Design & Implementation of Cognition-enabled Robot Agents

Module 10: Cognitive Architectures
Lecture 4: The CRAM Cognitive Architecture – Part 2

Institute for Artificial Intelligence
Universität Bremen

Winter Term 2020/21

Lecture Contents

1. Overview of CRAM operation
   - Recap of the key aspects of the CRAM cognitive architecture
   - Walk through the execution of a generalized action plan
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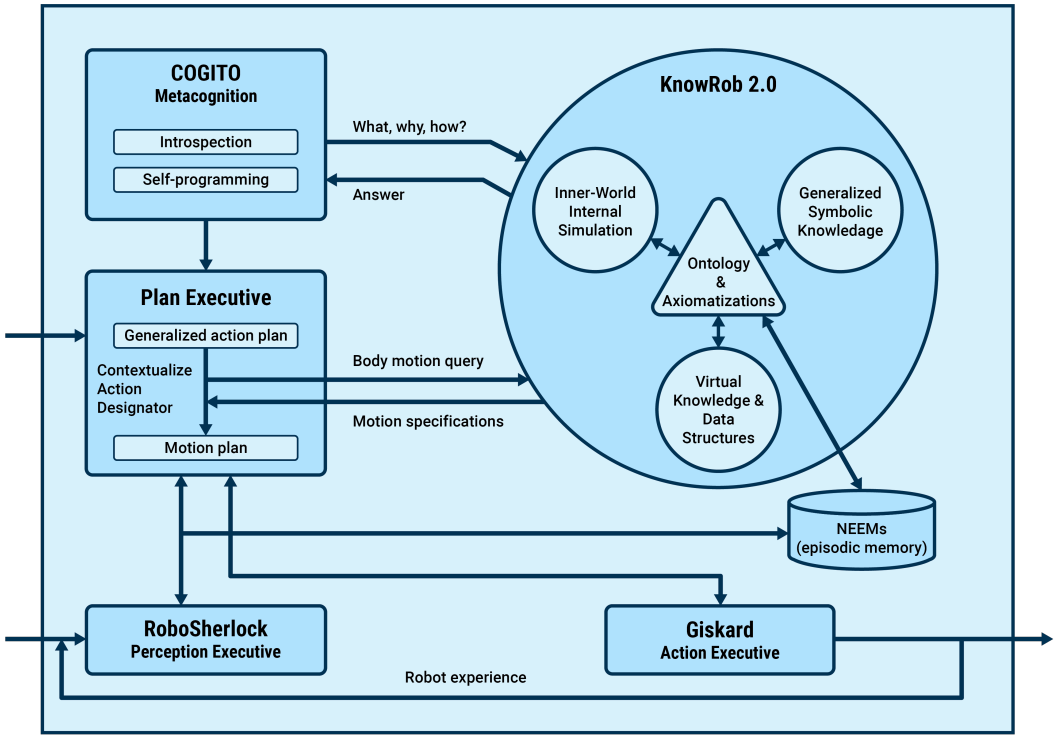
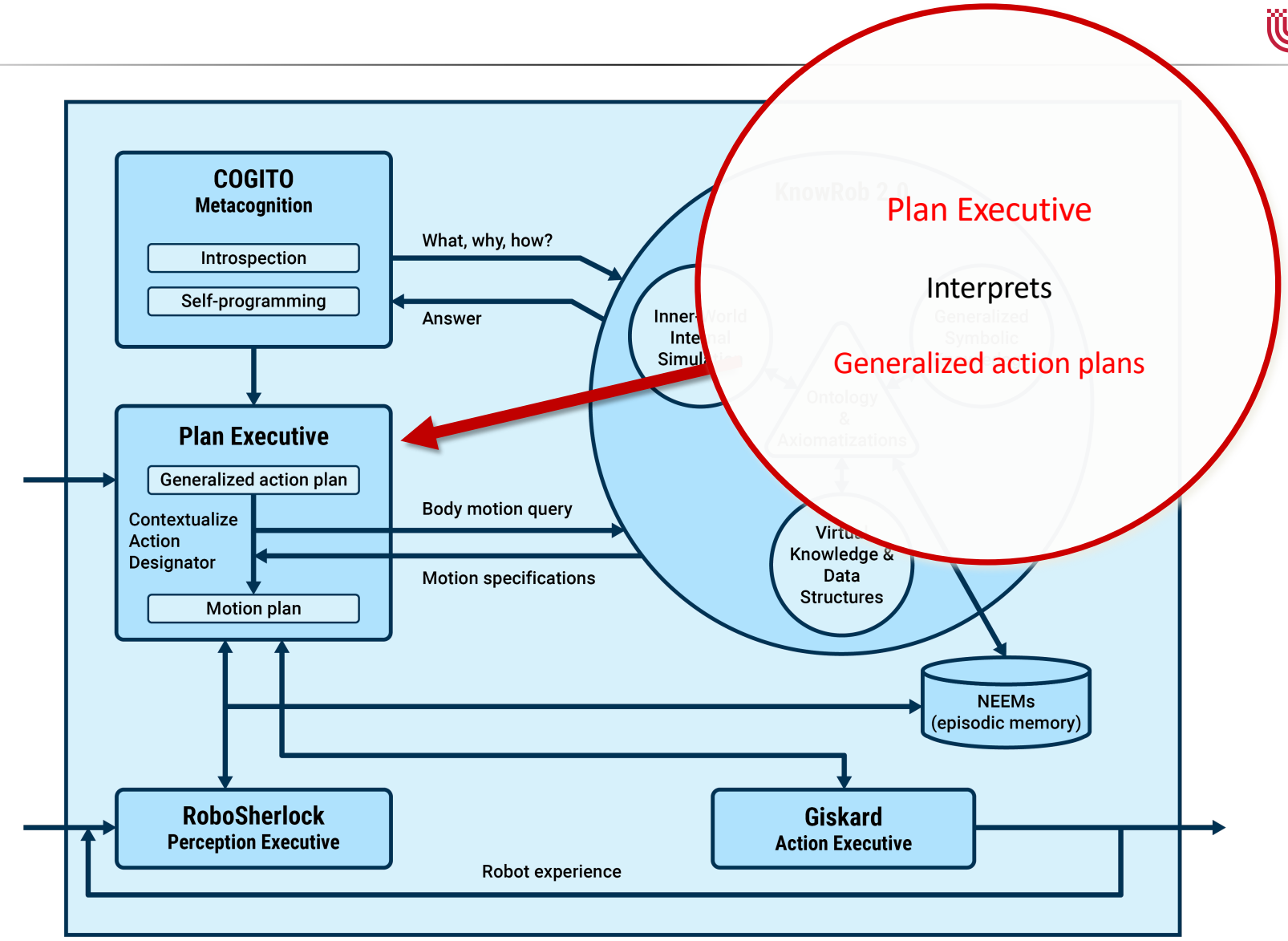
The CRAM Cognitive Architecture

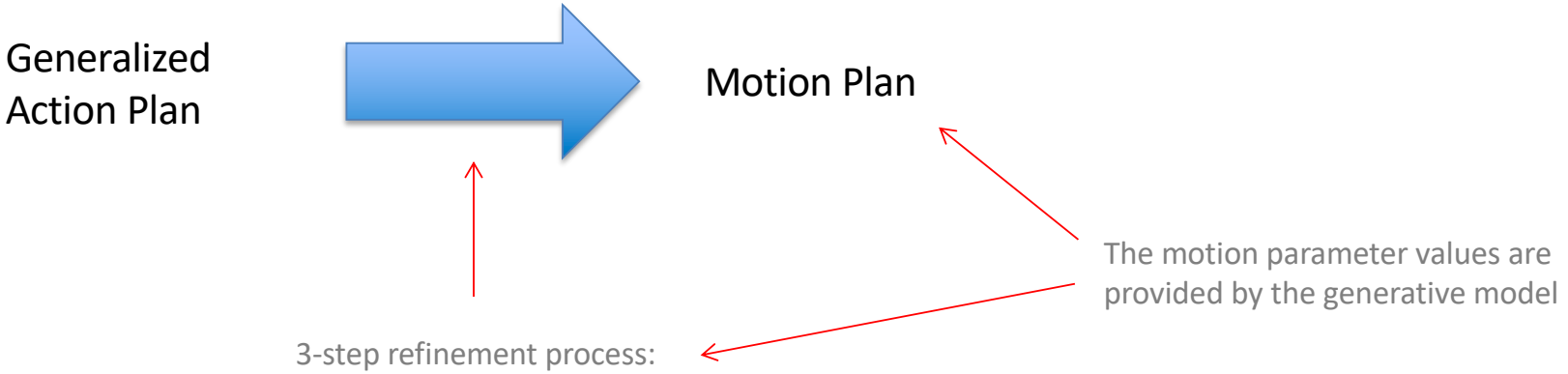
CRAM has five core elements:

1. CRAM Plan Language (CPL) executive
2. KnowRob2.0 knowledge-bases and associated reasoning processes
3. RoboSherlock, the perception executive
4. Giskard, the action executive
5. COGITO, a metacognition system

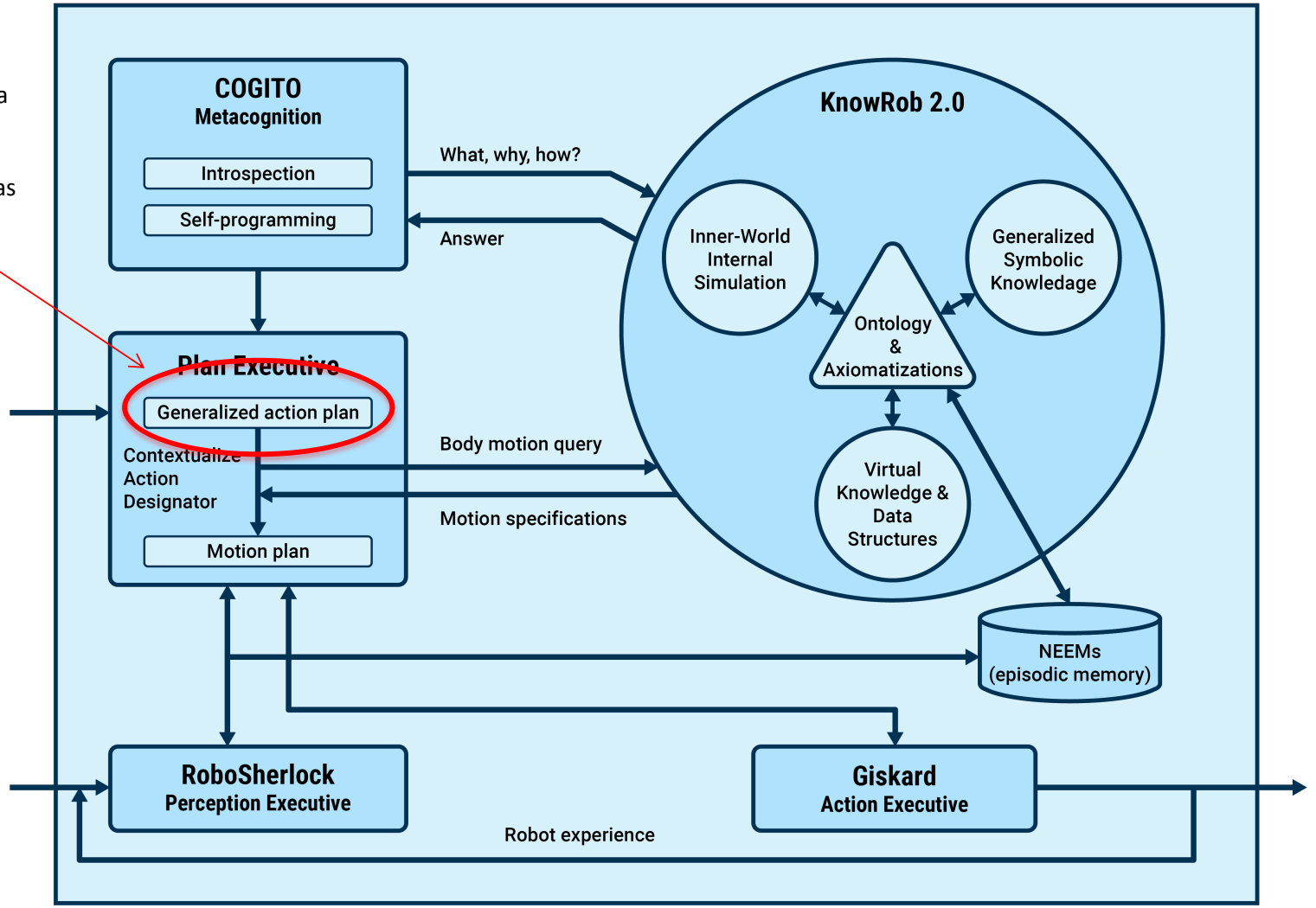



COGITO
Metacognition
Introspection
Self-programming
What, why, how?
Answer
Plan Executive
Generalized action plan
Contextualize
Action
Designator
Motion plan
Body motion query
Motion specifications
Knowledge &
Data
Structures
NEEMs
(episodic memory)
RoboSherlock
Perception Executive
Giskard
Action Executive
Robot experience
Plan Executive
Interprets
Generalized action plans

Walk through the execution of a generalized action plan



Recall:
The robot agent is equipped with a generalized action plan for each action category, which typically corresponds to action verbs such as fetch, place, pour, and cut.

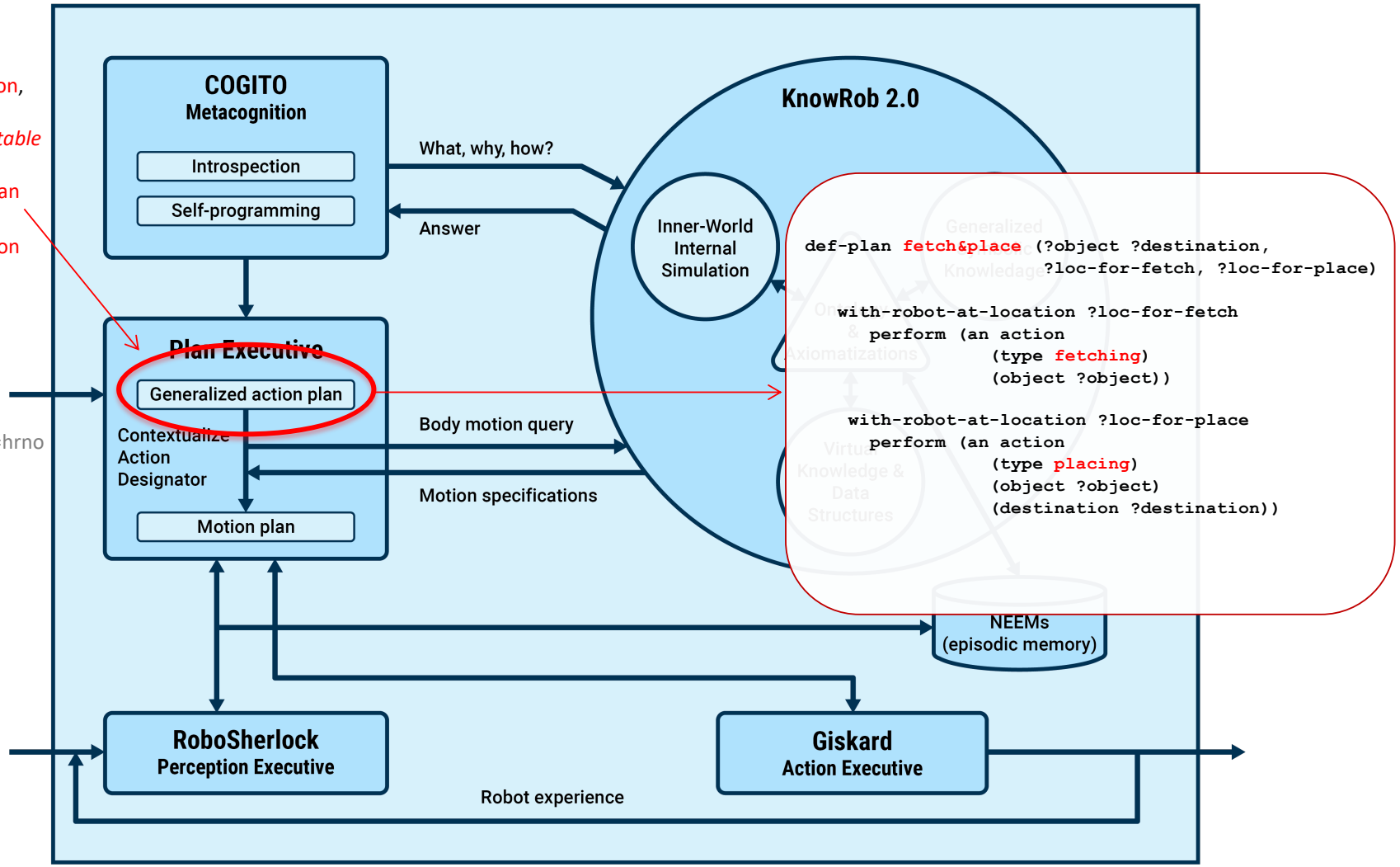


An action plan is invoked with
a request to perform
an underdetermined action description,

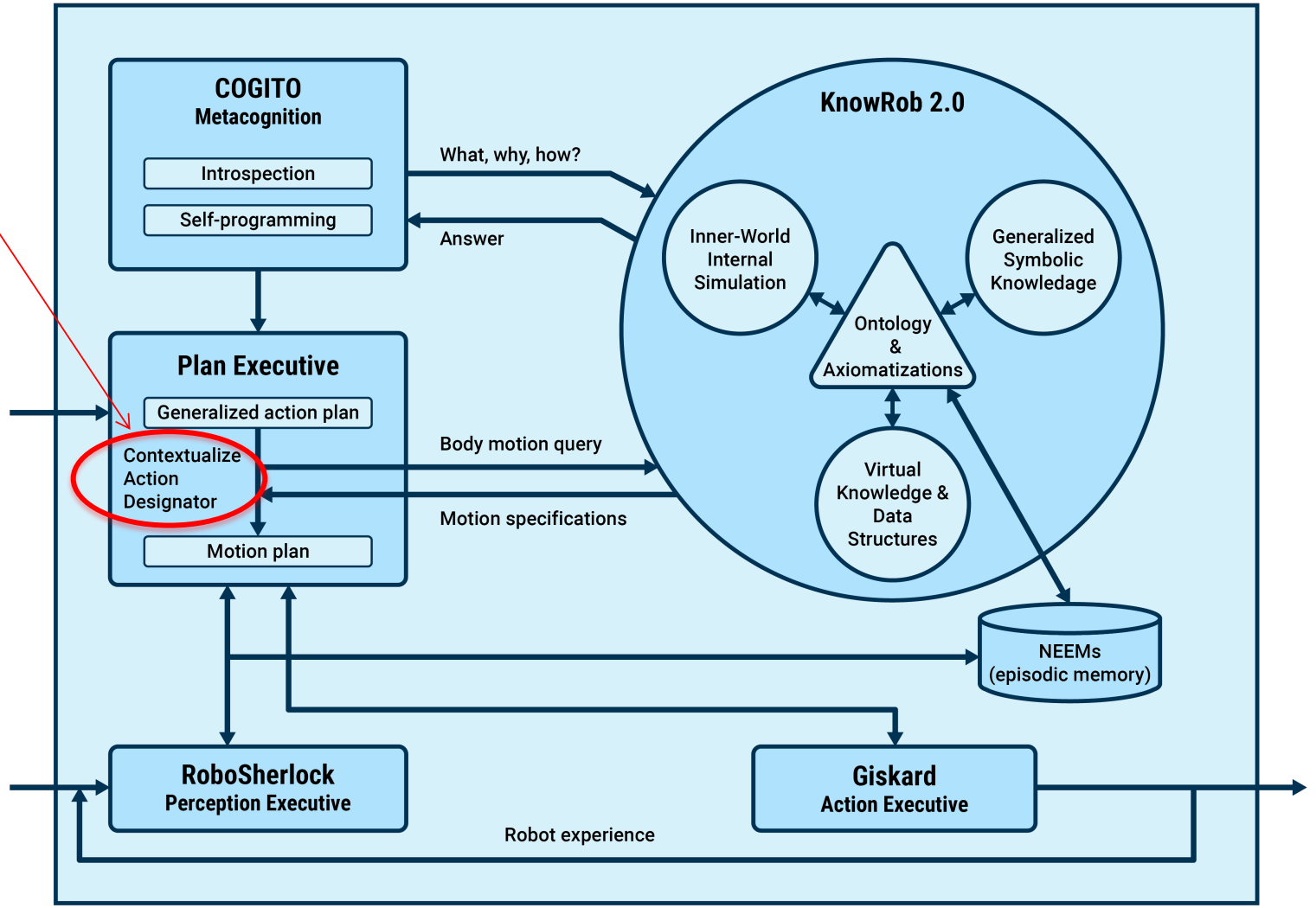
e.g. *fetch the cup and place it on the table*

by selecting the generalized action plan
for the action category
corresponding to the action description

(e.g. see the spoon challenge at
https://www.youtube.com/watch?v=hrnoY6J8ddE&feature=youtu.be)



The Plan Executive interprets the generalized action plan in process referred to as contextualization in three steps:

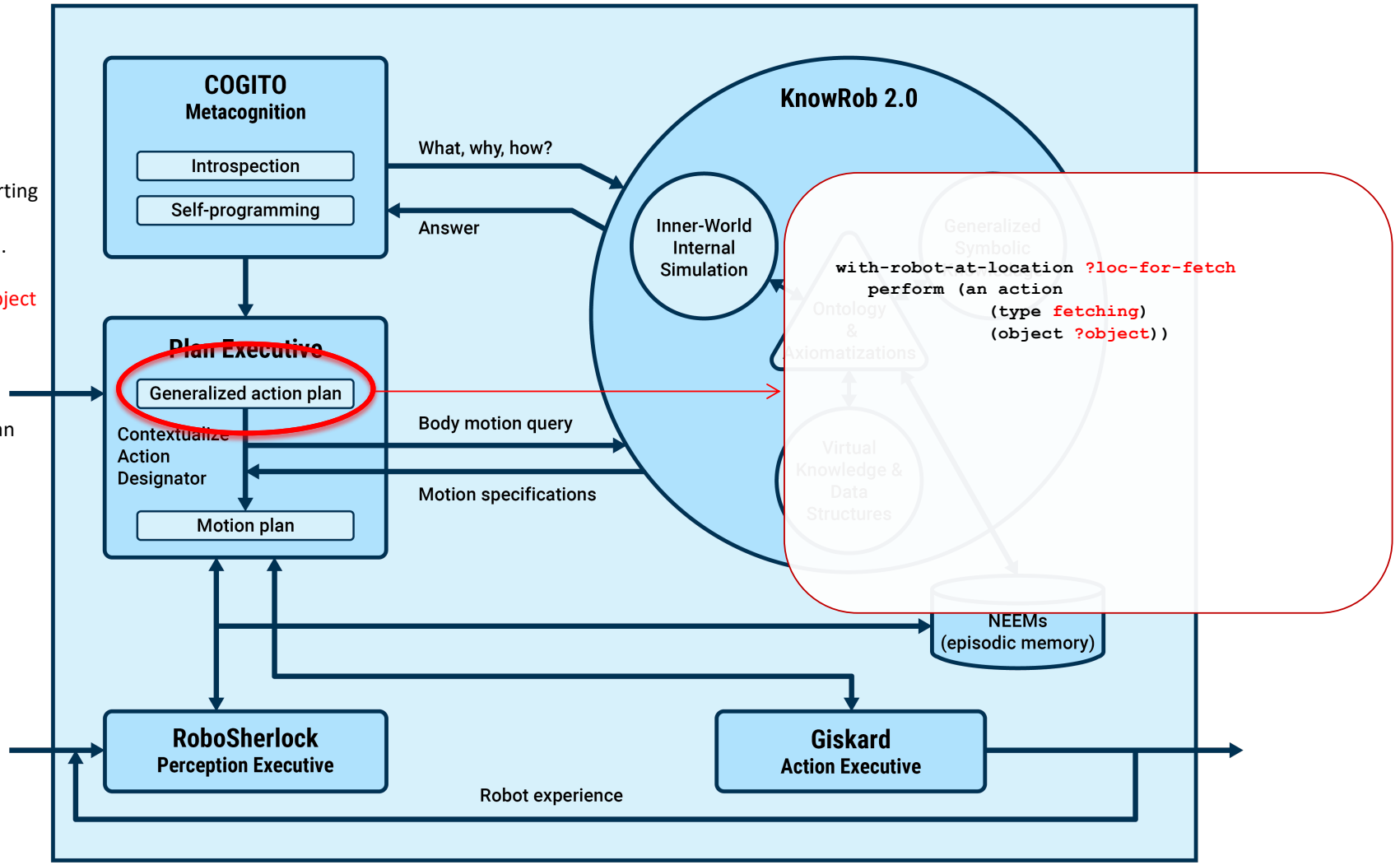


The Plan Executive interprets the generalized action plan in process referred to as contextualization in three steps:

1. Instantiate the selected generalized action plan by inserting the arguments required for the specific action to be performed.

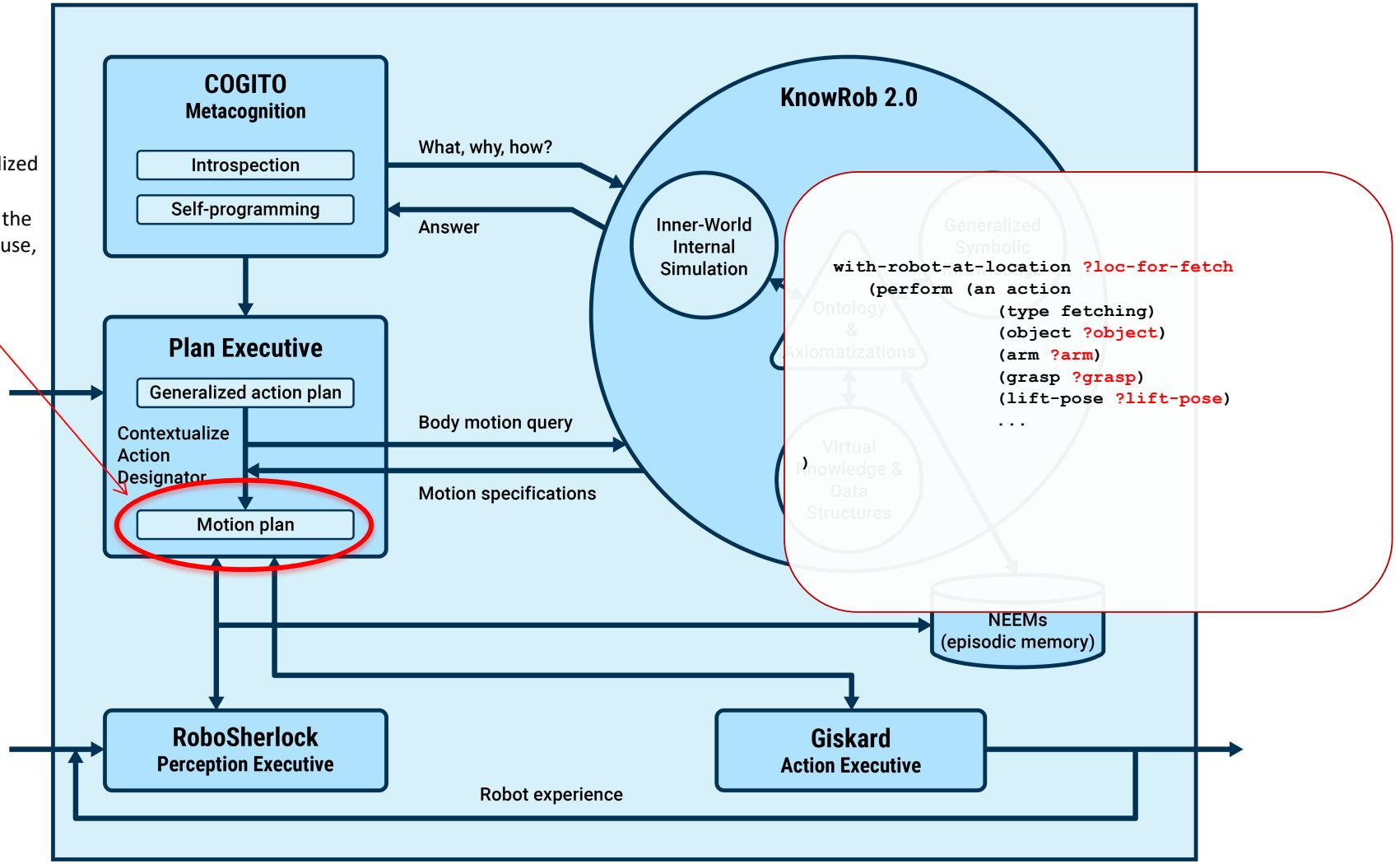
- For example, the type of the object to be manipulated or the destination location.

- These arguments are typically designators of some kind, e.g. an action, object, or location designator.



The Plan Executive interprets the generalized action plan in process referred to as contextualization in three steps:

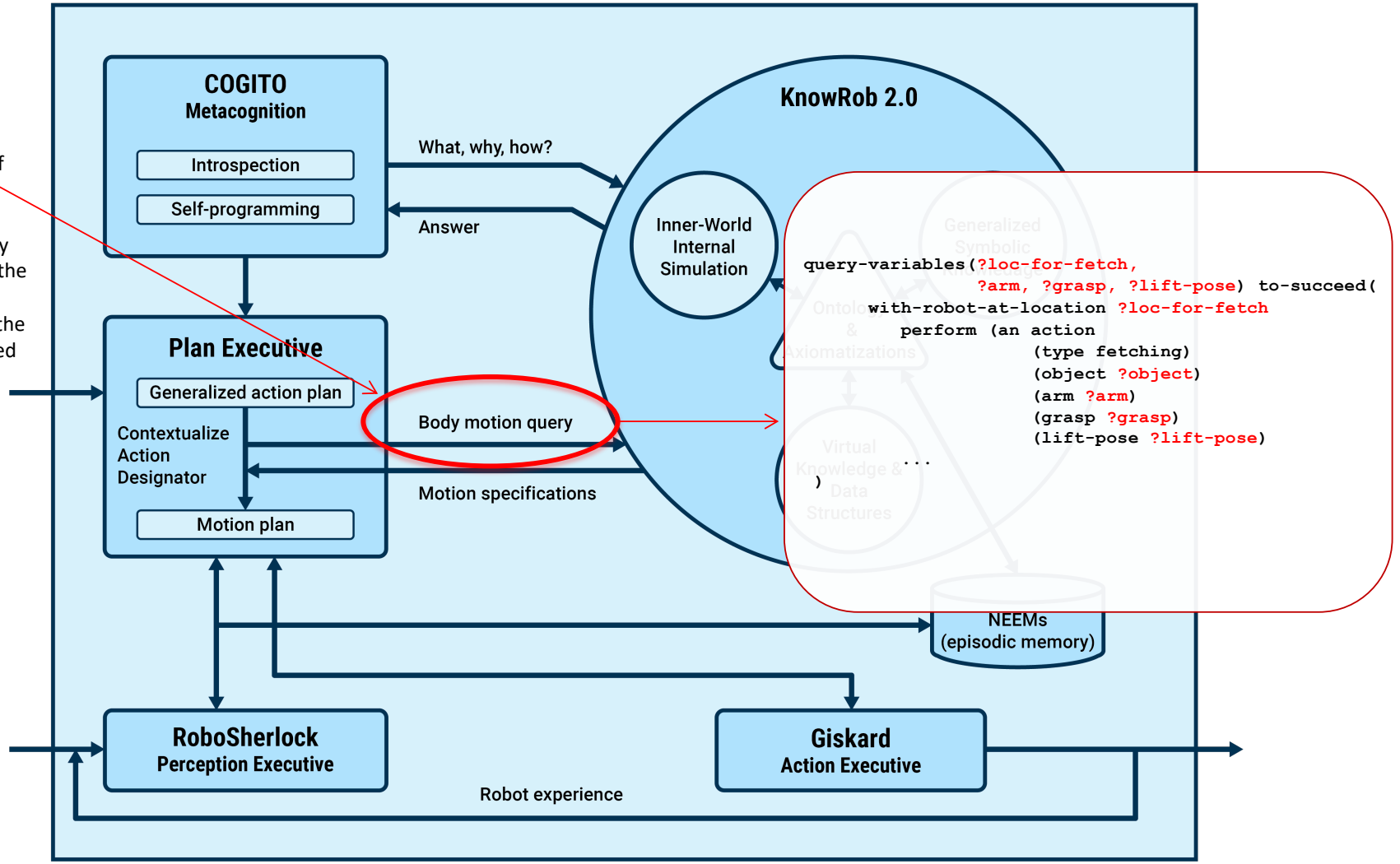
2. Extend the instantiated generalized action plan by adding the parameters needed to execute the motion plan, e.g. which arm to use, what grasp pose to use.



The Plan Executive interprets the generalized action plan in process referred to as contextualization in three steps:

3. Create a query for the values of these parameters

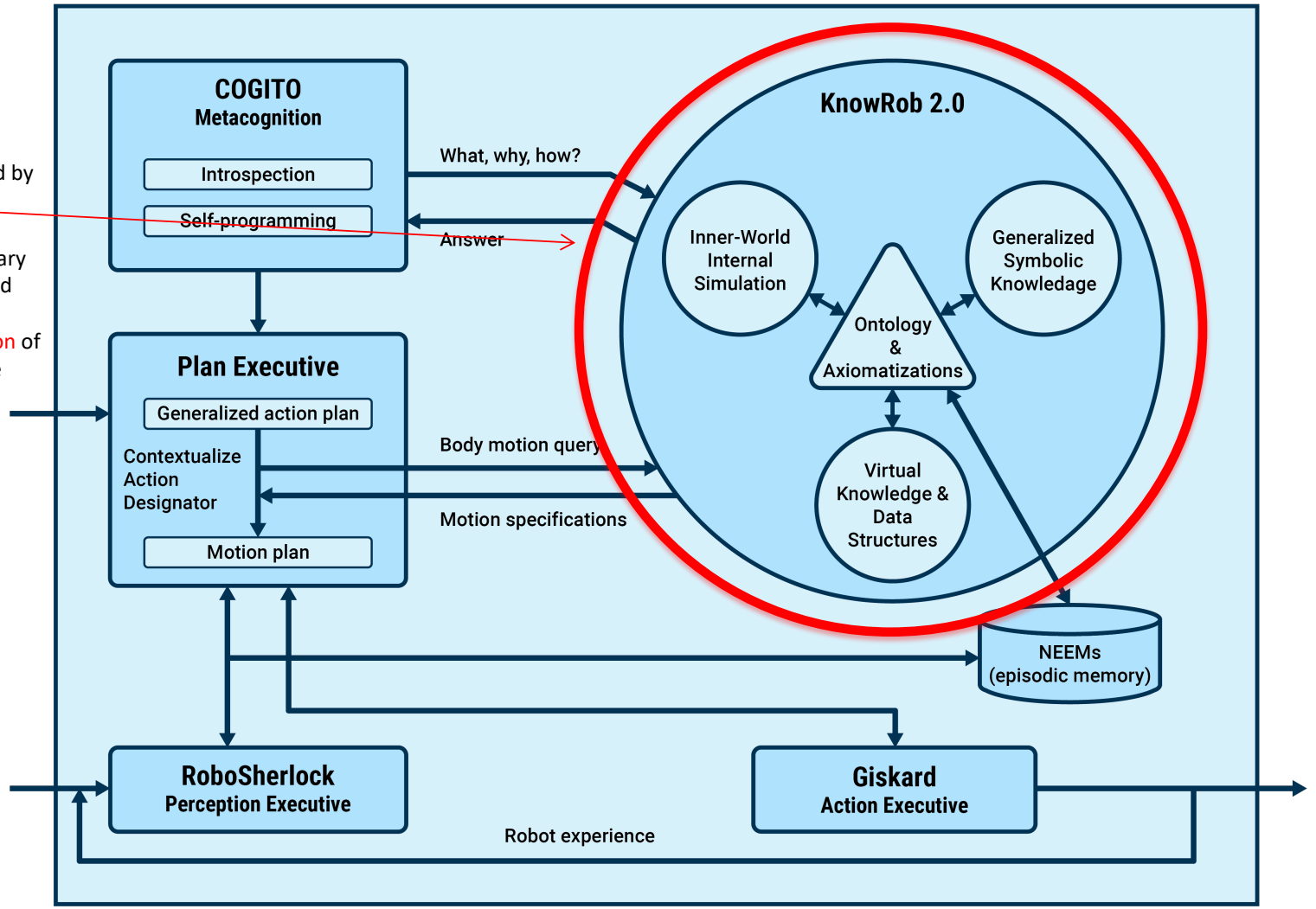
   (that would produce robot body motions to achieve the goal of the underdetermined action description and, equivalently, the associated instantiated extended generalized action plan).



The Plan Executive interprets the generalized action plan in process referred to as contextualization in three steps:

The contextualization is accomplished by KnowRob2.0.

The motion parameter values necessary to carry out the action are determined using a **generative model** effectively sampling a joint distribution of the motion parameter values and the associated outcome.

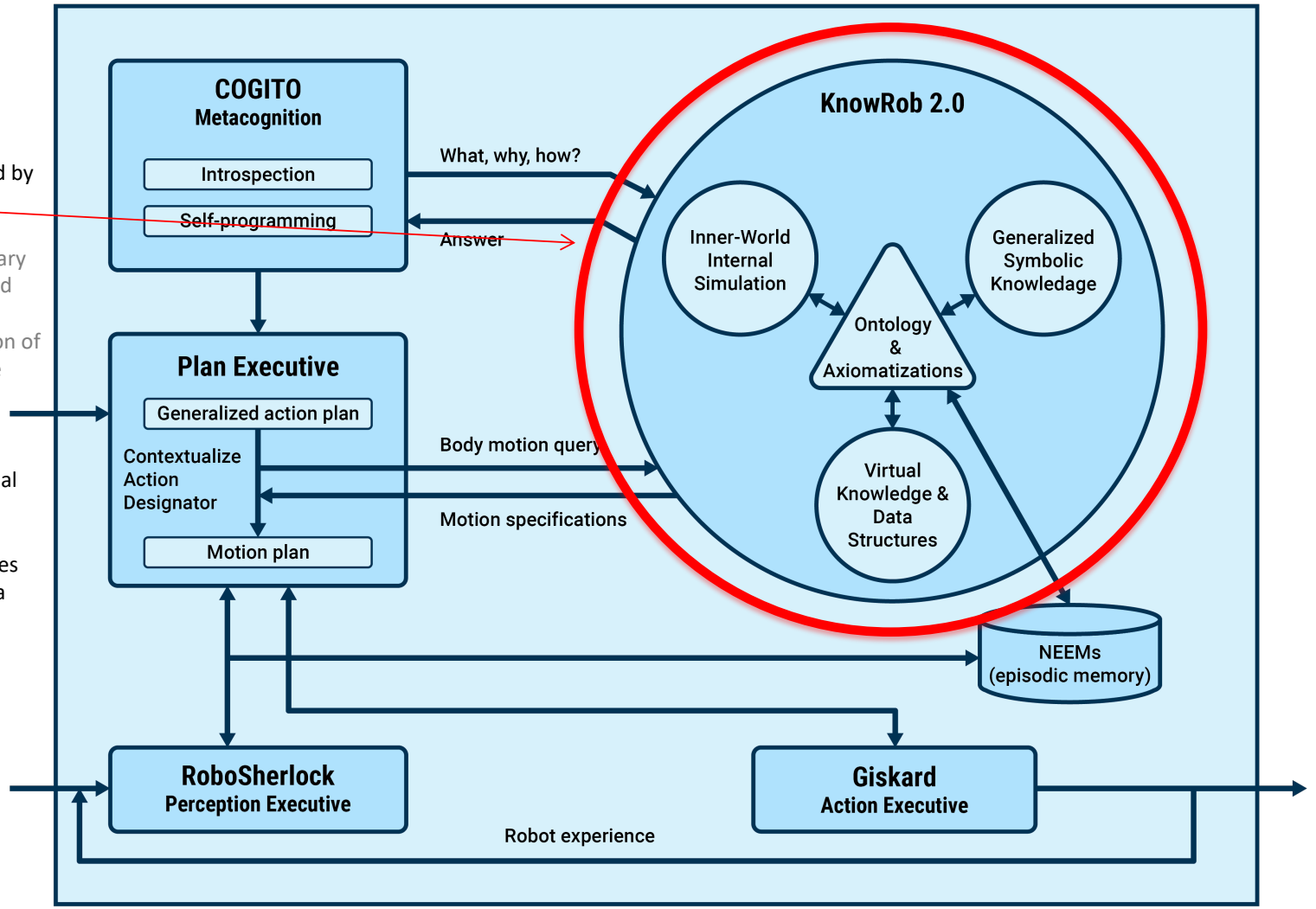


The Plan Executive interprets the generalized action plan in process referred to as contextualization in three steps:

The contextualization is accomplished by KnowRob2.0.

The motion parameter values necessary to carry out the action are determined using a generative model effectively sampling a joint distribution of the motion parameter values and the associated outcome.

It uses knowledge and reasoning, exploiting the constraints of contextual knowledge and current perceptual information, and prospection, to maximize the likelihood that the values identified are most likely to result in a successful action.



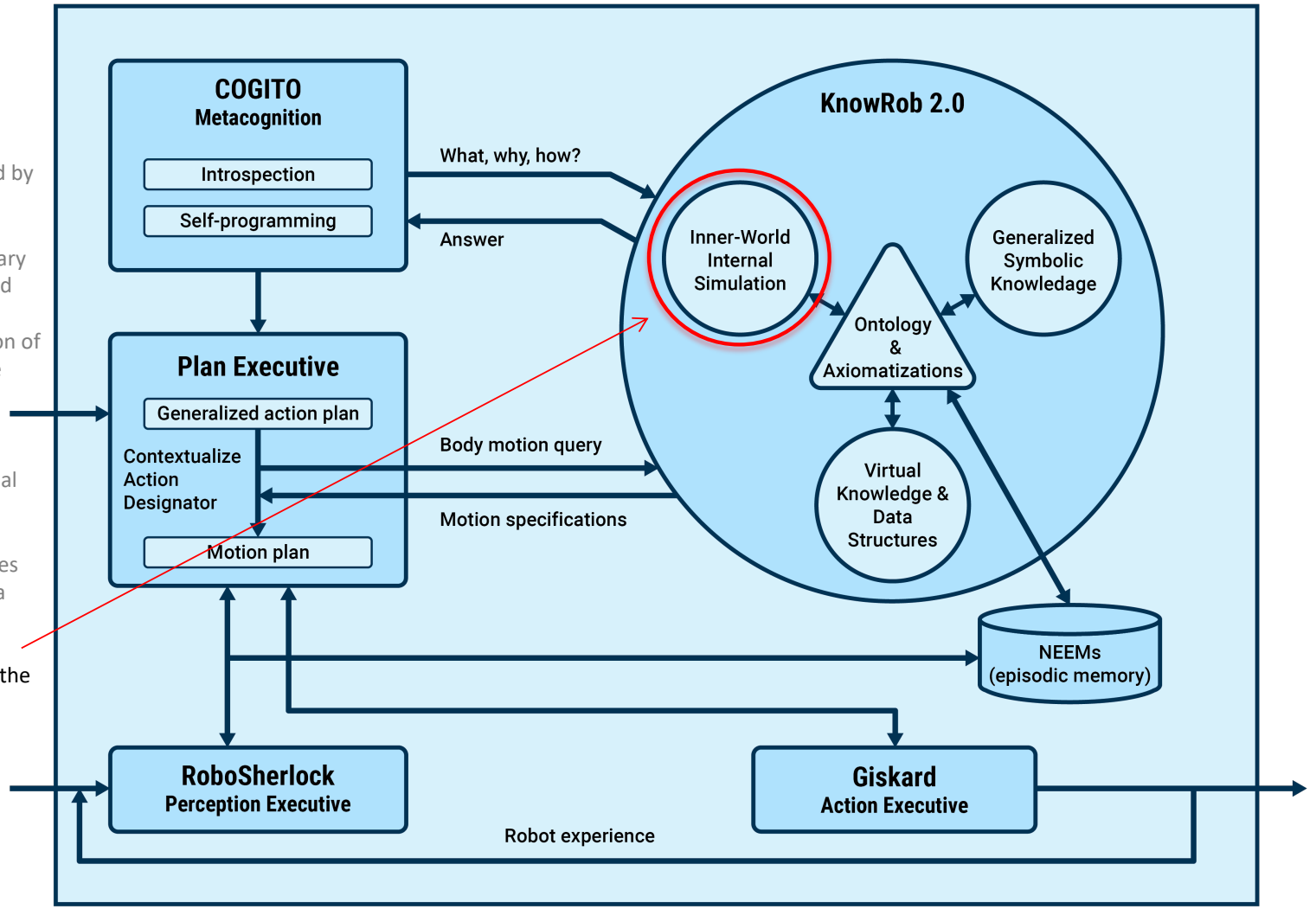
The Plan Executive interprets the generalized action plan in process referred to as contextualization in three steps:

The contextualization is accomplished by KnowRob2.0.

The motion parameter values necessary to carry out the action are determined using a generative model effectively sampling a joint distribution of the motion parameter values and the associated outcome.

It uses knowledge and reasoning, exploiting the constraints of contextual knowledge and current perceptual information, and prospection, to maximize the likelihood that the values identified are most likely to result in a successful action.

It accomplishes prospection by using the robot's inner world to simulate plan execution



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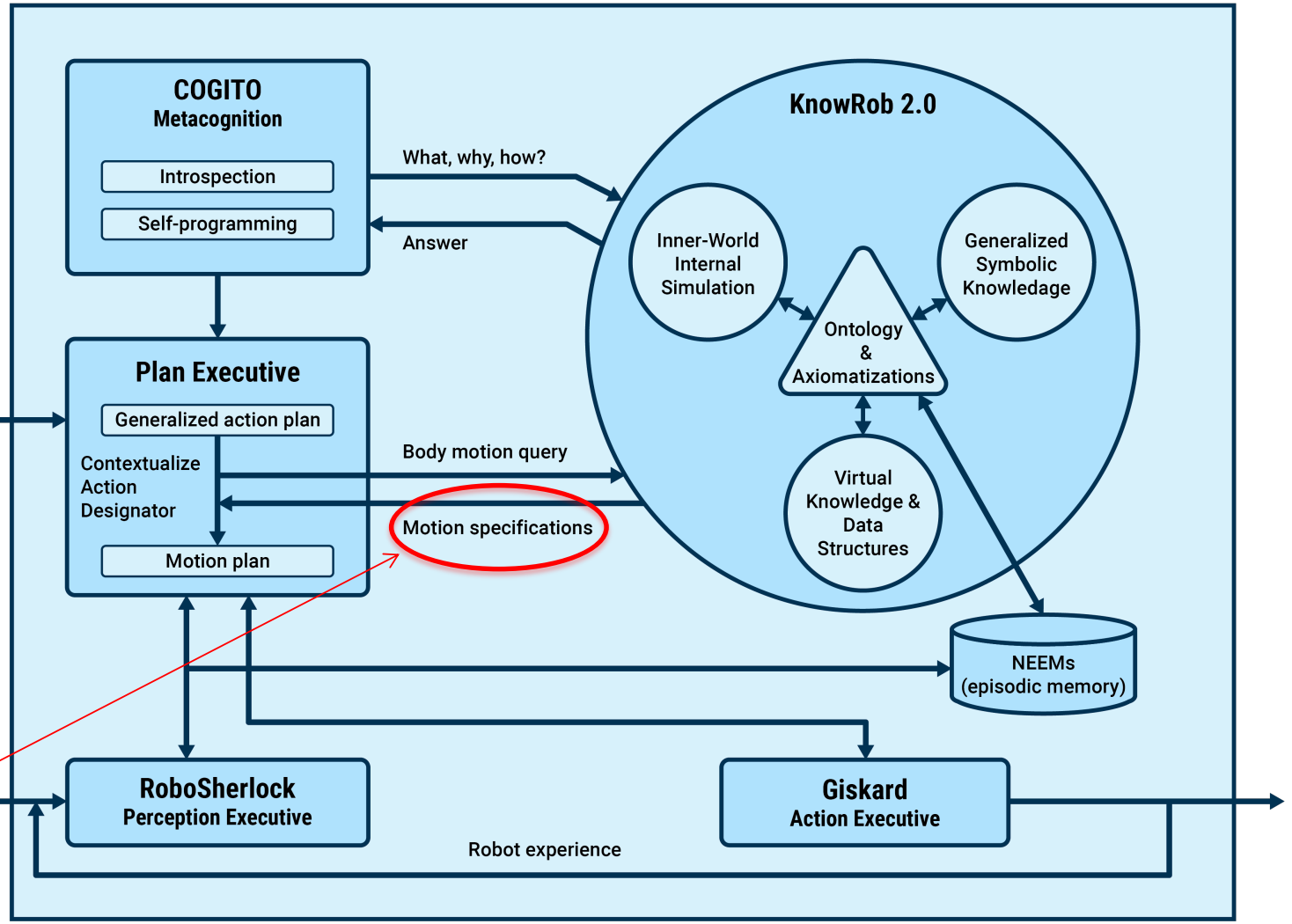
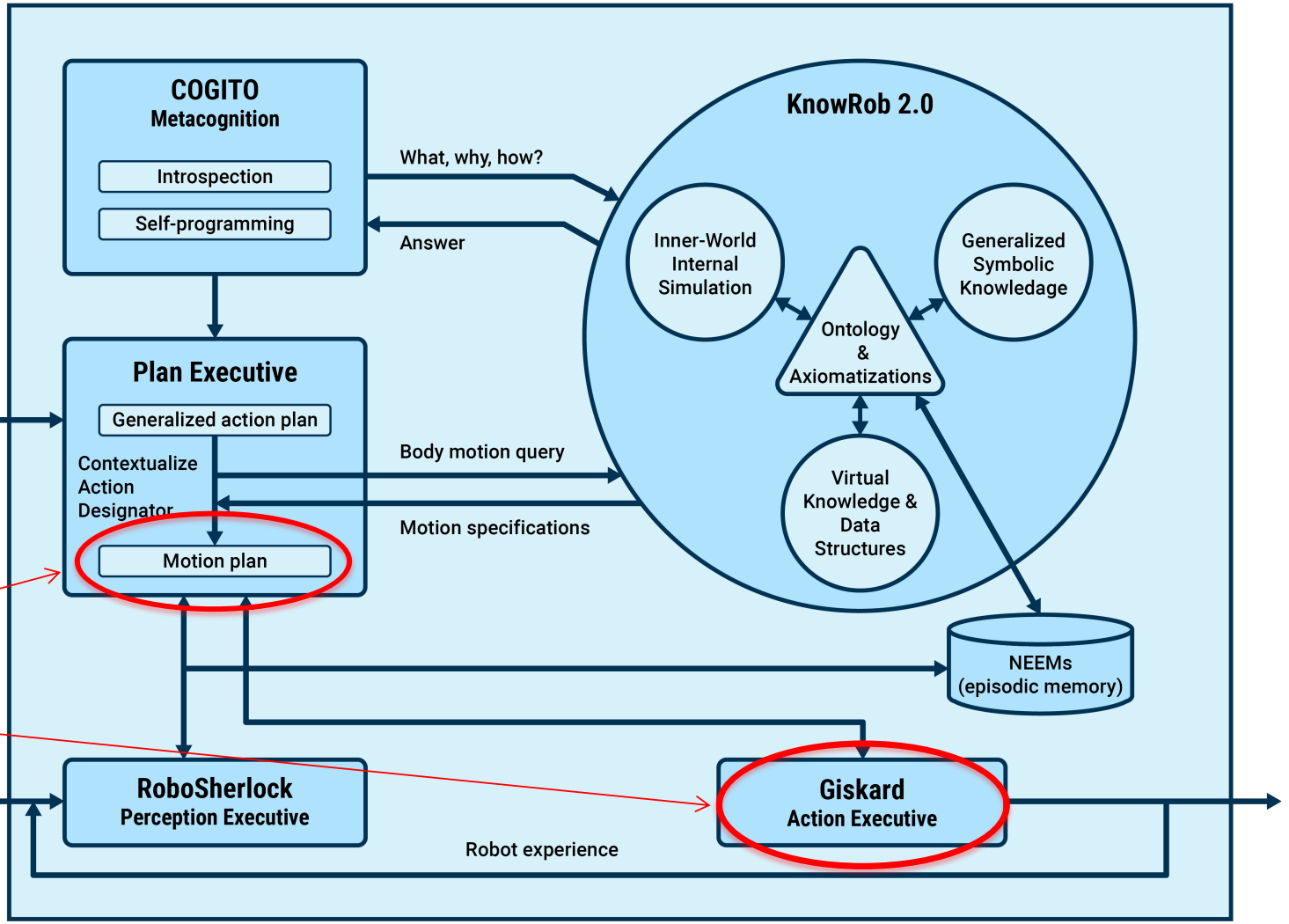
It accomplishes prospection by using the robot's inner world to simulate plan execution

The motion parameter values are returned to the Plan Executive





The motion plan is then executed by the Action Executive

Lecture Summary

1. The CRAM cognitive architecture maps a generalized action plan to a motion plan

2. It does so in three step process called contextualization

    1. Instantiate the generalized action plan corresponding to the required underdetermined action description
    2. Extend the generalized action plan by adding the motion parameters required for the generalized motion plan
    3. Query KnowRob2.0 for the values that will maximize the likelihood of the action being successful.

3. The generalized motion plan is then executed by the Action Executive, Giskard

Recommended Reading

M. Beetz, D. Beßler, A. Haidu, M. Pomarlan, A. Kaan Bozcuoglu, G. Bartels, "KnowRob 2.0 – A 2nd Generation Knowledge Processing Framework for Cognition-enabled Robotic Agents", In International Conference on Robotics and Automation (ICRA), Brisbane, Australia, 2018.

Recommended Videos

G. Kazhoyan. Tutorial on CRAM (Cognitive Robot Abstract Machine). https://youtu.be/0uJN-jRb7J4