Addressing Symbol Redundancy Representations in iStar Extensions

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Abstract. [context] iStar has been extended to include constructs of a great number of application areas by adding new symbols. We analyzed the existing iStar extensions in a Systematic Literature Review and identified the occurrence of symbol redundancy (constructs represented by two or more symbols) among the existing constructs. The occurrence of symbol redundancy can hinder the usage of these constructs. [objective] We are interested in defining a prioritization of the preferences of these symbols. Thus, we performed a survey with novices to analyze their preferences about the representations. [results] The 83 participants expressed their preferences concerning the most adequate graphical representation for each construct with symbol redundancy. We presented a ranking of the symbols for each concept with symbol redundancy. These results can be useful to extenders to choose the symbols of these constructs when reusing the extensions which propose them.
Keywords: iStar extensions, Symbol redundancy, Survey, Prioritization.

1 Introduction

We identified 96 iStar extensions in a Systematic Literature Review (SLR) [4] which were catalogued in [7] [8] . We also interviewed specialists in iStar extensions to find out how the extensions are proposed [5]. The lack of a process to systematically create an iStar extension leads to several problems, such as *Symbol redundancy* and *Symbol overload* [13]. We found that many of the iStar extensions have proposed symbols which are redundant (i.e. one construct with two or more symbols). *Symbol redundancy* can make the identification and usage of constructs of the extensions difficult. In our SLR [4] we identified 21 concepts with symbol redundancy. An experiment resolved six of these redundancies [9], while the proposal of an iStar extension mechanism could address six other redundancies [6]. Eight concepts are still redundant: *Commitment*, *Condition*, *Conflict*, *Context*, *Label in Nòmos 1*, *Label in Nòmos 2*, *Situation* and *Threat*. In this paper we address them.

We conducted a survey with 83 participants to mitigate symbol redundancy in iStar extensions, through the analysis of participants preferences about the symbols with redundancy and established a prioritization of those symbols. This result can help extenders and modellers to select redundant constructs when using iStar extensions. The rest of this paper is structured as follows: Section 2 presents the Methodology, Section 3 shows the related work, Section 4 describes the results, Section 5 presents the threats to validity and Section 6 discusses the conclusions.

2 Methodology

We analyzed the preferences of novice practitioners for each redundant graphical representation. Such empirical data could aid further prioritization of concrete syntax choices for iStar extensions. The survey was designed following the principles proposed in [12]. It is cross-sectional, where participants are requested at a single specific time. The main goal of this survey was to evaluate how suitable the representations of concepts with two or more representations to the participants were so that we prioritize these representations.

This study was conducted at Universidade Federal do Ceará - Campus Quixadá, in Brazil northeast region. We involved undergraduate students from various programs (Computer Science, Software Engineering, Information Systems, Digital Design and Computer Engineering). The study occurred between September of 2016 and January of 2017. Clarification and consent terms were prepared and sent to the participants for each step of the study.

The participants had no previous experience with iStar or its extensions. Hence, we provided to all students a basic (2 hours) training on iStar as well as the domains and application areas related to the concepts under investigation. This training was important to set a basic understanding of iStar fundamental constructs and purpose (goal modelling), which is something one needs to be aware of when proposing or evaluating extensions for the language.

After training, participants answered questionnaires composed of Likert-type scale questions to take the evaluation of preferences for each construct in conflict. For each construct in conflict, we presented all the redundant graphical representations found in the literature. The order of appearance of symbols was randomized to counteract sequence effects. For each representation, participants were asked to indicate its suitability using a Likert scale: Totally adequate, Partially adequate, Neutral, Partially inadequate, Totally inadequate. Clarification and consent terms were prepared and sent to the participants.

We performed a pilot involving ten participants. Next, we applied the survey between September of 2016 and January of 2017 and received 83 responses. The structure of the survey is available at https://www.cin.ufpe.br/~ler/addressing_symbol_redundancy/Survey.pdf. Data of the survey is available at https://www.cin.ufpe.br/~ler/addressing-symbol_redundancy/data.zip.

3 Related Work

Many surveys have been performed involving goal modelling and iStar. Granada et al. [10] analysed WebML (a modelling language for web applications) according to a set of solid principles, based on the theoretical and empirical evidence concerning the cognitive effectiveness of visual notations. As a result, they have identified a set of possible improvements, some of which have been verified by an empirical study. Ali, Yue and Briand [1] evaluated the "readability" of state machines when modelling crosscutting behaviour with trained graduate students. Both these works involved students as participants in order to analyze the cognitive aspects of visual modelling languages. None of the studies presented above describes an evaluation of symbols used in iStar extensions, to propose a ranking and be used as a parameter of choice in future extensions.

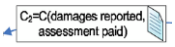
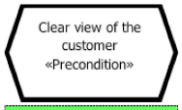
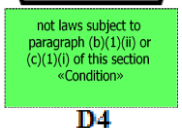
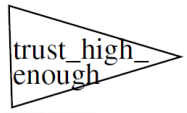
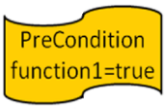
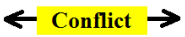
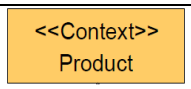
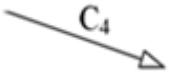
Some experiments have been performed to create or analyze symbols of iStar. The paper of Caire et al. [2] involves a set of experiments about the improvement of graphical representation of modelling languages, where the authors used iStar to illustrate the usage of their principles and propose more representative graphical symbols. Santos et al. [11] performed a quasi-experiment to assess the impact of the semantic transparency of the graphic symbols proposed by Caire et al. in understanding and reviewing tasks of iStar models. Although they found no significant difference in the speed and accuracy, the collected eye-tracking data revealed a significantly lower visual effort using the more semantically transparent symbols.

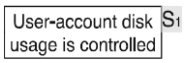
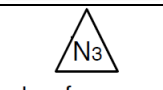
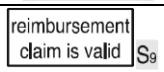
4 Survey Results

The results represent how suitable the representations are for the participants. The descriptive statistics results (median, mode, % adequate responses and % of adequate and inadequate responses) of the evaluation survey are shown in Table 1 and **Fig. 1**. **Fig. 1** presents the stacked bar chart of the answers for each construct. **Table 1** shows the result of the analysis of the following concepts: *Commitment*, *Condition*, *Conflict*, *Context*, *Label in Nòmos 1*, *Label in Nòmos 2*, *Situation* and *Threat*. The percentage of adequate responses includes the *Totally adequate* and *Partially adequate*. The percentage of inadequate responses involves the *Totally inadequate* and *Partially inadequate*.

We highlighted the representations with a better evaluation in **bold**. We sorted them based on values of the median, mode, % adequate responses and % inadequate responses, respectively. For *Commitment*, *Condition*, *Conflict*, *Label in Nomòs 2* and *Situation*, the median and mode were enough to rank. We needed to consider the % values of adequate responses and inadequate with regard to *Context*, *Label in Nòmos 1* and *Threat* concepts, since the median and mode are the same between their representations.

Table 1. Comparison of redundant graphical representation of constructs.

Construct		Symbol	Median	Mode	% Adeq	% Inadeq
Commitment	R1		**Partially Adequate**	**Totally Adequate**	**78.31**	**10.84**
	R2		Neutral	Partially Adequate	48.19	31.32
Condition	R3		**Partially Adequate**	**Partially Adequate**	**55.42**	**16.27**
	R4		Neutral	Partially Adequate	46.98	31.32
	R5		Neutral	Totally Inadequate	36.14	39.75
	R2		Neutral	Totally Inadequate	37.34	44.57
	R6		Partially Inadequate	Totally Inadequate	28.91	51.80
	R1		Partially Inadequate	Totally Inadequate	28.91	56.62
Conflict	R1		**Partially Adequate**	**Totally Adequate**	**67.46**	**24.09**
	R2		Neutral	Partially Inadequate	34.93	49.39
Context	R4		**Neutral**	**Neutral**	**49.39**	**21.68**
	R1		Neutral	Neutral	38.55	28.91
	R2		Neutral	Neutral	37.34	32.53
	R3		Neutral	Neutral	30.12	38.55

Label in Nòmos 1	R1		**Partially Adequate**	**Partially Adequate**	**60.24**	**14.45**
	R2		Partially Adequate	Partially Adequate	59.03	18.07
Label in Nòmos 2	R1		**Partially Adequate**	**Partially Adequate**	**67.46**	**16.86**
	R2		Neutral	Partially Adequate	40.96	34.93
Situation	R2		Partially Adequate	Partially Adequate	53.01	24.09
	R1		Neutral	Partially Adequate	48.19	27.71
Threat	R1		**Neutral**	**Partially Adequate**	**49.39**	**33.73**
	R2		Neutral	Partially Adequate	42.16	30.12

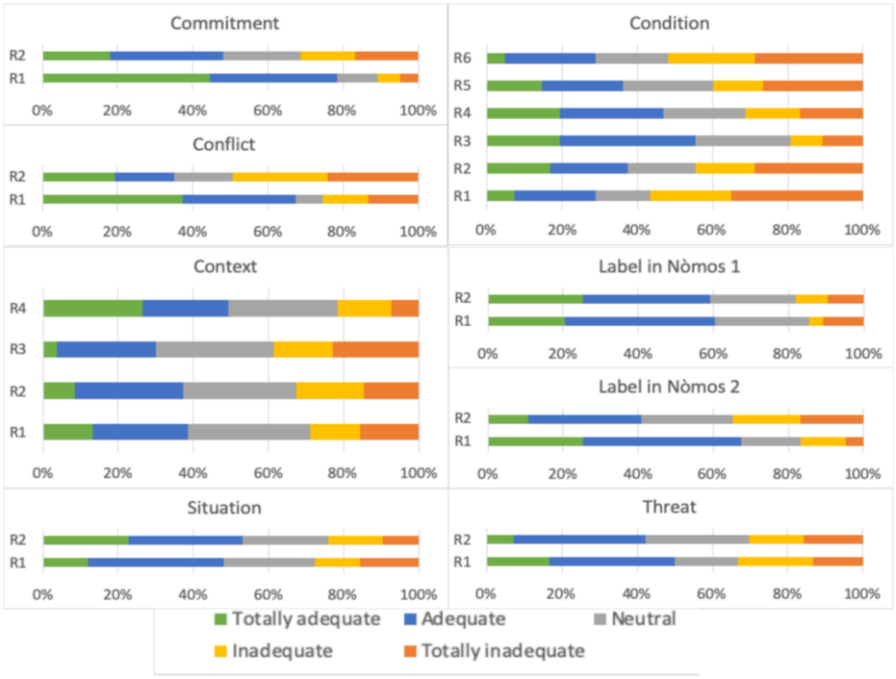


Fig. 1. Stacked bar charts of redundant graphical representation of constructs.

5 Threats to Validity

We present the threats to validity of our survey according to the aspects established in [11] and [12]: Conclusion Validity, Internal Validity External Validity, and Construct Validity. **Conclusion validity.** We recruited undergraduate students from computer science-related programs. Participants were homogenous regarding their lack of previous knowledge with goal modelling and basic skills in system modelling and development. All participants were asked to evaluate each redundant representation. Responses were treated as Likert item questions, as they could not be integrated as a scale. Therefore, we adopted the median as central tendency metric and provided an aggregate adequacy rate by summing up the proportions of the two positives Likert items ("Partially adequate" and "Totally adequate"). **Internal validity.** We provided basic training on iStar modelling to all participants, to present the language purpose and core constructs. Hence, they had contact with the language in a basic way. **External validity.** We chose undergraduate students as experimental participants, as they had no previous knowledge of the goal language notation, but they did have some knowledge about the application areas related to the constructs proposal. Such sample population can be considered a reasonable proxy for the non-experienced user profile in the context of modelling language usage (e.g. stakeholders who are not specialized in Requirements Engineering). **Construct Validity:** The construct validity was treated with a pilot execution involving ten participants. We analyzed their responses to identify how the pilot sample behaved. However, this is considered a limitation because we applied it only once and with a limited number of participants.

6 Conclusions and Further research

In this paper, we presented the results of a survey whose objective was to rank symbol redundancy graphical representations in iStar extensions. Thus, we identified the preference of the participants and presented a priority for each representation grouped by concept. These results may be useful when iStar extensions will be proposed, which reuse two or more extensions in conflict. The representations and prioritization also can be useful when designers need to use two or more extensions together to model their systems.

As future work, we intend to replicate this study with other students to compare the findings with the results of this work. We also intend to analyse the preference of experienced extenders to compare with the not-experienced ones. We are interested in analysing the preference of the representations in the context of models (not individually).

On another hand, we are currently working on a process to guide the proposal of next iStar extensions. This process is based on the reuse of existing extensions identified on the study [4], including the representations of this paper, and recommendations identified during the interviews of paper [5]. The process will consider the definition

of the related concepts, abstract and concrete syntax maintaining the traceability. Finally, it is important to illustrate the use of the process by proposing a new iStar extension in an application domain to be chosen.

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