by rviz



- ▶ roscore
- ▶ Robot state publisher
 - Subscribes to joint angles
 - Uses URDF model
 - Publishes poses of robot links
 - Used by rviz
- ▶ Diagnostics
 - Battery voltage
 - Timing offsets
 - Emergency button states
 - Graphical user interface



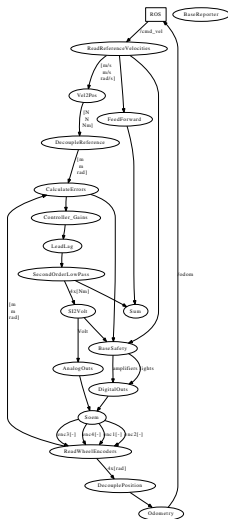
- ▶ Open RObot COntrol Software (Orocos) realtime toolkit (rtt)
 - Modular realtime software components
 - Launched in a rosnode
 - Configuration defined in deployment scripts
 - rtt component library

▶ Open Robot Control Software (Orocos) realtime toolkit (rtt)

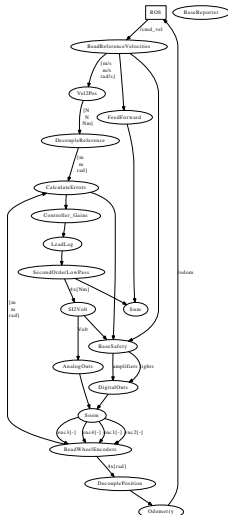
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▶ Deployment structure

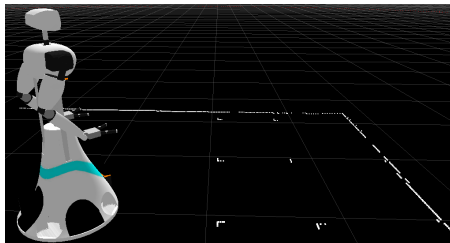
- Hardware communication (SOEM library)
- Controller architecture



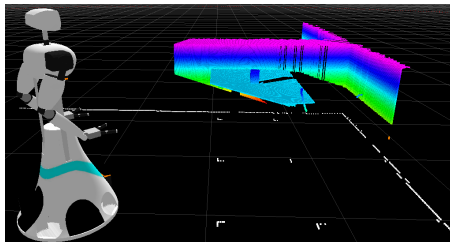
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- ▶ Deployment structure
 - Hardware communication (SOEM library)
 - Controller architecture
- ▶ Safety
- ▶ Supervisor



- ▶ Laser range finders
- ▶ (Kinect) cameras



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- ▶ (Kinect) cameras



- ▶ Navigate to party room

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- ▶ Ask for name and desired drink

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- ▶ Learn faces

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- ▶ Get the drinks

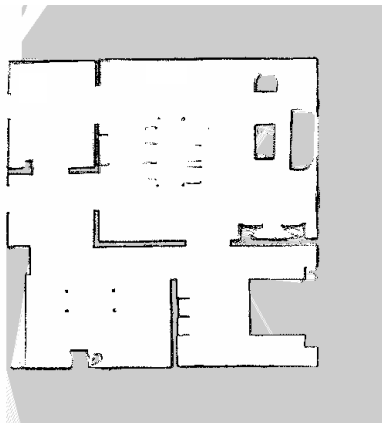
- ▶ Navigate to party room
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- ▶ Get the drinks
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- ▶ Leave the arena

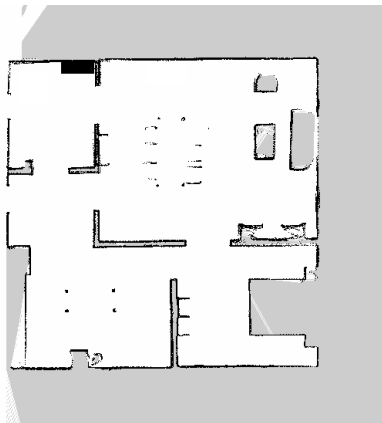
- ▶ **Navigate to party room: navigation**
- ▶ Ask for name and desired drink
- ▶ Learn faces
- ▶ Get the drinks
- ▶ Deliver the drinks
- ▶ Leave the arena

- ▶ Localization
 - AMCL
 - GMapping

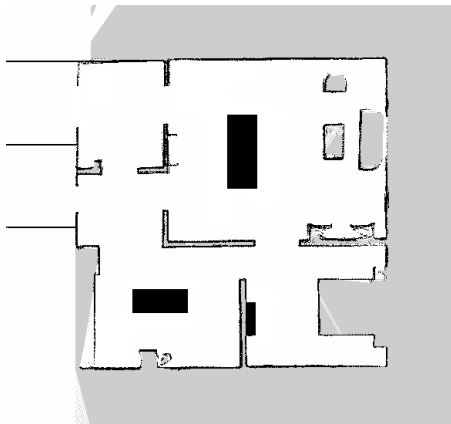
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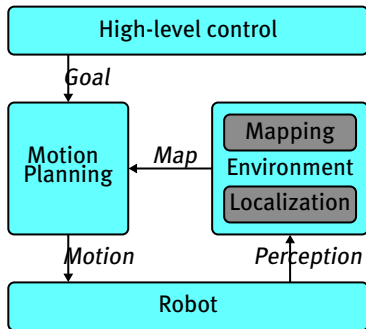
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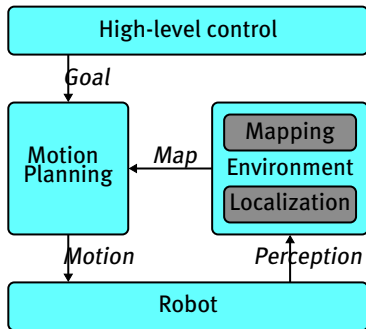
- ▶ Localization
- ▶ Path planning



- ▶ Localization
- ▶ Path planning
- ▶ Navigation pipeline
 - move base



- ▶ Localization
- ▶ Path planning
- ▶ Navigation pipeline
 - move base
- ▶ **Where are we going?**

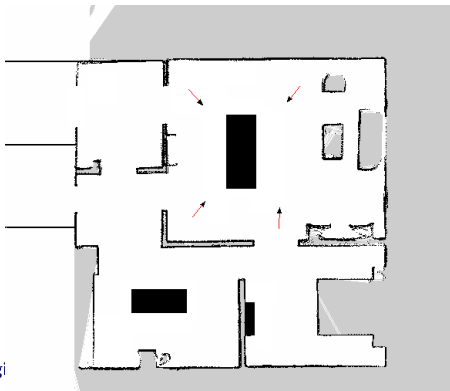


► Reasoning interface

- Expressive, semantic interface
- `waypoint(rwc2013, cocktailparty, partyroom, pose2d(3.712, -2.506, -1.348)).`



- ▶ Reasoning interface
 - Expressive, semantic interface
 - `waypoint(rwc2013, cocktailparty, partyroom, pose2d(3.712, -2.506, -1.348)).`
- ▶ Robustness
 - Multiple goals



- ▶ Reasoning interface
 - Expressive, semantic interface
 - `waypoint(rwc2013, cocktailparty, partyroom, pose2d(3.712, -2.506, -1.348)).`
- ▶ Robustness
 - Multiple goals
 - Goal area

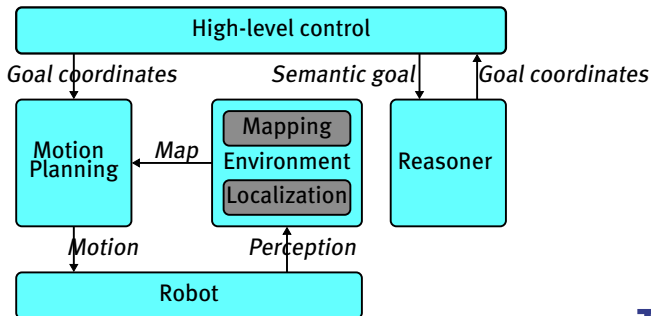


► Reasoning interface

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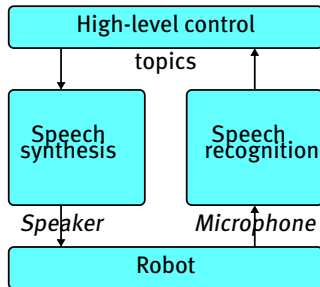
► Robustness

- Multiple goals
- Goal area

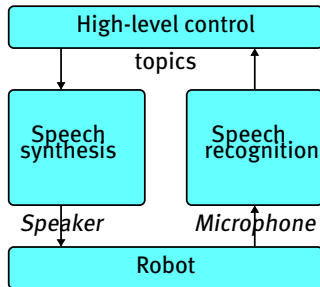


- ▶ Navigate to party room: navigation
- ▶ **Ask for name and desired drink: human-robot interaction**
- ▶ Learn faces
- ▶ Get the drinks
- ▶ Deliver the drinks
- ▶ Leave the arena

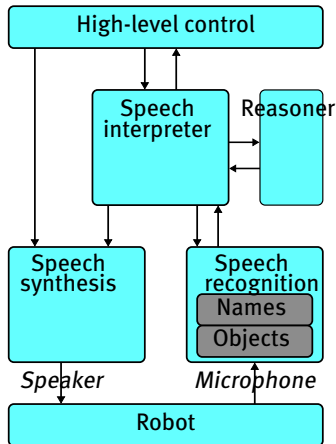
- ▶ Speech synthesis
 - Festival/eSpeak
 - Google
 - Philips
- ▶ Speech recognition
 - (Pocket)Sphinx



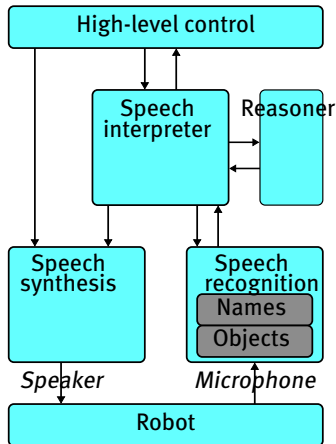
- ▶ Speech synthesis
- ▶ Speech recognition
- ▶ Issues
 - Multiple dictionaries
 - Advanced commands
 - Confirmations
 - Talking and not listening



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- ▶ Speech recognition
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 - Multiple dictionaries
 - Advanced commands
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 - Talking and not listening
- ▶ Speech interpreter
 - Parameterized request
 - Knowledge from reasoner
 - Active required dictionary

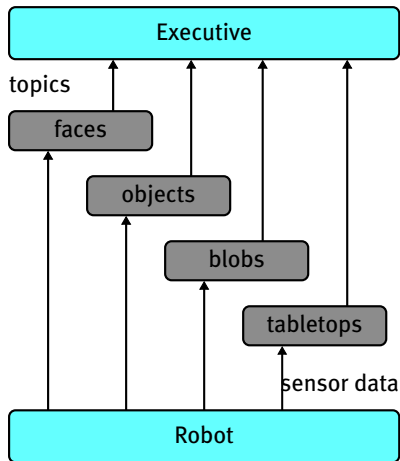


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- ▶ Speech recognition
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- ▶ LED bar

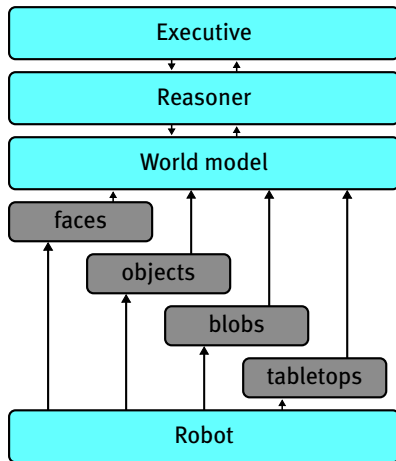


- ▶ Navigate to party room: navigation
- ▶ Ask for name and desired drink: human-robot interaction
- ▶ **Learn faces: perception**
- ▶ Get the drinks
- ▶ Deliver the drinks
- ▶ Leave the arena

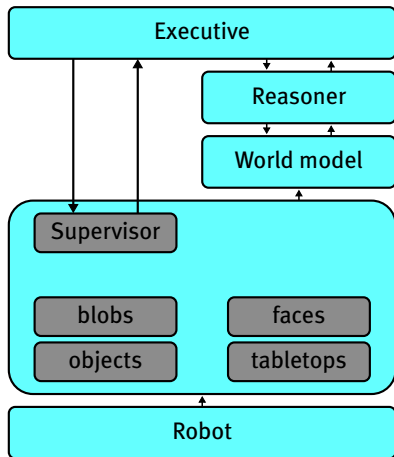
- ▶ Many routines for detecting and recognizing peoples and objects
 - Leg and torso detection
 - Face detection
 - Face recognition
 - Template matching
 - Blob clustering
 - Tabletop segmentation
 - Viewpoint Feature Histogram matching



- ▶ Many routines for detecting and recognizing peoples and objects
- ▶ World model
 - Consistent belief state
 - Sensor fusion
 - Probabilistic multiple-hypothesis approach
 - Memory
 - Reasoner provides interface between executive and world model

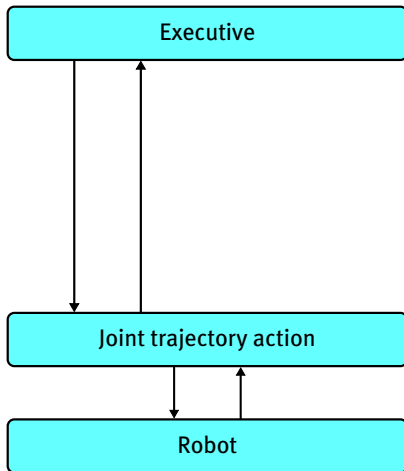


- ▶ Many routines for detecting and recognizing peoples and objects
- ▶ World model
- ▶ PErception INfrastructure
 - Reuse of code
 - Nodelet: prevent needless data copying
 - Modules can be switched on or off through supervisor

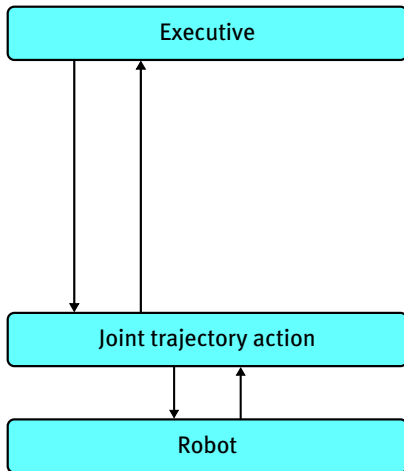


- ▶ Navigate to party room: navigation
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- ▶ **Get the drinks: manipulation**
- ▶ Deliver the drinks
- ▶ Leave the arena

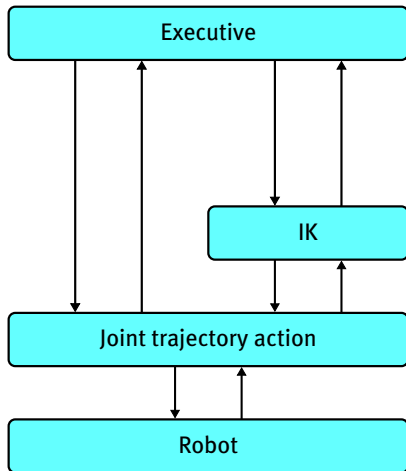
- ▶ Targets in joint space: Joint trajectory action
 - Actionlib interface



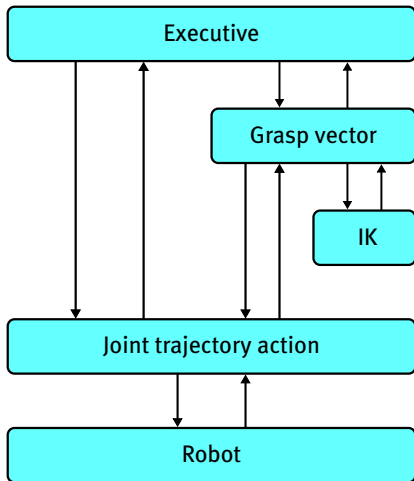
- ▶ Targets in joint space: Joint trajectory action
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- ▶ Targets in Cartesian space



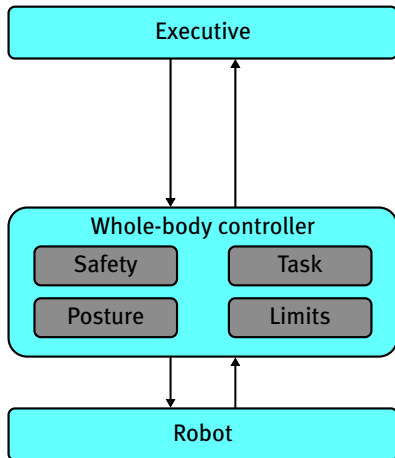
- ▶ Targets in joint space: Joint trajectory action
 - Actionlib interface
- ▶ Targets in Cartesian space
- ▶ Joint space control
 - Inverse Kinematics
 - Joint space planning



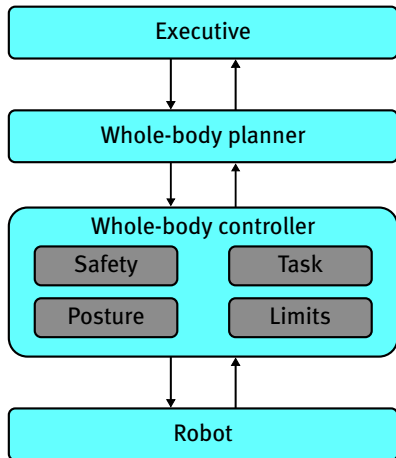
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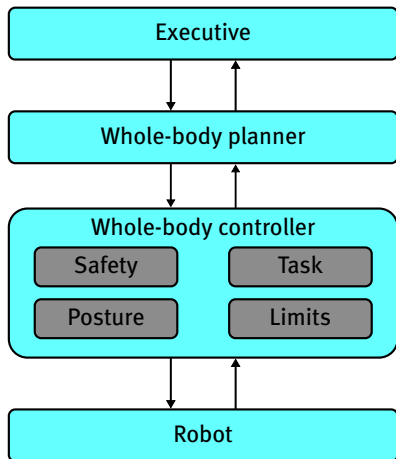
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- ▶ Cartesian space control
 - No explicit joint goals



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- ▶ Cartesian space control
 - No explicit joint goals
 - Local minima

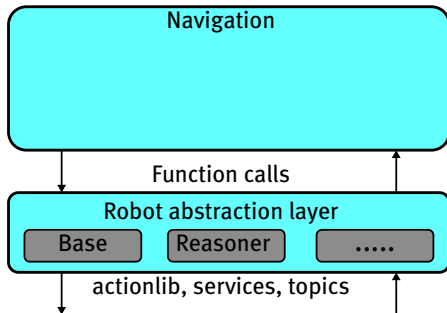


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 - Cartesian space planning
- ▶ Cartesian space control
 - No explicit joint goals
 - Local minima
- ▶ Visual feedback

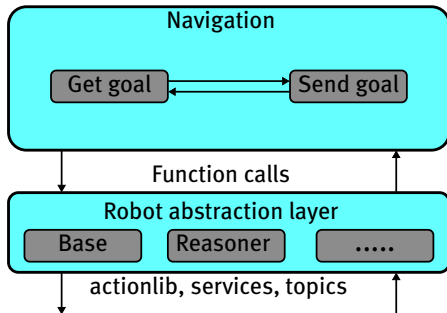


- ▶ Navigate to party room: navigation
- ▶ Ask for name and desired drink: human-robot interaction
- ▶ Learn faces: perception
- ▶ Get the drinks: manipulation
- ▶ **Deliver the drinks: composing hierarchical state machines**
- ▶ Leave the arena: failure handling

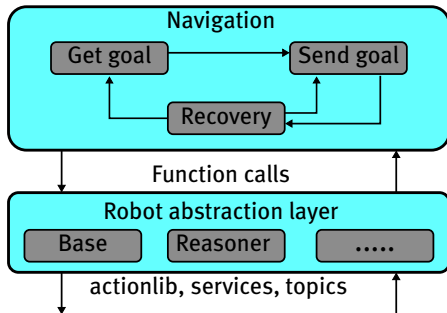
- ▶ SMACH state machine
 - Fast prototyping, complex state machines
 - SMACH states (Generic, CB)
 - SMACH containers (StateMachine, Iterator, Concurrency)
- ▶ Robot abstraction layer



- ▶ SMACH state machine
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- ▶ Hierarchical states

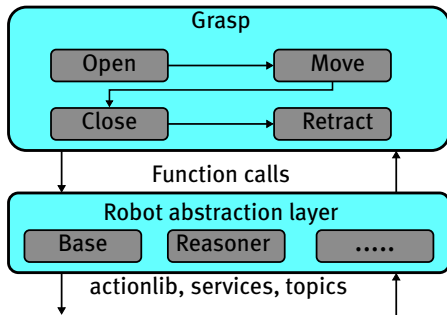


- ▶ SMACH state machine
 - Fast prototyping, complex state machines
 - SMACH states (Generic, CB)
 - SMACH containers (StateMachine, Iterator, Concurrency)
- ▶ Robot abstraction layer
- ▶ Hierarchical states
 - Scaling
 - Reuse of code

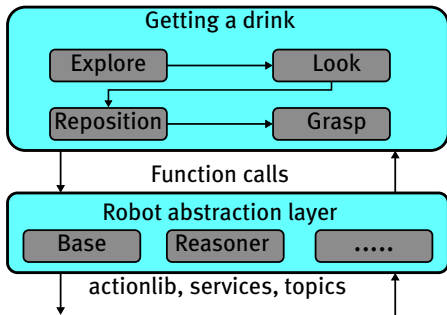


▶ Grasping

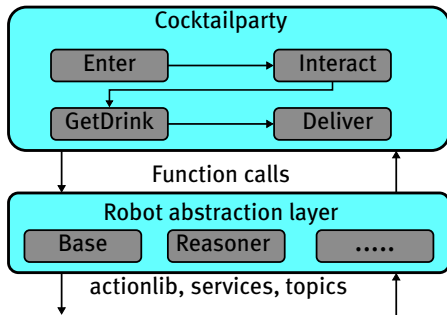
- Open gripper
- Move gripper to object
 - Multiple steps
 - Visual servo update
- Close gripper
- Retract arm



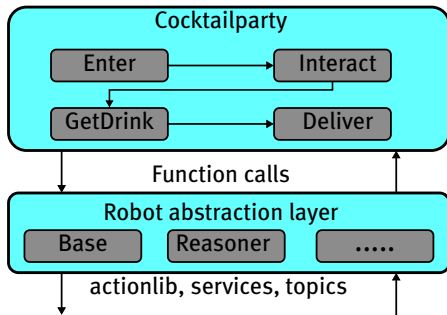
- ▶ Grasping
- ▶ Getting a drink
 - Navigate to possible storage locations
 - Get waypoints from reasoner
 - Look for objects
 - Perception algorithms
 - Reposition
 - Inverse reachability
 - Get target location from reasoner
 - Grasp



- ▶ Grasping
- ▶ Getting a drink
- ▶ Cocktailparty
 - Robot has the drink
 - Delivery



- ▶ Grasping
- ▶ Getting a drink
- ▶ Cocktailparty
- ▶ **AMIGO does not work in a perfect world!**

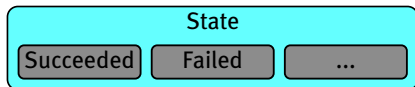


- ▶ Navigate to party room: navigation
- ▶ Ask for name and desired drink: human-robot interaction
- ▶ Learn faces: perception
- ▶ Get the drinks: manipulation
- ▶ Deliver the drinks: composing hierarchical state machines
- ▶ **Leave the arena: failure handling**

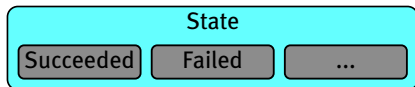
- ▶ Many sources of failures
 - Location unreachable
 - Cannot detect people
 - Cannot find object
 - Object out of reach
 - Hardware failure
 - ...

- ▶ Many sources of failures
- ▶ **What should the robot do when something does not work?**

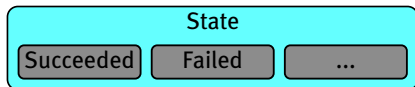
- ▶ Many sources of failures
- ▶ What should the robot do when something does not work?
- ▶ Building an application
 - State outcomes
 - Don't postpone developing fallback scenarios
 - Test *all* transitions



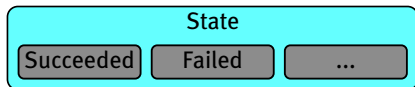
- ▶ Many sources of failures
- ▶ What should the robot do when something does not work?
- ▶ Building an application
- ▶ Time-outs
 - Blocking calls



- ▶ Many sources of failures
- ▶ What should the robot do when something does not work?
- ▶ Building an application
- ▶ Time-outs
- ▶ **Testing!**
 - Sensor noise
 - Servo errors
 - People
 - Startup situations
 - Test settings
 - ...



- ▶ Many sources of failures
- ▶ What should the robot do when something does not work?
- ▶ Building an application
- ▶ Time-outs
- ▶ Testing
- ▶ Task planning
 - Mission statemachine is not hardcoded
 - Useful for more tasks:
General Purpose Service
Robot



Questions?