Self-sustainable Agent Organizations in Massively Multi-Player On-Line Role-Playing Games – A Conceptual Framework

Igor Tomičić, Markus Schatten, Bogdan Okreša Đurić
University of Zagreb
Faculty of Organization and Informatics
Pavlinska 2, Varaždin, Croatia
{itomicic, mschatten, dokresa}@foi.hr

Jurica Ševa
Humboldt-Universität zu Berlin
Institut für Informatik
Unter den Linden 6, Berlin, Germany
seva@informatik.hu-berlin.de

Abstract. *Massively On-Line Role Playing Games (MMORPGs) costitute an ideal test-bed scenario for the development and testing of large-scale agent organizations. In this paper the possibility of using a recent agent-based framework called Smart Self-Sustainable Human Settlements (SSSHS) in agent based organizations is analyzed. We provide a conceptual framework for integrating SSSHS into a modelling tool that is being developed as part of the ModelMMORPG project that aims on establishing an organizational methodology for the development of large-scale multi-agent systems (LSMASs) in the context of current phenomena like the Internet of Things (IoT), smart cities and MMORPGs.*

Keywords. smart self-sustainable human settlements framework, mmorpg, agent based modeling, agent organizations

1 Introduction

The ModelMMORPG project aims on developing and testing various organizational methods for large-scale multi-agent systems (LSMASs) especially in the context of massively multi-player on-line role playing games (MMORPGs) which constitute an interesting phenomenon that allows for testing real-life scenarios (M. Schatten et al., 2016). The project analyzes such games from two perspectives: social science perspective (development of agent based modeling techniques to analyze and simulate player behaviour) as well as a computer science perspective (development of various types of agents like mobs, non-playing characters - NPCs, and artificial players).

Until now, the project team has developed a number of agent-based modeling techniques (Markus Schatten, Tomičić, et al., 2015) for the development of mobs and NCPs, as well as complex quests with various tasks that foster organization in player teams called parties. Additionally, an automated planning system based on the well known belief-desire-intention (BDI) (Rao and Georgeff, 1991) model for artificial players (bots) that uses a modified STRIPS algorithm (Ghallab et al., 2004) has been developed as well (Maliković and Markus Schatten, 2015).

Beside these methods, we have conducted an experiment with a specially designed instance of the open-source MMORPG called "The Mana World" (TMW)[1] to analyze player behaviour behaviour. In this experiment players were instructed to solve a special quest which we called "The quest for the dragon egg" which was designed to foster organizational behavior. Players were unable to solve the quest by them selves, and had to organize into parties in order to conduct the various tasks. Detailed data about player behaviour has been collected from this experiment, and part of the data has been analyzed in (Markus Schatten and Okreša Đurić, 2015; Markus Schatten and Okreša Đurić, 2016; Okreša Đurić and Konecki, 2015), by using a number of methods strongly related to big data analytics and social network analysis similar to those used in (Markus Schatten et al., 2015a; Markus Schatten et al., 2015b).

On the other hand, in parallel, a framework for agent-based modeling and simulation of smart self-sustainable human settlements (SSSHS) has been developed in (Tomičić and Markus Schatten, 2015; Tomičić and Markus Schatten, 2016). The framework allows for modeling of any type of resources in human settlements and introduces a number of smart mechanisms to foster self-sustainability. These mechanisms are of special interest to any type of agent organization, since they optimize resource production and usage, and thus allow agents to easier perform their tasks.

In the following we will try to apply these mechanisms, if applicable, on a higher level of abstraction to any agent organization which needs to manage resources. Then we shall specialize these mechanisms for player parties in MMORPGs, since player parties need to manage their resources optimally, in order to solve quests.

[1] see https://wiki.themanaworld.org/ and figure 1

Figure 1. An open source MMORPG called "The Mana World"

The rest of this article is organized as follows: in section 2 we introduce the SSSHS framework in more detail and discuss it's relevancy to the ModelMMORPG project. In section 3 we provide a more abstract view of the SSSHS framework to be able to apply it to any resource-managing agent organization. In section 4 we apply this conceptual model to the special case of "The Mana World" MMORPG. In the closing section 5 we draw our conclusions and give guidelines for future research.

2 The SSSHS Framework

SSSHS is an agent-based framework for modeling and simulation of self-sustainable systems that has been developed using a modified MaSE (Multiagent System Engineering) methodology (Deloach, 2004) that implements a number of self-sustainability mechanisms for resource management and provides a first step towards understanding such complex socio-cybernetic systems. "*Self-sustainability mechanisms (...) can be described as those methods, selected and activated by the framework, which have the ability to prolong the self-sustainability property of the modelled system*" (Tomičić, 2016, p. 51). In SSSHS there are two types of such mechanisms defined:

1. **Lower threshold mechanisms** - mechanisms which are triggered upon an event that indicates shortage of an observed resource due to overconsumption.

2. **Upper theshold mechanisms** - mechanisms which are triggered upon an event that indicated overflow of an observed resource due to overproduction.

Lower threshold mechanisms include: (1) the "Economy" mode - in which various appliances use less resources and thus lower consumption, (2) manipulation of operating times: delaying - appliances postpone their operating times to use less resources during peak periods, (3) resource negotiation with neighboring sub-systems - appliances try to acquire resources from neighbors. The last mechanism uses Raiffa's model for bilateral negotiation (Raiffa, 1982) and the finite state machine for the protocol as shown on figure 2.

Upper threshold mechanisms include: (1) restoring default consumption modes - appliances restore their default consumption mode after peak periods are over, (2) manipulation of operating times: advancing - appliances schedule their operating times earlier to use resources which would else overflow, (3) offering the resources to neighboring sub-systems - appliances offer their surplus resources to neighbors.

While these mechanisms are simple in principle, it has been shown through simulation of various real-world scenarios that they can have tremendous impact on the period some system can self-sustain their resources (Tomičić and Markus Schatten, 2016; Tomičić, 2016).

3 An Abstract View on SSSHS

In a more abstract view, a smart self-sustainable human settlement represents an agent organization with established links of both communication (the social net-

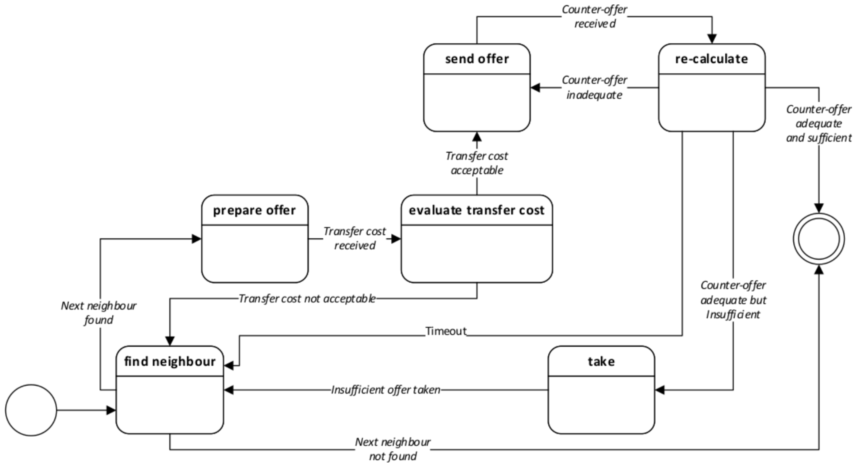

Figure 2. Finite state machine of the negotiation protocol (Tomičić, 2016, p. 54)

work) and resource exchange (the resource network). These two networks can be considered the organizational network. Agents inside this organizational unit can be producers, consumers or storages of one or more resources. The objective of the organizational unit is to produce enough resources to sustain all consumers in a given time period. The rates of resource production depend on a number of complex systems in the environment - meteorological and other conditions, human comfort levels etc.

In (Markus Schatten, 2012; Markus Schatten, 2014) we have defined organizational units as follows:

- Any agent is an organizational unit.
- If $O = \{o_1, o_2, ..., o_n\}$ is a set of organizational units which collaborate with a common objective, then O is an organizational unit.

The organizational unit defined within the SSSHS framework is a specialization of this definition. The set of agents within the organizational unit is given with the decomposition $0 = P \cup C \cup S$, whereby P is the set of producing agents, C is the set of consumer agents, and S is the set of storage agents. Note that $P \cap C \cap S$ is not necessarily $\varnothing$, e.g. some agents might be producers, consumers and/or storages simultaneously. Additionally, let $R = \{r_1, r_2, ..., r_m\}$ be a set of resources. Then we can define the relations ρ (defined on $O \times O \times R$) as the resource network between agents (e.g. which agents exchange which resources with each other), as well as four specializations of this network defined as $\rho_P \subseteq P \times S \times R$ (which producers store their resources in which storages), $\rho_C \subseteq S \times C \times R$ (which consumers use resources from which storages), $\rho_{CP} \subseteq C \times P \times R$ (which consumers consume resources from which producers), and $\rho_{PC} \subseteq P \times C \times R$ (which producers produce for which consumers). In the end we can define σ (defined on $O \times O$) as the social network of agents (e.g. which agents communicate with each other), and $\tau \subseteq O \times R$ that gives us the information on which agents use which types of resources.

A similar definition is given by (Krackhardt and K. M. Carley, 1998) in form of the PCANS model, and later by (K. Carley, 2003) in form of the MetaMatrix model, that has been extended in (Markus Schatten, 2013).

The objective is specialized as well: let us assume a time-set $\mathbb{T}$ isomorphic to the set of natural numbers $\mathbb{N}$. A time interval is then defined as an ordered pair of two points in $\mathbb{T}$, representing the time between these to points in time. For each agent we can define functions of the form $f : O \times R \times \mathbb{T} \rightarrow \mathbb{R}$ that provide the production/consumption/storage rates for each given time. The objective of the organizational unit is then defined as the constraint in a given time interval $\forall o \in O, \forall t \in (t_i, t_j), \forall r \in R : f(o, t, r) \geq 0 \wedge f(o, t, r) \leq o_{max}$ (where o_{max} is the maximal quantity of resources that can be stored in a given agent). We read, at each given moment in an observed period of time, each agent has to have enough resources available to function and additionally avoid overflow of resources.

Such a definition allows us now to model arbitrary agent organizations as SSSHS organizations, as we shall show in the following section.

4 Integrating SSSHS into TMW

One particular example of an agent organization is a players' party in an MMORPG. Herein we will use TMW as an example MMORPG, but most of the concepts analyzed herein, could be applied to any MMORPG which allows players to organize into parties, guilds, teams or similar organizational units.

In TMW we have developed a special quest called "The quest for the dragon egg" which was designed to foster organizational behaviour between players. In principle, it is impossible for a single player to solve the quest by him self. One crucial aspect of this quest is that players need to gather various types of items in order to be able to get all the ingredients to hatch a dragon egg. Since these items are scattered across the whole "Mana World" and time is limited, they need to manage their actions as well as their resources. Some of the gathered resources, are also needed for other activities, not related to the quest (e.g. other quest, gathering energy or experience etc.).

From this perspective the various items needed to solve the quest represent the resources (R) that are needed for the organizational unit to function. Agents, which can be producers, consumers and storage agents are the players which gather the items (by fighting mobs for example), NPCs which take the items to create other items or provide the players with certain possibilities (like the ability to enter a secret room), banks or vaults that enable players to store items when they haven't enough space in their local storage (the so called "back pack") etc. All these types of agents represent various elements of sets O, P, C and S.

In a party (artificial agent organizational unit) which tries to solve a quest, all of the aforementioned self-sustainability mechanisms can be applied to make the organization more efficient in terms of resource management. For example the "Economy" mode, will be the default behaviour for resources that are needed for a given quest - players who gather such items will not use them for any other tasks, except if it is unavoidable.

Delaying and advancing can (and has to) be used since when some items aren't available, then they cannot be used at a given time to perform some task. Also, if there is surplus for a given item, it can be used much sooner then planned.

Negotiation and offering of resources is crucial to the functioning of the party and solving of the quest. Most items cannot be gathered by only one player, which is why players have to exchange their gathered items, for the whole quest to be successful. By using various negotiation techniques, by for example including transport costs as a negotiable variable, this process can be optimized.

5 Conclusion

In this paper we have shown that it is possible to use the SSSHS framework for building agent organizations in the context of MMORPGs. We have provided an initial conceptualization of the framework that allows us to use it in any agent organization. Additionally, we have shown a simple example of how such a framework can be used to solve a special quest that has been developed for the open source MMORPG TMW.

Our future research will try to integrate this framework into an ontology of organizational design methods for LSMAS, and consequently into a metamodel for a modeling and development tool. We hope that this tool will allow us to model various types of agent organizations applicable in numerous areas like IoT, smart cities and MMORPGs.

Acknowledgements

This work has been supported in full by the Croatian Science Foundation under the project number 8537.

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