Context

In a context of home assistance for elderly people, a next-generation domestic assistant robot, named A-19, is designed to perform a series of household tasks, including cleaning the house and meal preparation. Equipped with a flexible structure and a wide range of advanced sensors (including cameras, tactile and pressure sensors, temperature sensors), A-19 can operate partially autonomously within the home environment, of which it has a 3D mapping obtained during an initial calibration phase.

At the beginning of its daily activity, A-19 evaluates the surrounding environment by integrating the initial static 3D map with current perceptions, using its visual sensors, and plans the optimal route to perform the assigned tasks, such as floor cleaning. Using path planning algorithms and environment mapping, the robot determines the most efficient and safe path to carry out the assigned activities, minimising the likelihood of interfering with the activities of the assisted person.

Once the house cleaning task has begun, for example, A-19 uses its sensors to detect the presence of dirt and dust on the floors. The robot autonomously decides which areas to clean (using surface characterisation algorithms) and selects the appropriate tools to clean effectively and efficiently; for cleaning, A-19 uses standard tools such as vacuum cleaners, brooms, and cleaning cloths, which it must retrieve and store when finished.

During meal preparation in the kitchen, A-19 uses its arms to manipulate kitchen utensils and ingredients, following pre-set recipes or vocal instructions provided by the person being assisted. The robot can perform cutting, mixing, and cooking operations with precision and safety.

Occasionally, during the execution of household tasks, A-19 may need to interact with the elderly person being assisted. For example, it may receive specific instructions regarding food preferences or the arrangement of objects in the home. We want to focus on the following situation:

1. While A-19 is preparing meals in the kitchen, it must decide whether to prepare a complex variant of a complex recipe that requires the use of additional appliances, or to opt for a simpler dish that can be prepared manually with fewer resources and in less time; to do this, it may interrupt the preparation and request the intervention of the assisted person; the presence of these recipe variants is described in a recipe script, which the robot has access to.

2. During house cleaning, A-19 detects a fragile object on the floor that should not be moved or handled; the fragility of the object is detected by appropriate algorithms. The robot must decide whether to ignore the object and continue cleaning, risking damage to it, or to report the situation to the elderly person and await instructions on how to proceed.

Problem

Using points 1/ and 2/ as general rules that A-19 must follow, design a cognitive architecture based on a series of software modules capable of ensuring A-19's overall behaviour given these normative rules.

A. Use UML formalism to describe the cognitive architecture of A-19, identifying reasonable software components.
B. Develop the component diagram of the cognitive architecture, highlighting the cloud-based cognitive components and the on-premises ones.
C. Selecting a software module from those provided, describe its state machine explicitly specifying states, events, transitions, and any sub-states.
D. Describe the activity diagram of the cognitive architecture.
E. Highlight the software components that are "adapters."
F. Highlight the software components that are "computational."
G. Highlight where the "publish-subscribe" communication mode is used.