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Multi-Agent Approach for Facing Challenges in Ultra-Large Scale systems

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ABSTRACT

The primary characteristics of ULS systems are ultra-large size, number of lines of code (LOC); number of people employing the systems; amount of data stored, accessed, manipulated, and refined; number of connections and interdependencies among software components; number of hardware elements. These characteristics of ULS systems make it impossible to rely on our current knowledge and techniques of software development. We will face fundamental challenges in the design and evolution, orchestration and control, and monitoring and assessment of ULS systems. In this paper we try to make a combination between ULS systems and Multi Agent Systems and to use Multi Agent System strengths to help tackling some challenges found in ultra-large scale systems. Banking system is an instance of ULS systems. As a case study, in a real project we have designed Automated Teller Machine (ATM) combination with biometric sensors based on multi-agent architecture.

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1. INTRODUCTION

When concept of ultra-largeness is added to software systems and agents, existing standards, existing theories and existing models encounter some deficiencies; because scale changes everything [1].Ultra-large systems are architecturally complex. Some researchers are done on agent interaction, task assignment among ultra-large multi-agent systems, self-adaptability and fault tolerance in ultra-large multi-agent systems but there is still much to be done.

A Negotiation Model for Large Scale Multi-Agent Systems is reviewed in [3]. CNCP protocol which is developed for task assignment in ultra-large scale multi-agent systems is explained in [4]. Self – adaptability and DimaX platform for fault-tolerance is researched in [5, 6]. In this paper we have tried to reconcile and combine multi-agent and ultra-large systems to find possible solution for some challenges in ultra-large multi agent systems. Anyway agents and multi-agent systems are older concepts than ultra-large systems. In the next section we introduce ultra-large systems characteristics.

2. ULS CHARACTERISTICS

There are characteristics of ULS systems that will arise because of their scale. Like a biological ecosystem, a ULS system is composed of dynamic community of interdependent and competing organisms in a complex and changing environment. Chapter 2 from [1] which is published by Carnegie-Mellon University gives an overview of ULS systems characteristics:

- Decentralization of data, Development, evolution, deployment: in ULS systems we have decentralized data, development, evolution, and operational control.
- Inherently conflicting, unknowable, and diverse requirements: ULS systems will be developed and used by a wide variety of stakeholders with unavoidably different, conflicting, complex, and changing needs.
- Continuous evolution and deployment: while ULS system is operating, new capability need to be integrated and unused capabilities will be dropped.
- Heterogeneous, inconsistent, and changing elements: A ULS system is constructed from non-uniform parts.
- Erosion of the people/system boundary: People will not just be users of a ULS system; they will be elements of the system, affecting its overall emergent behavior.
- Normal failures: Software and hardware failures will be the norm rather than the exception.
- New paradigms for acquisition and policy: The acquisition of a ULS system will be simultaneous with the operation of the system and require new methods for control.

3. MULTI AGENT SYSTEMS CHARACTERISTICS

Properties of ultra-large multi agent systems include:

- Distribution: multi agent systems are distributed which are spread across network. Socket communication or middleware are used to develop multi agent systems.
- Decentralization: there is no central node to collect results or issue commands. Agents act independently and attain their personal goal.
- Local views: no agent has a full global view of the system, or the system is too complex for an agent to make practical use of such knowledge.
- Self-organization and self-steering. Multi-agent systems can manifest self-organization as well as self-steering and other control paradigms and related complex behaviors even when the individual strategies of all their agents are simple.
- Social: in multi-agent system every agent knows other agents and their capabilities and may ask them for help.
- Interaction: agents interact and exchange information to cooperate.
- Goal-oriented: every agent follows goals which are specified by system or user.

The main advantages of multi-agent systems are their ability to cope with dynamics. Contrarily to objects, agents are not associated to a specific agent to perform a task. Agents ask other agents which one is able to do the task. Once an agent accepts the task, a contract is made between the two agents.

4. ASSOCIATION BETWEEN ULS AND MAS

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In this section, we show how agents and multi-agent systems are related in these characteristics and why agents could help approaching some ULS challenges. Challenges in ULS are mentioned in Section 2. We define associations between ULS challenges and MAS characteristics:

- Decentralization of data, Development, evolution, deployment: Organizations in multi-agent systems follow social theory and propose to use the notion of groups or the notion of markets [7]. Agents are constrained by norms and regulations and the organizations are thus called electronic institutions.
- Inherently conflicting, unknowable, and diverse requirements: Agents can Cooperate, coordinate, and negotiate with each other. These properties could be helpful in solving some challenges.
- Continuous evolution and deployment: There will be an increasing need to integrate new capabilities into a ULS system while it is operating. New and different capabilities will be deployed, and unused capabilities will be dropped; the system will be evolving not in phases, but continuously [1]. Object-oriented or component systems are facing problems to overcome this issue. Multi agent system platforms propose the notion of yellow pages where agents record their skills and services.
- Heterogeneous, inconsistent, and changing elements: A ULS system will not be constructed from uniform parts: there will be some misfits, especially as the system is extended and repaired [1]. Agents are using high-level interaction facilities such as interaction protocols.
- Erosion of the people/system boundary: People will not just be users of a ULS system; they will be elements of the system, affecting its overall emergent behavior. Agents could help with their planning skills. Users express their requirements and agents define a plan corresponding to these requirements based on the available software components [2].

- Normal failures: when failures occur, Agents can modify the software components
- New paradigms for acquisition and policy: Agents are Self organization, self-steering Agents and intelligent so that can be helpful in this area.

Table 1 . ULS characteristics associated with MAS characteristics

ULS characteristics	*Multi Agent Systems characteristic*
Decentralization of data, Development, evolution, deployment	Distributed across network Decentralization: There is no central node in MAS
Inherently conflicting, unknowable, and diverse requirements	Agents are Intelligent Agents can Cooperate, coordinate, and negotiate with each other
Continuous evolution and deployment	Social ability of Agents Agents are Self-organization and self-steering
Heterogeneous, inconsistent, and changing elements	Agents are using high-level interaction facilities such as interaction protocols[4]
Erosion of the people/system boundary	Planning skills of Agents Autonomy of Agents
Normal failures	Modifying software by Agents
New paradigms for acquisition and policy	Agents are Self-organization and self-steering Agents Are Independent and Intelligent

5. CASE STUDY

Iranian Telecommunication Manufacturing Company (ITMC) is a company operating in Electrical engineering and ICT areas. ITMC besides some products in electrical and communication area participates in software areas. One of these projects which are designed is Automated Teller Machine (ATM) combination with biometric sensors.

Traditionally, access to secure areas or sensitive information has been controlled by possession of a particular key card or password. Nowadays, people have PINs and passwords for a large number of devices, from the different social networks and sites, to their bank information. Biometric sensors can confirm that a person is actually present without requiring the user to remember anything and there is no security threat.

Banking system, based on its characteristics, is one of the instances of ULS systems. The details of the systems specification are mentioned in our book [8]. We have designed the projects based on multi agent architecture. In Table 2, we show how challenges of ATM system are satisfied.

This project leverages agent's potentials for tackling ULS challenges and was developed based on SQL Server and Visual C#.

Table 2. ATM characteristics

ATM Characteristics	**Multi Agent Systems characteristic**
– Decentralization of banking data	– Distributed agents across network
– Diverse requirements – Profound influence of environment	– Agents can Cooperate, coordinate, and negotiate with each other
– Competitive environment	– Agents are social
– Fast paced of technology	– Agents are Self-organization and self-steering
– Inconsistent needs in banking Systems	– Using high-level interaction facilities by Agents
– Customers and users of the system may be the same – Customers are the main element of the system	– Planning skills of Agents – Agents are autonomous
– Infrastructure failure	– Modifying software by Agents
– Problem in Telecommunications network	– Cooperation with monitoring and logging Agents
– New patterns for Security issues in Banking Systems	– Agents are Self-organization, Independent and Intelligent – Monitoring, Authentication and Authorization Agents

6. CONCLUSION

Ultra-large systems have fundamental challenges in comparison to traditional systems. Conventional methods of software engineering are not effective in this kind of systems because of problems of scale. The problems introduced by scale require new solution approaches and new concepts for system design, development, operation, and evolution. Agents and Multi-agent systems have the potential to respond to some of these challenges. In this paper we tried to make a correspondence between ULS systems challenges

and Multi Agent Systems characteristics and to use Multi Agent System strengths to help tackling some ultra-large scale systems challenges. For each challenging characteristic in ULS systems we can find an associated strength in MAS which could be helpful in solving some challenges. As a case study, in a real project we have designed Automated Teller Machine (ATM) combination with biometric sensors. Banking system is one of the instances of Ultra Large Scale Systems. For each challenges in ATM we showed in Table 2 how challenges of ATM system are satisfied by MAS potentials.

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