Structuring the Multi-Issue and Hub-Spoke Games Found in Public Administration

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Abstract--**Real world decision making on socio-technical systems, such as the railways, is complex. The system contains technical uncertainties; multiple actors with different incentives are involved; institutional rules play a role and external events have a big influence on the process of decision making. Game theory helps in understanding the complexity of the situation by structuring the different elements of the process: the actors, actions, payoffs and information. However, by only considering these elements, the situation is often made too simple and therefore not applicable by decision makers in real life situations. The field of public administration entails various concepts that do take the rich context of the decision making processes into account, however, the formal representation is missing. In this paper, we present examples of public administration concepts formalized using game theoretical methods. This way, we are able to capture more richness of the process while at the same time create structure and insight for the decision maker.**

I. INTRODUCTION

The contributions of this paper entail bridging the gap between public administration and game theory. Public administration does indicate the game elements in a real world decision making process. Nonetheless public administration does not analysis these elements in order to recommend actions or moments of intervention. We propose a framework that identifies the elements in a complex decision making process. By formalizing public administration game concepts using game theory tools we help to address this gap.

The eventual aim of this work, much like that of Williams [1], is to "enable project managers to choose effective ways to manage projects based on understanding and model-based theory". Project management is a major endeavour of engineering management. Effective project management requires creating "unique ventures" to meet "defined objectives" under constraints of "cost, time and quality" [1].

Conventional projects are subjected to serious failures, including a litany of cost overruns. The failures stem from a compounding of structural complexity, uncertainty, and tight time-constraints [1]. In this paper, we argue that there is another source of complexity – that of the actors and stakeholders engaged in the project. Actors playing the game and performing strategic behaviour can also disrupt a project, leading to failed objectives, and a failure to meet constraints [2]. And this complexity, too, can be better managed by the application of a model-based theory [3].

This complexity is not already addressed in project management theory because there is an existing set of normative assumptions about how real projects work, which are not borne out in reality. Morris [4], for instance, argues that project management is "in many respects still stuck in a 1960s time warp". More than twenty years later, there is still an insufficient attention paid to the wide variety of control structures which are actually used on real projects.

Project management assumes there is a leading actor in the project who steers its subordinates. This is one of the assumptions of hierarchical models. Other assumptions are that this hierarchical structure is reasonably stable and that there is a certain uniformity within or between organizations. Those hierarchical models are attractive since they reduce the complexity of the project such that it becomes transparent and manageable. However, the assumptions that a hierarchical model is based on will hardly ever manifest themselves in reality and thus limits a successful outcome of the project [5].

The question to ask then is, given that the conventional control models for projects do not work well, how should managers manage their projects differently? The answer from the discipline public administration is to use a process approach [5], [6]. The essence of the process approach is to organize the process of interactions between actors in such a way that incentives for cooperation arise. This is necessary because with the process approach one is much better able to address complex problems as they occur in reality since they tend to emphasize the dynamics of the process [7]. Complex decision making processes involve multiple actors having different perspectives on the problem and which connected to each other via a network structure. Various uncertainties about the system exist and, as well the actors, as the components of the system, are interdependent. Moreover, the entering and exiting of actors and issues creates a highly dynamic situation. There is contested reasoning about the problem. Therefore, additional project information will still not lead to the right decision [5].

Utilizing a project approach would, in this case, limit the prerogative of the actors while still not contributing to the desired outcome of a successful project. As said, the process approach creates incentives for cooperative behaviour, suggests to broaden to problem, the goals and increase the complexity by adding issues to the agenda in order to create decision-making space [6]. Offering room for the actors in the process, but in such a way that the actors less and less feel the need to use this room as the process proceeds [8]. Negotiated knowledge and the right process lead to the right decision. In addition, setting a deadline for the decision will be dysfunctional [6].

The results are a potential better understanding of decision making process in a variety of decision-making settings at the interface of the public and the private sectors. Public administration is increasingly concerned with managing complex socio-technical systems, such as the rail sector. Public administration is also strongly involved in developing constructive recommendations and processes for change. In a

further example technology management professionals are increasingly concerned with building the diverse coalitions of developers needed to actually produce, distribute and market a new technology.

The paper is structured as follows. Section 2 discusses the practice of finding strategic games in the real world using problem structuring methods. These techniques enable improved strategic decision-making. In section 3 relevant literature is presented concerning change processes. The practice of change management can benefit from heightened appraisal of strategic behavior. In section 4, a formal framework for public administration game concepts is introduced. The important elements occurring in complex decision making processes are defined. Moreover, we present a formalization of two public administration game concepts: the multi-issue and hub-spoke games. In the last two sections we discuss the proposed framework and we present directions for future research.

II. BACKGROUND TO THE PROBLEM

We can find numerous examples of formalization of real world situations and interactions in game theory [9]–[13]. Game theory does contain the tools needed for prescribing action. These tools help in structuring the decision making process, enabling us to specify the actors, their actions, payoffs and information. In particular, the relationship between these elements allows for deriving solutions, conclusions and recommendations.

Moreover, cooperative game theory takes into account coalition forming, values of actors and proposes various solution concepts. Game theory can create insight in specific situations and can help dissect the strategies and interactions which took place between actors. In addition, comparing and analyzing of elements can reveal hidden understanding of the situation [9], [11]. Applications of game theory for policy making are present in the literature [14]–[18]. The main contributions of these applications are describing the situation, predicting at a very simplified level wat the outcome of a certain strategy will be and evaluation of the policy making by the use of game theory [9], [19], [20].

Although game theory can structure decision making processes and thereby clarify the choices and dilemmas that actors face, it is limited in capturing all important elements of the situation [9]. Game theory is not able to capture all events, emotions, personally clashes, covert ambitions, private influences, organizational histories, etc., that combined lead to the outcome of the decision making process [9]. In short, it leaves out much contextual information. This results in a description or analysis of the real world decision making process together with recommendations restricted to the elements presented by game theory [11].

The simplification of the decision making process when using game theory is a problem since the decision maker is not much helped by the use of game theory. The fact that too much contextual information about the situation is left out makes game theory recommendations difficult to apply in real world decision making processes. Another argument, often mentioned against the use of models in general, is that there exists no model that can capture all the aspects of the real world, and thus that analysis by models never can predict. We do not disagree. However, we argue that models can be used to represent a part of the real world and can therefore steer on to take actions in the right direction [21].

So, regarding the decision making process, there exists two ways of modeling the decision making process. On the one hand, there is the rich empirical tradition of disciplines like public administration and, on the other hand, the game theoretical tradition of formalization. In the public administration literature the concept of game and game playing is often used, but hardly ever formalized. Our aim, in this paper, is to formalize a number of game patterns, using game theory tools, which can be found in empirical descriptions. This is potentially interesting because with formalization we can get more insight and reach towards a better understanding of reality. By analyzing the elements of the formalization, an optimal solution can be presented. This can contribute to the design of interventions. Moreover, it is possible to make better comparisons between case studies.

III. BACKGROUND ON CHANGE PROCESSES

In disciplines as public administration, political sciences, business and management sciences and sociology a great deal of research has been conducted on change processes. It is impossible to give a complete and detailed overview of this literature. We have restricted ourselves to a couple of main features taken from the literature: context, non-linear change, strategies and alignment of actors. The result of this effort is to better formalize a few of the most crucial public administration game concepts.

Considering the context of change processes, there are always a number of characteristics that make change processes complex. First, in reality there is no hierarchy in which one can induce change by command and control. In reality we have to deal with *networks*, multiple actors with different interests who are interdependent on one another. Every actor has a certain amount of power and no actor can control all the others. Second, problems in such networks are always *wicked or unstructured problems*. Because information is contested, e.g. there is disagreement about data, systems boundaries, methods, and there is no consensus on how to weigh different criteria. System criteria may be extremely varied, for instance encompassing factors of economy, environment, and health and safety [5]. Finally, the context is *dynamic*. This means that during the process the interdependencies, as well the definitions of the problem can change.

In a network, change processes rarely evolve in a sequential order. Linearity in a change process presumes that one actor can decide on goals and can plan up front, and can subsequently execute this planning. In a network of interdependencies this is not possible. In such a network a change process is by definition a process that is based on

interactions between different actors which occur in *non-linear order*.

Actors perform strategies occurring at least two levels. First, there is the level of individual actors and their strategies, examples are: wait-and-see, keep options open, search for connections with interests of other actors, inflating claims, keeping goals vague. Because these strategies are executed by different actors the change process proceeds in an often chaotic and unstructured way. Second, an actor faced with this chaotic and unstructured process, might develop strategies or interventions to deal with these processes. Several of these interventions have been previously described in the form of a game. We recall two of these public administration game concepts which will be described in more detail below. The games will be further formalized - multi-issue and hub-spoke games.

IV. GAME THEORY FORMULATION

This section contains the main part of the paper. We introduce a framework which presents a formalization of public administration game concepts using game theory tools. Given a real world decision making process, public administration describes the process, thereby abstracting and generalizing it. Public administration also identifies characteristic games or patterns which occur again and again across settings. The games are often recounted in the form of a narrative.

Formalization of this narrative requires at least three steps. First, we will have to identify and formalize the elements of the game. In order to first indicate the elements, we use public administration concept. In order to formalize these narratives into games we use game theory. Formalization of the elements of the game results in insight into any potential missing pieces. The formalization also helps to check whether the identified public administration concept is well-selected. The second step involves combining the elements to formulate a game. Here is where the formalization of the first step becomes important. An appropriate formalization requires that the elements are defined in an analytically tractable manner. A well-defined game then permits further analysis. The analysis then results in a range of possible outcomes or solutions, from which we want to distil appropriate strategic recommendations. Such outcomes are dependent both on what participants want, and how participants play the game. Both of these things need to be corroborated with the real world. In order to corroborate the analytical game with a real-world situation gaming simulation could be employed. Finally, as a result of employing game theory to formulate strategic recommendations we can: develop recommendations for action for the various decision-makers; evaluate possible system or socially optimal outcomes; compare different parts of the process to determine how they affect the whole.

In this paper, we focus on the first step of this methodology. We propose a framework for identifying elements of a strategic game. Then, we show how to use this framework by revealing the elements of two public administration game concepts: the multi-issue and hub and spoke game. In a later paper, we will perform further analysis by developing applied game theory models of these concepts. Before doing this a more mathematical representation of the game elements is necessary. The result will be a set of model objects to which various game theory solution concepts can be applied [11], [22]–[24].

A. Selecting the elements

The standard elements of a game, as presented by game theory, are actors, actions and strategies, payoffs and information [11]. Hence, if we consider a game in the game theory sense it will contain one or more of these elements. Game theory is, in total, a loose tool box for analysing strategic behaviour. In truth there is little pre-commitment to one element which must always be present in a game theory model. Perhaps the single most characteristic element of a game model is the payoffs.

In cooperative game theory, more elements are defined; such as coalitions and solution concepts [25]. Cooperative game theory is a reduced form of a more extensive strategic process. This permits analysts to focus more carefully on the concepts which interest them. In cooperative game theory this is who joins into a cooperative agreement, and how much it takes to actually secure this cooperation. For the definition of a public administration game concept, we also take these cooperative game elements into consideration.

Moreover, we consider elements that are not explicitly defined within game theory, but that are mentioned by scientists providing empirical descriptions of decision making processes in the form of case studies. For example, there is the element of trust, widely investigated by public administration authors [5], [26]. By considering these richer contextual elements, we are able to capture, on the one hand, a larger part of the complexity of the process and, on the other hand, we are able to use the analysing capabilities of game theory, in order to better present potential solutions to dilemmas of change.

B. Definition of public administration core concepts

The following elements can be considered as important, in order to describe the richness of the decision making process: actors, actions, strategies, payoffs, information (including both belief and knowledge), dynamics, relations, power, issues, coalitions and networks, solution concepts, outcomes, history, and trust.

Next, we present the elements in a table with their definitions, formal representation and equivalent terms. The definitions are either taken from game theory [11], or, if not specifically defined in game theory, the definition from public administration was adopted [5].

Element	Explanation/definition	GT definition/formalization	Equivalent terms
actors	Players are the individuals who make decisions. Each player's goals is to maximize his utility by choice of actions.	N={1, 2, …, n}	players, agents
action	A choice a player can make.	A_i={a_i} for i\in N	move, action set, choice
strategy	A player's strategy is a rule that tells him which action to choose at each instant of the game, given his information set.	S_i={s_i} for i\in N	
payoff	The utility a player receives after all players have picked their strategies and the game has played out; or the expected utility he receives as a function of the strategies chosen by himself and the other players.	\pi_i(s_1, …, s_n)	utility, value, interest, preference, view, opinion, aim, perception
information (belief, knowledge)	A player's information set at any particular point in the game is the set of different nodes in the game tree that he knows might be the actual node, but between which he cannot distinguish by direct observation.	w_i for i\in N	information set, information partition, (in)complete, (im)perfect, substantive versus strategic information (de Bruijn and ten Heuvelhof, 2008)
dynamics	Dynamics occurs with the entrance/leave of actors, changing position of actors; incoming new or changing issues; new solutions.		learning ?
relations	Dependence of an actor on other actors. These dependencies occur always in networks and are complex. Relations can block the decision making but can also offer major opportunities. Relations that an actor maintains can be characterized in two ways: functional and extrafunctional relations; strong and weak ties. Relations are important means to strengthen the actor's information position and the strategic position in the network.	i~j for i,j \in N	connection, resources
power	A power position of an actor is dependent and can be seen as the sum of resources, relations and repititive character of the relations. Three types of power positions can be distinguished: production power, blocking power and a diffuse power position.	P = {p, b, d}	
issues	An issue is a problem in the decision making process that is needs to be handled/the current status of the situation should be known in order to make the final decision.	I={a,b,c,…}	
coalitions	A group of players that makes a sharing agreement. The coalition generates a value through cooperation and the members can share the value of the coalitions between them (Transferable Utility game). In a Non-transferable utility game, the utility cannot be transfered and an agent cannot compare between other agents (Osborne and Rubinstein, 1994).	C\subseteq N	group

network	Changing patterns of social relationships between interdepent actors which take shape around policy problems and/or policy programs, and that are being formed, reproduced and changed by an ecology of games between these actors. Elements of networks are: actors, strategies, perceptions, interaction patterns, perception patterns and rules. Definition by de Bruijn and ten Heuvelhof (2008): a pattern of interdependent relations.		pattern of interdependent relations, the whole of relations that an actor maintains (redundant relations)	
solution concept	A solution concept is a rule that defines an equilibrium based on the possible strategy combinations and the payoff functions.	F: {S_1, …, S_N, \pi_1, …, \pi_n} \to s^*	equilibrium concept	
outcome	A set of interesting elements that the modeller picks from the values of actions, payoffs, and other variables after the game is played out.			win-win situation
history	Past event that took place and have an influence on the current state of the game.			
future	Future events that could take place and can have an influence on the state of the game.			
trust	Trust between actors generaly is described by the characteristics: vulnerability, risk and expectations. Trust is used as help against uncertainty.	For every actor j, j assigns a level of trust to every other agent. The level of trust depends on several other elements such as interest of the actor and information present.		

The defined elements include the four important elements of game theory: actors, actions, payoffs and information [11]. As mentioned before, considering only those four elements does not capture the complexity of a real world decision making process [27]. In order to take the important aspects of the decision making process into account and capture the richness of the process as public administration models do, the dynamics, relations, issues, network, history and trust between actors in the decision making process need to be considered. We are not claiming the selection of elements to be complete, however, we believe to be able to capture the richness of the decision making process, as described by public administration. The next section explains two public administration concepts and presents a way of demonstrating the framework presented in this section for these two concepts.

V. PUBLIC ADMINISTRATION CONCEPTS

In this section, the multi-issue and hub-spoke concepts will be described. Since these concepts can be seen as mirror images of one another, we also indicate the differences between the two. Moreover, for the two public administration game concepts, the elements, as defined in the previous section, are indicated and a first formalization is presented.

Multi-issue

The essence of a multi-issue game [5] can be made clear with help of an example. Imagine there is a family. A father, a mother and three children: an 18-year-old daughter, a 16-year-old daughter and a six-year-old son. The father knows that the eldest daughter will be leaving home at the end of summer, which means this summer is the last ever opportunity for the family to have a summer holiday together. This is important to him and he is willing to fund a really special holiday.

He analyses the situation, where has the family already been and where not? What activities do the family members enjoy and which not? What is the available budget? After a thorough analysis, he decides on a holiday on the East Coast of America, in August. He now needs to secure the support of his family members.

Not everyone likes the idea. One would like to go to the East Coast, but not with the whole family. The second keeps her options open and does not adopt a position. The third does not want to go with the whole family, may be tempted by America, but not the East Coast. The fourth wants to go to Europe. So the father has a problem. How does he solve it? His first option is to consult his family. If they do not change their position then he can pressure them to adopt his preferred solution. Will that help? Probably not. Another option would be to take control over the agenda, by introducing other

issues for discussion which were originally not under discussion.

A multi-issue game entails broadening the agenda, which is now not just about the holiday, but also asking the other players to come up with issues that matter to them. These new issues could be rules on going out, assigning household responsibilities, whether or not to have a pet, locations and dates for the summer holiday or a skiing holiday. Other issues could also be considered – perhaps someone is interested in passing the driving test or in visiting a famous museum. Each of the players must have a list of issues that are attractive, there needs to be a perspective of gain. But the list can also include issues that the players actually strongly oppose. The youngest daughter would really like a great skiing holiday in Italy, but is completely against having a pet, hence, there is some potential gain and pain on the agenda.

Figure 1 (below) displays some of the negotiation possibilities inherent in the game. It follows a convenient graphical framework introduced to good use by [24]. The space of negotiation involves values – these values are quantifiable in the sense that the family has clear preferences. Some options are clearly preferable to others. Although these values are quantifiable they are not, or at least not strictly, monetary in character. The game involves trade-offs between the choices of the father, and the family.

Neither the father nor the family should be made worse off than the status of not going on the vacation – this is represented by point O on the graph. The vacation options include going to the East Coast (point A), or other locations in the United States (point A'). These options are preferred by the father and at least somewhat by the rest of the family. Another option, strictly worse than the status quo for the father, is a vacation in Europe (A'').

A separate and unlinked issue involves expenses related to the car, and driving lessons. A compromise is possible on this issue, ranging from no action at all (O), partial expenses, or complete purchase of lessons (B). Compromises on this issue makes the family somewhat more satisfied, but the father greatly less satisfied. Now, what happens if these issues are linked in a single game?

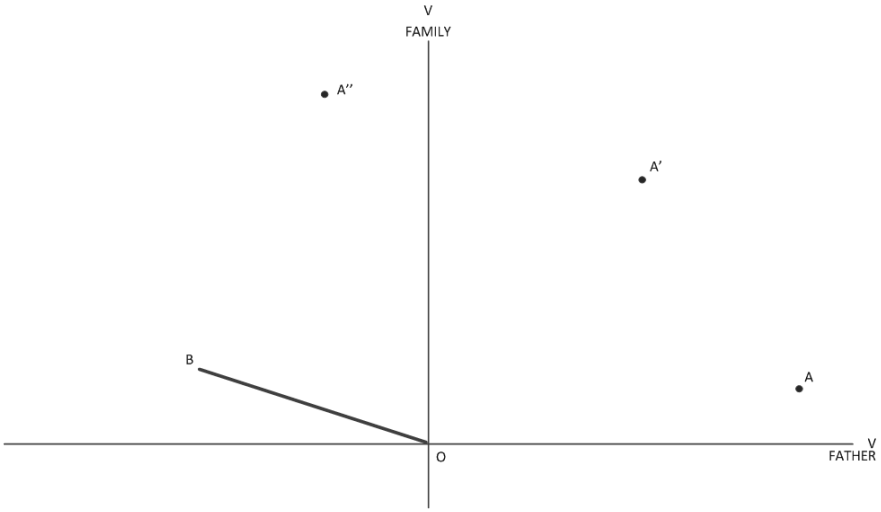

Figure 1. Single (Unlinked) Issue Game

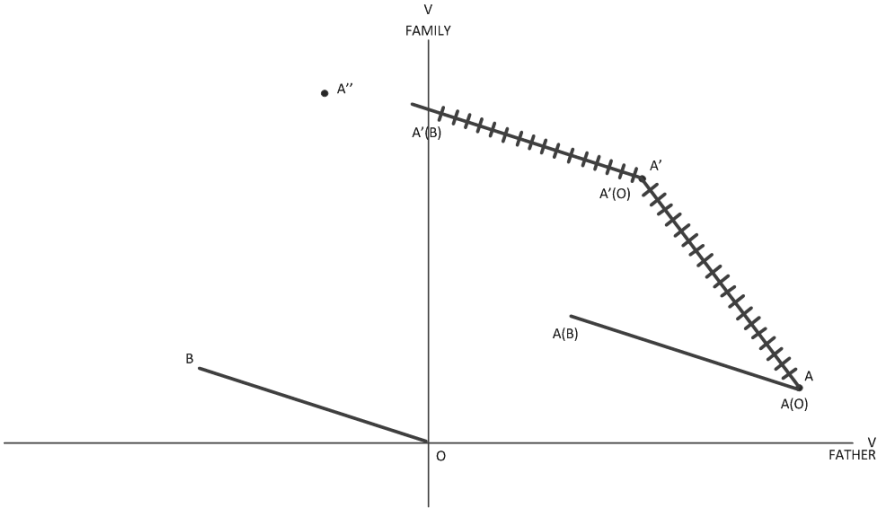

Figure 2. Multi-Issue Game

In this game the father has brought multiple members of the family to the table through the linkage of issues. The goal is to build a broad space of possible options in the north-east quadrant of the graph. First, he can compromise on the itinerary of the U.S. trip, building a possible frontier of satisfactory trips from A to A'. Second he can link the driving issue. If he links it to the East Coast itinerary he creates the segment A(0) to A(B). This segment is strictly worse for all involved than simply compromising on the itinerary. Alternatively, he can link it to the alternative U.S. destination (A') thereby creating the segment A'(0) to A'(B). The issue interlinkage in this case has created a robust portfolio of options in the north-east space of the graph which can then be subjected to further negotiation. The fact that the negotiation space has broadened means that all parties are more likely to exit the discussion feeling satisfied.

Hub-spoke

The hub-spoke game may be represented as the mirror image of multi-issue game. While the multi-issue game adds or subtracts issues, the hub-and-spoke game adds or subtracts strategic actors. The model can be explained by the following example. Imagine there is a company X, called the hub, who wants to found a business unit in a certain area. In order to succeed, it has to deal with several parties, which we call the spokes. Examples of spokes include municipalities and other local companies.

The company is the one who initiated the plan and starts making agreements with the other actors involved. In order to do so, company X can enact one of several strategies. For example, a hub can talk to the spokes one by one and proposing each a unique deal. Alternatively the hub can propose each of the spokes the self-same deal. A possible strategy of a spoke could be to block the plan of the hub or to apply a wait-and-see strategy. Exchange of information can take place between each of the spokes - they can inform each other about the specific deals proposed by the hub. The sequencing of communication presents many strategic issues to the hub.

Possible questions which one would like to have an answer on when one realizes this is a hub-spoke game might include:

- What is the optimal order in which the hub should approach the spokes?
- How should the spokes communicate with each other in order to get the highest payoff?
- What is the best response in a certain round for a spoke, i.e. what gives the highest payoff for the spoke?
- How do the players, the hub and spokes, learn during the game?
- When does the game end?
- How is an agreement defined?
- What is the highest threshold of payoffs the hub and spoke can reach? How much of the payoff of the whole should be assigned to respective spokes?

In order to show the difference between the multi-issue and hub-spoke we present in the table below.

The main characteristic element in the hub-spoke game is the fact that the hub thinks he is the most powerful player in the game. He will try to achieve and execute his plan, even if this should be against high costs. However, the spokes play an important role since they probably will communicate with each other and try to get the most out of it, they decide what will happen (how fast, how much money should be spend, etc.). This phenomenon is different from the multi-issue game where the father knows from the beginning that it could be the case that his most preferred holiday destination will not be chosen. The goal, in the multi-issue game, to go on a holiday, together with all family members, is more important for the father than push through his own plan against any cost.

We see hub-spoke and multi-issue as two opposite models which can describe decision making processes. They will serve as two extremes. In real life cases of decision making processes, it will never be the case that the complete process fits within one of these models. However, we believe that certain phases of the decision making process do fit or relate to one of these models. The aim would be to find these phases, where we observe the features of one of the models. In addition, we are interested in the moments where the decision making process changes from one model to the other. In order to account for these changes between models, we have to define models in-between the hub-spoke and multi-issue models. This is a suggestion for future work.

In the preceding, the multi-issue and hub-spoke public administration game concepts are described and compared. The following table presents how the two public administration game concepts can be interpreted in terms of the elements of public administration game concepts as previously defined. It should be noted that there is not one definite way on how to fill in the table, for example, depending on the decision making process one is dealing with, the actions or choices which can be performed are different.

Hub-spoke	**Multi-issue**
Negotiation follows plan	Plan follows negotiation
Bi-lateral	Multi-lateral
No combination of issues possible	Combination of issues possible
No peer pressure	Peer pressure
Non-cooperative	Cooperative
Engineering, systematic	Political
Operation	Board, management
One-way relation, from hub to spokes	Multiple-way relation, between all actors

PA concept	Multi-issue	Hub-spoke
Actors	N={father, mother, son 6 years, daughter 16 years, daughter 18 years}	N={0, 1, 2, …, n} with 0 being the 'hub' and 1, 2, …, n the spokes
Actions	a_1= raise issue; a_2= adapt issue; a_3= enter the game; a_4= leave the game	a_1= talk to spoke; a_2= talk to hub; a_3= talk to other spokes
Strategies	For father: 1. Consult with the family and if they do not change their position, you put them under pressure. 2. change the agenda and create a multi-issue game	For hub: start negotiating with different spokes, one after the other. For spoke: block, support or wait & see. Tit-for-that strategy: always do the same as the player did before you. Best response strategy Maximin strategy: Maximizes a player's minimum expeted payoff Minimax regret strategy: Minimizes a player's maximum expected loss Catch-as-catch-can strategy
Payoffs	Valuation function, dependent on the issues, dependent on the coalitions.	Valuation function dependend on on the plan proposed by the hub.
Information	Beliefs about what others as issues on their agendas have and thus who could be in for forming a coalition.	Beliefs about deals with other spokes. Infromation available about the plan of the hub.
Dynamics	Issues introduced in different rounds, changing coalitions depending on the issues.	New actors might get involved.
Relations	Relation tightness dependent on issues and coalitions formed between agents.	Relation tightness dependent on history with other actors, might result in different deals, however, less important than in multi-issue.
Power	P={production, blocking, wait and see}	Hub thinks he is the most powerful but this depends on how spokes cooperate. All together they can be very powerful too.
Issues	I={holiday, x, y, z, …}	One issue on the table, no connection of issues is possible since the hub deals with the spokes one by one.
Coalitions	Cooperative game: coalitions formed by agents dependend on the issue(s).	Non-cooperative game: hub does not form a coalition with the spokes, however, spokes can form coalitions.
Network	Two-way relations between actors, depending on the issue different coalitions are formed which changes the network.	One-way relations between the hub and the spokes. Between spokes two-way relations can emerge during the process.
Solution concepts	Consensus about the holiday destination	Win-win situation: for all players there is a payoff which increases; Synergy situation: there exist a player for which the payoff increases.
Outcome	Agreement on a certain holiday destination, including corresponding agreements on particular issues.	The hub succeeded in pushing through his plan, or not.
History	How did such processes evolve before or has there been a conflict before between family members. These events in history could play a role in the current process.	Past event that could have been on influence on the decision making process.
Trust	Trust is needed in order to form coalitions, also the history has an influence on the level of trust on assigns to another family member.	Trust between hub and different spokes could differ but is expected to be lower than trust between spokes since they are in a similar situation.

With this first step of formalizing public administration game concepts, the following benefits accrue. The table helps analysts to rapidly identify missing, hidden or unknown elements once the general setting of the problem is understood. The table is a useful prelude to more formal analysis and modelling. The table can help the analyst translate from often disparate theories so that a common basis of understanding can be achieved with decision-makers or specific analytical practitioners. The next step, after identifying these game components, is specifying the game, thereby potentially reaching strategically beneficial solutions and recommendations.

VI. DISCUSSION

The multi-issue and hub-spoke concepts from public administration show some overlap with prior work. The theory of negotiation arithmetic describes adding issues to a negotiation process – "an ancient and accepted practice in diplomacy" [28]. This process can create agreement where none heretofore existed. And, the processes used to build consensus can also be used to destroy any nascent agreement as well.

A multi-issue game has five potential effects on a strategic situation:

- It is an incentive for the parties to enter into a process of cooperation - to sit down with each other.
- It provides an incentive for playing the game of give-and-take.
- It will result in changing coalitions; per issue there will be a different coalition of proponents and opponents. This will create new types of interdependencies.
- Since the player can make smart combinations of issues, it promotes mutual discussion and dialog.

The negotiation arithmetic perspective also develops new propositions about the addition and subtraction of actors from a negotiation process, an idea that can be related to the hub-spoke game. This idea is comparatively unexplored by Sebenius [24]. However the addition or subtraction of actors in a coalition does play a central role in the notion of a cooperative game theory and n-person games [29].

Potential effects of the hub-spoke game are that:

- It creates separation between the actors, especially between the hub and the spokes.
- It provides an incentive for playing the game of "ask as much as you can" for the spoke.
- It provides incentives for non-cooperative behavior.
- It is often focused on a single issue and therefore beneficial combinations of issues cannot be made, and mutual learning cannot be enhanced.

The potential effects of multi-issue and hub-spoke are easily contrasted. Generally the multi-issue setting permits more mutual accommodation and learning, while the hub-spoke game is more confrontational. Actors are much more locked in to their current positions, and are much less able to learn about the perspectives of other actors. Early recognition of the actual problem setting can help change managers recognize and act upon these very significant differences.

We now turn to an important question – the benefits of adopting this strategic framework for analysing problems. For the decision maker in industry, an analysis creates more insight in the decision making process. Public administration provides the particular concepts present, however, by using the framework, it becomes clear which elements of the process are unknown or missing. Moreover, in the next step, analysis of the elements will provide further recommendation for action.

The benefits for the process are that structure is provided. Given the public administration game concepts, it becomes a valuable exercise to fill in the elements and perform the analysis at different moments in the process. It will create possibly hidden options and learning. The added value of the framework, especially with the next steps proposed, for science is that public administration models will be enriched. With a formalization provided using game theory tools, the descriptive application of public administration can strive to be more prescriptive.

However, one can also place some criticism on the approach and wonder why game theory itself did not propose such a formalization. We believe that the main reason for this is because in (applied) game theory the research is mainly focused on the mathematical representation. The concepts should be well defined such that analysis is possible. If this is not the case, a game theorist makes assumptions which are not necessarily in line with the real world but do fit analytical tractability. For a game theorist, this may even be a virtue of a theory. The resultant model contains many potential modes of behaviour yet hinges on relatively few assumptions.

As an example game theorists are rarely interested in multi-criteria or multi-issue problems, since in in most circumstances the various component issues sum up to one payoff. A drawback of these assumptions is that the real world situation is simplified too much by leaving out contextual information, which is relevant when one wants to make recommendations for actions. A further criticism to game theory is that is assumes player to behave rational [9], [30].

One could question whether the rationality assumption is not too strong, when considering real world decision making processes. However, since payoffs drive so much of the behaviour in game theory modes, rationality is simply a statement that the theorist actually knows what real world players actually want. Whether they can play the game successfully to get what they want is yet another matter. Behavioural game theory deals with this assumption and might be a possible direction to consider, when expanding the framework [31].

People might criticise the approach by saying that games do not exist; human people only do and behave in such a way

as is expected from them. We could see that in this case, the process of decision making can still be analysed using our framework, maybe even the possible actions are limited and thus the analysis will become more easy. In line with this criticism is the ludic fallacy, as identified by [32], which means the misuse of games to model real-life situations. Methodological individualism might say that individual choices matter. This can be captured by the framework by indicating these choices of particular actors as actions and perform the analysis with this information. We agree on the fact that it could be difficult to extract all the individual choices of all the actors. However, identifying the important choices will already create insight and material for recommendations.

VII. CONCLUSIONS AND FUTURE RESEARCH

In this paper, we presented a first step towards bridging the gap between public administration game concepts and formal game theory. Formalization of public administration game concepts requires at least three steps: one, identifying the elements of these concepts; two, combining the elements to form a game and perform analysis on the game; three, formulate strategic recommendations for decision makers. This paper focusses on the first step and makes this concrete by applying step one on two examples of public administration game concepts: multi-issue and hub-spoke. The framework we propose contributes to improving the understanding of the decision making process. For providing recommendations about the design of interventions in the process, the framework needs to be expanded. This will be done by formulating mathematical representations of the elements, equations and methods, in order to analyse combinations of elements. This is a direction we propose for further research.

Hub-spoke and multi-issue games are extreme examples of situations that can occur in decision making processes. In real world processes it will probably be a mixture of both, at least in different phases of the process. However, using the framework of multi-issue and hub-spoke, the elements and formal representation of them helps in indicating which of the two is most apparent at a certain moment in the process.

The formalization of more public administration game concepts, such as concepts in between multi-issue and hub-spoke, is another direction for future research. When more concepts are formalized, more parts of and patterns in the decision making process can be recognized and analysed. It will contribute to a broader understanding of the decision making process.

Another idea for future work is to not only bridge the gap between public administration game concepts and formal game theory, but to also make a connection between those formalized public administration game concepts and gaming simulation. The framework we propose, expanded with mathematical equations such that optimal solutions can be derived, could serve as input for gaming simulation. Indeed gaming simulation and game theory are often intertwined [33]. The link between them has been investigated [34]–[37]. Nonetheless not every gaming simulation can be easily captured by a game theoretical model. Further research on how our framework could serve as input for gaming simulation is an interesting question. Such research could contribute to establishing a fuller link between game theory and gaming simulation.

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