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To cite this version:

Jacques Calmet, Pierre Maret, Marvin Schneider. Epistemological Analysis of Decision Making -An Application to Trust. Group Decision and Negotiation, GDN 2014, Jun 2014, France. pp.168-177. hal-01015356

HAL Id: hal-01015356

https://hal.science/hal-01015356v1

Submitted on 26 Jun 2014

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Epistemological Analysis of Decision Making - An Application to Trust

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Abstract. Decision-making systems based upon multi-agent technology have epistemological implications that are seldom acknowledged. We provide a simple analysis arising from the method, inspired by theorem proving, we have designed along the years. We also specify the link with Web 3.0. The results of this analysis are applied to a new approach to trust making use of securitization. An important consequence of such an approach is to emphasize the interdisciplinary features of decision support systems.

Keywords: Decision making, agent, sociology, virtual knowledge, culture, topology, trust, securitization.

1 Introduction

We are concerned with the problem of decision making by multiple collaborating agents for knowledge systems in the framework of Web 3.0, i.e. in situations where knowledge is widely distributed. The goal of this short paper is twofold. The first one is to understand the contents and implications of such a knowledge challenge without restricting it to keywords. In generic wording this is what is called usually epistemology or theory of knowledge. The second one is to investigate the whole trail between a theoretical challenge and the business application. This is what a business plan is expected to do. Although the framework is very generic, we want to outline that it is suitable for addressing one of the main challenges of modern IT: trust.

The epistemological part of this report is based upon previous works [1 and references therein] of us introducing technical contents. Here we outline an analysis resulting from the technical contents. What is also fully new is the model we propose for trust that includes in particular a concept of securitization of trust. We must add as a remark that we are aware that the link between epistemology and knowledge is not as straightforward as suggested by our introduction. This has been much discussed for many years. However, we do not need to enter such discussions for our purposes.

A trivial preliminary remark is to note that very many factors do affect one's ability to make decisions in the domain of economics. For instance, the doctoral thesis of Anna Dreber Almenberg, entitled "Do sex hormones impact our economic decisions?" was nominated in 2013 for an award of the Stockholm School of

Economics. The program of Anna Dreber Almenberg conducts a series of experiments investigating how some sex hormones affect decision-making. Can they make us take more risks, or become more self-sacrificing or more competitive? We will exclude such behavioral facets of the economical investigation from our analysis. However, it could be included in the multi-agent model we select.

2 Web 3.0

Since its origin, between 1990 and 2000, the Web has seen several evolutions. The present one is labeled Web 3.0 (name suggested by John Markoff of the New York Times) and refers to a web more connected (IPV6, HTML5), more open (Web of data, Web of things) and more intelligent (content disambiguation, reasoning).

Tim Berners-Lee, the Web initiator, has described the Semantic Web as a main component of Web 3.0. It aims at describing one of the main features of Web 3.0: a Web of data that can be processed by machines. This means that the Web is now structured when compared to the previous versions.

A recent call for papers of the Semantic Web journal emphasizes an obvious link between Big Data and Semantic Web. It is phrased as follows: "One of the key challenges in making use of Big Data lies in finding ways of dealing with heterogeneity, diversity, and complexity of the data, while its volume and velocity forbid solutions available for smaller datasets as based, e.g., on manual curation or manual integration of data". Semantic Web technologies are meant to deal with these issues, and indeed since the advent of Linked Data a few years ago, they are becoming central to mainstream Semantic Web research and development. We can easily understand Linked Data as being a part of the greater Big Data landscape, as many of the challenges are the same. The linking component of Linked Data, however, introduces key features for the integration and conflation of data across multiple sources.

This is a fully meaningful description of the problem generated by the huge amount of available data for decision-making in a distributed environment. The integration of the Web of things is an additional facet to this approach, since any Linked Data network must be able to host the connections to Internet objects.

The specification methods lying at the heart of our framework [1] are fully suitable for Web 3.0. The suitability means that we do not have to introduce the features listed previously to specify the Web 3.0 but that they are already built in the framework we are designing. Unfortunately, because of the format of the paper we cannot detail more this fact.

3 Topology

The use of topology in knowledge representation is an old story. For instance, the map of the London underground is nothing else but a topological representation of the existing lines. Nowadays, topology is being used to manage huge data sets as described in [2] for instance. Along similar purposes, we introduced in [3] the

concept of logical fibering as an abstract data structure well suited for dealing with huge or smaller data sets. We investigate links between topology and AI along the following lines. Multi-agent system is a concept of distributed AI. The design of advanced models for AI computing faces some well-known challenges. Besides the processing of huge amounts of data one of them is knowledge engineering. This implies especially to define and extend the range of what is computable or not. The traditional solutions were to select specific logics or knowledge management methods as shown by any introductory book on AI. Nowadays, there are attempts to extend the limits of Gödel's theorem and the variety of Turing machines. These approaches are often summarized under the label of universal AI. There is also an attempt to define specific approaches such as "formal concept analysis". It is a formal concept in communication between types and attributes with origins in philosophy and sociology.

Epistemology reminds us that a few years ago mathematicians were defining AI as heuristic computing. It looks thus like going backward to rely on methods expressing through mathematical concepts the notion of heuristic computing. Any mathematician knows that fibers are enumerable. Thus, there is a strong motivation to introduce logical fibering as a relevant data structure. Similar arguments are presented in [5] in the framework of essays on scientific and philosophical understanding of foundation of information and computation. Such an analysis belongs obviously to an epistemological approach of the problem. The same author analyses further how basic concepts can be found lying in mathematical description in a paper entitled "From Descartes to Turing: The Computational content of Supervenience". The first author of this paper also pointed out the role played by Descartes "Discourse of the Method" on the early influences of philosophy and mathematics in [6].

The concept of logical fibering makes it possible to define a new type of Turing machine [15]. This provides a solid link between topology and AI computing.

4 Corporate Knowledge, Culture and Trust

The framework we do select in [1] is based upon multi-agent systems. But we have a slightly different definition of what an agent is compared to what most authors have. We introduce an agent oriented abstraction [4] enabling to label as agent humans as well as artifacts. For instance a simple thermostat is an agent since it makes a decision (to find the temperature) and can communicate (to display the temperature). The application to the Internet of Things is then straightforward.

At this stage several epistemological comments are in order. A first one is that systems of agents are in fact societies of agents. To define what kind of society we consider, we have to emphasize that we enforce the paradigm that the societies are defined by the actions of their agents. This means that we rely on the theme of social expectation and on the principles introduced in Sociology by Weber: the actions of the agents determine the society they build and not the converse. Another remark is to distinguish between a society and its governance. It is well understood that (even in everyday life) the governance of a society is a challenging question. It is even more obvious for multi-agent systems since the problem is usually overlooked and society

and governance are mixed without analyzing the implications. We make a strong distinction between society and governance. Thus, our framework is suitable for studying social relationship and networking in the context of sociological features for culture and social networks. We state that these are not general implications but as noted in [4] consequences of the method of Weber and its implication with the Theory of Games and Economic Behavior as introduced in 1944 by John von Neumann and Oskar Morgenstern.

The building stones of our implementation are the so-called "Virtual Knowledge Communities (VKC)". They are tools simple to implement and to reason about [11, 12]. We define a society of agents but not its governance. It is up to the designer of the system to define its governance. In political science, this is usually defined as the proximity and accessibility of the agents and the governing body.

We have shown [11] that this definition of agents is suitable to define a company through its corporate knowledge. Even the communication methodologies among the various entities of a corporation are defined through VKCs.

As for any methodology, the challenges are privacy, trust and security. We will emphasize this for intercultural communications where to enforce trust is mandatory.

The next step is to claim that culture belongs to the corporate knowledge of a nation of an international grouping of countries or of a corporation. We assume the very different approaches to culture that are investigated in various areas nowadays. Linguistic is a distinct one assuming that most troubles arise for an imperfect mastering of the languages. Economists do identify some criteria that are gathered in models and then assessed for a better accuracy. Sociologists are right to suggest that societal organizational features are at the origin of troubles. Philosophers will tend to put more weight on the native way of thinking of cultural groups, taking into account history and geography. Engineers with a solid background in management may propose meaningful changes in the decision making process. We do not claim that we have a new approach to what culture is. We simply claim that we can adopt any of these approaches, transform it into a knowledge management process that can be abstracted as Abstraction-Based Information Technology along the following lines:

- A theory is an ontology,
- The control means to infer facts from this ontology. It is a decision making process,
- The environment consists in specializing these facts to a specific cultural group.

Trust and culture did attract much attention in Sociology. A very rich book [13] is restricted to French-German cooperation but displays a large collection of intercultural troubles that are easy to find and difficult to solve. Although Germany and France do collaborate extensively for many years now, their collaboration is still prone to acute troubles. Paper [14] reports on trust and culture in virtual organizations. It is only one among many reports devoted to this topic. These two documents [13, 14] are written by sociologists in the framework of sociology. Our goal is to solve similar conflicts but with tools from Artificial Intelligence. The knowledge detained by people belonging to an organization is part of the corporate knowledge. Additional knowledge is detained within the IT system. Moreover,

corporate knowledge is composed of some communication means for exchanging information. Considering the definition of the VKC abstraction, we claim that it is a convenient abstraction for Corporate Knowledge. Indeed, VKC strongly supports the principle of autonomy of actors (individuals as well as artifacts). Actors hold knowledge and decision ability (algorithm). Thus, VKC allows building corporate knowledge in a bottom-up approach, which is fully compliant with real world processes and which can be implemented for fuzzy but effective knowledge exchanges and management. In [11, 12] we showed how to model corporate knowledge using VKCs. The latter look like knowledge bases and can be thought of as knowledge systems also.

5 Securitization of Trust

In our approach trust has several facets. Most of them are related to the context that can affect the belief in a "statement". In most cases the context can be represented by knowledge bases, in our model VKCs. Then, trust results from the exchange, sharing and mixing of knowledge bases. These operations can be disturbed by any intruder thus the idea to distribute knowledge as done for assets in finance using securitization. To start from we simply rely on definitions provided by Wikipedia: "Securitization is the financial practice of pooling various types of contractual debt such as residential mortgages, commercial mortgages, auto loans or credit card debt obligations and selling said consolidated debt as bonds, pass-through securities, or collateralized mortgage obligation (CMOs), to various investors. The principal and interest on the debt, underlying the security, is paid back to the various investors regularly. Securities backed by mortgage receivables are called mortgage-backed securities (MBS), while those backed by other types of receivables are asset-backed-securities (ABS)".

The concept has been made famous during the sub-primes crisis. But, it was already introduced in the area of international relation by the so-called Copenhagen's school as a synthesis of constructivist and classical political realism in an approach to international security [7]. This is not far away from the domain of trust that we investigate. It also implies a strong semantic meaning for each involved concept.

Another interesting recent piece of work is in the domain of re-insurance and achieved at the London School of Economics by Barrieu and Louberge [8]. They consider a simplified economy composed of three different types of agent, namely an insurer, a reinsurer and a representative investor. The exposure of the insurer can be diversified within a larger portfolio. The reinsurer can transfer part of its risk to the capital markets by sponsoring an insurance related bond. The decision criterion is based upon existing regulations. More precisely, the different agents considered assess their risk using a convex risk measure. For the sake of simplicity, they consider entropic risk measures in order to derive explicit formulae for the different quantities involved. In our framework, we can use well-known concepts of information theory. In information theory, Shannon entropy represents the information content of a message or, from the receiver point of view, the uncertainty about the message the sender produced prior to its reception. The Kullback-Leibler distance or relative entropy can be used to define a "distance" between two discrete sets. Basic definitions

can be found in [9]. A more general introduction to the relationship between entropy and knowledge is given in [10].

At this stage it is worth asking whether such ideas are relevant or not in economy. A supporting idea is in fact provided by the announcement by the Nobel committee of the laureates in 2013 for trend spotting in assets market. It is as follows: "There is no way to predict the price of stocks and bonds over the next few days or weeks. But it is quite possible to foresee the broad course of these prices over longer periods, such as the next three to five years. These findings, which might seem both surprising and contradictory, were made and analyzed by this year's Laureates, Eugene Fama, Lars Peter Hansen and Robert Shiller". This award unifies two lines of thinking that may be seen as opposite. We interpret it as a proof that there is a need to further the concept of trust and investigate new approaches.

A key remark is that trust results from sharing and exchanging knowledge bases. Thus, the link to our epistemological analysis ought to be now clear. Another link is the fact that we must be able to store very large amount of data. To this end, we use logical fibering as abstract data structures. Another feature is that logical fibering can be tailored to carry values of selected function as it is done for securitization in financial mathematics.

6 Draft of a Business Plan

The main steps of a business plan as taught in any business school cover well-known domains. A first one deals with the market environment and assesses the macro-economical environment, the market size, the consumer behaviors and an analysis of the competitive situation. A second one is more specific for the product under consideration. It evaluates the product, the localization or place, the price and the marketing or promotion expectations. The third one is usually referred to as SWOT (Strengths, Weaknesses, Opportunities and Threats) [16]. It covers both the external and internal criteria that an enterprise must face, including regulations and laws. Finally there is usually a finance plan covering between 1 and 5 years of business activities.

At this stage we do not want to fine analyze a business plan for Web-based business. A first remark is that if no company can start without a business plan, it usually proves itself to be inaccurate within the first months of activities, even when the company is successful. Such a comment is routinely made by most of business founders but usually not written down. This is a weakness that can be corrected. Indeed, each of the points mentioned in a business plan is a decision making step. We claim that having decision making modeled as theorem-proving process formalizes most of the steps of a business plan (once a product has been selected) and thus there is hope of a more meaningful business plan.

As mentioned previously the discourse on the method of Descartes is probably the first business plan presented to get a financial support. That it is mathematically oriented is almost trivial when translating "essences" into "axioms".

A complementary remark is that Virtual Knowledge Communities (VKCs) are fully suitable to represent each step of a business plan. Then, the trust model outlined

in this paper ought to increase the confidence level given to a business plan. This arises from the fact that any company can be modeled through VKCs and such a fact provides the skeleton of a business plan. More precise characteristics can be introduced as annotations within the logical fibers.

7 Conclusion

We have broadly outlined several concepts that arise from an epistemological analysis of decision-making system based on a specific multi-agents and theorem-proving technology and web-based communities. The resulting framework is fully suited for group making decision since each agent in the game can be regarded as carrying one decisions making actor. It is tailored for Web 3.0 because we do not distinguish between artifacts and humans and thus can readily model the Internet of Things.
Due to the required format of the paper and to the large multi-disciplinary scope of the problem, it is not possible to get into technical details.

Works in progress on logical fibering applied to the identification of denial of service attacks [15] and on the design of an Erasmus coach will bring more understanding. The topic of securitization of trust will also be better described in a forthcoming publication.

The main lesson to be learned from this brief outline is that it is not possible to ignore the epistemological consequences of decisions based upon some fashionable keywords. To put it gently, let us add that one cannot use a multi-agent system without understanding the conditions arising from the gathering of such agents into a society.

Acknowledgements: The authors thank the anonymous referees for interesting comments on the original version. The have been partly acknowledged but not fully because of the required format of the paper.

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