iStarML: Principles and Implications[†]

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Abstract. iStarML is an XML-based format for enabling *i** interoperability. A relevant difference with any other interoperability proposal is that iStarML is founded under the assumption that there is not a common ontology guiding this communication proposal. The different *i** variants and even particular applications proposing new language constructors forced to confront a theoretical approach for supporting an interoperability approach in an evolving and variable semantic scenario. In this paper we focused on the theories behind the iStarML proposal, which include sociological, cybernetics and linguistics approaches. Finally, we apply what these theories predict to the case of the *i** framework and its research community.

Keywords: *i** Framework, iStar, variants, interoperability.

1 Introduction

The *i** (iStar) framework has become a recognized and widespread framework in the Information Systems Engineering community. Given that the *i** framework incorporates goal- and agent-oriented modelling and reasoning tools, it has been a milestone for providing the basis, developing and spreading goal-orientation as a relevant paradigm in Requirements Engineering and agent orientation in Software Engineering. As a result of different interpretations and adoptions, several *i** variants have emerged, which have evolved at different maturity levels. Some of them have reached the category of industrial standard (e.g., GRL in ITU-T) whilst others are in some initial stages of development or were conceived for supporting a localized (in scope and time) problem. Besides, there is a set of proposals that cannot be considered *i** variants because they simply include new or modified language constructions. In [1] we have summarized a literature review reporting this fact.

As an effect of the past and even current proliferation of different *i** variants, a derived set of software tools and prototypes have been generated. However, interoperability has been an elusive target. Although there is a clear core common to virtually all *i** variants, tool interoperability is founded on an agreement that implies the existence of a shared ontology, which it has not been the case of *i** variants.

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We have tackled the problem of proposing an interoperability framework for *i** variants. The aim is model interchange to "work together", which is the deep meaning of interoperability. We have called iStarML to the proposal of a XML-based format language [2]. It incorporates structures which allows the representation of a wide set of *i** variants. As part of the theoretical approach that supports iStarML we have presented the proposal from [3] as a key theory because it introduces the concept of supermetamodel, which has been a key concept for demonstrating the reduction of complexity of the translation among *n i** variants. Besides, this framework introduce degrees of semantic preservation which we have used to qualify the translation from an *i** variant to another [1]. The iStarML applications and usages that we have promoted [4] illustrate the feasibility not only of interaction between different *i** variants but also the feasibility of using iStarML as a valid textual representation over which other applications can be built.

2 Objectives of the Research

However, we have not explained the theoretical principles which have supported the idea of enabling interoperability without having a shared and common ontology, i.e. why and how interoperability can be sustained in a human poly-semantic scenario. The goal of tackling this social perspective was to consider the Requirements Engineering's (and also Scientifics') principle of proposing a better approach if there a model (or theory) for *understanding why*.

In this paper we briefly present different theories that support the idea of having communication without a shared ontology, some of them from linguistics, others from cybernetics, and also from sociology of science. The social nature of these theories gives us some information of what could be expected as research community and the feasible social and technical scenarios that we could expect.

3 Scientific Contributions

Basic foundations in Computer Science affirm that interoperability requires a stable semantic scenario to reach high levels of interoperability. However, this is not the situation in the *i** community because different tools have been inspired on different *i** variants. They do not only have different metamodels (syntax) but also they have a different mapping to objects of reality (semantic) of their language constructs. We present principles from Sociology of Science, Cybernetics and Linguistics which support the idea of enabling interoperability in spite of the absence of a shared ontology.

3.1 Sociology of Science Approaches

Sociology of Science embraces those studies that explain the foundations of science (i.e., Philosophy of Science) from a sociological perspective. One of the relevant contemporary philosophers has been Thomas Kuhn, who has modelled science evolution through discontinuous jumps [5]. Kuhn called these jumps "scientific revolutions", which are leaded by a reduced set of pioneers who change the basic conceptualizations and build a new way of doing science. This new way of perceiving and researching is called "scientific paradigm". Each paradigm has an initial and underlying ontology, which is "known" (in the beginning) only by the pioneers, who try to communicate it and teach the new way of doing research using this ontology. The impossibility of explaining the new ontology based on the previous ontology is called by Kuhn "the incommensurability problem". In spite of that, along time, the ontology is spread, and used, not always as it was proposed but according to the particular interpretations of the followers. This phase is called "the revolutionary stage". However, at some moment, the conceptualization converges to a stable and shared ontology (the key concepts of the paradigms) and epistemology (what the community accept as valid methods for knowledge production). When it happens, the following phase, the normal-science stage, starts. The cycle continues when theoretical anomalies appear (unsatisfactory explanations) and a new pre-revolutionary stage germinates. Although the original Kuhn's idea was to explain big scientific movements, lately he recognizes that there are a lot of small and even micro-revolutions which present the same behaviour. Figure 1 illustrates the stages.

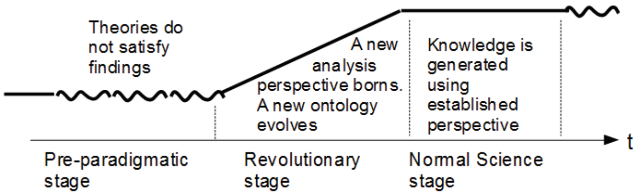

Fig. 1. Kuhn's model of a paradigmatic shift

Bourdieu's theory of scientific fields [6] is the second approach from sociology of science that we reviewed. In this theory the key concept is the symbolic capital. Scientific behaviour is associated to fields that have, in its centre, the highest concentration of symbolic capital; normally the leaders/pioneers of the fields occupy these positions. They dominate the concepts and try to spread their ideas. Scientifics try to maximize their symbolic capital by two ways: moving to the centre of the field, which means to exactly follow the pioneers' ideas and collaborate with them, or generating new scientific fields by the intersection with other fields that allow them occupying the centre of a new scientific field. Either in the zones of lower symbolic capital or in the new fields, the concepts are not used as in the centre of the reference scientific field. In Fig. 2, left, the idea of scientific field is illustrated.

In both theories it is recognized the fact that research activity without a fully shared ontology, as it happens in the *i** community, is feasible. Also, from these two theories, we cannot expect the paradigms (i.e., the *i** framework) be extended over time or the *i** field be kept the same way is in the centre and in the very far periphery. A point of difference among these two approaches is the position about community agreement on a shared ontology. From Kuhn it is predicted that having a shared ontology stops the revolutionary stage and from Bourdieu it is predicted that we will always have uncontrolled interpretations and uses. However, this apparent contraction is not real if we suppose that having static scientific fields is part of "normal science".

3.2 Cybernetics Approaches

Cybernetics has been conceptualized as the General Theory of Control [7]. We can rescue from Cybernetics both, classical and new conceptual frameworks. A classic contributor has been Ross Ashby, who proposed a definition of intelligence from the control perspective. Thus, intelligence is understood as a repertoire of behaviours; therefore having more intelligence or variability means having a broader repertoire of behaviours. In this theory it is said that humans are able to create intelligence amplifiers in order to enlarge their control capabilities, which means to increase variability. One of Ashby's examples is the difference between *the ships being loaded quickly and easily by movements of a control handle, or slowly and laboriously by hand* [8]. Other intelligence amplifiers can be a dictionary, a sunglasses, a calculator and of course, a modelling tool, because they improve the repertoire of behaviours.

In addition, contemporary cybernetics takes concepts as *autopoiesis* [9] to explain that biological-based systems continuously regenerate the processes that produce them (*autopoiesis*). This should be understood from both, as an internal point of view (transformations) and as an external one (interactions). It is said that biological systems are operationally closed systems which are self-produced and self-referred. It means their actions are the effect of their interpretations (meaning-making process). It also implies that operational distinctions (ontology) that use a system in order to guide its interactions and transformations are not observable ones since they are internal to the system. Therefore a biologically-based communication process emerges without an explicit (non-external and non-shared) ontology. As an extension of that, and due to intelligence amplifiers (e.g. modelling tools) are part of the interactions of the system with its environment, then interoperability will take place if the meaning-making process produces some interpretation (e.g. for an arriving model) which improve variability.

3.3 Semiotics Approaches

Semiotics is about the interpretation of signs, syntax, semantics and pragmatics as well. The main focuses are models that explain human communication from both individual and collective perspectives. A relevant semiotic concept is language expressions and their meanings, which changes depending on the community. What is interesting for us are collective perspectives because they may model communication in scientific communities. Semiotics considers that some language expressions can reach stable meanings in the natural dynamic of meaning systems which implies that these expressions can be used as *intepretants*, i.e. using in sentences that explain other meanings. This is why an explanation might be completely understood by some people meanwhile some others will have a different conception about it or partially get what it means.

Yuri Lotman [10] introduced the concept of semiosphere to explain communication inside medieval human cultures. Firstly he expresses that mono-semantic systems do not exist in isolation. These related systems are part of a continuous sphere of meaning called semiosphere. Lotman explains that the boundary is the area of accelerated semiotic process (interpretations). This theoretical approach affirms that in peripherical areas, where structures are "slippery", less organized and more flexible, the dynamic process meets with less opposition and, consequently, develops more quickly. Then, one may say that the new semiosphere grows leaving in the centre the dominant semiotic system constituted by a wide set of stable concepts. This theory seems be very applicable for *i** community as part of a more general software engineering community and also for a particular *i** variant community. From this perspective the sentence from Lotman saying that the creation of meta-structural self-descriptors (grammar) appears to be a factor which dramatically increases the rigidity of the semiosphere's structure and slows down its development, it can be easily understood, e.g. by producing some social-based standard. In Fig. 2, right, the general idea of semiosphere is illustrated.

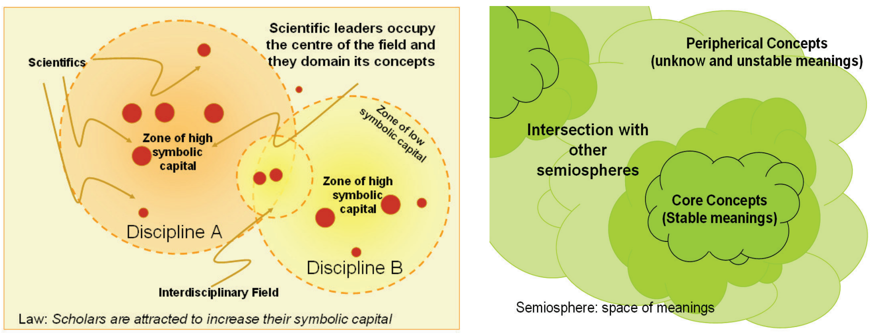

Fig. 2. Concepts on Bourdieu's Scientific Fields and Lotman's Semiospheres

3.4 Implications for iStarML and the *i** Research Community

After the theoretical analysis which only in part we have summarized here, some conclusions emerge. Firstly, a complete shared ontology is neither a human requisite for interaction nor for action, even when this communication is intermediated by intelligence amplifiers as software tools. Therefore, an interoperability proposal appears theoretically feasible. Moreover, we conclude that the structure of the interoperability language should correspond to the way of a Bourdieu's scientific field or, similarly, to a Lotman's semiosphere, i.e. core or stable concepts at the centre, and the increasing of semantic variability and additional constructs towards the periphery. If the inteoperability language may reproduce the semiosphere structure, then intermediate structures should be in terms of core structures. Therefore, we proposed iStarML using a concentric ring structure: (1) the core set of stable and common abstract concepts (*actor, intentional element*, *intentional link, dependency*), (2) a core set of common concepts established by a predefined set of main tag attributes (e.g., *type="softgoal"*), (3) a space for specifying variations on existing but not so common attributes (e.g., *value="xor"*) and (4) new elements (e.g. type="norm" prior="low". Therefore an iStarML message should be part of a meaning-making process, thus, it, could be interpreted depending of the target *i** variant community.

In addition, the application of these theoretical frameworks allows to derive some conjectures about *i** community: (1) If *i** represents a materialization of a scientific revolution then is not expected that the *i** ontology keeps being an underlying ontology. It will be explicitly expressed at some moment. (2) The externalization of an *i** ontology will not stop the scientific activity; it only will change its state. Proliferation of interpretations will be stopped but "normal" (in the sense of Kuhn) applications will be massively reported afterwards. (3) Following Lotman's and Bordieu's theories, externalizing an ontology may be a very difficult job if central scholars of the field are not involved. (4) Expressing an ontology will not avoid intersections to other scientific fields, therefore, proliferation of applications with and without *i** modifications will take place.

4 Conclusions

The theoretical foundation for proposing iStarML, an interoperability proposal for *i** variants, has been reviewed. It included sociology of science, cybernetics and semiotics. Following these theories about human communication and scientific behaviour we have explained some reasons behind central features of iStarML.

However, the social nature of this theoretical framework allowed obtaining conjectures (i.e. theory predictions) about the future of the *i** community. Mainly they point out to the expression and formalization of the *i** ontology which stops the revolutionary stage, fixes the grammar and establishes a new research period about applications under a stable semantic scenario. In this hypothetical scenario iStarML should be revised according to the inclusion of a set of language constructs from this explicit formalization.

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