A critical view over iStar visual constructs

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Abstract. The impact of the iStar (i*) on the requirements engineering community is corroborated by the large amount of research that cites, analyzes, and/or uses this modeling language. Since the creation of iStar, researchers have been using/evolving this language in different ways. Considering that iStar is strongly based on the use of graphic forms, it is important to pay special attention to the notation of its elements. This paper proposes a reflection over the modifications suggested for the graphical notation of iStar, based on the Physics of Notations. Our goal is to discuss the possible impacts of these suggestions, stressing some of its disadvantages.

Keywords: Framework iStar, Physics of Notations, Requirements Engineering.

1 Introduction

The iStar language [2] is strongly based on the use of graphic forms, therefore the importance of its visual notations. Moody's research [10] on the Physics of Notations (PoN) drew attention to the need of reevaluating the informative power of modeling languages taking into account the adopted graphic notation. Moody defines 9 principles that must be considered in order to increase the visual quality and the understanding of the models [10], they are: Semiotic Clarity, Perceptual Discriminability, Semantic Transparency, Complexity management, Cognitive Integration, Visual Expressiveness, Dual Coding, Graphic Economy and Cognitive Fit. The Physics of Notations has had a considerable impact on the academic community and served as the basis for further work [11]. This work [11] performs an analysis of the visual aspects of iStar, in which several problems were found and possible solutions to mitigate the problems were proposed. Analyzing the papers that quote the research on the improvement of the cognitive power of iStar [11], without considering the studies of Moody himself, there are only a few studies that perform some type of analysis of the problems and give suggestions for improvement [6,7,16,17]. These researches point indicators that the use of the alternative notation indicated by Moody may influence in the understanding of models. However, some Moody's suggestions did not obtain good results as, for example, the suggested modifications for the representation of dependencies in SD diagram [6,7]. Santos et al. [17] investigated the impact of semantic transparency on understanding and revising iStar models. After conducting an evaluative study [17], no evidence was found indicating that strategies related to the semantic transparency principle of Notation Physics [10] expedite the understanding of iStar models. The authors [17] concluded that model context definition may alleviate iStar's symbol comprehension deficit. Ruiz et al. [16] performed a comparison between the i* notation and the alternative Moody notation, but gave no details on the results of this comparison. We have found several papers that use the concepts of the Physics of Notations (PoN), but to analyze and/or evolve other modeling languages, for example: [5,15,19]. In addition, we have found examples addressing iStar research, which agree with some of the analysis of Moody's, but present different suggestions [4,8].

2 Research goal

Our goal is to provide a critical view over the problems detected by Moody [11]. We focused on some aspects of these problems and their proposed solutions.

3 Our Observations on iStar's Notation Problems

We will focus our observations on five of Moody's principles: Semiotic Clarity, Perceptual Discrimination, Semantic Transparency, Complexity Management and Cognitive Fit. For the cases where we understand that there is a need for modification in iStar we highlight possible solutions to be considered.

3.1 Semiotic Clarity

Moody quotes two instances of redundancy in iStar. The first case is related to the use of two different symbols to represent the "Belief" construct. The second case involves the actor-type element that is shown in two different ways: circles in SD diagrams and as a compound symbol in SR diagrams. Moody solutions are: ***a)*** Moody indicates the definition of a single "Belief" symbol to represent the construct and to remove the other from the notation, and **b)** Use the figure of a puppet in both diagrams (SD and SR), the expanded one to represent the SR diagram, showing the inner workings of each actor's mind (Figure 1).

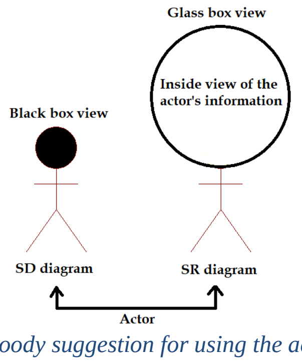

Figure 1 - Moody suggestion for using the actor element

On the first instance, in our view, the provision of an alternative version to refer to the belief element is not configured as a redundancy but as a feature of iStar flexibility. The modeler could use, for example, the cloud-shaped figure to indicate soft belief. For the second instance of the reported redundancy, we argue that the "Actor" type element is not being represented in two different ways. In our view, what we really have is the combination of the "Actor" construct and the use of bounding edges, indicating that the respective actor's SR (Strategic Rationale) will be described in that space. Another problem in iStar indicated by Moody and related to semiotic clarity principle is symbol overloading. That is, when a single symbol is used to represent many constructs (ambiguity). According to Moody there are in iStar 27 different types of relationships, but only 5 visually distinct graphical links. To solve the problem, it was suggested the use of different graphic shapes (instead of text or context) to distinguish between symbols. We disagree with Moody's, for us the association between textual elements and graphic symbols is a new symbol. We make an analogy with the traffic signs, where most of them completely change semantics according to the textual association. As shown in Figure 2. There are symbols that share the same graphical form of a red circle, but the associated text totally modifies the symbol and its respective semantics. We must also analyze the mandatory stop sign, whose reasoning about the exclusion of the word "Stop" leads us to think about the effectiveness of the semantics of this symbol**.**

Figure 2 - Traffic signs.

3.2. *Perceptual Discriminability*

Moody reports a problem in Semantic Discrimination of the SD (Strategic Dependencies) Model. It was argued that the use of the letter “D” is ineffective as a graphical representation and that the form of the letter “D” is very symmetrical, making it difficult to identify the direction of dependence. Finally, the use of the letter "D" on both sides of each dependence creates visual noise: iStar diagrams are unnecessarily confused by the amount of D's (Figure 3a). Moody solution uses conventional arrows, making sure to use a different type of arrows from those already used in iStar (Figure 3b).

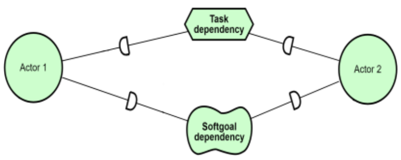

*Figure 3a – Example of an SD model of i**

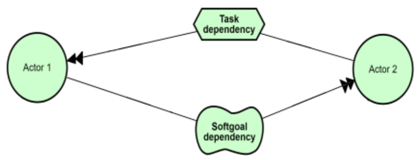

Figure 3b – Moody’s suggestion for modifying the i SD model*

We disagree with the problem appointed by Moody regarding the use of the letter D to promote the semantics of dependency among elements of iStar. In our view, the letter "D" carries a valid semantic load that facilitates the immediate understanding of dependencies in the SD diagram, also helping to understand the direction of the dependency. In addition, Moody's suggestion for the use of double arrows did not obtain a satisfactory result according to the experimental study presented by Laue et al. [6,7]. Laue et al. [6,7] claim that using the traditional "D" symbol to represent a dependency avoids misunderstanding of the interpretation between dependum and dependee. Faced with this type of result we must ask ourselves if the use of arrows could actually pass immediately the correct semantics of dependence between two elements. As a suggestion to improve the semantic understanding of the letter “D” in an SD model, we propose to fill in this letter. In this way, it would be even easier to identify dependum and dependee (Figure 4). According to Moody the textual differentiation results in symbol overload, because if we differentiate only by using labels, we will have no visual distance, obtaining homograph forms. The suggested solution was the usage of visual variables instead of text to distinguish between relationship types. We disagree with Moody's vision of homograph generation in iStar, as we explained in our analysis of the second problem related to the "Semiotic Clarity" principle. We agree, however, that the use of texts in iStar could be enriched with the use of visual elements.

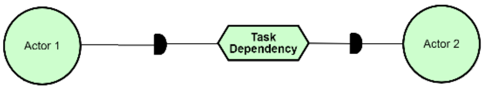

Figure 4 - Simple example of SD with the letter "D" fully blackened by the color black.

3.3. *Semantic Transparency*

Moody says that in iStar there is an absence of graphic representations more significant, because most of the symbols in iStar are abstract geometric forms that do not transmit anything on the constructions. It has been further stated that a beginner is unlikely to be able to guess what any of the symbols of Figure 5a mean. One suggestion is to use semantically richer figures to represent Actors. In Figure 5b Moody points out examples of suggestions such as, for example, saying that an Agent-like element could be shown by wearing sunglasses and holding a gun (by association with agents of type 007). Another example would be a role-type element, which could be shown with a hat. We disagree with the problem pointed by Moody and their respective suggestions. To argue, initially we defend that the graphic elements of iStar allow a greater flexibility as to the assignment of semantics. This procedure is context sensitive and allows modelers to indicate many types of semantics to elements of the Actor type. For example, Moura [12] and Oliveira et al. [13] used iStar as a target language for recovering Java programs, and modeled their classes as iStar Agents. Therefore, as long as it is concise and clear in the model, we are not restricted to the interpretation of an agent being a person. Finally, a stick figure using sunglasses and holding a gun could be understood as a crook, depending on the culture and region in question.

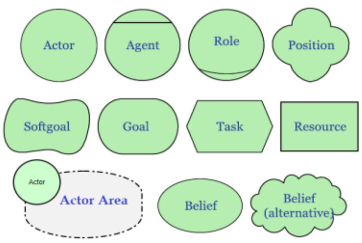

Figure 5a – iStar's graphic shapes

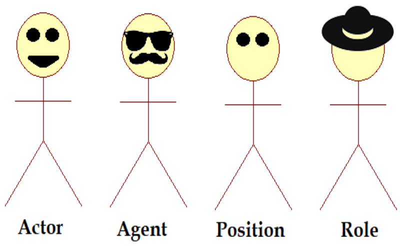

Figure 5b – Moody's suggestion for represent actors on iStar.

We are not necessarily criticizing the strategy of promoting clarity in the semantics of graphical elements present in modeling languages. We understand that defining and using more informative graphic forms may facilitate the use of models, such as the one presented by Caire et al. [1]. However, our discussions are based on the reassessment of some deficiencies pointed out by Moody on iStar and their respective solutions, based on the semantic transparency principle.

3.4. *Complexity management*

Moody argues that iStar supports only two types of decomposition: Element → element and Diagram → diagram. The author states that these two types of decomposition do not contribute to decrease complexity and that the main weakness of iStar is not supporting the recursive decomposition of the Element → Diagram type. This type of decomposition would allow elements to be decomposed into new diagrams, improving scalability and modularization. For this problem Moody solutions are: ***a)*** Partition the SR diagram, creating separate SRs for each actor defined in the SD diagram, and ***b)*** The iStar framework should provide recursive decomposition support, taking into account the concepts of hierarchical visual languages. The idea is to allow elements from one upper diagram to be represented in another diagram at the next level (Figure 6) [11]. For example, tasks may "explode" for task decomposition diagrams. This would result in a hierarchy of diagrams, with the SD diagram at the top level, SR diagrams (one for each ACTOR) at the second level and lower level diagrams (" exploding " elements in SR diagrams) for as many levels as required. About the idea of partitioning, we argue that there is no limitation or prohibition to accomplish this strategy. In our view, there has always been the flexibility of monolithic or separate representation of the created models. Regarding the recursive decomposition, considering the analogies with hierarchical visual languages, we emphasize that iStar has a network structure and is not related to hierarchy concepts such as, for example, in Data Flow Diagrams.

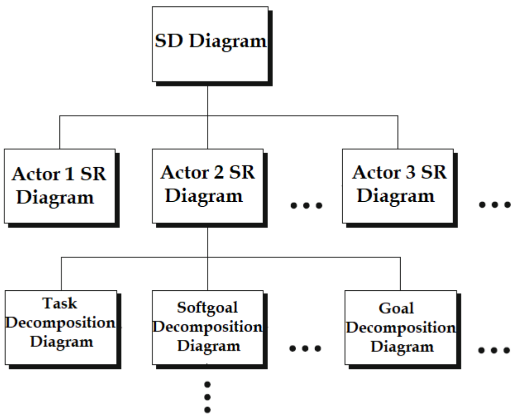

Figure 6 – Moody's Suggestion for hierarchy diagrams in iStar

There have been different suggestions to this problem. For example: Padua et al. [14] defined a strategy of modularization without changing the syntax of iStar, proposing the treatment of SD Situations diagrams, taking into account the situations of each scenario. Moody also highlights potential navigation problems in the diagrams created in the framework iStar. In this regard, we agree that some factors such as increased scalability can make it challenging to explore goal-oriented requirement models. In this context, the research by Silva et al. [18] presents a strategy based on visualization types to assist in navigating requirements artifacts, thus mitigating the complexity of understanding particular models.

3.5 *Cognitive Fit*

Moody argues that the framework iStar does not have any kind of treatment to help novice users. In fact we found evidence on the performance discrepancy of novice modelers in relation to those most experienced in the use of iStar [3,4,9]. However, we believe that this fact is related not only to graphical notation. It is also said that iStar provides poor support for manual modeling because representing constructs like Goals, Softgoals and Beliefs can become a tiresome. To solve this, the author suggests providing simplified symbols to create the initial sketches and a rich dialect for the final production of the diagrams (Figure 7a). We disagree, since [11] states that most iStar symbols are simple geometric shapes. Finally, another problem pointed in iStar is the little attention to the cultural context**.** The indicated solution was usage specific dialects/symbols according to the region. The suggestion is the use sports symbols depending on the context (Figure 7b). We disagree, because we believe the abstract symbols used by iStar are culturally neutral. Regarding the improvement suggestion we disagree that using sports-related figures to refer to the "goal" element would help in all contexts. We remember that modeling is context sensitive and should promote flexibility in assigning semantics to the elements used in the models. In this way, using sports figures may disrupt and not help communication among stakeholders.

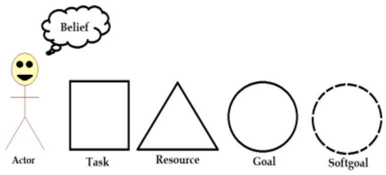

Figure 7a – Moody's suggestion of simplification of symbols

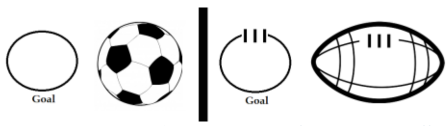

Figure 7b – Moody's suggestion for cultural differentiation for symbols

4 Conclusions

Our goal was to perform a critical analysis, taking into account the suggestions [11] and not necessarily the correctness of the PoN [10]. Our observations are mostly based on the author's iStar experience, but we also considered the existing literature. We understand the importance of conducting further qualitative studies to investigate whether the iStar framework community agrees with the views recorded here or not. Before accepting or discarding any ideas, no matter how promising they may seem, they should be discussed. Hence, we believe that our paper may be an opportunity for the iStar community to discuss ideas influenced by the Physics of Notations.

References

[1] Patrice Caire, Nicolas Genon, Patrick Heymans, and Daniel L. Moody. 2013. Visual notation design 2.0: Towards user comprehensible requirements engineering notations. In *2013 21st IEEE International Requirements Engineering Conference (RE)*, 115–124.

[2] S. Yu Eric. 1995. Modelling strategic relationships for process reengineering. (1995).

[3] Enyo Gonçalves, Marcos Antônio de Oliveira, Ingrid Monteiro, Jaelson Castro, and João Araújo. 2019. Understanding what is important in iStar extension proposals: the viewpoint of researchers. *Requirements Engineering* 24, 1 (2019), 55–84.

[4] Renata Guizzardi, Xavier Franch, and Giancarlo Guizzardi. 2012. Applying a foundational ontology to analyze means-end links in the i∗ framework. In *2012 Sixth International Conference on research challenges in information science (RCIS)*, 1–11.

[5] Gregor Jošt, Marjan Heričko, and Gregor Polančič. 2017. Theoretical foundations and implementation of business process diagrams' complexity management technique based on highlights. *Software & Systems Modeling* (2017), 1–17.

[6] Ralf Laue, Frank Hogrebe, Boris Böttcher, and Markus Nüttgens. 2014. Preliminary Results on the Understandability of ı Notations. *Ceur-Ws. Org* (2014), 1–6.

[7] Ralf Laue, Frank Hogrebe, Boris Böttcher, and Markus Nüttgens. 2014. Efficient visual notations for efficient stakeholder communication. In *2014 IEEE 22nd International Requirements Engineering Conference (RE)*, 329–330.

[8] Lidia López, Xavier Franch, and Jordi Marco. 2011. Making explicit some implicit i* language decisions. In *International Conference on Conceptual Modeling*, 62–77.

[9] Fabio Massacci, Federica Paci, and Alessandra Tedeschi. 2014. Assessing a requirements evolution approach: Empirical studies in the air traffic management domain. *Journal of Systems and Software* 95, (2014), 70–88.

[10] Daniel Moody. 2009. The "physics" of notations: toward a scientific basis for constructing visual notations in software engineering. *IEEE Transactions on software engineering* 35, 6 (2009), 756–779.

[11] Daniel L. Moody, Patrick Heymans, and Raimundas Matulevičius. 2010. Visual syntax does matter: improving the cognitive effectiveness of the i* visual notation. *Requirements Engineering* 15, 2 (2010), 141–175.

[12] Ana Maria da Mota Moura. 2017. Awareness Driven Software Reengineering. In *Requirements Engineering Conference (RE), 2017 IEEE 25th International*, 550–555.

[13] Romeu F. de Oliveira, Ana Maria da Mota Moura, and Julio Cesar Sampaio P. Leite. 2018. Reengineering for Accessibility: A Strategy Based on Software Awareness. In *Proceedings of the 17th Brazilian Symposium on Software Quality* (SBQS), 180–189. DOI:https://doi.org/10.1145/3275245.3275265

[14] Antonio Padua, A. Oliveira, and Luiz Marcio Cysneiros. 2006. Defining strategic dependency situations in requirements elicitation. (2006).

[15] Glaice KS Quirino, Monalessa P. Barcellos, and Ricardo A. Falbo. 2017. OPL-ML: A Modeling Language for Representing Ontology Pattern Languages. In *International Conference on Conceptual Modeling*, 187–201.

[16] Marcela Ruiz, Fatma Basak Aydemir, and Fabiano Dalpiaz. 2017. Using Conceptual Models in Research Methods Courses: An experience using iStar 2.0. In *Proceedings of the 5th Symposium on Conceptual Modeling Education and the 2nd International iStar Teaching Workshop co-located with the 36th International Conference on Conceptual Modeling (ER 2017), Valencia, Spain, November 6-9, 2017.*, 48–57.

[17] Mafalda Santos, Catarina Gralha, Miguel Goulão, João Araujo, and Ana Moreira. 2018. On the Impact of Semantic Transparency on Understanding and Reviewing Social Goal Models. In *2018 IEEE 26th International Requirements Engineering Conference (RE)*, 228–239.

[18] Lyrene Silva, Ana Moreira, João Araújo, Catarina Gralha, Miguel Goulão, and Vasco Amaral. 2016. Exploring views for goal-oriented requirements comprehension. In *International Conference on Conceptual Modeling*, 149–163.

[19] Jeannette Stark and Werner Esswein. 2017. Using secondary notation to improve the cognitive effectiveness of BPMN-Models. (2017).