

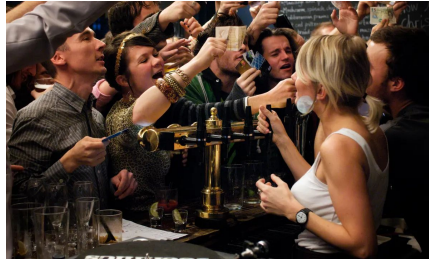
# Cocktail Bot

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# Introduction and motivation

In today's tech-driven era, autonomous systems are transforming industries for the better. One prevalent issue faced by bars is the extended waiting time for intricate cocktails.

Cocktail Bot - the autonomous cocktail robot, aims to revolutionize the cocktail-making process. Using automation we aim to minimize wait times and cost while improving operations efficiency and customer experience.



# Purpose and goals

**Main goal:** Autonomous robot capable of crafting a diverse range of cocktails.

## Sub-Goals:

1. **Exploration:** Autonomous gathering of knowledge about the environment. Collect information about storage places.
2. **Parse cocktail recipe:** Determine the objects that compose the recipe.
3. **Collect ingredients:** Discover/Move to ingredient locations, one at a time.
4. **Finish making cocktail:** Return to original location to deliver the cocktail.

# Problem description

## Exploration

How to get information about the environment?

What places should the robot explore?

Explore environment.

List of points of interest.

## Parse cocktail recipe

What ingredients is the cocktail made of?

Where can the ingredients be stored?

Query knowledge base.

Reason about object relations present in the ontology.

# Problem description

## Collect ingredients

Where is the ingredient located?

Where should I go to search for ingredient?

How do I move to a position?

How to identify the nearby object?

Access information stored over time.

Move to possible ingredient containers.

Navigation system.

Perceive nearby object and identify their type.

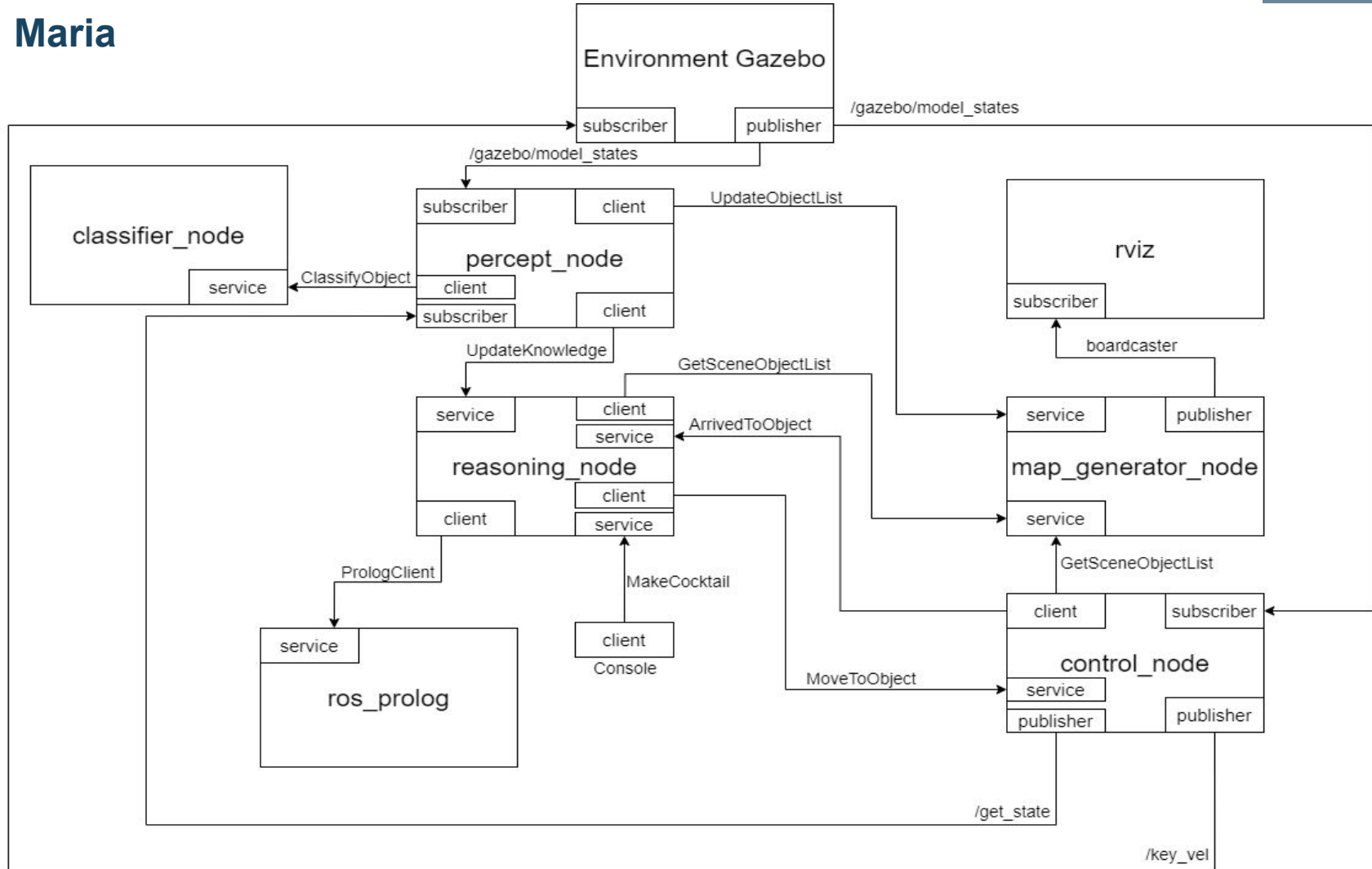
## Finish making cocktail

Did I pick up all the ingredients?

How do end the task?

Successfully reached all ingredients.

Move back to original station.



# Method and implementation

## (Nodes)

**Perception:** Collects information from the environment.

- **Gazebo Subscriber:** Gather knowledge about the nearby objects.
- **Classifier Client:** Object classification.
- **Update Object List Client:** Update object instance mapping.
- **Update Knowledge Client:** Update knowledge base instances.
- **Controller Subscriber:** Get current robot state.

**Classification:** Identify the type of object.

- **Classifier Service:** Classifies objects based on their characteristics.

# Method and implementation

## (Nodes)

**Reasoning:** Fulfills the cocktail request by telling the robot where to go.

- **Cocktail Service:** Responsible to process the cocktail request.
- **Update Knowledge Service:** Receives instances to update knowledge base.
- **Prolog Client:** Interacts with prolog knowledge base.
- **Move to Object Client:** Informs the controller which object to move to.
- **Arrived to Object Service:** Know when the robot has arrived to the target.
- **Get Object Client:** Requests information (pose) about a certain object.



# Method and implementation

## (Nodes)

**Mapping:** Stores information about the object position.

- **Rviz Publisher:** Broadcast object position to rviz node.
- **Get Object Service:** Provides the requested object(s) poses.
- **Update Object List Service:** Updates the map with the new object and respective pose.

# Method and implementation

## (Nodes)

**Controller:** Commands the robot to reach its destinations.

- **Move to Object Service:** Handles movement requests to the robot.
- **Get Object Client:** Requests information about the object pose.
- **Gazebo Subscriber:** Receives information about the current robot pose.
- **Controls Publisher:** Publishes movement controls to the robot.
- **State Publisher:** Publishes the current robot state.

# Reasoning description & implementation

## (Deductive reasoning)



- Verify if robot has picked up an ingredient/finish cocktail. **(Propositional Logic)**
  - Distance from target to robot  $< 1.5$  ?
  - Collected all ingredients ?
- Get recipe ingredients. **(First Order Logic)**
  - Premise: Margarita contains [Tequila, Lime, Salt, Ice].
  - Conclusion: We only need those ingredients for a margarita.
- Find the containers that store the ingredients. **(Description Logic)**
  - Premise: Tequila is a subclass of Drink.
  - Premise: Drinks are stored in a drink storage.
  - Conclusion: Tequila is stored in a drink storage.

# Reasoning description & implementation

## (Predicates)



### cocktail\_recipe/2

Defining cocktail recipes and their ingredients.

?Cocktail\_name

?Cocktail\_ingredients

cocktail\_recipe(margarita, ['Tequila', 'Lime', 'Salt', 'Ice']).

### get\_instances\_for\_cocktail/4

Obtain the instances for a given cocktail.

+Cocktail % Name of the cocktail

-Ingredients % List of ingredients

-Ingredient\_inst % List of instances for each ingredient

-Alternative\_inst % List of container instances for each ingredient

# Reasoning description & implementation

## (Predicates)

### `get_instances_for_class/3`

Return the instances for a given item class.

+Class % Name of the class

-Class\_inst % List of instances for the  
class

-Alt\_inst % List of container instances for  
the class

### `get_storage_for_class/2`

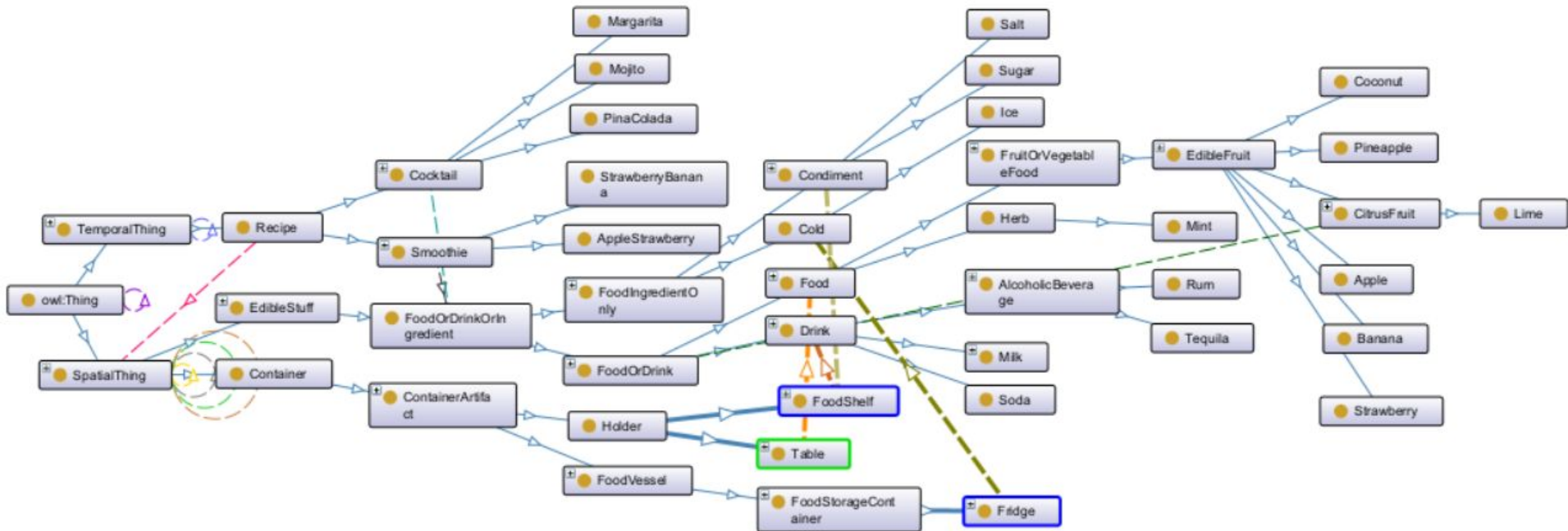
Return the storage class for a given item  
class.

+Class % Class name

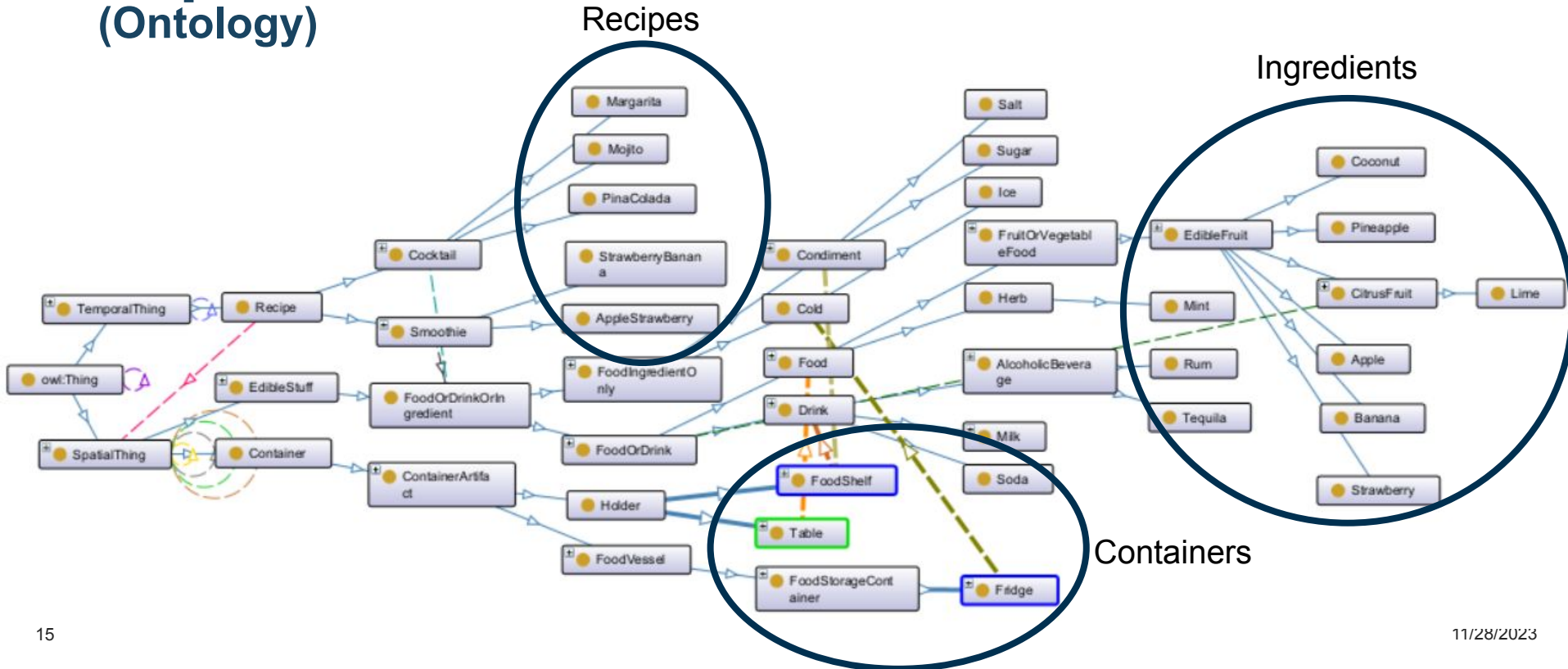
-Storage % Storage related to the class

# Reasoning description & implementation

## (Ontology)



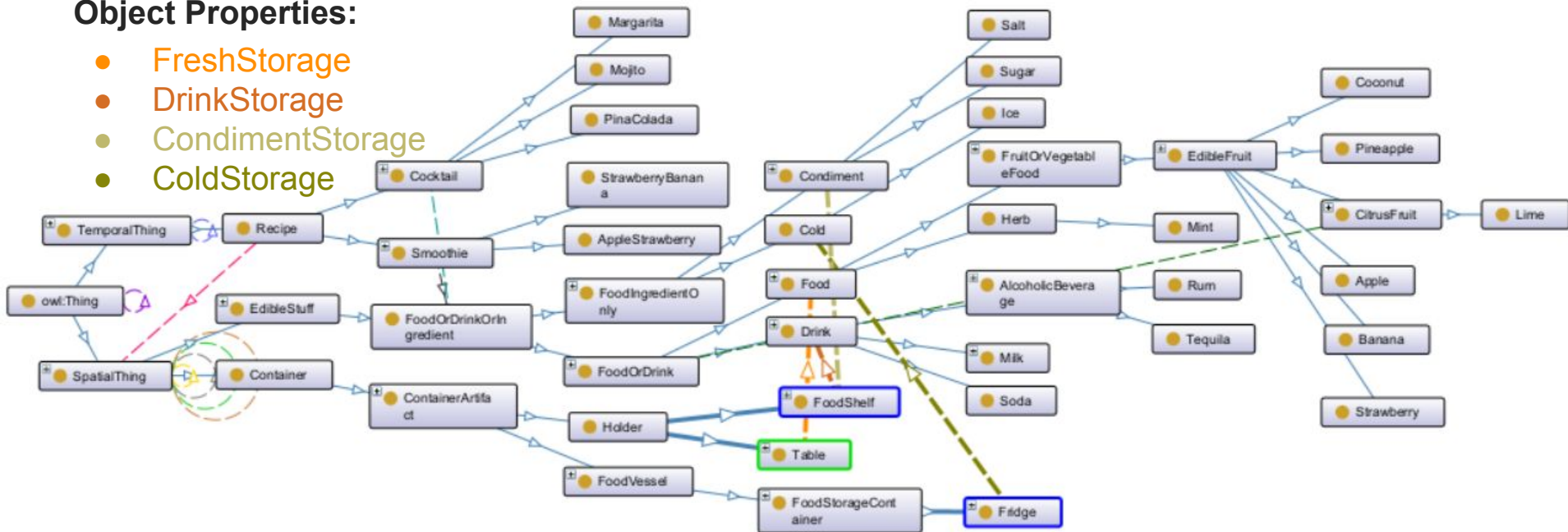
# Reasoning description & implementation (Ontology)



# Reasoning description & implementation (Ontology)

## Object Properties:

- FreshStorage
- DrinkStorage
- CondimentStorage
- ColdStorage





# Reasoning description & implementation

## (Inductive reasoning)



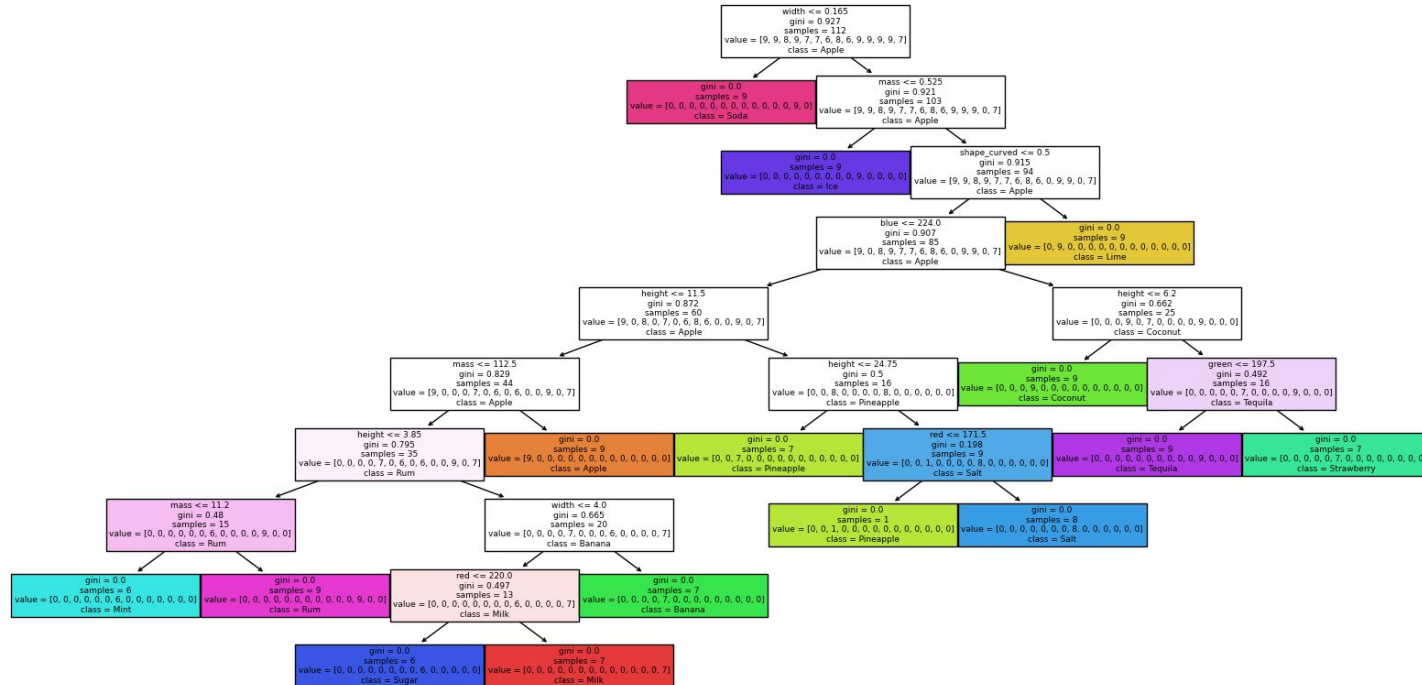
- Identify type of environment objects. (**Decision Tree**)
  - Premise: An apple's average mass is 165g.
  - Premise: Apple's have an oval shape.
  - Conclusion: All ovals objects with an average mass of 165g are apples.

# Learning Implementation

**Data:** Object label and 8 characteristics

- 140 rows.
- 14 unique classes.
- Generated with OpenAI large language model.

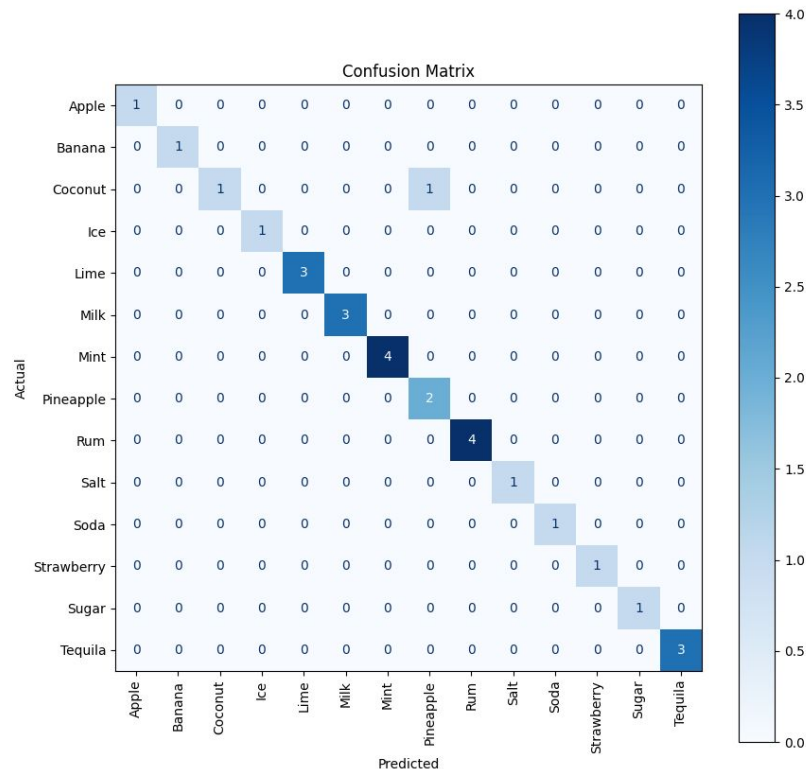
label	mass	width	height	shape	red	green	blue	alcohol
Apple	150	7	8	round	255	0	0	0
Apple	130	6.5	7.5	oval	220	20	60	0
Apple	180	7.5	8	irregular	255	165	0	0
Apple	140	6	7	round	0	128	0	0
Apple	160	7	7.5	oval	165	42	42	0
Apple	170	6.5	7	round	255	69	0	0
Apple	150	6.8	7.2	oval	218	165	32	0
Apple	140	6.2	7	round	255	223	0	0
Apple	160	6.7	7.3	oval	204	51	51	0
Apple	175	7.2	7.8	round	255	182	193	0
Lime	80	5	6	oval	0	255	0	0
Lime	60	4.5	5	round	0	128	0	0
Lime	90	5.5	6.5	oval	34	139	34	0
Lime	70	4.8	5.5	round	50	205	50	0
Lime	75	5	5.8	oval	0	255	127	0
Lime	85	4.5	7	cylinder	0	100	0	0
Lime	95	5.2	6.2	oval	173	255	47	0
Lime	78	4.7	5.7	round	144	238	144	0
Lime	80	5	6	oval	255	69	0	0
Lime	65	4.2	5	round	0	255	0	0
Pineapple	1200	20	30	oval	255	223	0	0
Pineapple	1400	22	35	oval	255	165	0	0
Pineapple	1100	18	28	oval	255	99	71	0
Pineapple	1000	15	25	cylinder	255	215	0	0
Pineapple	1300	21	32	oval	255	140	0	0



# Learning Implementation

**Accuracy: 96.43%**

lable	precision	recall	f1-score	support
Apple	1	1	1	1
Banana	1	1	1	1
Coconut	1	0.50	0.67	2
Ice	1	1	1	1
Lime	1	1	1	3
Milk	1	1	1	3
Mint	1	1	1	4
Pineapple	0.67	1	0.80	2
Rum	1	1	1	4
Salt	1	1	1	1
Soda	1	1	1	1
Strawberry	1	1	1	1
Sugar	1	1	1	1
Tequila	1	1	1	3



# Robotics Implementation

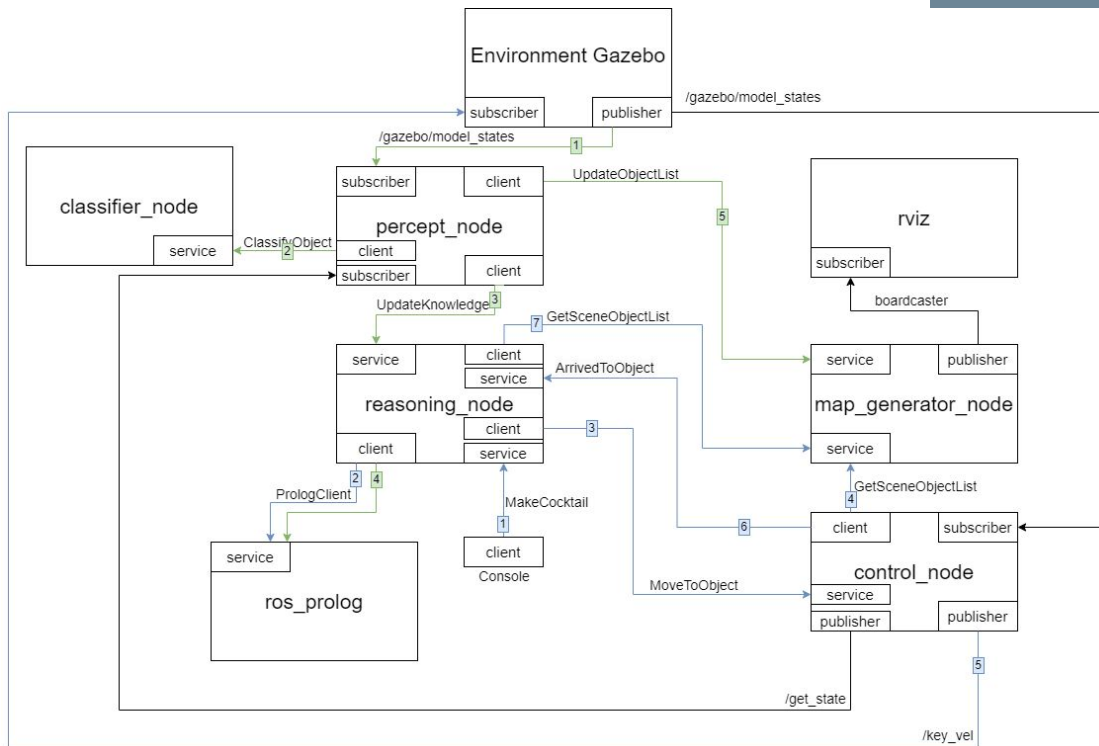
**Input:** Service call with recipe name, e.g.:

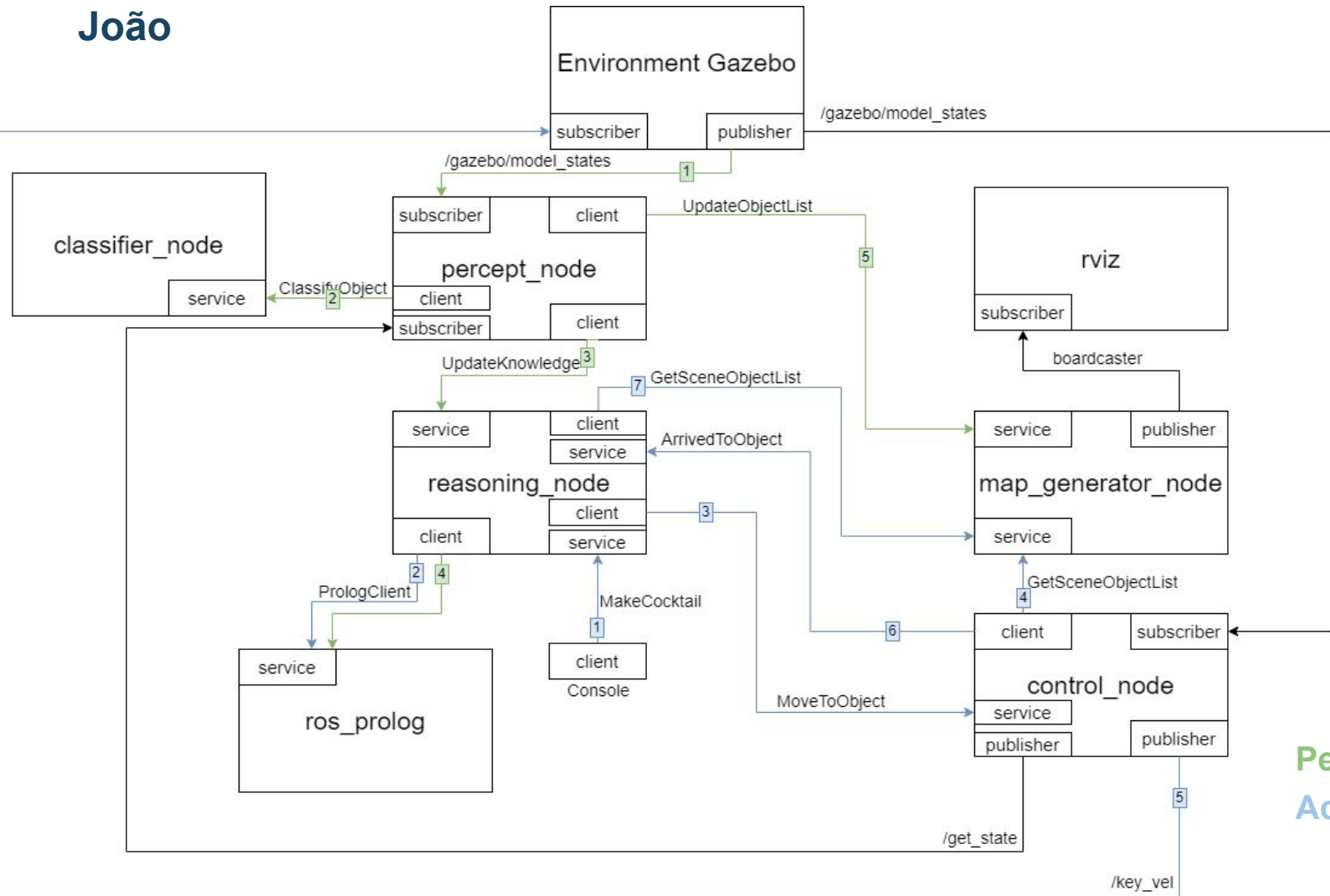
- margarita
- mojito
- pina\_colada

**Outcome:**

- Reason about ingredient locations
- Move to ingredient instances
- Return to base station

**Perception:** Proximity to objects.



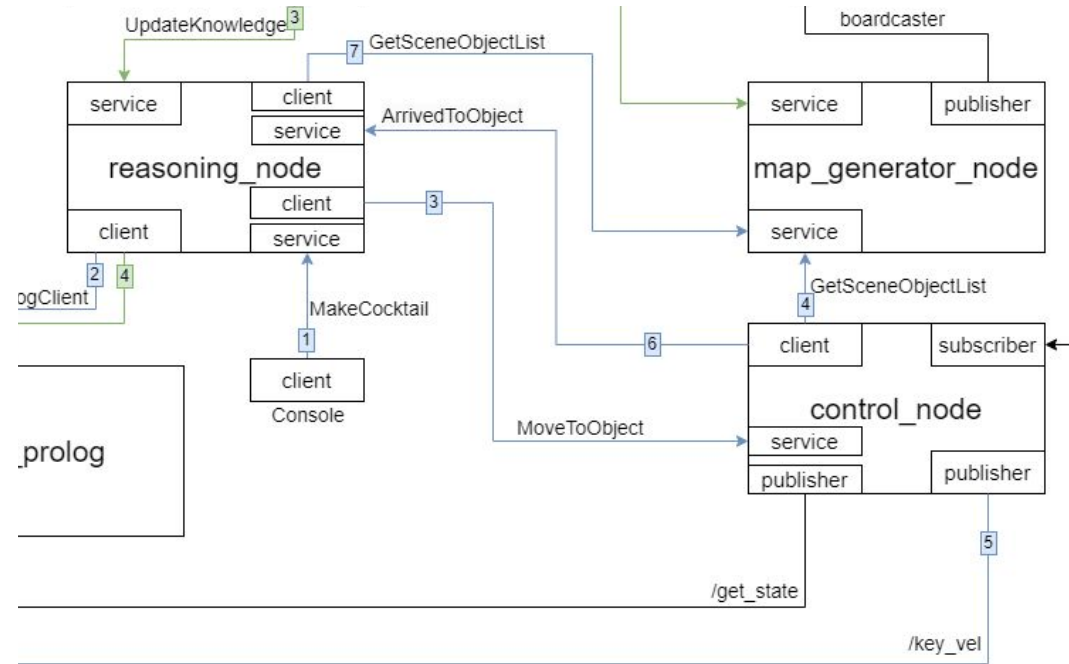


Perception  
Action

# Robotics Implementation

## Action loop:

1. Receive recipe from client.
2. Get recipe ingredients and containers instances from knowledge base.
3. Request to move to an object instance.
4. Get object's pose.
5. Calculate movement commands and send to robot.
6. Inform reasoner of robot arrival to target position.
7. If ingredient is not known, verify if any new instance is discovered and if it is close enough to pick up.

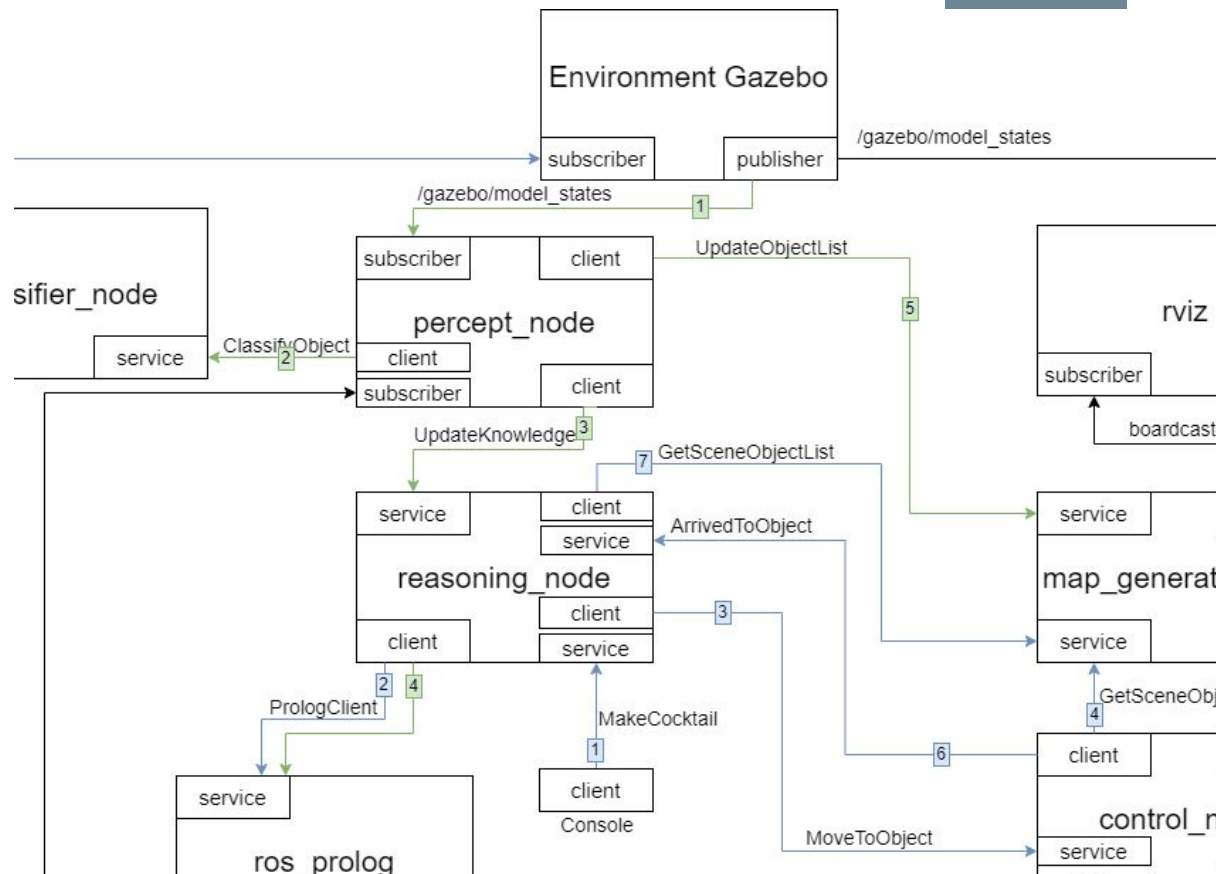


# Robotics Implementation



## Perception loop:

1. Perceive objects near the robot.
2. Classify the newly found object instance based on their characteristics.
3. Inform reasoner of new object instance.
4. Store object instance in knowledge base.
5. Store object pose in mapping node.





# Video demo



# Limitations

## Scope of the project:

- Grasping objects
- Image processing

## Implementation:

- Impossible to avoid obstacles (robot decides path in a straight line)
- The robot is not able to perceive any ingredient during the exploration phase (even though some may be close to it)
  - This also implies that if the robot misses a container it may never find certain ingredients

# Conclusion

The problem description highlighted intricate decision-making processes for autonomous cocktail creation, encompassing exploration, perception, and reasoning:

- Integration of perception and reasoning showcased the complexity necessary for successful autonomous operations;
- Machine learning, specifically a decision tree approach, emphasized the significance of data-driven decision-making;

The Cocktail Bot project demonstrated the integration of robotics, automation, and machine learning, emphasizing the practical relevance of these principles in addressing real-world challenges, making it a valuable learning experience in today's tech-driven landscape.

# Thank you

# Goal of this project

**Main goal:** Autonomous robot capable of crafting a diverse range of cocktails.

## Sub-Goals:

- **Knowledge Creation:** Autonomous gathering of knowledge about the environment (object classification and mapping).
- **Reasoning:** Enable the cocktail bot to associate common locations with specific objects. If an object is not found, explore alternative places within the environment.
- **Collision Avoidance:** Enhance the robot's safety features by incorporating dimension characteristics into its object recognition system, ensuring efficient collision avoidance during movement.

# Goal of this project

## Expected Results:

1. **Cocktail Production:** Automate the cocktail-making process, by finding the necessary objects and moving back to the bar counter.
2. **Diverse Cocktail Portfolio:** Successful craft of a wide array of cocktails (3 to 5) from known recipes.
3. **Enhanced Safety and Navigation:** Achieve a high level of safety through collision avoidance features.

# Problem definition

**Main problem:** Extended waiting times for intricate cocktails causing customer dissatisfaction and operational bottlenecks.

**Sub-Tasks:** [3]

**Previous approaches (Makr Shakr):**

- Pioneering company in the field of automated bartending systems.
- Present worldwide having already served more than 1.7 million cocktails.

**Problem relevancy:**

- Reduced human contact, speed up in the ordering process and reduced queues.

Average time to make a cocktail.

11/28/2023



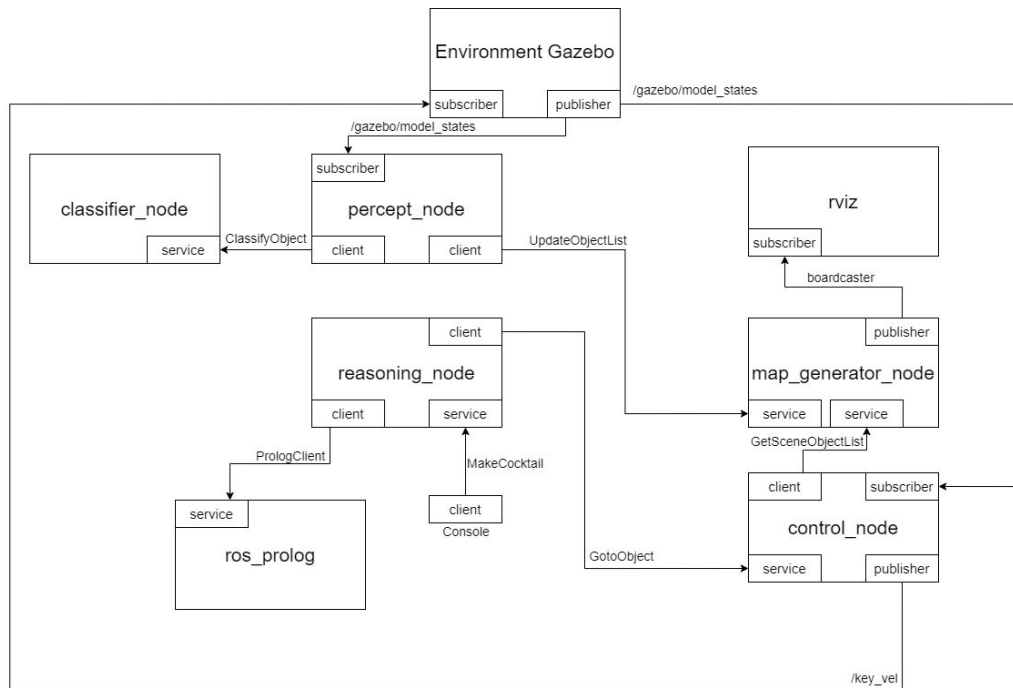
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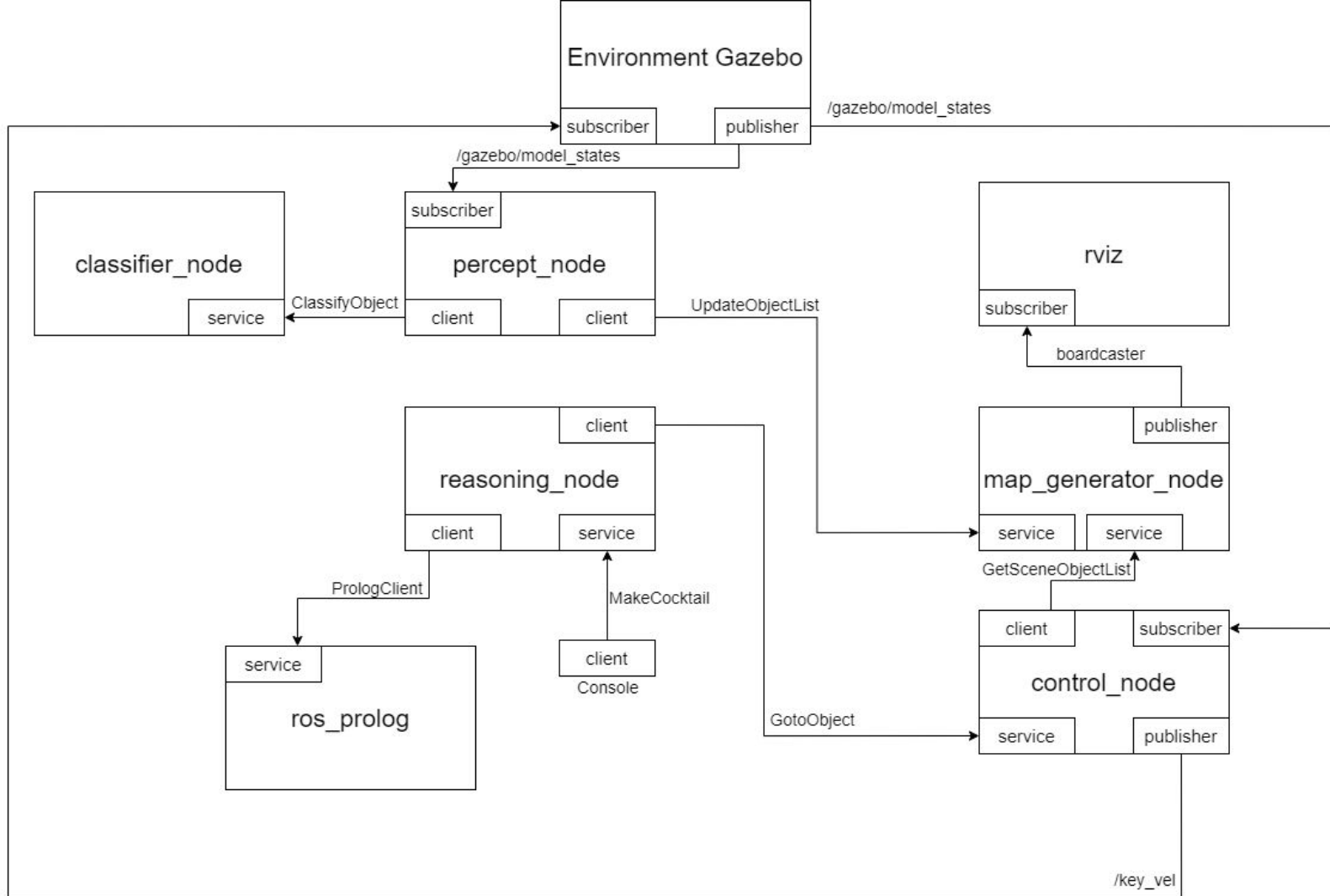


<https://www.youtube.com/watch?v=EivBxP3kqWs>



# Method and implementation (Architecture)





# Method and implementation

## (Modules)

### Perception:

- **Gazebo Subscriber:** Gathering knowledge about the nearby objects.
- **Classifier Client:** Object classification.
- **Update Client:** Update object mapping.

### Classification: Decision Tree

- **Classifier Service:** Classifies objects based on their characteristics.

# Method and implementation

## (Modules)

### Reasoning:

- **Cocktail Service:** Responsible to process the cocktail request.
- **Prolog Client:** Interacts with prolog knowledge base.
- **Goto Client:** Informs the controller which object to move to.

### Mapping:

- **Rviz Publisher:** Broadcast object position to rviz node.
- **Get Object Service:** Provides the requested object(s) poses.
- **Update Service:** Updates the map with the new object and respective pose.

# Method and implementation

## (Modules)

### Controller:

- **Goto Service:** Responsible for updating the actions in order to move to the given object.
- **Client Get Object:** Requests information about the object pose.
- **Gazebo Subscriber:** Receives information about the current robot position.
- **Action Publisher:** Send movement commands to the robot.

# Method and implementation

## (Performance Measure)

**Success Criteria:** Autonomous craft of the request cocktails.

### Measures:

- Number of ingredients found.
- Correct classification of objects.
- Speed of the process.

# Boundaries

## Assumptions:

- Availability of Ingredients
- Recipe Standardization
- Environment:
  - Partially observable
  - Stochastic
  - Sequential
  - Static
  - Continuous
  - Single Agent

# Boundaries

## Scope:

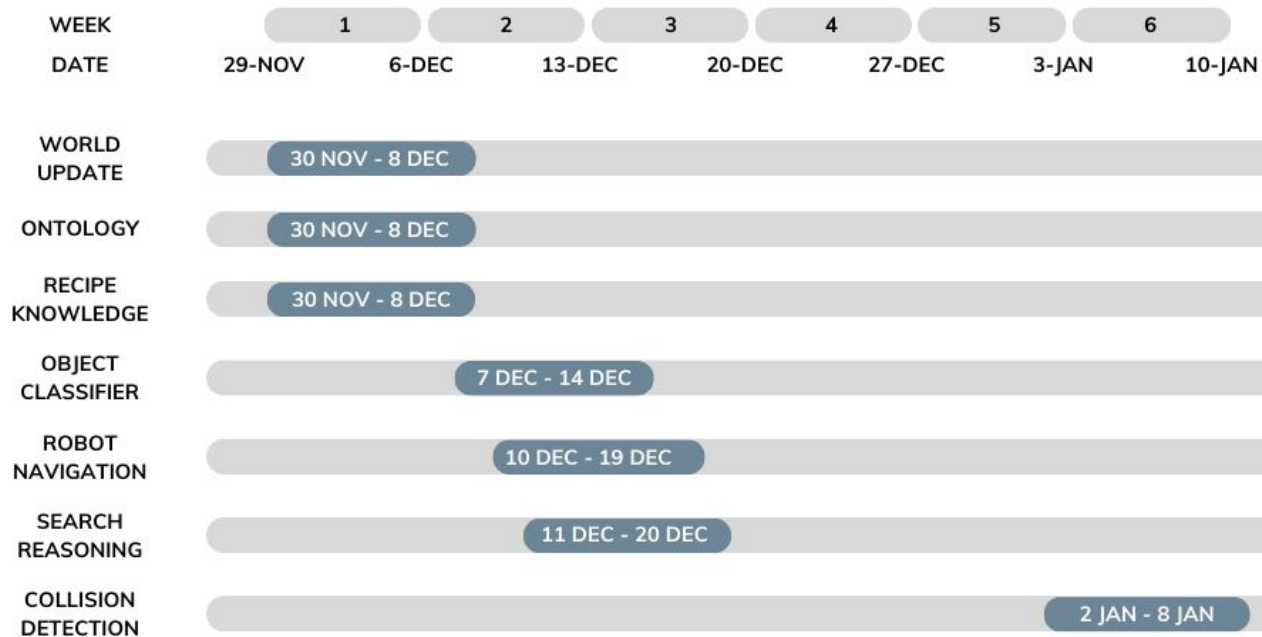
- Autonomous navigation
- Object identification and mapping (only by proximity)
- Ingredient search (reasoning)

## Out of Scope:

- Grasping objects
- Image processing



# Timetable





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