A game-based evaluation model for a successful cooperation in cloud computing

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Abstract: While the cloud concept has passed the hype of emerging technologies, community clouds became more popular, but are rarely addressed in publications so far. Within our research, we iteratively developed a business board game that contributes to give a more elaborate and realistic user experience for a complex cooperative situation and the strategy development in a community cloud. With action research, the game closely fits to a relevant defined problem and we validated its efficacy within a workshop with expert IT practitioners. Finally, we conclude with benefits for academic research and practical implementations.

1 Introduction

Over the last few years, cloud computing got established as a technology concept in the information technology (IT) industry. With this concept, customers can obtain freely scalable IT resources (e.g. servers, storage, applications, and network resources) in an on-demand manner via networks (intranet or internet) and pay usage-based fees [MG09], [We09]. These resources "as a Service" avoid long-term capital expenditures, can load for cost reductions and promote the flexibility of IT provisioning, particularly in the budget-limited public sector.

There exist four cloud provisioning models with an increasing legal separation of clients combined with a decreasing opening to publically accessible network resources: public (multi-tenancy, internet), private (single-tenancy, intranet), hybrid (combination of private and public), and the community cloud (restricted multi-tenancy, merger of intranets from several organizations). While the hype on public and private cloud services seems to be over, the community model rises as a relevant provisioning model in practice [Ga13], [Ha10], [Bu12]. Organizations with the same needs, legal requirements, goals or the same data can cooperate, merge their intranets, and use a common IT resource pool without dependences on third party vendors [BM09b]. This will overcome the lack of scalability and resource efficiency of private clouds and the loss of trust with public cloud services [BM09b], [Li12], [Re11].

As Henry Ford already mentioned, “Coming together is a beginning; keeping together is progress; working together is success” (Henry Ford, 1863-1947). For participating in a long-term cooperation, a high involvement is required for the community that takes into account the cooperative and competitive behaviour for each member. To cope with the sensitivity for this situation in advance, members will benefit from a simulation situation where they can test different strategies before they come to the decision to take part in the contract-related productive mode of the community cloud.

In this study, we are interested in examining if a business board game can contribute to a more elaborate and realistic user experience for the cooperative situation, the decision-making and the strategies to be pursued. For this approach, we will first give some theoretical background on cooperation in cloud computing and related work on the promoted game context. Afterwards we introduce our research approach and formulate the research questions. Then the background for the business board game is described as well as the game design and the evaluating experiments with IT service providers. The outcomes of our research will be relevant to comparable complex situations. We end with a discussion of the results and draw conclusions for academic research and practice.

2 Theoretical Foundation

Embodying cooperation in cloud computing, a community cloud describes a cloud provisioning model that “aspires to combine distributed resource provision from Grid Computing, distributed control from Digital Ecosystems and sustainability from Green Computing […], while making greater use of self-management advances from Autonomic Computing” [BM09a]. Following this conceptualization, we further propose the differentiation of two types of communities in the cloud: provider-based and customer-based community clouds (see Figure 1). In offering or using a distinct cloud service, either the providers or the customers can collaborate and cooperate.

A customer-based community cloud can be established if the same cloud service is used and shared by an association of customers. For example, a customer community cloud can be a governmental cloud service (e.g. software application) offered by one big cloud service provider for the cooperating institutions of a dedicated country or state with similar needs and interests. A provider-based community cloud is a service offered by a merger of cloud service providers with similar services and objectives. For instance, they collaborate to collectively provide a cloud service, to extend their range of services or to share their IT resource pools to gain resource efficiency. An exemplary scenario for a provider community is the assurance of high availability for services (e.g. disaster management). A mutual community cloud, i.e. a provider- and a customer-based community cloud at the same time, is for example a community of research and education facilities, where all community members have access to actual research data and can support each other by processing this research data. With the use of private clouds, high requirements for data protection are met as well. Therefore, also medical units or other fields with critical data can profit from this provisioning model. With our game-based research, we address the provider-based community cloud types.

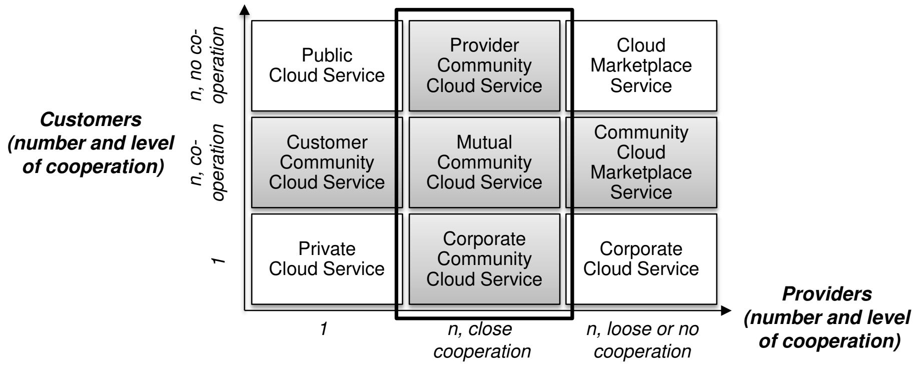

Figure 1: Types of a community cloud

3 Related Work

In academic research, community clouds are eminently underrepresented. Only a few authors have focused on this cloud provisioning model so far. Practical implementations of customer-based communities are seen in the public, medical or gaming sector, while provider-based communities are rare and still laboratory projects only.

Reasons for this gap can be high community entry barriers, high risks and investments, but uncertainty of success and a late reward. To address these issues, a possibility is required, where potential members can test their real behaviour in a simulated environment [LPN09] to decrease the uncertainty. Traditional methods for this goal do not provide the optimal opportunity to link abstract concepts with the background in practice [BC08] or have a higher financial effort [St08]. Therefore, serious games are proposed as evaluation tool [LPN09]. These games are systems with a specific intent to assist, persuade or deceive the player's behaviour [BGM87], [CP09], [Fo03], [OH09]. Other authors focus on the user activity of play and call it "meaningful play" [SZ04]. A similar approach are games with a human computer interface, supported by different authors. To support the practical context of such games, the design of the game must closely describe the context situation and decision processes [Be95], [Jo03], [Jo03]. Moreover, the game should differentiate which elements needs to be controlled or eliminated to finally get a relevant model [DG12] for community (cloud) cooperation in practice. A game manager plays an important role and provides immediate feedback to the players [Ki05]. Complementing the considerations, some authors provide summaries of related work for serious gaming in the business context [HV09], [LLS13], [Fa09].

Similar approaches are implemented in other research projects. One publication deals with a game-based approach for a similar complex situation, where astronauts can test personalized support situations in advance of a long duration mission [Sm10]. Other authors validate the game simulation method as a vehicle for testing an environment of decision-making for decision support systems [Be09] or the use of an enterprise resource planning system [FH11]. Complementing this, some authors propose a business game taxonomy to develop an international and open database for business games [GBN13] or to classify game-playing research [LLS13]. Considering this classification, game research rather focuses individualistic but less cooperative or competitive game design so far [LLS13].

4 Research Approach

The goal of our research is to develop a game that emulates the situation of a provider-based community cloud to promote the imagination of the players. This game should help to analyse the players' behaviour to finally derive implications for the success of a community cloud. Following this intention, we distinguish two research questions:

1. How should a business board game look like to emulate a provider-based community cloud and create a realistic experience for participating players?

2. Does the business board game produce a more elaborate user experience for the cooperative situation, the decision-making and the strategies to be pursued?

Within the scope of design science research [He04], we use a multi-method approach to follow a proposed four-step game development approach [LPN09]. First, the (1) problem definition is answered with action research, where we accompanied a community cloud project, conducted several interviews and a workshop with the community cloud members. From the results, we derive preconditions, basics and design principles for the (2) game conception. The game design aims to fulfil the development principles of persuasive system design [OH09], [PT12] for serious games or "games with a purpose" [AD08], [De11], [HSA12]. These guidelines propose e.g. enjoyment factors, an accurate game result insurance, and evaluation measures [AD08], [De11], [HSA12]. After the rough conceptualization, we (3) play the game and iteratively revise the specifications. Finally, we (4) analyse the game and validate the efficacy of the game approach with a workshop experiment with four practitioners having expertise in IT service providing but not as a community cloud member.

5 Community Cloud Game

5.1 Problem Definition

The game bases on the practical intention to implement a community cloud as part of the project "Government Green Cloud Laboratory (GGC-Lab)". The GGC-Lab project is funded by the German Federal Ministry of Economics and Energy to analyse the possibilities of environmental sustainability and resource efficiency of the IT in the public sector. The project covers the use case of providing intelligent and cloud-based software application services based on a community of cooperating IT service providers. The project consortium consists of currently four public IT service providers, where each provider serves his own customers in the public sector. While those customers use software applications, the IT service provider needs to handle the resulting computing load. In the GGC-Lab, this load can be decentrally processed on the distributed IT infrastructures of the community members. In case of capacity shortage or cost saving targets, each member has the choice to transfer the load to the community. Based on efficiency criteria, a resource controller balances the load to save costs and generate the best community profit. The efficiency is described by the energy costs for processing the load order. Other balancing strategies are considered as well, like the amount of energy, the emission of carbon dioxide or a sustainable energy mix. Summing up, the project intends to optimize the IT utilization, get a flexible resource approach, consolidate and standardize the service provisioning, increase the service quality and finally reduce the service costs.

This situation is emulated with the game, where the players benefit from a simulation framework for developing and testing strategies of potential community cloud members. Within the community game, the players have to process different load orders, can optimize their resource efficiency, and will be influenced by environmental events.

5.2 Game Conception

Along with the project GGC-Lab, the board game provides a fixed framework for long-term community cooperation. Static features display the community cloud construction and describe the game design. Procedural features model the community cloud processes and describe the playing process.

5.2.1 Static features of the game conception

The design of the board game considers a game board that represents the community cloud. Further, every player has a smaller personal board that depicts the own infrastructure resources (building and IT capacity) and is connected with the community game board. A deck of shuffled load order cards is positioned in the middle of the game board with the backside facing up. Controlled by a thrown dice, the players move on a game path in predefined rounds (see Table 1), influenced by random events:

- **Sit out**: “Your community contract is in revision, you have to miss a round.”
- **Heat**: “The temperature is rising and causes extra cooling effort for your IT. Your costs per processed unit increase about +5€.”
- **Cold**: “The temperature is decreasing and causes a less cooling effort of your IT. Your costs per processed unit decrease about -5€.”
- **Increasing energy costs**: “The energy price at the energy stock market increases. Your costs per processed unit increase about +5€.”
- **Decreasing energy costs**: “The energy price at the energy stock market drops. Your costs per processed unit decrease about -5€.”
- **Server infrastructure failure**: “Problems with your IT infrastructure force you to deliver your received load order to the community.”
- **Network failure**: “Problems with your network connection force you to process your received load order on your own.”

Feature	Characteristic	Background of the problem definition
Path event	The players move on a path of random event- and non-event-fields.	By operating a data centre, changing conditions and not anticipated events occur.
	The event fields influence the efficiency and the ability of the player to process or deliver load orders.	The data processing can be influenced by random environmental, technical, or contractual impacts.
Playthroughs	Fixed number of playthroughs per game, 2 to 4 are recommended.	This means the medium-term view of the cooperation.
Rounds	Fixed number of 4 rounds per playthrough.	It is the short-term equivalent with accounting periods.
	Changing starting player per round in clockwise direction.	This covers the varying order situation and balance the positions of the members.

Table 1: Static features of the game path

Moving on the game path, the players can optimize their own infrastructure resources (building and IT capacity) and need to process load orders. Load units are represented by cubed gaming pieces that differ in colour (shades of grey) to show the payment value of the load unit. Other cubed gaming pieces (white) signify capacity units in optimization mode. The concrete design of these features is justified with the practical background of the projects' problem definition (see Table 2).

Feature	Characteristic	Background of the problem definition
Capacity	Every player has 9 capacity units for load processing; a capacity unit can process a load unit.	Every IT service provider of the community has its own server infrastructure dedicated for community orders.
	The capacity units will be occupied for a round when they are optimized or process a load order.	While the server infrastructure is under construction for efficiency or busy, the capacity units will not be available.
Efficiency	The player starts with an efficiency of level "A" with 100€ costs per processed load unit.	At the beginning, the costs are relatively high and aligned with the revenue possibilities and an efficiency incentive.
	The optimization of capacity units costs 20€ per unit and upgrade ("A+++" is maximum) and causes -1€ costs for the efficiency in the next rounds.	The optimization costs for the capacity units are aligned with the amortization through energy savings of the IT investment after assumed 2 accounting periods.
	The optimization of the building and air-conditioning technology with 50€ per upgrade ("A+++" is maximum) has an effect of -4€ costs for the efficiency in the next rounds.	The optimization costs for the building and air-conditioning technology is aligned with the amortization through energy savings of the investment after assumed 12.5 accounting periods.
Orders	The load volume varies between 2 and 10 load units; the frequency distribution is equal for each load.	Variety of orders, from small to not grantable with own capacity. The frequency distribution is experimented and iteratively balanced with the capacities.
	The payment varies between 90€, 100€ and 110€ per processed load unit; the frequency distribution is equal for each payment.	Without optimization, the revenue covers the average costs of a members load processing. Underpaid orders are usual, e.g. to maintain an important customer.

	If a job can not be processed completely, a penalty (10% of the order value) occurs to the player who brings in the order.	This case corresponds with a violation of service level agreements. The handling in practice inspires the height of the penalty.
Finance	Players have a seed capital of 500€.	Members have limited financial background.
	Each round has fixed costs of 20€.	The height is iteratively balanced with the average costs and the revenue.

Table 2: Static features of the game content

5.2.2 Procedural features of the game conception

Starting the game process, the first player has to be drawn by a random method. He starts the first round in the first playthrough and can continue the game process (see activity chart in Figure 2, left). Each move of the active player contains sub-processes for optimization and load processing; both are pictured in another activity diagram (see Figure 3). After each player was in active mode, a balance of accounts follows (see Figure 2, right) and the next round starts. After pre-defined number of playthroughs, the game ends and a score needs to be calculated to determine the winner.

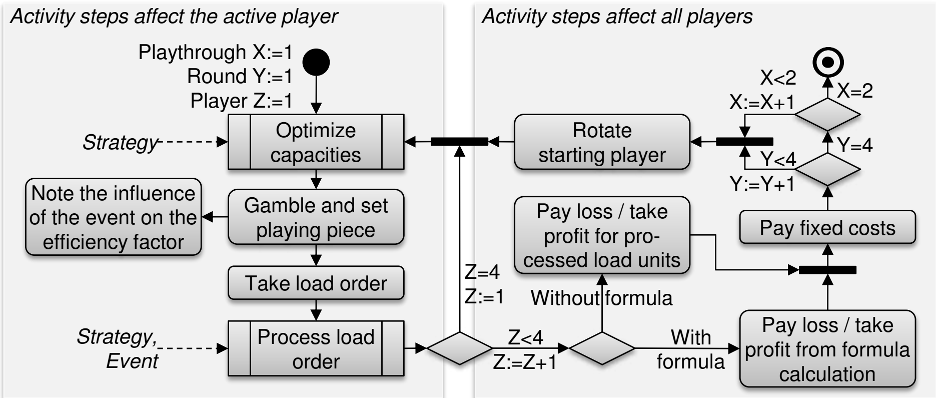

Figure 2: Activity diagram for the rule design in the game process

The first sub-process describes the optimization decision: a player can optionally optimize his resources for the next rounds but with the optimization mode, he occupies his resources for the actual round and has limited capacities to process load units and earn revenue. The more efficient a player is, the higher is his profit from the load order processing. The second sub-process describes the load processing decision: a player receives a load order and has to process the load within the limits of capacity or deliver load units to the community. By providing load units to the community, the next best efficient player has the first choice to process the load. This continues until the load order is fully processed or the delivering player needs to pay a penalty.

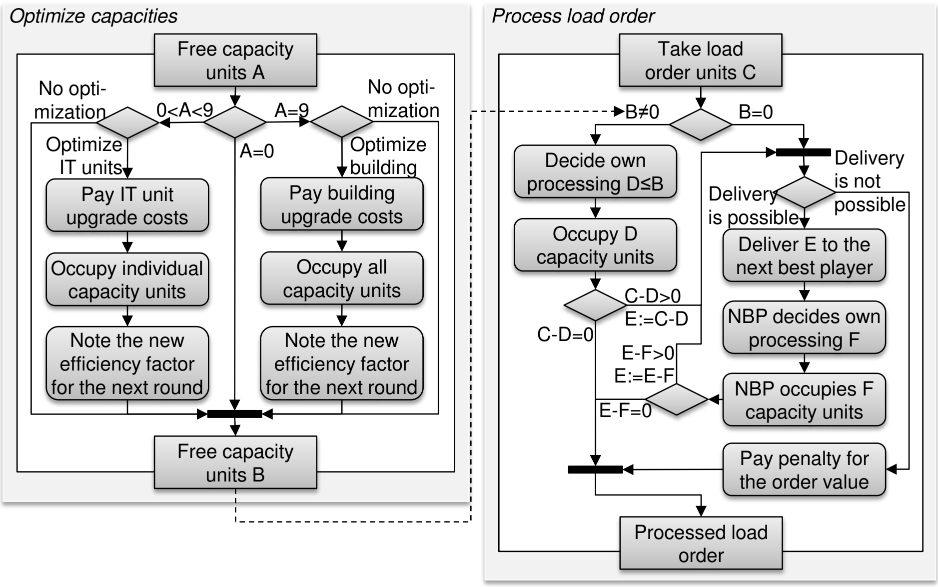

Figure 3: Activity diagram for the rule design in the sub-processes

5.3 Game Play and Game Strategy

Before playing the community cloud game, the players need to agree on a community strategy. There exist two opposite strategy positions: complete individual optimum (egoistic) and perfect community optimum (altruistic). While an egoistic strategy aims at maximizing the own infrastructure utilization and account balance, the altruistic strategy tends to optimize the overall savings. The final strategy can be positioned between both extremes and some policies for acting should be formulated, e.g. when is a player allowed to optimize his resources or when should a player deliver his load order to the community. A game manager can enforce the agreed strategy and plays an active role by reflecting the game decisions to the players.

The goal of the game is to be successful with the developed strategy. To measure this fact and to increase the players' enjoyment, we calculate a score for active and efficient behaviour. Each player wants to gain the highest score. Within an egoistic strategy, each player's goal is to optimize his account and have a higher balance than the other players do; therefore, the score includes the profit of the own load processing and the proportionally account balance. The other extreme is to renounce the freedom of choice for the load delivery to the community, so that only the efficient players will process the load orders. Following this strategy, the score includes the profit of the transferred overall profit and the proportionally efficiency factor.

To combine the advantages of both strategies, a hybrid strategy considers the resource and cost optimization of the community, but also optimizes and balances the individual optimum. Along with the approach of persuasive systems [LOD12], [OH09], [PT12], such a strategy should be incentivized within the game, e.g. with a special revenue sharing model. This model can (a) provide a commission for delivered load orders to incentivize the transfer of load units to the community. Moreover, the formula uses a profit share to (b) facilitate a compensation of the effort of joining and participation in the community and another share (c) according the efficiency performance of the members to incentivize the active involvement. The score for the members includes the profit of the own and the delivered load processing as well as the proportional account balance and efficiency factor.

We tested the game elements several times, e.g. with different load order volumes and compensations or costs for optimizations, to finally get a playable and interesting game. To give the reader a visual impression of the game, the prototype of the designed game is shown in the following picture (see Figure 4).

Figure 4: Game prototype

5.4 Game Analysis

We validated the game-based approach with an experimental workshop to demonstrate the effectiveness and reliability of the game. Four expert IT providers played the game to give qualitative feedback and develop the scope of pursued strategies and policies. Within this workshop, we tested two scenarios and compared the results of the incentivizing revenue sharing formula with the normal revenue sharing:

1. Egoistic strategy with the goal of maximization the own account balancing
2. Cooperative strategy with the goal of optimization the overall account balancing
    a. Regular revenue sharing option
    b. Revenue sharing formula option

We played both game variants with two playthroughs. The feedback of the players was eminently positive. Initially, the game was perceived as ‘complex’ but with the increasing understanding, the players perceived the simulation situation as very realistic and felt the fun factor when they can process a well-paid load order. Within the egoistic game variant, the players have the major challenge to decide for optimizing the IT or keep open the possibility of load processing for profit making. Playing the cooperative variant, the players got deep into the situation and became aware of the important things to decide and the common policies to be agreed upon. Once, the players had identified the cooperative goal and their individual roles, they improved their teamwork with strong coordination skills. They developed and pursued strategies and give ideas for changing or extending the rule-set to make the game more realistic.

Comparing the results from the egoistic and the cooperative game variants, we can detect tendencies for a more profitable processing in the cooperative variant (see Figure 5). The total number and average revenue of the processed units was approximately identical in both played variants, which promotes a comparability of the results. Comprehensible, the proportion of delivered units to the community is higher in the cooperative than the egoistic strategy. The delivery causes a higher profit in the cooperative game, even though the optimization effort was slightly smaller. The overall balancing of the accounts is a little higher with the cooperative strategy. This difference should increase with the number of playthroughs.

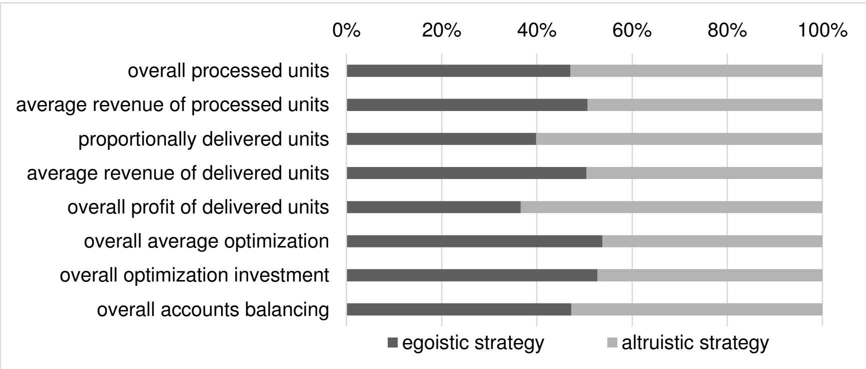

Figure 5: Comparison of the egoistic and the altruistic game strategy

The generated profit surplus with the cooperative strategy can be allocated to the players to incentivize their altruistic behaviour. This can be implemented with the proposed revenue sharing formula and aspire a more levelled balance of accounts (see Figure 6).

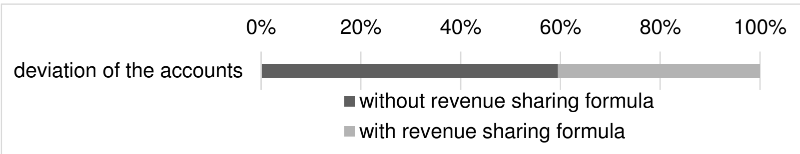

Figure 6: Deviation of the accounts within the altruistic game strategy

6 Conclusion and Outlook

With our research, we contribute with a novel evaluation method for testing realistic behaviour in a simulated situation. This situation is the participating and strategy developing in a community cloud, a relatively immature field in research and practice. Hence, our project is rather positioned as an invention, regarding the knowledge contribution framework of the design science research [GH13].

Answering the first research question, we developed a board game, closely derived from action research in a real project, and validated it with playing experiments in an expert workshop. Regarding the second research question, the workshop confirmed the expected intensification of the sensitivity for the cooperation scenario and the players appreciated the game for the simulation possibility.

Our benefits for academic research are manifold. For our research, we can determine the scope of strategies and goals for cooperating IT service providers in a community cloud. The game gives the possibility to analyse which strategies or rules are successful. Furthermore, we have a tool to simulate an implemented revenue sharing mechanism that helps to set incentives for a cooperative behaviour of the community members. Our theoretical implication is a transferable method to use a serious game for the analysis and understanding of the participants' behaviour.

In practical terms, the game can be used for workshops to inspire the participants with the possibilities of cooperative behaviour in cloud computing and help to shift traditional opinions. We have demonstrated that the concept is an enjoyable and inexpensive method to enable complex decision-making in a simulated environment.

Looking to future research options, the game should be analysed with more playthroughs to verify the results of the strategy comparison. Moreover, different experiment settings can be compared with control groups, the number of players could be raised, and a higher number of game processing gives more evaluated answers. Further, a structured survey can analyse how the game-based approach affects the players' opinion. Finally, to implement and automate the game process, an online version of the game could be valuable for more quantitative analyses.

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