An Actor Network Theory based Approach for the information Systems collaboration
Application of the Game Theory to the Sociology of translation

Abstract: The evolution of Information Systems and the dynamic nature of socio-economic factors have forced organizations to engage in new forms of collaboration to achieve their goals and create value. The emergence of information systems collaborative networks concept has enabled organizations to generate significant benefits.

It is in this context that the present work is inscribed. We address the information systems governance issue in an inter-organizational collaboration network.

For this purpose, a new approach for governance of information systems in a network mode of collaboration is proposed. Actor Network Theory is adopted as the framework to govern collaboration networks. Cooperative Game Theory is investigated to offering actors tools to monitor, decide and evaluate the ISCN through cost saving using quantitative profit estimation based on Shapley value.

Furthermore, we provide visualization tool that allows actors to explore collaboration network dynamics and simulate the impact of scenarios related to their future evolution. Finally, we validate the effectiveness of our approach through a real case study applied to digital government. The analyze reveals that we are able to increase the cost saving objectives within an effective information systems collaboration governance.

Keywords: Collaboration Network Governance, Actor Network Theory, Cost-Sharing, Cooperative Game Theory, Shapley value.

Résumé : L'évolution des systèmes d'information et le caractère dynamique des facteurs socioéconomiques ont forcé l'organisation à s'engager dans de nouvelles formes de collaboration pour atteindre ses objectifs et créer de la valeur. L'émergence des réseaux de collaboration des systèmes d'information a permis aux organisations de générer des avantages considérables.

C'est dans cette perspective que s'inscrit le présent travail. Nous abordons la problématique de la gouvernance des systèmes d'information dans un réseau de collaboration inter-organisationnel.

A cet effet, ce mémoire propose une nouvelle approche de gouvernance des systèmes d'information en réseau basée sur l'acteur network. L'approche proposée utilise Actor Network Theory (ANT) pour régir les réseaux de collaboration et offre aux acteurs des outils pour surveiller, décider et évaluer le système d'information des réseaux de collaboration grâce à des économies et partage de coûts.

Par ailleurs, ce travail s'intéresse aussi à la contribution de la théorie des jeux coopératifs pour la réalisation de l'estimation quantitative des gains et des possibilités d'amélioration de la collaboration IS en étudiant la sélection et l'évaluation des acteurs et de la coalition au cours du processus de traduction ANT.

De plus, nous fournissons un outil de visualisation qui permet aux acteurs d'explorer la dynamique des réseaux de collaboration et d'évaluer l'impact des scénarios liés à leurs évolutions futures. Nous validons l'efficacité de notre approche avec une étude de cas réelle appliquée au système de gouvernement digital. L'analyse révèle que nous sommes en mesure d'augmenter les objectifs de réduction des coûts dans le cadre d'une gouvernance efficace de la collaboration des systèmes d'information.

Mots-clés : Gouvernance des réseaux de collaboration, théorie du réseau d'acteurs, partage des coûts, théorie des jeux coopératifs, valeur de Shapley.

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Présentée par

Mohammed Salim BENQATLA

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IT governance in collaboration mode: building IT collaboration network using a socio technical approach based on actor network theory

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Abstract: IT governance of projects needs collaboration among several organisms. Collaboration is ensured by building network of collaboration between the collaborating entities; IT collaboration between organisations can play an important role to achieve business objectives. In order to build such networks of collaboration at a real scale need modelling social interactions between different actors in order to share, analyse, and suggest improvements for a collaborative perspective. This paper describes a new tool for collaboratively modelling based on actor network theory. *CollabANT system is based on actor network theory and game theory algorithm that efficiently provides abstract models of collaboration between different actors aiming at uncovering cost allocations concerns. We demonstrate the effectiveness of our approach with a real case study. The analyse of *interessement phase reveals that we are able to increase the cost saving objectives within a collaborative mode. We also present a what-if simulation feature to assess the impact of scenarios related to future collaboration evolution. Furthermore, we provide a live deployment of the *CollabANT system that allows users to explore the dynamics of collaboration networks in place as well as their involvement over time.

Keywords: actor network theory; AnT; IT governance; cost-sharing; cooperative game theory; Shapley value; collaboration network; socio-technique.

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1 Introduction

In order to study the construction of collaborative networks (CNs) within the social network, we begin with the CN, which enables companies to communicate and collaborate productively with their customers, partners and suppliers. This cooperation takes different forms, ranging from simple information exchange to interoperability of business processes between independent companies, but also in terms of cost sharing. We use game theory as a tool for cost sharing, whereby these actors can 'translate' their goals into goals that make sense to each actor.

Then, to motivate potential partners to join the network (the coalition is used in this article to describe a network of actors), the Shapley value is used in our framework as a fair cost-sharing solution to answer the question: how is the cost shared between the actors in their marginal contributions in an actor-network context?

The contribution of this work is the use of ANT for the construction of CNs in order to perform and evaluate IT governance of organisations, by interesting actors to choose the best coalition through cost savings by applying the Shapley value.

The main contributions of this work are summarised as follows:

- Incorporation of the cooperative game theory as a tool for identifying the actors.
- Describe the architecture of COLL-ANT system based on actor network theory (ANT) and game theory algorithm, and presentation of different functionality
- Simulation platform for design and simulate best coalitions, COLL-ANT.

The paper is organised as follows: Section 2 presents the motivation and background. Section 3 introduces the building of cooperative network using game theory. Section 4 presents the evaluation of our approach by calculating Shapley value in a realistic actor-network context, and describe developed platform. Finally, Section 5 concludes and outlines future work.

2 Concepts

2.1 Actor network theory

ANT has its origins in the field of scientific and technological studies, initiated by Bruno Latour, John Law and Michael Callon in the late 1970s and 1980s, and it has great similarities to Howard Garfinkel's ethnomethodology (Latour and Woolgar, 1979; Callon, 1986; Law, 1986; Garfinkel, 1967). Science and technology, sometimes known as STS, or the sociology of science, focuses on social construction, the interaction between scientists and their work environments, and how these interactions have some ideas accepted. However, a decisive aspect of ANT in treating human and non-human actants (entities with the potential to influence a social network) as equivalents, and gives them equal weight (influence) on other entities within their networks. (In ANT's terminology, actants become actors when they realise this potential and actually act on other parts of the network).

In order to reach a step of the construction of a network, Callon and Latour defined an approach, inspired by ethnomethodology (Goulet and Vinck, 2012), which bears on a sequence of steps called the translation sequence. To translate is to "express in his own language what others say and want, to set up as spokesman" (Dameri, 2010), but translate it is also, negotiate, perform a series of movements of all kinds and thus to each sequence of the process, which can be defined in four main steps (Figure 1):

- Problematisation

  "The problematisation or how to become essential?", "The problematisation, as its name indicates asking at first a problem. This is to raise awareness to a number of actors that are concerned with this problem, and that everyone can find satisfaction through a solution that translators are able to offer" (Callon, 2006), so problematisation is the effort made by the actors to convince that they have the right solution (Callon, 1986). It "describes a system of alliances or associations between entities, defining this, their identity and what they want" (Agndal and Nilsson, 2009).

- Interessement

  "The incentive devices or how to seal alliances", the incentive is in fact for Callon "all actions through which an entity is trying to impose and stabilise the identity of the other players who is defined in problematisation" (Callon, 2006) incentive is the second phase, consists of "deployment speeches, objects and devices intended to attract and attach different players to the Network" (Dreveton and Rocher, 2010).

  It is building the interface between the interests of different actors and the strengthening of the relationship between these interests. In the area of strategy, it can be a system of alliances to ensure that the different members of the organisation are involved in the strategic process.

  The main thing is to translate the interests of other actors in order to get them to take part in the network. To translate the interests of others, we can either convince them that there are common interests and that the proposed solution also serves their interests or manipulate their interests and objectives or finally become unavoidable.

- Enrolment

  "How to define and coordinate the roles", Enrolment is "the set of multilateral negotiations, beatings forces or tricks that come with sharing and allow it to succeed" (Callon, 2006).

  For enrolment, each actor in the network is assigned a role. This role is related to the translation of their interests. For Callon, "the enrollment is to describe the set of multilateral negotiations, coups or intelligence accompanying sharing and allow it to succeed" (Dreveton and Rocher, 2010). The enrolment can thus be regarded as stabilising the system of alliances set during the phase of the incentive. This system is the result of multilateral negotiations, trials of strength and stratagems (Dreveton and Rocher, 2010). It is during this phase to confront showdowns integrating new actors to the networks or by strengthening links between network members.

  The enrolment phase is the key to the success or failure of innovation (Batini et al., 2012), but this phase is not studied formally in the literature on control.

- Mobilisation

  The last phase of translation, the mobilisation is to gather its allies. It is the cockpit of the various interests in a way that they remain more or less stable (Parung and Bititci, 2006), it raises the question of the representation of stakeholders and enrolled in the project which is then established as spokespersons of the groups they represent (Camarinha-Matos and Fsarmanesh, 2005). However, "everyone can act very differently to the solution proposed: the abandon, accept it as it is, change the modalities which accompany or statement that it contains, or even they will be appropriated in the transferring in a completely different context" (Dreveton and Rocher, 2010).

  In a particular way, incentive phase of ANT can be analysed from a cooperative game with transferable utility point of view (Dreveton and Rocher, 2010). Our objective is to identify the actor-network through data quality. For that, we use the Shapley value to identify a better translation of the operating cost for improving data quality in an actor-network context.

2.2 Business collaborative mode

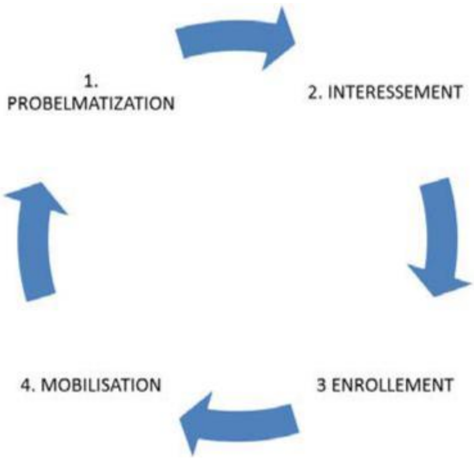
Collaboration is a process in which actors, with interests varied, working together to seek solutions to a common goal.

Collaborative design can be seen as a succession of actions leading to the definition of a product from a defined need so formal (specifications) or not (Snow et al., 2011).

The main goal of effective collaboration is to reduce the time to marketing of the product, to improve the design process and to Pilot the design information. Collaborative groups must have access to the information they need to succeed.

CN, is a term used to name "alliances constituted of a variety of organisations that are largely autonomous, geographically distributed, and heterogeneous in terms of their operating environment, culture, social capital and goals, but that collaborate to better achieve common or compatible goals, and whose interactions are supported by a computer network" (Mouritsen et al., 2001). The involvement in this kind of alliances is expected to increase the capacity of survival in market turbulence contexts, since enterprises can then acquire a larger apparent dimension, access to extended markets, access to new knowledge, and have a way to share risks and resources, while joining their complementary skills (Dreveton and Rocher, 2010).

Figure 1 Phases of ANT (see online version for colours)



The notion of network of collaboration is represented as a set collaborating of entities, autonomous and heterogeneous, being recovered from different domains of governance and working jointly with a view to attaining a series of common objectives or even supplementary (Pipino et al., 2002). The entities of network collaboration are broadly autonomous and heterogeneous in terms of their environments of working, of their organisational cultures, and of their issued capitals. Correlations are supported by group of means of support implicating the systems of information of stakeholders. The collaboration job takes a multitude of forms; it is used in the field of private service as part of a network of public administrations. This situation takes the existence of a contract of collaboration representing in a definite manner the responsibilities of every member of the network collaboration.

The literature on CNs has largely underlined several advantages of collaboration and presented the main requirements that should be met in order to promote network success and sustainability Michel Grabisch, Yukihiko Funaki. Several studies (Shin, 2010) have suggested that the sharing of objectives among members, the establishment of common infrastructures, a good level of mutual trust, and the acceptance (total or partial) of certain commercial practices and values are mandatory requirements to achieve a sustainable network, but little research has addressed the construction phase of CNs hence the purpose of our article.

2.3 Cooperative game

Game Theory is a mathematical tool which is used to analysis the strategic interaction between multiple decision makers (Shin, 2010). Initially it was used in economics for understanding the concept of economic behaviour. But now it is used in various fields such as communication, biology, psychology for modelling the decision making situation where the outcomes depend upon the interacting strategies of two or more agents (Callon, 1986).

The cooperative game theory can be applied to the case where actors can achieve more benefit by cooperating than staying alone, it consists of two elements:

1 a set of players

2 a characteristic function specifying the value created by different subsets of the players in the game (Latour, 1993).

The coalition formation problem is one of the important issues of game theory, both in cooperative and non-cooperative games. There are several attempts to analyse this problem. Many papers tried to find stable coalition structures in a cooperative game theoretic fashion. If we suppose that forming the grand coalition generates the largest total surplus, it is natural to assume that the grand coalition structure will eventually form after some negotiations.

Then, the worth of the grand coalition has to be allocated to the individual players, according to the contribution of each player. We are interested in this work in cost-sharing between coalition members likely to form using Game theory as a device for ANT interessement phase.

The Shapley value is a very common cost-sharing procedure in cooperative game theory essentially based on the so-called incremental costs (Latour, 1993). The Shapley value of player i in the game given by the characteristic function V is the share of the surplus should be assigned. It's a weighted average of the contributions of a player i to reach of the possible coalition.

For example, consider a game with three players, i1, i2 and i3. Assume that player i1 is the first player of the game, i2 is the second player to join the game and player i3 is the last one. Player i1 is allocated a cost C ({i1}), player i2 is allocated a cost C ({i1, i2}) – C ({i1}), and player i3 a cost C ({i1, i2, i3}) – C ({i1, i2}). The Shapley value assumes that the order of arrival is random and the probability that a player joins first, second, third, etc. a coalition is the same for all players. Assume that force of each coalition is known in the form of the characteristic function V. The cost allocated to a player i in a game, including a set N of players is given by:

$$\varphi i(N) = \left(\sum_{S \subseteq N i \in S} \left(\frac{(|S| - 1)!(|N|-|S|)!}{|N|!} \right) ([C(S) - C(S/\{i\})]) \right) \quad (1)$$

|N| and |S| respectively, the total number of players and the one belonging to the coalition S.

An alternative equivalent formula for the Shapley value is:

$$\varphi i(N) = \left(\frac{1}{|N|!} \sum_{R} (v(PRiU\{i\}) - v(PRi)) \right) \quad (2)$$

where the sum ranges over all |N| orders R of the players and PRi is the set of players in N which precede i in the order R.

Choosing a method of cost allocation is not an easy thing. According to the literature Shapley value seems to be suitable to this context of actor-network building game. In fact, Shapley imposes four axioms to be satisfied (efficiency, symmetry, dummy and additivity).

1 Efficiency: players precisely distribute among themselves the resources available to the grand coalition. Namely, efficiency: $\sum I \in N\varphi i\ (v) = v(N\ )$.

2 Symmetry: players i, j ∈ N are said to be symmetric with respect to game v if they make the same marginal contribution to any coalition, i.e., for each S ⊂ N with i, j ∉ S, v(S ∪ i) = v(S ∪ j). In another way, if the players i and j are symmetric with respect to game v, then $\varphi_i(v) = \varphi_j(v)$.

3 Dummy: if i is a dummy player, i.e., v(S ∪ i) – v(S) = 0 for every S ⊂ N, then $\varphi_i(v) = 0$.

4 Additivity: φ(v + w) = φ(v) + φ(w), where the game v + w is defined by (v + w) (S) = v(S) + w(S) for all S.

The dummy, symmetry (meaning that two players have the same strength Strategy will receive the same gain) and efficiency make the Shapley value, particularly attractive for treating the problem of equitable sharing of resources common to several economic agents.

3 Related works

In this section, we will discuss a representative set of existing studies that are working on CNs and collaboration theories used to build CNs applied to IT governance.

CNs is complex systems that can be described or modelled from multiple perspectives. The CN was studied by IT researchers as a virtual network. Camarinha Matos is one of the widely recognised researchers working in the field whose works are basically concerned about IT perspectives and requirements of CNs, despite the fact that they bear solid similitude’s to alternate approaches of CN too. During the later years and as a typical result of the difficulties confronted by both scientific and business terms, it has watched abundance in the sorts of rising CNs (Camarinha-Matos and Fsarmanesh, 2005). some research tries to recognise the particular impacts of the properties of network structure on the execution of firms (particularly, the quantity of licenses). Thought, the change of between firm connections and following impacts after some time were not considered. Many researchers have examined this field by the approach of Camarinha Matos and expounded the IT tools and its necessities to move forward. What’s more, different researchers have lead studies on a similar field of learning, however this time from various viewpoints, for example, organisation together or arranges in development organisations.

For example, Ahuja assesses the effects of firm’s network of relation on innovation and elaborates a theoretical framework that relates the aspects of firm’s ego network-direct ties, indirect ties and structural holes (disconnections between a firm’s partners). Chinowsky, studied the Construction Company’s networks by the approach of Social Network Analysis in company level and project level. Heedae Park studied collaboration effects on the profit amount of projects in Korean international contractors.

In this context, there is no single modelling formalism or ‘universal language’ that can cover all perspectives of interest. Since CNs have a clear multidisciplinary nature, it is natural that we search for applicable modelling tools and approaches originated in other disciplines. In fact, computer science, engineering, and management, among other fields have developed plenty of modelling tools that might have some applicability in CNs (Camarinha-Matos and Fsarmanesh, 2008).

There are also many developments in other disciplines that can contribute to the start of a foundation for CNs, e.g., in complexity theories, game theory, multi-agent systems, graph theory, formal engineering methods, federated systems, self-organising systems, swarm intelligence, and social networks.

The theoretical foundation work in the ECOLEAD project took the mentioned early works as a baseline.

Game theory can provide the concepts for the analysis of decision-making in cases involving multiple decision-makers who interact with each other. In the case of CNs, game theory could offer: tools to manage cost, risk and profit sharing among the network participants, and tools to design optimal incentives for the CN.

4 Saving costs for building collaboration network

4.1 Actors network building game

In our context players are actors of collaboration network. Actors are obligatory to collaborate in advance to take and implement joint decisions, coordinate their actions and pool their winnings & cost. It appears a cooperative game where the actors come together to form coalitions (Benqatla et al., 2016), and all of whom seek to optimise the cost of their own operations. They can, through cooperation, realise gains in the form of cost saving. We can debate it through the game in terms of the sharing of costs rather than gains. This is the method taken here. Costs are then divided between the players relative to their marginal contributions.

To validate the cost-sharing model with cooperative game in this coalition building process, we apply a concept of axiomatic solution, in this case the Shapley value.

Let N = {1 … n} be a limited set of players. A coalition is any subset of N. The set of all coalitions is denoted by 2^n.

A coalitional form concern a set of players S{1, …, n} is a function v from the set of all coalitions 2^n to the set of real numbers R with v(0/) = 0. V(S) represents the total worth the coalition S can get in the game v.

4.2 Algorithm

Algorithm Description: The input of the algorithm is matrix (a ∗ b) and the output is shapley values of size ‘b’.

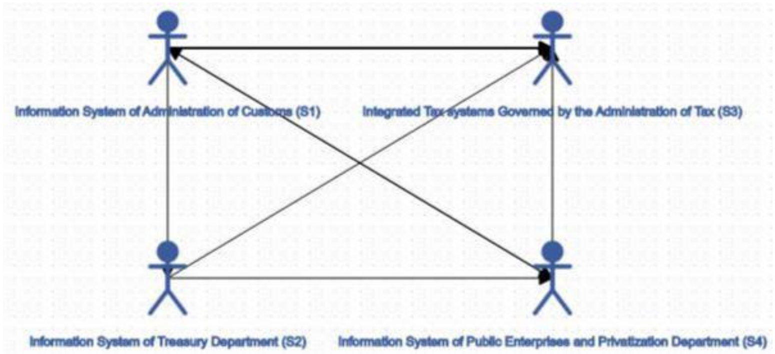
First stock the number of rows in variable ‘r’ and number of columns in variable ‘c’. Create an array(w) of size ‘c’, now make an array(shap_val) of size r. calculate sum of each column and store the resulting values in array(w).

```
INPUT: Binary matrix of size ‘a ∗ b’
OUTPUT: Shapley values of size ‘a’
Algorithm Shapley Values (a, b, r, c, w, shap_val)
r ← no of rows; //calculate number of rows
c ← no of columns; //calculate number of columns
```

```
For j ← 1 to c
  do w[j] ← ∑B[j]; //calculate sum of column and stoking in w
End For
For j ← 1 to c do
  For I ← 1 to r do
     If (B[i, j] == 1)
     shap[i, j]←1/w[j]
  End For
End For
For i ← 1 to r do
  shap _val[i] ←1/c ∑ shap[i] //calculate row sum & store in shap_val array
End For
```

Calculate sum of each row and store the values in array (shap_val). The values in shap_val array are the required Shapley values for classification.

Figure 2 Extract of a public financial authority process interaction (see online version for colours)



4.3 *Illustration*

In order to experiment our approach of actors identification based on ANT, we work on the inter-organisational data exchange project for the administration of customs of Morocco (see Figure 2).

- Information system of administration of customs (A)
- Information system of treasury department (B)
- Integrated tax systems governed by the administration of tax (C)

In our case, each system is managed by administration, A, B, C and each system has its specific characteristics (Figure 2).

The contract involving the three directions has a cost of 24. The cost function is given then by:

Table 1 Table of costs

Coalition	*Cost*
A	10
B	10
C	10
AB	16
AC	17
BC	18
ABC	24

The construction of a common backup site might be more profitable than building smaller sites. Indeed, the three directions get a fair deal, and are motivated to form a coalition since their cost parts are below their costs of going it alone. How costs should, they are distributed among the three directions?

A budget is allocated for this project between these four public administrations. We supposed that administration A must collaborate with the B in view of the functional dependency between the two institutions and that A has the choice between cooperating with C or not for the implementation of the exchange project. We will measure costs in each coalition:

Applying Shapley formula (1), there are six possible arrival orders (3!). They are enumerated in the following table which gives the marginal contributions, according to each of them. For example, A (ABC) = v ({A}) - v (θ) = 0 - 0 = 0, B (ABC) = v ({AB}) – v ({A}) = 4 – 0 = 4, etc.

The distribution of v (N) cost reduction, according to the Shapley value is given by φ(v) = (2.5, 2, 1.5). In terms of cost sharing, the calculation is illustrated in Table 2.

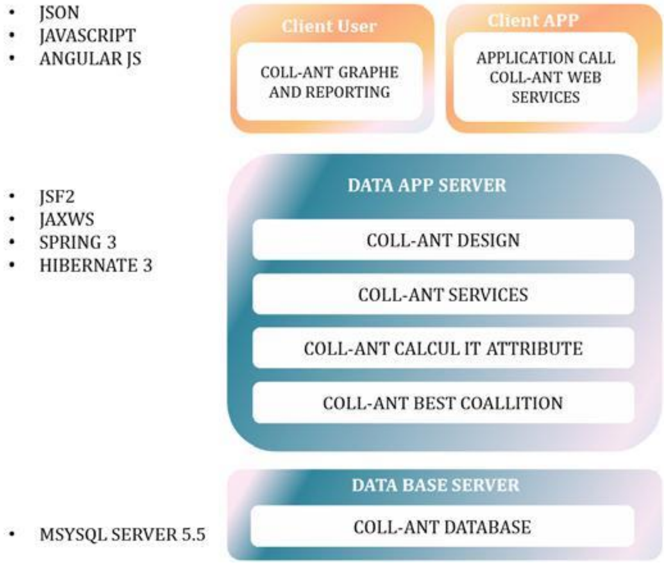
Table 2 Calculating the Shapley value

Entry order	*Marginal contributions*		
	A	*B*	*C*
ABC	0	4	2
ACB	0	3	3
BAC	4	0	2
BCA	4	0	2
CAB	3	3	0
CBA	4	2	0
Total	15	12	9
Shapley value	15/6	12/6	9/6

This means that about 24 millions, the directions A, B and C have to pay 7.5; 8 and 8.5 respectively.

We have implemented a Web application developed in JAVA/J2EE, COLL-ANT is composed of several modules developed in JAVA/J2EE technology, with an architecture separating the presentation part (front-end) from the business part (business, backend), the aim of this architecture is to allow ANT manager to interface with other platforms carried out by the research teams (Figure 3).

Figure 3 COLL-ANT software tool implementation architecture and technologies (see online version for colours)



The goal of this platform is to provide a decision-making tool for information systems managers, architects, in order to build the most appropriate CN for the administrative agency context.

COLL-ANT is currently composed of the following modules:

- Management of user authorisations.
- Workflow theory of network actors.
- Managing collaboration networks (adding an actor, linking a player to another).

Simulation management, according to the algorithm of the game theory (perform several simulations, simulation backup, simulation suppression export the simulation result in CSV format in order to analyse the various simulations carried out by the architect or the person in charge of the information systems.

5 Evaluation

After completing this research, and in order to validate the approach presented in this paper, we developed a web Java platform composed of different functional modules;

The Platform we developed is a platform collaborative centered in the networks of collaboration, the governorship of the systems of information and the theory of the actor network (ANT) which aims to put a tool of decision-making aid of the persons in charge of the information systems, architects, DSI,… in order to build the network of collaboration more adapted to the context of the administration's/entities.

The platform is composed of several modules developed in technology JAVA/J2EE, with the purpose of an architecture separating the part presentation (front-end) of the part trade (business, backend), this architecture is to make it possible to interface with other platforms carried out by the research teams, by exposing web-based-service.

The developed platform is composed of the following modules:

1 Management of users.

2 Management of workflow of the theory of the actor networks.

3 Management of the networks of collaboration (to add an actor, to bind an actor to another).

4 Management of simulation according to the algorithm of the game theory (To carry out several simulations, backup of simulation, suppression of simulation.

5 Export of the result of simulation under CSV format in order to analyse the different simulations carried out by the architect or the person in charge of the information systems.

Figure 4 Web application COLL-ANT (see online version for colours)

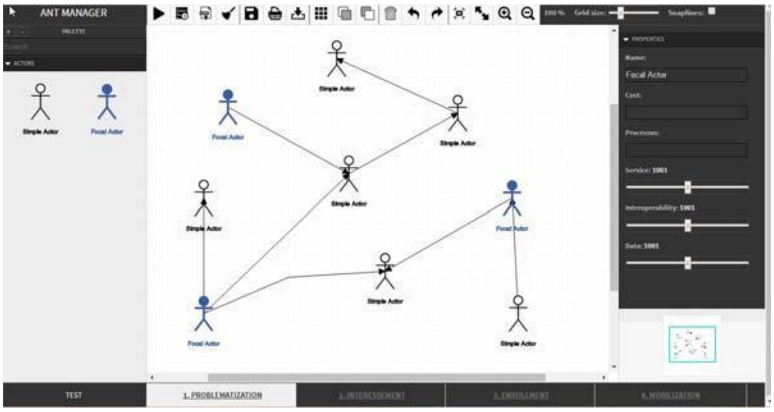
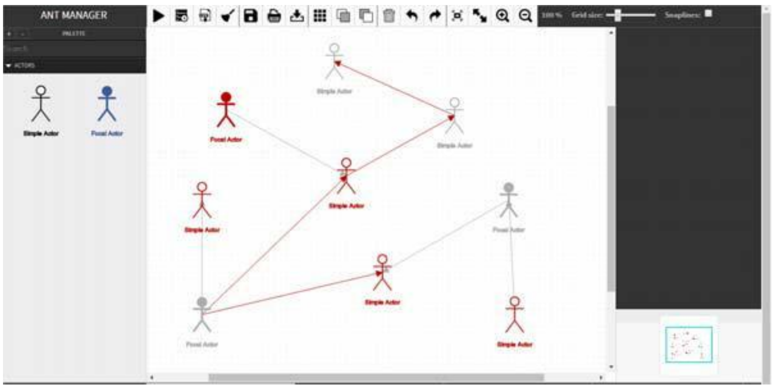


Figure 5 is capture of web application after simulating the best coalition in cost saving.

Figure 5 Web application COLL-ANT (see online version for colours)



Numerical results demonstrate that our approach permits to achieve very effective cost allocations, thus representing an efficient framework for the conception of stable networks.

6 Discussion

The purpose of the pilot case study is to explore how IT governance is built in a CN context. The study showed that the implementation of IT governance was facilitated by the application of the sociological approach ANT.

In addition, the study emphasised the crucial role played by socio-technical factors in improving the performance of IT governance.

Indeed each phase of the approach was tooled, so in this work the phase of interessement was tooled by the theory of cooperative games as a tool in order to interest the actors to integrate network of collaboration. Therefore the processes and operations of the CNs would be better coordinated because the partners had a good understanding of their roles and how they could be involved in the IT governance processes which represents the enrolment phase of ANT, also defining a leader as a social factor can play a crucial role in strengthening the IT governance structure; mobilisation phase.

To date, there is little study showing the influence of IT governance in a collaborative context, so we propose an ANT approach that allowed us to build an effective CN for effective IT governance. Consequently the effectiveness of IT governance in a CN can be influenced by two aspects:

1. How and by whom the rights and responsibilities related to IT decision-making are distributed.
2. Which relational mechanisms are essential to regulate the behaviours of the different stakeholders in order to ensure the alignment between the objectives of the company and the IT, for this ANT enabled us to identify the actors and the roles of each in the network following the four steps of ANT's approach, as it is very important to identify and evaluate all stakeholders (internal and external) of CNs, especially those who could positively or negatively affect the performance or results of information technology governance.

7 Conclusions

Displayed equations should be numbered consecutively in the paper, with the number set flush right and enclosed in parentheses.

Globalisation leads to increased competition and higher customer expectations. At the same time, companies are stressed to reduce production costs while fronting the challenges of increasing product complexity, environmental concerns. The collaboration of organisations with networks is not a new phenomenon. However, permanent progress of IT in terms of new, reliable, and cheaper

Information and communication technologies are a catalyst for collaboration in networks. Such collaboration is ensured by building a CN. Our approach highlights the identification of actors through saving costs in actor-network mode of collaboration.

The proposed work is supported by a software tool which enables to design networks and calculate actors Shapley value. The main contributions of this work can therefore be summarised as follows:

- Saving cost criteria to identify the selected actors to build the collaboration network.
- Implementation of a web application in order to design and simulate the actor-network evolution based on the cost calculation approach.
- After building network collaboration, we are particularly interested in applying social network analysis to analyse this established network.

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IT Governance in Actor-Network Mode of Collaboration : Cost Management Process Based on Game Theory

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Abstract

IT governance, like global governance of projects, requires cooperation between several actors. In general, such cooperation builds a collaboration network between entities. Many works in the literature interested in collaboration network, but no one of them were focused directly on how to build a network in an IT governance perspective. In this paper, we investigate how game theory can be exploited to provide a formal implementation of Cost Management Process, while highlighting Actor-Network as a framework of collaboration and its incentive stage as a key step for network construction. Our objective is to propose an approach of network establishment, by inciting actors through cost savings. For that, we use Shapley Value to answer the question: For the sake of IT governance, which coalitions are likely to form in order to ensure best cost-saving objectives in ANT mode of collaboration? A graphical tool is developed also to visualize and simulate networks evolution.

Keywords: Collaboration Network, Actor Network Theory, Cost-Sharing, Cooperative Game theory, Shapley Value, COBIT 5, IT System Governance.

1. Introduction

IT governance is a business function that relies on people to manage technological resources. Therefore, it is susceptible to the games they play and their consequences [6], as it happens during bargaining and cost sharing negotiations. In order to take advantage of their benefits, companies must promote the adoption of concepts and methods that favor the effective use of technological resources [5]; they are looking to best practice frameworks such as COBIT to improve the quality of their IT governance.

On another side, collaborative network has become a key enabler for trading success and economic growth. Within IT governance, cooperation takes different forms, from simple information exchange, to business processes interoperability among independent enterprises [6] [11], and also in term of cost-sharing. In fact, independent businesses become able to collaborate in order to have benefic results for all [2].

In this paper we investigate how IT governance can benefit from the use of game theory to implement Costs Management process. The Literature review shows that so far no publication has addressed this subject directly. Therefore, connecting game theory to IT governance seems to be an open road for research and publication [1] .

In our context we use Shapley value [10] as a fair cost sharing solution to divide costs between actors involved in IT project, relative to their marginal contributions.

We introduce Actor-Network Theory (ANT) [3], [4] as a framework of collaboration which helps us make sense to interaction evolution between different actors of business network. The paper is organized as follows: Section 2 presents a review of IT governance initiatives with Game Theory. Section 3 presents the different concepts and theories used. Section 4 introduces the proposed cooperative network building game. Section 5 presents numerical application that calculates shared-cost between actors using Shapley Value in a realistic Actor-network context via a developed java platform. Finally, Section 6 concludes this paper.

2. IT Governance Vs Game Theory - Literature Review

We provide in this section a brief literature review of game theory as a support in IT governance initiatives. In a Systematic literature Review [1] six papers was selected to aid the implementation of relevant aspects of governance using game theory. For example, the use of game theory to support the governance of common resources is approached in [27]. The prevention of environmental accidents and increasing readiness for action in the aftermath of accidents with the support of game theory and governance is discussed in [7]. The use of game theory to improve the planning of organizational change is dealt with in [8], and the use of game theory to improve the efficacy of governance committees in knowledge alliance is studied in [9]. The selected papers indicate that game theory could be used in similar ways to aid IT governance initiatives, but none of them deal with the governance of information technology directly. Therefore, the use of game theory to support IT governance is actually an open road for research and publication [1]. In fact, while involved in IT governance activities, actors are likely to play cooperative games.

3. CONCEPTS

3.1 COBIT

ISACA [14] develops and maintains the internationally recognized COBIT framework, helping IT professionals and enterprise leaders fulfill their IT Governance responsibilities while delivering value to the business.

COBIT (Control Objectives for Information and Related Technologies), now in its fifth edition released in April 2012, describes a set of good practices for the board, executive management, and operational business and IT managers. It helps organizations to create value from IT by maximizing the benefits and minimizing the risks associated with IT, ensuring that IT meets the legislative and regulatory requirements, and achieves alignment of IT strategy with business goals [12].

COBIT integrates IT governance into enterprise governance and covers the functions, processes and services across the enterprise, both internal and external.

The COBIT 5 processes are split into governance and management "areas". These 2 areas contain a total of 5 domains and 37 processes, Governance of Enterprise IT[Evaluate, Direct and Monitor (EDM)] and Management of Enterprise IT [Align, Plan and Organise (APO) ; Build Acquire and Implement (BAI) ; Deliver Service and Support (DSS); Monitor Evaluate and Assess (MEA)] [14].

We focus our work on the sixth process of APO domain; Budget and Cost management process.

3.2 Actor Network Theory (ANT)

The theory of translation or sociology of translation known as Actor Network Theory: (ANT) was developed as part of research on the innovation process and is rooted in a socio-technical approach to organizations. The founders of this current, Akrich, Callon and Latour [23] have shown that successful innovation depends on the success of unprecedented association between multiple and different actors. From this association, mobilization and cooperation of all stakeholders will emerge a socio-technical network and a dynamic production that aim process efficiency and success.

The second important notion of ANT is the "Actant" Callon and Latour borrow this concept to semiotician Greimas. The latter replaces the term personage by the term actant, that "who does or endure an act", because it applies not only to humans but also to animals, objects, concepts. The actants may be human or non-human and should be treated with the same importance as required by the principle of symmetry.

In order to reach a step of construction of a network, Callon and Latour defined an approach, inspired by ethnomethodology [27], which bears on a sequence of steps called the translation sequence. To translate is to "express in his own language what others say and want, to set up as spokesman" [3], but translate it is also, negotiate, perform a series of movements of all kinds and this to each sequence of the process, which can be defined in four main steps:

1. Problematization:

"The problematization or how to become essential?", "The problematization, as its name indicates asking at first a problem. This is to raise awareness to a number of actors that are concerned by this problem, and that everyone can find satisfaction through a solution that translators are able to offer" [17], so problematization is the effort made by the actors to convince that they have the right solution[16]. It "describes a system of alliances or associations between entities, defining this, [their] identity and what they want" [18].

2. Interessement

"The incentive devices or how to seal alliances", the incentive is in fact for Callon "all actions through which an entity is trying to impose and stabilize the identity of the other players who is defined in problematization" [17] incentive is the second phase, consists of "deployment speeches, objects and devices intended to attract and attach different players to the Network" [19].

It is building the interface between the interests of different actors and the strengthening of the relationship between these interests. In the area of strategy, it can be a

system of alliances to ensure that the different members of the organization are involved in the strategic process.

The main thing is to translate the interests of other actors in order to get them to take part in the network. To translate the interests of others, we can either convince them that there are common interests and that the proposed solution also serves their interests or manipulate their interests and objectives or finally become unavoidable.

3. Enrollment

"How to define and coordinate the roles", Enrollment is "the set of multilateral negotiations, beatings forces or tricks that come with sharing and allow it to succeed" [17]. For enrollment, each actor in the network is assigned a role. This role is related to the translation of their interests. For Callon, «the enrollment is to describe the set of multilateral negotiations, coups or intelligence accompanying sharing and allow it to succeed" [18] .The enrollment can thus be regarded as stabilizing the system of alliances set during the phase of the incentive. This system is the result of multilateral negotiations, trials of strength and stratagems [18]. It is during this phase to confront showdowns integrating new actors to the networks or by strengthening links between network members.

The enrollment phase is the key to the success or failure of innovation [18], but this phase is not studied formally in the literature on control.

4. Mobilization

Last phase of translation, the mobilization is to gather its allies. It is the cockpit of the various interests in a way that they remain more or less stable [20], it raises the question of the representation of stakeholders and enrolled in the project which is then established as spokespersons of the groups they represent [21]. However, "everyone can act very differently to the solution proposed: the abandon, accept it as it is, change the modalities which accompany or statement that it contains, or even they will be appropriated in the transferring in a completely different context" [18].

In a particular way, incentive phase of ANT can be analyzed from a cooperative game with transferable utility point of view. Our objective is to set up the network by incenting actors through cost savings. For that, we use Shapley Value to answer the question: Which coalitions are likely to form in order to ensure best translation of cost-saving objectives in an actor-network context?

3.3 Cooperative games theory

The cooperative game theory can be applied to the case where actors can achieve more benefit by cooperating than staying alone, it consists of two elements: (i) a set of players, and (ii) a characteristic function specifying the value created by different subsets of the players in the game [24]. The coalition formation problem is one of the important issues of game theory, both in cooperative and non-cooperative games. There are several attempts to analyze this problem. Many papers tried to find stable coalition structures in a cooperative game theoretic fashion. If we suppose that forming the grand coalition generates the largest total surplus, it is natural to assume that the grand coalition structure will eventually form after some negotiations [26]. Then, the worth of the grand coalition has to be allocated to the individual players, according to the contribution of each player [26]. We are interested in this work in cost-sharing between coalition members likely to form using Game theory as a device for ANT interessement stage.

3.4 Cost management process in a business collaboration network

A major concern of senior management is the level of the IT costs and their recovery. Implement a cost management process consists on comparing costs to budgets. Stakeholders are consulted to identify and control the total costs and benefits within the context of the IT strategic and tactical plans, and initiate corrective action where needed [30]. The process promotes partnership between the different actors; enables the rational use of IT resources; and provides transparency and accountability.

Collaboration network has created a need for new management control practices. Collaborative cost management process is defined as buyers‟ and suppliers; coordinated efforts to reduce costs [15]. The theoretical literature on interorganizational relationship formation is fragmented, with several disciplines contributing to the field. Transaction cost economics (TCE) [26], actor network theory [27], industrial network approach [28], and structuring theory [29] are the dominant theoretical perspective of interorganizational setting as well as interorganizational cost management research.

In this paper we focus on actor network theory approach and deal with cost management both as a process of IT governance and as a mechanism of interessement.

4. Actor-Network building Game

In our framework players are actors of network. To the extent that they may have common interests, actors are required to cooperate in advance to take and implement joint decisions, coordinate their actions and pool their winnings & cost. It appears a cooperative game where the actors come together to form coalitions, and all of whom seek to optimize the quality and cost of their own operations. They can, through cooperation, realize gains in the form of cost reduction. We can discuss it during the game in terms of the distribution of costs rather than gains.

This is the approach taken here. Then costs are divided between the players relative to their marginal contributions. To formalize the cost-sharing model with cooperative game in this coalition building process, we apply a concept of axiomatic solution, in this case the Shapley value.

Let N = {1, . . . , n} be a finite set of players. A coalition is any subset of N. The set of all coalitions is denoted by 2^n. A coalitional form concern on a finite set of players S{1, . . . , n} is a function v from the set of all coalitions 2^n to the set of real numbers R with v(∅) = 0. v(S) represents the total worth the coalition S can get in the game v.

4.1 The use of Shapley value

The Shapley value is a very common cost-sharing procedure in cooperative game theory essentially based on the so-called incremental costs [24]. The Shapley value of player i in the game given by the characteristic function V is the share of the surplus should be assign. It‟s a weighted average of the contributions of player i to reach of the possible coalition.

For example, consider a game with three players, i1, i2 and i3. Assume that player i1 is the first player of the game, i2 is the second player to join the game and player i3 is the last one. Player i1 is allocated a cost C({i1}), player i2 is allocated a cost C({i1, i2}) − C({i1}), and player i3 a cost C({i1, i2, i3}) − C({i1, i2}). The Shapley value assumes that the order of arrival is random and the probability that a player joins first, second, third, etc. a coalition is the same for all players. Assume that forces of each coalition are known in the form of the characteristic function V. The cost allocated to a player i in a game including a set N of players is given by:

$$\phi i(N) = (\sum_{S \subseteq N: i \in S} (\frac{(|S|-1)!(|N|-|S|)!}{|N|!}([C(S) - C(S \setminus \{\}i)]) \quad (1)$$

|N| and |S| respectively, the total number of players and the one belonging to the coalition S.

An alternative equivalent formula for the Shapley value is:

$$\phi i(N) = (\frac{1}{|N|!}\sum_R (v(PRi \quad \{i\}) - v(PRi)) \quad (2)$$

Where the sum ranges over all |N| orders R of the players and PRi is the set of players in N which precede i in the order R.

Choosing a method of cost allocation is not an easy thing. According to the literature Shapley value seems to be suitable to this context of actor-Network building game. In fact, Shapley imposes four axioms to be satisfied (Efficiency, Symmetry, Dummy and Additivity).

(i) **Efficiency**: players precisely distribute among themselves the resources available to the grand coalition. Namely, Efficiency: ∑i∈ N φi(v) = v(N).

(ii) **Symmetry**: Players i,j ∈ N are said to be symmetric with respect to game v if they make the same marginal contribution to any coalition, i.e., for each S ⊂ N with i,j ∉ S, v(S ∪ i) = v(S ∪ j). In another way if players i and j are symmetric with respect to game v, then φi(v) = φj(v).

(iii) **Dummy**: If i is a dummy player, i.e., v(S ∪ i)- v(S) = 0 for every S ⊂ N, then φi(v) = 0.

(iv) **Additivity**: φ (v+w) = φ (v) +φ (w), where the game v+w is defined by (v+w)(S) = v(S) +w(S) for all S.

The dummy, symmetry (meaning that two players have the same strength Strategic will receive the same gain) and efficiency make the Shapley value particularly attractive for treating the problem of equitable sharing of resources common to several economic agents.

4.2 Experimental setup of cost sharing within a public institution with several actors

An administration with several actors/stakeholders (department, partners, suppliers...) may wish to establish a costs management process that encourages collaborators to contribute to minimizing the common cost. As shown Shubik (1962), the allocation of common costs in the company can be seen as a cooperative game between different departments.

To fix ideas, consider the following example with three directions (A, B and C) of the same department that are in agreement with a company to perform backup sites. The project amounts to 10 million for each direction taken separately. For technical reasons, the service provider offers cost (reduced) respectively 16, 17 and 18 for joint contracts between A and B, A and C, B and C. The contract involving the three directions has a cost of 24. The cost function is given then by:

TABLE I. TABLEAU OF COSTS

Coalition	**Cost**
A	***10***
B	***10***
C	***10***
AB	***16***
AC	***17***
BC	***18***
ABC	***24***

The construction of a common backup site might be more profitable than building smaller sites. Indeed, the three directions get a fair deal, and are motivated to form a coalition since their cost parts are below their costs of

going it alone. How costs should they are distributed among the three directions?
This issue can be described by a three-player game, N = {A, B, C} is thus obtained:

TABLE II. THE CHARACTERISTIC FUNCTION ELEMENTS

Coalition	Gain
A	*0*
B	*0*
C	*0*
AB	*4*
AC	*3*
BC	*2*
ABC	*6*

Applying Shapley formula (1), there are six possible arrival orders (3!). They are listed in the following table which gives the marginal contributions according to each of them.
For example, P A(ABC) = v ({A}) - v (θ) = 0-0 = 0, P B(ABC) = v ({AB}) - v ({A}) = 4-0 = 4, etc.
The distribution of v (N) cost reduction according to the Shapley value is given by φ (v) = (2.5, 2, 1.5). In terms of cost sharing, the calculation is illustrated in Table III.

TABLE III. CALCULING SHAPLEY VALUE

Entry order	Marginal contributions		
	A	*B*	*C*
ABC	0	4	2
ACB	0	3	3
BAC	4	0	2
BCA	4	0	2
CAB	3	3	0
CBA	4	2	0
Total	15	12	9
Shapley Value	15/6	12/6	9/6

This means that about 24 million, the directions A, B and C have to pay 7.5; 8 and 8.5 respectively.

5. Experimental results

After completing this research, and in order to validate the approach presented in this paper, we developed a java platform composed of two modules; the first one allows to draw network as it is and design the different information about the actor network, the second module permits to calculate actors Shapely value and simulates coalitions costs.

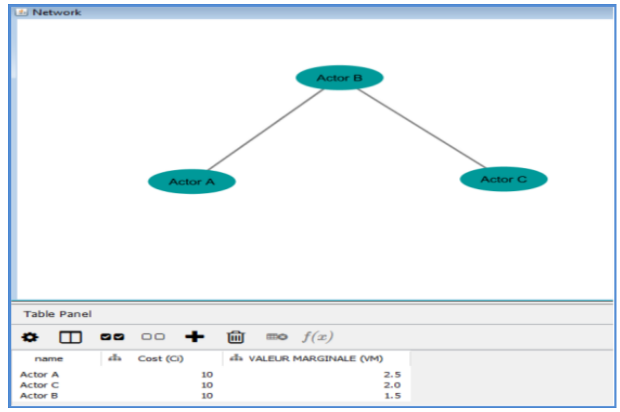

Figure 1. Marginal Values in ABC Coalition

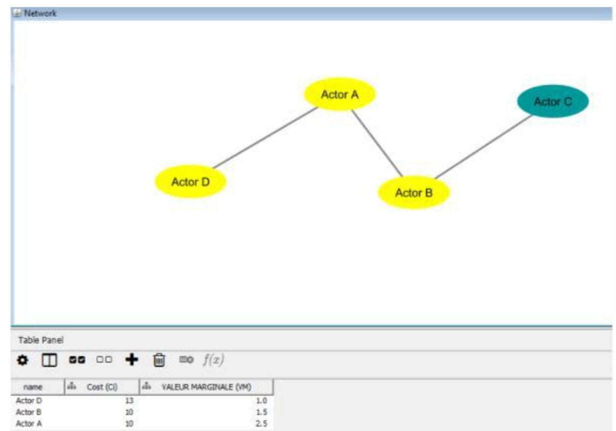

Figure 2. Marginal Values in ABCD Coalition

Numerical results demonstrate that our approach permits to achieve very effective cost allocations, thus representing an efficient framework for the conception of stable networks.

6. Conclusion

The build of partnership and coalition intra and inter-departments appears a strategic decision to reduce costs and achieve the submitted projects. This incentive approach could be introduced by the network administrator or the deciders makers in order to increase the users" cooperation level. The rules of sharing common costs and benefits of cooperation are important factors of competitiveness, performance, transparency and motivation, therefore for good governance.

We addressed in this paper It Governance, in particular, the Budget and Cost Management Process from a cooperative game point of view.

The feature of this work is the use of Actor-Network to establish collaborative network, by inciting actors to choose the best coalition through cost saving applying Shapley values. The proposed work is supported by a software tool which enables to design network and calculate actor‟s Shapley Value.

The main contributions of this work can therefore be summarized as follows:

- Cost sharing as incentive device and formal support of budget and costs management process
- Formulation of the Actor-network building problem as a cooperative game, where players (actors) cooperate to reduce costs
- Implementation of a graphical tool in order to design and simulate the actor-network evolution based on cost calculation approach

Apart from that, our present theoretical model still requires more elaboration on details, and the Shapely value that can be utilized to support interessement stage of ANT remains as a proposal in the case of budget and costs management process. Future work may require more empirical research with different types of actors and objectives.

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Evaluating a Collaborative Network of an Inter-organizational Data Exchange Project

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Abstract

The new data-oriented shape of organizations inevitably imposes the need to seal partnerships through data exchange projects. In fact, growing data exchange initiatives are offering increased monetary and non-monetary benefits for organizations. By and large, such partnerships are ensured by building collaborative networks. However, due to the multidisciplinary nature of collaborative networks, there is no single accepted approach that covers all the perspectives of various interest groups. This paper presents an approach that clearly identifies the opportunities for increased monetary and non-monetary benefits from data exchange projects, using Ant Network Theory.

Our approach applies cost-benefit analysis and multi-criteria evaluation to the Actor Network Theory translation process, while focusing on the problematization and interessement phases. The findings will allow to provide suggestions of alliances that are cost-effective and have a highly positive impact for the main protagonists. To facilitate the understanding of this approach, a Java EE Web application is developed and presented here.

Keywords: *Business Collaborative Network, Data Exchange Project, Actor Network Theory, Cost-Benefit Analysis, Interoperability.*

1. Introduction

Growing data exchange projects are offering increased monetary and non-monetary benefits for various stakeholders. These benefits include enhanced Information Quality (IQ) by reducing errors, easy access to information, reduced operating costs and increased revenues. On another hand, collaborative networks (CN) have become a key enabler for value creation and economic growth. In the context of IT governance, collaboration may take different forms. It ranges from business processes interoperability to data exchange, among autonomous organizations [1] [2].

Business collaboration refers to the process where several organizations work together to achieve mutual benefits, around clearly defined and agreed business or financial objectives.

Due to the multidisciplinary nature of collaborative networks, there is no single accepted approach that covers all the perspectives of various interest groups, and in particular how business and financial objectives are met and at what cost.

It this paper, we present an approach based on cost-benefit and multi-criteria analysis that can be used by different organizations that are planning to join a collaborative network, in order to gain a greater understanding of opportunities for increased benefits. The overall goal is not to build alliances by any means, but to carefully select potential collaborations that are cost-effective and have the most positive impact.

The organization of this paper is addressed as follows: section 2 presents a definition of the concepts of Ant Network Theory (ANT), business collaborative mode as well as multi-criteria and cost-benefit analysis. It also addresses the related work. Sections 3 describes the main steps of our approach. Section 4 presents the results from our case study. In section 5, the conclusions and future work are summarized.

2. Concepts and Related Work

2.1 Actor Network Theory

Actor Network Theory (ANT) conceptualizes social interactions in networks. In this context, networks integrate both the material and semiotic environments [3]. This theory suggests that there is no difference between the human and non-human parts of a technological system.

ANT declares that the world is full of hybrid entities [4]. The purpose of ANT analysis is to examine the process of translation, where one group's concerns are aligned with another's. The actors translate their interests by constructing a network and breaking the resistance of its members [3]. These actors could be an authority that either influences and uses others or has no interests and thus will follow the other actors' interests.

In order to construct a network, Callon and Latour defined an approach, inspired by ethnomethodology [5], which is based on a sequence of steps called the translation sequence. The act of translating consists of negotiating and performing a series of movements and decisions. The four main steps of the process of constructing an ANT network are as follows:

1. Problematization

The problematization phase defines the most important actors and their problems so that the other members perceive them as their own. In other words, it raises the awareness of all the actors to a specific problem, so that everyone moves towards a solution that translators are able to offer [6]. Problematization is the effort made by a number of actors to convince the others of their solution
[7]. It describes a system of alliances or associations, between entities, thereby defining the identity and what each one wants [8].

2. Interessement

For Callon, the interessement phase needs the incentive devices in order to seal alliance. The incentive may be defined as "all actions through which an entity is trying to impose and stabilize the identity of the other players who are defined in problematization" [7]. The incentive devices consist of "deployment speeches, objects and devices intended to attract and attach different players to the Network" [9].

In other words, the interessement phase is building an interface and strengthening the relationships between the interests of different actors. On a strategic level, interessement can form a system of alliances that ensure the involvement of different members of an organization in the strategic process.
The main goal is to translate the interests of some actors so that other actors find them attractive and take part in the network. This is accomplished by convincing them that there are common benefits and that the proposed solution serves both their purposes as well as those of others.

3. Enrollment

The enrollment phase tries to answer the question of how to define and coordinate the roles within the network. According to Callon, enrollment is "the set of multilateral negotiations, beatings forces or tricks that come with sharing and allow it to succeed" [7]. At the end of this phase, each actor in the network is assigned a specific role. This role is tightly linked to the translation of the actors' interests.

For Callon, "the enrollment is to describe the set of multilateral negotiations, coups or intelligence accompanying sharing and allow it to succeed" [7]. The enrollment can thus be described as stabilizing the system of alliances during the incentivizing phase. This configuration is the result of multilateral negotiations, trials of strength, and stratagems [7]. It is during this phase that all the network's interests are confronted to each other. This confrontation strengthens, thus, the links between all the members.

4. Mobilization

The last phase of translation is the mobilization of allies. These allies are the actors that are most affected by the various interests and should remain relatively stable in their positions [10]. They are the stakeholders and represent their groups [4]. However, everyone can act very differently to the proposed solution: abandon the coalition, accept it as it is or change the modalities

These four moments represent the phases of a general process of translation that allow building an actor network.

Figure 1 below illustrates the actor network lifecycle:

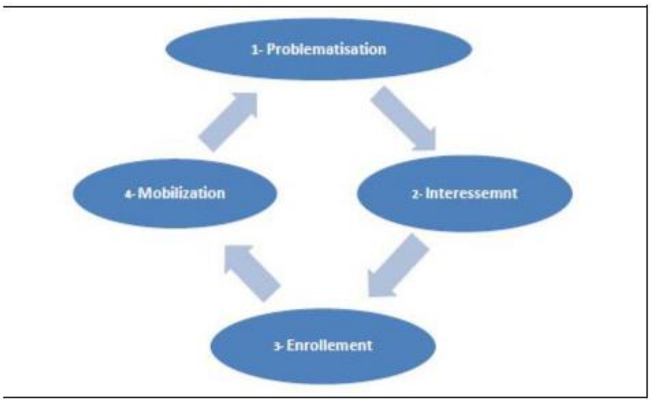

Fig. 1. Actor Network Lifecycle

2.2 Business Collaborative Mode

Collaboration represents one of the main relations among organizations. This means that organizations perform common jobs in order to achieve mutual benefits [11]. The same concept is used for both individuals and organizations, working together towards common objectives. The collaboration requires general, complete and lasting commitment in favor of a joint mission. Partners coordinate the collaboration and commitment to achieve the desired outcomes.

A collaboration network may represent a group of autonomous, heterogeneous and multidisciplinary entities working together in order to achieve common or complementary goals [10]. The environments in which these entities are collaborating as a network can also be heterogeneous. These differences are due to organizations' specific aspects and culture. Correlations are possible via a range of vehicles involving stockholders' Information Systems (IS).

It is suitable to note that our approach to evaluating a collaborative network of an inter-organizational data exchange project covers the problematization and interessement phases, and thus tries the answer the question of what are the essential actors and how the interests of each actor in the network are met.

For the actors who are involved in the network, our objective is not to construct alliances by any means, but to carefully select potential collaborations that are cost-effective and have the most positive impact.

In order to achieve this goal, we have implemented a cost-benefit and multi-criteria framework, for the mobilization and interessement phases.

2.3 Multi-Criteria and Cost-Benefit Analysis

1. Multi-criteria Analysis

Although the problems associated with decision-making are intrinsically idiosyncratic, they all share some common characteristics:

- A decision must address at least two alternatives to solve the problem;
- The alternatives are evaluated according to the values of the decision criteria;
- The criteria represent the factors that are important in the eyes of the decision-maker and that are influenced by alternatives.

Actually, the analysis becomes multi-criteria when it involves several criteria that are mutually exclusive in some instances.

We retain the following definition for multi-criteria evaluation: multi-criteria evaluation is "a decision support tool that allows to classify several alternatives in order of preference based on several criteria whose units may be different*"* [12].

To evaluate two job offers from two companies A and B, the decision criteria would be the: starting salary, evolution prospects, geographical proximity, size of the organization, etc. The importance given to each criterion is different depending on the person (the candidate in the case of the previous example) who must make the decision.

By and large, a decision-maker uses more than one criterion to evaluate different scenarios for a decision problem. Often, these criteria are mutually exclusive. In the case of an investment for instance, a decision-maker would like high profitability with a reduced level of risk. However, generally a high return on investment (ROI) would correspond to a high level of risk and vice versa. The decision-maker then has to figure out the most satisfactory balance between the ROI and the inherent risk.

There are several variants of multi-criteria decision aiding. One of them is the multi-criteria analysis using the Weighting Product Model (WPM).

In this method, each alternative has a corresponding score. The score is calculated based on the ratings assigned to the criteria, and the weighting coefficients that characterize the relative importance of each criterion, from decision- maker standpoint.

We denote by:

- S_{ij}, the score assigned to criterion i in alternative j;
- w_i the weight assigned to criterion i. The weight is invariable for all alternatives.

The weighted score for alternative j will be calculated according to the following formula:

$$\sum_i Sij * wi \qquad (1)$$

The decision maker will select the alternative with the highest weighted sum.

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The figure below depicts the global approach to formalizing a multi-criteria problem for decision aiding, using the WPM method.

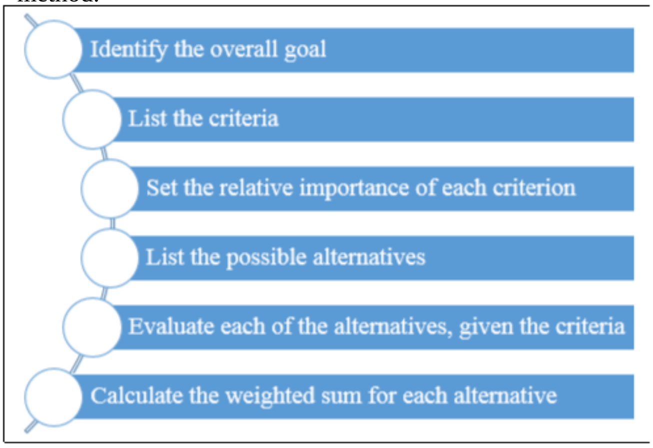

Fig. 2 Global Approach of a Multi-criteria Problem Using the WPM Method

Given the broad spectrum of decision-making problems, it should be noted that the criteria are not always quantifiable in monetary terms, making the task of evaluation even more complex. In the field of healthcare, for instance, the decision alternatives could be a medical treatment or an intervention. On the other hand, the decision criteria could be: the cost of the treatment and its effectiveness or the number of healthy years gained [13]. Under this scenario, the costs are monetary, but the profits correspond to non-monetary measures or valuations.

2. Cost-Benefit Analysis

In the same vein, cost-benefit analysis is a decision-aiding tool that can facilitate communication among stakeholders. It provides a structured framework presenting all the elements of the decision and their respective weighting, thus promoting the transparency of the process [14].
In the area of program or project management, the purpose of cost-benefit analysis is to [15]:

- Identify the best alternative or select a limited set of the best alternatives;
- Rank the alternatives from the best to the worst;
- Classify/sort the alternatives into predefined homogenous groups;
- Identify the major distinguishing features of the alternatives and describe them based on these features.

2.4 Related Work

The problem of implementing CN, particularly in the context of IT governance, has been given significant attention in the literature. Particularly in recent years, many types of CN [16] have been developed in response to the growing intricacies emerging from both academia and industry. Indeed, research studies trend to recognize the particular impact of the network structure on the success or failure of the CN.

As mentioned above, CN are complex systems that can be described or modeled from multiple perspectives. They were analyzed and studied by IT researchers as a virtual network. Camarinha-Matos is one of the widely recognized researchers whose contributions are focused on IT perspectives and requirements of CN.

Ahuja [17] assessed the effects of a firm's network of relations on innovation. He then elaborated a theoretical framework that links the innovation of a company to its direct ties, indirect ties and structural holes (disconnections between a firm's partners). Chinowsky [18] applied social network analysis in company level and project level to construction companies' networks. Park [19] studied collaboration effects on the resulting profit for Korean international contractors' projects.

Based on the examples mentioned above, there is no single modeling formalism or universal language that can cover all perspectives of various interest groups. Since CN have an obvious multidisciplinary nature, it is natural that we search for applicable modeling tools and approaches originating from other disciplines. In fact, computer science, engineering, and management, among other fields, have developed plenty of modeling tools that might have some applicability in CN [3].

There are also many developments in other disciplines that can contribute to the start of a foundation for CN : complexity theories, game theory, multi-agent systems, graph theory, decision aiding algorithms, formal engineering methods, federated systems, self-organizing systems, swarm intelligence, and social networks, to cite but a few.

Cost-benefit and multi-criteria analysis can provide a valuable tool in business cases involving many decision-makers who interact with each other. In the case of CN, these models could offer tools to: track ROI, manage cost and profit sharing among the network players, and highlight the most cost-effective alliances among the network.

In the next section, we will present our approach to implementing the problematization and interessement phases using a cost-benefit and multi-criteria framework.

3. Evaluating a Collaborative Network of an Inter-organizational Data Exchange Project

3.1 Positive Impact Assessment

The first part of our approach to tracking ROI of a network that collaborates to share data, consists of understanding how an organization's business/financial objectives and results are linked to the joining and taking part to a CN.

The following steps summarize the process of measuring the positive impact on the strategy execution of an organization:

1. Identify leading factors that contribute to achieving short-term business/financial objectives of an organization;
2. Configure the importance of these factors according to the specifications of each organization;
3. Measure the positive impact of each candidate according to the factors above;
4. Order potential candidates by positive impact.

1. Leading factors that contribute to achieving short-term business/financial objectives of an organization

Due to organizations' specific aspects and sets of success factors, and in order to provide a generic approach that can be implemented without any adjustment, the second step of our approach introduces the context-aware and configurable weighting coefficients (WC), illustrated in Table 1.

Table 1: Configuration Canvas for Positive Impact Calculation

Factor	Values	Rating	WC
Impact on daily operations	• true • false	• 1 • 0	
Impact on short-term business/financial objectives	• increasing revenues • increasing productivity • reducing costs • increasing end-user satisfaction • meeting regulatory driven compliance • other	• 0.15 • 0.15 • 0.15 • 0.15 • 0.15 • 0.15	
Impact on downstream analysis	• true • false	• 1 • 0	
Impact on decision making	• true • false	• 1 • 0	
The above results are provided quickly	• true • false	• 1 • 0	
Nature of data to exchange	• master data • transactional data • historical data	• 1 • 0.75 • 0.25	

The purpose behind using a weighing coefficient is to allow each organization to express the importance of a success factor, depending of its context and strategy.

To cite few examples where using different weighting coefficients is relevant:

- Public organizations may have more concerns about increasing end-users satisfaction (citizens in this particular case), than increasing revenues;
- Healthcare actors may give more attention to meeting regulatory driven compliance than to the other factors, while still important, owing to the fact that norms and standards are mandatory in the field of healthcare;
- Industrial companies may give the same importance to all the factors above.

2. Measurement of the impact of candidates on overall project

Business and IT leaders in charge if data exchange and sharing initiatives should:

1. List all the candidates of the problematization phase;
2. Configure the importance of each factor by acting on the associated weighting coefficient. The sum of all weighing coefficient must be equal to 100;
3. Answer the questions in the first column of Table 1.

The positive impact of each candidate will be calculated using the weighed sum strategy:

$$\sum_{i=1}^{m}(Ri * Ii)/100 \quad (2)$$

Where R_i is the rating for the factor "i" and I_i is the weighing coefficient that is associated with the factor "i", that was previously defined by both business and IT leaders. The obtained score ranges between 0 and 5, where "0" refers to "unnoticed impact" and "5" refers to "high positive impact".

Table 2. Positive Impact Levels

Impact score	Impact level
0 – 1.5	0 – unnoticed to low impact
1.5 – 3	1 – medium impact
3 – 4.25	2 – high impact
> 4.25	3 – very high impact

3. Order partners by positive impact

After iterating over all potential candidates and calculating the associated positive impact score, candidates are automatically classified by priority, in order to spot the point of departure to identify opportunities for increased benefits from data sharing.

3.2 Implementation Complexity Assessment

While the first part of our approach deals with understanding and assessing how possible candidates among a CN positively impact an organization's objectives and results, the second part of our approach focuses on the assessment of the implementation complexity associated with the realization of a CN.

The following steps detail the process of scoring the implementation complexity of a CN that aims to exchange and share data, what will allow to associate different levels of complexity (ranking from low to very high complexity) to data exchange projects:

1. Identify leading factors that contribute to the calculation of the implementation complexity of a data exchange network;
2. Configure the importance of these factors according to the specifications of each organization;
3. Measure the positive impact and the implementation complexity;
4. Prioritize data to improve according to the scores obtained in the previous step.

1. Leading factors that help in calculating the implementation complexity of data accuracy improvement.

Business experts should allow answering the questions in Table 3.

Table 3: Configuration Canvas for Implementation Complexity Calculation

Factor	Values	Rating	WC
Risk factors	• severe • major • standard • minor • minimal	• 1 • 0.75 • 0.5 • 0.25 • 0	
Level of changes	• severe • major • standard • minor • minimal	• 1 • 0.75 • 0.5 • 0.25 • 0	
Level of data quality	• low • medium • high • very high	• 1 • 0.75 • 0.5 • 0.25	
Does the data object have attributes with great weight identification in relation to another data source?	• false • true	• 0 • 1	
Is the data processing:	• manual • semi-automatic • automatic	• 1 • 0.5 • 0.25	
What is the size of the data to process?	• very large • large	• 1 • 0.75	

	• medium • low	• 0.5 • 0.25	

2. Measurement of the complexity of data accuracy improvement projects

The implementation complexity will be calculated as follows:

$$\sum_{i=1}^{m}(Ri * Ci)/100 \qquad (3)$$

Where R_i is the rating for the factor "i" and C_i is the weighing coefficient that is associated with the factor "i", that was defined previously by both business and IT leaders. The obtained score ranges between 0 and 5, here where "0" refers to "minimal complexity" and "5" refers to "severe complexity".

Table 4. Positive Impact Levels

Complexity score	Complexity level
0–1.5	0 – very low-to-low complexity
1.5–3	1 – medium complexity
3 – 4.25	2 – high complexity
> 4.25	3 – very high complexity

To summarize, our approach consists of:

1. In the context of a CN, determine what business candidates contribute the most to the business's objectives and results;
2. Determine the data exchange project complexity;
3. Recommend the optimal business case for the CN.

After completing our research and in order to calculate automatically our indicators, we have implemented a Java EE Web application, which main functionalities are:

1. Create a new candidate of a CN;
2. List registered candidates;
3. Assess the positive impact;
4. Assess the implementation complexity;
5. List all previous assessments.

The figure below depict a screenshot from our Java EE Web application:

4. A Use-Case Study

In order to test our approach of actors identification based on ANT, we work on the inter-organizational data exchange project for the Department of Lands of Morocco (DoL).

The DoL administers the State-owned land mass. Its primary purpose is to unlock the potential of State's lands for the economic, social and environmental benefits, while optimizing the value of the State's land assets. The DoL is pursuing its objectives through a number of fully automated business processes including: administering the sale of State's property, managing the Government's land acquisition program, leasing eligible lands for investment, revenue accounting, managing government employees housing, among others. In a dynamic and changing environment and to enable the DoL to carry out its attributions, it is important that the DoL works with its partners. In particular, data exchange projects allow enhancing the DoL's information quality, reducing errors

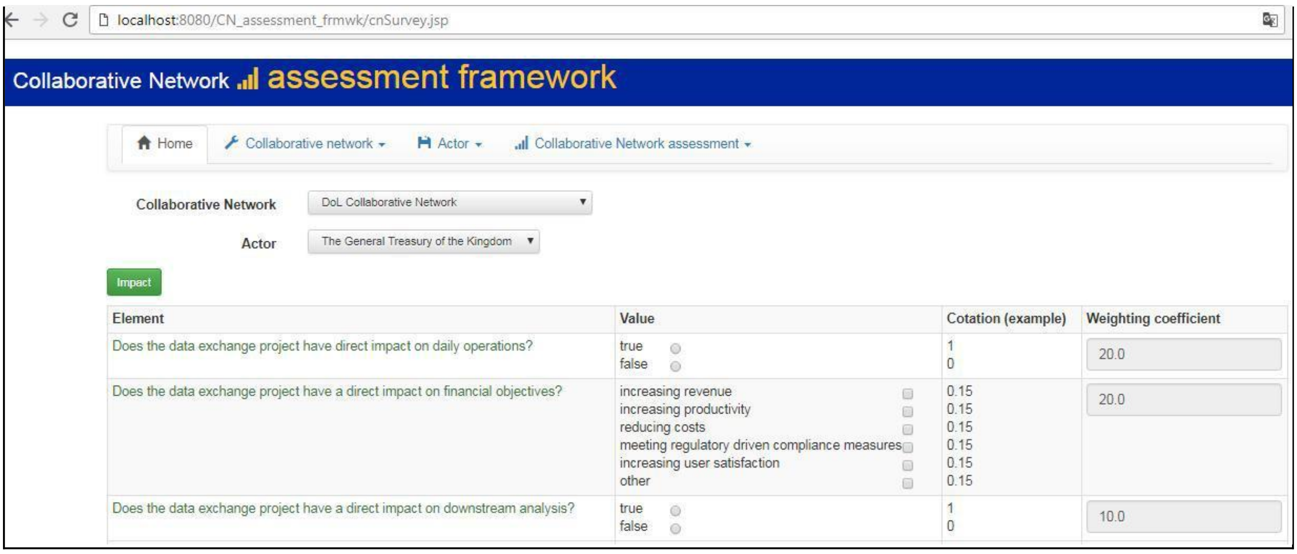

Fig. 3 Collaborative Network Assessment Framework

and thus processing time, enabling access to information and more importantly extracting true value through data. Given the current economic challenges and budgetary pressures facing most organizations, there is a substantial desire to achieve those targets successfully, with reasonable budget and changes.

In addition to the DoL, the data exchange project involves other departments of the Ministry of Economy and Finance:

- The Staff Administration Department (DDP[1])
- The Tax Directorate (DGI[2])
- The General Treasury of the Kingdom (TGR[3])
- The Budget Directorate (DB[4])

In the current case study, each actor has its own IS:

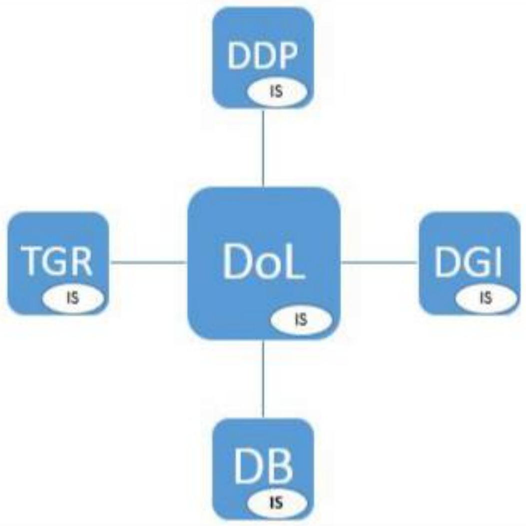

Fig. 4 Collaboration Network of the DoL

Our Web application was used to automatically calculate the positive impact and complexity indicators. The results of the experiment are provided below:

[1] *Direction des Dépenses du Personnel*
[2] *Direction Général des Impôts*
[3] *Trésorerie Générale du Royaume*
[4] *Direction du Budget*

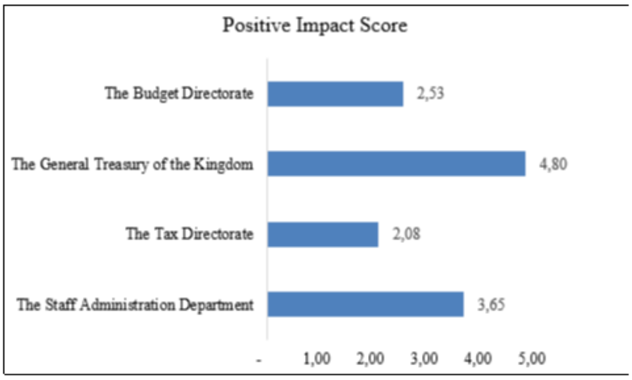

Fig. 5 Positive assessment score for the analyzed business partners

Figure 5 illustrate the results of the positive impact score calculation. As it can be observed, the highest impact score was related to "The General Treasury of the Kingdom", followed by "The Staff Administration Department". "The Budget Directorate" and "The Tax Directorate" had the least impact on the business/financial objectives of the DoL.

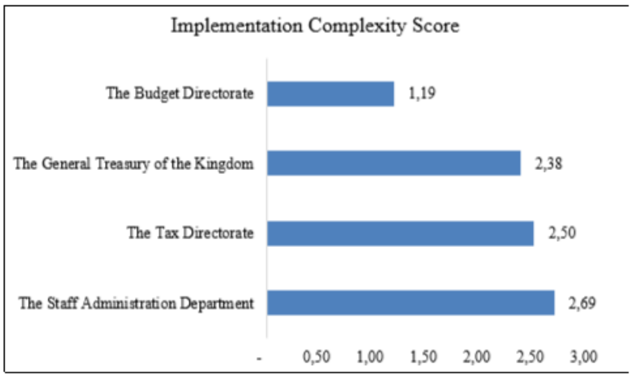

Fig. 6 Implementation Complexity Score for the Analyzed Business Partners

Figure 6 illustrates the results of the implementation complexity score calculation. As it can be observed, the highest score was related to "The Staff Administration Department".

A closer look at the results of the questionnaires administered via our Web application and the breakdown of these results in relation to the evaluation criteria provide information regarding the elements that contributed to high or low levels of positive impact and implementation complexity.

Collaboration with "The General Treasury of the Kingdom" has a significant impact as it contributes to almost all factors in table 2. However, this collaboration is

complex owing to the fact the processing is semi-manual and the size of data to process is high.

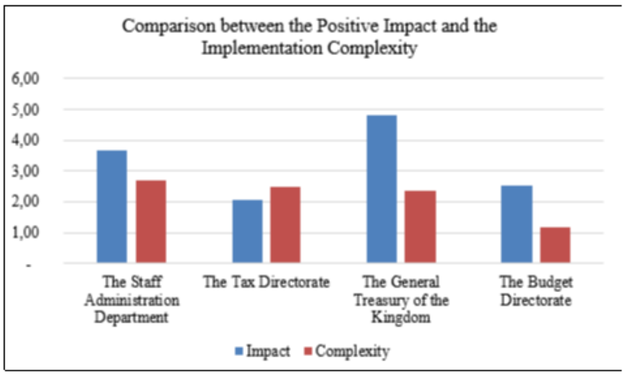

Fig. 7 Comparison between the positive impact and the implementation complexity

What we have accomplished so far allows us to associate quantitative measures to the positive impact and the implementation complexity of different alliances among a CN.

In order to build the optimal business case for their data exchange project, stakeholders at the DoL will use figures 5, 6 and 7 that represent respectively the benefits and the costs inherent to data exchange projects.

5. Conclusions

Organizations are discovering that embracing collaborative networks has a significant impact on their strategic goals, helping them achieving the growth, productivity and financial objectives they desire.

In data exchange project, partners collaborate to share information to reduce error rate, enhance information quality, enable access to information, increase efficiency and leverage true value through data.

The demand for collaborative networks assessment and cost-benefit analysis is maturing, especially when it comes to organizations having no or very little experience in the field of collaboration networks.

This work presents an approach to identify actors in a data exchange project, using ANT. Our approach investigates ANT translation process, while focusing on the problematization and interessement phases.

Our approach highlights the most cost-effective coalitions among a CN. In practical terms, we have established two global indicators of positive impact and implementation complexity, to measure the business value of data exchange projects.

To summarize, the result of the work accomplished so far shows how to measure in a quantitative manner the business value of data exchange projects, in the context of collaborative networks, by establishing two global indicators of positive impact and implementation complexity.

For our case study to be complete, we have to perform the same assessment from the DoL partners' side. The diversity of organizations' aspects makes it also challenging to see how our model will perform in other contexts other than public administration environment.

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IT COLLABORATION BASED ON ACTOR NETWORK THEORY: ACTORS IDENTIFICATION THROUGH DATA QUALITY

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Abstract. IT collaboration involves exchanging information and data within a network with several actors in order to achieve business objectives. Such cooperation is generally ensured by building a collaborative network. This work presents an approach of actors identification through data quality in Actor-Network mode of collaboration. Indeed, data quality is one of the important characteristics which expose the actor importance in the network. We investigate the translation process of ANT (Actor Network Theory), while focusing on the problematization phase in which actor-networks are identified according to the data quality level provided, and then translating this level into cost and analyzing all possible coalitions using cooperative game. The findings will allow identifying which coalitions enhance data quality. The build of such actor-network depends therefore on both data quality and the operating cost of these data between systems.

Keywords: Actor Network Theory; Data Quality; Business Collaboration Network; Cooperative Game Theory; Shapley Value

1 Introduction

Business Collaboration refers to the process where several organizations work together in an intersection of common goals. This organization manages to reach a set of strategic objectives through collaboration with partners and through the pooling of resources and the exchange of information and services with them. Objectives vary according to several criteria. However, restructuring resources, improving quality and efficiency of operations are among the main operational objectives. To define adequately the objectives and the context of the collaboration, partners must specify the needs and the goals to be reached as well as all the aspects likely to influence the choices and the mode of operation.

Data quality is among the major objectives of the collaboration, It is one of the important characteristics which exposes the actor importance in the network. It‟s a clue on how the actor will collaborate efficiently. Even if the dimensions of data quality are not universally agreed, we assume in this article that data quality level is determined by actors according to business objectives.

In this paper, we introduce the different concepts and theories used in this work, mainly Actor-Network Theory (ANT) [4], [5] as the framework of collaboration, Data quality as a characteristic for the identification of actors, Cooperative Game and Shapley Value as mechanism of cost and coalition analyzing. Then we describe the proposed approach of building an Actor-Network for data quality objective. We illustrate this work by an experimental setup applied in a realistic Actor-network context. Finally, we conclude this paper by summarizing aim points and the perspective works.

2 CONCEPTS

2.1 Actor Network Theory.

In general, ANT conceptualizes social interactions in networks. Networks integrate both the material environment and the semiotic environment [27]. In this theory, there is no difference between the human and non-human parts of a technological system. ANT mentions that the world is full of hybrid entities [28]. The core of ANT analysis is to examine the process of translation where actors align their interests of others with their own. The actors translate their interests by constructing a network and breaking the resistance of other actors and their network [27]. These actors can be an authority that either influence and use others or have no motivation and will be under the control of other actors.

In order to reach a step of the construction of a network, Callon and Latour defined an approach, inspired by ethnomethodology [8], which bears on a sequence of steps called the translation sequence. To translate is to “express in his own language what others say and want, to set up as spokesman” [4], but translate it is also, negotiate, perform a series of movements of all kinds and thus to each sequence of the process, which can be defined in four main steps:

1. Problematization

“The problematization or how to become essential?”, “The problematization, as its name indicates asking at first a problem. This is to raise awareness to a number of actors that are concerned with this problem, and that everyone can find satisfaction through a solution that translators are able to offer” [10], so problematization is the effort made by the actors to convince that they have the right solution [3]. It "describes a system of alliances or associations between entities, defining this, their identity and what they want" [21].

2. Interessement

"The incentive devices or how to seal alliances", the incentive is in fact for Callon "all actions through which an entity is trying to impose and stabilize the identity of the other players who is defined in problematization" [10] incentive is the second phase, consists of "deployment speeches, objects and devices intended to attract and attach different players to the Network" [12].

It is building the interface between the interests of different actors and the strengthening of the relationship between these interests. In the area of strategy, it can be a system of alliances to ensure that the different members of the organization are involved in the strategic process.

The main thing is to translate the interests of other actors in order to get them to take part in the network. To translate the interests of others, we can either convince them that there are common interests and that the proposed solution also serves their interests or manipulate their interests and objectives or finally become unavoidable.

3. Enrollment

"How to define and coordinate the roles", Enrollment is "the set of multilateral negotiations, beatings forces or tricks that come with sharing and allow it to succeed" [10].

For enrollment, each actor in the network is assigned a role. This role is related to the translation of their interests. For Callon, “the enrollment is to describe the set of multilateral negotiations, coups or intelligence accompanying sharing and allow it to succeed” [12]. The enrollment can thus be regarded as stabilizing the system of alliances set during the phase of the incentive. This system is the result of multilateral negotiations, trials of strength and stratagems [12]. It is during this phase to confront showdowns integrating new actors to the networks or by strengthening links between network members.

The enrollment phase is the key to the success or failure of innovation [18], but this phase is not studied formally in the literature on control.

4. Mobilization

The last phase of translation, the mobilization is to gather its allies. It is the cockpit of the various interests in a way that they remain more or less stable [13], it raises the question of the representation of stakeholders and enrolled in the project which is then established as spokespersons of the groups they represent [14]. However, “everyone can act very differently to the solution proposed: the abandon, accept it as it is, change the modalities which accompany or statement that it contains, or even they will be appropriated in the transferring in a completely different context" [12].

In a particular way, incentive phase of ANT can be analyzed from a cooperative game with transferable utility point of view [12]. Our objective is to identify the actor-network through data quality. For that, we use the Shapley Value to identify a better translation of the operating cost for improving data quality in an actor-network context.

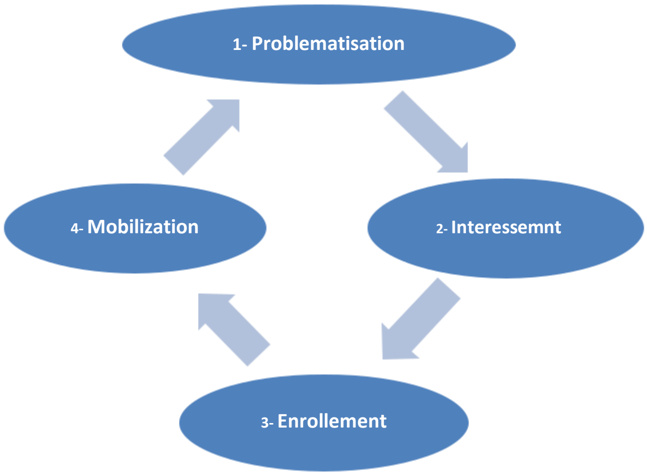

Fig. 1. Phases that compose actor network theory

2.2 Business collaborative mode

The collaboration represents one of the main relations between organizations partners. The most part of the definition of this concept agrees to mean joint job between several entities hoping for mutual benefits [15]. The same concept is used as well for the individuals as for organizations working together at common objectives. The collaboration connotes a relation lasting and made general for a complete commitment in favor of a common mission. Also, the collaboration consists in the commitment, mutual and coordinated by the partners to reach common.

The notion of network of collaboration is represented a group collaborating of entities, autonomous and heterogeneous, being recovered from different domains of governance and working jointly with a view to attaining a series of common objectives or even supplementary [16]. The entities of network collaboration are broadly autonomous and heterogeneous in terms of their environments of working, of their organizational cultures, and of their issued capitals. Correlations are supported by group of means of support implicating the systems of information of stakeholders. The collaboration job takes a multitude of forms; it is used in the field of private service as part of a network of public administrations. This situation takes the existence of a contract of collaboration representing in a definite manner the responsibilities of every member of the Network collaboration.

2.3 Data Quality

Data quality may be defined as "the degree to which information consistently meets the requirements and expectations of all knowledge workers who require it to perform their processes" [17], which can be summarized by the expression "fitness for use"
[1]. The term data quality dimension is widely used to describe the measurement of the quality of data. Even if the key DQ dimensions are not universally agreed amongst the academic community, we can refer to Pipino et al. [18] who have identified 15 dimensions:

Intrinsic: accuracy, believability, reputation and objectivity;

Contextual: value-added, relevance, completeness, timeliness and appropriate amount;

Representational and accessibility: understandability, interoperability, concise representation, accessibility, ease of operations and security.

All case studies that aimed at assessing and improving data quality have chosen a subset of data quality dimensions, depending on the objectives of the study [19, 20, 21, 22]. Measurable metrics were then defined to score each dimension. While it is difficult to agree on the dimensions that will determine the data quality, it is however possible, when taking users" perspective into account [23], to define a basic subset of key dimensions, including: accuracy, completeness and timeliness.

Accuracy is defined as "the closeness of the results of observations of the true values or values accepted as being true" [18]. Wang et al. [1] Define accuracy as "the extent to which data are correct, reliable and certified". The associated metric is as follows:

Completeness. Completeness specifies how "data is not missing and is sufficient to the task at hand" [22]. As completeness has often to deal with the meaning of null values, it may be expressed in terms of the" ratio between the number of non-null values in a source and the size of the universal relation" [21]. Completeness is usually associated with the metric below [23]:

Depending on the context, both accuracy and completeness may be calculated for:
a relation attribute, a database or a data warehouse [23].

Timeliness. Timeliness is a time-related dimension. It expresses "how current data are for the task at hand" [22].

As a matter of fact, even if a data is accurate and complete, it may be useless if not up-to-date.

2.4 Cooperative game

Game theory is a mathematical tool which is used to analysis the strategic interaction between multiple decision makers [24]. Initially it was used in economics for understanding the concept of economic behavior. But now it is used in various fields such as communication, biology, psychology for modeling the decision making situation where the outcomes depend upon the interacting strategies of two or more agents [3].

The cooperative game theory can be applied to the case where actors can achieve more benefit by cooperating than staying alone, it consists of two elements: (i) a set of players, and (ii) a characteristic function specifying the value created by different subsets of the players in the game [25]. The coalition formation problem is one of the important issues of game theory, both in cooperative and non-cooperative games. There are several attempts to analyze this problem. Many papers tried to find stable coalition structures in a cooperative game theoretic fashion. If we suppose that forming the grand coalition generates the largest total surplus, it is natu-ral to assume that the grand coalition structure will eventually form after some negoti-ations [26]. Then, the worth of the grand coalition has to be allocated to the individual players, according to the contribution of each player [26]. We are interested in this work in cost-sharing between coalition members likely to form using Game theory as a device for ANT interessement phase.

The Shapley value is a very common cost-sharing procedure in cooperative game theory essentially based on the so-called incremental costs [25]. The Shapley value of player i in the game given by the characteristic function V is the share of the surplus should be assigned. It‟s a weighted average of the contributions of a player i to reach of the possible coalition.

For example, consider a game with three players, i1, i2 and i3. Assume that player i1 is the first player of the game, i2 is the second player to join the game and player i3 is the last one. Player i1 is allocated a cost C ({i1}), player i2 is allocated a cost C ({i1, i2}) – C ({i1}), and player i3 a cost C ({i1, i2, i3}) – C ({i1, i2}). The Shapley value assumes that the order of arrival is random and the probability that a player joins first, second, third, etc. a coalition is the same for all players. Assume that force of each coalition is known in the form of the characteristic function V. The cost allocated to a player i in a game, including a set N of players is given by:

$$\phi i(N) = \left(\sum_{S \subseteq N: i \in S} \left(\frac{(|S|-1)!(|N|-|S|)!}{|N|!} \right) \left(\left[C(S) - C(S \setminus \{i\}) \right] \right) \right) \quad (4)$$

|N| and |S| respectively, the total number of players and the one belonging to the coalition S.

An alternative equivalent formula for the Shapley value is:

$$\phi i(N) = \left(\frac{1}{|N|!} \sum_{R} \left(v(PRi \cup \{i\}) - v(PRi) \right) \right) \quad (5)$$

Where the sum ranges over all |N| orders R of the players and PRi is the set of players in N which precede i in the order R.

Choosing a method of cost allocation is not an easy thing. According to the literature Shapley value seems to be suitable to this context of actor-Network building game. In fact, Shapley imposes four axioms to be satisfied (Efficiency, Symmetry, Dummy and Additivity).

1. Efficiency: players precisely distribute among themselves the resources available to the grand coalition. Namely, Efficiency: $\sum_{i \in N} \varphi_i (v) = v (N)$.
2. Symmetry: Players i, j ∈ N are said to be symmetric with respect to game v if they make the same marginal contribution to any coalition, i.e., for each $S \subset N$ with i, j $\notin S$, $v (S \cup i) = v (S \cup j)$. In another way, if players i and j are symmetric with re-spect to game v, then $\varphi_i (v) = \varphi_j (v)$.
3. Dummy: If i is a dummy player, i.e., $v (S \cup i) - v (S) = 0$ for every $S \subset N$, then $\varphi_i (v) = 0$.
4. Additivity: $\varphi (v+w) = \varphi (v) + \varphi (w)$, where the game v+w is defined by $(v+w) (S) = v (S) + w (S)$ for all S.

The dummy, symmetry (meaning that two players have the same strength Strategy will receive the same gain) and efficiency make the Shapley value, particularly attractive for treating the problem of equitable sharing of resources common to several economic agents.

3 Related works

In this section, we will deal with a representative set of existing studies that work on collaboration network and theories used to build the network of collaboration in the context of IT Governance.

Collaborative Networks (CNs) are complex systems that can be described or modeled from multiple perspectives. The collaborative network was presented and studied by IT researchers as a virtual network. Camarinha Matos is one of the widely recognized researchers working in the field whose works are basically concerned about IT perspectives and requirements of Collaborative Networks, despite the fact that they bear solid similitudes to alternate approaches of Collaborative Network too. During the later years and as a typical result of the difficulties confronted by both scientific and business terms, it has watched an abundance in the sorts of rising Collaborative Networks [28]. Some research tries to recognize the particular impacts of the properties of network structure on the execution of firms (particularly, the quantity of licenses) [29]. Thought, the change of between firm connections and following impacts after some time were not considered. [30] Many researchers have examined this field by the approach of Camarinha Matos and expounded the IT tools and its necessities to move forward. What's more, different researchers have lead studies on a similar field of learning, however this time from various viewpoints, for example, organization together or arranges in development organizations.

For example, Ahuja assesses the effects of firm‟s network of relation on innovation and elaborates a theoretical framework that relates the aspects of firm‟s ego network-direct ties, indirect ties and structural holes (disconnections between a firm‟s partners).Chinowsky, studied the Construction Company‟s networks by the approach of Social Network Analysis in company level and project level. Heedae Park studied collaboration effects on the profit amount of projects in Korean international contractors.

In this context, there is no single modeling formalism or "universal language" that can cover all perspectives of interest. Since CNs have a clear multidisciplinary nature, it is natural that we search for applicable modeling tools and approaches originated in other disciplines. In fact, Computer Science, Engineering, and Management, among other fields have developed plenty of modeling tools that might have some applicability in CNs [27].

There are also many developments in other disciplines that can contribute to the start of a foundation for collaborative networks, e.g. in complexity theories, game theory, multi-agent systems, graph theory, formal engineering methods, federated systems, self-organizing systems, swarm intelligence, and social networks. The theoretical foundation work in the ECOLEAD project took the mentioned early works as a baseline.

Game theory can provide the concepts for the analysis of decision-making in cases involving multiple decision-makers who interact with each other. In the case of CNs, game theory could offer: tools to manage cost, risk and profit sharing among the network participants, and tools to design optimal incentives for the VBE, VO, etc.

4 Data quality in network collaboration

4.1 Actors Identification through data quality

In our approach data quality is determined by taking into account users‟ perspective and objectives. An actor should decide on a subset of dimensions as mentioned above, the data quality level is then deducted from accuracy, completeness, and timeliness scores.

Data exchange „Relationship‟ (respecting ANT terminology) represents actor‟s interactions, which allows to spot future alliances and coalitions respectively conflicts and dissension.

We use the problematization step of the translation process to identify and characterize actors, as well as to analyze the scenario in which the network will operate. First, we identify actors with a height score of data quality, and then measuring data quality as proposed into [26] values and measuring the costs of operating this data in all possible coalitions. The choice of actor-network depends therefore on both data quality and the cost of using these data in each system, assessing the collaborative value of an actor can naturally be seen in terms of the cooperative game theory with a transferable utility, by means of Shapley value [2]. In fact the allocation of budgets depends on the contribution of each actor, in term of data quality translated to costs in our context.

4.2 Illustration

In order to experiment our approach of actors identification based on ANT, we work on the inter-organizational data exchange project for the administration of customs of Morocco (see Fig 2).

- Information System of Administration of Customs (S1)
- Information System of Treasury Department (S2)
- Integrated Tax systems Governed by the Administration of Tax (S3)
- Information System of Public Enterprises and Privatization Department (S4)

In our case, each system is managed by administration, S1, S2, S3, S4 and each system has its level of data quality.

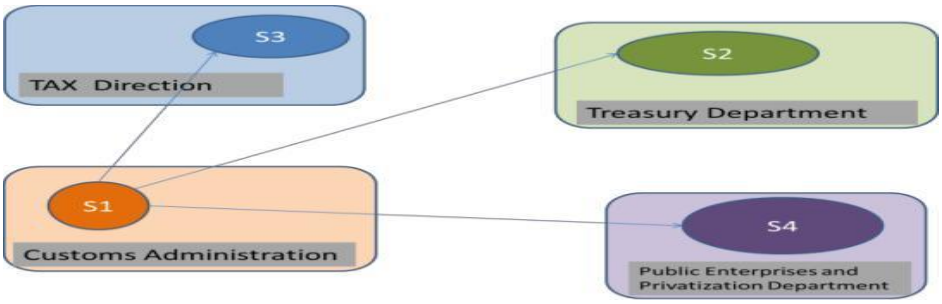

Fig. 2. Extract of a Public Financial Authority process interaction

Assuming that the result of the data quality analysis is presented as follows

Table 1. Table of data quality of network actors

Administrations	Actors	Data quality level
Customs Administration	S1	3
Treasury Department	S2	3
Administration of Tax	S3	5
Department Public Enterprises and Privatization	S4	2

A budget is allocated for this project between this four public administration.

We supposed that administration S1 must collaborate with the S2 in view of the functional dependency between the two institutions and that S1 has the choice between cooperating with S3 or S4 for the implementation of the exchange project. We will measure costs in each coalition:

<u>Coalition 1</u>: S1, S2

Table 2. Calculating Shapley Value

Administrations	Shapley value
S1	2.0
S2	5.0

Coalition 2: S1, S2, S4

The possibility of getting good data quality from S4, motivates the coalition building [S1, S2, S4]. The Shapley value gives the following results:

Table 3. Calculating Shapley Value

Administrations	Shapley value
S1	4.0
S2	5.0
S4	8.0

Coalition 3: S1, S2, S3

S3 has a similar situation as S4, and has the ability to produce high data quality. The best strategy of S1 is collaborating with S3 as it is the best source in terms of data quality, therefore a reduced cost, we get:

Table 4. Calculating Shapley Value

Administrations	Shapley value
S1	2.0
S2	5.0
S3	0.5

We have implemented a Web application developed in JAVA/J2EE, ANT MANGER is composed of several modules developed in JAVA / J2EE technology, with an architecture separating the presentation part (Front-end) from the Business part (Business, Backend), the aim of this architecture is to allow ANT Manager to interface with other platforms carried out by the research teams.

The goal of this platform is to provide a decision-making tool for information systems managers, architects, in order to build the most appropriate collaborative network for the administrative agency context.

ANT MANAGER is currently composed of the following modules:

- Management of user authorizations.
- Workflow theory of network actors.

- Managing collaboration networks (Adding an actor, Linking a player to another)
- Simulation management, according to the algorithm of the game theory (Perform several simulations, simulation backup, simulation suppression export the simulation result in CSV format in order to analyze the various simulations carried out by the architect or the person in charge of the information systems.

5 Conclusion

Displayed equations should be numbered consecutively in the paper, with the number set flush right and enclosed in parentheses.

Globalization leads to increased competition and higher customer expectations. At the same time, companies are stressed to reduce production costs while fronting the challenges of increasing product complexity, environmental concerns. The collaboration of organizations with networks is not a new phenomenon. However, permanent progress of IT in terms of new, reliable, and cheaper

Information and communication technologies are a catalyst for collaboration in networks. Such collaboration is ensured by building a collaborative network. Our approach highlights the identification of actors through data quality in Actor-Network mode of collaboration, this operation by improving the level of data quality translates to cost that is analyzed to all possible coalitions using cooperative game Shapley value.

The proposed work is supported by a software tool which enables to design networks and calculate actors Shapley Value. The main contributions of this work can therefore be summarized as follows:

- As Data quality criteria to identify the selected actors to build the collaboration network.
- Translating data quality objective into cost to analyze coalition.
- Implementation of a web application in order to design and simulate the actor-network evolution based on the cost calculation approach.

After building network collaboration, we are particularly interested in applying social network analysis to analyze this established network.

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Decision support system for implementing data quality projects

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Abstract. The new data-oriented shape of organizations inevitably imposes the need for the improvement or their data quality (DQ). In fact, growing data quality initiatives are offering increased monetary and non-monetary benefits for organizations. These benefits include increased customer satisfaction, reduced operating costs and increased revenues. However, regardless of the numerous initiatives, there is still no globally accepted approach for evaluating data quality projects in order to build the optimal business cases taking into account the benefits and the costs. This paper presents a model to clearly identify the oppor-tunities for increased monetary and non-monetary benefits from improved data quality within an Enterprise Architecture context. The aim of this paper is to measure, in a quantitative manner, how key business processes help to execute an organization's strategy and then to qualify the benefits as well as the com-plexity of improving data, that are consumed and produced by these processes. These findings will allow to select data quality improvement projects, based on the latter's benefits to the organization and their costs of implementation. To fa-cilitate the understanding of this approach, a Java EE Web application is devel-oped and presented here.

Keywords: cost/benefit analysis, data accuracy, data quality projects assess-ment, business processes

1 Introduction

As business processes have become increasingly automated, nothing is more likely to limit and penalize the business processes' performa nce and overall quality than ig-nored data quality. What impacts daily operations, financial and business objectives, downstream analysis for effective decision making and end-user satisfaction [1], whether it is a customer, a citizen, an institutional partner or a regulatory authority. The problem of identification and classification of costs inflicted by poor data quality, has been given great attention in literature [2,3], as well as the definition of approach-es to measure Return On Investment (ROI) of data quality initiatives in both research [4] and industrial areas [5].

Even though the work cited above establishes the overall methodology for measur-ing the business value of data quality initiatives, it lacks generic and concrete metrics, based on cost/benefit analysis, that can be used by different organizations in order to facilitate the identification of opportunities for increased benefits before launching further analysis using additional KPI that are specific to each organization. The over-all goal is not to improve data quality by any means, but to carefully plan data quality projects that are cost-effective and that will have the most positive impact. This guid-ance is particularly crucial for organizations with no or only little experience in data quality projects.

While it is difficult to develop a generic calculation framework to evaluate costs and benefits of data quality projects in money terms, the purpose of this paper is to find a suitable model to assess the positive impact of the improvement of quality of a data object used by a key business process alongside the implementation complexity. This is relevant because the positive impact and implantation complexity could be transformed to quantitative measures of monetary benefits and costs. The application of the proposed model is demonstrated on selected key business processes and business objects that are owned by the Department of Lands of Morocco and the results are presented here. The calculations are performed automatically via our Web applica-tion, which is an implementation of the proposed model.

The organization of this paper is addressed as follows: section 2 presents data qual-ity dimensions as well as data quality projects lifecycle, section 3 describes the main steps of our model and presents the results from our study case; in section 4, the dis-cussion and future work are summarized.

2 Data quality : definition, assessment and improvement

2.1 Data quality: definitions and assessment

Data quality may be defined as “the degree to which information consistently meets the requirements and expectations of all knowledge workers who require it to perform their processes” [6], which can be summarized by the expression “fitnes s for use” [1]. The term data quality dimension is widely used to describe the measurement of the quality of data. Even if the key DQ dimensions are not universally agreed amongst academic community, we can refer to Pipino et al. [7] who have identified 15 dimensions:

- Intrinsic: accuracy, believability, reputation and objectivity;
- Contextual: value-added, relevance, completeness, timeliness and appropriate amount;
- Representational and accessibility: understandability, interpretability, concise representation, accessibility, ease of operations and security.

All case studies that aimed at aassessing and improving data quality have chosen a subset of data quality dimensions, depending on the objectives of the study [8,9,10,11]. Measurable metrics were then defined to score each dimension.

While it is difficult to agree on the dimensions that will determine the data quality, it is however possible, when taking users' perspective into account [12], to define a basic subset of key dimensions, including: accuracy, completeness and timeliness.

Accuracy. Accuracy is defined as "the closeness of results o f observations to the true values or values accepted as being true" [7]. Wang et al. [1] define accuracy as "the extent to which data are correct, reliable and certified". The associated metric is as follows:

(1)

Completeness. Completeness specifies how "data is not missing and is sufficient to the task at hand" [13]. As completeness has often to deal with the meaning of null values, it may be expressed in terms of the" ratio between the number of non-null values in a source and the size of the universal relation" [11]. Completeness is usually associated to the metric below [15]:

(2)

Depending on the context, both accuracy and completeness may be calculated for: a relation attribute, a relation [14], a database or a data warehouse [16].

Timeliness. Timeliness is a time-related dimension. It expresses "how current data are for the task at hand" [13].

As a matter of fact, even if a data is accurate and complete, it may be useless if not up-to-date.

(3)

2.2 Data quality projects lifecycle

Research in this area has shown that poor data quality is costing businesses a significant portion of their revenues. In the US, The Postal Service estimated it cost $1.5 billion in fiscal year 2013 to process undeliverable as addressed mail [17]. A 2011 report by Gartner [5], for instance, noted that as much as 40% of the anticipated value of all business initiatives is never achieved due to poor data quality. In fact, poor data quality affects daily operations, labor productivity, management decision making and downstream analysis.

As such, companies have to evaluate different scenarios related to data quality pro-jects to implement. The optimal scenario should provide the greatest business value and meet requirements regarding the available time, resources and cost.

Prior to introducing our model in the next section, it is suitable to present the common phases that compose a basic data quality project in an enterprise architecture context:

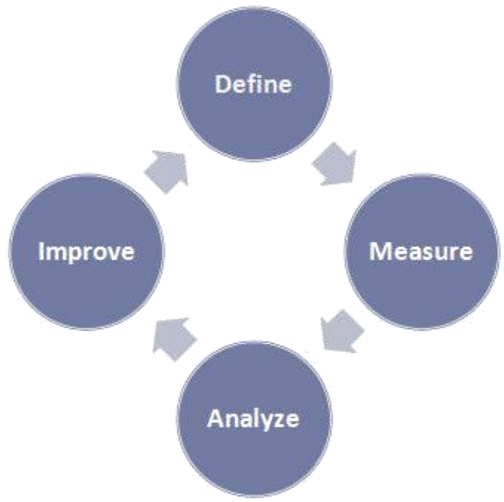

Fig. 1. Phases that compose a data quality project.

Define. Define the various dimensions of data quality from the perspective of the people using the data, using appropriate tools: survey studies, questionnaires, interviews, etc.
Measure. Associate data quality metrics to score each dimension.
Analyze. Interpret measurement results.
Improve. Design and implement improvement solutions on data and processes to meet requirements regarding the quality of data.

In an enterprise architecture context, it is also mandatory to perform process modeling. In fact, a piece of data represented by a business object is accessed in reading or writing modes by a process. Business objects produced by a process may serve as entry data to other downstream processes.

In a further step, it is also possible to perform data augmentation which consists of combining internal data with data from third parties to increase data coverage.

As cited above, we are particularly interested in assessing data quality projects that are related to specific dimensions of data quality, including: accuracy, completeness and timeliness. For the need of our case study, the remainder of this paper will focus on the accuracy dimension.

3 Model for assessing data quality projects

3.1 Business processes' positive impact assessment

The first part of our approach to track ROI of data quality projects consists of understanding how an organization's business/financial objectives and results are linked to key business processes' performance and overall quality. The following steps summarize the process of measuring the positive impact of the performance and overall qual-ity of business processes on the strategy execution of an organization:

1. Identify leading factors that contribute to achieving short-term business/financial objectives of an organization;
2. Configure the importance of these factors according to the specifications of each organization;
3. Measure the impact of key business processes' performance and overall quality on these factors;
4. Order business processes by positive impact.

Leading factors that help achieving business/financial objectives of an organization.

To understand how business processes' performance a nd overall quality affect the success of an organization, financial/business objectives and results are detailed as follows:

- Positive impact on daily operations;
- Increasing revenues;
- Increasing productivity;
- Reducing costs;
- Meeting regulatory driven compliance;
- Positive impact on effective decision making;
- Positive impact on downstream analysis.

Configuration of importance of the above factors according to the specifications of each organization.

Due to organizations' specific aspects and sets of success factors and in order to provide a generic approach that can be implemented without any adjustment, the second step of our approach introduces the context-aware and configurable weighting coefficients, illustrated in Table 1.

The purpose behind using a weighing coefficient is to allow each organization to express the importance of a success factor, depending of its context and strategy. To cite few examples where using different weighting coefficients is relevant:

- Public organizations may have more concerns about increasing end-users satisfaction (citizens in this particular case), than increasing revenues;
- Healthcare actors may give more attention to meeting regulatory driven compliance than to the other factors, while still important, owing to the fact that norms and standards are mandatory in the field of healthcare;
- Industrial companies may give the same importance to all the factors above.

Table 1. Configuration canvas for positive impact calculation

	Values	Rating (R) Weighting coefficient (I)
Impact on daily operations	• true	1
	• false	0
Impact on short-term business/financial objectives	• increasing revenues	0.15
	• increasing productivity	0.15
	• reducing costs	0.15
	• increasing end-user satisfaction	0.15
	• meeting regulatory driven compliance	0.15
	• other	0.15
Impact on decision making	• true	1
	• false	0
Is the process cross-functional?	• true	1
	• false	0

Measurement of the impact of key business processes' performance on overall quality

Business and IT leaders in charge of data quality initiatives should:

1. List all the key business processes;
2. Configure the importance of each factor by acting on the associated weighting coefficient. The sum of all weighing coefficient must be equal to 100;
3. For each factor in column 1, choose the corresponding value in column 2 and rating in column 3.

In the case of an organization with many key business processes, the positive impact of each business process will be calculated, using the weighted sum strategy:

$$(*)/100 \qquad (4)$$

Where R_i is the rating for the factor "i" and I_i is the weighing coefficient that is as-sociated with the factor "i", that was previously d efined by both business and IT lead-ers. The obtained score ranges between 0 and 5, where "0" refers to "unnoticed im-pact" and "5" refers to "high positive impact". The Table 2 depicts the correspond-ence between the positive impact score and the impact level.

Table 2. Positive impact levels

Impact score	Impact level
0 – 1.5	0 – unnoticed to low impact
1.5–3	1 – medium impact
3 – 4.25	2 – high impact
> 4.25	3 – very high impact

Order business processes by positive impact

After iterating over all key business processes and calculating the associated positive impact score, business processes are automatically classified by priority, in order to spot the point of departure to identify opportunities for increased benefits from improved data quality.

As business processes consume and produce data, classifying key business processes by positive impact on an organization's short-term objectives and results, should be followed by the identification of data quality options with the greatest busi-ness value at least-cost.

In addition to the positive impact score, other leading indicators may be assessed using the same approach, including: agile transformation of business processes and potential risks that are associated with data quality initiatives. These aspects will be explored in a future work.

Because business processes access data objects in reading and/or writing modes, it is normal that the quality of the data has an impact on the result of business processes' execution and vice-versa.

3.2 Implementation complexity assessment

While the first part of our approach deals with understanding and assessing how busi-ness processes' performance and overall quality positively impact an organization's objectives and results, the second part of our approach focuses on data that are con-sumed and used by these processes.

The following steps detail the process of scoring the implementation complexity of data accuracy improvement, what will allow to associate different levels of complexi-ty (ranking from low to very high complexity) to DQ improvement projects:

1. Identify leading factors that contribute to the calculation of the implementation complexity of data accuracy improvement;
2. Configure the importance of these factors according to the specifications of each organization;
3. Measure the positive impact and the implementation complexity;
4. Prioritize data to improve according to the scores obtained in the previous step.

Leading factors that help calculating the implementation complexity of data accuracy improvement.

Data profiling activities should allow answering the questions in Table 3.

Table 3. Configuration canvas for complexity calculation

	Values Rating (R) Weighting coefficient (C)	
Are there standards to restructure and validate the data?	• **false** • **true**	1 0
Is there an authentic source of data (repository) that allows to complement or contradict the data?	• **false** • **true**	1 0
Does the data object have attributes with great weight identification in relation to another data source?	• **false** • **true**	0 1
Is the data processing:	• **manual** • **semi-automatic** • **automatic**	1 0.5 0.25
What is the size of the data to process?	• **very large** • **large** • **medium** • **low**	1 0.75 0.5 0.25

In this part, the weighting coefficient plays the same role as in the previous part, as it allows taking into consideration the particularities of each organization.

Measurement of the complexity of data accuracy improvement projects.

For a given data used by a key business process, the implementation complexity will be calculated as follows:

$$\sum(\quad * \# \ )/100 \qquad (5)$$

Where R_i is the rating for the factor "i" and C_i is the weighing coefficient that is as-sociated with the factor "i", that was defined prev iously by both business and IT lead-ers. The obtained score ranges between 0 and 5, here where "0" refers to "minimal complexity" and "5" refers to "severe complexity". The Table 4 shows the corre-spondence between the complexity score and the complexity level.

Table 4. Complexity levels

Complexity score	Complexity level
0 – 1.5	0 – very low-to-low complexity
1.5–3	1 – medium complexity
3 – 4.25	2 – high complexity
> 4.25	3 – very high complexity

The Figure 2 presented below summarizes the main steps of our approach:

1. Determine what processes contribute the most to the business's objectives and results;
2. Determine data improvement complexity;
3. Recommend the optimal business case for data improvement.

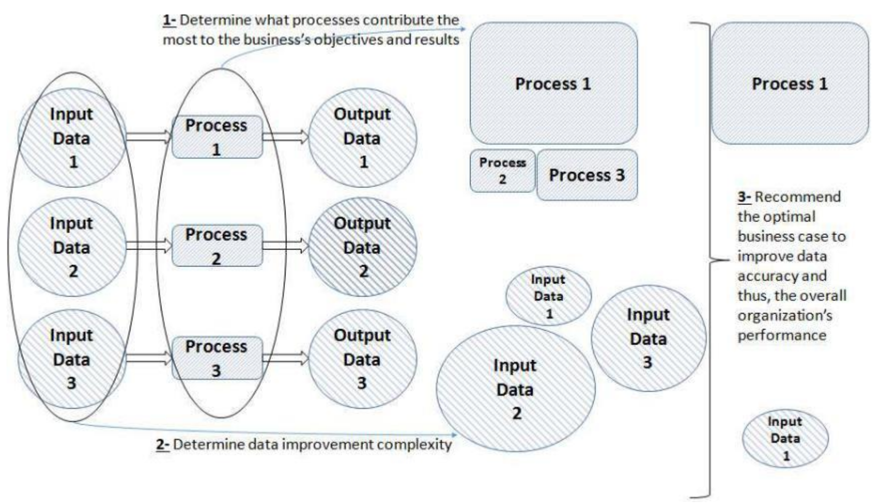

Fig. 2. Main phases.

After completing our research and in order to calculate automatically our indicators, we have implemented a Web application, which main functionalities are:

1. Create a new business process;
2. List registered business processes;
3. Add a new business object (physically implemented by a data object), that is used by a registered business process;
4. List registered business objects;
5. Assess data accuracy improvement projects;
6. List all previous assessments.

3.3 A Use Case Study : decision support system for implementing DQ projects in action

For the purpose of verifying and validating the decision support system for imple-menting DQ projects, we have performed an analysis of data for Morocco Department of Lands (DoL)[1].

The Department of Lands administers the State-owned land mass. Its primary pur-pose is to unlock the potential of State's lands for the economic, social and environ-mental benefits, while optimizing the value of the State's land assets. The Department of Lands is pursuing its objectives through a number of fully automated business pro-cesses including: administering the sale of State's property, managing the Govern-ment's land acquisition program, leasing eligible lands for investment, revenue ac-counting, managing government employees housing, among others. In a dynamic and changing environment and to enable the Department of Lands to carry out its attribu-tions, it is important that the DoL disposes of accurate data. Given the current eco-nomic challenges and budgetary pressures facing most organizations, there is a sub-stantial desire to eradicate quality issues in data through data quality improvement projects, with reasonable budget and changes. The phases that compose the method-ology adopted by the DoL for improving its data accuracy are as follows:

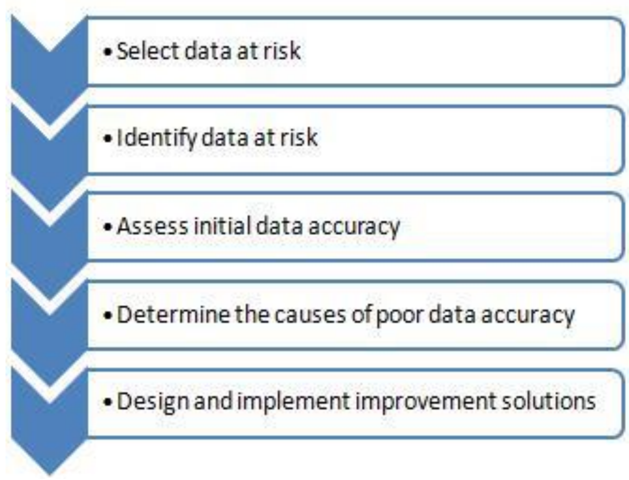

Fig. 3. Phases of the data quality improvement methodology adopted by the DoL.

Our field of intervention has covered phases 1, 2 and 5. In fact, our decision support system was used to identify individual quality projects with the greatest business val-ue at least-complexity, which could be directly correlated with monetary cost. The process of calculating the positive impact and implementation complexity factors was performed automatically via our Web application. The Web application first calcu-lates the positive impact of input business processes. For example, for "registration of

[1] http://www.domaines.gov.ma/

Land's titles" process, we obtained an impact score of 4.71, compared to 4.29 for "evaluation of lands/lodging prices" process. The second step is calculating the implementation complexity of data accuracy for a subset of data that are manipulated by the business processes. The third step is recommending the scenario with the greatest positive impact at least complexity and cost. The list of the selected business process-es and data objects that were considered for our experimental setup where suggested by the users of DoL Information System.

Table 5. Description of business objects

Business object	Definition	Attributes
Evaluated price	• The result of the evaluation of lands that are owned by the State, in order to sell them or lease them for investment	• #property_id • evaluated price
Property – legal information	• Information that describe the legal situation of a land that is owned by the State, in terms of its type (registered, requisition, unregistered), owners and quota shares	• #property_id • legal situation • owners • quota shares
Property – urban situation	• Information that describe the urban situation of a land that is owned by the State, in terms of its area and geographical data	• #property_id • area • zoning • geographical coordinates
Procedure file	• Information that describe the procedure file, including its identifier, location, file opened and closed dates, as well as the related business procedure	• #file_id • location • file opened date • file closed date • business procedure
Accounting document	• Information that describe the type of the accounting document (revenue or expanse), its identifier , amount and related business procedure	• #accounting_document_id • accounting_document_type • amount • business procedure
Beneficiary	• Information that identify the natural or the legal person	• #identifiers • category of the beneficiary • address

Table 5 above describes the potential business objects that are considered for data accuracy improvement. Meanwhile, Table 6 below shows how these business objects are manipulated by critical business processes in terms of database operations. For each business object, the identifier is preceded by the symbol "#".

Table 6. Access matrix

Business object	Business process				
	Evaluation of lands/lodging	Registration of Lands titles	Litigation proceedings	Revenue accounting	Government Employee Housing
Evaluated price	CRUD*	-	read	read	read
Property – legal information	read	CRUD	read	-	read
Property – urban situation	read	CRUD	read	-	read
Procedure file	read	read	CRUD	read	read
Accounting document	-	-	-	CRUD	read
Beneficiary	read	-	read	read	CRUD

(*) refers to database operations: Create, Read, Update and Delete.

Choosing a relevant subset

Keeping in mind that this issue is a statistical challenge because of the large size of databases and/or data files, we have chosen a statistical method for determining the reliable sample size with given restrictions such as the margin of error and the confidence level. The sample size is represented by the equation 6 [18]:

$$\frac{\$^{\%}\times' \times('-1)}{)^{\%}} \qquad (\mathbf{6})$$

In equation 6, (n) is the sample size, (e) is the margin of error and (s) is the per-centage of compliance between records in DoL internal databases and other authentic data sources. The margin of error indicates the accuracy of the chosen sample and the allowed deviation of the expected results. In our calculation, we used a 5% value for the margin error. The confidence level tells how often the true percentage of the sampled data satisfying the required condition lies within the confidence interval. Usually, (Z) is chosen to be 90 or 95%. For the latter value, Z takes a critical value of 1.96.

Decision support tool in action

Our Web application was used to automatically calculate the positive impact and complexity indicators. The results of the experiment are provided below:

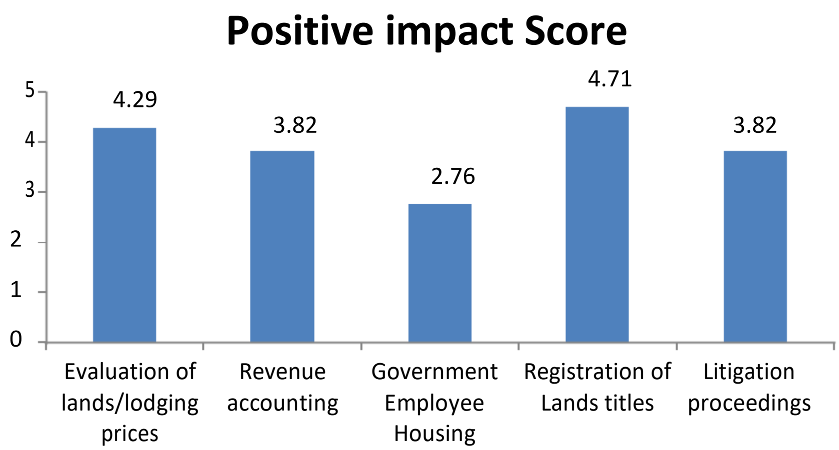

Fig. 4. Positive assessment score for the analyzed business processes.

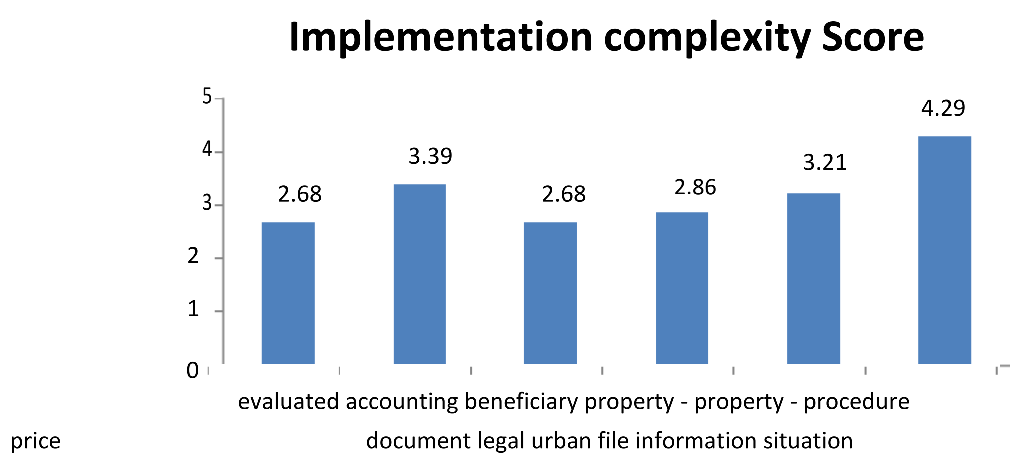

Fig. 5. Implementation complexity score for the analyzed business objects.

Figure 4 illustrates the re sults of the positive impact score calculation. As can be observed, the highest score was related to “registrat ion of Lands titles” process fol lo wed by “revenue accounting”. “Government Employee Housi ng” had the least i mp act. Figure 5 illustrates the res ults of the implementation complexity score calculation. As can be observed, the higheest score was related to “procedure file” data object.

A closer look at the results of the questionnaires administered via our Web appli ca-tion provides information regarding the elements that contributed to high or low lev-els of positive impact and implementation complexity. Data accuracy improvement for the “procedure file” is very complex to setup owing to the fact that there are nei-ther standards to restructu re and validate the data nor an authentic source of data t hat allows to complement or contradict the data. Also the file processing is manual and the size of data to process is high.

What we have so far a ccomplished allows us to associate quantitative measure s to the positive impact and the implementation complexity of data accuracy improvem ent projects. Meanwhile, when we try to estimate the costs that are associated with these projects, we should also take into consideration the initial accuracy of the business objects. This is relevant because it is less expensive to improve a data object w ith higher initial data accuracy.

What leads us to the th ird part of our approach: in figure 6, the x axis represents the accuracy while the y axis represents the cost or the effort associated to data accuracy improvement. For instanc e, it shows that even if the implementation complexity is the highest for the business object “procedure file” (see Figure. 5), improving the d ata object “property – urban s ituation” will be more expensive . This is due to the fact t hat the initial accuracy of “pr ocedure file” is higher that the initial accuracy of “property – urban situation”.

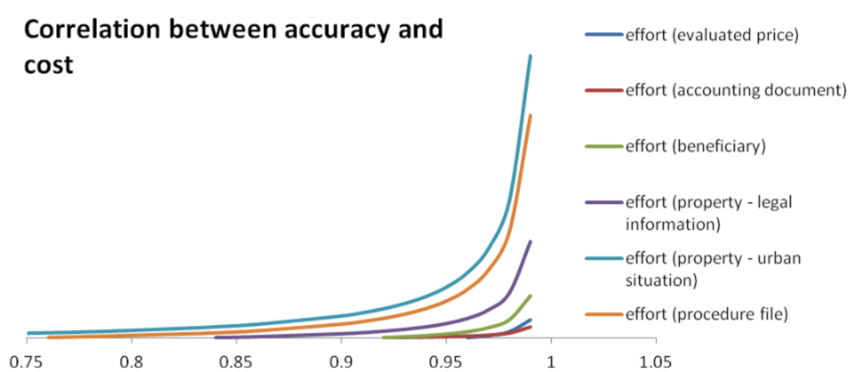

Fig. 6. C orrelation between accuracy and complexity.

In order to build the optimal business case to improve data accuracy and thus, the overall organization’s performance, stakeholders at the DoL will use figures 4 and 6 that represent respectively the benefits and the costs inherent to data accuracy improvement.

4 Discussion and future work

Organizations are discovering that poor data quality have a significant impact on their most strategic goals, often hindering them from achieving the growth, productivity and customer satisfaction that they desire. Minimizing rescissions, rejects and returns have positive impacts on daily operations, cost reduction and financial results. Thus, high-quality data are the precondition for leveraging processes run either by corpora-tions or government agencies, in order to achieve their business initiatives. The de-mand for data quality assessment and improvement methodologies is maturing, espe-cially when it comes to organizations having no or very little experience in the field of data quality projects.

Since the automation of business processes guarantees, in a way, the quality of their execution, actions must be directed towards the improvement of the accuracy of the data used by these processes. Our approach highlights the most cost-effective data accuracy improvement projects. We have established two global indicators of positive impact and implementation complexity, to measure the business value of data accura-cy improvement projects. Furthermore and in order to recommend the optimal busi-ness case to improve data accuracy and thus, the overall organization’s performance, our model takes into account: 1) – the initial data accuracy level (as-is), 2) – the posi-tive impact of the key process that uses the data and 3) – the implementation com-plexity of data accuracy improvement initiative. According to the values of these indicators and to the targeted accuracy level (to-be), two business cases may be con-sidered:

The first one is based on the improvement of data accuracy by determining and an-alyzing the sources of low quality, such as uncontrolled data acquisition, updates problems, etc.

The second one is process-driven as it encourages the improvement of processes (reengineering, control, etc.), by enhancing their execution accuracy. This is a short term option that is generally less expensive, but requires change management because it affects the work processes; In fact, while technology plays a key role in data quality improvement, changes in working methods are critical.

To summarize, the result of the work accomplished so far shows how to measure in a quantitative manner the business value of data quality improvement projects by establishing two global indicators of positive impact and implementation complexity.

As each organization environment is different, it is challenging to see how our model will perform in other contexts other than Enterprise Architecture environment. We are particularly interested in applying it to the context of Open Data that are produced by national governments, where data quality issue could derail the Open Data projects from their purpose.

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ACTOR NETWORK THEORY AS A FRAMEWORK TO BUILD BUSINESS COLLABORATION NETWORK APPLIED TO DIGITAL GOVERNMENT

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ABSTRACT

IT Collaboration applied to digital government between organizations play an essential role to accomplish business objectives. In order to construct networks of collaboration on a real scale using modeling social interactions between different actors. This paper explains a new platform for collaborative designing based on Socio, technical approach Actor Network Theory. ANT4D-GOV software platform implements the steps of Actor Network Theory and collaborative Game Theory algorithm that efficiently provides abstract models of collaboration between different actors by saving cost allocations. The effectiveness of our approach was demonstrated with a real case study. The analyze of the interessement phase reveals the ability to reduce the cost objectives within a collaborative mode. We also present a what-if simulation feature to assess the impact of scenarios related to future collaboration evolution. Furthermore, in providing a live deployment of the * ANT4D-GOV system that allows users to explore the dynamics of collaboration networks in place as well as their involvement over time.

CCS CONCEPTS

• **Smart system → E-Government**;

KEYWORDS

Actor Network Theory; Cost-Sharing, Cooperative game theory, Shapley value; Business Collaboration Network, Digital Government

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1 INTRODUCTION

Network perspective has been an important factor in inter-organizational project governance, and has consequently become a visible concern for a large number of researches. The cooperation within business networks has become a key enabler for trading success.

In order to study the construction of collaborative networks applied to digital government, first we define the Collaborative Network (CN), which permits enterprises to interconnect and collaborate efficiently with their allies and suppliers.

Collaboration between agencies in order to share R&D investments, product development costs and reduce time-to-market becomes more and more common with the increasing market competition and globalization.

The collaboration includes establishment and sharing of knowledge about markets and technologies, setting market standards, sharing facilities. The benefits of collaboration efforts can only be defined by analyzing the conditions that collaboration requires.

So, to encourage potential actors to join the network, the use of game theory mostly the Shapley value is used in our framework to save cost-sharing solution to answer the question. : In what way is the cost shared between the actors in their marginal contributions?

The paper is organized as follows: Section 2 presents the concepts. Section 3 introduces the building of cooperative network applied to digital government using game theory. Section 4 describes developed platform. Finally, Section 5 concludes and plans coming works.

2 CONCEPTS

2.1 Actor Network Theory

Actor Network Theory developed for the domain of science and technology studies during the 1980s particularly related to the work of three academies: Michel Callon, Bruno Latour and John

Law. Taking the name first, ANT tries to understand how networks of actors form. The notion of ‗actor' is more heterogeneous than that: it can cover collectivities of humans (groups, organizations), it can cover non-humans (animals, machines, plants, documents), and it can be argued to cover the intangible (institutions, ideas). [2]

In order to achieve a step of the build and also evaluate network collaboration, Callon and Latour defined an approach, issued by ethnomethodology [3], which allows on a sequence of steps called the translation sequence. To translate is to ―express in his own language what others say and want, to set up as spokesman‖ [4], but translate it is also, negotiate, perform a series of movements of all kinds and thus to each sequence of the process, which can be defined in four main steps (FIGURE. 1):

- Problematization

The problematization consists first of all in identifying the actors involved, their identity and their interests. The intentions of each stakeholder to pose as Obligatory Points Pass (PPO). They present themselves as the indispensable people to achieve the objectives of each. They put together a project that reconciles different interests.

- Interessement

At this stage, the identities and roles of each are defined, a system of alliances or associations is formed. However, it has not been tested yet. The entities designated by the innovators can accept, refuse or discuss what the project promoters propose to them. The next step is a series of negotiations: experiments and adjustments of what has been posed by problematization.

Once interested, the actor engages in the project, he becomes a partner. It recognizes, by this action, the status attributed to it. This phase can be performed using tools called incentive schemes.

- Enrollment

The enrollment phase is the key to the success or failure of innovation [6], but this phase is not studied formally in the literature on control.

Once the profit sharing is successful, the project enters the enrollment phase [5]. With enrollment, the identities proposed by the problematization [7], refined by the incentive, are now locked. Enrollment can be done through discussion, persuasion, negotiation, or violence.

- Mobilization

The last phase of translation, the mobilization is to bring together its allies. the question of whether what is valid for the project participants is equally valid for those they represent [8], Are these spokespersons appropriate representatives of the mass of invisible people in whose name they express themselves? [9] However, "everyone can act separately to the proposed solution: abandon it, accept it as such, modify the methods that join or define it, or adapt them in a completely different context [6].

In a specific way, incentive phase of ANT can be implemented from a cooperative game with transferable utility point of view [6]. Our purpose is to identify the actor-network by using the Shapley Value to identify a better translation of the operating cost for building digital government in an actor-network context.

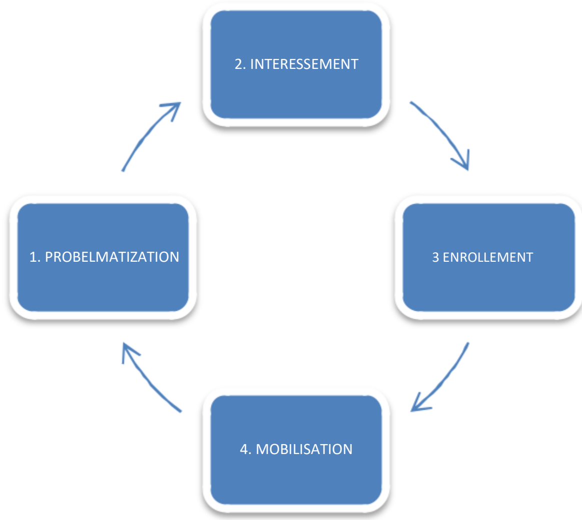

FIGURE. 1. Phases of actor network theory

2.2 Collaborative Network

A collaborative network is network containing a variety of entities that are mostly independent, geographically dispersed, and varied in terms of their operating environment, culture, social capital and goals, but that collaborate to improved achieve common or compatible goals, thus cooperatively producing value, and whose relations are supported by computer networks [1].

A Collaborative Networked Organization (NOC), or simply a collaborative network, is a term used to define "alliances between different organizations".

Participation in these types of networks will increase survivability and competitiveness in confusing contexts as companies can access large markets, reach new knowledge and share risks and resources, while joining complementary skills [12]. The industrial sector [13, 14], the agro-food sector [16], ICT, the transport sector [15], health [17, 18], also other areas of activity that benefited from the adoption of a collaborative network [19] etc.

Distinct forms of collaborative networks, including virtual enterprises (VE), virtual organizations (VO), dynamic supply chains, industry clusters, business ecosystems, virtual organizations, Professional virtual networks can be found in our society. These cases are classified according to their internal structure and organizational model, purpose or business model [20].

2.3 Cooperative Game

Game theory is a mathematical tool that is used to analyze the strategic interaction between multiple decision makers (Shin, D. H. 2010). Firstly it was used in economics for understanding the concept of economic behavior. But now it is used in various fields such as communication, biology, psychology for modeling the decision making situation where the outcomes depend upon the interacting strategies of many agents.

The theory of cooperative games is applied to the actors to obtain more gains by collaborating than by remaining closed. The cooperative game theory is composed of two elements: (i) a set of players, and (ii) a characteristic function detailing the value created by the different subsets of players in the game [10].

The difficulty in building coalitions is one of the important issues in game theory, both in cooperative and non-cooperative games. There are several works done to analyze this problem, many researches have tried to find stable coalition structures in a cooperative game mode.

Then, the value created as a result of the grand coalition must be assigned to the individual players, depending on the contribution of each player. The interest of this work is the sharing of the gains between the actors of the coalition likely to be formed by using the game theory like tool to implement the phase of interest of the theory ANT.

The value of Shapley is a cost-sharing method widely used in cooperative game theory based primarily on incremental costs [10]. The Shapley value of a player i in a given game characterized by the characteristic function V is the part of the surplus that must be allocated. It is a weighted average of a player's participation in reaching the possible coalition.

For example, consider a game of three players, i1, i2 and i3, suppose the player i1 is the first player in the game, i2 is the second player to integrate the game and the player i3 is the last player

Player i1 is allocated a cost C ({i1}), player i2 is allocated a cost C ({i1, i2}) – C ({i1}), and player i3 a cost C ({i1, i2, i3}) – C ({i1, i2}). The Shapley value accepts that the order of appearance is arbitrary and the possibility that a player joins first, second, third, etc. a coalition is the same for all players. Assume that force of each coalition is known in the form of the characteristic function V. The cost allocated to a player i in a game, including a set N of players is given by:

$$\phi i(N) = \left(\sum_{S \subseteq N : i \in S} \left(\frac{(|S|-1)!(|N|-|S|)!}{|N|!} \left(\left[C(S) - C(S \setminus \{\} i) \right] \right) \right. \right. \quad (4)$$

|N| and |S| respectively, the total number of players and the one belonging to the coalition S.

An alternative equivalent formula for the Shapley value is:

$$\phi i(N) = \left(\frac{1}{|N|!} \sum_{R} (v(\mathrm{P}Ri \quad \{i\}) - v(\mathrm{P}Ri)) \right. \quad (5)$$

Where the sum ranges over all |N| orders R for the players and PRi is the set of players in N which lead i in the order R.

The choice of the cost allocation approach is a difficult choice. According to the literature, Shapley's value seems to fit this context of building stakeholder-network collaboration networks to implement and evaluate digital governance. Indeed, Shapley imposes four axioms to satisfy (Efficiency, Symmetry, Dummy and Additivity).

(i) Efficiency: the sum of the values attributed to the players must be equal to what the coalition of all the players can obtain: $\sum I \in N \ \varphi_i (v) = v (N)$.

(ii) Symmetry: Players i, j ∈ N are said to be symmetric, If two players can substitute in each coalition, then they receive the same gain: i.e., for each S ⊂ N with i, j ∉S, v(S ∪ i) = v(S ∪ j). In another way, if the players i and j are symmetric with respect to game v, then

$\varphi_i (v) = \varphi_j (v)$.

(iii) Dummy: If i is a dummy player, i.e., v(S ∪ i) - v(S) = 0 for every S ⊂ N, then $\varphi_i (v) = 0$.

(iv) Additivity: φ (v+w) = φ (v) +φ (w), where the game v+w is defined by
(v+w) (S) = v(S) +w(S) for all S.

The dummy, symmetry (significance that two players have the same strength Strategy will obtain the similar gain) and efficiency make the Shapley value, particularly attractive for treating the problem of equitable sharing of resources common to several economic agents.

2.3 Digital government

Governments worldwide, identify e-Government as a strategic option to improve their (internal and external) operations. In order to implement citizen-centric services, these services need to integrate with stakeholders both vertically and horizontally. This can be achieved by bringing the efficiency and experience of e-Government. This requires new e-gov models to reduce costs and improve government services [20].

Digital government, e-Government is terms that have become synonymous with the usage of information and communication technologies in government agencies. Inter-organizational information integration has become a key enabler for e-Government. Integrating and sharing information across traditional government boundaries involves complex interactions between a variety of participants all using complicated technical and organizational processes. From a technical perspective, systems designers and developers must regularly overcome problems related to the existence of multiple platforms, diverse database designs and data structures, highly variable data quality, and incompatible network infrastructure. From an organizational perspective, these technical processes often contain new processes, mobilization of limited resources, and evolving inter-organizational relationships. These essential changes are influenced by explicit types of social collaboration, which take the form of network collaboration decision-making, learning, understanding, trust building, and conflict resolution [21].

A recent line of e-Government research has highlighted the importance of inter-organizational information sharing in the public domain. For example, [21] explored information sharing relative to service performance..

This collaboration inter-organizational improvement in information sharing will develop the performance of public sector services [21].

In order to take advantage of the great benefits of digital government, the integration of information across organizational barriers is necessary. However, these digital government initiatives face bottlenecks because the required level of inter-organizational collaboration and trust is often not supported by institutional arrangements, organizational structures. [22]

Although several digital researchers divide research focuses on access to technology, another cause of the split is the absence of information awareness called information asymmetries which are often seems to be from inadequate information sharing [23].

3 RELATED WORKS

In this section, we will discuss a representative set of existing studies that are working on collaborative networks and collaboration theories used to build collaborative networks applied to digital government.

Collaborative Network (CN) are complex systems that can be described or modeled from multiple perspectives. The collaborative network was detailed by researchers as a virtual network. Camarinha Matos is one of the widely recognized researchers working in the domain whose researchers are essentially converged on IT perspectives and necessities of Collaborative Networks.

Today, the notion of ―network‖ is a central issue in many domains, including: social sciences, communications, computer science, physics, and even biology and ecosystems, [24] Given the large diversity of manifestations of collaborative networks in different application domains, often using different terminologies, it is important to elaborate nomenclature of the various organizational forms and provide a (informal) definition or description of the terms used. Collaborative networks are usually identified as significant instrument in existence of organizations in a period of turbulent socio-economic variations. A rising number of diverse CN forms are emerging like supply chain, Virtual Business Enterprise (VBE), Virtual government or collaborative e-government as a result of the progresses in ICT, the market and societal needs.

Inter-organizational are generally recognized as a powerful strategy to improve public sector initiatives, but the build of such programs requires deep collaboration and an appropriate institutional environment [25].

Collaborative digital government projects have some unities [25]. Several of these initiatives create from problems within a single management agency that generate a necessity to collaborate. They require the integration of various sources of information, which represents technical and organizational challenges. Participating agencies face the technical challenge of promoting the interconnection between different information systems, created in different architectures and structures, on the one hand, and the challenges of collaborating with the owners of these data - on the other hand. Organizational boundaries to share information ressources and develop the new system.

Using the results of previous work on enterprise modeling such as Zachman, CIM-OSA, GERAM, etc., ARCON aims to assist in better representation of collaborative networks and to provide a more systematic foundation for the design and development of collaborative networks. Analysis of new NOCs. A first complete reference model for collaborative networks applying the ARCON framework was developed by the ECOLEAD project [26].

The ECOLEAD project followed a more complete approach considering both long-term and temporary organizations as well as networks of organizations and networks of people.

In this context, there is no single modeling formalism or ―universal language‖ that can cover all perspectives of interest.

4 ACTORS NETWORK BUILDING GAME

In our context players are actors of collaboration network. Actors are obligatory to collaborate in advance to take and implement joint decisions, coordinate their actions and pool their winnings & cost. It appears a cooperative game where the actors come together to form coalitions, and all of whom seek to optimize the cost of their own operations. They can, through cooperation, realize gains in the form of cost saving. This is the method taken here. Costs are then divided between the players relative to their marginal contributions [28].

To validate the cost-sharing model with cooperative game in this coalition building process, by applying a concept of axiomatic solution, in this case the Shapley value [29].

Let N = {1 . . . n} is a set of players. A coalition is any subset of N. The set of all coalitions is represented by 2^n.

A coalitional form concern on a finite set of players S {1, . . . , n} is a function v from the set of all coalitions 2^n to the set of real numbers R with v (∅) = 0. V (S) characterizes the total worth the coalition S can get in the game v.

The experimentation of this approach of identification actors based on approach ANT, was executed on the inter-organizational sharing data project for the administration of customs of Morocco by using a developed a platform to design the collaboration network by implementing the cooperative game theory and ANT [27]

5 TECHNICAL ARCHITECTURE

The development of a Web application in JAVA/J2EE, ANT4D-GOV is composed of several modules developed in JAVA / J2EE technology, with an architecture separating the presentation part (Front-end) from the Business part (Business, Backend), the aim of this architecture is to allow ANT Manager to interface with other platforms carried out by the research teams (FIGURE 2).

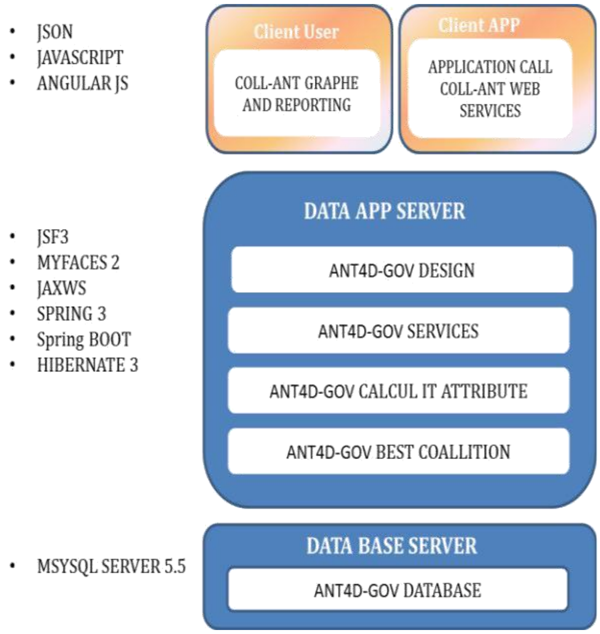

FIGURE 2. ANT4D-GOV Software Tool Implementation Architecture and technologies.

The goal of this platform is to provide a decision-making tool for information systems managers, architects, in order to build the most appropriate collaborative network for the administrative agency context.

ANT4D-GOV is currently composed of the following modules:

- Management of user authorizations.
- Workflow theory of network actors.
- Managing collaboration networks (Adding an actor, Linking a player to another)

The application is a platform collaborative centered in the networks of collaboration, the governorship of the systems of information and the theory of the actor network (Actor Network Theory) which goals to put a tool of decision-making aid of the persons in charge of the information systems, architects, DSI,… in order to build the network of collaboration more adapted to the context of the administration's/Entities.

The platform is composed of several modules developed in technology JAVA/J2EE, with the purpose of an architecture separating the part presentation (Front-end) of the part Trade (Business, Backend), this architecture is to make it possible to interface with other platforms carried out by the research teams, by exposing web-based-service.

The developed platform is composed of the following modules:

1. Management of users.
2. Management of workflow of the theory of the actor networks.
3. Management of the networks of collaboration (To add an actor, To bind an actor to another).
4. Management of simulation according to the algorithm of the game theory (To carry out several simulations, backup of simulation, suppression of simulation (FIGURE 3).
5. Extract the result of model in a data file in order to study the different models designed by the architect of the information systems.

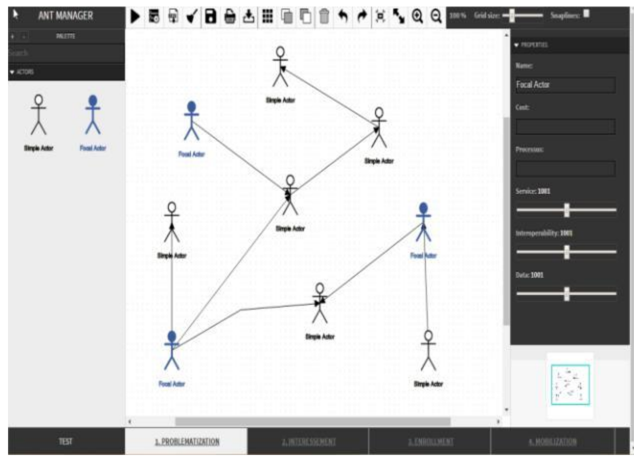

FIGURE 3. Web Application ANT4D-GOV

Numerical results demonstrate that our approach permits to achieve very effective cost allocations, thus representing an efficient framework for the conception of stable networks.

6 Conclusion

Information and communication technologies have been considered as one powerful strategy for service improvement in government. . Recently, experiments have shown that in order to use of the benefits of digital government, the incorporation of information through organizational restrictions is necessary. However, these digital government initiatives face additional challenges, since the required level of inter-organizational collaboration and trust is often not maintained by current institutional arrangements, organizational structures, and executive processes. Based on an extensive case study in the Moroccan government, especially in the ministry of finance, this paper highlights the identification of actors by saving costs in the Actor-Network mode of collaboration applied to digital government.

Also the proposed work presents the development software tool which enables to conceptualize networks and calculate Shapley Value of the network.

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ACTOR NETWORK THEORY A FRAMEWORK OF IT COLLABORATION

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***Abstract*—Collaboration between organization changes dynamically and spreads rapidly through a Collaborative Network (CN). Developing methods for handling such networks of collaboration on a real scale requires modeling social interactions between different actors in order to share, analyze, and suggest improvements for a collaboration perspective. This paper describes a new tool for collaboration modeling based on Actor Network Theory. *ANTCollab system is based on Actor Network Theory and Game Theory algorithm that efficiently provides abstract models of collaboration between different actors aiming at uncovering cost allocations concerns. We demonstrate the effectiveness of our approach with a real case study. The analyze of the *interessement phase reveals that we are able to increase the cost saving objectives within a collaborative mode. We also present a what-if simulation feature to assess the impact of scenarios related to future collaboration evolution. Furthermore, we provide a live deployment of the *ANTCollab system that allows users to explore the dynamics of collaboration networks in place as well as their involvement over time.**

Keywords—Collaboration Network, Actor Network Theory, Cost-Sharing, Cooperative game theory, Shapley value

I. INTRODUCTION

A collaborative network (CN) is constituted by a variety of entities (e.g., organizations and people) that are largely autonomous, geographically distributed, and heterogeneous in terms of their: operating environment, culture, social capital, and goals. [15].

In order to study the best collaboration network under the scope of social network, we need to present collaboration network (CN) which enables companies to communicate and collaborate with their customers, partners and suppliers in a productive way [1]. This cooperation takes different forms, from simple information exchange, to business process interoperability among independent enterprises [6], [11], and also in term of cost-sharing. In fact, independent businesses become able to collaborate in order to have beneficial results for all [2], We use game theory as a cost-sharing arrangement, whereby those actors are able to "translate" their goals into objectives that make sense to each actor. Then, to motivate eventual partners to join the network (coalition is used to in this paper to describe an actor-network), Shapley value [10] is used in our framework as a fair cost sharing solution to respond the question: How the costs are divided between actors relative to their marginal contributions in an actor-network context?

This paper present research was conducted iteratively, this leads us to introduce Actor-Network Theory (ANT) [3], [4] as a social framework of collaboration, that helps us make sense of collaboration evolution between the different actors of the network.

The originality of this work is the use of ANT to build collaborative networks, by inciting actors to choose the best coalition through cost saving applying Shapley values.

The main contributions of this work are summarized as follows:

- Presentation of the architecture of ANTCollab system based on Actor Network Theory and Game Theory algorithm
- Integration of the cooperative game theory as an algorithm for identifying the actors.
- Simulation platform for design and simulate best coalitions, ANTCollab.

The paper is structured as follows: Section 2 presents the motivation and background. Section 3 introduces the building of cooperative network using game theory. Section 4 presents the evaluation of our approach by calculating Shapley Value in a realistic Actor-network context, and describe developed platform. Finally, Section 5 concludes and outlines future work.

II. BACKGROUND

A. *Business Collaboration Network*

The cooperation speaks to a test for open and private associations. It is both a wellspring of added esteem and use to a superior working of associations through enhanced operational execution. The conceivable outcomes offered by the stages of the Information Systems develop progressively to new types of participation with accomplices. The business

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arranged structures are among the most utilized structures to accomplish the target of the worldwide administration in a collaborative context.

Collaboration Network includes a set of cooperating entities, autonomous and heterogeneous, under different governance areas and working together. Collaboration refers to the act to establish a group of common interest in the short, medium or long term and work in synergy in an environment of trust for achieving common or complementary objectives [5]. This situation assumes the existence of a formal cooperation agreement representing the responsibilities of each member of network collaboration.

The economic environment of the private sector is strongly growing; companies are facing increased competition and saturated markets. They must improve their productivity, profitability and show flexibility to the demands of the market while remaining at the top in their sectors of competence, also and above saving costs. In addition, customers are becoming more demanding of the products and services offered to them [7].

Similarly, the public government receives more openness and a readiness to break with the practical boundaries, organizational and technology in order to propose homogeneous and coherent services and could well serve clients transparently [8]. At last, the collaboration in the delivery of public services involves increasingly the use, to private organism as a major aspect of the Public Private Partnership [9].

Confronted with these difficulties, bury authoritative collaboration is defended as basic vital basic for better working [12], particularly, by and large; a solitary association can't fulfill client prerequisites at a cost sensible [13].

In such situation, any organization has an interest to rethink its ways of working and better organize them, either internally or in inter organizational framework. Such network of collaboration consists of a set of cooperating entities combining efficiently during the life of cooperation, tools and adequate resources to meet a common need [14].

Therefore new forms of collaborative spaces where various structures work and react together, appears in various forms such as virtual organization, network of organizations, organization of alliance, network organization extended, etc. The Figure 1, outcome of the reference model of collaborative networks established by the European research project "European Collaborative networked organizations leadership", which illustrates the possible forms of these networks and the relationships between them

To analysis the constitution of the collaboration network process, we will mobilize the sociology of translation, also called Actor Network Theory (ANT). This theory is particularly pertinent in explaining the behavior of actors in collaborative networks, it consists of four steps: Problematization, Interessement, Enrollment, and Mobilization. In this paper, we focus on the second phase, which is the interessement of actor network using cost sharing and cooperative game.

B. Actor Network Theory (ANT)

Actor Network Theory (ANT) was developed as part of research on the innovation process and is rooted in a socio-technical approach to organizations. The founders of this current, Akrich, Callon and Latour [23] have shown that successful innovation depends on the success of an unprecedented association between multiple and different actors. From this association, mobilization and cooperation of all stakeholders will emerge a socio-technical network and a dynamic production that aims process efficiency and success.

The second important notion of ANT is the “Actant” Callon and Latour borrow this concept to semiotician Greimas. The latter replaces the term personage by the term actant, that “who does or endure an act”, because it applies not only to humans but also to animals, objects, concepts. The actants may be human or non-human and should be treated with the same importance as required by the principle of symmetry.

In order to reach a step of the construction of a network, Callon and Latour defined an approach, inspired by ethnomethodology [27], which bears on a sequence of steps called the translation sequence. To translate is to “express in his own language what others say and want, to set up as spokesman” [3], but translate it is also, negotiate, perform a series of movements of all kinds and this to each sequence of the process, which can be defined in four main steps:

Problematization:

“The problematization or how to become essential?”, “The problematization, as its name indicates asking at first a problem. This is to raise awareness to a number of actors that are concerned by this problem, and that everyone can find satisfaction through a solution that translators are able to offer” [17], so problematization is the effort made by the actors to convince that they have the right solution[16]. It "describes a system of alliances or associations between entities, defining this, [their] identity and what they want" [18].

Interessement:

"The incentive devices or how to seal alliances", the incentive is in fact for Callon "all actions through which an entity is trying to impose and stabilize the identity of the other players who is defined in problematization" [17] incentive is the second phase, consists of "deployment speeches, objects and devices intended to attract and attach different players to the Network" [19].

It is building the interface between the interests of different actors and the strengthening of the relationship between these interests. In the area of strategy, it can be a system of alliances to ensure that the different members of the organization are involved in the strategic process.

The main thing is to translate the interests of other actors in order to get them to take part in the network. To translate the interests of others, we can either convince them that there are common interests and that the proposed solution also serves their interests or manipulate their interests and objectives or finally become unavoidable.

Enrollment:

"How to define and coordinate the roles", Enrollment is "the set of multilateral negotiations, beatings forces or tricks that come with sharing and allow it to succeed" [17].

For enrollment, each actor in the network is assigned a role. This role is related to the translation of their interests. For Callon, «the enrollment is to describe the set of multilateral negotiations, coups or intelligence accompanying sharing and allow it to succeed" [18]. The enrollment can thus be regarded as stabilizing the system of alliances set during the phase of the incentive. This system is the result of multilateral negotiations, trials of strength and stratagems [18]. It is during this phase to confront showdowns integrating new actors to the networks or by strengthening links between network members.

The enrollment phase is the key to the success or failure of innovation [18], but this phase is not studied formally in the literature on control.

Mobilization:

The last phase of translation, the mobilization is to gather its allies. It is the cockpit of the various interests in a way that they remain more or less stable [20], it raises the question of the representation of stakeholders and enrolled in the project which is then established as spokespersons of the groups they represent [21]. However, "everyone can act very differently to the solution proposed: the abandon, accept it as it is, change the modalities which accompany or statement that it contains, or even they will be appropriated in the transferring in a completely different context" [18].

In a particular way, incentive phase of ANT can be analyzed from a cooperative game with transferable utility point of view. Our objective is to set up the network by incenting actors through cost savings. For that, we use the Shapley Value to answer the question: Which coalitions are likely to form in order to ensure best translation of cost-saving objectives in an actor-network context?

C. Cooperative game theory

It is agreed to distinguish two major gaming families: cooperative games in which players build agreements which bind them and non-cooperative games in which players are entirely free from their decisions as they make their choices.

The cooperative game theory can be applied to the case where actors can achieve more benefit by cooperating than staying alone, it consists of two elements: (i) a set of players, and (ii) a characteristic function specifying the value created by different subsets of the players in the game [24]. The coalition formation problem is one of the important issues of game theory, both in cooperative and non-cooperative games. There are several attempts to analyze this problem. Many papers tried to find stable coalition structures in a cooperative game theoretic fashion. If we suppose that forming the grand coalition generates the largest total surplus, it is natural to assume that the grand coalition structure will eventually form after some negotiations [26].

Then, the worth of the grand coalition has to be allocated to the individual players, according to the contribution of each player [26]. We are interested in this work in cost-sharing between coalition members likely to form using Game theory as a device for ANT interessement phase

D. Cost-Sharing for profit collaboration

The call for projects is one of incentive mechanisms used to encourage actors in organizations and administrations to join forces and coordinate in order to submit, develop and make this public act together. The build on partnership and coalition intra and inter-departments appears a strategic decision to reduce costs and achieve the submitted projects. The rules of sharing common costs and benefits of cooperation are important factors of competitiveness, performance and motivation. Actor being rational; should join the coalition that provides the best gain, the lowest cost respectively. Indeed cost-sharing is a way to incite actors to join coalition whereby project managers are able to "translate" their goals (especially financial ones) into objectives that make sense to each actor. These allocations or shares should not determine by free and anonymous markets, but rather by administrative rules and explicit mutual agreements descended from economic theories.

E. Actor-Network building Game

In our framework players are actors of network. To the extent that they may have common interests, actors are required to cooperate in advance to take and implement joint decisions, coordinate their actions and pool their winnings & cost. It appears a cooperative game where the actors come together to form coalitions, and all of whom seek to optimize the quality and cost of their own operations. They can, through cooperation, realize gains in the form of cost reduction. We can discuss it during the game in terms of the distribution of costs rather than gains. This is the approach taken here. Costs are then divided between the players relative to their marginal contributions.

To formalize the cost-sharing model with cooperative game in this coalition building process, we apply a concept of axiomatic solution, in this case the Shapley value.

Let $N = \{1. . .n\}$ be a finite set of players. A coalition is any subset of N. The set of all coalitions is denoted by 2^n.

A coalitional form concern on a finite set of players $S\{1, . . . , n\}$ is a function v from the set of all coalitions 2^n to the set of real numbers R with $v(\emptyset) = 0$. V (S) represents the total worth the coalition S can get in the game v.

F. The use of Shapley value

The Shapley value is a very common cost-sharing procedure in cooperative game theory essentially based on the so -called incremental costs [24]. The Shapley value of player i in the game given by the characteristic function V is the share of the surplus should be assigned. It's a weighted average of the contributions of a player i to reach of the possible coalition.

For example, consider a game with three players, i_1, i_2 and i_3. Assume that player i1 is the first player of the game, i_2 is the second player to join the game and player i_3 is the last one. Player i1 is allocated a cost $C(\{i_1\})$, player i_2 is allocated a cost $C(\{i_1, i_2\}) - C(\{i1\})$, and player i3 a cost $C(\{i_1, i_2, i_3\}) - C$

({i_1, i_2}). The Shapley value assumes that the order of arrival is random and the probability that a player joins first, second, third, etc. a coalition is the same for all players. Assume that force of each coalition are known in the form of the characteristic function V. The cost allocated to a player i in a game, including a set N of players is given by:

$$\varphi i(N) = (\sum_{S \subseteq N: i \in S} (\frac{(|S|-1)!(|N|-|S|)!}{|N|!}([C(S) - C(S \setminus \{i\})])$$

N| and |S| respectively, the total number of players and the one belonging to the coalition S.

An alternative equivalent formula for the Shapley value is:

$$\varphi i(N) = (\frac{1}{|N|!}\sum_{R} (v(P_{R}i \ \{i\}) - v(P_{R}i))$$

Where the sum ranges over all |N| orders R for the players and P Ri is the set of players in N which precede i in the order R.

Choosing a method of cost allocation is not an easy thing. According to the literature Shapley value seems to be suitable to this context of actor-Network building game. In fact, Shapley imposes four axioms to be satisfied (Efficiency, Symmetry, Dummy and Additivity).

(i) Efficiency: players precisely distribute among themselves the resources available to the grand coalition. Namely, Efficiency: $\sum I \in N \varphi_i (v) = v(N)$.

(ii) Symmetry: Players i, j ∈ N are said to be symmetric with respect to game v if they make the same marginal contribution to any coalition, i.e., for each $S \subset N$ with

$i, j \notin S$, $v(S \cup i) = v(S \cup j)$. In another way, if the players i and j are symmetric with respect to game v, then $\varphi_i (v) = \varphi_j (v)$.

(iii) Dummy: If i is a dummy player, i.e., $v(S \cup i) - v(S) = 0$ for every $S \subset N$, then $\varphi_i (v) = 0$.

(iv) Additivity: $\varphi (v+w) = \varphi (v) + \varphi (w)$, where the game v+w is defined by $(v+w)(S) = v(S) + w(S)$ for all S.

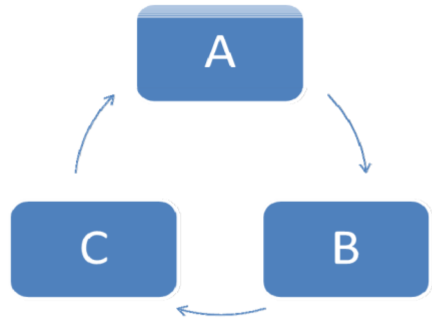
The dummy, symmetry (meaning that two players have the same strength Strategy will receive the same gain) and efficiency make the Shapley value, particularly attractive for treating the problem of equitable sharing of resources common to several economic agents.

G. *Applied cost saving within a public institution with several actors*

An administration with several actors (department, partners, suppliers...) may wish to establish a methodology for the allocation of common costs that encourages collaborators to contribute to minimizing the common cost. As shown Shubik (1962), the allocation of common costs in the company can be seen as a cooperative game between different departments.

To fix ideas, consider the following example with three directions (A, B and C) of the same department that are in agreement with a company to perform backup sites. The project amounts to 10 million for each direction taken separately. For technical reasons, the service provider offers cost (reduced) respectively 16, 17 and 18 for joint contracts between A and B, A and C, B and C.

Fig. 1. NETWORK COLLABORATION OF ADMINISTRATIONS



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The contract involving the three directions has a cost of 24. The cost function is given then by:

TABLE I. TABLE OF COSTS

Coalition	Cost
A	10
B	10
C	10
AB	16
AC	17
BC	18
ABC	24

The construction of a common backup site might be more profitable than building smaller sites. Indeed, the three directions get a fair deal, and are motivated to form a coalition since their cost parts are below their costs of going it alone. How costs should, they are distributed among the three directions?

This issue can be described by a three-player game, N = {A, B, C} is thus obtained:

TABLE II. THE CHARACTERISTIC FUNCTION ELEMENTS

Coalition	Gain
A	0
B	0
C	0
AB	4
AC	3
BC	2
ABC	6

Applying Shapley formula (1), there are six possible arrival orders (3!). They are listed in the following table which gives the marginal contributions, according to each of them. For example, P_A (ABC) = v ({A}) - v (θ) = 0 - 0 = 0, P_B (ABC) = v ({AB}) - v ({A}) = 4-0 = 4, etc.

The distribution of v (N) cost reduction, according to the Shapley value is given by φ (v) = (2.5, 2, 1.5). In terms of cost sharing, the calculation is illustrated in Table below.

TABLE III. CALCULATING THE SHAPLEY VALUE

Entry order	**Marginal contributions**		
	A	**B**	**C**
ABC	0	4	2
ACB	0	3	3
BAC	4	0	2
BCA	4	0	2
CAB	3	3	0
CBA	4	2	0
Total	15	12	9
Shapley Value	15/6	12/6	9/6

This means that about 24 million, the directions A, B and C have to pay 7.5; 8 and 8.5 respectively.

III. EVALUATION

After completing this research, and in order to validate the approach presented in this paper, we developed a web Java platform composed of different functional modules;

The Platform we developed is a platform collaborative centered in the networks of collaboration, the governorship of the systems of information and the theory of the actor network (Actor Network Theory) which aims to put a tool of decision-making aid of the persons in charge of the information systems, architects, DSI,… in order to build the network of collaboration more adapted to the context of the administration's/Entities.

The platform is composed of several modules developed in technology JAVA/J2EE, with the purpose of an architecture separating the part presentation (Front-end) of the part Trade (Business, Backend), this architecture is to make it possible to interface with other platforms carried out by the research teams, by exposing web-based-service.

The developed platform is composed of the following modules:

1) Management of users.

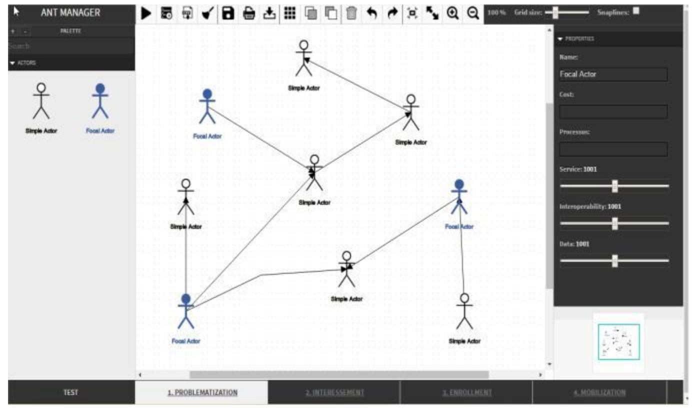
2) Management of workflow of the theory of the actor networks.

3) Management of the networks of collaboration (To add an actor, To bind an actor to another).

4) Management of simulation according to the algorithm of the game theory (To carry out several simulations, backup of simulation, suppression of simulation.

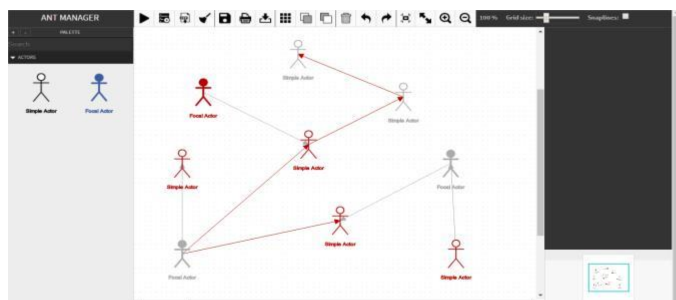
5) Export of the result of simulation under CSV format in order to analyze the different simulations carried out by the architect or the person in charge of the information systems.

Fig. 2. WEB APPLICATION ANT MANAGER



The fig2 is capture of web application after simulating the best coalition in cost saving

Fig. 3. WEB APPLICATION ANT MANAGER



Numerical results demonstrate that our approach permits to achieve very effective cost allocations, thus representing an efficient framework for the conception of stable networks.

IV. RELATED WORKS

ANT was initially proposed by Michael Callon and Bruno Latour in the mid-1980s to describe the creation and advancement of social-specialized systems [31]. The hypothesis was later developed and formalized [29]; [30]. In its unique conceptualization the theory concentrated on performing artists characterized as: "any component which twists space around itself makes different components subordinate upon itself and makes an interpretation of their will into the dialect of its own" [31]. This translation of interests leads to the creation of networks of aligned interests.

Most of the studies we reviewed were case studies of an attempt to implement collaborative governance in a particular sector.

V. CONCLUSION AND FUTUR WORK

The present paper has displayed an approach of system foundation, by inciting actors through cost saving. For that, Shapley Value of cooperative game is exploited to determine the adequate coalition to to form in order to ensure best cost-saving objectives in ANT mode of collaboration. The proposed work is implemented by a platform JAVA/J2EE which enables to configuration system and figure actor's Shapley Value.

Aside from that, our present theoretical model still requires more elaboration on points of interest, and the Shapely value that can be used to support interessement phase of ANT remains as a proposal on account of financial goals. Future work may require more observational research with various sorts of actors and targets.

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IT COLLABORATION BASED ON ACTOR NETWORK THEORY: ACTORS IDENTIFICATION THROUGH DATA QUALITY

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Abstract. IT collaboration involves exchanging information and data within a network with several actors in order to achieve business objectives. Such cooperation is generally ensured by building a collaborative network. This work presents an approach of actors identification through data quality in Actor-Network mode of collaboration. Indeed, data quality is one of the important characteristics which expose the actor importance in the network. We investigate the translation process of ANT (Actor Network Theory), while focusing on the problematization phase in which actor-networks are identified according to the data quality level provided, and then translating this level into cost and analyzing all possible coalitions using cooperative game. The findings will allow identifying which coalitions enhance data quality. The build of such actor-network depends therefore on both data quality and the operating cost of these data between systems.

Keywords: Actor Network Theory; Data Quality; Business Collaboration Network; Cooperative Game Theory; Shapley Value

1 Introduction

Business Collaboration refers to the process where several organizations work together in an intersection of common goals. This organization manages to reach a set of strategic objectives through collaboration with partners and through the pooling of resources and the exchange of information and services with them. Objectives vary according to several criteria. However, restructuring resources, improving quality and efficiency of operations are among the main operational objectives. To define adequately the objectives and the context of the collaboration, partners must specify the needs and the goals to be reached as well as all the aspects likely to influence the choices and the mode of operation.

Data quality is among the major objectives of the collaboration, It is one of the important characteristics which exposes the actor importance in the network. It"s a clue on how the actor will collaborate efficiently. Even if the dimensions of data quality are not universally agreed, we assume in this article that data quality level is determined by actors according to business objectives.

In this paper, we introduce the different concepts and theories used in this work, mainly Actor-Network Theory (ANT) [4], [5] as the framework of collaboration, Data quality as a characteristic for the identification of actors, Cooperative Game and Shapley Value as mechanism of cost and coalition analyzing. Then we describe the proposed approach of building an Actor-Network for data quality objective. We illustrate this work by an experimental setup applied in a realistic Actor-network context. Finally, we conclude this paper by summarizing aim points and the perspective works.

2 CONCEPTS

2.1 Actor Network Theory.

In general, ANT conceptualizes social interactions in networks. Networks integrate both the material environment and the semiotic environment [27]. In this theory, there is no difference between the human and non-human parts of a technological system. ANT mentions that the world is full of hybrid entities [28]. The core of ANT analysis is to examine the process of translation where actors align their interests of others with their own. The actors translate their interests by constructing a network and breaking the resistance of other actors and their network [27]. These actors can be an authority that either influence and use others or have no motivation and will be under the control of other actors.

In order to reach a step of the construction of a network, Callon and Latour defined an approach, inspired by ethnomethodology [8], which bears on a sequence of steps called the translation sequence. To translate is to "express in his own language what others say and want, to set up as spokesman" [4], but translate it is also, negotiate, perform a series of movements of all kinds and thus to each sequence of the process, which can be defined in four main steps:

1. Problematization

"The problematization or how to become essential?", "The problematization, as its name indicates asking at first a problem. This is to raise awareness to a number of actors that are concerned with this problem, and that everyone can find satisfaction through a solution that translators are able to offer" [10], so problematization is the effort made by the actors to convince that they have the right solution [3]. It "describes a system of alliances or associations between entities, defining this, their identity and what they want" [21].

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It is building the interface between the interests of different actors and the strengthening of the relationship between these interests. In the area of strategy, it can be a system of alliances to ensure that the different members of the organization are involved in the strategic process.

The main thing is to translate the interests of other actors in order to get them to take part in the network. To translate the interests of others, we can either convince them that there are common interests and that the proposed solution also serves their interests or manipulate their interests and objectives or finally become unavoidable.

3. Enrollment

"How to define and coordinate the roles", Enrollment is "the set of multilateral negotiations, beatings forces or tricks that come with sharing and allow it to succeed" [10].

For enrollment, each actor in the network is assigned a role. This role is related to the translation of their interests. For Callon, "the enrollment is to describe the set of multilateral negotiations, coups or intelligence accompanying sharing and allow it to succeed" [12]. The enrollment can thus be regarded as stabilizing the system of alliances set during the phase of the incentive. This system is the result of multilateral negotiations, trials of strength and stratagems [12]. It is during this phase to confront showdowns integrating new actors to the networks or by strengthening links between network members.

The enrollment phase is the key to the success or failure of innovation [18], but this phase is not studied formally in the literature on control.

4. Mobilization

The last phase of translation, the mobilization is to gather its allies. It is the cockpit of the various interests in a way that they remain more or less stable [13], it raises the question of the representation of stakeholders and enrolled in the project which is then established as spokespersons of the groups they represent [14]. However, "everyone can act very differently to the solution proposed: the abandon, accept it as it is, change the modalities which accompany or statement that it contains, or even they will be appropriated in the transferring in a completely different context" [12].

In a particular way, incentive phase of ANT can be analyzed from a cooperative game with transferable utility point of view [12]. Our objective is to identify the actor-network through data quality. For that, we use the Shapley Value to identify a better translation of the operating cost for improving data quality in an actor-network context.

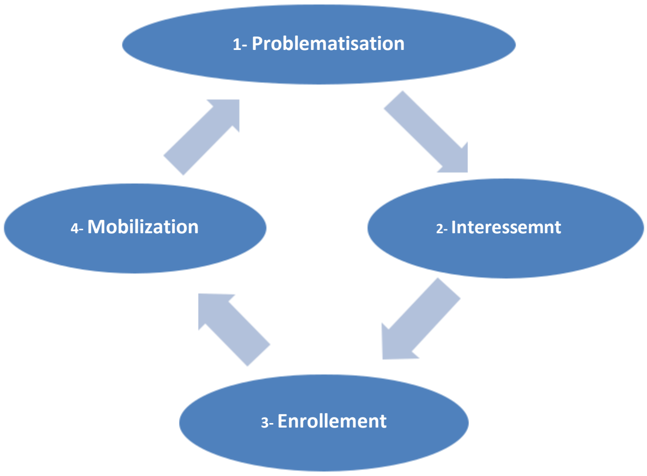

Fig. 1. Phases that compose actor network theory

2.2 Business collaborative mode

The collaboration represents one of the main relations between organizations partners. The most part of the definition of this concept agrees to mean joint job between several entities hoping for mutual benefits [15]. The same concept is used as well for the individuals as for organizations working together at common objectives. The collaboration connotes a relation lasting and made general for a complete commitment in favor of a common mission. Also, the collaboration consists in the commitment, mutual and coordinated by the partners to reach common.

The notion of network of collaboration is represented a group collaborating of entities, autonomous and heterogeneous, being recovered from different domains of governance and working jointly with a view to attaining a series of common objectives or even supplementary [16]. The entities of network collaboration are broadly autonomous and heterogeneous in terms of their environments of working, of their organizational cultures, and of their issued capitals. Correlations are supported by group of means of support implicating the systems of information of stakeholders. The collaboration job takes a multitude of forms; it is used in the field of private service as part of a network of public administrations. This situation takes the existence of a contract of collaboration representing in a definite manner the responsibilities of every member of the Network collaboration.

2.3 Data Quality

Data quality may be defined as "the degree to which information consistently meets the requirements and expectations of all knowledge workers who require it to perform their processes" [17], which can be summarized by the expression "fitness for use" [1]. The term data quality dimension is widely used to describe the measurement of the quality of data. Even if the key DQ dimensions are not universally agreed amongst the academic community, we can refer to Pipino et al. [18] who have identified 15 dimensions:

Intrinsic: accuracy, believability, reputation and objectivity;

Contextual: value-added, relevance, completeness, timeliness and appropriate amount;

Representational and accessibility: understandability, interoperability, concise representation, accessibility, ease of operations and security.

All case studies that aimed at assessing and improving data quality have chosen a subset of data quality dimensions, depending on the objectives of the study [19, 20, 21, 22]. Measurable metrics were then defined to score each dimension. While it is difficult to agree on the dimensions that will determine the data quality, it is however possible, when taking users‟ perspective into account [23], to define a basic subset of key dimensions, including: accuracy, completeness and timeliness.

Accuracy is defined as "the closeness of the results of observations of the true values or values accepted as being true" [18]. Wang et al. [1] Define accuracy as "the extent to which data are correct, reliable and certified". The associated metric is as follows:

Completeness. Completeness specifies how "data is not missing and is sufficient to the task at hand" [22]. As completeness has often to deal with the meaning of null values, it may be expressed in terms of the" ratio between the number of non-null values in a source and the size of the universal relation" [21]. Completeness is usually associated with the metric below [23]:

Depending on the context, both accuracy and completeness may be calculated for: a relation attribute, a database or a data warehouse [23].

Timeliness. Timeliness is a time-related dimension. It expresses "how current data are for the task at hand" [22].

As a matter of fact, even if a data is accurate and complete, it may be useless if not up-to-date.

2.4 Cooperative game

Game theory is a mathematical tool which is used to analysis the strategic interaction between multiple decision makers [24]. Initially it was used in economics for understanding the concept of economic behavior. But now it is used in various fields such as communication, biology, psychology for modeling the decision making situation where the outcomes depend upon the interacting strategies of two or more agents [3].

The cooperative game theory can be applied to the case where actors can achieve more benefit by cooperating than staying alone, it consists of two elements: (i) a set of players, and (ii) a characteristic function specifying the value created by different subsets of the players in the game [25]. The coalition formation problem is one of the important issues of game theory, both in cooperative and non-cooperative games. There are several attempts to analyze this problem. Many papers tried to find stable coalition structures in a cooperative game theoretic fashion. If we suppose that forming the grand coalition generates the largest total surplus, it is natu-ral to assume that the grand coalition structure will eventually form after some negoti-ations [26]. Then, the worth of the grand coalition has to be allocated to the individual players, according to the contribution of each player [26]. We are interested in this work in cost-sharing between coalition members likely to form using Game theory as a device for ANT interessement phase.

The Shapley value is a very common cost-sharing procedure in cooperative game theory essentially based on the so-called incremental costs [25]. The Shapley value of player i in the game given by the characteristic function V is the share of the surplus should be assigned. It‟s a weighted average of the contributions of a player i to reach of the possible coalition.

For example, consider a game with three players, i1, i2 and i3. Assume that player i1 is the first player of the game, i2 is the second player to join the game and player i3 is the last one. Player i1 is allocated a cost C ({i1}), player i2 is allocated a cost C ({i1, i2}) – C ({i1}), and player i3 a cost C ({i1, i2, i3}) – C ({i1, i2}). The Shapley value assumes that the order of arrival is random and the probability that a player joins first, second, third, etc. a coalition is the same for all players. Assume that force of each coalition is known in the form of the characteristic function V. The cost allocated to a player i in a game, including a set N of players is given by:

$$\phi i(N) = \left(\sum_{S \subseteq N : i \in S} \left(\frac{(|S|-1)!(|N|-|S|)!}{|N|!} \left(\left[C(S) - C(S \setminus \{i\}) \right] \right) \right) \right) \quad (4)$$

|N| and |S| respectively, the total number of players and the one belonging to the coalition S.

An alternative equivalent formula for the Shapley value is:

$$\phi i(N) = \left(\frac{1}{|N|!} \sum_{R} \left(v(\mathrm{P}Ri \cup \{i\}) - v(\mathrm{P}Ri) \right) \right) \quad (5)$$

Where the sum ranges over all |N| orders R of the players and PRi is the set of players in N which precede i in the order R.

Choosing a method of cost allocation is not an easy thing. According to the literature Shapley value seems to be suitable to this context of actor-Network building game. In fact, Shapley imposes four axioms to be satisfied (Efficiency, Symmetry, Dummy and Additivity).

1. Efficiency: players precisely distribute among themselves the resources available to the grand coalition. Namely, Efficiency: $\sum_{i \in N} \varphi_i (v) = v (N)$.
2. Symmetry: Players i, j ∈ N are said to be symmetric with respect to game v if they make the same marginal contribution to any coalition, i.e., for each S ⊂ N with i, j ∉ S, v (S ∪ i) = v (S ∪j). In another way, if players i and j are symmetric with re-spect to game v, then $\varphi_i (v) = \varphi_j (v)$.
3. Dummy: If i is a dummy player, i.e., v (S ∪i)- v (S) = 0 for every S ⊂ N, then φ_i (v) = 0.
4. Additivity: φ (v+w) = φ (v) + φ (w), where the game v+w is defined by (v+w) (S) = v (S) + w (S) for all S.

The dummy, symmetry (meaning that two players have the same strength Strategy will receive the same gain) and efficiency make the Shapley value, particularly attractive for treating the problem of equitable sharing of resources common to several economic agents.

3 Related works

In this section, we will deal with a representative set of existing studies that work on collaboration network and theories used to build the network of collaboration in the context of IT Governance.

Collaborative Networks (CNs) are complex systems that can be described or modeled from multiple perspectives. The collaborative network was presented and studied by IT researchers as a virtual network. Camarinha Matos is one of the widely recognized researchers working in the field whose works are basically concerned about IT perspectives and requirements of Collaborative Networks, despite the fact that they bear solid similitudes to alternate approaches of Collaborative Network too. During the later years and as a typical result of the difficulties confronted by both scientific and business terms, it has watched an abundance in the sorts of rising Collaborative Networks [28]. Some research tries to recognize the particular impacts of the properties of network structure on the execution of firms (particularly, the quantity of licenses) [29]. Thought, the change of between firm connections and following impacts after some time were not considered. [30] Many researchers have examined this field by the approach of Camarinha Matos and expounded the IT tools and its necessities to move forward. What's more, different researchers have lead studies on a similar field of learning, however this time from various viewpoints, for example, organization together or arranges in development organizations.

For example, Ahuja assesses the effects of firm‟s network of relation on innovation and elaborates a theoretical framework that relates the aspects of firm‟s ego network-direct ties, indirect ties and structural holes (disconnections between a firm‟s partners).Chinowsky, studied the Construction Company‟s networks by the approach of Social Network Analysis in company level and project level. Heedae Park studied collaboration effects on the profit amount of projects in Korean international contractors.

In this context, there is no single modeling formalism or "universal language" that can cover all perspectives of interest. Since CNs have a clear multidisciplinary nature, it is natural that we search for applicable modeling tools and approaches originated in other disciplines. In fact, Computer Science, Engineering, and Management, among other fields have developed plenty of modeling tools that might have some applicability in CNs [27].

There are also many developments in other disciplines that can contribute to the start of a foundation for collaborative networks, e.g. in complexity theories, game theory, multi-agent systems, graph theory, formal engineering methods, federated systems, self-organizing systems, swarm intelligence, and social networks. The theoretical foundation work in the ECOLEAD project took the mentioned early works as a baseline.

Game theory can provide the concepts for the analysis of decision-making in cases involving multiple decision-makers who interact with each other. In the case of CNs, game theory could offer: tools to manage cost, risk and profit sharing among the network participants, and tools to design optimal incentives for the VBE, VO, etc.

4 Data quality in network collaboration

4.1 Actors Identification through data quality

In our approach data quality is determined by taking into account users‟ perspective and objectives. An actor should decide on a subset of dimensions as mentioned above, the data quality level is then deducted from accuracy, completeness, and timeliness scores.

Data exchange „Relationship‟ (respecting ANT terminology) represents actor‟s interactions, which allows to spot future alliances and coalitions respectively conflicts and dissension.

We use the problematization step of the translation process to identify and characterize actors, as well as to analyze the scenario in which the network will operate. First, we identify actors with a height score of data quality, and then measuring data quality as proposed into [26] values and measuring the costs of operating this data in all possible coalitions. The choice of actor-network depends therefore on both data quality and the cost of using these data in each system, assessing the collaborative value of an actor can naturally be seen in terms of the cooperative game theory with a transferable utility, by means of Shapley value [2]. In fact the allocation of budgets depends on the contribution of each actor, in term of data quality translated to costs in our context.

4.2 Illustration

In order to experiment our approach of actors identification based on ANT, we work on the inter-organizational data exchange project for the administration of customs of Morocco (see Fig 2).

- Information System of Administration of Customs (S1)
- Information System of Treasury Department (S2)
- Integrated Tax systems Governed by the Administration of Tax (S3)
- Information System of Public Enterprises and Privatization Department (S4)

In our case, each system is managed by administration, S1, S2, S3, S4 and each system has its level of data quality.

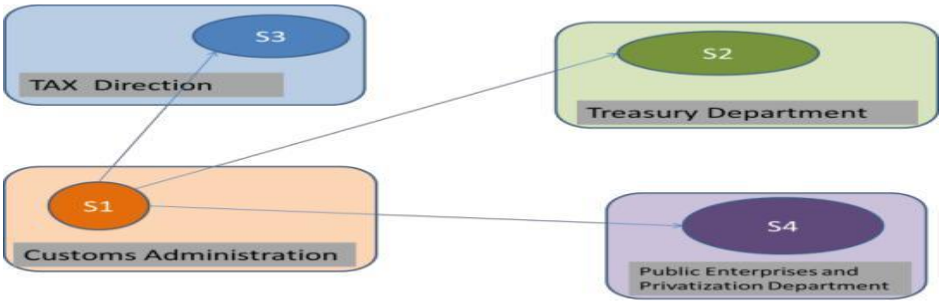

Fig. 2. Extract of a Public Financial Authority process interaction

Assuming that the result of the data quality analysis is presented as follows

Table 1. Table of data quality of network actors

Administrations	Actors	Data quality level
Customs Administration	S1	3
Treasury Department	S2	3
Administration of Tax	S3	5
Department Public Enterprises and Privatization	S4	2

A budget is allocated for this project between this four public administration.

We supposed that administration S1 must collaborate with the S2 in view of the functional dependency between the two institutions and that S1 has the choice between cooperating with S3 or S4 for the implementation of the exchange project. We will measure costs in each coalition:

Coalition 1: S1, S2

Table 2. Calculating Shapley Value

Administrations	Shapley value
S1	2.0
S2	5.0

Coalition 2: S1, S2, S4

The possibility of getting good data quality from S4, motivates the coalition building [S1, S2, S4]. The Shapley value gives the following results:

Table 3. Calculating Shapley Value

Administrations	Shapley value
S1	4.0
S2	5.0
S4	8.0

Coalition 3: S1, S2, S3

S3 has a similar situation as S4, and has the ability to produce high data quality. The best strategy of S1 is collaborating with S3 as it is the best source in terms of data quality, therefore a reduced cost, we get:

Table 4. Calculating Shapley Value

Administrations	Shapley value
S1	2.0
S2	5.0
S3	0.5

We have implemented a Web application developed in JAVA/J2EE, ANT MANGER is composed of several modules developed in JAVA / J2EE technology, with an architecture separating the presentation part (Front-end) from the Business part (Business, Backend), the aim of this architecture is to allow ANT Manager to interface with other platforms carried out by the research teams.

The goal of this platform is to provide a decision-making tool for information systems managers, architects, in order to build the most appropriate collaborative network for the administrative agency context.

ANT MANAGER is currently composed of the following modules:

- Management of user authorizations.
- Workflow theory of network actors.

- Managing collaboration networks (Adding an actor, Linking a player to another)
- Simulation management, according to the algorithm of the game theory (Perform several simulations, simulation backup, simulation suppression export the simulation result in CSV format in order to analyze the various simulations carried out by the architect or the person in charge of the information systems.

5 Conclusion

Displayed equations should be numbered consecutively in the paper, with the number set flush right and enclosed in parentheses.

Globalization leads to increased competition and higher customer expectations. At the same time, companies are stressed to reduce production costs while fronting the challenges of increasing product complexity, environmental concerns. The collaboration of organizations with networks is not a new phenomenon. However, permanent progress of IT in terms of new, reliable, and cheaper

Information and communication technologies are a catalyst for collaboration in networks. Such collaboration is ensured by building a collaborative network. Our approach highlights the identification of actors through data quality in Actor-Network mode of collaboration, this operation by improving the level of data quality translates to cost that is analyzed to all possible coalitions using cooperative game Shapley value.

The proposed work is supported by a software tool which enables to design networks and calculate actors Shapley Value. The main contributions of this work can therefore be summarized as follows:

- As Data quality criteria to identify the selected actors to build the collaboration network.
- Translating data quality objective into cost to analyze coalition.
- Implementation of a web application in order to design and simulate the actor-network evolution based on the cost calculation approach.

After building network collaboration, we are particularly interested in applying social network analysis to analyze this established network.

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COMBININING THE ACTOR-NETWORK THEORY AND GAME THEORY IN THE BUILDING OF COLLABORATION NETWORK

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Abstract—Governance of projects requires cooperation between several actors. In general, such cooperation is ensured by building network collaboration between entities who want to collaborate. In spite of the existence of a number of works interested in collaboration network, only few of them were focused on how to construct a network. In this paper, we address this topic through Actor Network Theory. In particular way, we analyze interessement phase of ANT from a cooperative game point of view. Indeed, it's about negotiations between actors involved in business project. Our objective is to propose an approach of network establishment, by inciting actors through cost savings. For that, we use Shapley Value to answer the question: Which coalitions are likely to form in order to ensure best cost-saving objectives in ANT mode of collaboration? We propose also a graphical tool for visualizing networks and simulating their evolution.

Keywords: Collaboration Network, Actor Network Theory, Cost-Sharing, Cooperative game theory, Shapley value

I. INTRODUCTION

Network perspective has been an important factor in inter-organizational project governance, and has consequently become a conspicuous concern for a large number of researches. The cooperation within business networks has become a key enabler for trading success.

Business Collaboration refers to the process where several companies work together in an intersection of common goals. A business collaboration network (BCN) enables companies to communicate and collaborate with their customers, partners and suppliers in a productive way [1]. This cooperation takes different forms, from simple information exchange, to business processes interoperability among independent enterprises [6], [11], and also in term of cost-sharing. In fact, independent businesses become able to collaborate in order to have benefic results for all [2].

The present research was conducted iteratively, this leads us to introduce Actor-Network theory (ANT) [3], [4] as a framework of collaboration, that helps us make sense to interaction evolution between different actors of the network. We use game theory as a cost-sharing arrangement whereby those actors are able to "translate" their goals (especially financials ones) into objectives that make sense to each actor.

Then, to motivate eventual partners to join network (coalition is used too in this paper to describe an actor-network), Shapley value [10] is used in our framework as a fair cost sharing solution to respond the question: How the costs are divided between actors relative to their marginal contributions in an actor-network context?

The originality of this work is the use of ANT to build collaborative network, by inciting actors to choose the best coalition through cost saving applying Shapley values.

The main contributions of this work can therefore be summarized as follows:

- Cost sharing as incentive device in a actor-network mode of cooperation
- The formulation of the Actor-network building problem as a cooperative game, where players (actors) cooperate to reduce costs.
- The implementation of a graphical tool in order to design and simulate the actor-network evolution based on cost calculation approach

The paper is organized as follows: Section 2 presents the different concepts and theories used. Section 3 introduces the proposed cooperative network building game. Section 4 presents numerical application that calculates shared-cost between actors using Shapley Value in a realistic Actor-network context via developed platform. Finally, Section 5 concludes this paper.

I. OVERVIEW ANT

ANT was originally proposed by Michael Callon and Bruno Latour in the early 1980s to describe the creation and evolution of socio-technical networks [31]. The theory was later extended and formalized [29]; [30]. In its original conceptualization the theory focused on actors defined as: ―any element which bends space around itself, makes other elements dependent upon itself and translates their will into the language of its own‖ [31]. This translation of interests leads to the creation of networks of aligned interests.

Among the early applications of ANT in Information System (IS) research, [25] ANT was used to examine a variety of IS-related phenomena including the causes of failure of a large business process change initiative [33] and to examine issues related to standardization in IS [32]. ANT was also used for exploring a variety of organizational and business issues (e.g., Newton 2002).

II. CONCEPTS

A. Value Networks

Value networks consist of multiple organizations that collaborate and utilize their resources and capabilities to produce and deliver a product or service to an end customer and create value for the organizations within the value network [5].

In the following sections two value network development methodologies are described to answer the second research question; what methodologies exist for the development of value networks?

For the purpose of this study value network development methodologies are examined in order to determine their usage combined with business models. The respective value network development methodologies have been selected based on their expected suitability for an application in practical settings.

Value networks are defined as ―any purposeful group of people or organizations creating social and economic good through complex dynamic exchanges of tangible and intangible value‖ (p. 3). While her approach enables the analysis of value creating roles and relations and the utilization and conversion of tangible and intangible assets, for the purpose of this study Allee's value network analysis techniques are considered less suitable due to the emphasis on value conversion, in contrast to the business oriented emphasis on value exchange for the purpose of this study. Furthermore, other research on value networks is considered to be less suitable for this study due to their theory testing (such the paper [35] where hypotheses are developed and tested to determine governance mechanisms of value network) and theory developing (such as the paper [8] that classifies types of value networks to structure the theoretical field) natures. Therefore, to my best knowledge the hereafter described two methodologies for value network analysis of

[9] and [34] are the most up-to date and practice oriented papers on value network development available.

[9] describe the value network as an interconnected network of organizations that form a value creating systems in which providers, partners and customers work together to co-produce value. The authors suggest the Network Value Analysis methodology of which the aim is to indicate where value lies in the network and how it is created. Network Value Analysis consists of five steps

(Figure 1) and is meant to clarify implications for value network development.

Through the application of Network Value Analysis the following questions supposed to be answered [12], [9]:

- What roles (or groups of players) are benefiting most in the configuration?
- What are the key resources they need to have?
- Could an actor build the resources and capabilities required to compete in its role?
- Which roles are appropriate for each actor?

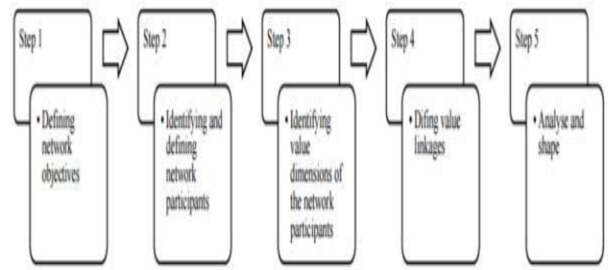

Figure 1. Network Value Analysis methodology

The purpose of the first step is to define the network and its boundaries from the perspective of the network focal. The network focal is the organization whose business model is dependent upon the network. Step two requires the identification of the organizations that could influence the value which is delivered through the value network to the customer. Step three involves clarifying the perceived values that participants may acquire when participating to the network such as access to new, complementary resources; reducing costs; reducing time to market; access to new markets; risk reduction and risk sharing; access to new technologies; and learning [13]. [14] and [9] investigating perceived advantages and disadvantages of actors regarding their participation in the value network is important because ―perceived value is a key driver of behavior… it is the perceived values that steer what people and firms are willing to do and not do‖ [14].

The investigation of positive and negative effects of the value network perceived by participants is in particular advantageous for opportunity networks which are emerging networks of which ―no one knows what they will look like in the future‖ [9]. Opportunity networks are classified as emerging business nets that are managed through an informal leadership style and self-coordination and where collaboration is based on trust and norms [8]. Furthermore [8] state that emerging business nets have a low level of determination – which is the extend that value activities of the business net and the resources of the participant to carry them out are clarified. [8] The fourth step involves the identification of influences such linkages between network members and concern what flows in the network. Finally in step five the value network is analyzed and shaped. [14]. [9] indicate that the behavior of the network should also be examined, for instance by describing different types of networks, network participants and their roles and future scenarios which may be contingent upon external factors such as market, regulation and technology [9].

B. *Actor Network Theory (ANT):*

The theory of translation or sociology of translation known as Actor Network Theory: (ANT) was developed as part of research on the innovation process and is rooted in a socio-technical approach to organizations. The founders of this current, Akrich, Callon and Latour [23] have shown that successful innovation depends on the success of unprecedented association between multiple and different actors. From this association, mobilization and cooperation of all stakeholders will emerge a socio-technical network and a dynamic production that aim process efficiency and success.

The second important notion of ANT is the ―Actant‖ Callon and Latour borrow this concept to semiotician Greimas. The latter replaces the term personage by the term actant, that ―who does or endure an act‖, because it applies not only to humans but also to animals, objects, concepts. The actants may be human or non-human and should be treated with the same importance as required by the principle of symmetry.

In order to reach a step of construction of a network, Callon and Latour defined an approach, inspired by ethnomethodology [27], which bears on a sequence of steps called the translation sequence. To translate is to ―express in his own language what others say and want, to set up as spokesman‖ [3], but translate it is also, negotiate, perform a series of movements of all kinds and this to each sequence of the process, which can be defined in four main steps:

1. Problematization:

―The problematization or how to become essential?‖, ―The problematization, as its name indicates asking at first a problem. This is to raise awareness to a number of actors that are concerned by this problem, and that everyone can find satisfaction through a solution that translators are able to offer‖ [17], so problematization is the effort made by the actors to convince that they have the right solution[16]. It "describes a system of alliances or associations between entities, defining this, [their] identity and what they want" [18].

2. Interessement:

"The incentive devices or how to seal alliances", the incentive is in fact for Callon "all actions through which an entity is trying to impose and stabilize the identity of the other players who is defined in problematization" [17] incentive is the second phase, consists of "deployment speeches, objects and devices intended to attract and attach different players to the Network" [19].

It is building the interface between the interests of different actors and the strengthening of the relationship between these interests. In the area of strategy, it can be a system of alliances to ensure that the different members of the organization are involved in the strategic process.

The main thing is to translate the interests of other actors in order to get them to take part in the network. To translate the interests of others, we can either convince them that there are common interests and that the proposed solution also serves their interests or manipulate their interests and objectives or finally become unavoidable.

3. Enrollment:

"How to define and coordinate the roles", Enrollment is "the set of multilateral negotiations, beatings forces or tricks that come with sharing and allow it to succeed" [17].

For enrollment, each actor in the network is assigned a role. This role is related to the translation of their interests. For Callon, «the enrollment is to describe the set of multilateral negotiations, coups or intelligence accompanying sharing and allow it to succeed" [18] .The enrollment can thus be regarded as stabilizing the system of alliances set during the phase of the incentive. This system is the result of multilateral negotiations, trials of strength and stratagems [18]. It is during this phase to confront showdowns integrating new actors to the networks or by strengthening links between network members.

The enrollment phase is the key to the success or failure of innovation [18], but this phase is not studied formally in the literature on control.

4. Mobilization:

Last phase of translation, the mobilization is to gather its allies. It is the cockpit of the various interests in a way that they remain more or less stable [20], it raises the question of the representation of stakeholders and enrolled in the project which is then established as spokespersons of the groups they represent [21]. However, ―everyone can act very differently to the solution proposed: the abandon, accept it as it is, change the modalities which accompany or statement that it contains, or even they will be appropriated in the transferring in a completely different context" [18].

In a particular way, incentive phase of ANT can be analyzed from a cooperative game with transferable utility point of view. Our objective is to set up the network by incenting actors through cost savings. For that, we use Shapley Value to answer the question: Which coalitions are likely to form in order to ensure best translation of cost-saving objectives in an actor-network context?

C. *Cooperative games theory:*

The cooperative game theory can be applied to the case where actors can achieve more benefit by cooperating than staying alone, it consists of two elements: (i) a set of players, and (ii) a characteristic function specifying the value created by different subsets of the players in the game [24]. The coalition formation problem is one of the important issues of game theory, both in cooperative and non-cooperative games. There are several attempts to analyze this problem. Many papers tried to find stable coalition structures in a cooperative game theoretic fashion. If we suppose that forming the grand coalition generates the largest total surplus, it is natural to assume that the grand coalition structure will eventually form after some negotiations [26]. Then, the worth of the grand coalition has to be allocated to the individual players, according to the contribution of each player [26]. We are interested in this work in cost-sharing between coalition members likely to form using Game theory as a device for ANT interessement phase

D. Cost-Sharing for profit collaboration

The call for projects is one of incentive mechanisms used to encourage actors in organizations and administrations to join forces and coordinate in order to submit, develop and make this public act together. The build of partnership and coalition intra and inter-departments appears a strategic decision to reduce costs and achieve the submitted projects. The rules of sharing common costs and benefits of cooperation are important factors of competitiveness, performance and motivation. Actor being rational; should join the coalition that provides the best gain, the lowest cost respectively. Indeed cost-sharing is a way to incite actors to join coalition whereby project managers are able to "translate" their goals (especially financials ones) into objectives that make sense to each actor. These allocations or shares should not determine by free and anonymous markets but rather by administrative rules and explicit mutual agreements descended from economic theories.

E. Actor-Network building Game

In our framework players are actors of network. To the extent that they may have common interests, actors are required to cooperate in advance to take and implement joint decisions, coordinate their actions and pool their winnings & cost. It appears a cooperative game where the actors come together to form coalitions, and all of whom seek to optimize the quality and cost of their own operations. They can, through cooperation, realize gains in the form of cost reduction. We can discuss it during the game in terms of the distribution of costs rather than gains. This is the approach taken here. Then costs are divided between the players relative to their marginal contributions.

To formalize the cost-sharing model with cooperative game in this coalition building process, we apply a concept of axiomatic solution, in this case the Shapley value.

Let N = {1, . . . , n} be a finite set of players. A coalition is any subset of N. The set of all coalitions is denoted by 2^n.

A coalitional form concern on a finite set of players S{1, . . . , n} is a function v from the set of all coalitions 2^n to the set of real numbers R with v(∅) = 0. v(S) represents the total worth the coalition S can get in the game v.

F. The use of Shapley value

The Shapley value is a very common cost-sharing procedure in cooperative game theory essentially based on the so-called incremental costs [24]. The Shapley value of player i in the game given by the characteristic function V is the share of the surplus should be assign. It's a weighted average of the contributions of player i to reach of the possible coalition.

For example, consider a game with three players, i1, i2 and i3. Assume that player i1 is the first player of the game, i2 is the second player to join the game and player i3 is the last one. Player i1 is allocated a cost C({i1}), player i2 is allocated a cost C({i1, i2}) − C({i1}), and player i3 a cost C({i1, i2, i3}) − C({i1, i2}). The Shapley value assumes that the order of arrival is random and the probability that a player joins first, second, third, etc. a coalition is the same for all players. Assume that forces of each coalition are known in the form of the characteristic function V. The cost allocated to a player i in a game including a set N of players is given by:

$$\phi i(N) = \Big(\sum_{S \subseteq N : i \in S} \Big(\frac{(|S|-1)!(|N|-|S|)!}{|N|!} \big([C(S) - C(S \setminus \{\}i)] \big) \qquad (1)$$

|N| and |S| respectively, the total number of players and the one belonging to the coalition S.

An alternative equivalent formula for the Shapley value is:

$$\phi i(N) = \Big(\frac{1}{|N|!} \sum_R (v(\mathrm{P}Ri \quad \{i\}) - v(\mathrm{P}Ri)) \qquad (2)$$

Where the sum ranges over all |N| orders R of the players and PRi is the set of players in N which precede i in the order R.

Choosing a method of cost allocation is not an easy thing. According to the literature Shapley value seems to be suitable to this context of actor-Network building game. In fact, Shapley imposes four axioms to be satisfied (Efficiency, Symmetry, Dummy and Additivity).

(i) Efficiency: players precisely distribute among themselves the resources available to the grand coalition. Namely, Efficiency: ∑i∈N φi(v) = v(N).

(ii) Symmetry: Players i,j ∈ N are said to be symmetric with respect to game v if they make the same marginal contribution to any coalition, i.e., for each S ⊂ N with i,j ∉S, v(S ∪ i) = v(S ∪ j). In another way if players i and j are symmetric with respect to game v, then φi(v) = φj(v).

(iii) Dummy: If i is a dummy player, i.e., v(S ∪ i)- v(S) = 0 for every S ⊂ N, then φi(v) = 0.

(iv) Additivity: φ(v+w) = φ(v) +φ(w), where the game v+w is defined by (v+w)(S) = v(S) +w(S) for all S.

The dummy, symmetry (meaning that two players have the same strength Strategic will receive the same gain) and efficiency make the Shapley value particularly attractive for treating the problem of equitable sharing of resources common to several economic agents.

G. Example of cost sharing within a public institution with several actors

An administration with several actors (department, partners, suppliers...) may wish to establish a methodology for the allocation of common costs that encourages collaborators to contribute to minimizing the common cost. As shown Shubik (1962), the allocation of common costs in the company can be seen as a cooperative game between different departments.

To fix ideas, consider the following example with three directions (A, B and C) of the same department that are in agreement with a company to perform backup sites. The project amounts to 10 million for each direction taken separately. For technical reasons, the service provider offers cost (reduced) respectively 16, 17 and 18 for joint contracts between A and B, A and C, B and C. The contract involving the three directions has a cost of 24. The cost function is given then by:

TABLE I. TABLEAU OF COSTS

Coalition	**Cost**
A	***10***
B	***10***
C	***10***
AB	***16***
AC	***17***
BC	***18***
ABC	***24***

The construction of a common backup site might be more profitable than building smaller sites. Indeed, the three directions get a fair deal, and are motivated to form a coalition since their cost parts are below their costs of going it alone. How costs should they are distributed among the three directions?

This issue can be described by a three-player game,

N = {A, B, C} is thus obtained:

TABLE II. THE CHARACTERISTIC FUNCTION ELEMENTS

Coalition	**Gain**
A	***0***
B	***0***
C	***0***
AB	***4***
AC	***3***
BC	***2***
ABC	***6***

Applying Shapley formula (1), there are six possible arrival orders (3!). They are listed in the following table which gives the marginal contributions according to each of them. For example, $P_A(ABC) = v(\{A\}) - v(\theta) = 0\text{-}0 = 0$,
$P_B(ABC) = v(\{AB\}) - v(\{A\}) = 4\text{-}0 = 4$, etc.

The distribution of v (N) cost reduction according to the Shapley value is given by φ (v) = (2.5, 2, 1.5). In terms of cost sharing, the calculation is illustrated in Table III.

TABLE III. CALCULING SHAPLEY VALUE

Entry order	**Marginal contributions**		
	A	***B***	***C***
ABC	0	4	2
ACB	0	3	3
BAC	4	0	2
BCA	4	0	2
CAB	3	3	0
CBA	4	2	0
Total	15	12	9
Shapley Value	15/6	12/6	9/6

This means that about 24 million, the directions A, B and C have to pay 7.5; 8 and 8.5 respectively.

III. EXPERIMENTAL RESULTS

After completing this research, and in order to validate the approach presented in this paper, we developed a java platform composed of two modules; the first one allows to draw network as it is and design the different information about the actor network, the second module permits to calculate actors Shapely value and simulates coalitions costs.

The platform developed is based on framework RCP of Eclipse (Rich Client Platform), by developing plug-in to draw the network collaboration and the property of each actor in order to propose the better network with the best cost saving .

We propose a method of visualization of collaboration networks from a reticular analysis based on the ANT. The platform provides a method of graphical visualization of organization networks and their evolution. Besides this methodological enrichment, our graph feasible in real time is bound to facilitate visualization of a possible risky path. Thus and pragmatically, visualization projects should help project stakeholders to step back on the progress collaborative enjoying a clear view of the latter and its evolution towards convergence or divergence of the total cost of the network.

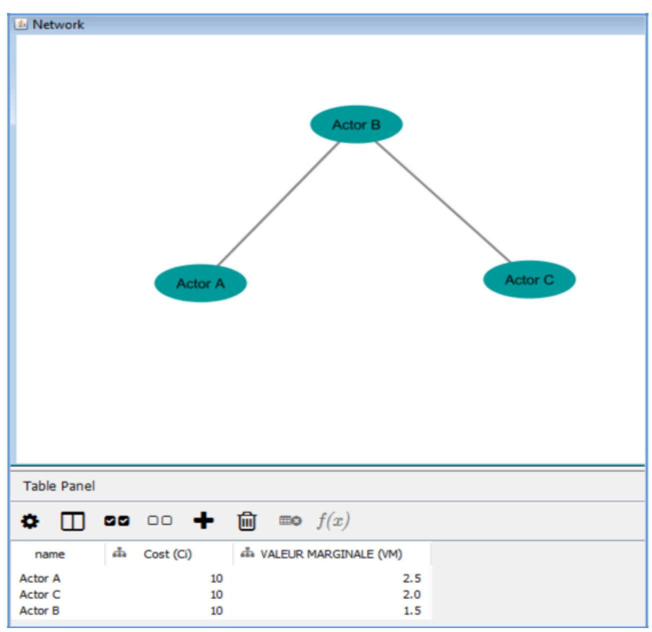

Figure 2. Marginal Values in ABC Coalition

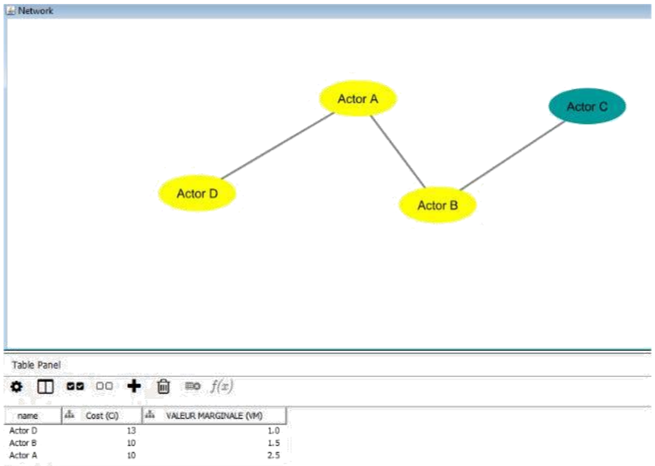

Figure 3. Marginal Values in ABCD Coalition

Numerical results demonstrate that our approach permits to achieve very effective cost allocations, thus representing an efficient framework for the conception of stable networks.

IV. CONCLUSIONS

The primary purpose of this study is to enrich the network perspective in collaboration mode. We introduce the actor-network theory (ANT) perspective, which helps to understand the network for best governance.

We addressed in this paper the interessement phase of actor-network theory from a cooperative game point of view.

The build of partnership and coalition intra and inter-departments appears a strategic decision to reduce costs and achieve the submitted projects. This incentive approach could be introduced by the network administrator or the government authority in order to increase the users' cooperation level. The rules of sharing common costs and benefits of cooperation are important factors of competitiveness, performance, transparency and motivation.

The present paper has presented an approach of network establishment, by inciting actors through cost savings. For that, Shapley Value of cooperative game is exploited to determine the adequate coalition to form in order to ensure best cost-saving objectives in ANT mode of collaboration. The proposed work is supported by a software tool which enables to design network and calculate actor‘s Shapley Value.

Apart from that, our present theoretical model still requires more elaboration on details, and the Shapely value that can be utilized to support interessement phase of ANT remains as a proposal in the case of financial objectives. Future work may require more empirical research with different types of actors and objectives.

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Risk Assessment Approach to Support IT Collaboration Network

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Abstract. This paper addresses an IT Governance improvement approach based on Risk Assessment in Network Collaboration context. Designing methodologies that allow IT risk analysis in changing and heterogeneous business climate is increasingly critical in order to ensure effective governance. In this perspective, we investigate the contribution of Social Network Analysis (SNA) to conduct a quantitative risk assessment and IT Collaboration improvement opportunities, by studying actors and relationships. SNA is an area which has been researched in many different disciplines, we examine it in our approach, focusing on IT Gov-ernance suppliers' selection process.

Keywords: risk assessment, IT governance, collaboration network, social net-work analysis, suppliers management.

1 Introduction

Business major goal is to create value for shareholders as well as for stakeholders. This goal is perceived as realizing benefits at optimal resources cost while optimizing risks [3]. By collaborating together, organizations can achieve demanding and complex finalities they cannot attain on their own [1].

Effective IT Governance supports generating real business benefits such as enhanced reputation, trust, product leadership, and reduced costs [2]. However, managing the 21stCentury IT organization is a highly complex task. Information Technology has become deeply entrenched as a critical dependency for many internal and external actors. Effective governance of the broader context (of Consultants, Contractors, Sub-Contractors and Suppliers) has become increasingly critical to strategic business success.

On the other hand, almost every business decision involves executives and managers to strike the balance between risk and benefits. Effectively managing the business risks is essential to an enterprise's success. Risk Management is becoming increasingly im-portant in various domains. Most project management disciplines prescribe it as a best practice. Even in new types of contracts and in innovative, collaborative forms of organization and management, we still perceive risk management failing to deal with the dynamics business climate changing.

Consequently, it is necessary to use appropriate techniques that allow a diagnosis as exhaustive as possible, to detect risks in just appropriate time, depending on its type, and accordingly advance treatment options that minimize the impact. In this paper is investigated how through the application of social network theory is possible to identify and quantify existing or potential risk among several IT actors in a collaborative net-work context. And to explore the role of quantitative risk assessment in the success of suppliers selection.

The structure of this paper is as follows. Section 2 presents the relevant concepts. Section 3 introduces brief literature background of Collaboration Network and Risk Assessment using SNA. Section 4 and 5, present the proposed risk-based approach to support IT Collaboration though exploring its application on the suppliers' management process of IT Governance. Conclusions and extensions of the research work are addressed in section 6.

2 Concepts

2.1 IT Governance in Collaboration Network Context

During the past two decades, researchers have studied network management and the associated value creation process; they have attested to the innovation strength of networks and their ability to react flexibly to changing conditions [6]. Studies of IT Governance and Collaboration Network have not cohered around a common theoretic framework, and many lack grounding in an established theoretical tradition. Some fo-cus on network structures and its effectiveness in general way including IT[7]; others on network management and coordination processes[8]; still others on institutional fac-tors such as coalition membership, resources, and decision making[9]. Several recent analyses construct their own frameworks using a blending of constructs. But there is little research examining IT Governance from a Collaboration Network viewpoint.

Research on IT governance in Network context has been attracting more and more attention, as the importance of IT in increasing business performance. Researchers have attested to the innovation strength of networks and their ability to react flexibly to changing conditions [6]. this area, however, remained limited [21]. Although, it only recently that it becomes fashionable.

2.2 SNA, Concepts & Indicators

2.2.1 SNA: Concepts

The volume of research related to social networks is growing exponentially within the management and organizational sciences [10]. Actually, SNA has been researched in many different fields, it uses graphical and mathematical methods to analyze the social structures of networks (Scott, 2000), is above all a toolbox for visualizing and modeling social relations as nodes (Actors, individuals, organizations ...) and links (relationships manage and supervise them. IT risk management is in alignment with enterprise risk management [20], and involve four key steps : Context establishment Risk identification ; Risk assessment ; Risk treatment; Risk management plan evaluation/review :

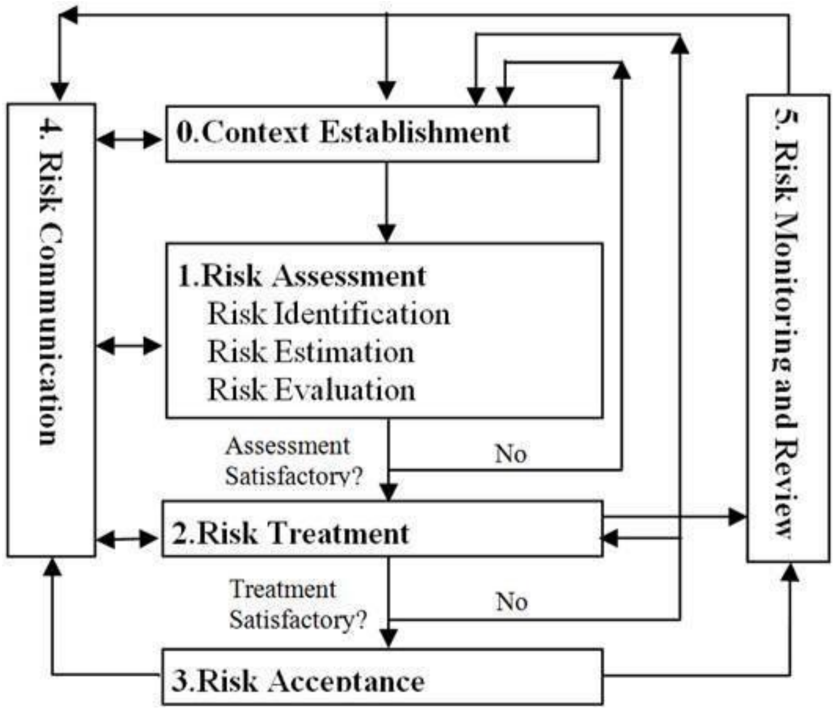

Fig. 1. Guidelines for information security risk management by ISO/IEC 27005.

The literature distinguishes too risk assessment approach: Qualitative risk analysis consists of assessing identified risks using a pre-defined rating scale, risks will be scored based on their probability or likelihood of occurring and the impact on project objectives should they occur; and Quantitative risk by analyzing reel data and exploit data bases to provides a quantitative approach to making decisions.

Qualitative risk analysis should generally be performed on all risks, quantitative risk depends on the project risks nature, and the availability of data to use to conduct the quantitative analysis.

3 LITERATURE REVIEW of Collaboration Network and Risk Assessment using SNA

The analysis of collaboration network is far from new. Borgatti et al (2009) cite the development of Moreno's sociometry in the 1930 as the precursor of SNA. In the 1950s, experimental studies of networks aimed to show that centralized decision making was more effective than decentralized [22]. They studied network using relational algebra used in SNA and research of causal power. In the mid-1970s Granovetter (1973) ad-vanced an influential theory of the strength of weak ties. SNA is often used to study leaders and could in theory tell us much about the relational dimension, but it wasn't used explicitly to analyze IT Risk within IT Governance Network.

There are several methods in Literature that can be used to analyze risk [11] [15] [18]. However, none of them were address directly risk based approach to support the IT governance in a collaborative Network. In order to address this problem, the issue of risk analysis in collaborative network seems to be a useful instrument for IT govern-ance and sustainability of the collaborative network.

On the other hand, Collaboration Network and SNA was explored in researches to view networks as analytical tools that encompasses and explains relationship, hierar-chies as variations of network structures, but no study combined this too theories to deal with risk-based approach to support IT Collaboration Network problematics.

4 Risk assessment to support IT Collaboration

The successful implementation of IT governance and risk management implies the par-ticipation of all involved in the process from the management team of the company to the operational level.

In the Collaboration Network perspective, effective risk management program re-quires internals and externals partners consideration and cooperation, that involves all levels of network collaboration in conducting risk assessments and formalizing the treatment plans. Focusing on the IT Collaboration's strategic objectives, risk manage-ment should be acknowledged as being directly connected to the development of stra-tegic project and business plans. Some critical strategic decisions may impact on the Collaboration's objectives and visibly the significance of such events require a vigilant appreciation of the associated risks. Collaborative Risk Management supports decision making processes internally and externally, at a governance level management and op-erational level to achieve a joint consensus on results.

Therefore, to highlight the importance of this risk-based approach to place an effec-tive collaborative IT governance structures, processes, operations and relational mech-anisms, and to increase our understanding of the risk factors influencing IT governance networks. We propose in our approach some tools, especially social analysis mecha-nism, to conduct qualitative risk-assessment process.

SNA is defined as any object, individual or group of objects or individuals that are involved in the network of Relations, which is well-suited with the basics of collabora-tion as a network. The motivation to use SNA is that is a tool which can be used just before the construction, during and right after the construction of the collaboration net-work, so permits to assess, reduce and monitor risks.

5 Quantitative Risk assessment approach using SNA applied to suppliers' selection process

5.1 Suppliers management

Suppliers are an extension of organization's operations and so they must reflect their values and work towards their objectives. An effective IT Governance includes man-agement of integrated technology suppliers. For example, according to COBIT 5 [14], the organization should have a fair and formal practice of suppliers' selection to ensure a viable best fit based on specified requirements, it should identify evaluation criteria and evaluate the overall portfolio of existing and alternatives suppliers.

In our use case applied to Collaboration Network within IT Governance frame, par-ticularly on the process of supplier selection, SNA is used to enable better suppliers' selection, as a tool for managing risk and value creation. In fact; a system of intercon-nected buyers and suppliers is better modeled as a network than as a linear chain. Sup-pliers selection process is the investigative process by which a company or other third party is reviewed to determine its suitability for a given task.

According to a Gartner study [16] IT organization use four categories of vendors. Hardware vendors sell or lease physical products and sell related support such as repair and maintenance. Software vendors sell commercial off the shelf (COTS) products, or offer licenses to an existing product line. Service vendors which can be either long term, such as an outsourcing annuity-based contract, or short term, such as staff augmentation services used to supplement enterprise personnel. Telecommunications vendors supply telephones, networks, circuits and network services. We use this categorization to clas-sify the suppliers network.

5.2 SNA to improve suppliers' management within IT Collaboration Network

An organization who collaborates with several partners is looking to strengthen the IT governance of its information system. For this purpose, the management decides to se-lect a contractor to conduct an external IT security control audit. Supplier management process should help to select the appropriate supplier to perform this task.

The principal objective fixed for this project is the objectivity of the audit delivera-bles. Risk is defined as the possibility of an event occurring that will have an impact on the achievement of the objective aimed by this IT Security audit. the risk of violating the objectivity of the audit is closely linked to the chosen contractor. In fact, we face in this case the Critical Employee Risk – related to supplier who may have critical information or resources and he is assigned to a critical task.

The management decide to exclude the supplier who may not drive objectively the IT Security audit.

The main question addressed to analyze suppliers is: Which suppliers among the tenderers are involved in IT collaboration network and what are their collaborative relationships?

To answer this question the following matrix is addressed:

Supplier / Materials and services	S1	S2	S3	S4
Hardware	1	0	0	1
Software	0	1	0	0
Services	1	1	1	0
Telecom	0	0	0	0

Table 1. T1- incidence matrix indicating the intervention area of each supplier

The second question to answer is: What is the level of integration of each supplier in IT Governance network?

	S1	S2	S3	S4
S1	-	1	1	1
S2	1	-	1	0
S3	1	1	-	0
S4	1	0	0	-

Table 2. T2- Adjacency suppliers' matrix derived from T1

Then the degree of each supplier is calculated to determine its level of integration. In fact, to ensure audit objectivity, the organization should choose the least involved supplier in its information system.

Degree is calculated by the following formula [17]:

$$N$$

$$Da = \left(\sum_{i}^{N-1} d(a,j)\right)$$

Where Da is the centrality degree of the actor a; D(a,j) represents the value of a relation from the a actor directed to the jth actor in the network. N is the number of actors in the network.

	Degree	standarized degree
S1	3	1
S2	2	2/3
S3	2	2/3
S4	1	1/3

Table 3. T3- Suppliers' Degree

In T3, the degree of S4 is "1" because Actor S4 has only one direct contact with another actor, Actor S1. The degree of an actor can be interpreted as the "point central-ity" of the actor. A point is central then, if it has a high degree. The actor can be said to be "well-connected,".

By dividing the measure of degree with 3 (the total number of other actors 4-1), a relative measure called the "standardized degree" of an actor measures how connected a supplier relative to others.

S4 has the smallest centrality degree (1/3), it means that it is the least implicated supplier in the IT collaboration network of this organization, therefore in the best posi-tion to conduct the external audit mission objectively.

6 Conclusion

In business today, risk plays a critical role. IT Governance supports organization to execute new IT projects in a controlled manner to deliver value for the business while minimizing the risk of change. Managing risk is a part of several IT Governance frame-works and standards. Organizations seek for good governance, but then again to achieve it in a collaborative context, more systematic and quantitative analysis for risks is re-quired. Reaching a better characterization and understanding of the potential risks in collaborative processes is an important pre-condition to avoid project faillure. Through increasing partners integration, companies have attempted to manage this enlarged level of complexity. IT Service vendors integration has been identified as a key practice to achieve superior IT Governance performance. Given the risk exposure and costs in-volved, quantitative risk assessment can be a cost-effective methodology that a com-pany can implement and witch may contribute in many significant ways.

From the beginning, this paper has highlighted how the social network aspect of information technology -- interactions among actors-- can strongly influence IT Col-laboration decision. This has led to apply network theories, particularly, Social Network Analysis (SNA) to IT governance. We have investigated SNA concepts especially, de-gree centralities to answer questions that help designing, implementing, assessing and improving IT Governance suppliers' selection process.

This research is expected to help organizations in a number of ways. It provides insights that steering committees can use to establish an effective collaborative IT Gov-ernance, we gave supplier management process example. As not all supplier relation-ships should be the same, it is necessary to establish the level of importance of individ-ual suppliers not just in terms of the relationship but also the risk, the criticality of the contract as illustrated in the application case of the audit mission.

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between these nodes), using results from sociometry, mathematics and anthropology. This structural approach which focuses specifically on the description and analysis of the different possible modes of relationship: interdependence, centrality, Holes, frequency... The strength of this structural analysis lies in its ability to represent in a simplified way the complexity and diversity of relations between actors.

SNA has already proven useful in economic, political, social, professional, and med-ical contexts. In contrast to these other fields, IT governance has only recently begun to be addressed using SNA.

2.2.2 SNA: principal indicators:

Network metrics can be calculated at two levels—the node level and -the network level. Node-level network metrics reveal how a node is implanted in a network from that individual node's perspective. Freeman (1979) provides a measure of the prominence of a given actor within a network, it's defined what is called centrality, in different aspects. Most important are:

Degree centrality as defined by Freeman, provides a measure of communication ac-tivity, when a node is connected to a large number of other nodes, the node has high degree centrality. This metric was adopted in favour of the other two types of centrality identified by Freeman:

Betweenness: The extent to which an actor acts as a posits "broker" or intermediatery"gatekeeper" in the network, means that other nodes are dependent on this node to reach out to the rest of the network.)

Closeness: this metric focuses on how close a node is to all the other nodes in the network. An actor is "close" when it has the shortest paths to all others, he is central if it can quickly reach all the others.

Network level metrics compute how the overall network ties are organized:

Network density is the number of total ties in a network compared with the number of potential ties. It is measure of the overall connectedness of a network (Scott, 2000)—density of one means that all nodes of the network are connected with each other.

Network centralization captures the extent to which the overall connectedness is or-ganized around particular nodes in a network (Provan and Milward, 1995). Highest possible centralization is of a network with a star structure. Network with lowest centralization is when all nodes have the same number of connections.

Network complexity is defined as "the number of dependency relations within a net-work"; it depends on the number of nodes in the network and the degree to which they are interlinked [13].

2.3 Risk Management.

IT Governance frameworks like COBIT 5 cover the general concept of the IT Risk through specific processes, one of which focuses on stakeholder risk-related objectives: EDM03 Ensure risk optimization. Risk management frameworks and standards (Risk IT ISACA, ISO 31000, ISO 27005…) are designed to identify, analyze, mitigate, man-age, monitor and communicate IT-related business risks and determine how to reduce,