GenAI for Automotive Software Unit:

Multi-Agent System Approach for Test Case Generation of Advanced Driver Assistance System(ADAS)

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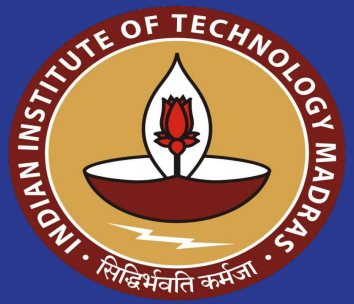

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Contents

Multi-Agent Systems(MAS)

- Multi-agent systems enhance the capabilities of single LLM agents by leveraging collaborations among agents and their specialized abilities.
- Utilizing collaboration and coordination among agents to execute tasks that are beyond the capability of any individual agent.
- Each agent is equipped with distinctive capabilities and roles, collaborating towards the fulfillment of some common objectives. Such collaboration, characterized by activities such as debate and reflection, has proven particularly effective for tasks requiring deep thought and innovation.
- Handling complex real-world scenarios like simulating interactive environments, role playing, reasoning etc.

Multi-Agent Systems(MAS): Agents-environment interface

1. **Sandbox Interface**

   A simulated or virtual environment created by humans where agents can freely interact and experiment with various actions and strategies.

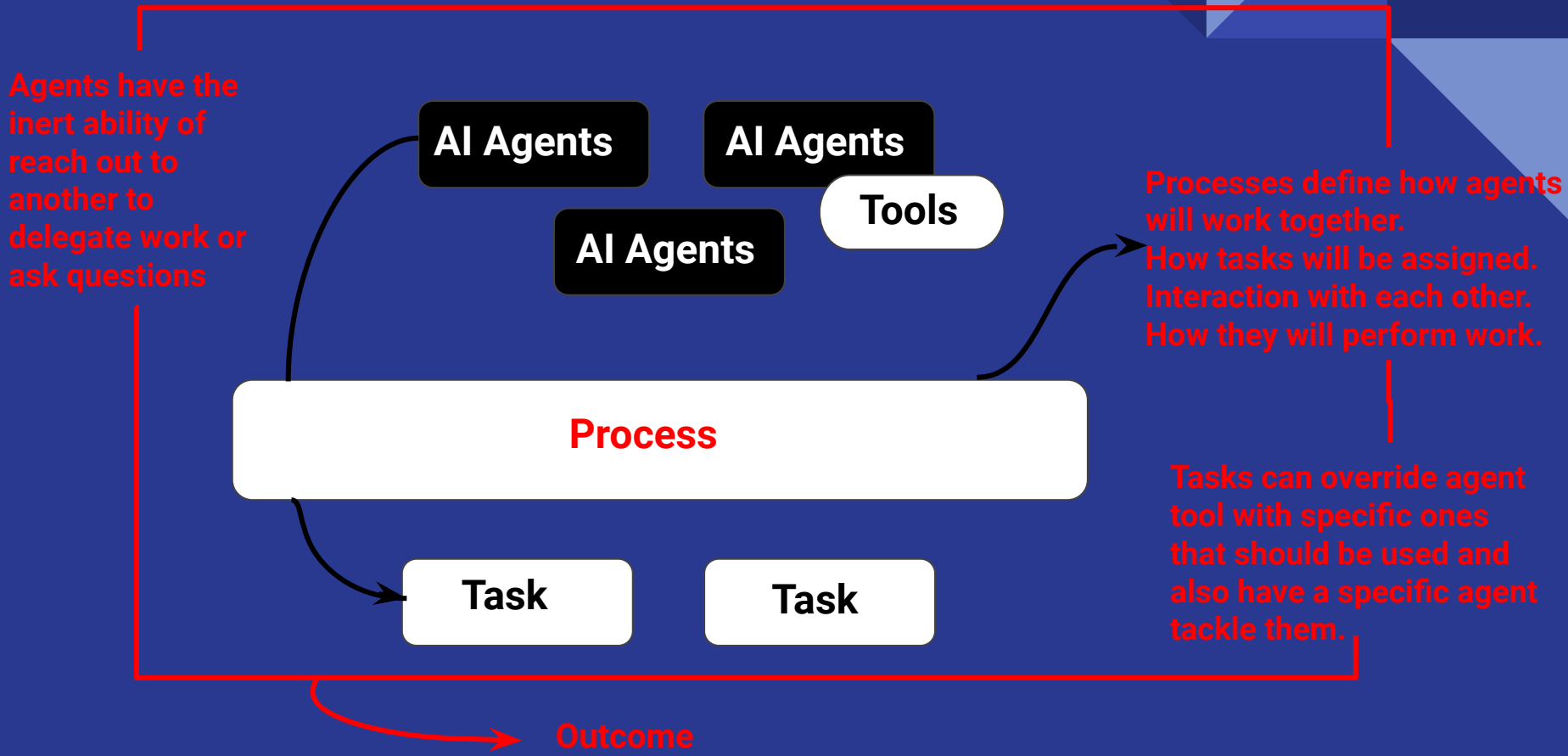
2. **Physical Interface**

   A real-world setting where agents interact with physical entities and must comply with the laws of physics and other real-world constraints.

3. **None Interface**

   Involves scenarios where agents operate without interacting with a traditional external environment, focusing instead on internal communications.

Multi-Agent Systems(MAS): Agents-environment interface



Multi-Agent Systems(MAS): Agent profiling

Agent profiling involves defining specific traits, actions, and skills for each agent within the system. These profiles are tailored to meet predefined objectives and significantly affect how agents interact and perform within the system. The profiles encapsulate:

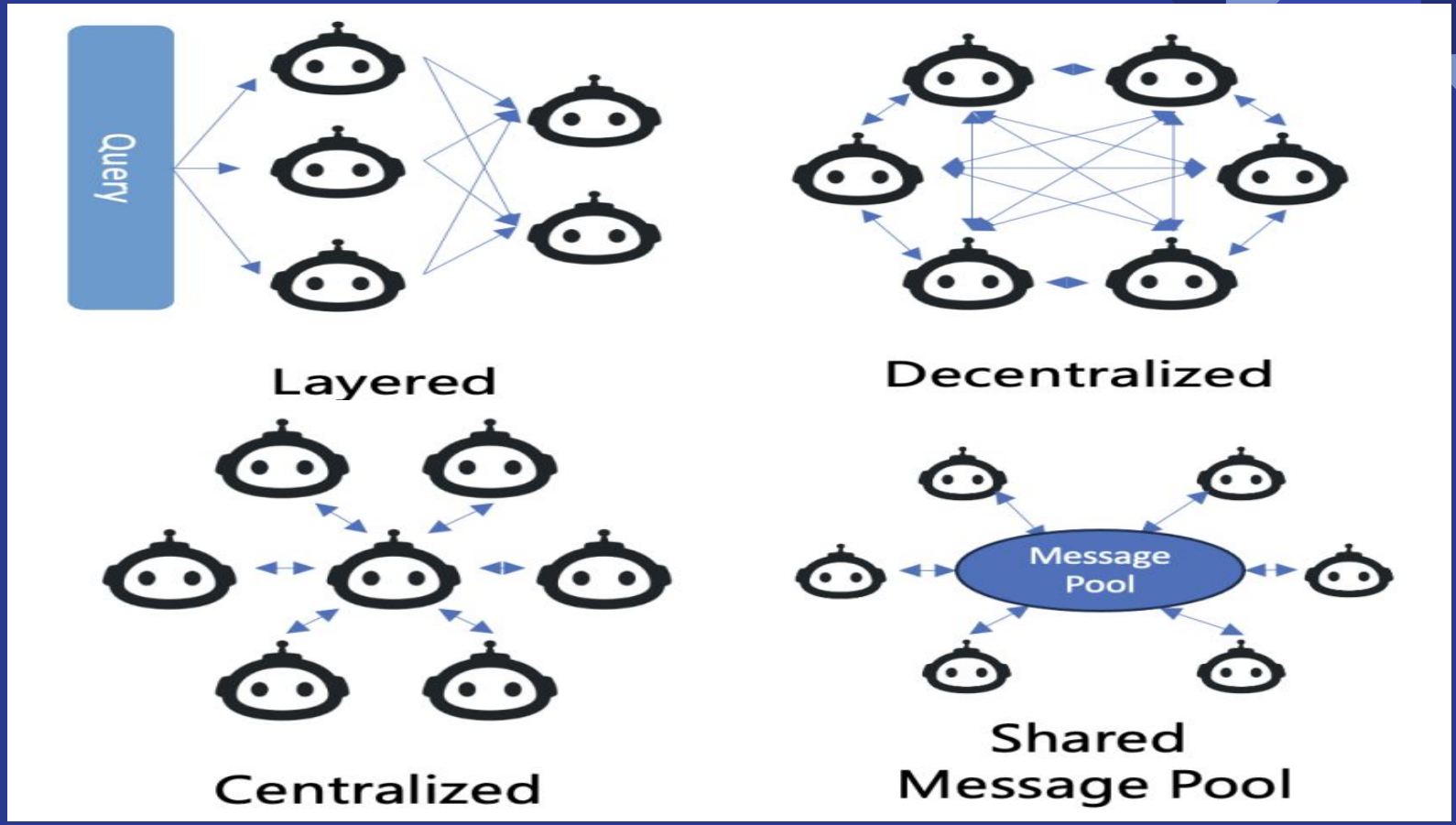
- **Characteristics**: Attributes that define the nature of the agent, such as aggressiveness, cooperativeness, or responsiveness.
- **Capabilities**: Skills or competencies that the agent possesses, which could include technical skills in software environments or strategic thinking in competitive settings.
- **Behaviors**: Patterns of action that the agent follows under certain conditions, which could be scripted or learned.
- **Constraints**: Limitations or conditions that restrict the agent's actions or behaviors.

Multi-Agent Systems(MAS):Agent communication

Communication paradigms define the inherent interaction styles between agents. These paradigms shape how agents exchange information and influence each other's actions. The main paradigms are:

- **Cooperative**: Agents collaboratively work towards a common goal. Information is shared openly to synchronize efforts and optimize group outcomes. This paradigm is often used in systems where the success of the collective is the priority, such as team-based robotics or cooperative problem-solving scenarios.
- **Debate**: This paradigm involves agents engaging in structured argumentative exchanges where they present, defend, and critique ideas. It is particularly useful in environments where decision-making processes benefit from diverse viewpoints, such as in policy formulation or ethical debates.
- **Competitive**: In this setting, agents pursue individual goals that may conflict with the objectives of others. Communication may be strategic or minimal to maximize personal advantages. This paradigm is common in scenarios like auctions, adversarial negotiations, or games where each agent aims to outperform the others.

Multi-Agent Systems(MAS):Agent communication Structure



Multi-Agent Systems(MAS):Agent capability acquisition

Types of Feedback for Agents

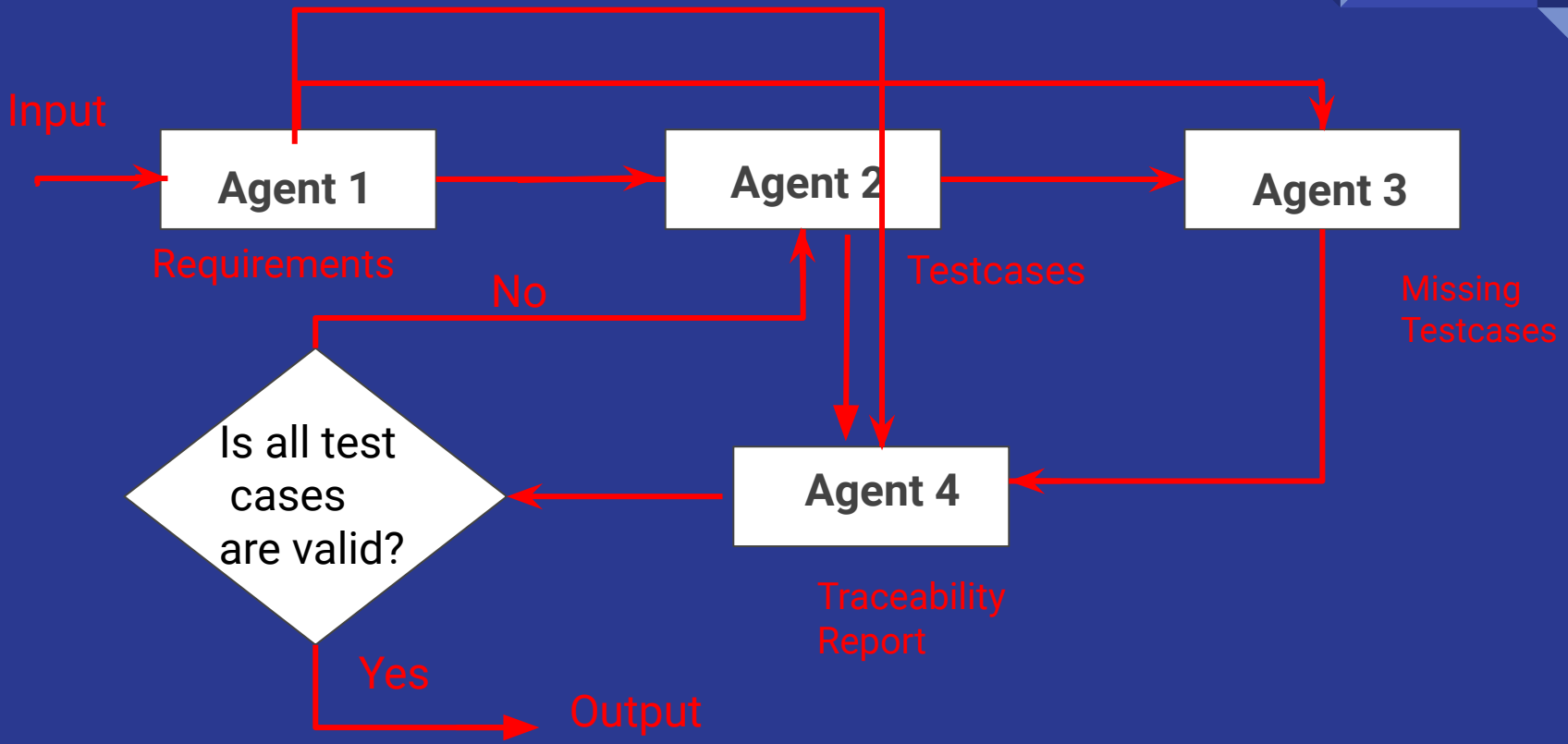
1. **Feedback from Environment**: Agents receive feedback from their actions in real-world or virtual environments. This is typical in software development, where agents learn from code interpreters, or in robotic systems, where feedback might come from physical or simulated interactions.
2. **Feedback from Agent Interactions**: This feedback arises from communications or judgments between agents. It is prevalent in settings like science debates or game simulations, where agents refine their strategies based on past interactions.
3. **Human Feedback**: Direct input from human users or overseers helps align the agents actions with human values and preferences, crucial in human-in-the-loop systems.
4. **No Feedback**: In certain simulation scenarios aimed primarily at analyzing outcomes, agents may receive no feedback, focusing instead on the analysis of these results without adjusting their actions.

Multi-Agent Systems(MAS):Agent capability acquisition

Strategies for Agent Adjustment to Complex Problems

1. **Memory**: Agents use a memory module to store and recall information from past interactions and feedback. This stored memory aids agents in refining their actions based on successful past experiences, enhancing their decision-making for similar future scenarios.
2. **Self-Evolution**: Beyond relying on past data, agents dynamically evolve by modifying their goals, strategies, and learning from new feedback. Techniques include self-control loops for improved self-management and adaptation, and Learning through Communication (LTC), which uses interaction logs to continuously train and refine agent models.
3. **Dynamic Generation**: Some systems can generate new agents on-the-fly to meet immediate needs or solve emerging challenges, allowing for rapid adaptation and scalability within the system.

Flowchart of Multi-agent system collaboration



Requirements Generation for ADAS

Requirement ID	Requirement Description
REQ-001	The Adaptive Cruise Control (ACC) system shall maintain a gap from the vehicle ahead or a set road speed if there is no slower vehicle ahead.
REQ-002	The ACC system shall be able to set a speed between 32 km/h (20 mph) and 180 km/h (112 mph).
REQ-003	The ACC system shall regulate the speed of the vehicle using engine control and the brakes.
REQ-004	The ACC system shall not be a collision warning or avoidance system.
REQ-005	The ACC system shall not react to pedestrians or objects on the roadway.
REQ-006	The ACC system shall not react to oncoming vehicles in the same lane.
REQ-007	The ACC system shall use a radar sensor to detect vehicles ahead.
REQ-008	The ACC system shall only be used when conditions are suitable, i.e., main roads with traffic moving in lanes.
REQ-009	The ACC system shall not be used in areas with road obstructions, traffic islands, junctions, areas with many parked vehicles or areas shared with pedestrians.
REQ-010	The ACC system shall not be used in poor visibility, specifically fog, heavy rain, spray or snow.
REQ-011	The driver shall be responsible to stay alert, drive safely, and remain in control of the vehicle at all times.
REQ-012	The front of the vehicle shall not be obstructed by sensors or objects, including vehicle front protectors, which may prevent the radar sensor from operating.
REQ-013	The ACC system shall be operated by controls mounted on the steering wheel.
REQ-014	The driver shall be able to interrupt it at any time by the use of the brake or accelerator pedals.
REQ-015	The ACC system shall be able to adhere to the vehicle's set speed.
REQ-016	The ACC warning lamp shall be visible when the system is operational.
REQ-017	The ACC system shall be able to resume the last set speed above the vehicle's current speed.
REQ-018	The ACC system shall be able to resume the set speed after the system has been disengaged.
REQ-019	The ACC system shall be able to cancel the set speed manually.
REQ-020	The ACC system shall be able to detect moving vehicles ahead.
REQ-021	The ACC system shall be able to decrease the set speed when required.
REQ-022	The ACC system shall be able to decrease the gap to the vehicle ahead.
REQ-023	The ACC system shall be able to increase the follow mode gap.
REQ-024	The ACC system shall be able to maintain a constant time gap to the vehicle ahead until disengaged.

Test Cases Generation for ADAS

Test Case ID	Test Case Description	Requirement ID
TC-001	**Description:** Verify that the ACC system maintains a gap from the vehicle ahead when there is no slower vehicle ahead. **Precondition:** The ACC system is engaged and the vehicle is travelling at a constant speed. **Steps:** 1. Drive the vehicle towards a slower vehicle ahead. 2. Observe the behavior of the ACC system. **Input:** N/A **Expected Result:** The ACC system maintains a gap from the slower vehicle ahead.	REQ-001
TC-002	**Description:** Verify that the ACC system uses a radar sensor to detect objects ahead. **Precondition:** The ACC system is engaged and the vehicle is travelling at a constant speed. **Steps:** 1. Cover the radar sensor and observe the system behavior. **Expected Result:** The ACC system alerts the driver and disengages the ACC feature.	REQ-002
TC-003	**Description:** Verify that the ACC system is only used when conditions are favorable, i.e., no rain, snow, or fog. **Precondition:** The ACC system is engaged and the vehicle is travelling at a constant speed. **Steps:** 1. Operate the ACC system in adverse weather conditions and observe the behavior. **Expected Result:** The ACC system alerts the driver and disengages automatically.	REQ-003
TC-004	**Description:** Verify that the ACC system is not used during abrupt sharp turns, e.g., traffic islands or roundabouts. **Precondition:** The ACC system is engaged and the vehicle is travelling at a constant speed. **Steps:** 1. Take abrupt turns while the ACC is active and observe the system response. **Expected Result:** The ACC system disengages or alerts the driver.	REQ-004
TC-005	**Description:** Verify that the ACC system is not used in poor visibility, specifically foggy roads. **Precondition:** The ACC system is engaged and the vehicle is travelling at a constant speed. **Steps:** 1. Drive the vehicle on foggy roads and monitor system performance. **Expected Result:** The ACC system disengages or alerts the driver to the poor visibility.	REQ-005

Future Works

Create a Robust Multi-agent system for ADAS which generate

- Requirements
- Testcases(specific formats like Traditional Test Case Format,Gherkin format(Given-When-Then))
- Traceability Report(Check validation of testcases as per the requirements)
- Automated Metrics: BLEU (Bilingual Evaluation Understudy),ROUGE (Recall-Oriented Understudy for Gisting Evaluation)

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THANK YOU

Towards a Reliable ADAS Future with GenAI

GenAI is poised to revolutionize ADAS development by automating tasks, enhancing quality, and accelerating innovation. By leveraging its capabilities, we can create a future where ADAS systems are reliable, safe, and highly effective, contributing to a safer and more efficient automotive landscape.