SIMULATING PUBLIC PRIVATE NETWORKS as EVOLVING SYSTEMS

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ABSTRACT

Public-private service networks (PPSN) consist of social and technology components. Development of PPSN is ill-understood as these are dependent on a complex mix of interactions among stakeholders and their technologies and is influenced by contemporary developments. The aim of this paper is to advance our understanding of PPSN by modeling its evolution. Agent-based modeling (ABM) is used to understand and analyses self-organization and emergent aspects. In a case study of the vehicle administration we show the evolution of PPSN including changes in the structure of network.

INTRODUCTION

The most difficult challenge in understanding social phenomena and also PPSN is their intractably complex nature (Peltoniemi 2005). For much of the 20th century social researchers attempted to unravel the complexities of the social scope by simulating the methodologies of the natural sciences (Jacobson 2011). Although these approaches enhanced social science research, they have fallen short of capturing emergent behavior and self-organization. Nowadays, new approaches to the study of Complex Adaptive Systems (CASs) have offered researchers in both the physical and social sciences an important new theoretical and methodological framework for helping to understand a variety of nonlinear, dynamic systems. CAS is characterized often by ‘‘agents’’ interacting or capable of interacting with each other in a dynamic environment and in nonlinear ways (Furneaux 2009).
Complex systems are systems with multiple interacting components whose behavior cannot be simply inferred from the behavior of the components. In a similar vein, Public-private service networks (PPSN) consist of interacting organizations and persons supported by technology. Coleman (1994) proposes to explain “the behavior of social systems by means of three components: the effects of properties of the system on the constraints or orientations of actors; the actions of actors who are within the system; and the combination or interaction of those actions, bringing about the systemic behavior” (p. 27). Social system can be considered as network which PPSN is part of this network. In PPSNs are actors are self-interested and interact with each other and environment. These interactions make up the structure of network. Agent-based modeling can be used to model social interaction, structure and technology (Bradshaw 2008), and will be used to model the system in this research.
The aim of this paper is to advance our insight in the evolution of PPSN. We investigate the case of the PPSN of the vehicle administration and use ABM to model its evolution. The paper is organized as following. In the following section we give an overview of PPSN. Thereafter we present a case study and conceptualize the case by using agents, actors and taking technology components in account. This is followed by the specification of the model with empirical data. We run the model in which it evolves from the old to the new situation. Finally, conclusions are drawn and further research steps are discussed.

PPSN

Organizations can be viewed as a shifting multiple-goal political coalition (March 1989). Network organizations can be defined by elements of structure, process, and purpose (Podolny and Page 1998). Structurally, a network consists of self-interested organizations. Procedurally, a network organization constrains participating agents' actions via their roles and positions within the network while allowing agents' influence to emerge or fade with the (Baker 1992).
A network organization is usually considered as an organization that is quick and flexible in adapting to changes in its environment. But changes in the structure of the organization can also be detrimental in the medium run, since it is partly the knowledge of the organizations structure that mediates (Podolny and Page 1998). This is what is called evolving phenomenon which is the subject of this research.
PPSN is a specific type of organizational network in which public and private organizations collaborate. PPSN *can be defined as a network consisting of (at least three) autonomous public, private and non-profit organizations which aim to provide a service to individual citizens or businesses (Deljoo 2013).* PPSN consists of many organizations having their own goals, requirements and installed base of systems that determine the network evolvement. The behavior of PPSN is made up by interacting organizations.

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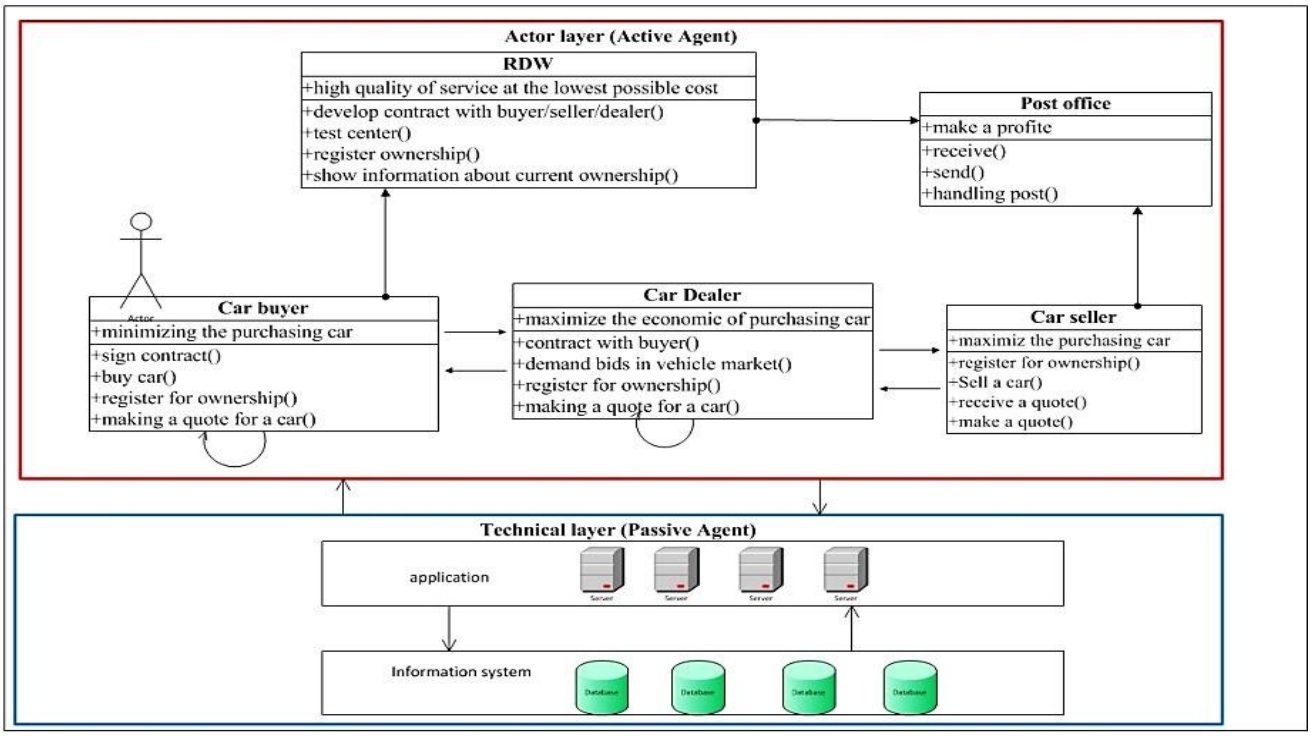


Figure 1: Structure of Agent and Interaction in Vehicle Organization (blue color: passive layer, red color: active layer)

CASE STUDY: VEHICLE ADMINISTRATION

Our aim is to investigate the evolvement of the PPSN surrounding the vehicle administration. We focused on the Dutch organizations as data concerning its evolvement was available. This allowed for conceptualizing and specifying a model with empirical data. In principle, the same conceptualization can be used to simulate many other countries, simply by using different data sets and different network.

The RDW is an executive agency under the responsibility of the Ministry of Infrastructure and Environment. The RDW is the Dutch admission authority for vehicles: passenger cars, vans, trucks, motorcycles, mopeds, scooters, etc. The RDW is aimed at ensuring that vehicles meet the required safety and environmental aspects. The RDW is also the manager of the basic registration vehicles in the Netherlands based on information stewardship. These are vehicle registration data and the data of the owner / keeper. Many government organizations and in some cases companies like insurance companies make use of this register. For this paper we consider the organizations: Car buyers, Sellers, Car dealers, Post office, RDW.

MODEL CONCEPTUALIZATION

The conceptualization is aimed at modeling the evolvement of the organizational network which is determined by technology adoption. Therefore we both model the organizations and the technology components. The organizations interacting with each other are the Car buyers, Sellers, Car dealers, Post office, RDW. The organizations utilized technologies to communicate with each other. Actor layer (model as active agent as actors are purposeful) and technical layer (passive agent as they can only be manipulated by actors) as a whole is depicted in figure 1. We distinguished two layers with two different colors, blue color for passive layer, and red color for active layer. The actors are modeled by their goals and by their interactions with each other. The technical layers consist of information systems and applications supporting organizational processes and interactions with other organizations. The entities in both layers have interactions with each other. As shown in figure 1 car buyers, and dealers are connected with each other and car sellers reconnected to dealers, which in turn are connected to the RDW and post office. Each agent in the actor layer has a relationship with themself for transfer their experience about the other agents (car buyer/dealer, seller) and organizations. In the technical layer there are a variety of information systems and applications for establishing the communication between the agents in the up layers (actor layer) and also, for storing data, searching, and generated report. This layer is used for facilitating and supporting the interactions among the active agent. Each layer has an impact on another layer.

The actors in the active layer are represented as *active agents* in the model. *Car buyer* takes the actual decisions about which car to buy from which car seller or dealer. The car price is determined by the negotiation between the car buyer and dealer.

A buyer, in this case, is the representation of somebody who wants to buy a car and to which the ownership of the car should be transferred. Buyer choice is contracted by a variety of factors such as (color, model, guaranty, second/first hand). Finally, the government sets the rules of the game (regulative author): it implements policies and acts on them, for instance by collecting taxes, asking for information such as the total distance covered by the car (to avoid fraud) and the requirement to register ownership.

Table 1: Structuring of The Agent and Interactions

Actors	Objective	Behavior and interaction
Car Buyer	Minimizing the purchasing cost Minimizing administrative costs	(1) Behaviors: sign contract with car dealer, pay tax and insurance bill to RDW, sign contract with insurance company (2) Interactions with internal /external agents
Car Dealer	Maximize the economic benefit of purchasing car Minimizing administrative costs	(1) Behaviors: Develop contracts with buyer and the RDW, make demand bids in vehicle market (2) Interactions with external agents
RDW	high quality of service at the lowest possible cost Ensure safety and security of Vehicles Minimizing administrative costs	(1) Behaviors: Test Centre, register, license, sign contract with car dealer, buyers, tax organizations, insurance organizations

In addition to the organizations, which are represented by active agents, there are technological components, representing by passive agents. We do not model the actual cars that are traded, instead we focus on the information and communication components that support the information exchange, as these determine how the network evolves. The following list comprises the main components in the physical subsystem:

- applications
- Information systems

Interactions. Interactions take place between the actors and their applications and information systems. We define social interactions to be between social components, technical interactions to be between technical components, and socio-technical interactions to be between social and technical components.
Social Interactions are communications and negotiations between social elements or agents. A main type of social interaction is contact between buyers, car sellers, car dealers and insurance companies, and tax administration and RDW through their social network. Buyer may discuss about car and experiences with others or observe others. Government interacts with RDW by providing information through information and awareness campaigns. Furthermore, governments can implement policies, such as bans on products (i.e. cars with a lot of pollution), taxation schemes and subsidies. RDW interact with car dealers by signing a contract and collecting information about their purchase and sales. Car dealers, seller and buyers interact with each other to buy and sell products and determine the price.

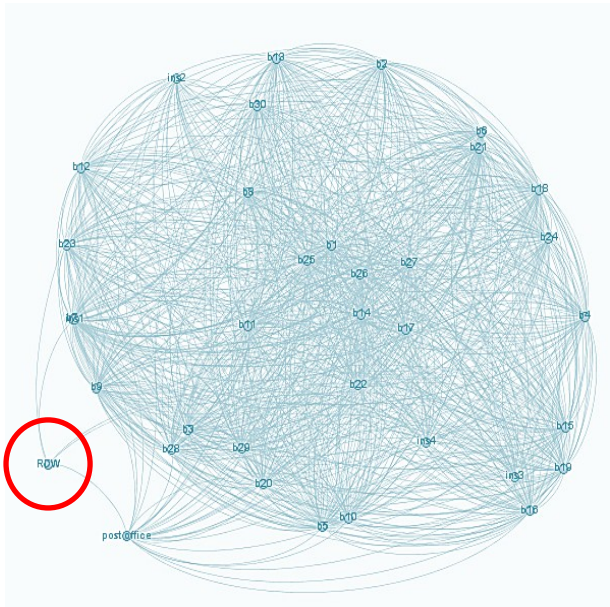
Performance indicators. We wanted to have insight in the resulting network to compare the performance differential between the initial and the evolved situation. For this purpose we used social network parameters *and* operational indicators. We used operational parameters information quality (IQ), lead time and social network metric betweenness centrality and closeness centrality for measuring the functionality of the network which they are SNA indicator (Otte and Rousseau 2002). Betweenness centrality is a measure of the centrality of a node in a network, and is normally calculated as the fraction of shortest paths between node pairs that pass through the node of interest. In our work the interest node is RDW and node pairs are car buyer, dealer and seller and post office. Closeness centrality is an important concept in social network analysis. In a graph representing a social network, closeness centrality measures how close a vertex is to all other vertices in the graph we measured the distance of RDW to the other vertex (L.Breiger 2004). Hence, by figure out the closeness centrality we can investigate the lead time and IQ. The first are focused on the operational (day-to-day) behavior of the system, whereas the latter provides insight in the evolution from the traditional situation in which car buyers and sellers provide information to the RDW to the situation in which care dealers provide this information to the RDW.

MODEL SPECIFICATION

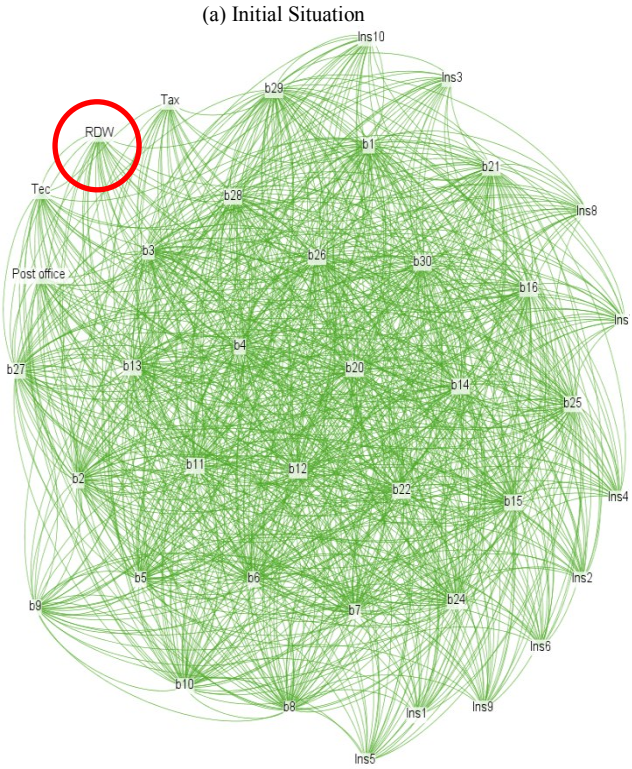
We implemented the model in network analyzer Gephi (Bastian et al. 2009). An agent-based model of the vehicle organization is developed, which include car buyer agent as a customer, a car dealer as retailer agent, and a portfolio of database and software (portal) as technology the car buyer, seller and car dealer agents are at the core of the model: it makes the decision to purchase/buy car. In deciding which insurance company chose, a buyer will need information on the different existing alternatives and this process applies for when car buyers are searching for sellers. Agents use their individual preferences to compare the alternatives and make a choice. In addition, the agents interact with the other agents like: insurance company, technology, RDW and environment. This is schematically shown in figure 2. In these figures we have different groups of agent and organization and their connections with different view we will discuss about it in the next section. We have a different group in this network for example group b_i (***b***uyer i, i=1 till n), group c_j (***c***ar dealer j, j=1 till m), and group INS_k (***I***nsurance company k, k=1 till[1]), and RDW, post office and tax company. For the model used n= 50, m= 30 and o= 20. In figure 2(a) the network is enhance than

[1] o= 20

the network in figure 2(b) because of the number of agent which is added to the network during time. Structure of the network is changed during time. In this paper for make and analysis sociometric of PPSN we chose Gephi analyzer (Bastian et al. 2009).
When evolving the number of players (n buyers, m car dealers and k insurance companies) can change, as new players enter the market and old players may disappear.



(a) Initial Situation



(b) Situation after Evolving

Figure 2: (a) Social Structure of New Network as the start (b) and after the network has evolved

RESULTS

In this section we discuss the result of the simulation and investigated the functionality of RDW after having evolved to the new situation.
As we shown in the figure 2 (a, b) we model our system. In the initial situation, the system has limited in the physical layer and functionality (figure 2(a)). In this model, car buyer for registration his/her vehicle is used to refer to the post office and in the post office they are asking an owner to fill in the form. After that, they check the information and when they confirm that the information is correct so, they send the information to the RDW. In this perspective, customer and RDW have no contact with each other and a customer take a lot of time to register his/her vehicle in the system.
Due to the technology changes, new types of interactions become available resulting in the evolvement of the network. In new situation of network, structure and the policy of network is changed. In this form, because of the number of car buyer, car dealer is raised network structure is changed as we shown in figure 2(b). This new form of network, RDW is the center of network and plays an intermediate role between other agents with government. In spite of the other network each agent can access to the post office and RDW simultaneously.
In the traditional situation the post office is the center of the relationship in the system in addition in this view customer must be waiting very long to register in this system. In the evolved situation the number of car buyers because of bid for vehicles are increased and in the network we have a numerous interactions between the stakeholders and other organizations, which is combination the network for example: tax organization, insurance company, and RDW. As we shown in the figure 1, car buyers have social interaction with each other car buyers and with car seller, car dealer and post office and RDW. In the second situation, each car buyer directly makes a relationship with the RDW and registers his/her vehicle in the vehicle organizations without asking the post office for permission. In this network, cycle of registration or change information in the network takes a less time than the older one.
The purpose of this paper is to understand how a PPSN evolves. Deep insight into the evolving phenomenon shows that is the PPSN gradually changing over time. New interactions are introduced and more and more car dealers connect directly to the RDW instead of using the post office. For this purpose new information systems are adopted. For this concept, systems (organization) are changed and expand their domain while these developments are occurred during the life of system (organization). System will grow gradually (i.e. develop the scope, more employee, more facilities, more sub-domain, etc.) without changing in the mission of this system (Stebbings and Braganza 2009).

The model is changed, by increasing the number of information system and applications. As we shown in figure 2 by red circles in the initial state RDW organization have 5 connections to the other organizations such as post office, insurance company, car dealer/ car seller and technologies. On the other hand, in figure 2(b) after evolving in the network, RDW has a more connections to the other agents (e.g. car buyer/dealer/ seller) and insurance company and post office and technologies. Therefore, the structure of network is changed.

Previous studies have identified that evolving changing in the system without changing or modifying in the structure (Capra 2002) but in this paper the structure of the network is changing. In this regards, both organizations (public or private organizations) during time added to the PPSN. Figure 2 (b) shows that the network is adapted to the new form.

CAS acknowledge that the system is changing this has impact to the other agents and environment (Dooley 1997; Eidelson 1997). In our situation new technology is introduced to enable new interactions between the parties which results in changes in the interactions among participants. Over time the post office is bypassed and more and more direct communication between car dealers and RDW takes place. The car dealer functions as a trusted party for the RDW ensuring the quality and correctness of the ownership transfer.

In table 2 the results on the performance indicators show the performance differential between the initial and new situation of the network. In the new form of network closeness centrality is less than in the initial network. The indicators show that density of network is increased and network is grown and that the network adapted to the modifications. Also the lead time decreased; as a result customer satisfaction is higher because the process of registration or transformation is quickly.

Less missing data and an increased leading time is realized due to the system evolvement. In the old situation processing of data was done by hand resulting in data entering mistakes and difficult to read forms. From another standpoint, customer satisfaction and IQ in the new form of network is higher. Instead, betweenness centrality decreases as decrease in Lead time and seeks to describe cycle of information in the both networks, and in table 2 we show that the new system has rapid movement for data.

Table 2 : Performance of the old and adapted network

Quality measurement	**Old situation**	**situation after evolving**
Lead time	2days	days
IQ	Low	High
Betweenness centrality	3.056	2.667
Closeness centrality	1.971	1.650

CONCLUSION

The conceptualization of PPSN of the RDW helps to understand the evolvement, as it shows the emergent effects of new technology and organizations in the network. Both the organizations as well as the technology components are conceptualized. The visualization helped to understand the changes in interactions among parties, whereas the performance indicators provide insight into the overall performance of the systems. The introduction of new technology results in the bypassing of the post office and car dealers acting as trusted parties communicating the transfer of the ownership to the vehicle administration. We demonstrated the new face of evolving when the mission and the structure of the network changed. In the RDW case study we demonstrated the evolvement and investigated the effect of the evolvement on various criteria. Qualitative criteria include: IQ, lead time, customer satisfaction, betweenness centrality, and closeness centrality. In this paper, we are modeling both organizational and technology aspect of PPSN.

The concept of evolving in complex adaptive systems provides a useful construct to understand the dynamics of public-private network, particularly when changes are occurred in the structure of network. Our conceptualization of the situation was initialing held at a high level of abstraction. Our further empirical work is aimed at eliciting additional changes to rules, agent to increase the depth and breadth of analysis.

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