Towards LLM-augmented multiagent systems for agile software engineering

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ABSTRACT

A cognitive multi-agent ecosystem designed for efficient software engineering using Agile methodologies can significantly improve software development processes. Key components include the integration of Multi-Agent Systems (MAS) and Large Language Models (LLMs), utilizing Dynamic Context techniques for agent profiling, and Theory of Mind to enhance collaboration. The CogniSim Ecosystem analyzes problems, proposes solutions, constructs and validates plans, and coordinates specialized agents playing roles such as developers, executors, quality checkers, and methodology reviewers. These agents produce documentation, models, and diagrams (e.g., UML) while adhering to predefined quality and performance measures. The ecosystem also simulates the impact of various team configurations on problem-solving effectiveness, helping organizations identify optimal team structures. Case studies and simulations demonstrate its practical applications.

CCS CONCEPTS

• **Computing methodologies** → **Multi-agent systems**; • **Software and its engineering** → *Agile software development*.

KEYWORDS

Multi-Agent Systems, Large Language Models, Software Engineering, Collaboration Automation, methodologies, SAFe, CogniSim

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1 INTRODUCTION

Integrating advanced technologies like Multi-Agent Systems and Large Language Models is crucial in addressing modern software engineering (SE) challenges [9]. Agile methodologies help with iterative development but struggle with scalability and complexity management [10]. LLMs (like GPT-4) further improve productivity by automating routine SE tasks [6]. The synergy of MAS and LLMs creates adaptive systems capable of handling complex tasks, enhancing teamwork and productivity [5]. The CogniSim Ecosystem leverages MAS and LLMs to coordinate SE tasks, demonstrating its effectiveness through case studies and simulations.

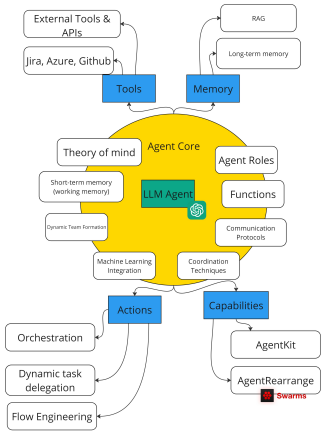

Figure 1: Architecture of the Single Agent

2 FUNDAMENTALS AND ECOSYSTEM OF MULTI-AGENT SYSTEMS

Multi-agent systems decentralize and optimize modern manufacturing processes, such as scheduling, assembly line design, and robot control, enhancing flexibility and efficiency [8]. By modularizing complex tasks into autonomous agents, MAS improve adaptability beyond traditional methods. Techniques like formal specifications, coordination, and machine learning are integrated to increase their effectiveness in dynamic environments [12]. Agile methodologies, particularly the Scaled Agile Framework (SAFe), facilitate MAS integration into large-scale Agile environments, managing multi-team projects with flexibility and efficiency [11].

3 COGNISIM - MULTI AGENT COGNITIVE ECOSYSTEM

The integration of cognitive agents, powered by LLMs, is significantly transforming software project management within MAS by enhancing the adaptability and efficiency of Agile methodologies like SCRUM. These agents automate tasks such as backlog refinement and sprint planning, offering deep insights and improved agility in project execution. Frameworks like LangChain facilitate

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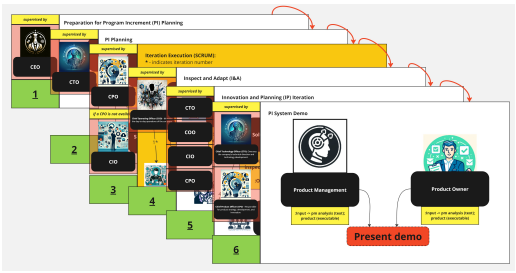

Figure 2: Agents' flow in CogniSim Ecosystem[3].

the deployment of these intelligent agents, with dynamic sequencing driven by language models to support complex decision-making processes [2]. Multi-agent dialogue simulations further aid in mimicking real-world project dynamics, helping agents generate appropriate responses and manage discussions effectively.

Cognitive agents within MAS, exemplified by the CogniSim ecosystem, improve decision-making, problem-solving, and overall efficiency in project management. These AI-driven agents continuously learn and adapt based on their environment, improving their performance over time. The core components of the CogniSim ecosystem include cognitive agents, communication protocols, learning algorithms, decision-making frameworks, and collaboration tools, all of which contribute to more efficient, accurate, and adaptable project outcomes [3]. These agents' ability to collaborate effectively simulates human team dynamics, enhancing communication, coordination, and overall project management efficiency. The example CogniSim simulation is presented in Figure 2.

4 EVALUATION AND CASE STUDIES

The evaluation of LLMs in Agile software engineering underscores their strong performance in tasks like financial statement analysis, where models such as GPT-4 surpass human analysts [6]. Metrics like relevance, coherence, readability, and error rate are essential for assessing content quality [7]. Robust baselines and domain-specific factors are critical for accurate evaluations.

Our case study highlights the practical implementation, essential characteristics, and efficacy of the CogniSim framework in real-world software engineering settings. It offers empirical evidence, facilitates performance assessment, and supports ongoing research.

5 CONCLUSIONS AND FUTURE DIRECTIONS

Cognitive agents enhance efficiency, adaptability, and decision-making in agile engineering, optimizing workflows and reducing cognitive load [5] [1].

Figure 3 shows the general concept diagram of the CogniSim multi-agent system, highlighting its key components, including risk management, task allocation, problem solving, project management, training and learning, and documentation, along with the various internal and external interfaces that interact with the system.

Future work on the CogniSim will focus on enhancing key functionalities, including contextual understanding to help agents interpret nuanced information for informed decision-making [5]. Emotional intelligence will be incorporated to improve human-agent interactions and collaborative decision-making [4]. Ethical decision-making frameworks will ensure trust and integrity in sensitive scenarios [1]. Scalability and flexibility mechanisms will allow the system to adapt to varying demands, and continuous improvements to the user interface will make it more intuitive and user-friendly.

Figure 3: Concept Diagram

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