Using i* to Capture Consumer Preferences as Requirements for Software Product Lines

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Abstract. The need for software to fit to diversity of numerous consumers has become a norm. Furthermore, technology innovations stimulate the growth of such software, thus making it even more available and appealing to consumers. Although how economic values relate and influence IT systems is an area that has been addressed, it is not clear whether and how consumer values do so. To address this challenge, this study aims to using i* establish a link between preferences of consumers and system requirements for Software Product Line (SPL) as a seamless way for systematically realizing variations. The presented results are grounded in an empirical study related to the development of a system for Online Education.

Key words. Consumer Value, SPL, Goal Modeling, i*, System Requirements

1   Introduction

There are a number of types of value: quantitative, or economic, are generally understood as an amount in goods, products, services or money, considered as a suitable equivalent for something else: a fair price or return for an investment [1]. In contra poise are values with a qualitative nature, detailing how a good, product, or service is delivered to, or perceived by, the consumer. These have been variously termed non-economic values, internal values, and most often - *consumer values* [2].

While the impact of quantitative values on information systems is readily seen and acknowledged, particularly within software engineering, qualitative values have been researched to a much lesser degree, in particular consumer values. Several attempts to address this deficiency in non-economic values within the development space have been made, however, none have had an explicit consumer focus. This is a failing because the values of an individual have an effect on their behavior as consumers [3].

Take, for instance, a situation where Consumers A and B both want "convenient" book delivery. For A that means downloading an electronic book immediately, while for B it means dispatching the book via post quickly to a location near to the consumer's residence. The consumer value "convenient" is not clearly defined, so the business cannot develop the proper support systems required to deliver what the consumers' desire. As both a theory and a set of practices Software Product Lines

(SPL) promises to address the challenges outlined above through the design of software products sharing a common set of features, which at the same time are specialized to satisfy the specific needs of a particular market segment.

2 Objectives of the Research

The objective of this study is to present how consumer preferences can be captured in the development of IT systems, by using the theory for the design of a collection of similar software products, namely SPL. We propose a method for linking consumer values with Goal-Oriented Requirements Engineering (GORE) approaches, as they are acknowledged for effective exploration of alternatives in requirements, and more specifically, for elicitation of variable and common requirements of SPL. Using the i* framework as the example for GORE, we also leverage from the existing proposals the ability to link goals to feature models, leading further to the configuration of SPL.

The research approach taken in this paper is conceptual and empirical. Concepts used in value modeling and consumer representation are integrated with those of i* and SPL. The theory is tested through a study on Online Education systems.

3 Scientific Contributions

3.1 Consumer Values

Holbrook's Typology of Consumer Value [2] classifies the preference of individuals concerning the goods or services that they evaluate for a potential use, or appraise from their previous consummations. According to Holbrook, a consumer value is a) *interactive,* as it entails an interaction between a subject and an object, b) *relativistic* refers to consumer values being comparative, c) *preferential* as consumer values are the outcome of an evaluative judgment, d) and *experience* meaning that consumer values not reside in the product/service acquired, but in the consumption experience.

Three consumer value dimensions are the basis of Holbrook's typology: *Extrinsic/Intrinsic*, *Self-oriented/Other-oriented*, and *Active/Reactive*. Based on them, eight archetypes representing distinct types of value in the consumption experience are derived (Table 1):

Table 1. Holbrook's Typology of Consumer Values

Extrinsic	*Intrinsic*		
Efficiency	**Play**	*Self-Oriented*	*Active*
Excellence	**Aesthetics**		*Reactive*
Status	**Ethics**	*Other-Oriented*	*Active*
Esteem	**Spirituality**		*Reactive*

Empirical Study. The main challenges in online education concern creating software for courseware appealing to diverse students. To encourage students' attention and

learning, one of the crucial factors is to design software systems in the way to support both intrinsic and extrinsic motivations/values of students.

In our research we have performed an empirical study with the students of Stockholm University, Non-Master and Master, to examine their preferences for the online education system, as well as to assess their importance. For the first, we have profiled Consumer Values through individual interviews, where the students were asked to describe their preferences for an online education system in terms of each of the eight Holbrook's value archetypes. From around 220 value examples that were collected, in Table 2 below we present some of them.

Table 2. Examples of Consumer Values obtained during the interview process.

Holbrook Value	Example (Measure)
Ethics	-Prevent cheating
	-Provide materials
	-Communication rules
	-Promote professionalism
Play	-Discussion with others
	-Whimsical
	-Provide fun learning
	-Make layout customizable
	-Provide push-pull functions
Aesthetics	-Access (through web browser or app)
	-Interactive
	-No mountains of text
Efficiency	-Save time
	-Access whenever/wherever
	-Time limits for completing assignments

To assess the importance of 8 archetype values (Table 1), we have used the survey instrument of the Basic Value framework of Schwartz [2], administered as the European Social Survey (ESS) - we have collected the weights (importance) of generic values of a large sample of students (>200), and owing to the established mapping between the value frameworks of Schwartz and Holbrook [4], we assessed the importance of the concretizations of Consumer Values of Holbrook elicited in the individual interviews (Table 2) according to the survey's results. As an illustration, the survey results showed that Ethics is the most important to Non-Master students, while Play to Master students. Another finding was that Aesthetics and Efficiency are highly weighted from the both student segments, though in the opposite order.

3.2 From Consumer Preferences to Requirements for SPL

Once a product is examined by different consumer segments for desired properties and their importance, the collected information can be transformed further to a requirements model, with the purpose to configure a Software Product Line. Based on

[5], where the mappings between e^3 value model and i* goal framework are analyzed, we propose the construction of an i* SR model from Holbrook's consumer framework by mapping:

- Consumer (Student) and product Provider (University), to distinct *Actors* in i*.
- The exchange of the economic value (Online Education), to *Resource Dependency* in i*, further elaborated within Provider, through a System type sub-Actor.
- Consumer Value to the *Beliefs* of the consumer i* actor, i.e. to the conditions about the world that the consumer holds to be true; the beliefs become the *Soft Goals* of the Provider, i.e. the intentions without a clear-cut criterion of achievement, thus requiring further refinement (decomposition).
- The weight of a population's consumer value, to a numbered annotation* in the belief representing the value (ex. Play has priority 3 for non-master, and 1 master)

* Another way to manage priorities is based on the notion of precedence of goals, and among goals [6]; however, since there is no i* implementation available, we have not considered this extension in our study.
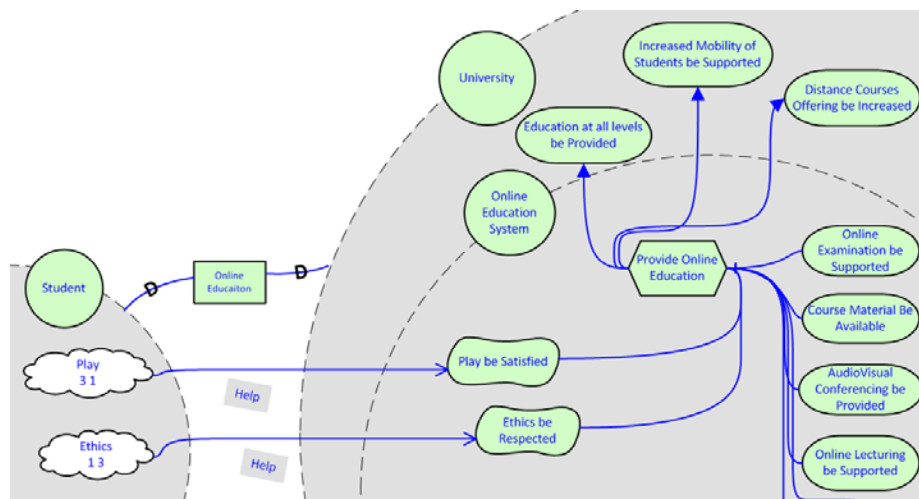

Fig. 1. An excerpt of the top-level i* model for the Online Education System product line. Apart from the elements derived from the mappings from the Consumer Value framework, the model also captures the core goals of the University, and of the Online Education System.

The refinements of Holbrook's consumer values (see Table2 for examples), concretizing (i.e. measuring) the eight archetype values from Table 1 for a software product in the consideration, are modeled as Resources or Tasks in i* through the decompositions of the soft goals corresponding to the values. In the following figure we present a detailed part of the i* SR model where Ethics, the value highly assessed by the both student sub-populations (priority 1 for non-master, and 3 for master) is further elaborated:
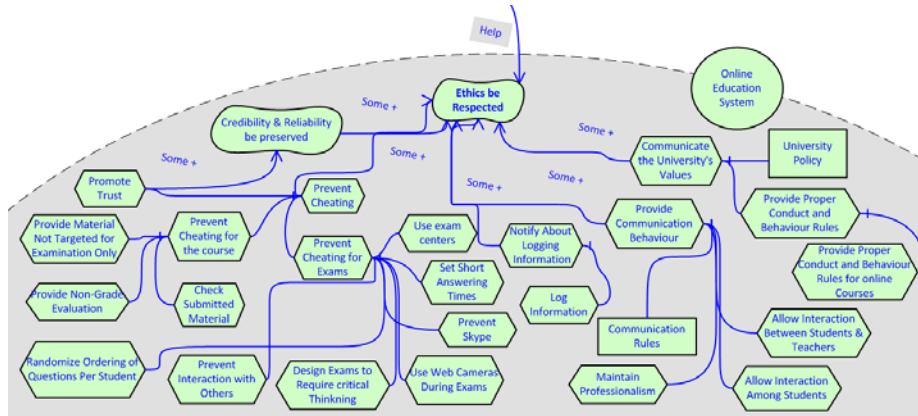
Fig. 2. Decomposition of Soft Goal "Ethics be Respected".

The "system" (Online Education System in Figure 2) is the actor representing future SPL. To link the i* SR model with a configuration for SPL, the theory of feature modeling is applied, where features are used as the basis for analyzing and representing *commonality* and *variability* of systems in a solution domain [7].

For the elaboration of the requirements for SPL from an i* SR model using features, the guidelines concerning feature identification presented in a goal oriented approach for SPL (G2SPL) [8] are considered. The main difference is that in our approach the features originate from consumer values, and as such, in addition to their elicitation, they are classified (as common or variable) and prioritized in an early stage of the requirements collection - i.e. within i*, according to the mappings from consumer preferences. A small sub-set of the feature elicited in the empirical study for the value Ethics is presented in Table 3 below. In the table, common features are the ones identified in both segments. For example, *Prevent Cheating for Exams* is a feature elicited as a preference by the both student segments. Variable features are the ones not identified in both segments, i.e. including a priority number for some segments and "-" for at least one segment. For example, *Provide Communication Rules* is a feature elicited only by Non-Master students.

Table 3. Excerpt with features for the soft-goal "Ethics be Respected".

Element	FatherElement	Feature	Priority	
			NonM	Master
Prevent cheating for exams	Prevent cheating	Prevent cheating for exams	1	3
Log information	Notify about logging	Log all events and documents	-	3
Provide communication behavior	-	Provide communication behavior	1	3
Communication rules	Provide communication behavior	Provide Communication rules	1	-

The features identified valid for Master students will be the subjects of the requirements for the online education system product developed for them, while the features identified to be valid for Non-Master students will be part of the other product. For more details about mapping the features to requirements, see [8].

4   Conclusions

In this paper we have presented a consumer-based approach to collecting requirements for SPL. The use of the consumer framework for elicitation of requirements for SPL is argued and demonstrated through the mappings of a consumer value framework to the i* goal framework for RE. The objective has been to elevate the alignment between user needs and the final software by proposing a systematic approach for structuring of a diversity of preferences of consumers bundled into a SPL.

5   Ongoing and Future Work

The main ongoing work concerns further development of our Consumer Preference Meta-Model (CPMM) [9], meant to integrate the core elements of the business value modeling, as well as those of consumer frameworks, such as preferences, segmentation, context of use, and preference measures.

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