Defining Ontology Combining Concepts of Massive Multi-Player Online Role Playing Games and Organization of Large-Scale Multi-Agent Systems

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Abstract— **Large-scale multi-agent systems (LSMAS) development methods are becoming a necessity in a world of ever growing numbers of computer agents incorporated in various devices and services used by people in all areas of life. Organization in such large-scale systems, becomes therefore a very relevant concept in research on LSMAS, as the mentioned agents are expected to cooperate, compete, and share information, hence improving quality of peoples' life. An example application domain of LSMAS are massive multi-player online games (MMOG), and their specific genre – MMO role-playing games (MMORPG). MMORPGs provide us with the opportunity to study both large-scale virtual interaction of players (agents), and coordination of large-scale distributed artificial intelligence. In this paper, we will present an ontology of organizational concepts, suited for LSMAS development, merged with an ontology containing elements of a specific MMORPG. Combining these two ontologies with a special accent on identifying elements and aspects of organization, will hopefully present us with a basis for LSMAS structures which follow organizational constraints and are suitable for LSMAS development in the MMORPG context.**

Keywords— ***MMORPG, LSMAS, organization, ontology, software development***

I. Introduction

Organization has always been present in the lives of people, yet only the last few years show an emergent need for organization in the digital world. The number of interconnected digital devices is increasing on a daily basis, and their capabilities are developing rapidly. Such a rapid development led to the Internet of Things (IoT) and increased activity in the digital (virtual) environment [1]. This increase in numbers of various smart devices led to a noticeable increase in the number of heterogeneous computer software agents co-existing the digital world. Interconnected using the Internet and other available networks, these computer agents have to be able to communicate with each other, cooperate, compete and interact in various ways both mutually and with their human owners. Since these software systems are distributed and smart, multi-agent systems (MAS) become a natural abstraction for the development of such complex socio-cybernetic systems. The idea of using organizational concepts in multiagent systems is not new [2], [3], but has only recently been proposed for the use in LSMAS [4], [5].

Organization of large-scale multi-agent systems (LSMAS) has only recently had an attempt in formalizing applicable organizational design methods, presented in [6]. The ultimate objective of the mentioned research is seen in a formalized organizational design ontology that is to act as a metamodel for a to be established LSMAS development framework.

One of the application domains of LSMAS are massive multi-player online role playing games (MMORPG). MMORPG is a mixture of role playing (RPG) games (genre of computer games in which players control actions of a protagonist in a virtual world), and of massive multi-player online (MMO) games (computer games that allow for a great number of players to play the same game simultaneously online, often causing, or demanding, interaction amongst them), as is stated in [7]. MMORPGs are therefore a valuable source of data on the matter of organization and interaction of agents (real in the role of players or virtual in the role of non-player character (NPCs)). Since MMORPGs include a great number of players, these players can be digitalized, or the player characters can be given autonomy and systems for reasoning and interaction with the virtual environment of their world, thus creating a dynamic LSMAS. Characters of a game enhanced in the said manner gain basic elements of an agent [8, p. 34].

The objective of this work in progress paper is to present initial developments in creating a joint comprehensive ontology covering concepts included in the domain of LSMAS organization, and those of a specific MMORPG ontology developed for the purposes of the *Large-scale Multi-Agent Modelling of Massively Multi-player On-line Role-Playing*

Games - ModelMMORPG[1] project. This domain ontology is particularly bound to The Mana World[2], which is an open-source MMORPG and subject to our study. The long-term objective of this research is a continuation on the work presented in [6], [9], [4], and aims to create a metamodel for organization-based LSMAS development framework. We hope that by combining the organizational design ontology with a domain specific ontology of MMORPGs, we will soon be able to develop LSMAS applications for MMORPGs.

The rest of the paper is structured as follows: Section II provides an overview of related work, Section III covers details about the two involved ontologies - one dealing with MMORPGs, and the other describing LSMAS organizational design; Section IV contains descriptions of the developed joint ontology. Section V contains conclusions and gives an outline of future research.

II. RELATED WORK

Organization modeling *per se*, as well as its application to MAS development has been subject to a number of studies and can be considered a well established field of research (see [4] for a comprehensive state-of-the art overview). Organization of LSMAS has only recently been touched upon, since the specifics of large-scale systems haven't been in the focus of most organizational design related MAS development studies. Therefore, the present study builds on previously published research (see [6], [9], [10], [11], [7], [4]) lies in comprehension - greater inclusion of organizational modeling concepts, and their application to LSMAS elements.

A core ontology for organizational structures was published by World Wide Web Consortium (W3C) as a W3C recommendation in January 2014 [12]. This ontology allows for domain-specific extensions and can be used to describe organizational structures. Although this ontology is recommended, its applicability is constrained on the mentioned case of modeling structure only.

An overview of some of the most recent research on organizing MAS is given in [13], where the authors describe two levels of types of organization that can be used for organizing agents in a MAS: the individual level, and the organizational level. These levels of MAS organization are backed up by techniques for statically or dynamically organizing agents in MAS.

Organizational techniques for LSMAS are given in [9], covering organizational design methods for organizations consisting entirely of agents and agent systems. Work towards formalizing organizational design techniques aimed to provide a foundation for future studies of automated LSMAS development was presented therein.

Finally, an initial ontology about LSMAS organization is presented in [6]. The proposed ontology is extensive, since it includes organizational modeling concepts referring to organizational structure, organizational culture, strategy, processes,

individual agents, organizational dynamics, as well as context and inter-organizational aspects.

Several papers contain records of gaming ontologies, specifically covering MMO, RPG, or MMORPG genre, on various levels of abstraction. The earliest found research with a specific result was [14] introducing the Game Ontology Project as a framework for description, analysis and study of games. Goal of representing an ontology including concepts related to a play event, rather than to the game as a piece itself is presented in [15]. In [16] it is aimed to better define a fantasy RPG using an ontology and creating a knowledge base. The Video Game Ontology, presented in [17], is aimed at modelling video game related information with the main goal of capturing knowledge about events that happen in video games and information about players. Basics for The Mana World ontology, as a work in progress, are laid out in [10].

III. BASIC ONTOLOGIES

Two ontologies were used in order to create a joint ontology containing concepts related to organization of a specific LSMAS contained in The Mana World MMORPG. The organization-related ontology, based on various identified perspectives for modeling organization, is detailed in section III.A. The Mana World ontology contains all the identified most relevant concepts for describing the mentioned MMORPG [7], as is further detailed in section III.B.

A. *Organizational Design of LSMAS Ontology*

As mentioned above, this ontology is based on seven perspectives for complex organizational system modeling, as described in [6]:

- **Organizational structure** describes decision and information flows within an organization;
- **Organizational culture** defines relevant intangible concepts of an organization, including knowledge, norms, language, etc.;
- **Strategy** describes long-term objectives of the given organization along with action plans for their realization, and means of success measurement;
- **Processes** contain activities and procedures within an organization;
- **Individual agents** are the most important part of an organization, representing individuals who perform the work;
- **Organizational dynamics** represent organizational change, including reorganization of the earlier mentioned concepts;
- **Context and inter-organizational aspects** define organizational behaviour towards the environment of the organization, as well as relations between organizations.

The mentioned concepts are defined in the ontology using classes, as seen on Fig 1.

The most interesting aspects of definitions of the mentioned concepts, stated in [6], are recursive definitions which allow for working with individual agents, and various groups of agents, in the same manner. Furthermore, recursive definitions
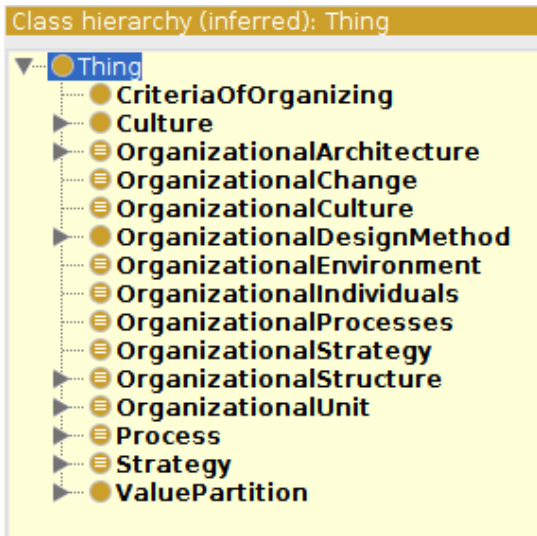
Fig. 1: Inferred class hierarchy of organizational concepts of the organizational ontology [6], as shown by Protégé
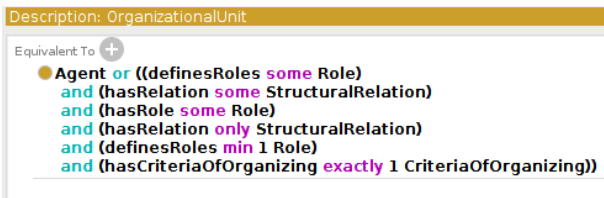

Fig. 2: Description of class `OrganizationalUnit`, as shown by Protégé

are used for organizational processes, organizational strategy and organizational knowledge artifacts as well. Such a nature of concept definitions enable us to work with the mentioned organizational concepts on various levels, i.e. from individual concepts representing individuals, to individual concepts representing groups of individuals. Furthermore, the important classes are defined using object properties, as depicted on Fig 2.

The ontology contains all the necessary concepts needed for description of organization of an LSMAS, thus proved an invaluable knowledge repository for the joint ontology.

B. The Mana World

The second ontology, which will be used to introduce basic MMORPG concepts to the organizational ontology mentioned earlier, is based on The Mana World MMORPG which contains most of the basic concepts which can be found in this genre of computer games. The Mana World ontology is interconnected with two more ontologies: Friend of a Friend (FOAF), and the Video Game Ontology (VGO). FOAF is a "project devoted to linking people and information using the Web."[3] The idea of FOAF is integration of three kinds of networks: social networks, representational networks, and information networks. On the other hand, VGO is "aimed at
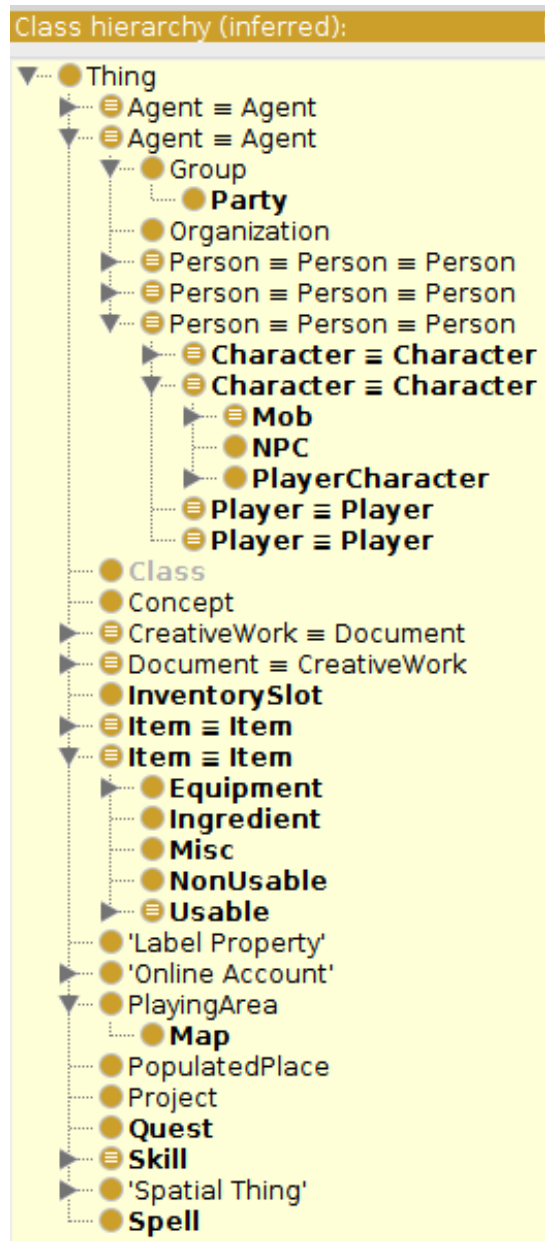

Fig. 3: Inferred class hierarchy of organizational concepts of The Mana World ontology [10], as shown by Protégé

modelling video game related information."[4] Furthermore, the main goal of VGO is "to capture knowledge about events that happen in video games and information about players." Both these ontologies are used in order to hone one of the main ideas of the Semantic Web, which is to allow an agent to "*start off in one database, and then move through an unending set of databases which are connected not by wires but by being about the same thing*" [18].

Hierarchy of the defined classes of concepts needed to describe The Mana World, and the included RPG elements, is shown in Fig. 3. Some similarities between the mentioned

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[3]For more information see http://xmlns.com/foaf/spec/

[4]For more information visit http://vocab.linkeddata.es/vgo/

two ontologies (the organizational one and The Mana World one) are identifiable even by simple comparison of their class hierarchies, yet their further identified bonding places will be described in section IV. Several classes have been added to enrich the VGO ontology, e.g. specialization of Character class (representing all the characters that can be found in the game), Party class as a specialization of the FOAF Group class (containing all the groups of player characters, called parties), specialization of Item class, etc.

IV. Modeling Ontology

The ontology to be presented in this paper is created by combining both organizational ontology (section III. A) and The Mana World ontology (section III. B), in order to define concepts related to both MMORPG domain and the organizational domain, thus performing the first step towards an ontology encompassing organizational concepts needed for organization of LSMAS.

The organizational ontology already identified some of the most important concepts of organizational modeling, using an extensive literature review, as described in [6], [9]. On the other hand, The Mana World ontology identified most of the very important concepts of modeling this particular MMORPG, although it is a work in progress.

As mentioned earlier, the goal of joining these ontologies is in identifying elements of MMORPG as organizational elements, hence allowing for application of organizational modeling concepts on them. The joining points were identified as follows:

- `foaf#Agent` is equivalent to `org#Agent`
  - `foaf#Agent` contains all the character, character group and player classes of MMORPG ontology
- `mmorpg#Quest` is a `org#Objective`
- `mmorpg#CharacterClass` is a `org#Norm`
- `org#CriteriaOfOrganizing` contains the following:
  - `mmorpg#Item`
  - `mmorpg#Quest`
  - `mmorpg#Skill`

The mentioned joining points are described in further detail in the following subsections. Included are both specifications of the stated relations and applicable observations.

A. Organizational Unit

The most obvious class of the organization ontology that can be joined with the MMORPG ontology is `org#OrganizationalUnit` class, which represents agents as basic parts of an organization. `org#Agent` class of the organizational ontology, representing those agents which are organizational units, was identified to be equal to the `foaf#Agent` class already existing in the MMORPG ontology. Such a definition states that every agent contained by `Agent` class is considered an organizational unit, whether it is a single agent, or a group of agents, as defined by [6] in definition 6: *Any agent is an organizational unit. If*
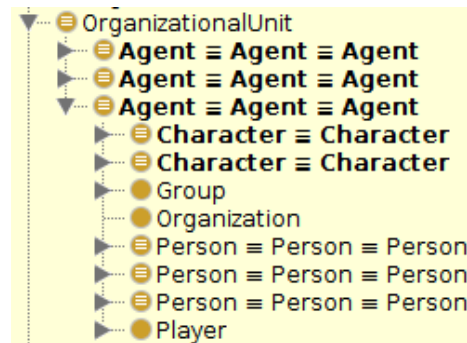

Fig. 4: Inferred class hierarchy of `OrganizationalUnit` class, as shown by Protégé

$OU = (O, R, C)$ *is a labeled graph in which O is the set of organizational units (nodes), R is a labeled set of roles (relations, arcs) and C is a criteria of organizing then OU is an organizational unit.*. The stated description is hierarchically represented in Fig. 4.

B. Organizational Objective

An important element of every organization are organizational goals, the driving force of an organization. The driving force of an RPG are quests which reward players with items or resources in exchange for a successfully completed quest. Each quest consists of a number of goals with specific criteria to be met in order for the quest to be completed. Therefore, quests can be categorized as a sort of objectives when speaking in the language of organization. Quests are one of the reasons why parties are created in a game and why players cooperate, since there are always quests that cannot be completed by players acting on their own, without cooperation with other players.

C. Organizational Norm

Normative system of an organization, as a concept combining all the norms applicable to an organization, and norms as acceptable behaviour in a group, which act as a behaviour template in the given group, have a very similar concept in the RPG world. Usually, player characters of MMORPGs are, in the course of the game, specialized in various classes. In some games this specialization occurs in the very beginning, and in some games this happens during the game, but the concept exists in most of RPG games. Character class defines the basic way a certain player, i.e. their character, is supposed to behave in the given world. For example, wizard class will definitely base on magic and magical powers, warrior class will build their strength skills and melee weapon usage thus specializing in hand-to-hand combat, whereas archer class will specialize in ranged attacks, agility skills and speed. Other classes may exist, usually as various combinations of those just mentioned. Based on everything stated, character class behaves as a certain norm, since it defines players and creates a set of behaviour expected of a certain class.

D. Role of an Agent

Although rather similar to a character class mentioned earlier, a role is argued to be a slightly different concept. Still being discussed, agent role may represent a temporary behaviour blueprint of an agent. If a role contains a set of permitted or suggested actions for an agent, then roles are temporary types of behaviour expected of an agent, containing processes, goals and actions which are supposed to lead the agent to fulfill their goals. For example, an agent with a goal of successfully solving a quest requiring them to gather 10 instances of an item available in the wild, may consider taking upon themselves a role of *Gatherer* which contains all the actions required for gathering resources, and strategy for successfully solving such goals. Other thoughts about roles in RPGs are contained in the view that character class may be a role that a player's character can take. This understanding of a role depends on the definition of a character class, which is, usually, fixed once chosen, and cannot be changed. Even though this constraint must be taken into account, character classes do pose certain normative restrictions on characters, e.g. a preferred type of battle, favoured character traits, skill, or basic stats, special kind of weapon, etc. Supporting this view of classes as roles, agents would have some constraints placed upon their behaviour and possible actions, as well as some customization of their goals, based on their chosen classes. For example, a Wizard class can use only weapons of type Staff, favours character stat Intelligence, prefers Ranged battle or Supportive battle, and their goals are concerned with upgrading said features.

E. Criteria of Organizing

The organizational modeling ontology describes the `org#CriteriaOfOrganizing` class as "*A particular criteria for organizing things like processes, organizational units, strategies or cultural artifacts.*" There are several concepts in the MMORPG world which may be used for organizing some of the stated concepts. The main criteria for creating a group of agents, i.e. an organizational unit consisting of several agents, may be the `mmorpg#Quest` concept, which consists of all the quests in the game. Agents currently trying to solve a specific quest may group in order to surpass requirements of the quest, e.g. a strong boss monsters. Class containing all the skills a character can have in the game, `mmorpg#Skill`, may be used for gathering a group of agents whose characters possess certain skills desired at the moment (whether needed by a specific quest, or another goal of an agent), e.g. specific school of magic, poison resistance, or close combat skill. Lastly, items, gathered in class `mmorpg#Item`, may be considered as criteria of organizing, since not all items are the same. Some monsters may be killed more efficiently with e.g. ranged weapons, some items are stronger than others hence being more suitable for group leaders, some items are required by a quest, etc. Described relations are shown in Fig. 5
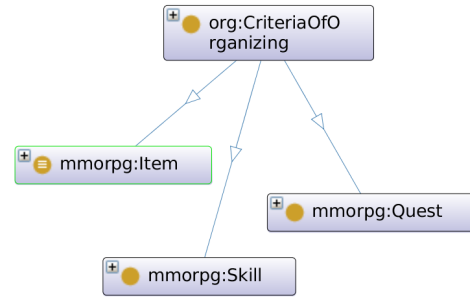

Fig. 5: Class hierarchy of `org#CriteriaOfOrganizing`, including classes `mmorpg#Quest`, `mmorpg#Skill`, and `mmorpg#Item`, as shown by Protégé

V. Conclusion

In this paper a work-in-progress integration between an organizational design ontology for the development of LSMAS as well as a specific domain ontology for MMORPGs has been presented. The main objective of the study is to develop an all purpose LSMAS ontology-based modeling framework that will be tested on MMORPGs as one of the obvious application domains. Thus, it was necessary to combine these two ontologies in order to allow for modeling of LSMAS in MMORPG scenarios, by using concepts from both domains.

As has been shown in this paper, the organizational design LSMAS ontology is applicable to the MMORPG domain and most important concepts can be mapped to meaningful concepts in the other ontology. In future research we hope to apply the organizational design ontology on other domains as well, especially the Internet of Things and Smart City domains.

In short term, we will try to develop a metamodel out of the organizational design ontology, that will be the main building block of a to be developed modeling tool for LSMAS. The modeling tool shall be tested in an MMORPG environment through the development of artificial player parties and their testing in special test-bed scenarios.

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