

Improvement and development of simulation scenarios for air traffic management using Large Language Models (LLM)

Artificial intelligence (AI) in the context of safe and efficient air traffic management ¹

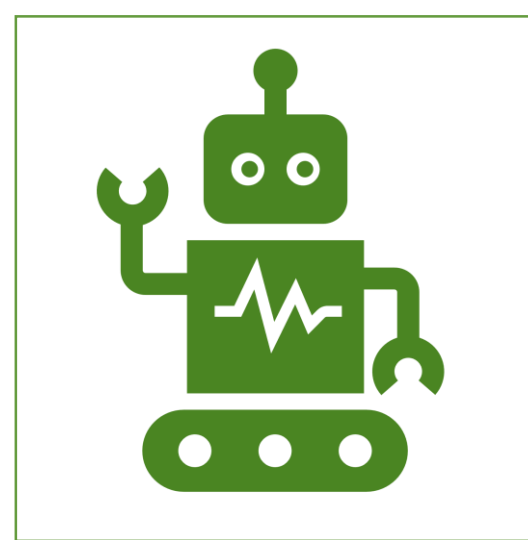
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Abstract

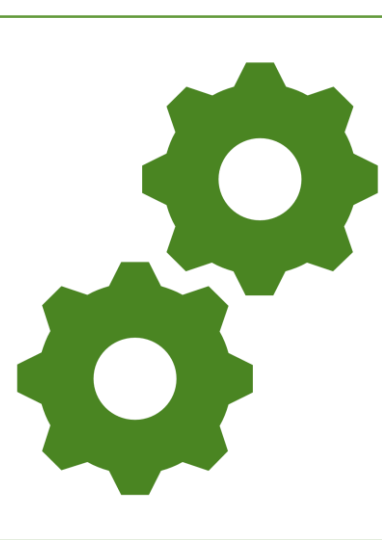
Air Traffic Management – ATM validation scenario creation often rely on manual scripting, which can be time-consuming and limited in scope. The use of LLMs offers a novel solution by automating scenario generation based on natural text or speech input.

Objectives



Automate and optimize :
Automate and optimize the creation of air traffic management (ATM) simulation scenarios.

Generate:
Generate diverse and adaptive scenarios based on natural text or speech input.



Customize:
Customize simulations to reflect various operational conditions (e.g. airspace congestion, weather changes).

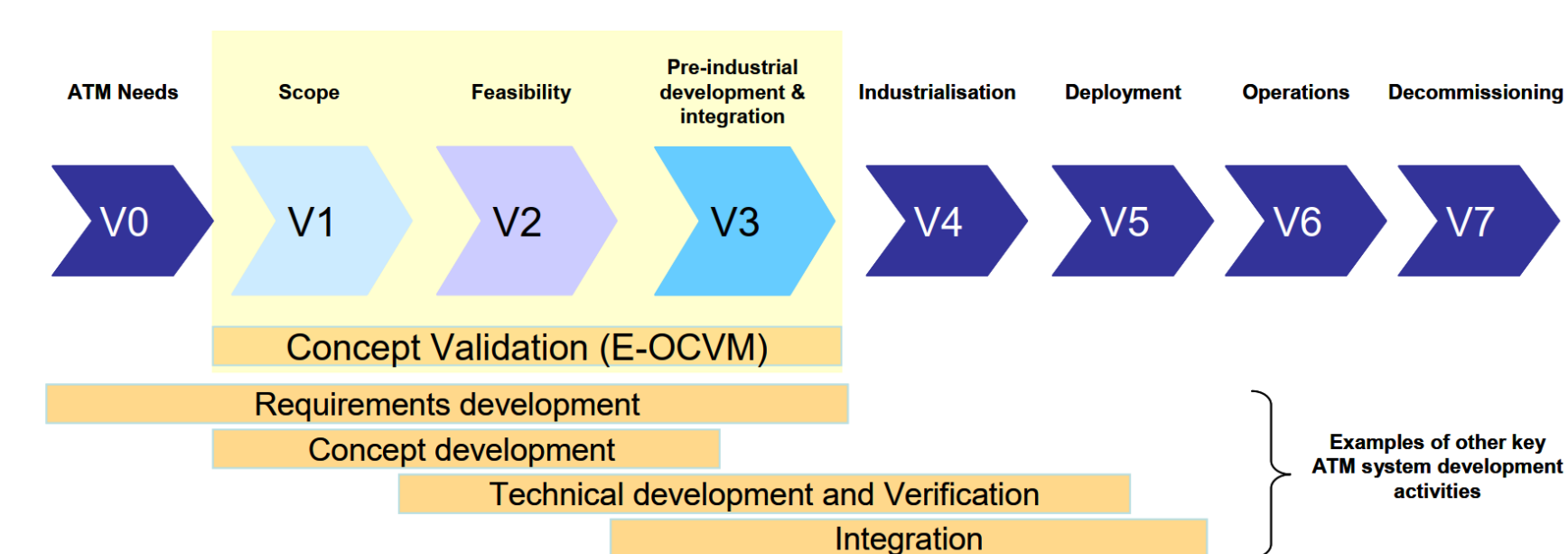
Simulation and E-OCVM

Fundamental requirement for evaluating research content is to have the infrastructure to simulate and assess new concepts and systems.



DLR Apron and Tower Simulator - ATS Real Time Simulation ² - Air Traffic Validation Center

Validation is the examination of a concept to determine whether the expected objectives can be achieved through its use. Validation is about answering the question: Have we built the right system?



E-OCVM - European Operational Concept Validation Methodology ³

Methodology

Using Generative AI, the specific branch of artificial intelligence that uses generative models, known as Large Language Models to produce text, images, and other content from natural language prompts.

To investigate how LLMs can leverage the automated scenario generation based on natural language input, the following methods are under investigation:

- One & Few Shots
- Chain-of-Thought (CoT)
- Prompt-Functions
- Agentic Design Patterns

Framework for categorizing design patterns for building agents ⁴ :

Reflection:

- The LLM examines its own work to come up with ways to improve it.

Tool use:

- The LLM is given tools such as web search, code execution, or any other function to help it gather information, take action, or process data.

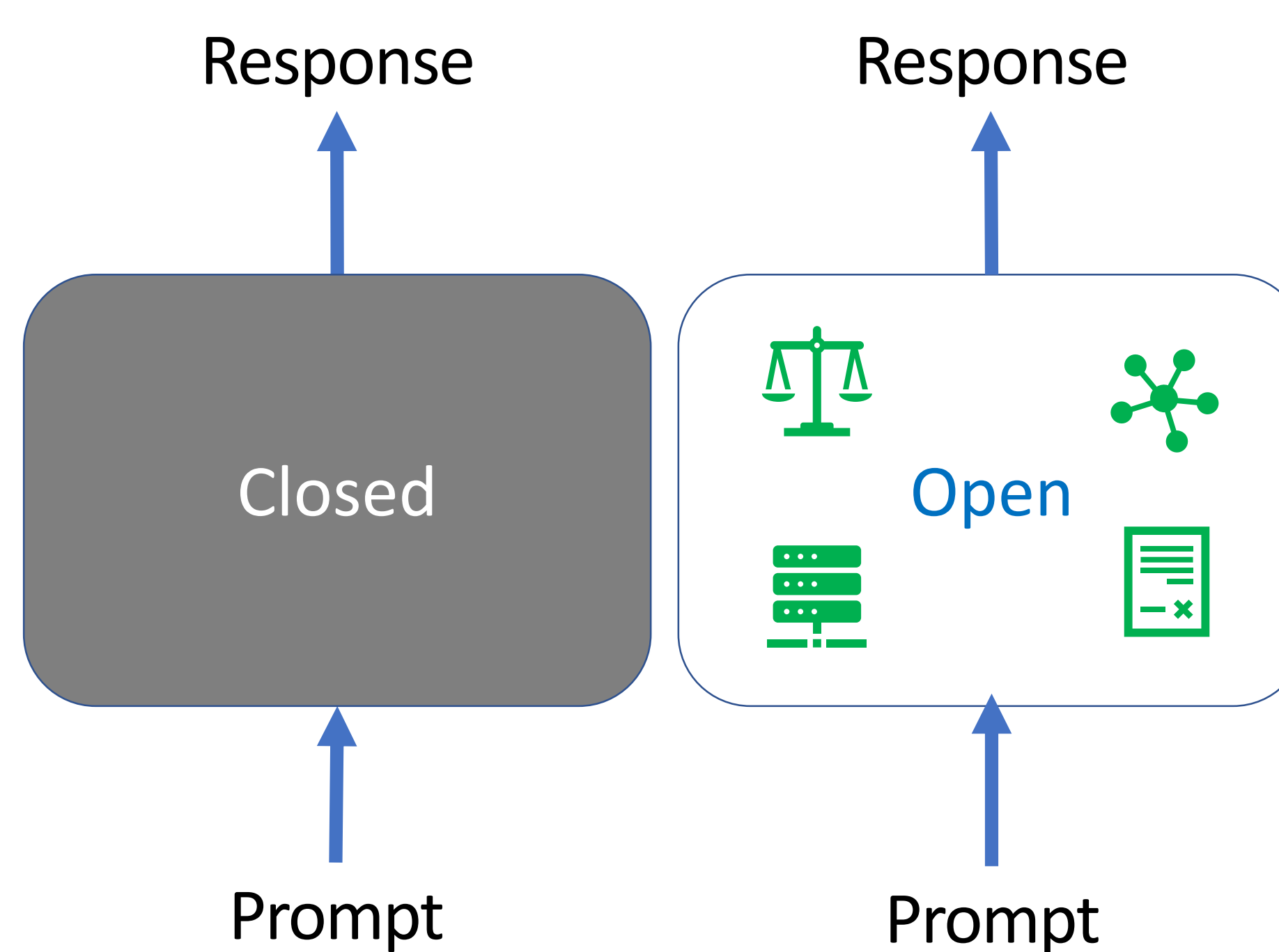
Planning:

- The LLM comes up with, and executes, a multistep plan to achieve a goal (for example, generating simple base scenario, then doing online research, then refining the scenario, and so on).

Multi-agent collaboration:

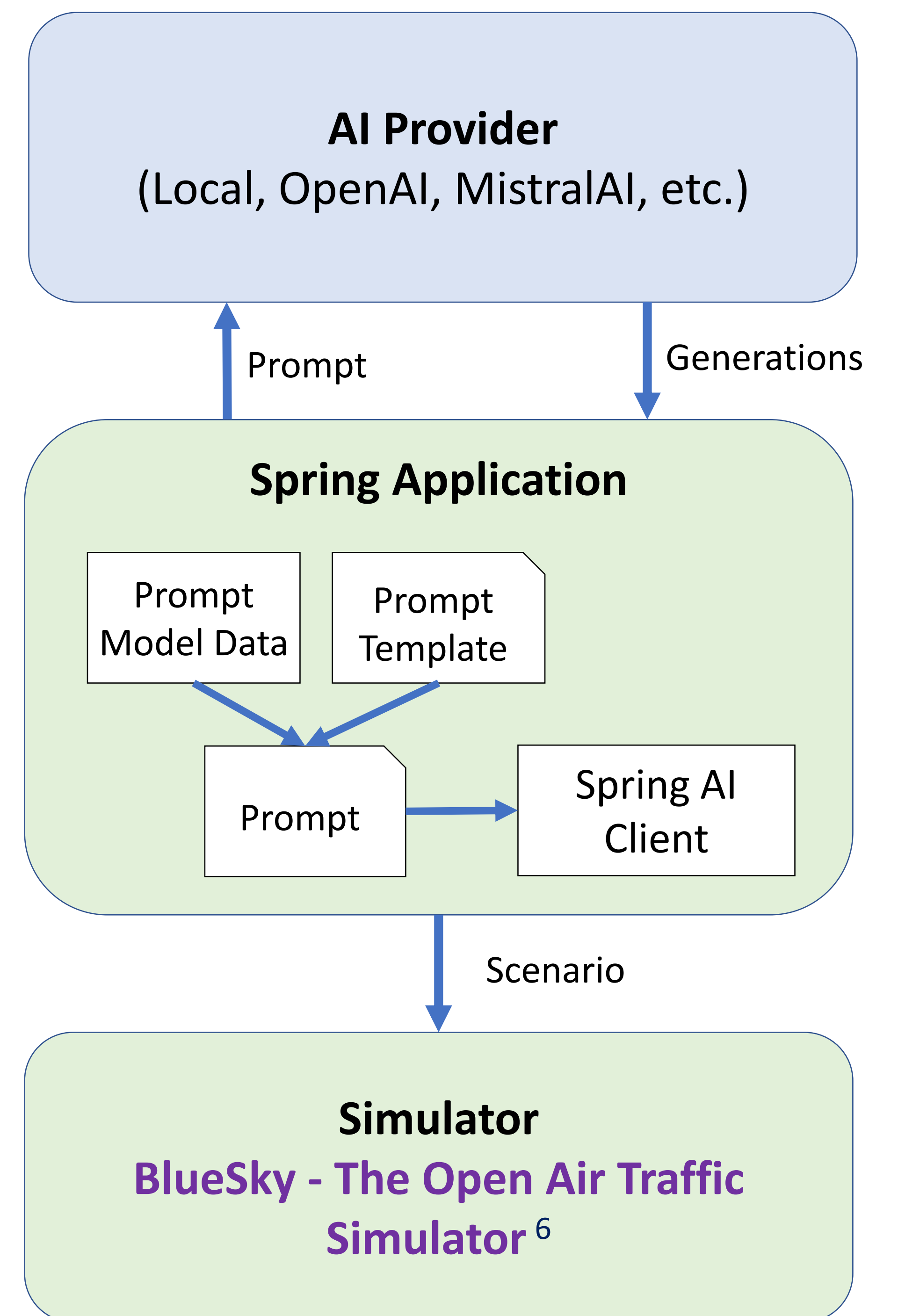
- More than one AI agent work together, splitting up tasks and discussing and debating ideas, to come up with better solutions than a single agent would.

Open vs. Closed Models



Ollama ⁵ - An option for running several open-source models free and locally on your own hardware, including several popular models offered by some of the cloud-based services.

Example Architecture



Key Features & Innovations

Dynamic Scenario Generation:

LLMs has the potential to simulate real-world events such as traffic mix, aircraft malfunctions or weather anomalies.

Customization for Training & Research:

Simulations can be adjusted for specific training or research objectives.

Efficient Development Process:

Reduces manual effort and development time, making the scenario generation process faster and more scalable.

Conclusion & Future Work

- LLMs offer potential for ATM simulations by enabling rapid, flexible, and realistic scenario creation.
- Enhancing LLM models for even more nuanced scenarios.
- Expanding ATM scenario generation to include more complex operational environments.
- Research is still in progress to investigate the utilization of prompt engineering and AI agent workflows in modeling ATM simulation scenarios with LLMs.

References

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