Modelling Forming of Temporary Coalitions in the Context of Massively Multiplayer Online Role-Playing Games

Bogdan Okreša Đurić, Igor Tomičić
Artificial Intelligence Laboratory
Faculty of Organization and Informatics
Pavlinska 2, 42000 Varaždin, Croatia
{dokresa, igor.tomicic}@foi.hr

Abstract. *This work presents coalition-forming methods within the environment of a massively multi-player online role-playing game (MMORPG), since coalitions, both of short- and long-spanned existence, are important for players of such a game genre insomuch that in some scenarios completing the long-term complex tasks (game quests) is not possible without using a coalition of players. The coalition-forming method based on the complementary skillsets is further enhanced with the recipeWorld, which can simulate the emergence of networks out of decentralized autonomous agent interaction. The ideas presented herein are tentative work, and are meant for showing the possible applications of coalition forming through the lens of recipeWorld modelling methods in multiagent systems (MAS) applied to MMORPG domain.*

Keywords. agents, computer games, multiagent systems, coalitions, mmorpg

1 Introduction

Social component is very important in the world of massively multiplayer online role-playing games (MMORPGs), and massively multiplayer online games (MMOGs) in general. In particular, communication, interaction, and cooperation allow players to advance through the game in a manner that is ultimately easier than it would be without utilising the social component. Players share knowledge, help each other in finishing various quests (sets of in-game tasks), and provide backup or vital support when needed. Furthermore, some parts of an MMORPG can be restricted, i.e. reachable only to players who formed a party. A party is a mostly temporary coalition of players created for the sake of achieving a specific goal. Being a part of a party has some benefits, and some set rules, such as sharing loot (items found in various ways), sharing experience points, access to otherwise restricted areas, etc. One of the most prominent reasons of why players form temporary coalitions (referred to coalitions in this work) is to make finishing a specific quest easier.

An important addition here is that, in a standard MMORPG, players have a set of skills or character traits which they build throughout the game. These skills determine the roles players can play, e.g. Scout, Warrior, Miner, etc. Roles are a set of constraints that model how players can approach the surrounding world, and which actions they can conduct. Actions are grouped into processes that can be used to achieve a specific goal, e.g. Move, Fight, Mine, etc. Each quest, being a set of tasks or goals to be finished, requires a particular set of processes in order to be completed. Therefore, every quest has specific requirements (presumably made of skill requirements) that have to be met in order for the quest to be undertaken.

The problem this work will deal with is modelling coalition forming process coupled with trust issues. Both these concepts will be observed in a multiagent system (MAS) environment set in the context of an MMORPG. An important presumption is that the system consists of agents that are autonomous, and are not given a complete set of organisational or behavioural rules, i.e. coalitions are not formed by a higher entity and forced upon the system, but are a result of player agent's interaction.

Coalition formation is needed in a system as described since players have to cooperate in order to advance through the game. Automated coalition formation model presented in this work is based on player's skills, and their relation to skills and processes needed in order to complete a particular quest. (Sec. 3)

1.1 Introductory Example

Figure 1 represents a simple example from the recipeWorld, with two factories (red nodes), and two orders (green nodes) with two recipe pieces (gray nodes) each.

The recipeWorld, as "an agent-based model that simulates the emergence of networks out of a decentralized autonomous interaction" (Fontana and Terna, 2015), consists of three fundamental elements:

- recipes - steps needed to be taken in order to achieve a certain end, vary in number;
- orders - objects that represent specific end to be pursued, and contain technical information, as well as

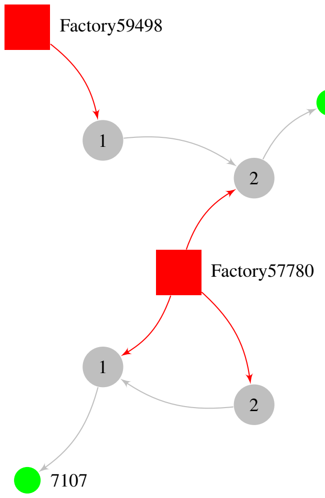

Figure 1: Visualised simple example using basic recipeWorld concepts

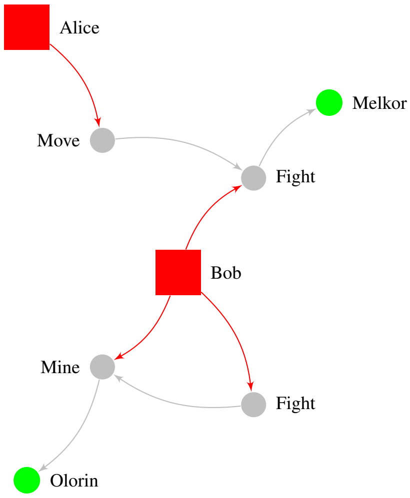

Figure 2: Use of recipeWorld elements in an MMORPG domain example

basic data about the order instance;

- agents - problem-solving cores that can be active or inactive, and are able to perform some of the steps needed to complete a given recipe.

Generalising the recipeWorld, it is possible to translate basic concepts into a more widely applicable concepts, hence the figure above represents two service provider agents (red nodes) and two service seeking agents (green nodes) that seek two specific services (grey nodes) each. The upper right service seeker had their services provided by both existing service providers, and the lower service seeker had both their specific services provided by only one service provider.

In order to translate the provided example to the MMORPG domain, service providers become players (red nodes), and service seekers become non-player characters (NPCs) (green nodes). Specific services can be translated as processes (grey nodes) needed for a quest, i.e. sets of actions the player can conduct that can achieve a specific goal (preferably a subgoal of a quest).

An even more specific example includes two players: Alice and Bob, two NPCs: Olorin and Melkor. Alice is only a beginner in the game, and can perform only a single process: Move. Bob is somewhat more advanced than Alice, and can perform one additional action, thus having three processes at his disposal: Move, Fight, and Mine. Olorin is an NPC that gives out quests (tasks in the world of MMORPGs given by NPCs providing players with rewards for their completion) that need two specific process: Fight and Mine. Melkor is an NPC who gives quests demanding somewhat different processes: Move and Fight. Quests have no entry constraints, making them available to any one player, but they cannot be finished without using the mentioned processes. Because of his level and his collection of processes, Bob managed to successfully complete Olorin's quest utilising his Fight and Mine processes. Alice, being an inexperienced player, started Melkor's quest, although she cannot finish it.

Therefore, Alice is trying to form a coalition (usually called a party in an MMORPG) with a more advanced player who can provide her the missing service. Bob is such a player, and he joins Alice. Together, they can provide two services: Walk and Fight, and that is enough to finish the given quest.

2 Related work

According to (Griffiths and Luck, 2003), existing models of cooperation can be divided into two general categories: teamwork and coalition formation. Within this classification, teamwork is typically viewed as short-termed and aimed towards completing a relatively simple task. Coalition forming, on the other hand, is aimed towards achieving more complex goals, or in terms of MMORPGs, quests, especially ones that cannot be achieved by individual players/agents. Authors notice that task-based/teamwork approach suffers from the same reason by which the team is formed in the first place - focus on immediate benefits, where long-term benefits (for example, quest completion) is overlooked and not taken into account, resulting in never formed coalitions that might have provided these long-termed benefits.

These missed opportunities can be observed through earlier works on motivation (Griffiths, 2000; Luck, d'Inverno et al., 1995), where an agent would cooperate according to the motivation that has the highest priority - at that moment - prevailing over any long-term perspective.

Besides motivation, there are also notions of trust (Griffiths and Luck, 2003) and commitment within the context of coalitions. According to (Bratman, 1992) and (Levesque et al., 1990), agents need some form of commitment attached to the cooperation activity, and the party *"must be aware of and care about the status of the group effort as a whole."* (Levesque et al., 1990).

In the forming of long-termed coalitions, the benefit assessment to an individual joining the party is viewed through the utility gained by the party with respect to achieving a common goal (Klusch and Shehory, 1996; Breban and Vassileva, 2001; Shehory and Kraus, 1995).

Searching for other agents to work with might introduce additional costs for coalition forming, which might require additional solutions within this context. For example, a technique called congregating addresses this issue (Brooks and Durfee, 2002; Brooks, Durfee and Armstrong, 2000), where agents congregate into groups and search for other potential members of the team within the congregation rather that searching the whole population.

In scaling up the coalition formation, Janovsky and DeLoach (Janovsky and DeLoach, 2016) are looking for sub-optimal solution in which thousands of agents are forming coalitions through multi-agent simulation. Their approach is heuristic and an iterative one, where agents join and leave coalitions based on the information gathered from current and previous iterations.

Coalition formation in general can usually be solved by several available approaches: graph-based algorithms (for example, (Sless et al., 2014)), heuristic algorithms (such as (Shehory and Kraus, 1998)), hierarchical clustering (for example, (Farinelli et al., 2013), where algorithm is able to find sub-optimal solution for 2732 agents in 4 minutes), and dynamic programming (Yeh, 1986; Rahwan and Jennings, 2008). Because in our work we are tending to model scalable multi-agent system native to the domain of MMORPGs, heuristic algorithms or hierarchical clustering should be taken into account, considering their ability to solve large-scale coalition problems. The approach in (Merida-Campos and Willmott, 2004) describes agents which randomly choose coalitions in order to achieve tasks, but have simple strategies according to which they choose to leave or stay in coalition, lacking the long-term aspect of the coalition in solving more complex tasks/quests.

We are taking the similar approach and expand it further with graph-based recipeWorld modelling technique, having a long-termed coalition perspective in mind. With the recipeWorld, we have the advantage of modelling and simulating social network development based on the interaction patterns of the involved agents – both the service providing and the service seeking ones. The resulting network can be used to provide insight on various aspects of the modelled system, such as: how the observed agents' network grows with time; the dynamics of their interaction and the nature of their interaction instances, with regard to the various attributes of the interacting agents; simulation of how feasible it is for players to solve various quests given by the other agents, and many more. The latter is particularly interesting in the context of automated or simulated game testing, in the context of testing its logical soundness and gameplayability (similar to (Schatten, Okreša Đurić et al., 2017)). In other words, a simulation run using an adapted recipeWorld model could provide us with insight into quests that cannot be completed by any combination of players since they are defined poorly, or have exaggerated prerequisites.

3 An MMORPG Coalition Forming

If we observe individual agents as organisational units, as per OOVASIS ontology (Schatten, Grd et al., 2014), then coalitions are organisational units on a higher level, i.e. organisations. An advantage of this view is that organisations have a certain criteria of organising (e.g. a task or a goal), yet coalitions will be considered here as organisations without more advanced organisational features, e.g. organisational structure. Furthermore, a coalition organisational paradigm finely portraits the idea of agent-grouping as short-lived and with a particular purpose (Rahwan, Michalak et al., 2015).

Upon forming a coalition, it should be noted that a task of an agent becomes a task of the formed coalition. It may be possible for the task to remain individual though, thus making the individual agent a sure leader of the coalition, since only they know details of the task. Other included agents are selected based on their ability to aid in finishing the given task, e.g. their disposable actions based on the roles they can play, character traits, inventory, etc.

Much remains to be negotiated after a coalition is formed, e.g. loot distribution, leadership (if not set by coalition needs), experience sharing, friendly-fire ability (stating whether a player can harm their ally), etc.

An interesting idea of coalition-forming applicable to this problem, coalitional games with skills (Ohta et al., 2006; Bachrach and Rosenschein, 2008), is described in (Rahwan, Michalak et al., 2015), and will be utilised in this work. The respective authors' formalism was led by the idea that "*the value of a coalition can be defined in terms of the skills that are possessed by the agents.*" (Rahwan, Michalak et al., 2015)

This approach was further evolved by introducing tasks, i.e. there is a set of tasks where every task has a specific skill requirement, and a task can be achieved only if all the necessary skills are present in a coalition. More formally, there is a set of skills S, and each agent $a_i \in A$ has some specific skills $S^{a_i} \subseteq S$. Additionally, there is a set of tasks Γ where every task $\tau \in \Gamma$ has some skills as a requirement $S^\tau \subseteq S$. A coalition $C \subseteq A$ can achieve a task τ if it satisfies all the skill requirements for τ, i.e. if $S^\tau \subseteq \cup_{a_i \in C} S^{a_i}$.

A very interesting addition to this approach to representation is its generalisation (Thanh et al., 2013) called the Coalitional Skill Vector (CSV). Skills are proposed to be characterised by a skill vector, as opposed to a subset of available skills. More specific-

Table 1: Starting presumptions about players and roles of the example

Players		**Strength**	**Dexterity**	**Intelligence**
Alice	$r_{Alice} = (3,4,8)$	3	4	8
Bob	$r_{Bob} = (2,2,2)$	2	2	2
Charles	$r_{Charles} = (10,4,2)$	10	4	2
Duncan	$r_{Duncan} = (7,3,9)$	7	3	9
Eveline	$r_{Eveline} = (6,4,6)$	6	4	6
Roles				
Archer	$r_{Archer} = (3,6,4)$	3	6	4
Farmer	$r_{Farmer} = (2,2,4)$	2	2	4
Smith	$r_{Smith} = (5,3,5)$	5	3	5
Warrior	$r_{Warrior} = (8,3,2)$	8	3	2
Wizard	$r_{Wizard} = (2,4,8)$	2	4	8
Scout	$r_{Scout} = (1,1,1)$	1	1	1

ally, each agent a_i is given an $|S|$-dimensional vector of skills $r_i = (r_{i1}, \ldots, r_{i|S|})$ values of which represent skill-mastery of the respective skill for the given agent. Identified advantage of this approach is that it is possible to express agent's degree of mastery for a specific skill. Additionally, skill vector of a coalition $C \subseteq A$ is defined as $r(C) = \Sigma_{a_i \in C} r_i$. Goal of any given coalition C is to utilise agent skills and to cover the distance between coalition's skill vector and the set of goals requirements. A system like this can be applied in this research as is described in the example below.

Since the idea of this research is not to impose organisation in the context of creating a perfect coalition structure and imposing it on the agents within the system, but rather one of agents autonomously looking for coalitions and forming them as necessary in order to achieve their set goals, further discussion about coalition value and search process for an optimal coalition structure is not a part of this paper.

3.1 Coalition Forming Example

A proposed system has five agents $A = \{Alice, Bob, Charles, Duncan, Eveline\}$, seven roles $R = \{Archer, Farmer, Smith, Warrior, Wizard, Clerk, Scout\}$, and three skills $S = \{Strength, Dexterity, Intelligence\}$.

Each player agent $a_i \in A$ can play a certain role $\rho \in R$ that has a set of actions $\alpha_r = \alpha_{r1}, \ldots, \alpha_{rn}$. Each role has a specific skill requirement to be played, e.g. Archer can be played by agents with skill values at least 5, 10, 4, for strength, dexterity, and intelligence skills respectively, i.e. $r_{Archer} = (5, 10, 4)$. Every player has, at the moment of observing this particular example, mastered the available skills represented as $r_{Alice} = (3, 4, 8)$. Full specification of the available players and roles is as shown in Tbl. 1.

Charles is given a quest (the concept of a task in MMORPGs given out by an NPC) that demands of him to enter a mine of rare ore by killing the beast guarding it, return with the ore, and craft an item of great value to the quest giver.

Such a task demands actions available to several roles, namely: Warrior, Smith, Scout. This dependence is derived from modelled roles, their available actions and processes, and goals reachable by given processes. Scouting role is available to all the characters of this example, since its skill requirements $r_{Scout} = (1, 1, 1)$ are met by all the players. Warrior role ($r_{Warrior} = (8, 3, 2)$) can be played only by Charles ($r_{Charles} = (10, 4, 2)$) since he is the only player with high enough Strength skill value. Finally, Smith role can be played by both Duncan and Eveline, since their skill values meet the given role's skill requirements.

Skill requirements of the given quest are derived from the roles and processes needed for its completion. The given quest therefore has the requirement $r_{Quest} = (8, 3, 5)$. Charles alone cannot fulfil the requirements, and decides to look for other players willing to form a coalition. His call is published on the market that is accessible by all the other agents. As they discover the published call, they decide to answer it if at least one of their skill values is higher than or equal to the wanted skill value, i.e. $\vec{r}_{Qa_i} = \vec{r}_{a_i} - \vec{r}_Q$ and $\exists \vec{r}_{Qa_ij} : \vec{r}_{Qa_ij} > 0$. An agent can answer a call, but they are not obliged to do so. Eveline was on a lookout for a new quest, so she decides to answer the call, since her skill values allow her to, i.e. $\vec{r}_{Eveline} - \vec{r}_{Quest} = (-2, 1, 1)$. Duncan, although he is highly skilled in one of the wanted skills, decided to pass the opportunity.

As an automatically set leader of the coalition (since he started the coalition), Charles has the ability to allow or deny access to the coalition, or to exempt somebody from the coalition at any given point in time. Since he is not a strict player, Charles allows Eveline to join him on his quest.

After the coalition membership is initially approved of, the new coalition still has to decide on how the loot and experience points are going to be split, which is conducted by simple voting mechanism based on preset options.

4 Problems

For a more real simulation of an MMORPG, one should have to consider other types of characters (namely NPCs) in the game, e.g. NPC merchant does not usually provide quests, but provides services, in which case they should be service providing agents, and player agents should be playing service-using roles. This situation can be solved by allowing player agents to play both service-providing and service-using roles, according to their needs. This problem resides beyond the scope of this paper, since NPC interaction has no prerequisite in coalition formation. NPC interaction that would require a given player to be a part of a party, i.e. a coalition, is a rare sight in MMORPGs, although a possible case.

A potentially big problem that can emerge is agent behaviour where agents intentionally refuse to form a coalition with other agents or other agents of specific attributes, effectively creating a form of class-defined society whose interaction is based on agents possessing specific attributes.

The described system of coalition forming is exclusive, insomuch that it does not allow players not explicitly contributing to the formed coalition. Different approach to the coalition forming process could be used, such that the players who reach none of the skill requirements of a coalition can be included in one, since that may be beneficial for the included players of lower level in their pursuit of game advancement. This could be solved by accepting players in a coalition based on trust or another attribute that would prove the player to be provided as a worthy addition to the coalition.

A potential improvement to the proposed approach to forming coalitions is defining skill vector of a coalition as a vector of maximum values provided by the included players, as opposed to the earlier stated form of summing skill values of the included players ($r(C) = \Sigma_{a_i \in C} r_i$). This change is motivated by a simple example where five players with skill values $r_{a_i} = (1, 1, 1)$ cannot solve quests with skill requirement of $r_{Q_i} = (5, 5, 5)$ since none of them will be able to play a role requiring such a high skill value.

5 Conclusion

The described approach to coalition forming can be tested out using an agent-based model independent of the actual implementation in a particular MMORPG, but tests undertaken in such an environment would be useful only for model-profiling purposes in the context of MMORPGs.

A very important aspect of note here is that the described model is concerned with emerging organisation, i.e. the goal is to allow player-agents to create coalitions the way and at time they think that is necessary. This approach is different to most of the approaches reviewed in (Rahwan, Michalak et al., 2015), since they work with the idea of an imposed organisation, i.e. the system is instructed on coalitions that have to be formed, and therefore an optimal solution is usually sought after. Conversely, the model of this research works on an *ad-hoc* basis, and requires no optimal solution, since the coalitions are primarily temporary and not of a fixed nature, since MMORPGs tend to provide a socially engaging environment for their players.

References

Bachrach, Y. & Rosenschein, J. S. (2008). Coalitional skill games. In *Proceedings of the 7th international joint conference on autonomous agents and multiagent systems* (Vol. 2, pp. 1023–1030). Estoril, Portugal: International Foundation for Autonomous Agents and Multiagent Systems.

Bratman, M. E. (1992). Shared cooperative activity. *The philosophical review*, *101*(2), 327–341.

Breban, S. & Vassileva, J. (2001). Long-term coalitions for the electronic marketplace. In *Proceedings of the e-commerce applications workshop, canadian ai conference*.

Brooks, C. H. & Durfee, E. H. (2002). Congregating and market formation. In *Proceedings of the first international joint conference on autonomous agents and multiagent systems: Part 1* (pp. 96–103). ACM.

Brooks, C. H., Durfee, E. H. & Armstrong, A. (2000). An introduction to congregating in multi-agent systems. In *Proceedings fourth international conference on multiagent systems* (pp. 79–86). IEEE.

Farinelli, A., Bicego, M., Ramchurn, S. & Zucchelli, M. (2013). C-link: A hierarchical clustering approach to large-scale near-optimal coalition formation. In *Twenty-third international joint conference on artificial intelligence*.

Fontana, M. & Terna, P. (2015). From Agent-based models to network analysis (and return): the policy-making perspective. *Working Paper Series*, *07*.

Griffiths, N. (2000). *Motivated cooperation in autonomous agents.* (Doctoral dissertation, University of Warwick).

Griffiths, N. & Luck, M. (2003). Coalition formation through motivation and trust. In *Proceedings of the second international joint conference on autonomous agents and multiagent systems* (pp. 17–24). ACM.

Janovsky, P. & DeLoach, S. A. (2016). Multi-agent simulation framework for large-scale coalition formation. In *2016 ieee/wic/acm international conference on web intelligence (wi)* (pp. 343–350). IEEE.

Klusch, M. & Shehory, O. (1996). Coalition formation among rational information agents. In *European workshop on modelling autonomous agents in a multi-agent world* (pp. 204–217). Springer.

Levesque, H. J., Cohen, P. R. & Nunes, J. H. (1990). On acting together. In *Aaai* (Vol. 90, pp. 94–99).

Luck, M., d'Inverno, M. et al. (1995). A formal framework for agency and autonomy. In *Icmas* (Vol. 95, pp. 254–260).

Merida-Campos, C. & Willmott, S. (2004). Modelling coalition formation over time for iterative coalition games. In *Proceedings of the third international joint conference on autonomous agents and multiagent systems-volume 2* (pp. 572–579). IEEE Computer Society.

Ohta, N., Iwasaki, A., Yokoo, M., Maruono, K., Conitzer, V. & Sandholm, T. (2006). A compact representation scheme for coalitional games in open anonymous environments. In *Proceedings of the national conference on artificial intelligence* (Vol. 1).

Rahwan, T. & Jennings, N. R. (2008). An improved dynamic programming algorithm for coalition structure generation. In *Proceedings of the 7th international joint conference on autonomous agents and multiagent systems-volume 3* (pp. 1417–1420). International Foundation for Autonomous Agents and Multiagent Systems.

Rahwan, T., Michalak, T. P., Wooldridge, M. & Jennings, N. R. (2015). Coalition structure generation: A survey. *Artificial Intelligence*, *229*, 139–174. doi:10.1016/j.artint.2015.08.004

Schatten, M., Grd, P., Konecki, M. & Kudelić, R. (2014). Towards a Formal Conceptualization of Organizational Design Techniques for Large Scale Multi Agent Systems. *Procedia Technology*, *15*, 577–586. doi:10.1016/j.protcy.2014.09.018

Schatten, M., Okreša Đurić, B., Tomičič, I. & Ivkovič, N. (2017). Automated MMORPG Testing – An Agent-Based Approach. In Y. Demazeau, P. Davidsson, J. Bajo & Z. Vale (Eds.), *Advances in practical applications of cyber-physical multi-agent systems: The paams collection* (pp. 359–363). Lecture Notes in Artificial Intelligence 10349. Cham, Switzerland: Springer International Publishing. doi:10.1007/978-3-319-59930-4_38

Shehory, O. & Kraus, S. (1995). Task allocation via coalition formation among autonomous agents. In *Ijcai (1)* (pp. 655–661). Citeseer.

Shehory, O. & Kraus, S. (1998). Methods for task allocation via agent coalition formation. *Artificial intelligence*, *101*(1-2), 165–200.

Sless, L., Hazon, N., Kraus, S. & Wooldridge, M. (2014). Forming coalitions and facilitating relationships for completing tasks in social networks. In *Proceedings of the 2014 international conference on autonomous agents and multi-agent systems* (pp. 261–268). International Foundation for Autonomous Agents and Multiagent Systems.

Thanh, L. T., Nguyen, T. D., Rahwan, T., Rogers, A. & Jennings, N. R. (2013). An Efficient Vector – Based Representation for Coalitional Games. *Proceedings of the Twenty-Third International Joint Conference on Artificial Intelligence*, 383–389.

Yeh, D. Y. (1986). A dynamic programming approach to the complete set partitioning problem. *BIT Numerical Mathematics*, *26*(4), 467–474.