A Situated and Embodied Approach to Service-oriented Modeling

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Abstract

[Context] As opposed to the traditional approach to problem solving, which limits the scope of the solution to the stated problem, the mandate for services is to go deeper and focus on the value that the proposed solution creates for the entities affected by the problem. **[Problem]** In the absence of any formal characterization of the value concept, service designers often fail to decode the complete information available in a consumer's expression of value. The dominant approach to interpreting value expressions considers service as a work system, and the value provided by the service as a specific task that the work system helps the consumer accomplish. Such an exclusively functional view of the value concept fails to process value expressions, which reveal the affective states that a service invokes at the consumer. Affective states correspond to the internal feelings of the consumer and, if reasoned appropriately, these states can help identify an additional set of tasks that the service helps accomplish for the consumer. Situating the problem solution in a larger set of work systems will provide the service designer a wide range of design choices, thereby increasing the likelihood that the resulting service achieves the desired objective. **[Idea]** This work takes an experience-design based approach to services. It models the value a service offers to the consumer as the change the consumer experiences. Experience refers to the consumer's cognitive act of appreciating the service. Cognition is a grounded phenomenon, and to understand the cause-and-effects underlying the consumer's appreciation of the service requires attention to the consumer both as a social being, as well as a bodily being. The basic idea is to model the consumer's interaction with the service in terms of the action the service helps the consumer perform in different situations (situated actions - situatedness), and the affective states that the service invokes in the consumer (bodily states - embodiment). **[Contribution]** The contributions of this work are two fold. First, it provides a set of four force-dynamic patterns - Value Frames, which the service designer can use to model the causal basis of the affective states revealed in the consumer's expression of value. The insight here is that in the context of value creation, the source of change is not restricted to only those force-factors that bring about an observable change at the consumer. Instead, all force-factors that are capable of gaining appreciation from the consumer, even if the appreciation does not necessarily manifest itself through observable state transitions, should be acknowledged. The claim this work makes is that the nature of the problem that the service helps the consumer overcome, and the change the service introduces to do so, together provide a conceptual basis for modeling the appreciation that the service invokes at the consumer. The second outcome of this work is a value-oriented conceptual modeling method – TRIBE, which specifies the process for developing some initial problem solution into a service specification. **[Relevance]** In addition to the conceptual contribution that this work makes in specifying the cognitive semantics of service design, it also provides the apparatus and method necessary to conduct a service-oriented inquiry. This thesis includes a case study that illustrates the application of the proposed modeling method, and the modeling constructs, to a real-world problem situation – the case of food-grain storage and distribution in India. The results of the case study confirm that the proposed modeling method helps service designers not just discover new features for their service but also identify the entities required to implement these features. As the field of Service Science matures, it will have to develop a more normative body of knowledge, which the service designers can use in their day-to-day practice. This work is one such effort towards that end.

Keywords: Service Design, Cognitive Semantics, Force-dynamics, and Design Patterns

Résumé

Contrairement à l'approche "résolution de problème", qui limite l'espace des solutions au problème exprimé, le but pour les services est d'aller plus profond et de focaliser sur la valeur que la solution proposée amène aux entités affectées par le problème.

En l'absence de caractérisation formelle du concept de valeur, les concepteurs de services échouent souvent à décoder l'information disponible sur la valeur perçue par le client. L'approche dominante d'interprétation de la valeur consiste à considérer le service comme un système qui fournit un travail; la valeur créée par le service est alors une tâche spécifique que le système aide à accomplir. Une vue aussi fonctionnelle du concept de valeur n'inclut pas l'état affectif créé par le service chez le client. Les états affectifs correspondent aux sentiments internes du client, et – avec le raisonnement adéquat - ces états permettent de trouver un ensemble supplémentaire de tâches que le service permet au client d'accomplir. En positionnant la solution du problème dans un plus grand ensemble de systèmes fournissant du travail, fournira au concepteur de service un large éventail de choix de design, et donc augmentera les chances que le service résultant réalise l'objectif désiré.

Ce travail propose une approche basée sur l'expérience pour la conception de services. Il modèle la valeur offerte par un service comme un changement dans l'expérience utilisateur. Le terme expérience se réfère à l'acte cognitif d'appréciation du service. L'acte cognitif est un phénomène « ancré ». La compréhension de la relation de cause à effet sous-jacente à l'appréciation du client exige de considérer le client comme, à la fois, un être social et un être incarné dans un corps. L'idée de base consiste à modéliser l'interaction du client avec le service en termes d'actions que le service permet au client d'effectuer dans différentes situations (« situated actions » - « situatedness») et en termes d'états affectifs que le service active chez le client (« bodily states» – « embodiement »).

Les contributions de ce travail ont deux aspects. Premièrement, il y a un ensemble de quatre canevas d'analyse, canevas basés sur la dynamique des forces – les « Value Frames ». Le concepteur de service utilise ces canevas pour modéliser les causes des états affectifs lié à l'expression de valeur du client. L'idée est que dans le contexte de la création de valeur, la source du changement ne se limite pas aux forces qui amènent un changement observable chez le client. Au contraire, toutes les forces qui peuvent être appréciées par le client, même celles qui ne créées pas un changement observable, sont prises en considérations. L'aspect innovant que ce travail met en avant est que la nature du problème résolu par le service pour le client, et que les changements que le service introduit, ensemble fournissent une base conceptuelle pour modéliser l'appréciation créée par le service chez le client. Le deuxième résultat de ce travail est une méthode de modélisation de la valeur – TRIBE, qui décrit le processus pour transformer une description de problème en une spécification de service.

En plus de la contribution conceptuelle que ce travail fait en spécifiant la sémantique cognitive de la conception de service, il fournit aussi l'appareillage et la méthode nécessaire pour conduire un analyse orientée service. Ce doctorat inclut une étude de cas qui illustre l'application de la méthode proposée, et les constructions utilisées. Cette étude analyse un problème réel et concret – le stockage et la distribution de céréales en Inde. Les résultats de l'étude confirment que la méthode proposée aide les concepteurs de service, non seulement à découvrir de nouvelles fonctionnalités pour leurs services, mais aussi pour découvrir les entités nécessaires à la réalisation du service. Avec le temps et avec l'augmentation de maturité, la science des services va développer un savoir faire que les concepteurs utiliseront quotidiennement. Ce travail est une contribution à cette finalité.

Keywords: Service Design, Cognitive Semantics, Force-dynamics, and Design Patterns

1. Introduction

The work presented in this thesis proposes a service-oriented conceptual modeling method called TRIBE. TRIBE includes a set of modeling constructs, and a modeling process, which together provide the service designer the tools necessary to develop a service-oriented model of the problem solution. A service-oriented model organizes the available information in a way that exposes the cause-and-effect relationships underlying the problem situation. A systematic approach to specifying the causal organization of a situation will help the service designer identify the need for any additional information, and develop precise inquires to fulfill them. This chapter begins with an overview of the services approach to problem solving that illustrates how co-creation is at the heart of any service-oriented design activity. Next, it briefly introduces the notions of situatedness and embodiment as concepts that can help the service-designer gain important insights about the causal basis of the consumer's value expression. The chapter also includes a state of the art section, where the research results presented in this thesis are positioned in the context of recent developments both in the field of Service Science and Requirements Engineering. The chapter ends with an assessment of the research design pursued in this work. For this purpose I use the seven guidelines proposed by Hevner for evaluating design science research.

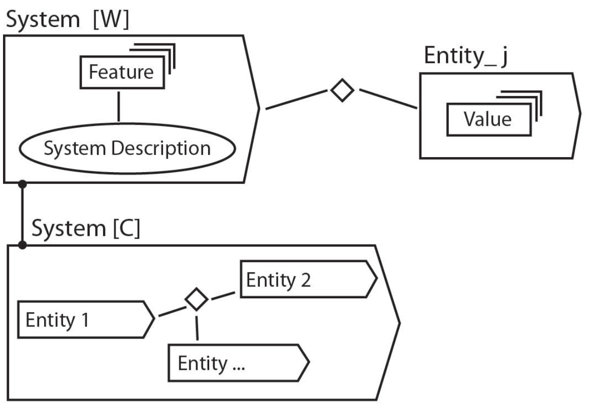
1.1 The Services Concept

Service is defined as "the application of specialized competences for the benefit of another entity or the entity itself" [1]. The conceptual foundation of services is grounded in the logic of value creation and is referred to as the service-dominant logic of problem-solving [2]. As opposed to the traditional approach to problem solving, which limits the scope of the solution to the stated problem, the mandate for services is to go deeper and focus on the value that the service creates for the entities affected by the problem. The shift from problem-solution to value-creation highlights the extended life cycle of services, which includes both the creation phase and the consumption phase of the solution. An important tenet of service-dominant logic is the **co-creation principle,** which stipulates that the consumers of a service should not only be seen as entities that derive benefit from the service but also as suppliers that contribute to the creation of the service. At the very least, consumers undertake the role of suppliers by virtue of them providing their bodies, minds, belongings or information as ports through which they consume the service [3]. These ports are points of experience [4], in the sense that experience is the true expression of a consumer's desire and that value creation should focus on invoking the desired experience [5].

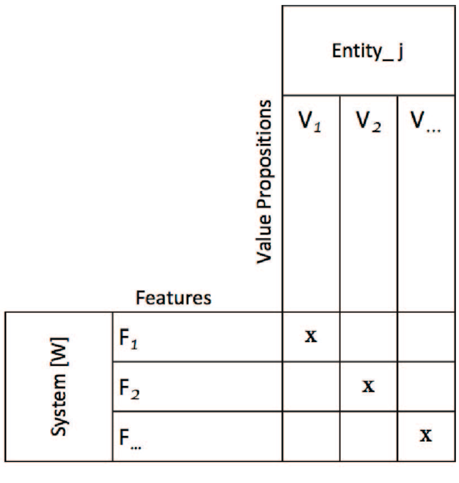
Before going any further, I first introduce the visual notation that will be used in this thesis to represent service-oriented models of problem solutions. Next, I will use this visual notation to illustrate the services concept for the case of mixed mode commuter service. The idea is to use this example to highlight the different challenges that a service designer faces in specifying the service, and how the method proposed in this work addresses these challenges.

1.1.1 The Visual Notation Used

The visual notation used in this work is an extension of an existing visual modeling tool called SEAM [6]. SEAM is a set of Systemic Enterprise Architecture Methods based on the principles of General Systems Thinking (GST) [7]. GST advocates that the component parts of a system can be best understood in the context of relationships with each other, rather than in isolation. An important way to fully analyze a system is to understand the part in relation to the whole. SEAM represents any perceived reality as a hierarchy of systems. Each system can be analysed as a whole [W] - showing its externally visible characteristics or as a composite [C] – showing the constituents of the system as a set of interrelated parts. For ease of comprehension, the SEAM visual library supports two ways of representing a problem solution. The first is referred to as the System Layout view and the second is referred to as the Feature-Value Matrix view. The System Layout view provides a visual depiction of the systems constituting the situation being modeled. In doing so, it provides the liberty to either model the system as a white box – where the composition of the system is revealed and hence the use of the marker [C], or as a black box – where the system is represented as a unified whole and hence the use of marker [W]. As the name suggests, the Feature-Value Matrix view provides a matrix representation of what the system does, i.e. the features supported by the system, and what benefits these features provide to the different entities constituting the situation being modeled. The SEAM visual notation is illustrated in Figure 1.



(a) System Layout view



(b) Feature-Value Matrix view

Figure 1 The SEAM visual notation

When using SEAM to model a service, I use an extended version of the SEAM visual notation to model an entity's interaction with the service at three levels. The entity for which the value offered by the service is to be analysed is referred to as the **Focal Entity (FEN)**. The focal entity itself is modelled at a level that reveals the competence that it gains by virtue of adopting the service. This is visually represented using an orange colour stick figure with subscript 'C', which emphasizes the competence exhibiting view of the focal entity. As a supplier of the service, the focal entity contributes to the creation of the service along with other suppliers of the service. This aspect of the focal entity is referred to as the **Focal Supply Element (FSE)**, and is visually represented using a green color stick figure with subscript 'R', which emphasizes the resource providing view of the focal entity. As a consumer of the service, the focal entity benefits from the competence that the focal entity gains by virtue of adopting the service. It does so by activating the newly gained competence in different consumption contexts, thereby invoking desired experiences. This aspect of the focal entity is referred to as the **Focal Consumption Element (FCE)**, and is visually represented using a blue color stick figure with subscript 'V', which emphasizes the value expecting view of the focal entity. An important challenge that co-creation presents in identifying service systems is the need to model the supplier and consumer roles that an entity undertakes with respect to the service [8]. An extended set of SEAM visual notation used in this work is illustrated in Figure 2.

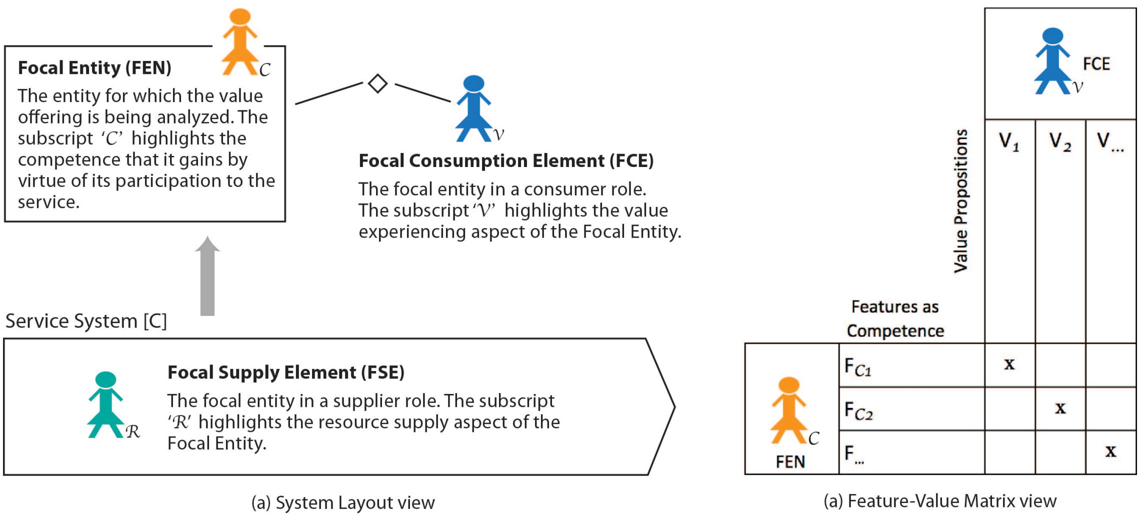


Figure 2 An extended version of the SEAM visual notation

From a service-design perspective, the artifact that implements the service is called a **Service System**. As defined in [9], service systems are configurations of people, technology, and other resources that co-create value. An important challenge that co-creation presents in identifying service systems is the need to model the supplier and consumer roles that an entity undertakes with respect to the service [8]. It is important to note that even though Figure 2 shows the service system as composed of only FSEs, it is not to suggest that the service is implemented solely by the focal entity. Depiction of FSE as constituting the service system is only to emphasize the co-creation principle of service design, which suggests that for an entity to benefit from a service, the entity should also contribute towards the realization of the service. A service system will include several other entities in addition to the focal entity.

1.1.2 An Example Illustration

To illustrate the co-creation principle of the services concept, I take the example of use of foldable-bike as part of a mixed-mode commuter service. Mixed-mode commute refers to the use of two or more modes of transport for regular travel between home and place of work. For ease of exposition, I restrict the interpretation of mixed-mode commute to the combination of bike and train. Foldable-bike refers to bike designs, which have a collapsible frame, whereby when not in use their form-factor can be reduced to a shape and size of a conventional luggage allowed on-board most public transports. At first sight it might seem that to realize a mixed-mode commuter service one only needs the following resources: a train network capable of taking people from one place to the other, a bike manufacturer providing bikes, and a road network that enables people to bike from one place to the other. Nevertheless, the proposed mixed-mode commuter service will only be able to provide value to the commuter if the commuter, as part of her daily commute to work, agrees to travel in the train, and ride the bike. The contribution that the commuter makes in realizing the service can be substantiated by referring to the energy the commuter supplies to pedal the bike, walking to the train, getting on the train, etc.

From this perspective, the commuter plays an important role in creating the competence of mixed-mode commute, which the commuter then also benefits from by activating this competence in different consumption contexts to realize desired benefits. For example, the value that this service offers to the commuter could be that it increases the likelihood that the commuter gets to office on time, avoids inconvenience to passengers, saves money and reduces health problems. Each of these value-propositions hints at a distinct consumption context, which assigns the commuter the consumer-roles of employee, co-passenger, homemaker and a health-conscious-person.

Figure 3 provides a Systems layout view of the mixed-mode commuter service. In the context of the current example, the focal entity is the commuter. The commuter gains the competence of mixed-mode commute by adopting the mixed-mode commuter service. The features of the mixed-mode-commute competence include the ability to avoid traffic delays, ability to avoid travel with oversized objects, ability to reduce cost of travel, and the ability to perform physical workout. A mapping between the features of the competence that the focal entity exhibits by virtue of adopting the mixed-mode commuter service, and the value that this competence realizes for the focal entity in different consumption contexts is represented as feature-value matrix, Table 1.

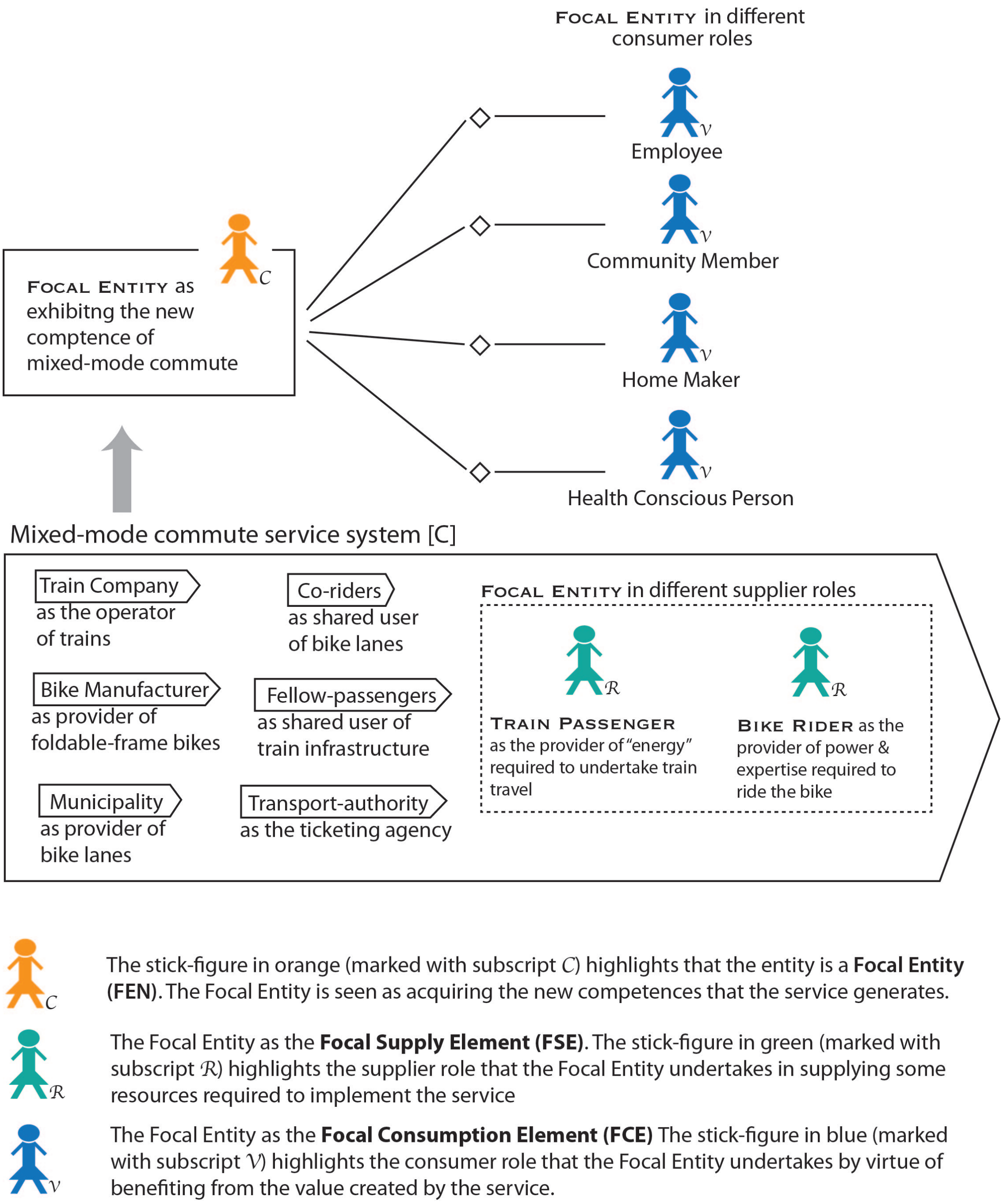


Figure 3 An initial Systems layout view of the mixed-mode commuter service

Table 1 An initial Feature-value matrix view of the mixed-mode commuter service

		Focal Consumtpion Element (FCE)	FCE_1: Focal Entity as an **Employee**	FCE_2: Focal Entity as a **Community Member**	FCE_3:Focal Entity as a **Home Maker**	FCE_4: Focal Entity as a **Health Conscious Person**
		Value Proposition (V)	V_1: Increased likelihood to get to office on time	V_2: Increased likelihood to avoid inconvenience to fellow passengers	V_3: Increased likelihood to spend more on household purchases	V_4: Increased likelihood to reduce health problems
		Features (F_c)				
FOCAL ENTITY	Initial features	F_{C1}: Ability to avoid traffic delays	x			
		F_{C2}: Ability to avoid travel with oversized objects		x		
		F_{C3}: Ability to reduce cost of travel			x	
		F_{C4}: Ability to perform physical workout				x

1.1.3 Challenges in Service Design

In the real-world, service design activities do not start from scratch. They are based on some initial idea to address a problem situation. This initial idea is what I refer to as the problem solution. The service designer takes this as a starting point, and develops the problem solution into a comprehensive and viable solution, i.e. a service offering. Very often a problem solution in its native form is either commerically not viable, or functionally so restricted in scope that it is unable to bring about any appreciable change in entities of interest. Comprehensive and viable are subjective terms that refer to the service designers choice of setting the scope of the service. In doing so, the service designer relies on her experience to identify the need for additional information, to formulate precise inquires to gather this information, and to organize the information gathered in a way that helps reason the cause-and-effect relationships constituting the enhanced scope of the service. The challenge for the service design community is to formalize the service-oriented inquiry process such that the activity of service design is not restricted to some select experienced professionals, rather available as a well defined process that can be executed effectively even by entry level professionals. The three main challenges that I think are important to address are as follows:

1. ***How does the service designer identify additional scenarios, which can possibly be affected by the proposed problem solution? And what is the likely value proposition that the service can offer to the focal entity in this scenario?***

   Additional scenarios may not always surface from an exclusively behaviorist approach. Thinking in terms of 'What work a problem solution can get done?' is, no doubt, the most natural approach to conceptualizing new scenarios. Nevertheless, it is not the only approach. Many a times new scenarios, which otherwise are far off in the causal chain of analysis and, hence, do not surface in response to 'get work done queries', can be identified by paying attention to the affective states that get invoked at the focal entity in response to the problem solution. These affective states can be surfaced by solicting experience revealing expressions of value.

2. ***How does the service designer identify the features, i.e. the competence that should be built at the focal entity, to realize the value focal entity desires from the service?***

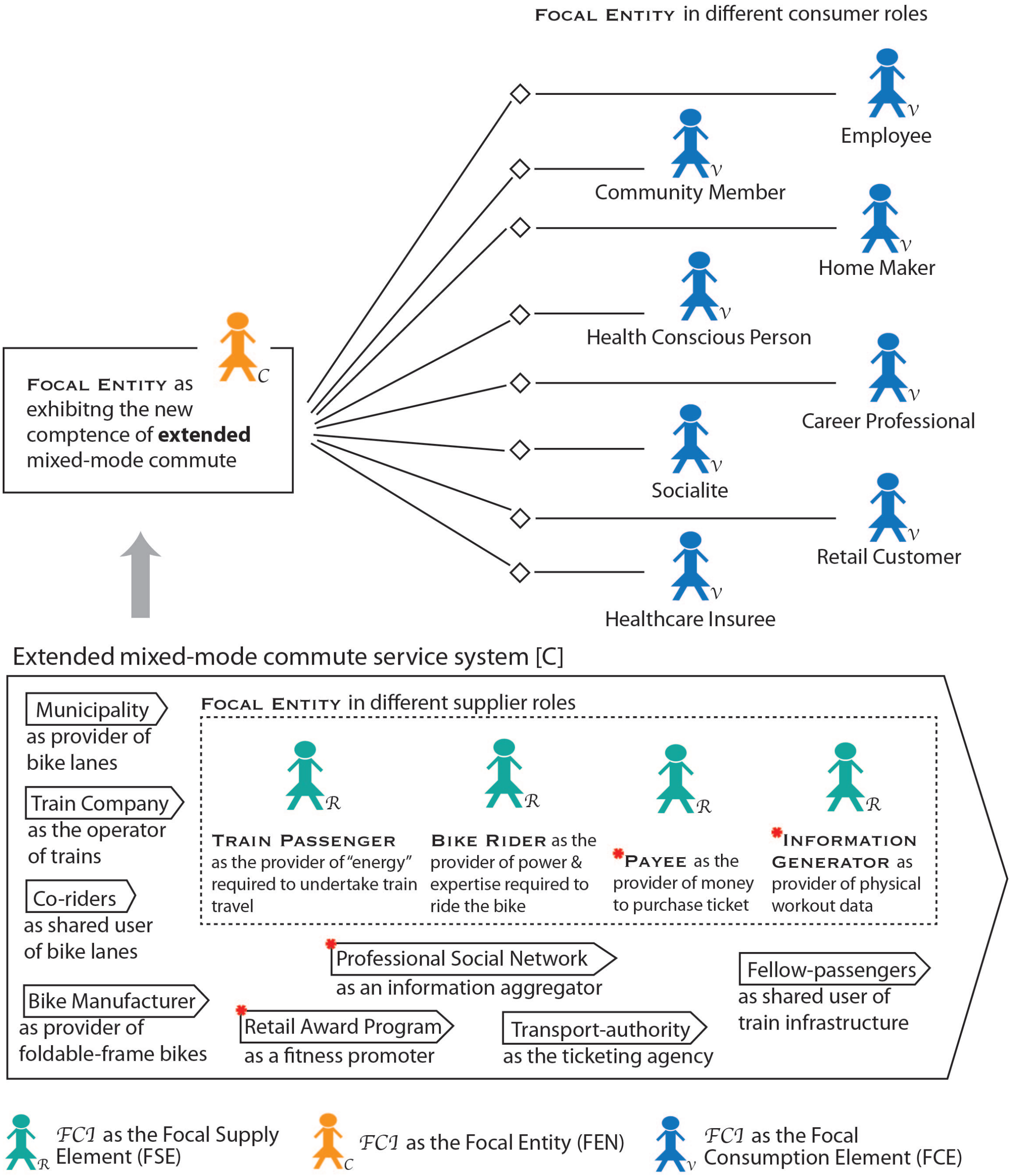
   Experience revealing expressions of value may not, by default, make explicit the behavioral change required to create the experience desired by the focal entity. It is only when the service designer is able to identify the behavioral change, i.e., the set of new interactions that bring about some observable state change, capable of creating the desired experience that she can precisely specify the features that constitute the service.

3. ***How does the service designer reason which enities, and in what roles, are required to implement the above identified features of the service?***

   Roles are not assigned in isolation. Identifying the role an entity undertakes requires service-designers to critically reflect on the situation that is invoked while analyzing the focal entity's interaction with the world. Situations are contextualized interpretations of the interactions of the participating entities [10]. Thinking in terms of situation helps to identify additional entities that are required to implement the service.

An illustration of the extended scope of an initial service model of the problem solution

To illustrate what these challenges mean in a real setting, lets undertake a revision of our mixed-mode commuter service. The revised version is referred to as the extended mixed-mode commuter service. The mixed-mode commuter service system presented in Figure 3, and the feature-value matrix presented in Table 1, can be seen as representing an initial version of the service based on some preliminary idea of increasing the use of public transport by promoting the use of foldable bikes. Based on this initial model of the service, the service designer can identify additional requirements to make the service more rewarding. The service system implementing the extended mixed-mode commuter service is depicted in Figure 4. The corresponding feature-value matrix is depicted in Table 2.



* New role assignments to implement the revised version of the mixed-mode commute service

Figure 4 An example illustration of the extended version of the mixed-mode commute service

Table 2 Feature value matrix of the extended version of the mixed-mode commute service

Focal Entity		Features (F_c) \ Focal Consumption Element (FCE) / Value Proposition (V)	FCE_1: Focal Entity as an **Employee** V_1: Increased likelihood to get to office on time	FCE_2: Focal Entity as a **Community Member** V_2: Increased likelihood to avoid inconvenience to fellow passengers	FCE_3: Focal Entity as a **Home Maker** V_3: Increased likelihood to spend more on household purchases	FCE_4: Focal Entity as a **Health Conscious Person** V_4: Increased likelihood to reduce health problems	FCE_5: Focal Entity as a **Career Professional** V_5: Increased likelihood to fast-track career progression	FCE_6: Focal Entity as a **Socialite** V_6: Increased likelihood to earn greater social recognition	FCE_7: Focal Entity as a **Retail Customer** V_7: Increased likelihood of additional support for household expenses	FCE_8: Focal Entity as a **Healthcare Insuree** V_8: Increased likelihood to save money
Focal Entity	Initial features	F_{C1}: Ability to avoid traffic delays	to reduce commute time							
	Initial features	F_{C2}: Ability to avoid travel with oversized objects		to avoid inconvenience to fellow passengers						
	Initial features	F_{C3}: Ability to reduce cost of travel			to generate additional funds					
	Initial features	F_{C4}: Ability to perform physical workout				to find time for physical workout				
	Newly discovered features	F_{C5}: Ability to enhance professional profile on the web					to share punctiality credentials			
	Newly discovered features	F_{C6}: Ability to provide next-to-each-other seating for friends						tomaintain social interaction during commute		
	Newly discovered features	F_{C7}: Ability to access retail discounts							to meet household needs	
	Newly discovered features	F_{C8}: Ability to access verifiable data on physical workout								to meet health care costs

The shaded region of the matrix highlights the new feature-value tuples that constitute the extended version of the mixed-mode commute service

Consider two new value propositions of the revised service – 'fast-track career progression' and 'greater social recognition'. Unlike the value propositions of the initial service, which are more objective in their value claims, the new value propositions of the revised service are more affective in nature. The value propositions in Table 1 refer to observable state changes like the change of arriving at the office on time, the change of carrying on-board form-compliant objects, the change of increased savings, and the change of exhibiting better vital signs during medical examination. The new value-propositions introduced above were specifically chosen to highlight the deeper semantics of value propositions, one that go beyond observable state change and reside in the consumer's affective judgments of appreciation of the service [11].

The true semantics of appreciation is sticky in nature [12]. It is internal to the consumer and may not always reflect in the consumer's interactions with the world. One interpretation of 'fast-track career progression' value expression could be the desire to overcome the challenge of 'establishing oneself as a punctual employee'. Based on the underlying situation and the entities revealed therein, the service designer may choose to extend the initial service system by including a 'professional social network site' as a supplier that provides automatic updates to the employee's punctuality profile on the web. Similarly, one interpretation of 'earn greater social recognition' value expression could be the desire to overcome the challenge of 'reduced social interaction during train travel'. Again, based on the underlying situation and the entities revealed therein, the service designer may choose to extend the initial service system. In this case it may assign an additional role to an existing supplier entity, the bike-manufacturer. In the original version of the service, the bike manufacturer as a supplier was undertaking the role of a foldable-frame-bike manufacturer. The extended version of the service, assigns an additional supplier role to the bike manufacturer – the role of an innovative designer, which designs bike in a way that enhances the possibility of social interaction, e.g., a bike design that folds to create shared seating space for two will help a socially inclined commuter to have guaranteed seating with a friend. In addition to the two new value propositions that I discussed here, Table 2 also includes some additional entities and roles as part of the extended mixed mode commuter service system. These are the retail award program, and the payee and information generator roles undertaken by the commuter. These will be discussed later as part of the overall illustration of the method proposed in this paper.

To summarize, the challenge that is addressed in this thesis is that given an initial set of service specification (the non-shaded regions of the feature-value matrix – Table 2, and the unmarked roles of the service system – Figure 4), how can a service designer systematize the service-oriented inquiry process such that it helps her extend the initial service specification by identifying additional features of the service (the shaded region of the feature-value matrix – Table 2) and the entities required to implement these features (roles marked with red asterisk – Figure 4).

1.2 Theory Base Referred: Cognitive Semantics

The work presented in this thesis provides a conceptual framework that provides service designers the modeling apparatus and method required to develop a service-oriented model of the problem solution. A service-oriented model organizes the available information in a way that exposes the cause-and-effect relationships underlying the problem situations. This helps the service designer ask questions, answers to which, I believe, will help her address the three challenges highlighted in section 1.1.3. First, what experiences can the service invoke? Second, what should be the features of the service to realize these experiences? Third, which entities are required to implement these features?

In doing so, we take an experience-design based approach, [13], to service systems modeling. We define the value that a service offers to a consumer as the change the consumer experiences. By experience we mean the consumer's cognitive act of appreciating the service [11]. Cognition is a grounded phenomenon [14], and to understand the cause-and-effects underlying the consumer's appreciation of the service requires attention to the consumer both as a social and bodily being. The basic idea is to model the consumer's interaction with the service in terms of the action the service helps the consumer perform in different situations (situated actions), and the affective states that the service invokes in the consumer (bodily states). We do so by employing the notions of embodiment and situatedness.

1.2.1 The Concept of Situatedness

Situatedness refers to the inter-connectedness of the entities observed in a situation by virtue of which the entities exhibit a behavior that cannot be construed from any subset of these entities [15]. The basic challenge in identifying the supplier and consumer roles that the focal entity undertakes with regards to the service is that the causal relevance of the focal entity, in the various service related situations examined by the service designer, may not always be obvious. The default level of human reasoning at which one tends to reason with minimal cognitive effort, also referred to as the basic level of conceptualization [16], the cognitive basis for acknowledging an entity as part of the conceptualized situation can be historically inspired, empirically informed, rationally thought, or pragmatically focused [17]. From a service-design perspective, the interest in a given situation is limited to its functional organization, which requires taking an exclusively pragmatic view of the world.

We activate the semantics of situatedness by modeling situations in terms of the image they invoke. The belief is that an image-oriented conceptualization of the situation [18], will help the service designer reason the epistemic groundings of the observed entities by drawing parallels with more widely shared aspects of visual perception such as, form-oriented roles of gestalt completion, including background-foreground, cognitive reference and base-profile [19]. Requiring service designers to make explicit their interpretation of the conceptual relevance of the entity observed in a situation will help them specify more clearly the roles that the observed entity undertakes with regards to realizing the different aspects of the lifecycle of the service being conceptualized.

In this work, we refer to image as a pictorial mode of expressing situations. Pictures provide a powerful metaphor for analyzing situations. The two adages – "a picture is worth million words" and "beauty lies in the eyes of the beholder", aptly summarizes the effectiveness of pictures in assigning semantics to situations. The first adage refers to the richness of the pictorial representation in its ability to synthesize large amounts of information succinctly. Perception is a cognitive phenomenon that goes beyond the motor-sensory act of seeing and invokes some past experience. Humans are experiential beings, each influenced with their own set of real-life experiences. Thus, as an artifact for human perception, a picture goes beyond the effective synthesis of information but also reveals the different viewpoints that underlie the perceived information – the later aptly conveyed by the second adage. An image based modeling of the situations of interest, identified through various environmental scanning techniques, such as brainstorming sessions, interviews and field visits, helps emphasize the synthetic nature of conceptualization and the need that the focal entity's participation in a situation is seen at two levels. One set of roles that the focal entity undertakes is by virtue of it being a constituent, typically functional constituent as far as service-design is concerned, of the different activities perceived in the situation. The other is the level, which reveals aspects of focal entity's identity that it gains by virtue of the emergent properties that result from the synthesis of the constituent activities. In the context of service design, the first set of roles describe the behavior of the service, while the later can be interpreted as signifying the change that leads to the focal entity becoming additionally competent. For example, the image

For example, consider a bike manufacturer conducting an inquiry on the use of bike to school. One popular image of a person biking to school is where she carries a bag. The inclusion of bag in the 'biking to school' conceptualization may be grounded in historicism, as historically we have been exposed to the act of carrying reading, writing instruments and lunch box to school. From a bike manufacturer perspective, the role of 'bag-carrier' undertaken by the person biking to school is not, by default, relevant. This, initially historicism inspired, role gains significance for the inquiry only when it is shown to have some causal relevance to biking to school say, increased tiredness due to weight on shoulder, reduced maneuverability in traffic, ergonomic considerations, etc.

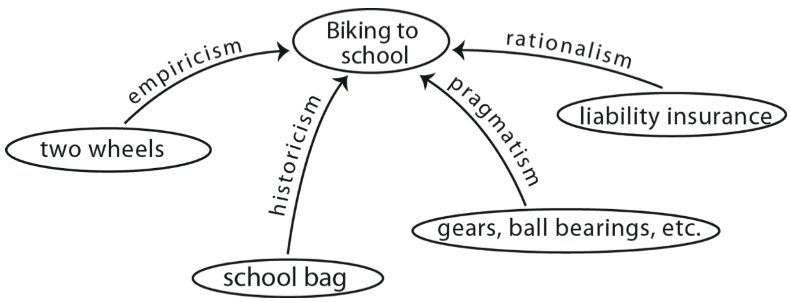


Figure 5 Situatedness as drawing attention to the epistemic groundings of the underlying imagery

<<commuter riding the bike>> reveals many constituent roles that the commuter undertakes in riding the bike, such as the provider of power for pedaling the bike, provider of knowledgeable about traffic rules, etc. At the same time, the higher-level semantics of the image reveals the functional change the commuter undergoes- as in becoming a mixed-mode commuter.

1.2.2 The Concept of Embodiment

Embodiment refers to the bodily states that the human body retains in the memory as internal reference to experiences from past situations [20]. An embodied approach to service design acknowledges the significance of previously acquired bodily states in invoking judgments of appreciation. As suggested in [21], we see embodiment as a “pattern-completion inference mechanism” that completes a cause-and-effect pattern by revealing the effect (the appreciative judgment) when provided with the cause (the situation), and by revealing the cause (the situation) when provided with the effect (the appreciative judgment). We employ the semantics of embodiment to activate our proposal of modeling service-value as the change the consumer experiences. By modeling change in terms of bodily states, we ensure the coverage of both types of action-outcomes – ones that bring about observable state change, e.g. on-time arrival, and others that invoke affective judgments of appreciation, e.g. social recognition.

The field of Cognitive Semantics [22-25], which is the study of language from a cognitive perspective, suggests that the meaning of a concept resides in the human conceptual system and

For example, the stretching of facial muscles in a certain way that constitutes a smile (the smiling musculature) is a common embodiment for situations that invoke pleasant experiences. Researchers have shown that even if the smiling musculature is engaged in a different setting say, holding a pencil in the mouth in a certain way, it still invokes a positive affect in the experiencer. In the case of smiling, the appreciative judgment is the feeling of happiness, and the situation is holding a pencil in the mouth. There can be several situations that invoke the same appreciative judgment, e.g., the smiling musculature can be achieved by holding a pencil in the mouth, eating big-bite size food, undergoing facial therapy, or even community laughter clubs that practice voluntary laughter to feel happy.

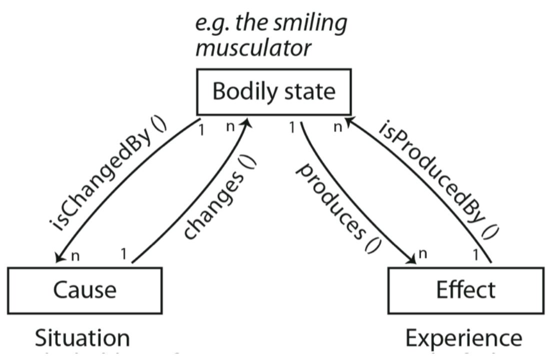


Figure 6 Embodiment as bodily mediation of cause-and-effect

cannot be specified in terms of necessary and sufficient conditions that refer to some entity or relation in the real world. The later represents classical theories of semantics such as the work by Alfred Tarski and Donald Davidson on truth-conditional semantics [26]. An important work in the field of Cognitive Semantics is that of Leonard Talmy, [25], who studied the cognitive grounding of the concept of causation and proposed a force-dynamic framework to reason change. Talmy proposes the idea of extended causation, which includes all such situations as causative where there is evidence of mutually opposing forces trying to bring about some change in the existing state of affairs.

Value Frames: Force-dynamic Patterns of Value Creation

This work adopts the notion of extend causation as the basis for modeling the affective states that the service invokes at the consumer. The proposal put forward in this thesis is that the

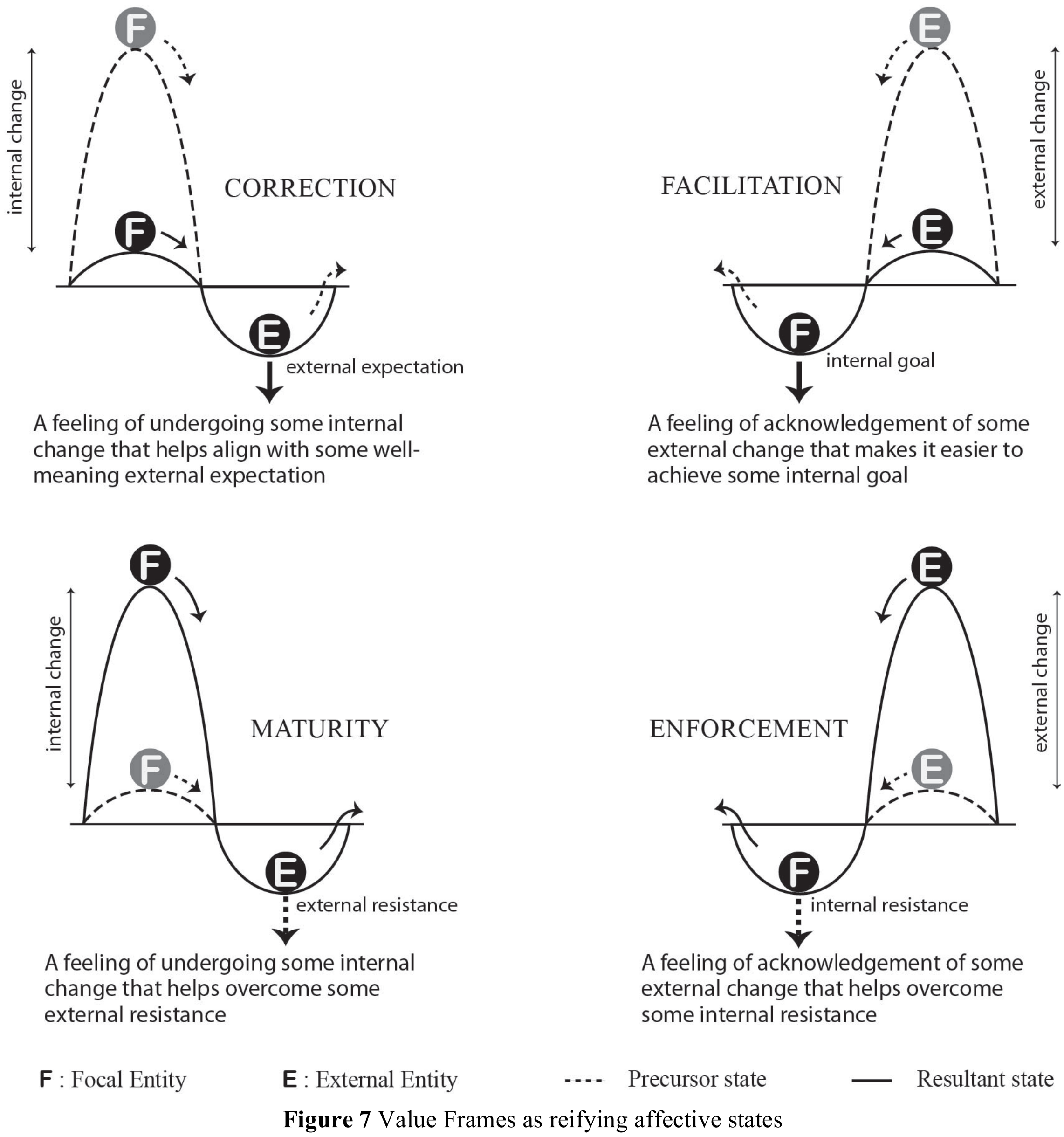


Figure 7 Value Frames as reifying affective states

causal organization of an affective state embedded in a value expression can be explained on the basis of the following two factors:

- The nature of the challenge that the service helps the consumer overcome - the four types of challenges considered include imposing, blocking, hindering and disrupting forms of challenge
- The nature of intervention that the service introduced to overcome the challenge - the two types of interventions considered are weakening and strengthening of the forces exhibited by the interacting entities.

The combination of these two factors leads to four distinct force-dynamic patterns namely, CORRECTION, FACILITATION, MATURITY and ENFORCEMENT frames. The claim is

Table 3 Information structure of Value Frame

<type of> VALUE FRAME	
Focal Supplier Element (FSE)	< the force exerted by the FSE, f_{FSE} >
Friction Introducing Element (FIE)	< the force exerted by the FIE, f_{FIE} >
Context (C)	< challenge faced by the FSE > *Inferred from the combination of* f_{FSE} *and* f_{FIE}
Service Enabling Element (SEE)	< the force exerted by SEE, f_{SEE} >
Feature (F_c)	< service-feature expressed as a proposition > *Inferred from* f_{SSE}
Value (V)	< service-value expressed as a proposition > *Inferred from* f_{SSE} *and* C

that the feeling that a service invokes at the consumer is causally grounded in one of these four types of interactions that the consumer engages with other entities; or more simply put four types of situations. The information these patters reveal is organized as a frame. These force-dynamic patterns are called Value Frames. Figure 7 provides a brief description of each of the four Value Frames and a peak-and-trough based visual representation to aid the inquiry process. Frames are attribute-value constructs [27], which organize the information elements representing some coherent region of conceptual space. Use of Value Frames help reveal the information about the different elements, and their interactions, constituting the value creation process. The information structure used for documenting Value Frames is presented in Table 3.

1.3 The Proposed Modeling Method: TRIBE

The value-oriented inquiry method that activates the modeling apparatus presented in the earlier chapters of this thesis is called TRIBE (**Tri**ple **BE**). The choice of name reflects the three levels at which this method explores an entity's interaction with the service. These three levels are:

Behaving		The contribution of the entity in realizing the behavior exhibited by the service.
Becoming		The transformation that the entity undergoes by virtue of it adopting the competence that the service creates.
Being		The appreciative judgments that the service invokes at the entity.

The claim is that analyzing a service at each of these three levels will not only help the service designer in the causal reasoning of the service in situations known a priori, but also help in identifying additional situations that the service can potentially influence. The ability to situate a service in multiple settings will help the service designer reason the composition of the service from multiple viewpoints, thereby providing a service specification that is more likely to yield the desired results.

TRIBE is an extension of an existing enterprise architecture method, SEAM. As the name suggests, SEAM - the Systemic Enterprise Architecture Method, takes a Systems approach to service design. SEAM models value-creation as an emergent phenomenon; one that emerges by virtue of the different entities working together as one system. TRIBE activates the Systems view of service by introducing the semantics of situatedness and embodiment.

When a service designer conceptualizes a service, she consciously or otherwise, initiates a re-simulation of some earlier encountered situations. In TRIBE we account for two expressions of such conceptualizations. One, where the service designer provides a situational expression of her conceptualization; say, a narrative, in visual-image form, that reveals the entities observed in the conceptualized situation. Second, where the service designer provides an embodied expression of her conceptualization; say, in terms of the affective states that the conceptualization invokes in the service designer.

While dealing with situational expressions of conceptualization, TRIBE users are required to critically reflect on the contribution that the entity observed in the situation makes towards the semantics of the situation. At a given level of discourse, an entity's occurrence in a situation may or may not be functionally explainable. The set of functionally relevant entities constitute the work system of the service. Work system implements the service and is more commonly referred to as the Service System.

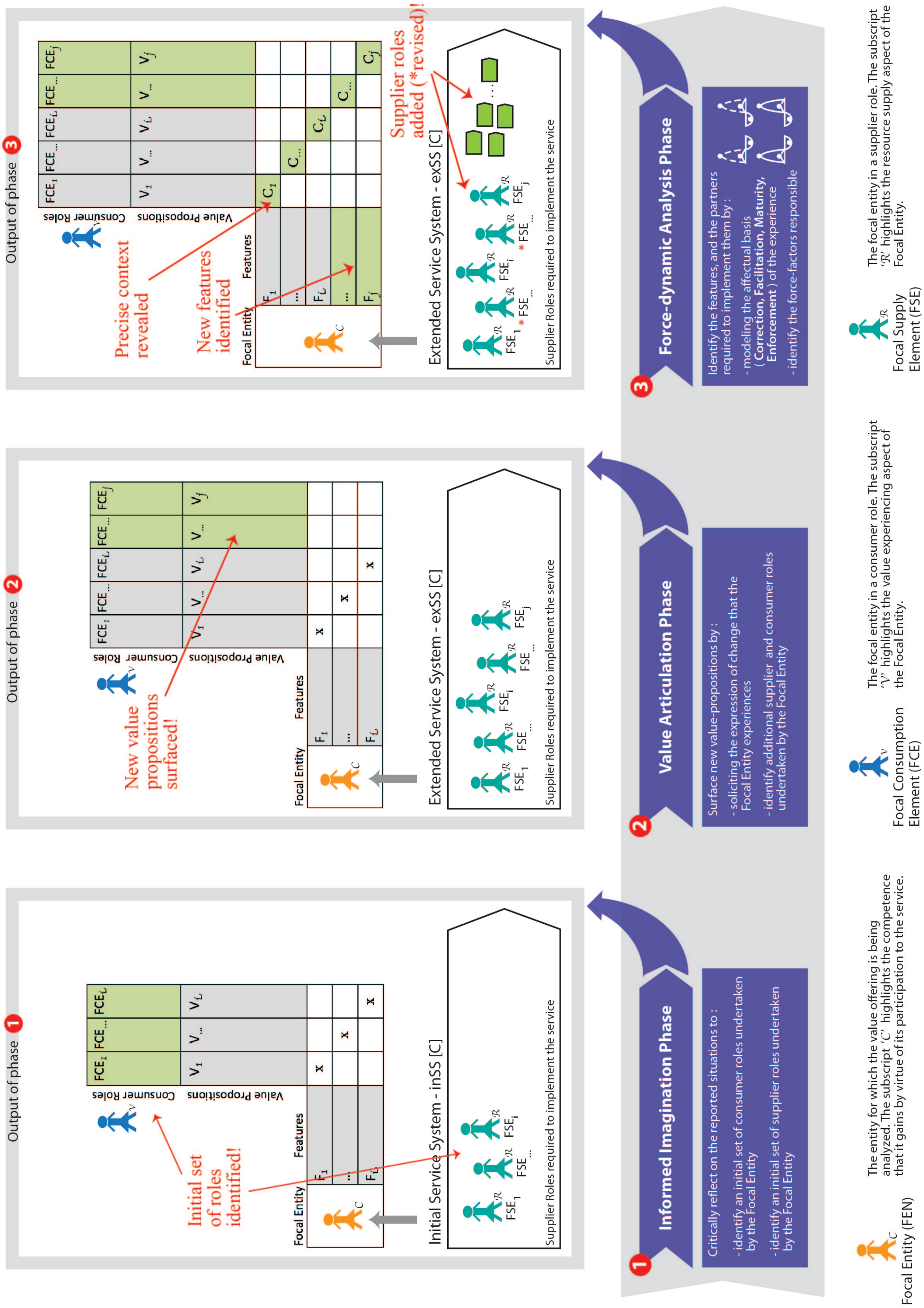


Figure 8 An outline of the proposed service-oriented modeling framework

The fact that TRIBE users model situations and not just systems helps them retain access to all those entities, which at the given level of discourse are not found to be functionally relevant. Nevertheless, exploring their non-functional groundings often unravels new situations of relevance to the service. Similarly, analyzing the affective grounding of the service designer's conceptualization of the service also helps surface new situations of relevance to the service.

TRIBE prescribes a three-phase process for developing a problem solution into a service offering. It takes as input an initial idea to solve a problem, and helps the service designer identify additional situations that reveal the value that the problem solution can create for the affected entity. The method uses Value Frames to specify the causal basis of the experience that the identified situations invoke at the entity. This helps the service designer in identifying prospective features, and the partners required to implement these features, that should be added to the initial problem solution. Doing so not only makes the service more rewarding for the consumer, many a times it also helps ensure the overall viability of the service. The three phases of TRIBE inquiry process are depicted in Figure 8, and explained in the following sub-sections.

1.3.1 The Informed Imagination Phase

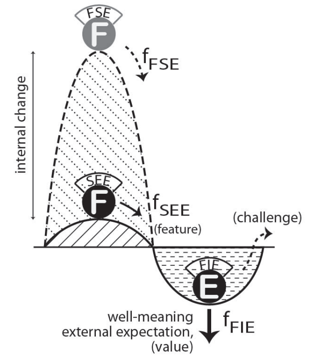
In this first phase of the TRIBE inquiry process, the service designer takes as input an initial idea to solve a problem. The service designer is encouraged to identify situations that will benefit from the proposed problem-solution. For this purpose she might undertake several environmental scanning techniques like brain storming, interview sessions, field studies, market surveys, etc. The information gathered is organized into a simple cause-and-effect model that helps answer the following questions: what is the problem, how does the idea solve the problem, who will benefit from the problem solution and how, and who all will be required to implement the problem solution? The resulting model provides an un-influenced, as far as TRIBE is concerned, view of the problem solution and is hence referred to as the **Nativist Model** of the problem solution.

1.3.2 The Value Articulation Phase

In this second phase of the TRIBE inquiry process, the service designer extends the initial set of value propositions by invoking embodied expressions of experience for the already available features of the service. As described in section 1.2.2, embodiment is a bodily mediation between cause and effect. TRIBE service designers use this interpretation of embodiment to identify new situations. The idea is to surface the affective states that get invoked in the Focal Entity in response to him gaining the competencies that the service creates for the Focal Entity. Using the initial set of competencies that are identified in the first phase of the TRIBE inquiry process, the service designer poses questions like 'What change does the Focal Entity experiences by virtue of gaining a certain competence?' Answers to such queries can be obtained either by the service designer trying to play the role of the Focal Entity and imagining what the Focal Entity would feel, or by interviewing the Focal Entity itself. The later is the preferred approach. Though very often a well-informed service designer may provide a richer response to such queries.

1.3.3 The Force-dynamic Analysis Phase

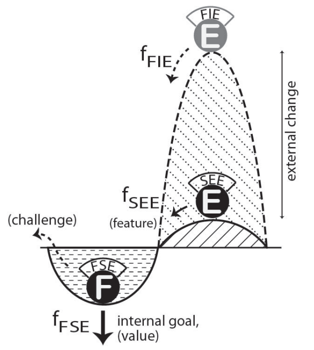
In this third and final phase of the TRIBE inquiry process, the service designer tries to surface the force factors that invoke the value propositions identified so far. TRIBE defines the value of a service as the change the Focal Entity experiences. The reference to change is not limited to the behaviorally visible state changes. It also includes the affective states invoked at the Focal Entity. To understand the force factors underlying these changes, TRIBE uses the four force-dynamic patterns described earlier. To recall these patterns claim that the feelings invoked at the Focal Entity, by virtue of the change it experiences due to the adoption of the service, can be mapped to one of the four Value Frames. Once the value frame corresponding to the feeling invoked at the Focal Entity is identified, the TRIBE service designer can use the relevant peak-and-trough visual pattern to guide the process of surfacing the causal basis of the invoked feeling. The interactions suggested to surface the desired information, is depicted in Figure 9.



CORRECTION VALUE FRAME

reifies the feeling of undergoing some internal change that helps align with some well-meaning external expectation

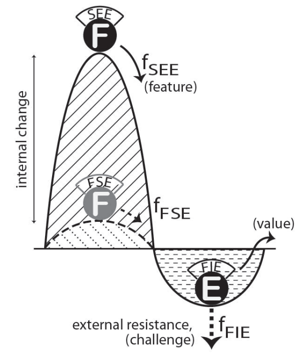
1. What is that well-meaning external expectation and who is it's source?
   - cause < > and effect < f_{FIE} >
   - source of expectation < FIE >
2. What has been the Focal Entity's behavior with regards to f_{FIE}?
   - cause < > and effect < f_{FSE} >
3. What is the changed behavior of the Focal Entity that helps align with the f_{FIE}?
   - cause < > and effect < f_{SEE} >



FACILITATION VALUE FRAME

reifies the feeling of acknowledgement of some external change that makes it easier to achieve some internal goal

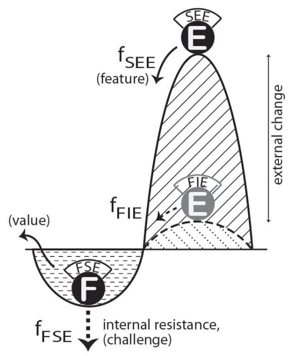
1. What is that internal goal?
   - cause < > and effect < f_{FSE} >
2. What resistance does Focal Entity face from the Environment with regards to f_{FSE} and who in the environment is responsible for it?
   - cause < > and effect < f_{FIE} >
   - source of resistance <FIE>
3. What is the changed behavior of the Environment that helps the Focal Entity achieve its internal goal f_{FSE}?
   - cause < > and effect < f_{SEE} >
   - responsible entity in the enviornment <SEE>



MATURITY VALUE FRAME

reifies the feeling of undergoing some internal change that helps overcome some external resistance

1. What is that external resistance and who is it's source?
   - cause < > and effect < f_{FIE} >
   - source of expectation < FIE >
2. What has been the Focal Entity's behavior with regards to f_{FIE}?
   - cause < > and effect < f_{FSE} >
3. What is the changed behavior of the Focal Entity that helps overcome f_{FIE}?
   - cause < > and effect < f_{SEE} >



ENFORCEMENT VALUE FRAME

reifies the feeling of acknowledgement of some external change that helps overcome some internal resistance

1. What is that internal resistance?
   - cause < > and effect < f_{FSE} >
2. What is the Environment's behavior with regards to f_{FSE} , and who in the environment is responsible for it?
   - cause < > and effect < f_{FIE} >
   - responsible entity in the environment <FIE>
3. What is the changed behavior of the Environment that helps the Focal Entity overcome the internal resistance f_{FSE}?
   - cause < > and effect < f_{SEE} >
   - responsible entity in the enviornment <SEE>

F : Focal entity in the role of
- **FSE** : Focal Supplier Element
- **FIE** : Friction Introducing Element
- **SEE** : Service Enabling Element

E : Entity in the Environment in the role of
- **SEE** : Service Enabling Element
- **FIE** : Friction Introducing Element

Precursor state visual depiction

Resultant state visual depiction

Figure 9 Causal analysis of value propositions using a visual interpretation of Value Frames

Using these patterns the TRIBE service designer identifies new features of the service and the entities required to implement these features. The information that emerges from these patterns is documented in the Value Frame data structure. The mapping between the Value Frame information elements and the TRIBE model elements is shown in Figure 10.

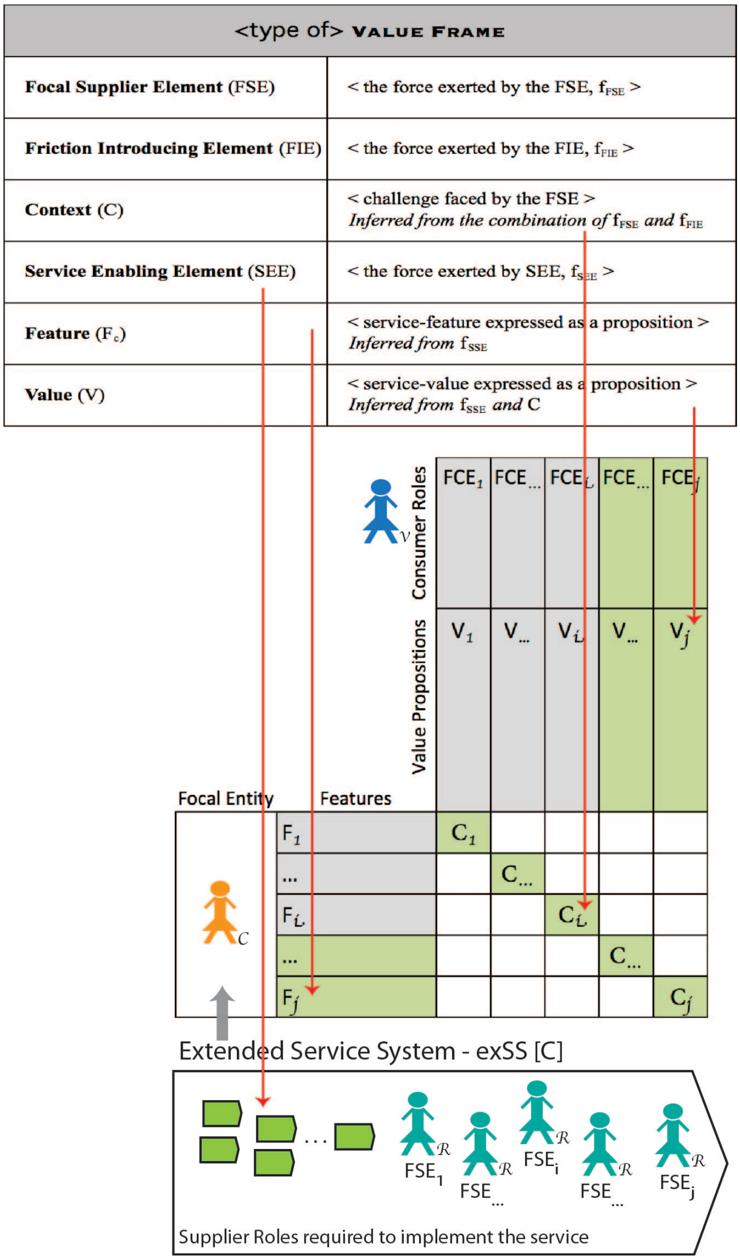


Figure 10 Value Frame information populating the TRIBE model

1.4 State of the Art

This thesis presents a proposal for a service-oriented conceptual modeling method that provides the service-designers with the modeling apparatus required to identify the features of the service and the entities required to implement these features. From an engineering perspective, this corresponds to the field of Requirements Engineering (RE). RE is a sub discipline of Systems and Software engineering and is aimed at advancing the theory and practice of specifying the design requirements of a system. Though originally limited to issues related to design of IT systems, RE has matured as a field to gain wider acceptance as the discipline relevant to requirements engineering of all kinds of systems be it product or service, for individuals or organizations. In this section we present a brief review of the state of art in the field of Requirements Engineering (RE) and demonstrate how this work contributes to the requirements engineering of services. Nevertheless, before doing so I briefly describe a service design method, Service Blueprinting, which also takes a visual approach to modeling services, and how this work differs from it.

1.4.1 Service Blueprinting

Existing service design methods acknowledge the subjective nature of the value concept. Nevertheless, in the absence of any systematic approach to characterize value, these methods fail to go beyond propositional considerations, such as the emphasis on the use of modal expressions to highlight the affective judgment of the adopter with regards to the service. Service blueprinting is one design methodology that is widely used for the design of services [28]. Service blueprinting takes a transactional approach to services [29], and helps represent the service as a process diagram that uses the standard visual modeling notations of boxes and arrows to document the different components of the service, and the interaction points through which the consumer interacts with the service. The visual mode of representation makes service blueprinting an effective tool to communicate with the stakeholders, for example in visualizing the quality of experience that the service provides to the customer at different points of interaction. Nevertheless, service blueprinting does not contribute much to the semantics of service systems. It only helps document the customer's response to the service in a way that highlights the specific aspect of the service to which the response pertains. This, undoubtedly, provides a good starting point to reason about the cause-and-effect relationships that may have influenced the customer's experience of the service. It, in itself, does not provide any means, conceptual or otherwise, to reason the customer's judgment of the service. In the past, there has been some effort to emphasize the affective nature of experience by enhancing the traditional blueprint format with dedicated visual icons for representing the emotional state of the customer [30]. This certainly enhances the visual appeal of the blueprint format making it more thought provoking for the users, though it continues to remain propositional in nature – the difference being that textual representation has made way for visual icons.

1.4.2 Requirements Engineering

RE, as the name suggests, is a general theory about identifying the requirements of a target system. The different activities that an RE process includes can be roughly categorized under the following five task categories: elicitation, modeling, requirements analysis, validation & verification, and requirements management [31], [32]. Over the years, the RE community has developed a variety of artifacts that address the numerous research challenges these tasks present. A summary of these contributions is presented in Table 4.

Table 4 Requirements Engineering overview, adapted from [31]

<table>
<tr><th colspan="2">Requirements Tasks</th><th>Research Focus</th><th>Artifacts</th></tr>
<tr><td>Early Phase</td><td>Elicitation</td><td>Understanding stakeholder interests in various system-and-environment alternatives</td><td>Techniques for identifying stakeholder
Analogical techniques like metaphors, personas
Contextual and personal techniques
Techniques for inventing requirements
Feedback techniques</td></tr>
<tr><td rowspan="4">Late Phase</td><td>Modeling</td><td>Completeness, consistency and un-ambiguity of requirements</td><td>Stategies for structuring models
Techniques to encode solutions as re-usable patterns
Model transformations to manipulate derived models</td></tr>
<tr><td>Requirements Analysis</td><td>Objective evaluation of recorded requirements w.r.t some well-formedness criteria</td><td>Techniques to evaluate the quality of recorded requirements
Techniques for risk and impact analysis
Presentation techniques to aid decision making</td></tr>
<tr><td>Verification & validation</td><td>Subjective evaluation of recorded requirements w.r.t. stakeholders' needs</td><td>Animation and Simulation techniques to improve feedback delivery to stakeholders
Techniques to check models meet requirements</td></tr>
<tr><td>Requirements Management</td><td>Evolution of requirements over time</td><td>Techniques to identify and document traceability links among requirements
Techniques that analyze the maturity and stability of elicited requirements
Techniques to organize large number of requirements</td></tr>
</table>

Traditionally, RE techniques contributed more to the "late-phase" of requirements engineering, focusing on issues of completeness, consistency, and automated verification and management of requirements. Aspects related to "early phase", e.g. analyzing stakeholder interests and how they might be addressed, or compromised, by various system-and-environment alternatives were researched as the RE discipline matured [33]. The most promising requirements elicitation schemes include Goal-Oriented RE, Scenario-Based and Value-Based RE.

- **Goal-Oriented Requirements Engineering (GORE)** [34] is the oldest of these initiatives and is regarded by the RE community as its most important development since the early 1990s. At its root GORE methods attempt to elevate the analysis of stakeholders' needs by asking why and how rather than what questions. Why questions reveal higher-level goals of stakeholders whereas how questions reveal lower level goals. The most prominent of the GORE methods is i* [35]. Stakeholders are modeled in i* as actors that have goals with clear-cut criteria for their achievement and soft-goals with unclear criteria for achievement. Actors also have resources, tasks and dependency relations with other actors. While GORE methods have contributed significantly towards modeling, specifying and reasoning system requirements, their contribution towards requirements elicitation has been limited to refinement and abstraction of a known set of initial goals.

Goal identification is not an easy task. Sometimes they are explicitly stated by stakeholders or in preliminary material available to requirements engineers. On other occasions they are implicit and require some kind of goal elicitation. In the context of enterprises, goals can be identified by searching for intentional keywords in the information initially provided, including documents and interview transcripts. In other less documented and massively multi-dimensional worlds like industry regulation, systematic identification of goals still remains a challenge.

- **Scenario-Based Requirements Engineering** [36] aims at using scenarios to represent paths of possible behavior as use-cases which are then used to elaborate requirements. The focus here is more on generalizing the knowledge captured through scenarios and linking them to design patterns. There has been substantial work linking scenarios and goals together. Scenarios are concrete, narrative, procedural and leave intended properties implicit; whereas goals are abstract, declarative and make intended properties explicit. These complementary characteristics have, however, only been used to aid the verification and validation of requirements and have not been exploited in the context of requirements elicitation.

- **Value-based RE methods** [37] seek to link RE and business discourse. e3-value is a method designed to explore innovative e-commerce ideas. It acknowledges the multi-perspective nature of RE and proposes a multi-viewpoint approach to decompose complicated requirement issues into self-contained perspectives, which can be addressed and decided on relatively independent from each other. This class of methods also shares a similar limitation as the ones above – to find a suitable set of initial viewpoints. It is often recommended that during the early phase of RE the number of views to be developed should be limited [38]. This is plausible if system analysis is strictly restricted to a single domain. In that case, the domain specific knowledge can be used to derive connected viewpoints or even enriches them. In multidisciplinary, multi-stakeholder systems the challenge is to decide on a minimum threshold of initial viewpoints, which are representative enough of the overall diversity of the system - the different skills, responsibilities, knowledge and expertise of different stakeholders [39].

1.4.3 Specific Advancements

This work exceeds the state-of-the-art in service-oriented modeling in several ways.

- It provides an approach for analyzing viewpoints. A viewpoint highlights the subjectivity that the observer brings to her view of the world. During the early phase of the inquiry, the service designer tries to develop an understanding of the phenomenon of interest by gathering information from various sources. To use this information effectively, the service designer should be able to make explicit the viewpoints embedded in the information she gathered. This work provides an image-oriented method for reasoning situations that helps reveal the epistemic groundings of an observation. Knowledge of why-someone-sees what-she-sees helps the designer reconcile diverse viewpoints.

- It goes beyond the traditional stimulus-response based behaviorist approach and models cause-and-effect relations in terms of the dynamics of the underlying cognitive forces. Modeling a situation as a set of competing forces helps not only in identifying existing root-cause - by virtue of a stronger force resulting in some undesired outcome, but also potential source for future issues - by acknowledging the resistance being faced even though the outcome is favorable. A service-oriented approach to problem solving seeks to specify solutions that maximize the likelihood of creating value for the adopter. Prior knowledge of the potential risks helps the service designers make informed decisions in choosing appropriate risk mitigation strategies, thereby increasing the likelihood that the service delivers desired results.

- It acknowledges the subjectivity of the value concept by adopting the design-for-emergence philosophy. Value is modeled as an ordered pair of change and experience. Modeling the value concept at two levels helps reveal the role of the adopter's internal organization, human or otherwise, in connecting these two levels.

1.5 Assessment of Research Design

The research approach employed in this work is the Design Science research methodology. The specific model of Design Science selected for use here is that presented by Hevner [40], Figure 11. As opposed to the natural sciences, e.g. physics and biology, which focus on revealing the truth, the design sciences, which as a concept have their genesis in Herbert Simon's 'Sciences of the Artificial' [41] and include all forms of engineering, medicine, aspects of law, architecture and business, focus on usefulness. It is in this spirit that the work presented in this thesis is primarily concerned with producing a service-oriented modeling framework that helps the service designer in her day-to-day practice of specifying service-oriented solutions for real world problem situations. In doing so I draw on existing knowledge from various domains, particularly from the field of cognitive semantics.

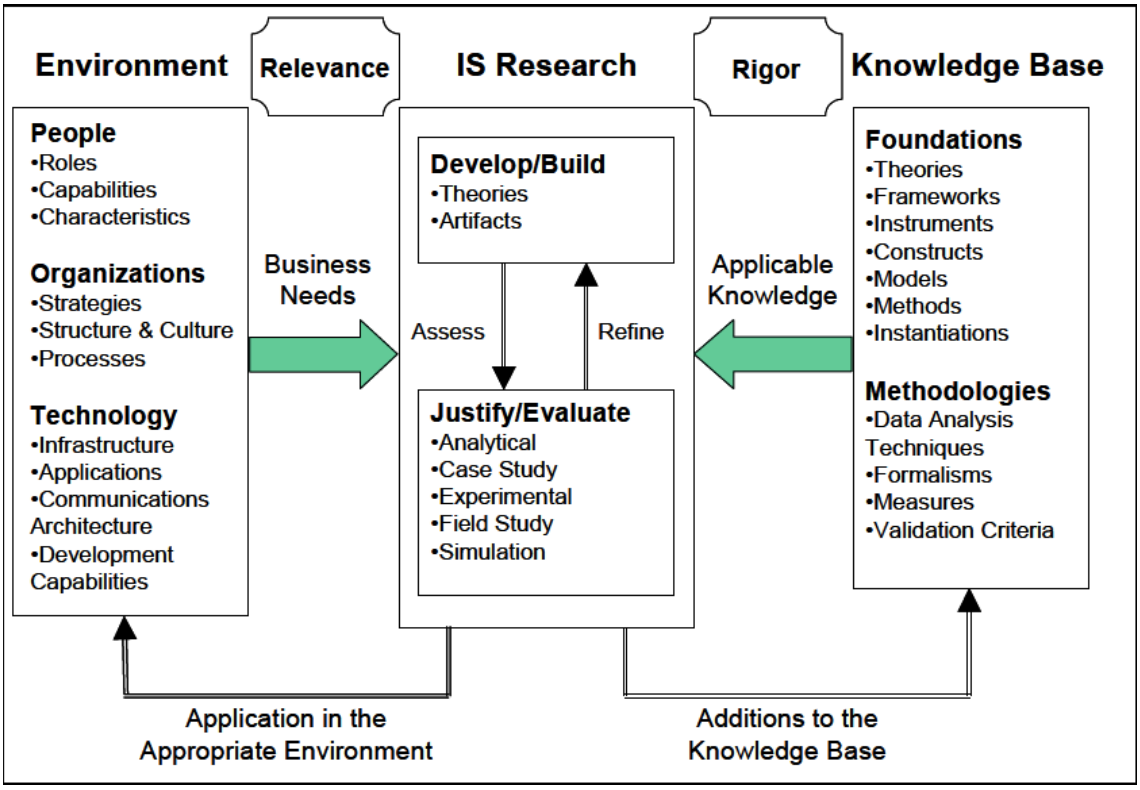


Figure 11 The Design Science framework proposed by Hevner

Hevner presents a number of criteria and guidelines for critically appraising the rigor and relevance of Design Science research. In Table 4, we list these guidelines along with their description and discuss how the work presented in this thesis meets these guidelines.

Table 7 Guidelines for assessment of Design Science research, adapted from Hevner [40]

Guideline	Description	Discussion
"Design as an Artifact"	"Design Science research must produce a viable artifact in the form of a construct (vocabulary & symbols), a model (abstractions & representations), a method (algorithms & practices), or an instantiation (implemented & prototype systems)."	The artifacts produced through this work include: - **Force-dynamic constructs** to surface the causal basis of affective states embedded in a value expression - **A method** that guides the process of instantiating the proposed service-oriented conceptual model (composed of the constructs and model elements mentioned above)
"Problem Relevance"	"The objective of Design Science research is to develop technology-based solutions to important and relevant business problems."	This work is aimed at helping service-designers in addressing the three basic aspects of **requirements engineering for services**: - What experiences can the service invoke? - What should be the features of the service to realize these experiences? - Which entities are required to implement these features?
"Design Evaluation"	"The utility, quality, and efficacy of a design artifact must be rigorously demonstrated via well-executed evaluation methods."	The design evaluation method used belongs to the observational class. We conducted a **case study**, which helped conduct an in depth study of the service-oriented conceptual framework proposed in this thesis. This case study was aimed at taking an initial idea and developing it into a service-oriented solution for the **storage and distribution of food-grains in India**.
"Research Contributions"	"Effective Design Science research must provide clear and verifiable contributions in the areas of the design artifact, design foundations, and/or design methodologies."	At a foundational level this work contributes to the field of service science by providing a **Situated and Embodied interpretation of the service-dominant logic of problem solving.** Service science as a discipline has benefited from the fields of computer science, operations research and management sciences. Given its focus on value-creation as opposed to only problem solving, no formalism can be brought to this field unless the concept of value is itself formalized. This work is an attempt to provide some concreteness to the concept of value by acknowledging the cognitive processes (situatedness and embodiment) that contribute to the semantics of the value concept.

"Research Rigor"	"Design Science research relies upon the application of rigorous methods in both the construction and evaluation of the design artifact."	From a rigor perspective, the proposal made in this research is **grounded in the theory of cognitive semantics**. For example, the extended view of causation used to model the affective aspects of value propositions is grounded in the theory of cognitive semantics, which highlights the fact that linguistic evidence suggests that humans concept of change is much deeper than just the acknowledgement of behavioral change. This is reflected in the lexicon of the language – e.g. the use of words like 'hindrance' and 'let' in addition to 'despite/although' suggest that at a concept level humans acknowledge "changes" beyond the obvious behavior exhibiting state changes.
"Design as Search"	"The search for an effective artifact requires utilizing available means to reach desired ends while satisfying laws in the problem environment."	The central constraint of the service-dominant logic is the **Co-creation principle**, which stipulates that an adopter of the service is both the consumer and supplier of the service. We developed our search for an effective artifact within this constraint. A closer analysis of the linguistic expression of value propositions commonly used to articulate the adopter's desire/expectation from a problem solution, led us to the theory of extended causation. We based our research on this theoretical base and developed specific constructs to aid the reasoning of value expressions.
"Communication of Research"	"Design Science research must be presented effectively both to technology-oriented as well as management-oriented audiences."	To facilitate the communication of research results to a wider community, including both the technology-oriented and management-oriented audiences, we developed a set of **peak-and-trough metaphor based visual patterns** to facilitate the use of proposed force-dynamic constructs in the causal reasoning of problem-situations. These patterns were found to be effective in conveying the research results to the diverse participants of several workshops that were conducted using these visual patterns. These workshops included representatives from social sector organizations, business organizations, government departments and supply chain technology experts.

1.6 Thesis Organization

Most of the material presented in this thesis has been published or accepted for publication at various conferences and journal in the fields of Service Science, Cybernetics and Knowledge Engineering.

Chapter 2: This chapter is titled 'Informed Imagination'. It presents the theory underlying the first phase of the proposed modeling method, TRIBE. It discusses the different types of cognitive biases that can influence the service designer's perception of reality. Being aware of why-you-see what-you-see will help the service designer critically reason the relevance of an entities occurrence in an imagined situation. This is useful in activating the concept of service system in terms of the functional requirements that need to be implemented to realize the behavior desired from the service.

Related Publication [42, 43]:

Title: A Situated Approach to Systems Based Modeling of Services [42]
Conference: IEEE International Conference on Systems, Man, and Cybernetics (SMC), Manchester, UK October 13-16, 2013.

Title: On the Situated Semantics of Service Systems [43]
Conference: IEEE International Conference on Service Oriented Computing and Applications (SOCA), Hawaii, USA December 16-18, 2013.

Chapter 3: This chapter is titled 'Value Articulation and Force-dynamic Analysis Phase'. It presents the theory underlying the second and third phase of the proposed modeling method, TRIBE. More specifically, it describes the four force-dynamic patterns that guide the process of specifying the change that the service brings about at the consumer.

Related Publication [44]:

Title: A Situated and Embodied Approach to Service Design
Conference: Hawaii International Conference on System Sciences (HICSS), Hawaii, USA January 6-9, 2014.

Chapter 4: This chapter presents a case study that was conducted using the proposed modeling method, TRIBE. This study was conducted with a non-government organization in India on developing a service view of their initial idea of developing a distributed network of community owned food-grain storage and distribution facilities.

Appendices: This thesis concludes with three related papers included as appendices.

Appendix 1 summarizes an initial effort to clarify the semantics of the Systemic concept based on the different types of emergence studied in Complex Systems Theory. This study helped put this research project of a firm theoretical foundation.

Appendix 2 summarizes some initial results in automating the process of identifying Service Systems by conducting text-mining experiments on unstructured natural language text.

Appendix 3 summarizes the results of the application of an early version of this work to identify the requirements for a regulatory system to manage the time-based pricing of electricity supply in urban-residential areas. This study was conducted using an earlier version of the Systemic Enterprise Architecture Method (SEAM) developed at the Systemic Modeling Laboratory at the School of Computer and Communication Sciences at EPFL. The material presented in Chapters 1-4 owe many of its theoretical groundings to SEAM such as the Systems approach to categorization, the three level model (known as Resource-Feature-Value in SEAM) for specifying services and the use of refinement mappings to reason the alignment between the different levels of inquiry.

Title: From Composites to Service Systems: The Role of Emergence in Service Design [45]
Conference: IEEE International Conference on Systems, Man, and Cybernetics (SMC), Seoul, South Korea October 14-17, 2012.

Title: A Cognitive Reference Based Model for Learning Compositional Hierarchies with Whole-Composite Tags [46]
Conference: International Conference on Knowledge Discovery and Information Retrieval (KDIR-IC3K), Vilamoura, Algarve, Portugal 19-22 September 2013

Title: A Systemic Design of Regulation Enabling Ontology [47]
Conference: International Conference on Knowledge Engineering and Ontology Development (KEOD-IC3K), Valencia, Spain 25-28 October 2010

Title: A Systemic Approach to Multi-Party Relationship Modeling [48]
Journal: Communications in Computer and Information Science, CCIS, vol. 272, p. 241-257, 2012.

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2 Informed Imagination

Situatedness refers to the imagery that conceptualization invokes. The image, as a whole, provides the context for interpreting the relevance of the categories revealed in the image. At a basic level of conceptualization, the causal relevance of an observed category can be historically inspired, empirically informed, rationally thought, or pragmatically focused. From a service-design perspective, the interest in a given phenomenon is limited to its functional organization, which requires taking an exclusively pragmatic view of the world. In this chapter, we propose a role-based approach to modeling categories, which requires service-designers assign functional and non-functional roles to categories by making explicit their interpretation of the conceptual relevance of these categories. Staying aware of the design choices will help the service-designer develop an informed model of observed reality, leading to better alignment between the scope and the purpose of the inquiry.

2.1 The Situated Nature of Conceptualization

Cognitively, conceptualization is situated [2]. Situatedness refers to the imagery that conceptualization invokes. It is the reenactment of a combination of prior experiences that together simulate a perceptual experience in the form of a situation - experienced or imaginary. The imagistic nature of conceptualization is enabled through different epistemic considerations. The four prominent epistemological theories that are considered relevant from an information science perspective include historicism, empiricism, rationalism and pragmatism. It is the contribution of these different epistemological views in activating an imagined situation that lends semantics its encyclopedic nature [11].

For example, consider the case of a bike manufacturer conducting an inquiry on the use of bike to go to school. One popular image of a person biking to school is where she carries a bag. The inclusion of bag in the 'bike to school' conceptualization may be grounded in historicism, as historically we, as students, have been exposed to the act of carrying reading, writing instruments and lunch box to school. From a bike manufacturer's perspective, the role of 'bag-carrier' undertaken by the person biking to school is not, by default, relevant. This, initially historicism inspired, role gains significance for the inquiry only when it is shown to have some functional relevance to the 'bike to school' phenomenon; say, increased tiredness of the biker due to the weight of the bag on the shoulder, reduced maneuverability in traffic, ergonomic considerations, etc. Figure 1 highlights the different epistemic groundings that may contribute to the popular imagery of an individual biking to school. In the following we refer to [3] in providing a detailed account of these epistemological groundings.

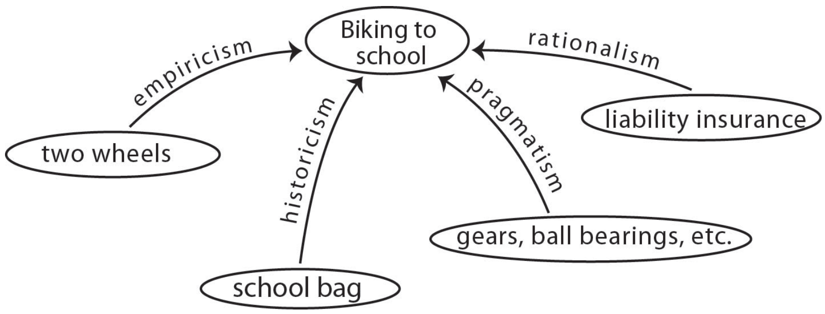

Figure 1 Epistemological grounding of an example conceptualization

2.1.1 Empiricism

Empiricism is that epistemic influence on conceptualization, where judgment is based solely on observations. It is considered a bottom-up approach where knowledge is created by virtue of the observer being exposed to a certain sample set and patterns of association formed based on repeated occurrence of a category. In the absence of any theoretical base, the associations are purely symbolic in nature. For example, the popular image of bike, depicted in Figure 1, models bike as having two wheels. Historically, we are aware of bikes with one wheel. Also, rationally speaking there is no logical reason for only having two wheels in the bike. Pragmatically too, the need to stay put with two-wheel bike configuration is not a necessary one - be it in terms of balancing or maneuverability. Nevertheless, our exposure to bikes with two wheels has been considerably higher amongst our overall experience of the bike as a concept. Such number-of-exposure based reinforcement of a concept is referred to as grounded in empiricist consideration.

2.1.2 Rationalism

Rationalism is that epistemic influence on conceptualization, which is grounded in the tradition of logic. Rationally inspired conceptualization exposes the mental model of the modeler who builds the logical argument to deduce a specific inference. For example, the inclusion of liability insurance as an element of the popular image of bike, depicted in Figure 1, reveals the authors' mental model of biking in a country like Switzerland where all risks are appropriated.

2.1.3 Historicism

Historicism is that epistemic influence on conceptualization, which is based on social contexts and historical developments. It relies on culturally grounded experience that is accumulated overtime. For example, in Figure 1, the inclusion of bag in the 'biking to school' conceptualization may be grounded in historicism, as historically we have been exposed to the act of carrying reading, writing instruments and lunch box to school. This may not necessarily hold today as adoption of IT based teaching methods have made stationary redundant and home-packed lunch has made way for cafeteria food.

2.1.4 Pragmatism

Pragmatism is that epistemic consideration which is driven by the purpose of the conceptualization. It promotes a functional view of reality where categories are acknowledged by virtue of their relevance to explaining the causal organization of the phenomenon of interest. For example, in Figure 1, the inclusion of ball bearings and gear as part of popular imagery of the bike as a means of transport, exhibits the bike manufacturers' purpose of conducting the inquiry – to come up with new bike designs.

Thus, the categories revealed in a conceptualization may not always undertake a functional role. They may also undertake non-functional roles that contribute to the imagery at the structural level [12]. For example, the mere acknowledgment of the category 'school-bag' as part of the 'bike to school' conceptualization does not suggest that 'school-bag' has some causal relevance to the phenomenon of biking to school. At this level of conceptualization, 'school-bag' undertakes a more structural role, helping construct an image that has conceptual relevance for the modeler. May be in this case, what distinguishes the image of a 'general bike ride' from the 'bike to school' phenomenon is the inclusion of school bag in the popular imagery of an individual biking to school. Base/profile is a typical non-functional role that interests the image processing community. At the level of conceptualization depicted in Figure 1, the 'school bag' undertakes the role of a cognitive reference point, which helps to profile a category, 'bike to school', by referring to a cognitively related category 'school bag'. This is not to suggest that 'school bag' does not have any functional relevance to 'biking to school' phenomenon. Its relevance to the causal organization is revealed when the scope of the 'bike to school' activity is refined to the 'bike-ride to school'. The 'bike-ride to school' has a reduced scope in terms of focusing only on the riding experience of the rider but has a higher resolution in terms of revealing categories like tiredness, maneuverability in traffic etc. It is in this context that 'school bag' undertakes a functional role, as it is part of the cause-effect relation whose relevance to the refined scope of the phenomenon of interest is easily demonstrable.

2.2 Why-you-see What-you-see

As discussed in Section II, Service-system is an abstract concept that is aimed at organizing the observed reality in a way that helps specify the design requirements of the behavior required to create value for the Focal-element. Categories are observed in relation to other categories that together invoke the image of some earlier experienced situation. Instantiating the Service-system from observed reality presents two main challenges.

First, the causal relevance of each observed category to the behavior exhibited by the entire set of observed categories, also referred to as the phenomenon of interest, has to be established. In the following part of this section, we propose an approach that requires service designers critically reflect on the reasons why they see what they see. This helps reveal the cause-and-effect relationship that the observed category may have with the phenomenon of interest. Second, given the situated nature of categories, the categories identified to have a causal relevance for the phenomenon of interest do so in the context of the image/situation through which they were invoked. As a result, any reification of Service-system should be done in a way that retains the binding that a category enjoys with the image through which it is invoked. The traditional approach built around the notion of stakeholder is to map these categories to entities in the physical world – ontological categories like a person, group of people, institutions, etc. Nevertheless, the mapping between categories and entities is not one-to-one. Entities may participate in multiple cause-and-effect relations constituting a phenomenon of interest and representing each of these instances based on their shared body form, i.e. the entity itself, overlooks important information regarding the cause-and-effect relation through which they contribute to the phenomenon of interest. Towards this end, we recommend that Service-systems be instantiated by qualifying entities with the functional roles they undertake. Roles reveal the semantics of an entity's participation to a situation and should not be seen as truth-conditional labels [13]. Since the end objective of service design is to identify the design requirements of the intended behavior, knowledge of the functional roles that an entity undertakes helps in identifying the activities that need to be undertaken to engineer that behavior.

2.2.1 Critical Reflection

The categories observed in the real world can have several different cognitive groundings. A category can be perceptually relevant to the observer due to its role in form-oriented completion of the imagery. Form-oriented synthesis of reality is widely studied as part of the Gestalt movement in psychology [12]. Gestalt refers to the unity of human experience. The claim of Gestalt Theory is that humans experience wholes not parts, and the whole is more than the sum of its parts. For example, when looking at a complex arrangement of individual elements, humans tend to first look for a single, recognizable pattern. There is, therefore, a constant effort to categorize observed reality at a level of granularity that provides a cognitive closure of sorts and thus lead to unity of experience. For example, Figure–ground organization is a type of perceptual grouping, which is vital for recognizing objects through vision.

Elements are perceived as either figures -distinct elements of focus, or ground - the background or landscape on which the figures rests. Other prominent patterns of Gestalt completion include Base-profile for uniformity-oriented completion and Cognitive reference for proximity-oriented completion. Gestalt formation is a functional activity as far as the synthesis of experience is concerned but does not contribute functionally to the cause-and-effect relationships that constitute the semantics of the phenomenon.

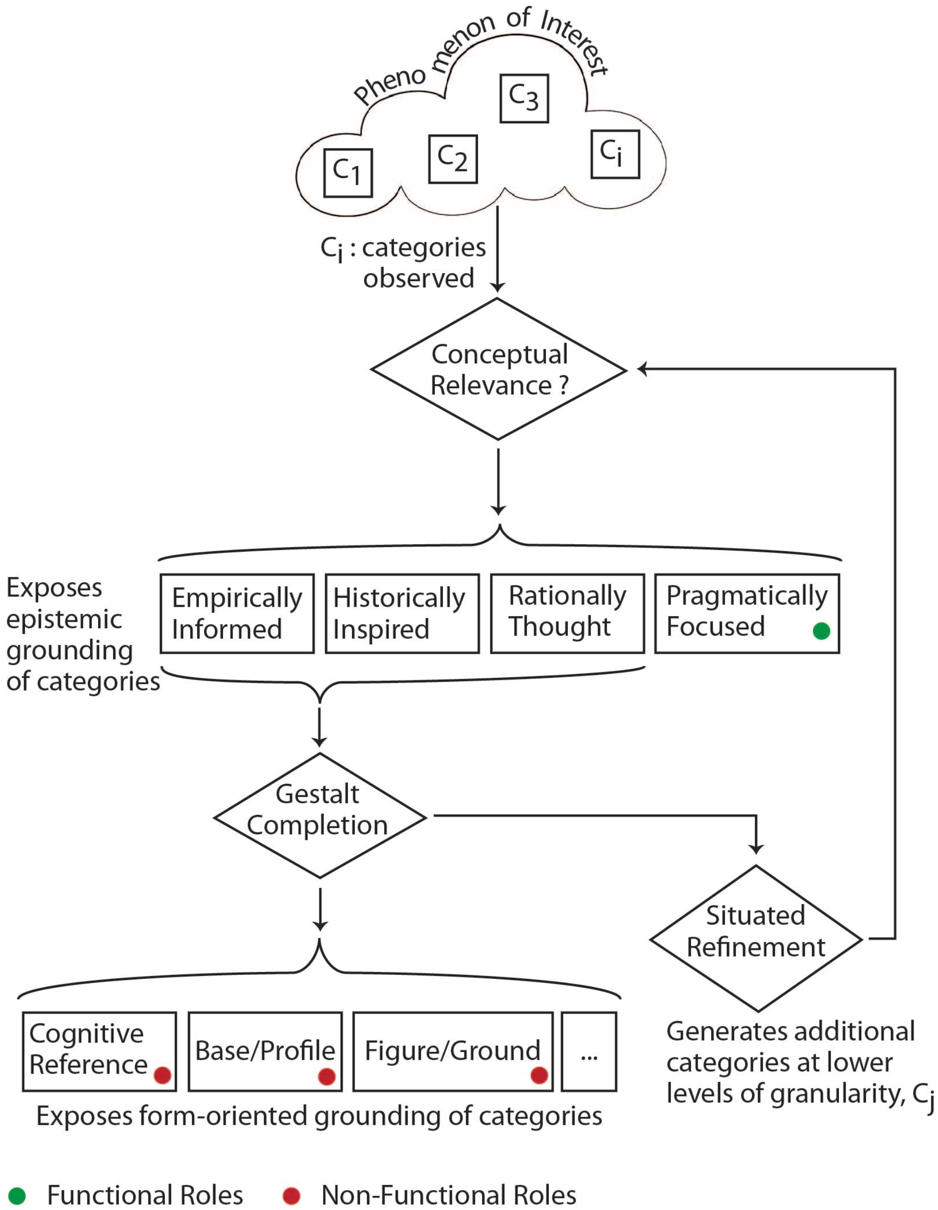

Figure 2 Cognitive grounding of observed categories

To ascertain if the observed category has an exclusively Gestalt role or is also influencing the observed behavior through some cause-and-effect relationship, we recommend the service-designer reflects on the nature of the conceptual relevance that the observed categories may have for her. The questions that she can pose to herself are:

Why do I see, what I see? How is this relevant to my inquiry?

- Is it because I am used to seeing this aspect in this situation, but don't know why?
- Is it because I am used to seeing this aspect in this situation, and that is because of my social or cultural exposure to a specific kind of world, which includes beliefs/upbringing/atmosphere?
- Is it because that is how I think it should be? Whenever you see this one thing, there has to be this other thing, whether explicitly mentioned or not – its logical.
- Is it because this has some relevance to the purpose of my inquiry? And the relevance can be explained in terms of a cause-and-effect relation.

These questions help the service-designer identify the epistemic groundings of the observed categories by reflecting if the conceptualization of the category is empirically informed, historically inspired, rationally thought or pragmatically focused. As is evident from these questions, it is only the pragmatically grounded category that contributes to the causal understanding of the phenomenon of interest. Figure 2, provides a process-oriented overview of the approach suggested to identify the cognitive grounding of categories and thereby assign functional or non-functional roles.

2.2.2 Situated Refinement

To recall, conceptualization is situated and invokes the image of some earlier experienced situation. During critical reflection, the service-designer tries to understand the relevance of an observed category in the context of the invoked image. It is quite possible that an initial acknowledgement of a category may be embedded in a situation that does not readily reveal the causal relevance of the category. In that case, the service-designer can imagine new situations, which further situate the category in an image of higher resolution and reduced scope. The service-designer then undertakes, once again, the same process of identifying the causal relevance of the category, but now in the context of this new situation. The process of generating new situations from the old one is essentially a process of moving from a higher level of abstraction to a lower level of abstraction, and is commonly referred to as the refinement process [14].

For example, as shown in Figure 1, the category of 'school-bag' – as part of the 'bike-to-school' imagery, is assigned a non-functional role based as it is reported to have conceptual relevance by virtue of its historical grounding. Nevertheless, when refined to the situation of ‘bike-ride to school’, the causal relevance of the category ‘school-bag’ can be more readily interpreted in terms of the physical tiredness it brings to the bike-rider, etc. Here the image of ‘bike to school’ is seen as representing a higher-level phenomenon that includes host of categories, such as the traffic on the road, the biker, and the parking place. Where as, the image of ‘bike-ride to school’ is seen as a refinement, which focuses exclusively on the bike-rider’s physical experience of riding the bike.

Refinement of a conceptualization alters the scope of the situation that the conceptualization invokes. Theoretically, any role can be mapped to a functional role by changing the scope of the underlying situation. Nevertheless, refinement adds to the semantic distance between the original situation and the resulting situation. Constraint-free refinements, though eventually, reveal a lower-level functional role corresponding to some higher-level non-functional role, the semantic gap between the functional role revealed and the phenomenon of interest may become so large that it may render the entire refinement chain conceptually intractable; for example, the scope degenerating to sub-atomic levels of matter.

Thus, situated refinement is the idea to make the service-designer aware of the choices it makes by requiring her to make the process of generating additional categories more transparent. By doing so the service-designer is made to reflect on the reasons why she thinks a specific refinement is justified in relation to the purpose of the inquiry, and that she is not extending the scope of the inquiry beyond relevant issues.

2.3 The Example of Mixed-mode Commute

In this section we develop a service-design scenario, which is representative of the real world problems that a modeler has to address while specifying a service. The objective is to illustrate the process of critical reflection and demonstrate how it helps in identifying service-systems.

Case Description

The purpose of inquiry we undertake is *to study the impact of the use of foldable-bike on the adoption of mixed-mode of transport*. Mixed-mode of transport refers to mobility solutions that involve the use of more than one mode of transport. For the purpose of this study we restrict ourselves to the combination of bike and train. Foldable-bike refers to those bike designs, which have a collapsible frame, whereby when not in use their form-factor can be reduced to a shape and size comparable with a conventional luggage-bag allowed on board most public transports. The idea is to model the behavior that a foldable-bike manufacturer intends to realize for the people using these bikes. For the purpose of exposition, we limit the scope of our model to include only those users of foldable-bike who avail mixed-mode of transport for their commute to the workplace. More concretely, we assume the Focal-element here to be the *user* in her role as an *office-worker*. It is important to note that there is no loss of generality here due to this simplifying assumption. Our focus here is on identifying the service-system, which intends to realize a behavior that creates value for the user, possibly in several different ways – one of which we highlight as being an office-worker.

Experimental Setup

The process of critical reflection assumes a phase of informed imagination that provides the basic-level conceptualization, and thus acts as a starting point for the service-designer to reflect and identify which categories revealed therein are relevant for specifying the intended behavior of the service. Informed imagination can be facilitated through brainstorming sessions, interviews, field visits and other forms of environmental scanning techniques. In the context of this study, we highlight three situations that were identified, amongst several others, during a brainstorming session amongst a community who themselves have not had first hand experience of mixed-mode of commute involving travel with a foldable-bike in the train. Nevertheless, they are well aware of the experience that travelling in a train and riding the bike entails. The selection of such, seemingly under-informed, subjects is to stay representative of the conditions in which a service-design activity is undertaken in the real world. As indicated in our definition of service-design – "as an engineering endeavor to enrich some aspect of the real world through a man-made artifact", the reference to enrichment suggests that the focus is on realizing a novel behavior, which by definition excludes the possibility that the service-designer may have access to a subject who can completely specify the intended behavior a-priori. A well-informed imagination phase can, at best, specify the behavior of the constituent activities, from which the intended behavior needs to be constructed.

Situated Role Assignment

The three situations we consider here are depicted in the Figure 3 below. Figure 3(a) depicts the outcome of the modeler's inquiry into the epistemic grounding of the image of *a person boarding the train with a bag*. Based on the semantics the service-designer assigns to this image will reveal the epistemic grounding of the categories *bag*, *person* and *train*. As explained in the figure, the semantics of this situation could well be inspired due to cultural influences, such as considering carrying personal belongings in a bag as part of a social norm enforcing civilized behavior.

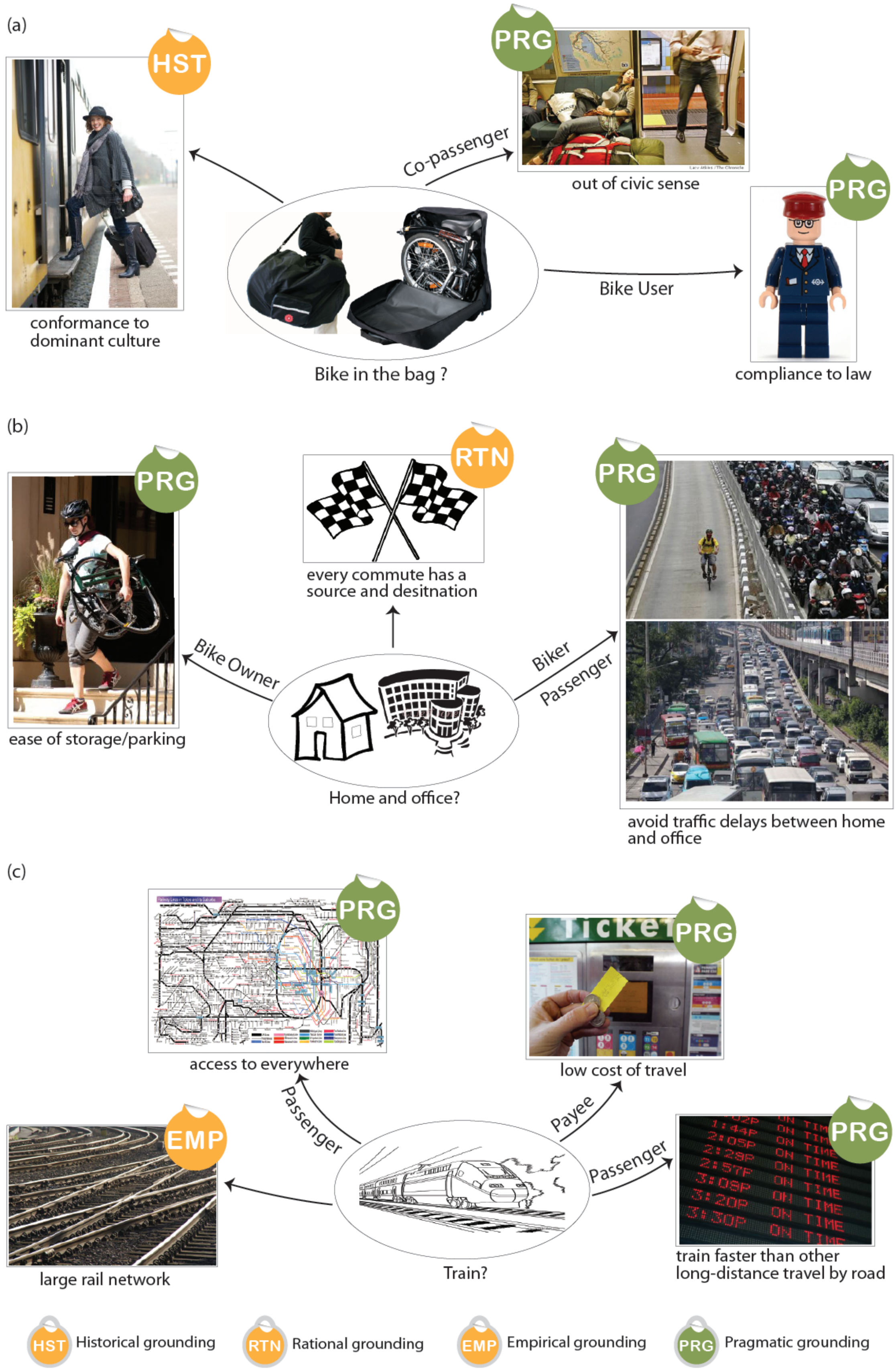

Figure 3: Critical reflection in action

In that context, the categories do not seem to have any causal relevance to the phenomenon of mixed-mode of transport, unless we assume that conforming to social norms is also part of the design objective, which is a completely justified design constraint. Nevertheless, for the purpose of this illustration we discard that possibility. On the other hand, if we interpret the bike-in-the-bag imagery to convey the need to comply with local transport regulation, which requires bikes stored in the passenger area to stay in a bag at all times, then it does reveal the pragmatic basis of the imagery and, hence, assigns the categories a functional role. For example, in this case the person undertaking the role of the *Bike User* responsible for the outcomes arising out of the usage of the bike, as in storing the bag while on board the public transport. Another, pragmatic reasoning could be grounded in the person's concern for the inconvenience of the fellow passengers. In that case, the person may store the bike in the bag out his civic sense to avoid any injury to fellow commuters from the exposed sharp edges of the bike or the grease on the mechanical parts of the bike leaving stains on their clothes. Here the person can be modeled as undertaking the functional role of a *Co-passenger.*

Figure 3(b) depicts the outcome of the modeler's inquiry into the epistemic grounding of the image of *home to office commute*. The three possible semantics explored for this situation are included here. First is a rationally oriented conceptualization, which is based on the logic that the categories of source and destination are always present whenever there is any reference to commute. Second is a pragmatic orientation, which reveals the issue related to the storing/parking of bike at home, thereby highlighting the role of the person as a *Bike Owner* concerned about the safety of her bike. Third is another pragmatic orientation, which reveals the issue of the person being able to avoid both the intra-city and inter-city traffic. In this case the semantics of the situation highlight the role of the person as a *Biker* and *Passenger.* It is important to note that some of the above pragmatically oriented interpretations of a situation required several refinements.

Figure 3(c) depicts the outcome of the modeler's inquiry into the epistemic grounding of the image of the *train as means of public transport*. An initial interpretation of this situation could be grounded in empirical consideration, which is based purely on the observations that there is a *large rail network in the area*. Nevertheless, in the absence of any judgment it remains unclear how this rail network provides means of transport for people. It could be the case that the region has a large rail network to support freight movement, as is often the case in a port city, manufacturing hub, or an area rich in minerals. In an effort to identify the causal relevance of this observation, the service-designer might be inclined to explore other refinements of this situation. For example, further reflection may reveal the existence of a transport network that takes advantage of this large rail network to provide people *access to everywhere* in the sense of universal coverage. It is then easy to accept the causal relevance of train as a public-transport, which the user can take as part of the mixed-mode transport thereby assigning the functional role of *Passenger* to the user. This role is also discovered as part of critical reflection on the situation in Figure 3(b). As it will be clear in the following subsection, we are using the role *Passenger* to refer to all the cause-and-effect relations the user will participate to by virtue of her using the train as a means of public-transport. Figure 3(c) includes another grounding – of the train being faster than other means of long-distance travel, which is considered to enforce the earlier role of user as a *Passenger.* The final refinement included here, with reference to the interpretation of the *train as a means of public transport* imagery, exposes its pragmatic grounding in the low cost of travel that the train may provide to commuters. In that case it highlights the user playing the functional role of the *Payee* of public-transport travel cost.

Service System

Based on the situations that were admitted during the informed imagination of the phenomenon of *use of foldable-bike as part of mixed-mode commute*, including the three situations specifically discussed above, we present the service-system that specifies the behavior that the foldable-bike manufacturer should realize to create value for the user in her role as an office-worker. Figure 4 provides a visual depiction of this service-system. The Service-system specifies all the roles that the participating entities play in realizing the intended behavior. Thus, the inclusion of the Train Company, Bike Manufacturer and Municipality refers to all the functional roles that each of them undertakes as part of their participation to the phenomenon of *mixed-mode commute using foldable-bike.* Train Company here refers to the agency managing all aspects of the railways as a means-of-public transport, including rail network, rolling stock, commercial operations such as ticketing and legal compliance to relevant civil code. Bike Manufacturer refers to the company that designs, develops, produces and sells bike as a physical product. Municipality refers to the agency that is responsible for city infrastructure, including roads and parking places. In addition, we also highlighted two other roles undertaken by human actors other than the user. Co-rider refers to the group of people, excluding the user, on the road in their role of being part of the city commuter traffic. Similarly, Co-passenger refers to the group of people, excluding the user, in their role of being on board the same train as the user, or in general using the same rail transport network. As for the user, we represent her only in two roles – as a Biker and as a Passenger. These roles are higher-level roles, which together subsume all other functional roles that the user was shown to undertake in the three situations that we analyzed earlier.

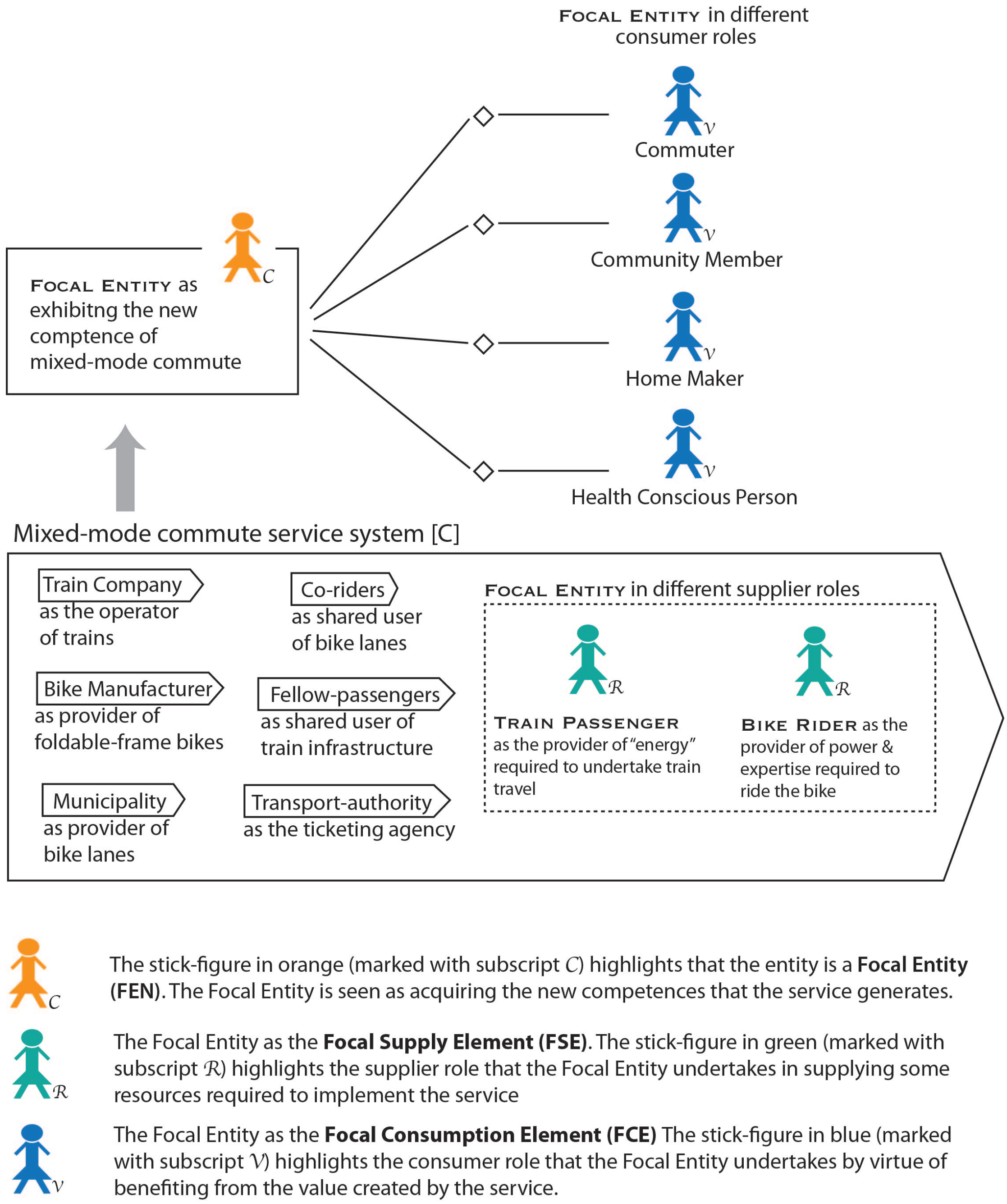

Figure 4 An example service system as an outcome of situated modeling

Detailed information about the functional relevance of the different entities found to be participating to the phenomenon of interest is presented in Figure 5. Organizing the functional composition of the phenomenon as a hierarchy helps clarify the relation between roles. For example, the role Biker as being composed of the roles Bike Owner, Bike Rider and Bike User. Note that the role of Co-passenger undertaken by the user in relation to her fellow commuters on the train, and the role of Co-passenger undertaken by other people on train in relations to the user, can be distinguished in the figure by taking note of the different body shapes used to model different entities. The observant reader will notice an additional role at the highest-level in the compositional hierarchy - *mixed mode commuter using foldable-bike.* This is a special role in the sense it represents what the user becomes by virtue of her adopting the service or, to put it differently, what does the realization of the intended behavior make of the user. In this case, she becomes a mixed-commuter who uses a foldable-bike for short distance intra city commute and train as the means of public transport for long distance inter city commute.

It is important to note that the process of identifying the functional role a category undertakes, applies to all observed categories. In this illustration, we have restricted our focus on the functional roles undertaken by the user, i.e. the entity corresponding to the Focal-element, henceforth referred to as the Focal-entity. There are two motivations for this choice. First, we wanted to keep the depiction of service-system simple to ease comprehension. Second, by focusing on the focal-entity we wanted to highlight a frequently used simplifying assumption in services modeling, which advocates modeling focal-entity exclusively in its role as the consumer of the service, i.e. only as the focal-element. While this may seem to work for simple cases, it surely is not universal in its appeal. The approach that focal-entity undertakes at least two roles – one as the focal-element and the other as part of the service-system, is theoretically grounded in the end-to-end view of services, which includes the process of consuming the service as part of the service-offering. This, in fact, is one of the primary features that distinguish service-oriented approach from other traditional approaches of economic exchange.

Further, a role based modeling of the service-system not only identifies all the relevant activities required to realize the intended behavior, often referred to as the lifecycle of the phenomenon of interest, but also reveals the precise activities through which the user interacts with the service. Knowledge of these interface points provides important insight to the service designer in terms of identifying the new features that she can include in the design to enrich the existing behavior.

A complete service specification requires answering the how, what and why of the service. How corresponds to the behavior that is to be realized as part of the service offering. What corresponds to the potential this behavior has to induce change. And why corresponds to the experience that is created by virtue of this change, thereby justifying why the service should be adopted. Identifying the service-system is the first step in this three-staged process of specifying the service.

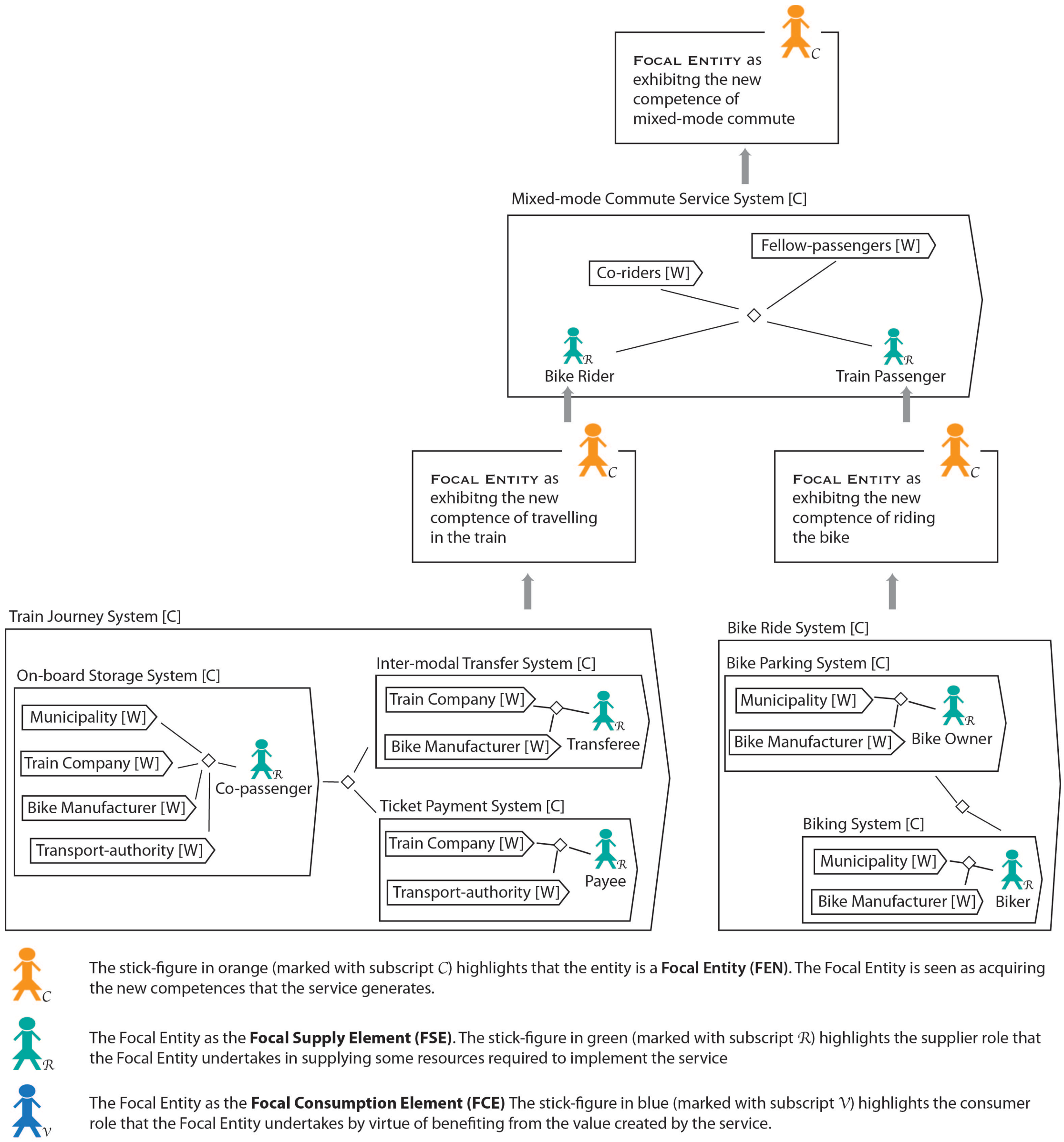

Figure 5 Hierarchically organized functional composition of the service behavior

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3. Value Articulation and Force-dynamic Analysis

This chapter presents a set of four force-dynamic frames aimed at helping service designers surface the cause-and-effects underlying a value expression. In addition to the modeling apparatus that constitutes these frames, this chapter also provides a detailed account of how these frames are put to use in developing service-oriented models of problem solutions. For ease of exposition, I continue to refer to the mixed-mode commute example introduced in the first chapter.

3.1 The Embodied Nature of Value Expressions

The field of Cognitive Semantics [1-4], which is the study of language from a cognitive perspective, suggests that the meaning of a concept resides in the human conceptual system and cannot be specified in terms of necessary and sufficient conditions that refer to some entity or relation in the real world. The later represents classical theories of semantics such as the work by Alfred Tarski and Donald Davidson on truth-conditional semantics [5]. For instance, the natural language expression '*foldable-frame design of bikes helps commuters avail mixed-modes of transport*' is a proposition that seeks to convey a conceptualization highlighting the ease with which bike-riders can commute longer distances by taking foldable-bikes on-board public transport. Nevertheless, the true semantics of this proposition differs from one commuter to the other. The '*help in availing mixed-mode of transport*' could be by virtue of the ease of storage due to small form factor of foldable bikes, or the reduction in cost of travel due to the policy of the government to allow transport of collapsible bikes for free, or simply the reduction in psyche cost of bike-ownership for the commuter who likes to be associated with new and trendy designs. From a service-design perspective, it is important that the service designer is able to surface the specific cause-and-effect relation underlying a value expression.

An important work in the field of Cognitive Semantics is that of Leonard Talmy, [4], who studied the cognitive grounding of the concept of causation, and proposed a force-dynamic framework to reason change. Talmy introduced the idea of extended causation, which defines all such situations as causative where there is evidence of mutually opposing forces trying to bring about some change in the existing state of affairs. The claim that extended causation enjoys a conceptual status, resides in the linguistic evidence that suggests human beings are perceptive (i.e. get recorded in the human perceptual system) of all those interactions with the external world, which can be modeled in terms of "a stronger force opposing a weaker force head on, with all-or-none conditions". This is reflected in the lexicon of natural languages. For example, the English language not only includes words like 'despite' and 'although' that suggest observable state change, but also ‘let’ and ‘hindrance’ that convey the presence of some opposing force even though the opposition is not strong enough to bring about any observable state change. Perception, though, differs from judgment [6]. The consumer’s appreciation of a service is a judgment that emerges by contrasting some perception of the consumer before the adoption of the service, and some perception of the consumer after the adoption of the service. From a service design perspective, it is this change that the service designer strives to understand from the available value expression. Here I model this change as an ordered-pair of force-dynamic patterns – the first specifying the nature of the challenge that the consumer of the service faces, and the second specifying the nature of the response that the service should bring about. Thus, given a value expression, we identify the forces influencing (both cause and effect) this judgment, and the entities that are responsible for exerting these forces.

3.2 Value Frames: Force-dynamic Patterns of Causality

Force-dynamics refers to the interactions between entities with respect to the forces that they exert and undergo. The concept of force has its origin in natural sciences, where it is defined as the “influence that causes an object [with mass] to undergo a certain change, either concerning its movement, direction, or geometrical construction” [7]. In the context of human-oriented problem solving, the more relevant force factors are the ones originating in the psychological and sociological domains – e.g. goals, beliefs, desires, intentions, and other action concepts [8].

In their most general form, force-dynamic patterns are schemas that organize the information related to the interaction between entities, such that the resulting information structure reveals the cause-and-effects that underlie their behavior. As schemas, their effectiveness in modeling a real-world situation is dependent on the service designer’s choice of force factors and the interpretation she lends to these forces. Nevertheless, in specifying force-dynamic patterns for the purpose of service-oriented conceptualization (SoC), I make the following design choices. These choices are aimed at simplifying the design space but do not, in any way lead to any loss of generality of the proposed modeling apparatus.

3.2.1 Design Choice

In the context of SoC, the following design choices were made for force-dynamic based causal reasoning:

- **SoC force-dynamic patterns model interaction between an entity of interest – the focal Entity (F), and some entity in the environment (E).** For simplicity reasons, we model each entity with a single force. This can be easily extended to include more fine-grained force features for example, the ones mentioned in theory of planned behavior [9]. Further, the two forces are considered to be opposing each other.

- **SoC force-dynamic pattern admits only those forces, which are oriented along one unique semantic dimension.** This ensures that the forces interact head-on and the resultant force is also along the same dimension. This unique semantic dimension that keeps all forces in a frame aligned can be interpreted from the context of the SoC. Construal is the perspective that a specific SoC takes of the phenomenon of interest. It is specified at the lowest level of granularity possible and hence can be seen as the finest grained semantic dimension.
- **SoC force-dynamic patterns deal with only two types of forces**: reluctance to change and tendency to change. Broadly speaking, they can be interpreted as rooted in maintenance and attainment goals respectively. Reluctance to change can be viewed as a manifestation of behavioral inertia that strives to retain its state, while goal pursuit can be viewed as a tendency to bring about some state change.

Each SoC force-dynamic pattern is modeled as an interaction between two opposing forces, representing the beliefs of the two entities. These two forces are also of different types. This restricts the SoC force-dynamic patterns to the following four types. Before we elaborate on the semantics of these patterns we introduce the visual representation that we propose for these patterns.

3.2.2 Visual Semantics

To facilitate the visual apprehension [10] of force-dynamic patterns, we employ the peak-and-trough metaphor to assign a set of visual semantics [11], which convey the meaning of these force-dynamic patterns through commonly encountered visual patterns, such as a rock rolling down a hill or an instance of marble running down a wooden chute in a game of marble-run. The basic idea, which these visual patterns try to convey, is that every action has a normative core [9]. Depending on the situation, an action may manifest itself overtly - in terms of

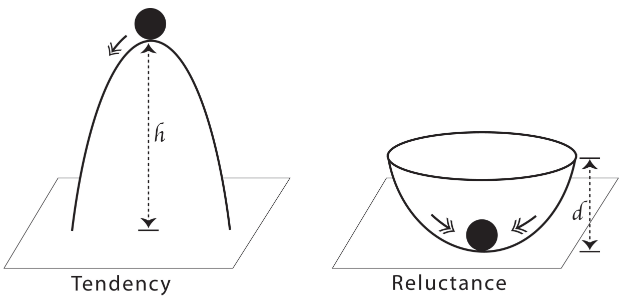


Figure 1 Visual interpretation of force factors

achieving some new state, or inertly in terms of maintaining an existing state. We invoke the peak-and-trough metaphor to convey these overt and inert manifestations of a norm. The visual of a marble perched on an elevated chute is used to simulate the overt expression of a norm as the tendency of the marble to roll down the chute and bring about the desired change by displacing other marbles that come in its way. The height of the peak represents the strength with which this tendency is being pursued. The visual of a marble in a trough is used to simulate the inert expression of a norm as the reluctance of the marble to get displaced. The depth of the trough represents the strength with which this reluctance is being held. This visual interpretation of force-factors is depicted in Figure 1.

The semantics of the different force-dynamic patterns is conveyed visually by interchanging the positions of **F** and **E** between being held in the trough or perched on the peak, and varying the height of the peak and the depth of the trough. The **E** perched on a peak high enough to displace the **F** held in a trough ($h_2>d_1$) represents a situation where the resultant force experienced by the focal-entity is one of imposition – the **IMPOSE** pattern. On the other hand, the **E** perched on a peak not high enough to displace the **F** held in a deep trough ($h_1<d_2$) represents a situation where the resultant force experienced by the focal-entity is one of disruption – the **DISRUPT** pattern. The visual semantics of the force-dynamic patterns - **HINDER** and **BLOCK** can also be interpreted in a similar manner by interchanging the positions of **F** and **E**. Figure 2 provides a visual depiction of the force-dynamic patterns proposed for developing a service-oriented model of the problem situation.

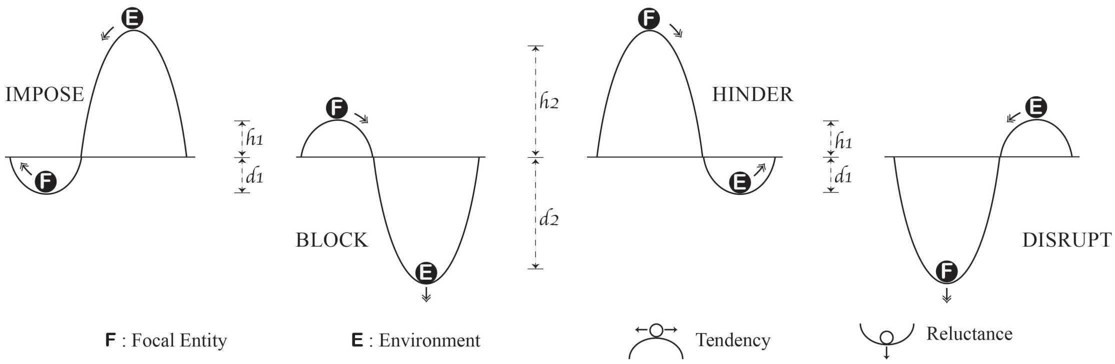


Figure 2 SoC specific force-dynamic patterns of causation

The Four Frames of Value Creation

SoC models value creation as a transition from the precursor state to the resultant state. The idea is to focus on modeling the change that the adoption of a service brings about. SoC is, thus, represented as an ***ordered pair of force-dynamic patterns*** – one that reflects the cause-and-effects underlying the precursor state, and the other that reflects the cause-and-effects underlying the resultant state.

The basic assumption here is that the consumption of a service-feature affects only one entity at a time. It could bring about change at the focal entity or in the environment. This would result in a new force at the affected entity. The other entity will have its force characterization unchanged. There is no loss of generality due to this assumption as multiple affects of the same feature can be modeled separately as new service-feature or the same service-feature but in a new perspective (construal). The entity affected is the one, which demonstrates active goal pursuit tendency in the precursor state. Maintenance goal is a higher-level construct from which action concepts are derived. A maintenance goal may get realized in its native form, which we model as reluctance to change, or may get refined to some specialized goal oriented action, which we define as the goal pursuit tendency. This refinement of maintenance goal into an attainment goal happens within the context provided by the construal. The fact that one entity exhibits force at a level of abstraction higher than the other suggests increased stickiness of behavior at the entity operating at the higher level. As a result, we assume that the adoption of a service changes the force factor at the entity, which exhibits the tendency of goal pursuit in the precursor state. The type of the force does not change between precursor state and resultant state, only the strength of the tendency exhibited by the goal pursuing tendency changes by virtue of it exhibiting a different force, though of the same type. The new tendency is either stronger or weaker than the reluctance of the other entity, which stays the same across the two states.

The constraint that we place on change is that it only acts on the entity, which demonstrates an active tendency towards goal pursuit. Reluctance here represents normative behavior, which by definition stays the same across different situations. The new tendency is either stronger or weaker than the reluctance of the other entity. This assumption limits the number

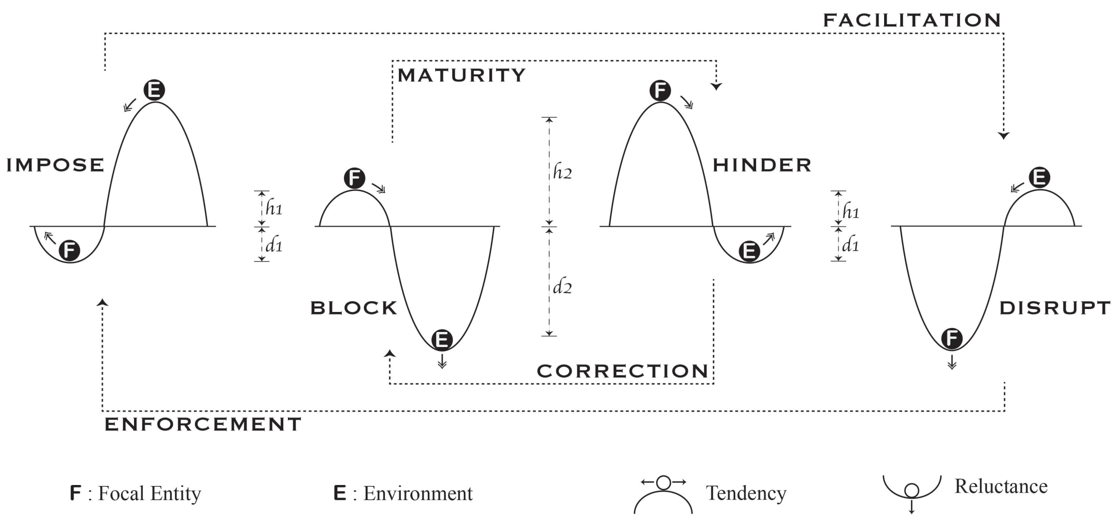


Figure 3 Value frames as an ordered-pair of force-dynamic patterns

of valid transitions to the following ordered-pair of force-dynamic patterns: (IMPOSE, DISRUPT) – the FACILITATION FRAME, (DISRUPT, IMPOSE) – the ENFORCEMENT FRAME, (HINDER, BLOCK) – the CORRECTION FRAME and (BLOCK, ALLOW) – the MATURITY FRAME. These transitions are shown in Figure 3. Figure 4 provides a concise representation of the same transitions.

The Correction Frame

The service semantics reified in the Correction frame is one where value is created by virtue of the service-feature weakening the focal entity's pursuit of change, which otherwise was strong enough to overcome the resistance offered by the reluctance of the environment in accepting the change. In a sense, the adoption of the service corrects the behavior of the focal entity to stop overpowering the environment, thereby creating value. The situation modeled in this frame is one where some internal change at the focal entity helps align with some well-meaning external expectation of the environment.

The Facilitation Frame

The service semantics reified in the Facilitation frame is one where value is created by virtue of the service-feature weakening the environments' force that otherwise was strong enough to bring about change at the focal-entity. With the adoption of the service, the environmental

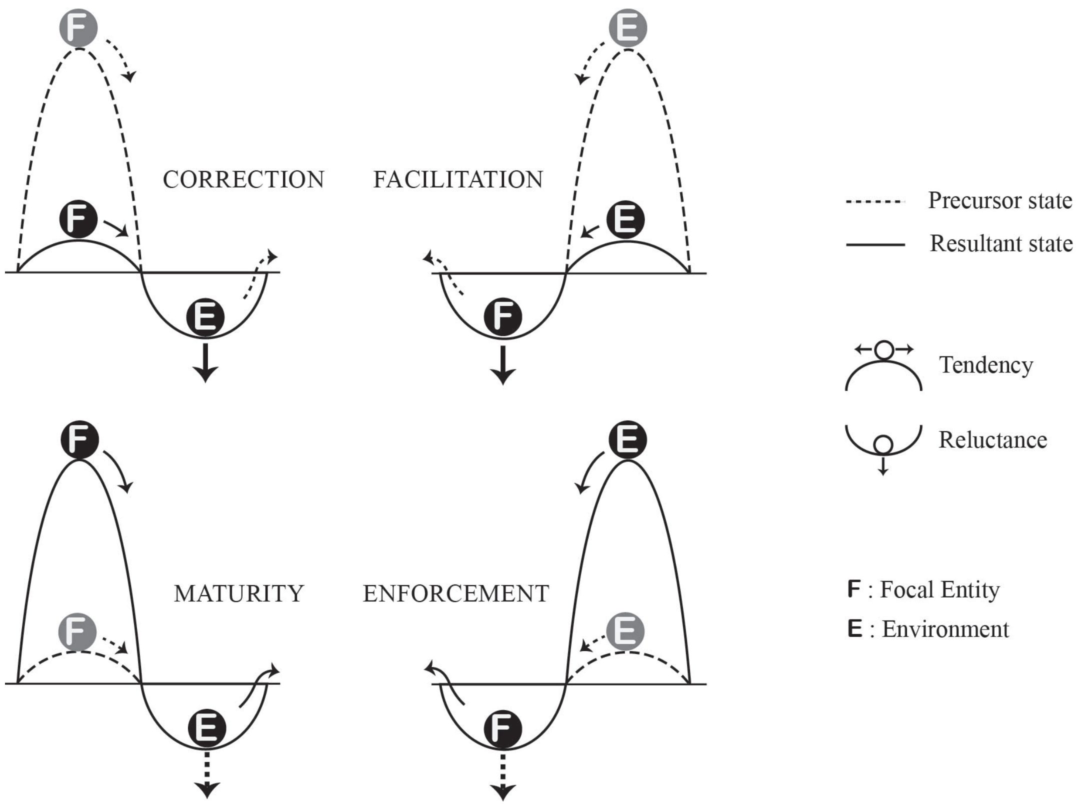


Figure 4 A concise representation of Value frames

force resisting the norm secedes so as to facilitate the focal-entity in retaining its original state. The situation modeled in this frame is one where some external change in the environment helps the focal entity achieve some internal goal.

The Maturity Frame

The service semantics reified in the Maturity frame is one where value is created by virtue of the service-feature strengthening the focal entity's pursuit of change, which otherwise was blocked by virtue of the environment reluctance to accept change. In a sense, the adoption of the service helped the focal entity mature and exert greater pressure on the environment to change, thereby achieving a goal that brings it the desired value. The situation modeled in this frame is one where some internal change at the focal entity helps overcome the resistance offered by the environment.

The Enforcement Frame

The service semantics reified in the Enforcement frame is one where value is created by virtue of the service-feature strengthening the tendency of the environment to bring about some change at the focal entity. In the precursor state, the environmental force was not strong enough to change the behavior of the focal entity, which was reluctant to give up a behavior that was hindering the value creation. By strengthening the environment, a well-meaning change is enforced on the focal entity. The situation modeled in this frame is one where some external change in the environment helps the focal entity overcome some internal resistance.

3.2.3 Information Structure

The insight that this work provides is that the change that the service should implement to realize a given value-proposition, can be characterized in terms of the nature of the underlying challenge that the service helps the consumer overcome, and the way it does so. As shown in Figure 5, we model the **challenge** that the Focal Entity, in the consumption context indicated by the **Focal Consumption Element (FCE)**, faces as having a protagonist and an antagonist. *The protagonist here is the entity that is identified as trying to resist the challenge*, *while antagonist is the entity that is identified as abetting the challenge*. It is important to note that the role of Environment is modeled as one of providing friction, the **Friction Introducing Element (FIE)**. This is different from the role of antagonist and protagonist. Antagonist and protagonist roles are the modeler's judgment about an entity's role in opposing or supporting a value creation process. Whereas, FIE is the mere acknowledgment of the existence of a force factor that opposes the force exhibited by the

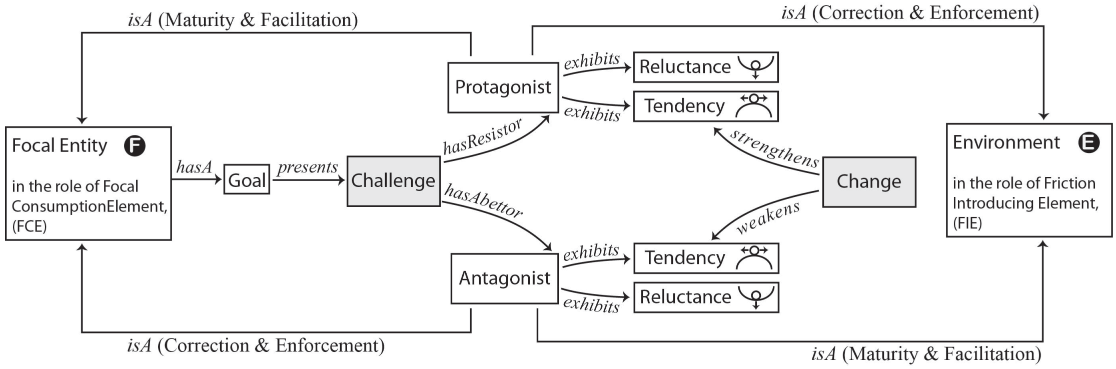


Figure 5 The conceptual model underlying Value Frames

Focal Entity. On its own, FIE does not include any judgment about the value-oriented nature of the force exhibited by the Focal Entity.

Value is created when the challenge is addressed by bringing about some **change**. The basic assumption here is that a service-feature, which brings about the required change, acts on one entity at a time. It could bring about change at the Focal Entity, referred to as internal change, or change the relevant elements in the Environment, referred to as the external change. There is no loss of generality due to this assumption. In fact, we believe this is useful in untangling feature bundles by clearly specifying the context, i.e. the underlying challenge, to which the feature is relevant and also what change it brings about to realize the proposed value. In case there are multiple challenges wedded in one value proposition, we suggest using techniques like FCA (Formal Concept Analysis) [12], to untangle them. The model element that represents the agent of this change is referred to as the **Service Enabling Element (SEE).** It is important to note that behaviorally, change is a differential between two states. As a result, Value Frames document both interactions, before the change and after the change. Before the feature is introduced, the interaction is between the **Focal Supply Element (FSE)**, which is the process view of the Focal Entity, and the Frictional Introducing Element (FIE). After the feature is introduced, the interaction model is between the Service Enabling Element (SEE)

Table 1 The nature of change introduced by the service

VALUE FRAME	SERVICE ENABLING ELEMENT, SEE (as the agent of change)
Maturity	Internal change **(Focal Entity initially FSE, becomes SEE)** that helps overcome some external resistance from the Environment (FIE)
Facilitation	External change **(Environment initially FIE, becomes SEE)** that makes it easier to achieve some internal goal of the Focal Entity (FSE)
Correction	Internal change **(Focal Entity initially FSE, becomes SEE)** that helps align with some well-meaning external expectation of the Environment (FIE)
Enforcement	External change **(Environment initially FIE, becomes SEE)** that helps overcome some internal resistance from the Focal Entity (FSE)

Table 2 The information structure of Value Frames

<type of> **VALUE FRAME**	
Focal Consumption Element (FCE)	< challenge faced by the FCE providing the context (C) for the frame >
Focal Supplier Element (FSE)	< the force exerted by the FSE, f_{FSE} >
Friction Introducing Element (FIE)	< the force exerted by the FIE, f_{FIE} >
Service Enabling Element (SEE)	< the force exerted by SEE, f_{SEE} >
Feature (F_c)	< service-feature expressed as a proposition > *Inferred from* f_{SEE}
Value (V)	< service-value expressed as a proposition > *Inferred from* f_{SEE} *and* C

and one of the following two – FSE or FIE. The precise interactions modeled based on the nature of change introduced are documented in Table 1.

To ensure that the ordered pair is able to convey the complete information related to the change that is required to realize the value-proposition, we represent it as a Frame. Frame is an approach to organizing information that represents a cohesive region in conceptual space [13]. It includes information on all aspects of a situation that may be required to recreate the imagistic character that the conceptualization entails. In addition to the two force-dynamic patterns, Value Frame also includes the context that lends the frame a semantic orientation, and also includes propositional claims of the service-feature and the value that it claims to create. Further, it also includes attribute-value pairs disclosing the identity of the focal-entity and the identity of the most prominent entity from amongst the group of entities represented in the environment. The information structure of the value frame is shown in Table 2.

3.3 The Example of Mixed-mode Commuter Service

The method, used to model a service in terms of the Value Frames proposed in this paper, systematizes the inquiry by guiding it through the possibility space in an interactive manner. The interaction is formalized as a set of questions that help the service-designer seek answers that will help develop a service-oriented model of the problem situation. The method assumes the existence of an initial feature-value matrix: a matrix with service-features listed as row entries and value-propositions listed as columns. A service-feature is assumed to deliver a specific value if the relevant row-column intersection is marked.

We assume the existence of some initial idea of the service that the service-designer tries to transform into a commercially meaningful offering. For continuity of illustration, we continue with the example of designing a foldable-bike based mixed-mode commute service. The initial version of the mixed-mode commute service is depicted in Figure 6 (service system) and Table 3 (the feature-value matrix).

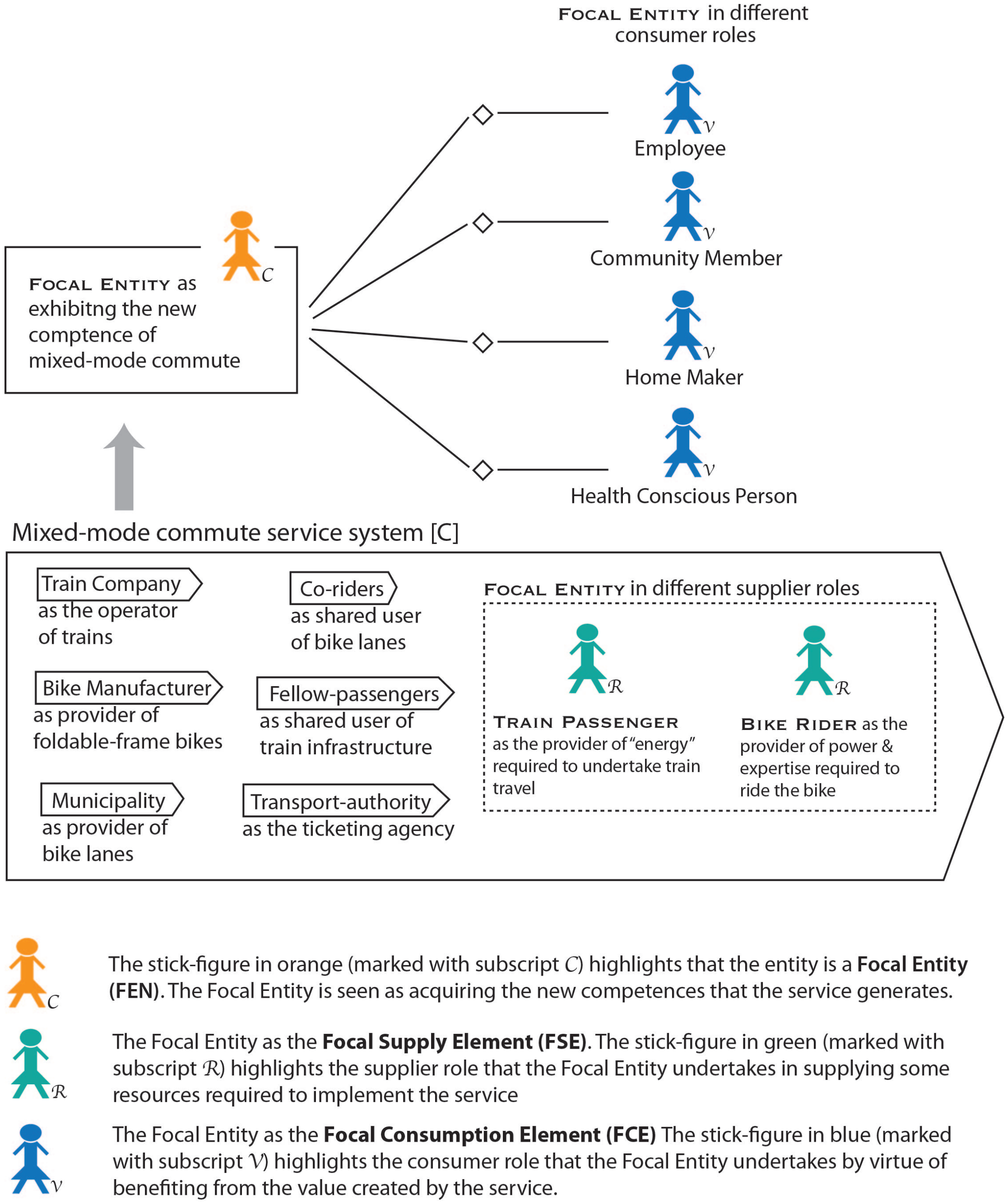


Figure 6 An initial version of the mixed-mode commute service system

Table 3 An initial feature-value matrix for mixed-mode commute service

		Focal Consumption Element (FCE)	FCE_1: Focal Entity as an **Employee**	FCE_2: Focal Entity as a **Community Member**	FCE_3:Focal Entity as a **Home Maker**	FCE_4: Focal Entity as a **Health Conscious Person**
		Value Proposition (V)	V_1: Increased likelihood to get to office on time	V_2: Increased likelihood to avoid inconvenience to fellow passengers	V_3: Increased likelihood to spend more on household purchases	V_4: Increased likelihood to reduce health problems
		Features (F_c)				
FOCAL ENTITY	Initial features	F_{C1}: Ability to avoid traffic delays	x			
		F_{C2}: Ability to avoid travel with oversized objects		x		
		F_{C3}: Ability to reduce cost of travel			x	
		F_{C4}: Ability to perform physical workout				x

3.3.1 Value Articulation

A value-frame based inquiry systematizes the design process by guiding the service-designer through the possibility space in an interactive manner. The idea is to articulate value-propositions while focusing on the being of the focal entity and not any specific role that she might be undertaking. As shown in Table 4, the value-propositions V_5-V_8 are the result of applying this strategy on the initial value propositions, V_1-V_4 (Table 3). For example, the question that generates V_5 from V_1 is: *What benefit does the increased likelihood to get to office on time provides to the adopter*? One answer could be *the increased likelihood to fast track career progression*. The basic motivation behind surfacing embodied expressions of value is that of free association [14], a psychoanalysis technique proposed by the noted neurologist Sigmund Freud. Free association refers to the narrative, which is free of any external influences and thus reveals the inner self. In the context of value articulation, embodied expression of the focal entity's value expectation from the service can be surfaced by framing context free queries about the focal entity's opinion about the benefits of the service. This requires the focal entity to situate the service in a context that comes to fore based on her past experience. Revealing this consumption context as an expression of the value expected from the service is an important piece of information that can help the service designer surface important requirements for the service.

Table 4 Interactions for surfacing embodied expressions of value

Question	What benefit does the `increased likelihood to get to office on time` provides to the focal entity, the commuter?
New value proposition	`Increased likelihood to fast track career progression` (V_5)

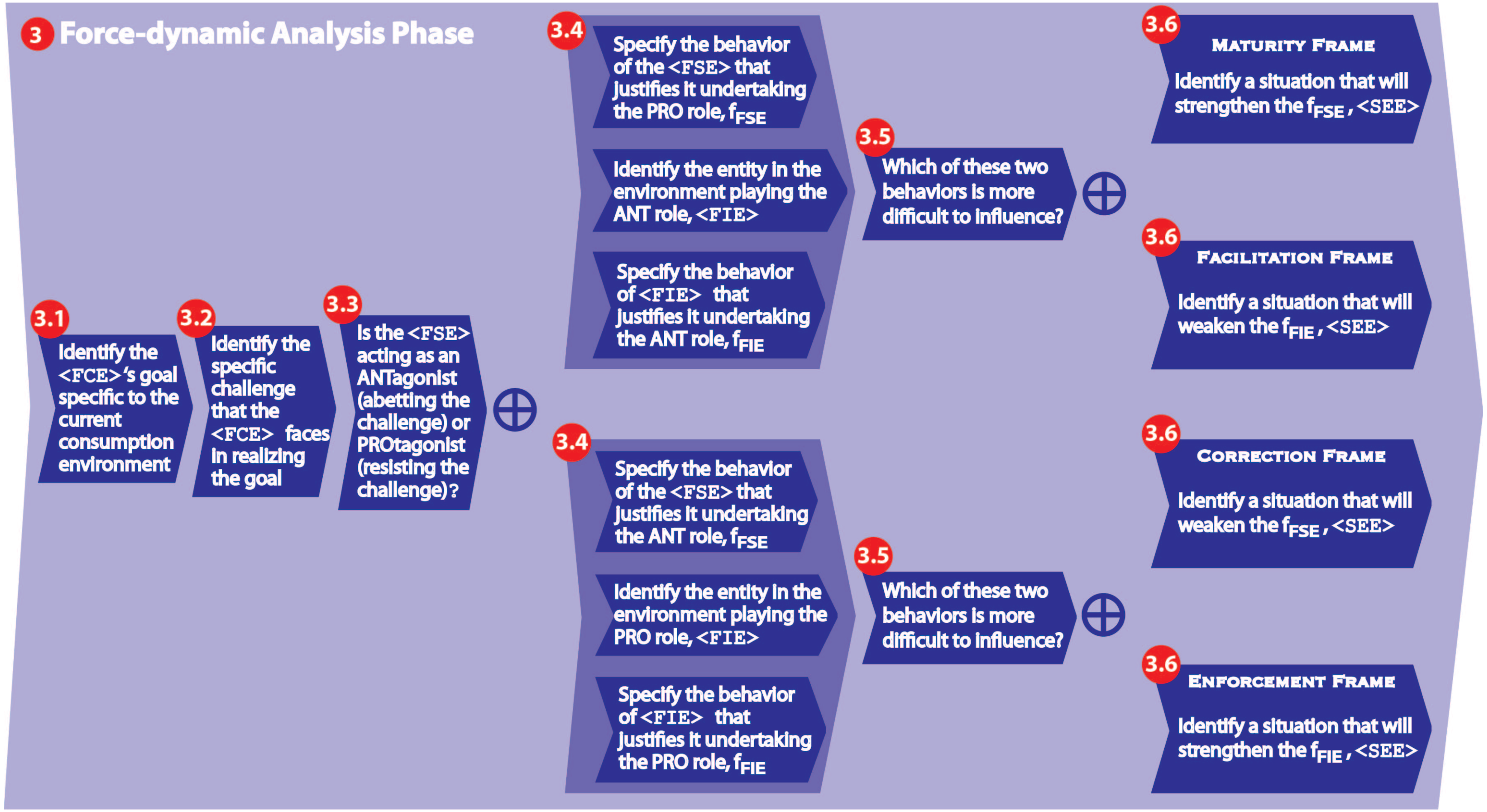
Question	What benefit does the `increased likelihood to avoid inconvenience to fellow passengers` provides to the focal entity, the commuter?
New value proposition	`Increased likelihood to earn greater social recognition` (V_6)

Question	What benefit does the `increased likelihood to save money` provides to the focal entity, the commuter?
New value proposition	`Increased likelihood to provide additional support for household expenses` (V_7)

Question	What benefit does the `increased likelihood to reduce health problems` provides to the focal entity, the commuter?
New value proposition	`Increased likelihood to save money` (V_8)

3.3.2 Value Frame Selection and Population

The next step is to identify the value-frame most appropriate for each value proposition. Systematically analyzing the cause-and-effects underlying the value-proposition helps identify the precise change required to invoke the appreciation that the value-proposition expresses. As mentioned earlier, for already identified feature-value pairs, V_1-V_4 in Table 3, application of value-frames can be seen as checking their alignment, i.e. as a means to reason if the stated feature bring about the change that the associated value-proposition claims. For the newly surfaced value-propositions, V_5-V_8 in Table 4, it helps to identify the features required to realize these value expectations, and the entities required to implement these feature.



FCE : Focal Consumption Element, the Focal Entity in the consumer role
FSE : Focal Supply Element, the Focal Entity in the supplier role
FIE : Friction Introducing Element, the entity in the Environment in friction generating role
PRO : The role which resists the challenge faced by the FE
ANT : The role which aids the challenge faced by the FE

Figure 7 An illustration of the steps undertaken in the Force-dynamic analysis phase

Table 5 Mapping the outcome of the Force-dynamic analysis phase on to the information fields of the Value Frame

<type of> Value Frame		
Focal Consumption Element (FCE)	< challenge faced by the FCE providing the context (C) for the frame >	3.2
Focal Supplier Element (FSE)	< the force exerted by the FSE, f_{FSE} >	3.4
Friction Introducing Element (FIE)	< the force exerted by the FIE, f_{FIE} >	3.4
Service Enabling Element (SEE)	< the force exerted by SEE, f_{SEE} >	3.6
Feature (F_c)	< service-feature expressed as a proposition > *Inferred from* f_{SEE}	3.6
Value (V)	< service-value expressed as a proposition > *Inferred from* f_{SEE} *and* C	3.6

Figure 7 lays out the process that guides the Value Frame based inquiry. It shows the steps that the service designer should undertake to identify the additional information required to develop an initial idea into a service specification. The service designer begins by identifying the goal of the focal entity as the focal consumption element <FCE>, and the specific challenge that the value proposition seems to be addressing. This information populates the Context field of the frame structure. Next, the service designer should try to understand what role the focal entity as the focal supply element <FSE> plays towards this challenge. Is the <FSE> contributing to the making of the challenge, i.e. the focal entity by virtue of its behavior is obstructing the value that would have otherwise gotten created had there been no such challenge – the ANTAGONIST role, or is it resisting the challenge, i.e. the focal entity by virtue of her behavior is supporting the creation of the value that would have otherwise gotten created had there been no such challenge – the PROTAGONIST role? Identifying the entity from the environment <FIE> that introduces the friction in terms of offering resistance to the FSE helps to reconstruct the situation that underlies the value expression. Knowledge of the behavior that these entities exhibit in this situation is captured in the information fields of the frame structure, Table 2. Based on which of these two interacting entities, the <FSE> or the <FIE>, undertakes which of the two roles, the PRO or the ANT, helps to identify the value frame most suitable to model the situation. The selection of frame helps identify the service-enabling element, <SEE>. SEE is the role, which introduces the change that results in creating the desired value for the focal entity. This role can either be played by the focal entity itself – a situation of internal creating value, or by an entity in the environment – a situation of external change creating value. Table 1 lists the agent of change for each of these four Value Frames. This is a choice that the service designer has to make in proposing the service feature. Nevertheless, with all the information available about the dynamics of the interaction between the entities constituting the situation underlying the challenge, the decision of the service designer with regards to proposing the new feature will be an informed decision thereby much more likely to be yield positive results.

As an illustration, we applied the Value Frame inquiry method to extending an initial idea of the mixed-mode commute service. We took the value propositions V_1-V_4 in Table 3 and reasoned if the features that were proposed, as part of the initial specification, to realize these value propositions were indeed competent in doing so. Similarly, when applied to value propositions V_5-V_8 in Table 4 we identified new features, F_5-F_8 in Table 7. The new patient roles that the focal entity and other entities are required to undertake so as to implement the service are marked with red asterisk in Figure 8. Patient roles constitute the service system required to implement the service.

Table 6 Value Frames for mixed-mode commute service

Frame 1: Maturity	
Focal Consumption Element (FCE_1) :: Mixed-mode Commuter as an Employee	to get to office - the challenge of spending too much time in commute (C_1)
Focal Supplier Element (FSE_1) :: Mixed-mode Commuter as a Commuter	tendency to get to office on time
Friction Introducing Element (FIE_1) :: Co-commuter	reluctance to give up personal conveyance for office commute to reduce rush-hour traffic
Service Enabling Element (SEE_1) :: Mixed-mode Commuter as a Passenger	switching to public transport helps avoid traffic delays
Feature (F_{C1})	ability to avoid traffic delays
Value Proposition (V_1)	increased likelihood to get to office on time

Frame 2: Facilitation	
Focal Consumption Element (FCE_2) :: Mixed-mode Commuter as a Community Member	to comply with civic norms - the challenge of avoid causing injury to fellow passengers from the bike (C_2)
Focal Supply Element (FSE_2) :: Mixed-mode Commuter as a Co-passenger	reluctance to travel with baggage that causes inconvenience to fellow passengers
Friction Introducing Element (FIE_2) :: Bike Manufacturer as a Rigid-frame-bike Manufacturer	tendency to manufacture rigid-design bikes
Service Enabling Element (SEE_2) :: Bike Manufacturer as a foldable-frame-bike Manufacturer	Bike Manufacturer provide collapsible frame-design that helps avoid travel with oversized objects
Feature (F_{C2})	ability to avoid travel with oversized objects
Value Proposition (V_2)	increased likelihood to avoid inconvenience to fellow passengers

Frame 3: Maturity	
Focal Consumption Element (FCE_3) :: Mixed-mode Commuter as a Home Maker	to manage household budget - the challenge of generating additional support for household purchases (C_3)
Focal Supply Element (FSE_3) :: Mixed-mode Commuter as a Home Maker	tendency to increase income by cutting costs
Friction Introducing Element (FIE_3) :: Family	reluctance to reduce household demands
Service Enabling Element (SEE_3) :: Mixed-mode Commuter as a Payee	reduced cost of travel by train helps saving cost.
Feature (F_{C3})	ability to reduce cost of travel
Value Proposition (V_3)	increased likelihood to spend more on household purchases

Frame 4: Correction	
Focal Consumption Element (FCE_4) :: Mixed-mode Commuter as a Health Conscious Person	to stay healthy - the challenge of finding time to do physical workout (C_4)
Focal Supply Element (FSE_4) :: Mixed-mode Commuter as a Health Conscious Person	tendency to not allocate separate time for physical fitness
Friction Introducing Element (FIE_4) :: Doctors	reluctance to consider physically unfit people as healthy
Service Enabling Element (SEE_4) :: Mixed-mode Commuter as a Bike rider	riding the bike requires the adopter undertake physical workout that helps reduce health problems
Feature (F_{C4})	ability to perform physical workout
Value Proposition (V_4)	increased likelihood to reduce health problems

FRAME 5: ENFORCEMENT	
FOCAL CONSUMPTION ELEMENT (FCE_5) :: Mixed-mode Commuter as a Career Professional	to progress in career - the challenge of establishing oneself as a punctual employee (C_5)
FOCAL SUPPLY ELEMENT (FSE_5) :: Mixed-mode Commuter as a Career Professional	reluctance to publicize oneself's punctuality to work
FRICTION INTERACTING ELEMENT (FIE_5) :: Professional Social Network as a Publisher	tendency to request creating punctuality profile
SERVICE ENABLING ELEMENT (SEE_5) :: Professional Social Network as an Information Aggregator	provides an IT interface to automatically gather data from corporate networks on arrival and departure time of office workers
FEATURE (F_{C5})	helps enhance professional profile on the web
VALUE PROPOSITION (V_5)	possibility to fast track career progression

FRAME 6: FACILITATION	
FOCAL CONSUMPTION ELEMENT (FCE_6) :: Mixed-mode Commuter as a Socialite	to stay socially active (C_6) - the challenge of reduced social interaction during travel in public transport
FOCAL SUPPLY ELEMENT (FSE_6) :: Mixed-mode Commuter as a Co-passenger	reluctance to stay away from personal baggage
FRICTION INTRODUCING ELEMENT (FIE_6) :: Bike Manufacturer as a traditional designer	tendency to think of bike as a liability to carry
SERVICE ENABLING ELEMENT (SEE_6) :: Bike Manufacturer as an innovative designer	new design of bikes provides seating for two when folded
FEATURE (F_{C6})	helps provide next-to-each-other seating for friends
VALUE PROPOSITION (V_6)	potential to earn greater social recognition

FRAME 7: FACILITATION	
FOCAL CONSUMPTION ELEMENT (FCE_7) :: Mixed-mode Commuter as a Retail Customer	to increase buying capacity (C_7) - the challenge of meeting household needs
FOCAL SUPPLY ELEMENT (FSE_7) :: Mixed-mode Commuter as a Retail Customer	reluctance to spend beyond monthly budget
FRICTION INTRODUCING ELEMENT (FIE_7) :: Retail Award Program as a Loyalty Promoter	tendency to provide special offers to qualified customers
SERVICE ENABLING ELEMENT (SEE_7) :: Retail Award Program as a Fitness Promoter	include mixed-mode commuters in their award program for promoting lifestyle trendsetters footfall
FEATURE (F_{C7})	provides access to retail discounts
VALUE PROPOSITION (V_7)	potential to increase household purchases

FRAME 8: MATURITY	
FOCAL CONSUMPTION ELEMENT (FCE_8) :: Mixed-mode Commuter as a Healthcare Insuree	to reduce healthcare costs - the challenge of high health care costs (C_8)
FOCAL SUPPLY ELEMENT (FSE_8) :: Mixed-mode Commuter as a Healthcare Insuree	pay higher insurance premiums due to lack of evidence of using bike
FRICTION INTRODUCING ELEMENT (FIE_8) :: Insurance Company	reluctance to reduce insurance premiums for people with no evidence to support claims of healthy lifestyle
SERVICE ENABLING ELEMENT (SEE_8) :: Mixed-mode Commuter as an Information Generator	lower insurance premiums by providing insurance companies easy access to verifiable data on user's physical workout
FEATURE (F_{C8})	helps provide easy access to verifiable data on physical workout
VALUE PROPOSITION (V_8)	potential to save money

Table 7 A Value Frame based extension of the feature-value matrix for the extended version of the mixed-mode commute service

FOCAL ENTITY		Focal Consumtpion Element (FCE)	FCE$_1$: Focal Entity as an **Employee**	FCE$_2$: Focal Entity as a **Community Member**	FCE$_3$: Focal Entity as a **Home Maker**	FCE$_4$: Focal Entity as a **Health Conscious Person**	FCE$_5$: Focal Entity as a **Career Professional**	FCE$_6$: Focal Entity as a **Socialite**	FCE$_7$: Focal Entity as a **Retail Customer**	FCE$_8$: Focal Entity as a **Healthcare Insuree**
		Features (F$_c$) / Value Proposition (V)	V$_1$: Increased likelihood to get to office on time	V$_2$: Increased likelihood to avoid inconvenience to fellow passengers	V$_3$: Increased likelihood to spend more on household purchases	V$_4$: Increased likelihood to reduce health problems	V$_5$: Increased likelihood to fast-track career progression	V$_6$: Increased likelihood to earn greater social recognition	V$_7$: Increased likelihood of additional support for household expenses	V$_8$: Increased likelihood to save money
	Initial features	F$_{C1}$: Ability to avoid traffic delays	to reduce commute time							
	Initial features	F$_{C2}$: Ability to avoid travel with oversized objects		to avoid inconvenience to fellow passengers						
	Initial features	F$_{C3}$: Ability to reduce cost of travel			to generate additional funds					
	Initial features	F$_{C4}$: Ability to perform physical workout				to find time for physical workout				
	Newly discovered features	F$_{C5}$: Ability to enhance professional profile on the web					to share punctiality credentials			
	Newly discovered features	F$_{C6}$: Ability to provide next-to-each-other seating for friends						tomaintain social interaction during commute		
	Newly discovered features	F$_{C7}$: Ability to access retail discounts							to meet household needs	
	Newly discovered features	F$_{C8}$: Ability to access verifiable data on physical workout								to meet health care costs

The shaded region of the matrix highlights the new feature-value tuples that constitute the extended version of the mixed-mode commute service

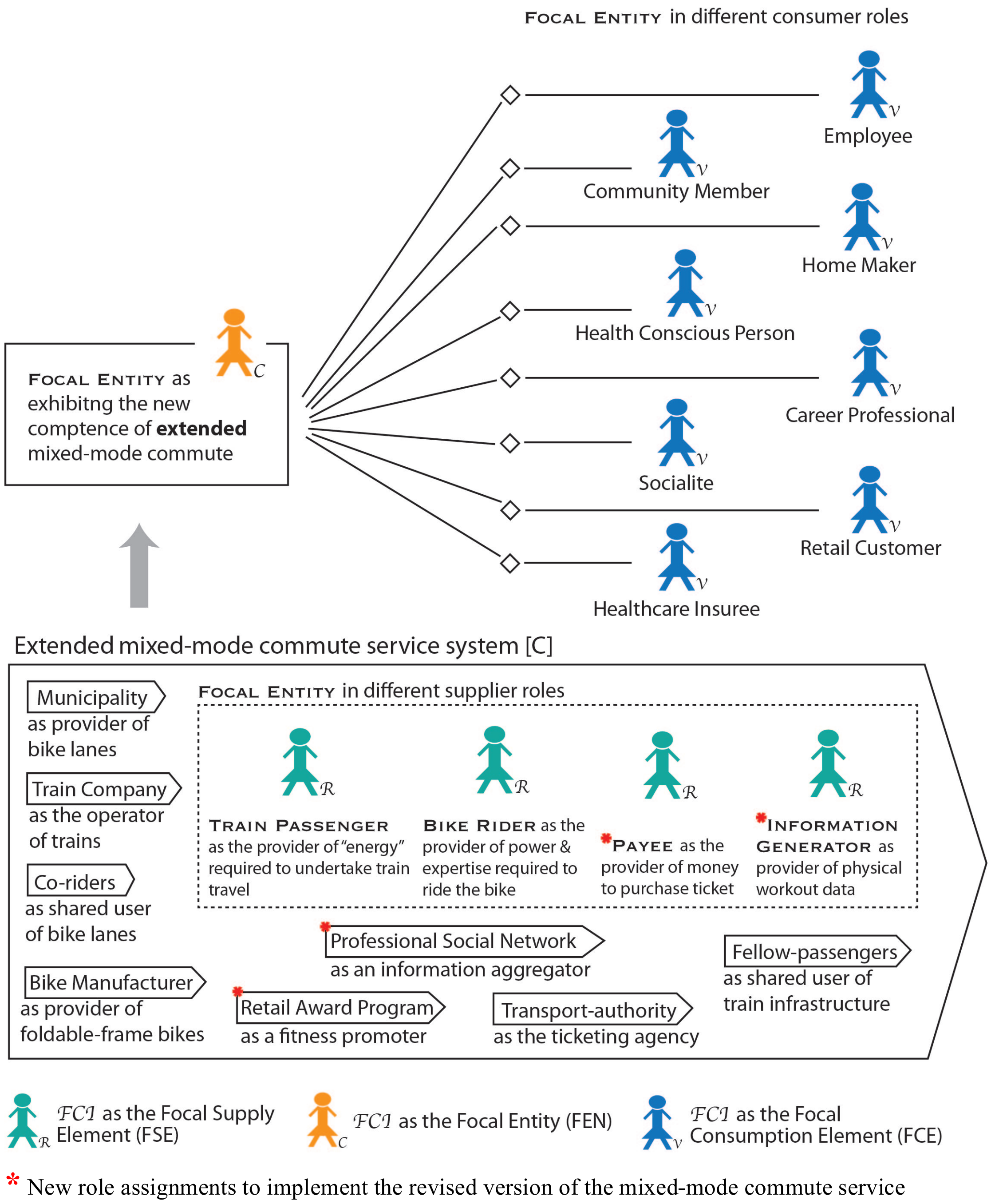


Figure 8 An extended version of the mixed-mode commute service

3.3.3 Discussion

The Value Frame method helps the modeler acknowledge the various facets of an entity's interaction with the service. A closer look at the constituent fields of the Value Frame structure reveals that for each value proposition three roles are identified. From a service system specification point of view, two roles are external to it and one role is internal to it. For example, consider the Frame 5 in Table 6. The three roles here are: the Focal Entity as the commuter, as a Career Professional, the Professional Social Network as a Publisher of information on the web, and the Professional Social Network as an Aggregator of information, which links with the corporate IT infrastructure to automatically gather arrival and departure times of the Adopter so that the same can be published proactively on the Adopter's social network account. This inside outside view is important, as conventional modeling techniques do not take cognizance of the different situations that underlie different references to the same entity. Here one reference to the Professional Social Network is in its roles as a Publisher, and the other in its roles as an Information aggregator. Being aware of these different aspects of the Professional Social Network will help the service designer specify precisely what kind partnership is required from the network, say an operation level agreement (OLA) that suggests that users workplace mobility data will be available no later than 12 hours of the actual event and that as an information aggregator it is only responsible to make this data available in the account of the adopter. It is the Adopter who will have the control on when to publish this data. As a certified information gatherer, the network will have to keep the trace of its collection for a period of 2 years. Such detailed arrangements can only be spelled out if the precise role in which the partner has to be engaged is known. **Error! Reference source not found.** shows these roles undertaken by the network as inside and outside of the mixed mode commute service system. The role outside is not indicated in this figure. It is only shown as 'Professional social network' rather than 'Professional social network as a publisher'. This is primarily to keep things simple, as the main use of roles is to work out the details of the contract. And the contracts are worked out for the roles inside the service system. Nevertheless, the reference to Professional social network while it is outside the service system is actually a reference to its publisher role.

It is also important to note that value-frames encourage the designer to consider multiple viewpoints while selecting the most appropriate frame to narrate the underlying situation. Here we only show one point of view, i.e. only one frame for a given value proposition. This is primarily due to the fact that the focus of this paper has been to illustrate the Value Frame modeling apparatus and the process that the service designer needs to follow to conduct a Value Frame based inquiry. An ideal inquiry mode will be one where a service designer can be assisted by a team of four people each trying to model the cause-and-effect underlying a value proposition in accordance with one of the Value Frame types. This will result in having four different views, i.e. four candidates situations, for the same value proposition. The service designer can then select the one that is preferred by the adopter.

In future we plan to make experiments on the use of Value Frames with team sizes in multiples of four. This will help us study the process of viewpoint generation, and if there is a bias in humans towards any specific way of modeling problem situations. For instance, is there some inherent inclination towards one type of Value Frame? Nevertheless, to do this will require some IT-support in managing the huge amount of data (instances of frame) that will be generated.

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4. The Case of Storage and Distribution of Food-grains in India

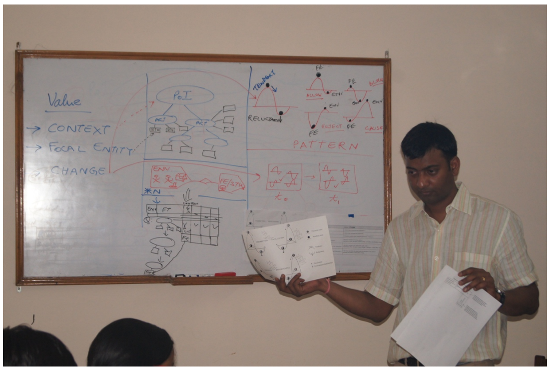
4.1 Problem Description

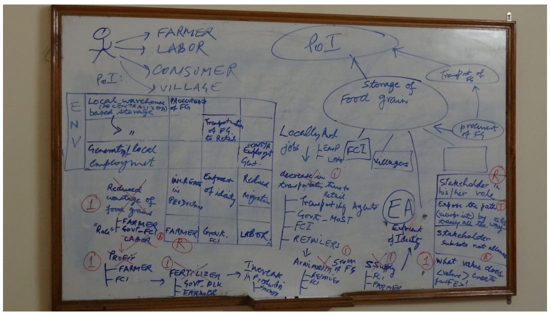
This case study is about the storage and distribution of food-grains in India. Food-grain storage is currently a hotly debated public-policy issue in India [1]. India is self-sufficient in food production. It produces enough food grain to feed its 1.2 billion population comfortably and still have surplus to sell internationally. Nonetheless, inefficiencies in food-grain storage and distribution have resulted in almost 200 million food-insecure people in India. Two important government programs are relevant in ensuring the food security of the citizens – FCI and PDS. FCI (Food Corporation of India) is the agency, which procures food-grains from farmers and stores it in warehouses for distribution. PDS (Public Distribution System) is the agency, which receives the food-grains from the FCI warehouses and sells them at subsidized price to the common man. FCI follows a centralized storage policy, storing food-grains at select strategic locations across the country. As a result, FCI warehouses often fall short on infrastructure required to store such huge volumes of food-grains. Further, their far-off location results in significant transportation costs, both while procurement and distribution. To overcome these shortcomings in food-grain storage and distribution, various alternative policies are being discussed. One such policy prescription promotes the idea of rural warehouse scheme [2], [3]. The basic idea here is to adopt a distributed storage approach for food-grains. And use the funds to build these new warehouses from another government program, NREGA (National Rural Employment Guarantee Act) [4], which guarantees 100 days of gainful rural employment every year – primarily, unskilled construction jobs. The primary purpose of this study was to help an NGO (a non-governmental organization) develop their idea of ***community owned food-grain storage facilities***, as a project proposal for consideration by the FCI management committee.

4.2 Workshop Setup

This study is an outcome of several workshops that were conducted with various government and non-government organizations in India. It was conducted in partnership with an NGO engaged in the field of development projects and their social-impact assessment. Workshops participants included affiliates of the NGO, representatives from the government, and other civil society organizations representing farmers and village communities. A total of 9 participants were present during these workshops. In terms of their qualifications, all representatives were graduates, and above, in disciplines like commerce, economics, management sciences, and law. 6 out of the 9 participants had extensive experience in carrying out field level interventions in both urban and rural parts of India. 3 participants had exposure in policy analysis and formulation at the government level. They had first hand information about the governance structure and it's functioning with regards to the implementation of the different welfare schemes of the government. Here are some pictures from one such workshop that was conducted at the participating NGO's premises in the city of Lucknow, India.





4.3 TRIBE Model Development

A. The Informed Imagination Phase

The NGO's proposal to solve the problem of food-grain storage and distribution in India was to engage with the rural communities and develop a decentralized community owned network of food-grain storage facilities that can be partially funded by the government's NREGA program. NREGA is aimed at providing employment for unskilled rural workers locally. To ensure that the proposed food-grain storage solution is eligible for funding from NREGA, the NGO suggested that the rural storage facilities be constructed using designs, which the local communities were knowledgeable about. The nativist model of the food-grain storage and distribution problem solution, as narrated by the NGO, is presented in Figure 1 (Systems Layout view), and Table 1 (Feature-Value Matrix view).

The initial description provided by the NGO identified four entities that they thought would benefit from the proposed problem solution. These are – the Citizen, who purchases food-grains,

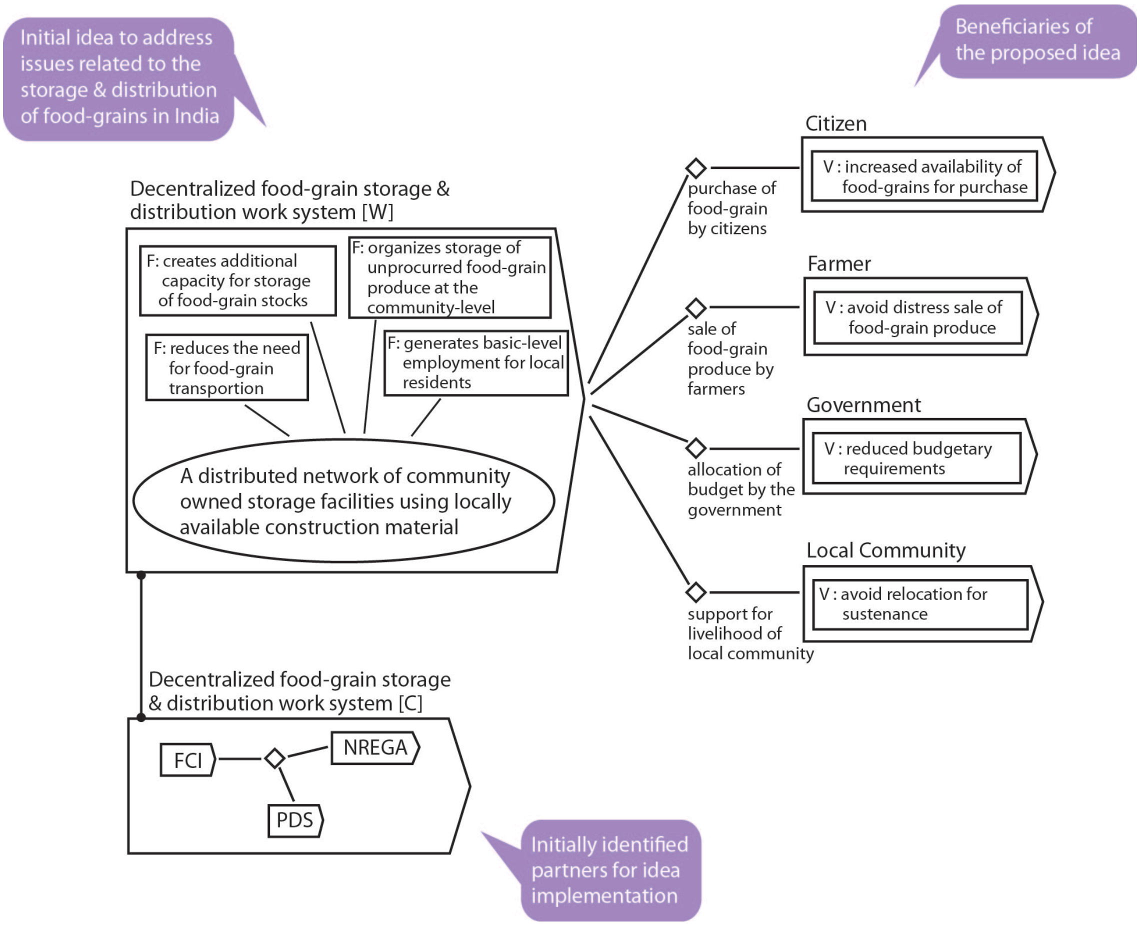


Figure 1 Systems Layout view of the Nativist Model of food-grain storage and distribution

will benefit from the increased availability of food-grains in the government's food-grain distribution system; the Farmer, who has to sell his food-grain produce, will benefit by not being forced to sell the produce immediately due to lack of storage facility; the Government, which can now save money due to reduced expenditure by FCI; and the Local Community, which will not have to relocate due to lack of employment opportunities locally. The three entities that were seen as working together to implement the proposed solution are FCI, NREGA and PDS. The Systems Layout view of the problem solution shows these entities as the constituents of the work system that implements the proposed solution. The Feature-Value Matrix view organizes the features and value of the proposed solution in a matrix representation.

Table 1 Feature-Value Matrix view of the Nativist Model of food-grain storage and distribution

		Citizen	**Farmer**	**Government**	**Local Community**
	Features / Value Proposition	V_1:inreased availability of food-grains for purchase by citizens	V_2: avoids distress sale of food-grain produce by farmers	V_3: reduced budgetary requirements from the government	V_4: avoids relocation by local communities for sustenance purposes
Decentralized food-grain storage & distribution Work System [W]	F_1: creates additional capacity for storage of food-grain stocks	food-grain purchase by citizens			
	F_2: organizes storage of unprocurred food-grain produce at the community-level		sale of food-grain by farmers		
	F_3: reduces the need for food-grain transportation			allocation of budget by the government	
	F_4: generates basic-level employment for local residents				support for livelihood of local communities

As mentioned earlier, the purpose of inquiry here was the NGO's desire to develop a project proposal based on their idea of food-grain storage and distribution management. Since the project proposal was aimed at providing suggestions to FCI to re-organize itself in a more effective food-grain management agency, it was natural for the NGO to be interested in understanding what benefits will their proposed idea bring to FCI. From the modeling perspective, this helped set the **Focal Entity as FCI**.

To derive a TRIBE model, with FCI as the Focal Entity, from the nativist model of food-grain storage and distribution, the workshop participants were asked to focus on the four different situations that were reported in the nativist model – <<the situation of food-grain purchase by citizens>>, <<the situation of sale of food-grains by farmers>>, <<the situation of allocation of budget by the government>>, and <<the situation of support for livelihood of local communities>>. They were specifically asked to reflect on the semantics of FCI's occurrence in these situations. To help them in this process, they were first asked to elaborate on the role that the beneficiary entities, i.e. the citizen, the farmer, the government, and the local community, were playing in this situation. Figure 2 documents the interaction that helped surface the desired information.

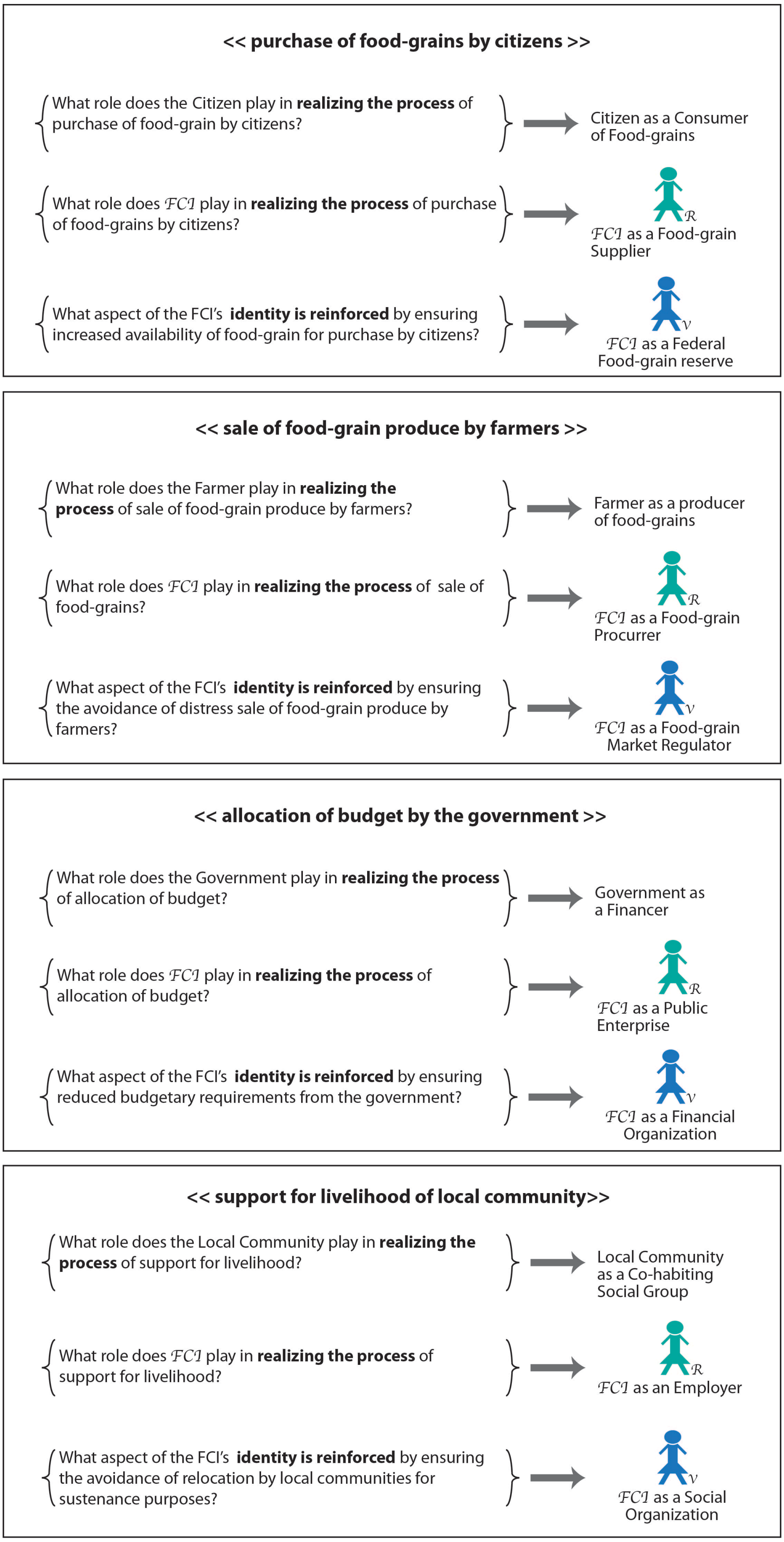


Figure 2 Critical reflections on the FCI's occurrence in situations known a-priori

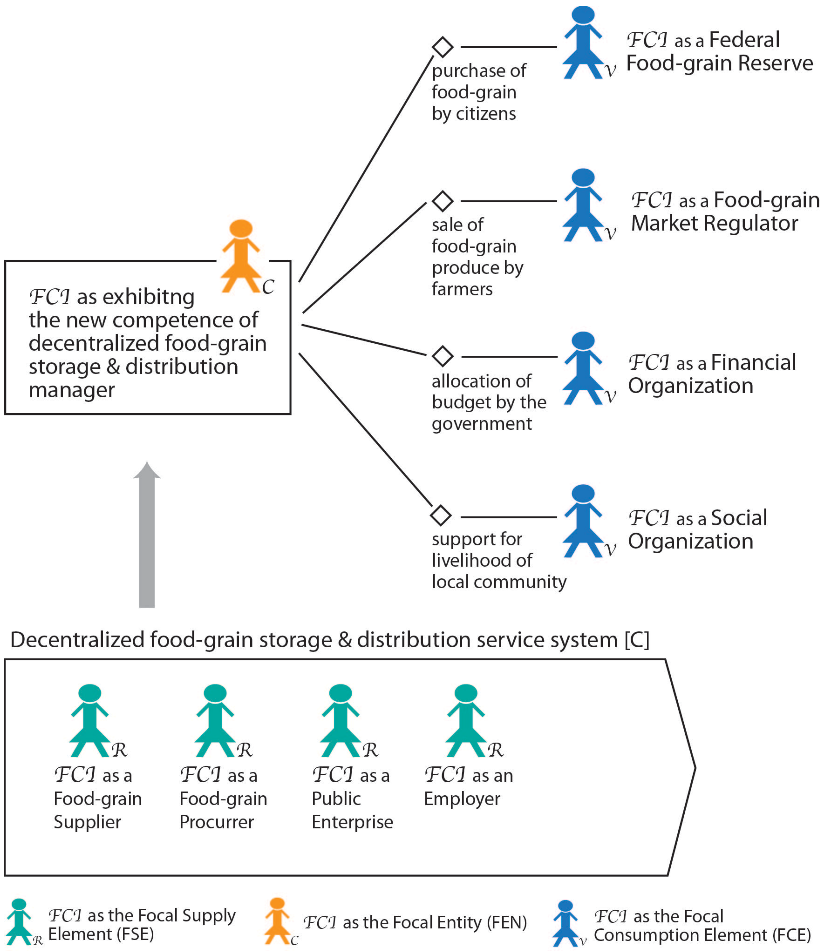


Figure 3 Systems Layout view of the initial TRIBE model

Based on the information surfaced through the interactions reported in Figure 2, the following TRIBE model (System Layout view) was developed, Figure 3. An alert reader will notice that there is no mention of any element other than the Focal Supply Elements as contributing to the implementation of the proposed service. This is not to suggest that the only supplier required to implement this service is the Focal Entity in different supplier roles. In this first phase of the TRIBE inquiry process, the focus is squarely on surfacing the three different aspects of the interaction of the Focal Entity with the proposed service. More supply elements will be added during the subsequent phases of the TRIBE inquiry process.

Next, we derive a new feature-value matrix based on the features and value mentioned in the nativist model. The idea is to use a vocabulary and a point-of-view that is aligned with the elements identified in the TRIBE model. Table 2 documents the interactions that helped surface the updated features and value. The key here was to ask the participants to respond in terms of cause and effect statements. Cause predicates were interpreted as features and the effect predicates were interpreted as value. The resulting Feature-Value Matrix for the TRIBE model is documented in the integrated view depicted in Figure 4.

Table 2 Interactions to update the nativist view of initial feature/value propositions

How does the ability to `create additional capacity for storage of food-grain stocks` helps a `Federal Food-grain Reserve` influence the activity of `food-grain purchase by citizens`?
<effect> `Increased likelihood of ensuring security of food-grain supply` by being able to <cause> `maintain sufficient quantities of food-grain reserves`

How does the ability to `organize storage of unprocured food-grain produce at the community-level` helps a `Food-grain Market Regulator` influence the activity of `sale of food-grain by farmers`?
<effect> `Increased likelihood of ensuring fair conditions for trade of food-grains` by being able to <cause> `plug systemic shortcommings in community storage infrastructure`

How does the ability to `reduce the need for food-grain transportation` helps a `Financial Organization` influence the activity of `allocation of budget by the government`?
<effect> `Increased likelihood of containing the organization's budget deficit` by being able to <cause> `reduce cost of operations`

How does the ability to `generate basic-level employment for local residents` helps a `Social Organization` influence the activity of `support for livelihood of local communities`?
<effect>`Increased likelihood of promoting social harmony` by being able to <cause> `provide local opportunities of earning livelihood`

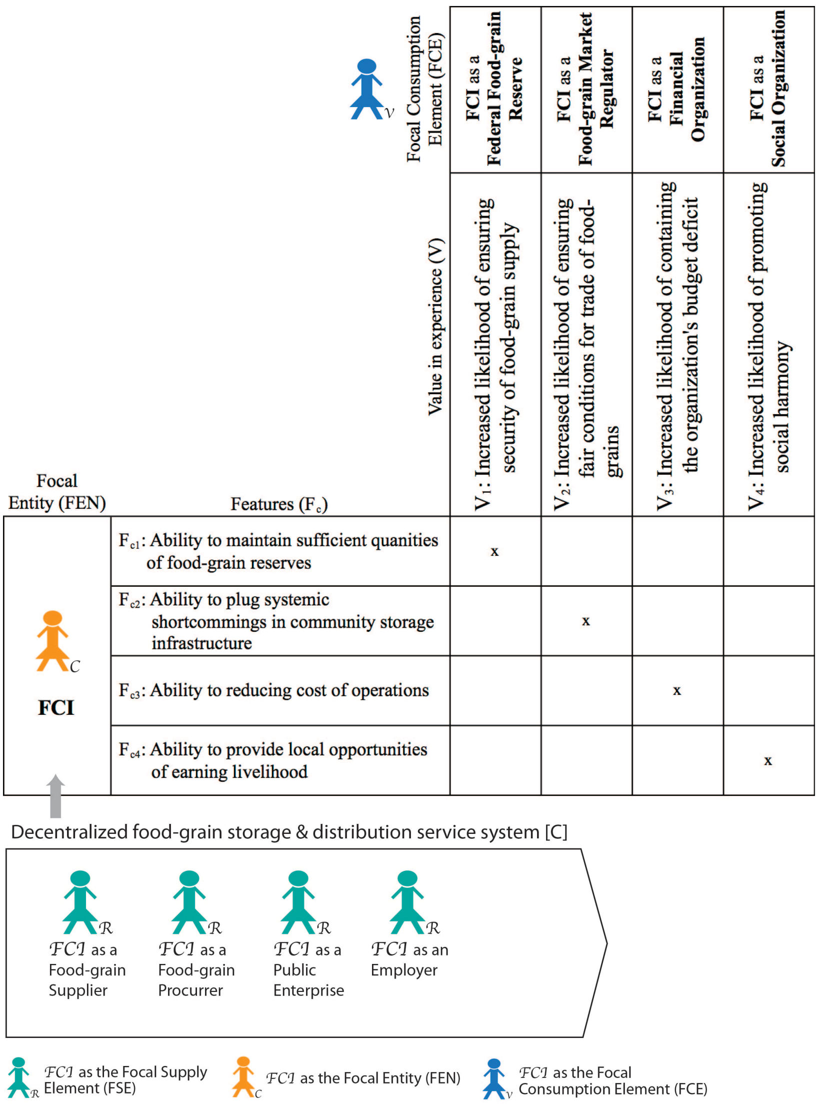


Figure 4 An integrated view of the initial TRIBE model

B. The Value Articulation Phase

The objective of this phase is to surface new value propositions, which otherwise are not readily available from the situations imagined during the initial phase. This is not to suggest that new situations, if they come to fore later should not be admitted. The initial phase of informed imagination should be seen as a continuously alive phase, and so are all the phases of the TRIBE inquiry process. The inquiry does not end till all the information available in the earlier phase has been processed in the later phases. In this phase, the focus is to augment the already identified value propositions with affective expressions of the Focal Entity's experience of the service. The belief is that such embodied expressions very often lead to unearthing new situations which otherwise would have been hard to surface, as they are comparatively far off from the basic level categories associated with the problem solution.

To surface these affective expressions of experience, we treat the Focal Entity as an embodied entity. For example, we do not address the Focal Entity in a specific role, rather as a unified entity letting the respondent freely associate with any feeling that she might be experiencing. Table 3 documents the interactions that helped surface these additional value propositions.

Table 3 Interactions to surface affective expressions of FCI's experience of the service

What change does FCI experience by virtue of it gaining the ability to `procure food-grains in sufficient quantities?`

- `Reduced reservation in specifying food-grain export quotas`

  What benefit does this change create and for whom?
  - `Helps Private Export Companies increase export of food-grains`

What change does FCI experience by virtue of it gaining the ability to `plug systemic shortcommings in community storage infrastructure?`

- `Additional responsibility of ensuring quality control of community administered storage facilities`

  What benefit does this change create and for whom?
  - `Helps Local Communities monitor the quality of food-grains in community storage`

What change does FCI experience by virtue of it gaining the ability to `reducing cost of operations?`

- `Increased flexibility to redeploy resources to build core competence`

  What benefit does this change create and for whom?
  - `Helps the Government integrate all material-based welfare delivery schemes`

What change does FCI experience by virtue of it gaining the ability to `provide local opportunities of earning livelihood?`

- `Enhanced trust levels with the local community`

  What benefit does this change create and for whom?
  - `Helps Local Communities develop the local economy`

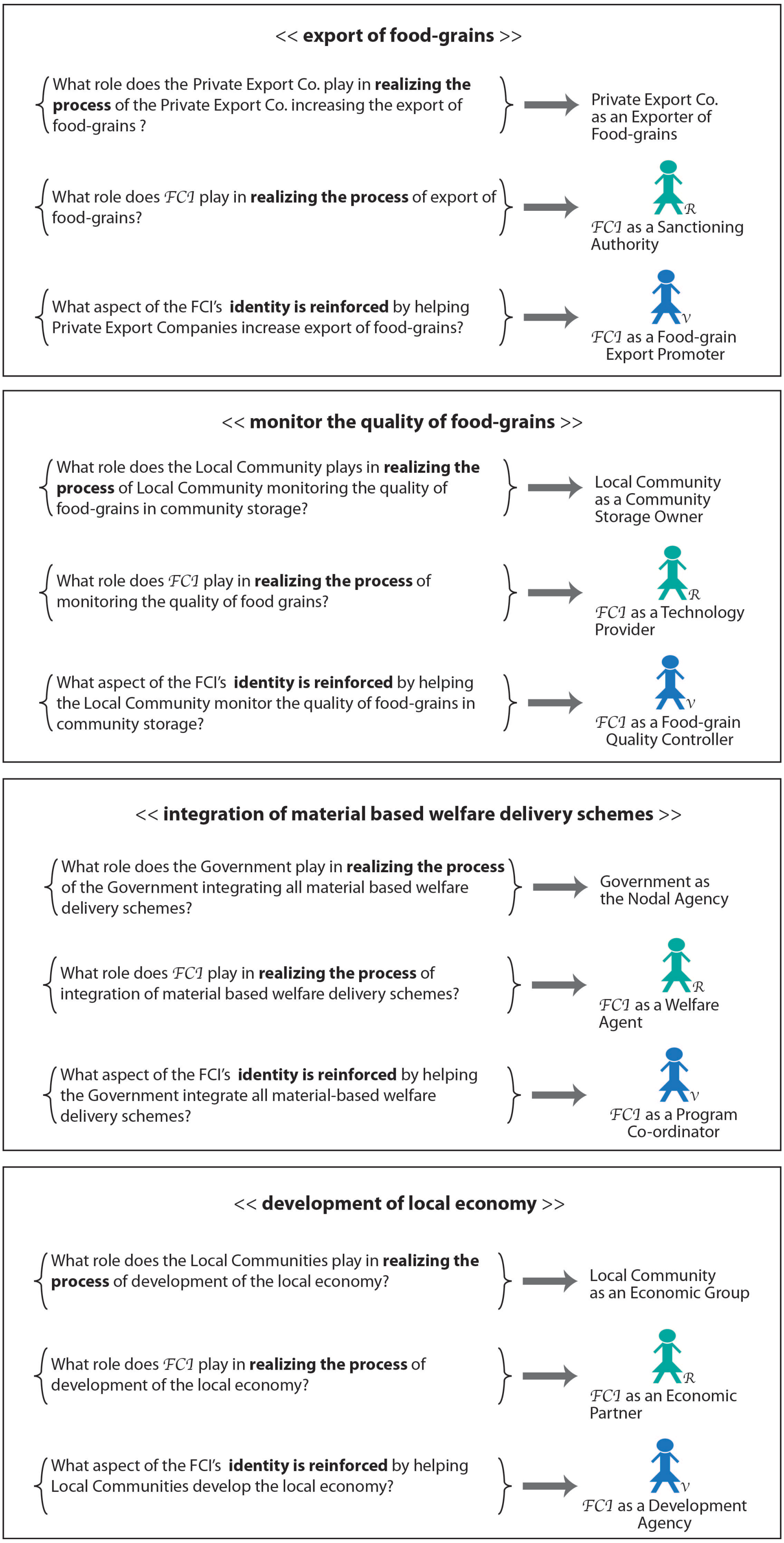


Figure 5 Critical reflections on the FCI's occurrence in newly identified situations

Figure 5 documents the interaction aimed at revealing the situations underlying the value expressions surfaced in Table 3. The updated TRIBE model, in an integrated form – Service System from the System Layout view and the matrix from the Feature-Value view, is depicted in Figure 6.

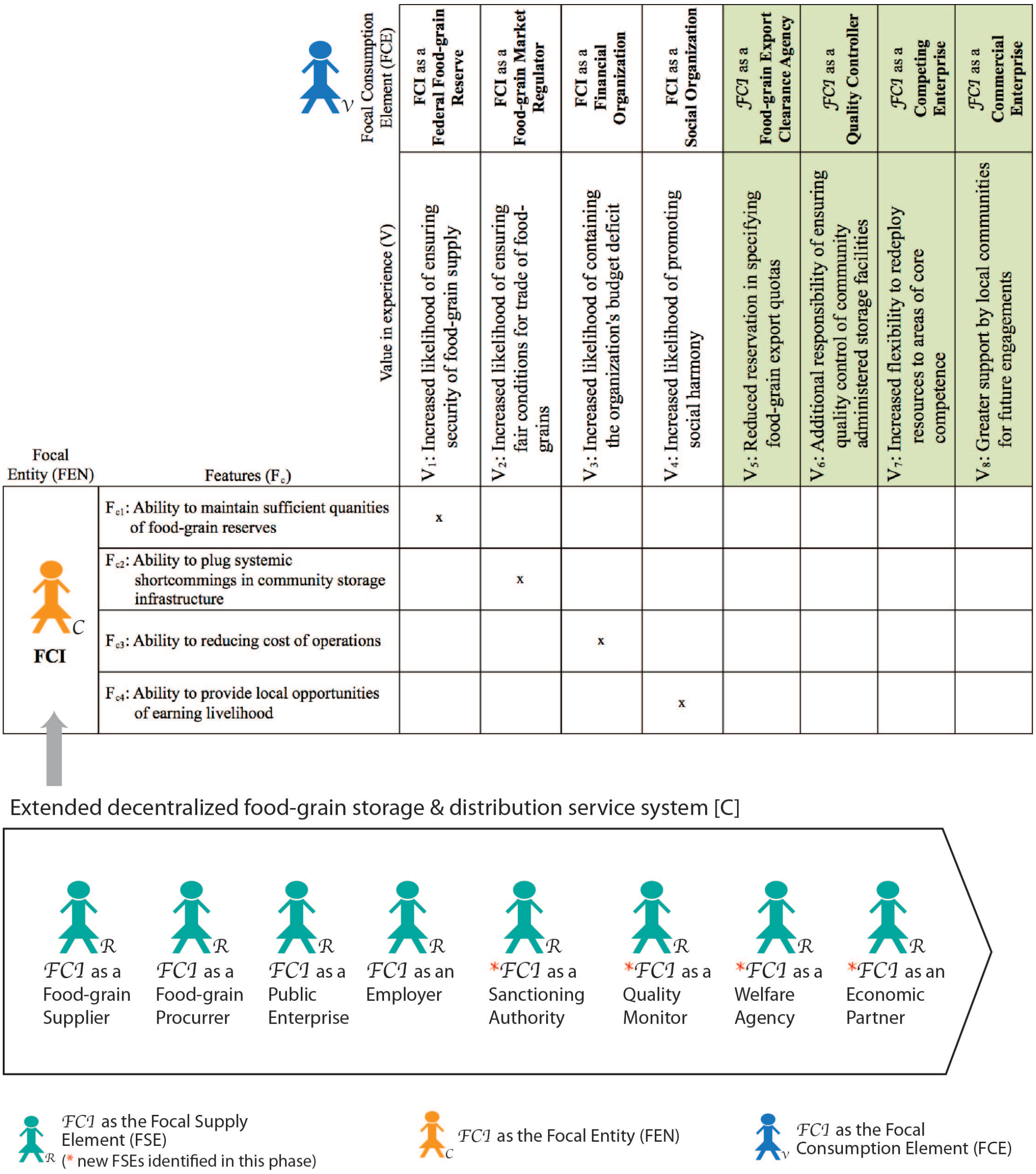


Figure 6 An integrated view of the extended TRIBE model

C. The Force-dynamic Analysis Phase

In this phase, the objective is to identify the causal basis of value propositions reported in the extended TRIBE model. The Force-dynamic analysis ensures that the causal reasoning is not limited behaviorally observed state changes. It first tries to identify the feeling that the change reported in the value proposition invokes at the Focal Entity. Towards this end, TRIBE uses the four-force dynamic patterns proposed in Value Frames. Mapping the feelings of the Focal Entity to Value Frames helps the TRIBE service designer surface the causal organization of the situations underlying these feelings.

Table 4 documents the interactions aimed at identifying which of the four Value Frames is representative of the feelings invoked at the Focal Entity. It is important to note that there is no one-to-one mapping between the feeling invoked and the value frame. A feeling could be a synthesis of more than one Value Frame. For instance one could feel Mature, Corrected, Facilitated and Enforced at the same time. To keep the analysis simple, in this case study we restricted to modeling only the most prominent Value Frame associated with a feeling.

Table 4 Interactions to identify the Value Frames that best capture the feeling invoked at the FCI

What feeling does this experience invoke within FCI?	Does it invoke the feeling of being CORRECTED?	Does it invoke the feeling of being FACILITATED?	Does it invoke the feeling of getting MATURE?	Does it invoke the feeling of being ENFORCED?
	A feeling of undergoing some internal change that helps align with some well-meaning external expectation	A feeling of acknowledgement of some external change that makes it easier to achieve some internal goal	A feeling of undergoing some internal change that helps overcome some external resistance	A feeling of acknowledgement of some external change that helps overcome some internal resistance
V_1: Increased likelihood of ensuring security of food-grain supply		a sense of facilitation		
V_2: Increased likelihood of ensuring fair conditions for trade of food-grains	a sense of correction			
V_3: Increased likelihood of containing the organization's budget deficit	a sense of correction			
V_4: Increased likelihood of promoting social harmony		a sense of facilitation		
V_5: Reduced reservation in specifying food-grain export quotas		a sense of facilitation		
V_6: Additional responsibility of ensuring quality control of thrid party administered storage facilities				a sense of enforcement
V_7: Increased flexibility to redeploy resources to build core competence			a sense of maturity	
V_8: Enhanced trust levels with the local community			a sense of maturity	

Table 5 documents the information surfaced by virtue of the interaction guided by the interaction laid out in Table 4.

Table 5 Value Frame information structures exposing the causal organization of value propositions

Frame 1: Facilitation	
Focal Supplier Element (FSE$_1$) FCI as a Food-grain Supplier	<norm> FCI requires additional funds to increase storage capacity
Friction Introducing Element (FIE$_1$) Government as a Financer	<cause_1> Government lacks resources <effect_1> unable to meet FCI budget requirements
Context (C$_1$)	<norm+effect_1> to increase food-grain storage capacity
Service Enabling Element (SEE$_1$) Local Community as Community Storage Owner	<cause_2> local community willing to undertake responsibility of managing community warehouse <effect_vert> helping FCI maintain sufficient quantities of food-grain reserves <effect_horz> require assistance from FCI in monitoring the quality of food-grains in community stores
Feature (F$_{C1}$)	<effect_vert> ability to maintain sufficient quanities of food-grain reserves
Value (V$_1$)	<norm+effect_vert> increased likelihood of ensuring security of food-grain supply

Frame 2: Correction	
Focal Supplier Element (FSE$_2$) FCI as a Food-grain Procurrer	<cause_1> limited storage capacity at FCI leads to <effect_1> FCI procurement open for a restricted duration post-harvest
Friction Introducing Element (FIE$_2$) Farmer as producer of food-grains	<norm> Farmer not willing to sell produce below minimum support price (i.e. below cost of produce + basic incentive)
Context (C$_2$)	<norm+effect_1> inability to ensure minimum support price for all food-grain transactions (beyond just self procurement by FCI)
Service Enabling Element (SEE$_2$) FCI as a year-round procurrer	<cause_2> FCI opening its procurement period all year round will <effect_vert> ensure minimum-support-price guidance for all market transactions all time of the year <effect_horz> requires Farmers to participate in community storage to augment FCI storage capacity
Feature (F$_{C2}$)	<effect_vert> ability to provide minimum-support-price guidance for all market transactions all time of the year
Value (V$_2$)	<norm+effect_vert> increased likelihood of ensuring fair conditions for trade of food-grains

Frame 3: Correction	
Focal Supplier Element (FSE$_3$) FCI as a Food-grain supplier	<cause_1> FCI's centralized and big warehouse approach to food-grain storage results <effect_1> in high cost of food-grain transportation
Friction Introducing Element (FIE$_3$) Government as a Financer	<norm> Government encourages public enterprises to reduce budget requirements
Context (C$_3$)	<norm+effect_1> to reduce budgetary requirements for financing operations
Service Enabling Element (SEE$_3$) FCI as a Joint Partner of community storage facilities	<cause_2> FCI partnering with local communities to support a community warehouse based distributed network of food-grain storage will <effect_vert> reduce the food-grain transportion costs <effect_horz> requires Government to allow a third-party ownership model in the storage of food-grain storage facilities
Feature (F$_{C3}$)	<effect_vert> ability to reduce the costs of food-grain transportation
Value (V$_3$)	<norm+effect_vert> increased likelihood of containing the organization's budget deficit

Frame 4: Facilitation	
Focal Supplier Element (FSE_4) FCI as an Employer	<norm> requires additional funds to construct community storage facilities
Friction Introducing Element (FIE_4) Government as a Financer	<cause_1> unable to meet FCI budget requirements due to lack of resources <effect_1>
Context (C_4)	<norm+effect_1> avoid disruption to family living
Service Enabling Element (SEE_4) NREGA as Financer of unskilled work-force	<cause_2> NREGA sponsors sponsoring unskilled construction work locally leading to <effect_vert> provisions for FCI to provide local opportunities of earning livelihood <effect_horz> requires FCI to employ locally implementable designs for constructing community storage facilities
Feature (F_{C4})	<effect_vert> Ability to provide local opportunities of earning livelihood
Value (V_4)	<norm+effect_vert> Increased likelihood of promoting social harmony

Frame 5: Facilitation	
Focal Supplier Element (FSE_5) FCI as a Sanctioning Authority	<norm> makes decision based on significantly reliable market information
Friction Introducing Element (FIE_5) Private Traders of food-grain	<cause_1> acquire marketable surplus for cheap from farmers and have <effect_1> little incentive to divulge holding information
Context (C_5)	<norm+effect_1> to gather information on marketable surplus food-grains stocks
Service Enabling Element (SEE_5) Farmers as user of community storage	<cause_2> willing to store marketable surplus in shared (government supervised, community owned) community storages <effect_vert> providing FCI access to real-time information on marketable surplus <effect_horz> require assurance from FCI on protection from lower than minimum support price
Feature (F_{C5})	<effect_vert> ability to provide access to real-time information on marketable surplus
Value (V_5)	<norm+effect_vert> reduced reservation in specifying food-grain export quotas

Frame 5': Enforcement	
Focal Supplier Element ($FSE_{5'}$) FCI as a Food-grain Procurrer	<norm> procurement limited to the duration it takes to fill storage capacity
Friction Introducing Element ($FIE_{5'}$) Farmer as an instant seller of farm produce	<cause_1> not confident (risk averse) about his ability to keep food-grains in good quality <effect_1> distress sale
Context ($C_{5'}$)	<norm+effect_1> to MSP available for limited duration in a year
Service Enabling Element ($SEE_{5'}$) Farmer as user of community storage (price-risk averse seller of food-grains)	<cause_2> Lack of confidence that the market will honor MSP after FCI's procurement period is over, hence <effect_horz> requires FCI to maintain year round procurement <effect_vert> requires FCI to keep offloading food-grain stocks to be able to support year-round procurement
Feature ($F_{C5'}=F_{C2}$)	<effect_horz> Ability to be a year-round procurrer
Value Proposition ($V_{E5'}=V_{E2}$)	<norm+effect_horz> MSP available all year round

Frame 6: Enforcement	
Focal Supplier Element (FSE_6) FCI as a Food-grain Quality Monitor	<norm> exposure limited to human inspection based monitoring of food-grain quality
Friction Introducing Element (FIE_6) Government as a financer	<cause_1> human inspection based monitoring inefficient and hence <effect_1> discouraged
Context (C_6)	<norm+effect_1> to ensure quality control of third-party administered storage facilities
Service Enabling Element (SEE_6) Local community as risk averse manager of community storage facilities	<cause_2> Lack of confidence of the local community to maintain the quality of food-grains in community storage facilities <effect_horz> motivates local communities to grant FCI supervisory access to community storage facilties <effect_vert> requires assistance from FCI in ensuring quality control of third party administered storage facilities
Feature (F_{C5})	<effect_horz> Ability to have supervisory access to community storage facilities
Value (V_6)	<norm+effect_horz> Additional responsibility of ensuring quality control of third party administered storage facilities

Frame 7: Maturity	
Focal Supplier Element (FSE_7) FCI as a Food-grain supply-chain Manager	<cause_1> focus squarely on the operational management of food-grains supply <effect_1> led to the image that FCI expertise restricted to food-grain specific supply chain management
Friction Introducing Element (FIE_7) Other Welfare Agencies	<norm> new entrants equipped with industry best practices provide stiff competition in acquiring new welfare delivery business
Context (C_7)	<norm+effect_1> to compete with other welfare delivery agencies
Service Enabling Element (SEE_7) FCI as a Supply-chain Knowledge Center	<cause_2> focus on generalizing learnings from food-grain specific supply-chain management leads to <effect_horz> FCI becoming a competence center for supply-chain knowledge <effect_vert> Other welfare agencies also gain access to supply-chain knowledge base
Feature (F_{C5})	<effect_horz> Ability to become a competence center for supply-chain knowledge
Value (V_7)	<norm+effect_horz> increased likelihood to be regarded as the competent authority for all types of supply chain for welfare programs

Frame 8: Maturity	
Focal Supplier Element (FSE_8) FCI as an Economic Partner	<cause_1> engagement limited to interactions required to realize the core business <effect_1> superficial understanding of the local community
Friction Introducing Element (FIE_8) Local Community as owner of scarce resources	<norm> communities skeptical of engagement due to fear of being exploited
Context (C_8)	<norm+effect_1> to promote engagement with the local community
Service Enabling Element (SEE_8) FCI as a community programs conceptualizer	<cause_2> focus on community programs beyond trading relations helps <effect_horz> devise innovative programs for encouraging community engagement <effect_vert> Local Community may get used to being courted and not take initiatives on their own
Feature (F_{C5})	<effect_horz> Ability to devise innovative programs for encouraging community engagement
Value (V_8)	<norm+effect_horz> Increased likelihood of support from local communities for future engagements

Following the mappings depicted in the earlier chapters, the information elements of the Value Frames from Table 5 are used to update the TRIBE model. An integrated view of the final TRIBE model is depicted in Figure 7.

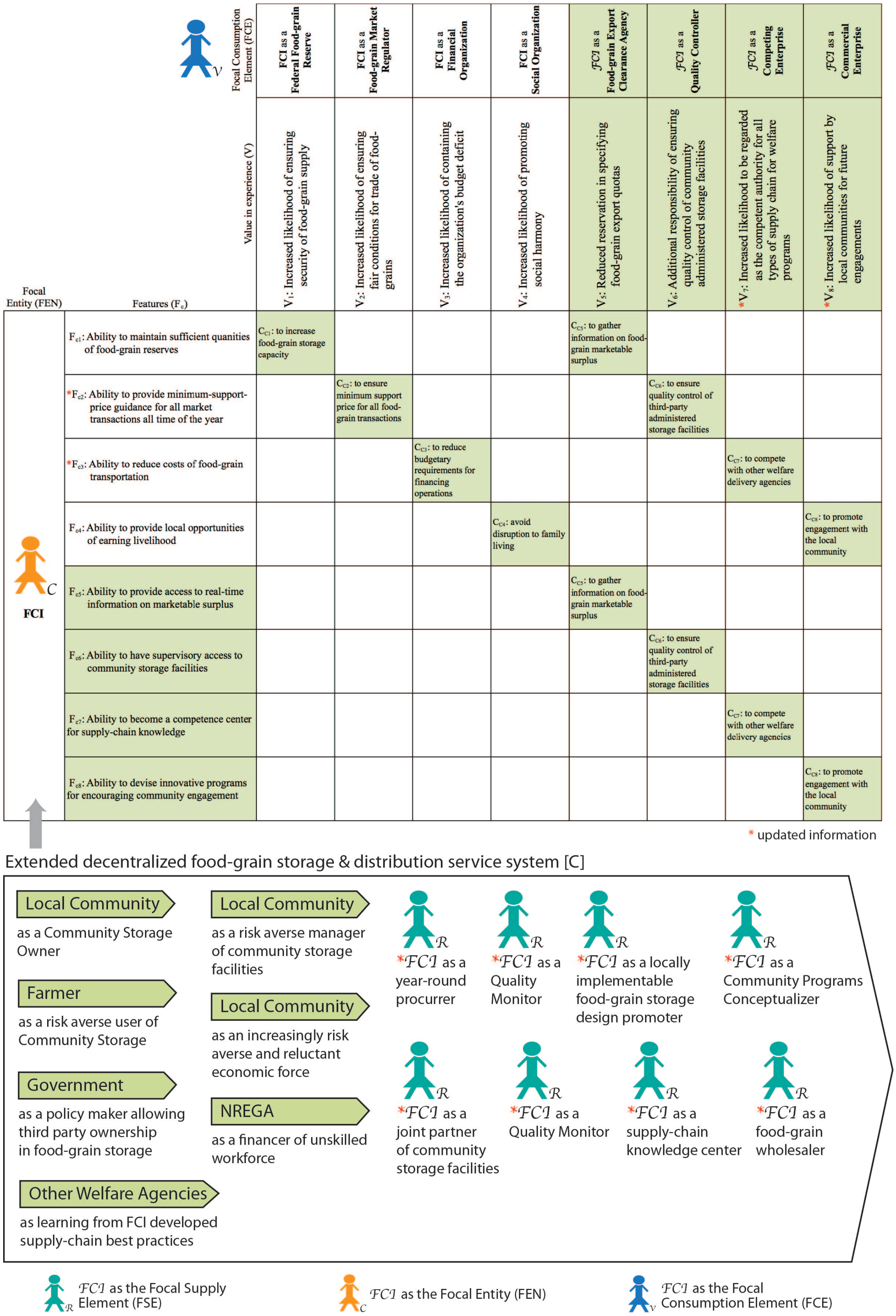


Figure 7 An integrated view of the final TRIBE model

4.4 Discussion

Some important observations about the TRIBE inquiry process that were made during the course of the case study are as follows:

- *While reasoning situations to assign roles to the entities occurring in that situation, some epistemic groundings more natural to reason than others*

  While analyzing the situations that were identified during the informed imagination phase, identifying the functional role played by the entities observed in those situations was greatly facilitated by asking the participants to reason in terms of the epistemic groundings of these situations. Participants were asked to reflect on the basis due to which they see an entity as part of the situation. Use of "epistemic grounding" seemed to scare them off. Nevertheless, they got the idea well when the four dimensions (historicism, empiricism, rationalism, and pragmatism) were explained with day-to-day examples. Amongst these four dimensions, the participants seemed to gravitate towards historicism, i.e., ascribing their view of the world to their cultural exposure, and towards pragmatism, i.e., clear cause-and-effect in the functional sense. The later was much welcomed, as the main focus of the inquiry was to identify the cause-and-effects underlying the relation that an entity has with a situation. Nevertheless, to be able to generate additional situations through refinements it was important for the participants to differentiate what rationalism and empiricism meant. Rationalism led to lots of discussion on risk as everyone had a different logical model of risk. Empiricism, in terms of mere observation and no inference, could not be seen to explain any reported situation. One of the reasons could be that as humans it's hard to just limit our reports to mere observation. It flows through the conceptual system and comes out as a judgment, which means there is more to it than just based on observation. As a result, all situations were found to enjoy one of the three epistemic groundings – historically reinforced, rationally thought, or pragmatically inspired. One possibility that can be explored in the future is to have one's imagination critically analyzed by someone else. Such situations are not entirely imaginative. Technique like Photo-elicitation, where photos from the field are used to analyze the situations remotely, is one such approach where someone else analyzes someone's view of the world in his absence.

- *The use of peak-and-trough visual patterns to model the forces constituting a Value Frame resulted in the realization that modeling forces in terms of vertical and horizontal components can further enrich the visual semantics of Value Frames.*

  The visual depiction of modeling the vertical and horizontal components of force-factors is depicted in Figure 8. This is also reflected in the modeling of forces in Table 5. The forces are modeled <effect_horz> and <effect_vert>. The outcome of modeling a force in terms of its

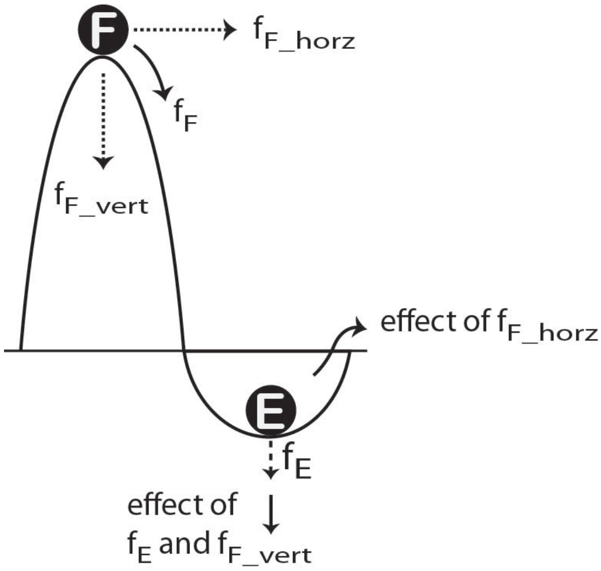


Figure 8 Modeling the horizontal and vertical components of force-factors

components was particularly rewarding in analyzing the contribution of Service Enabling Element in realizing the feature of the service. The two components of f_{SEE} where each interpreted individually, which led to identifying two enabling elements for each frame. For example, SEE field in Frame 1 in Table 5 models <effect_vert> as - helping FCI maintain sufficient quantities of food-grain reserves, and <effect_horz> as - require assistance from FCI in monitoring the quality of food-grains in community storage facilities. In this case, <effect_vert> is the contribution that SEE – Local Community as Community Storage Owner, makes towards implementing the feature. At the same time, <effect_horz> shows that this contribution of SEE is contingent on the FCI undertaking the responsibility of monitoring the quality of food-grains. The additional role that the component based modeling of force-factors helped surface can be interpreted as a change management role. The realization that these visual patterns can also be used to convey the message that change management is an integral component of adopting a new service was the most important learning towards extending the TRIBE modeling framework.

4.5 Results

The TRIBE inquiry process helped the NGO develop a better understanding of the impact that their idea of 'a distributed network of community owned food-grain storage facilities' will have on FCI. The precise contributions of adopting a TRIBE inquiry process can be determined by contrasting the initial TRIBE model, Figure 4, and the final TRIBE model, Figure 7. The comparison is both quantitative and qualitative. TRIBE analysis of the initial idea led to the identification of new features (F_{c4}-F_{c8}) and several additional suppliers (constituents of the extended service system – both FSEs and other external entities) required for realizing these features. The concept of supplier is used here in a generic sense – all those entities that can influence the outcome of the service are considered as part of the service system.

To verify the qualitative contribution of the TRIBE inquiry process, expert feedback was solicited on two accounts:

1) The participants of the workshop were asked to reflect on the novelty of the information that the TRIBE inquiry process helped surface. The objective here was to assess if the participants found TRIBE a useful method and if they were willing to use it again for future project proposal preparations. In this case the workshop participants were considered experts from a project proposal preparation point of view. Many of the participants had coordinated several such project proposal applications successfully. The feedback that was received can be summarized around two themes.

   Ability to expose novel aspects

   The participants referred to several information elements in the final TRIBE model that they acknowledged were not considered before the discussions in this workshop.

   - For instance, they did not think that they could also position their project proposal as one where *FCI becomes a center of competence for material based welfare delivery.*
   - Another instance was regarding the shared ownership model of community food-grain storage facilities. The realization that by undertaking *the responsibility of quality monitoring of food-grains stored in community storage facilities*, FCI can make the proposal of distributed storage more appealing for communities was also a novel addition for them.

   Ease of use of the method

   From an ease of use point of view, the workshop participants were exposed to two different approaches of conducting the Force-dynamic Analysis Phase of the TRIBE inquiry process. The two approaches differ in their application of Value Frames.

   - The first approach focuses on the *individual model elements of the Value Frame conceptual model* (Figure 5 of Chapter 3), and linearizes the inquiry process by trying to instantiate these model elements in a sequence that is aligned with the internal dependencies of the model. The dependencies here refer to the information that one model element (imagine as a higher level node) requires from another model element (imagine as a lower level node). This approach required them to identify, in this order of sequence, the goal of the focal entity, the challenge this goal poses to it, the antagonist and protagonist roles undertaken by the focal entity and the different entities from the environment. Once these model elements are known it identifies which Value Frame is applicable, one of the four patterns – Correction, Facilitation, Maturity, or

Enforcement, and suggests a suitable configuration of the situation that the service should try to realize. Suitable configuration refers to the nature of intervention the service should implement, and the entity through which it should be introduced, i.e., the Service Enabling Element. This process is depicted in Figure 7 of Chapter 3. This way of activating Value Frames expected the participants to adopt an exclusively rational approach to conceptualization, *making the workshop less interactive*. To commit the focal entity to a specific goal in the very beginning of the inquiry gave the participants the feeling of locking themselves to a very specific view of the focal entity very early on. The feedback we got for this approach reiterated the fact that a rational model of reality is not necessarily the most natural model of reality for human beings. Humans are experiential beings and their basic expression of a conceptualization is affective in nature.

- The second approach focuses on the *synthetic nature of Value Frames* as reifying feelings invoked in response to a benefit that an entity receives from a service. Asking the participants to share the feelings that are invoked in response to a benefit that the service provided resulted in *high levels of engagement from the participants*. This suggested that thinking in terms of feelings was more natural for the participants. Further, the use of peak-and-trough visual model of Value Frames was also reported by the participants as a useful aid in instantiating the model elements of the chosen Value Frame.

2) The results of this inquiry were also shared with two senior officials of FCI to solicit their feedback on the two project proposals – one based on the Nativist Model, Figure 6 of Chapter 4, and the other based on the final TRIBE model, Figure 7. These officials were not part of the workshop and had no knowledge about the TRIBE process or the discussions that took place during the workshop sessions. The feedback that was received can be summarized around two themes.

Completeness

One of the remarks was that the TRIBE model based project proposal seems to reveal an *"…extended chain of reasoning"* which is useful to show how the intervention suggested will affect the stakeholders of FCI. In that sense it is more complete and reduces the cognitive effort of the sanctioning committee in evaluating the achievement of the proposed project.

Feasibility

Another feedback that I received was that *"... the more you promise the riskier it sounds"*. This is to suggest that, from a project management perspective, one needs to clearly specify the contractual arrangement that will be required between the proposed suppliers to be able to commit to a certain level of measurable quality of service. Existing specification of the service systems reveals the context in which the different suppliers work together, thereby providing a good first step to initiate future investigations in this regard.

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5. Conclusions and Future Research Directions

Design Science is the scientific study of the art of designing artifacts. As opposed to the natural sciences, e.g. physics and biology, which focus on revealing the truth, the design sciences, e.g., engineering, medicine, law, architecture and business, focus on the 'usefulness of the artifact' produced. Herbert Simon referred to this scientific study of designing artifacts as the 'Sciences of the Artificial'.

The work presented in this thesis considers the study of Services as an effort in making the discipline of Design Science more rigorous by formalizing the notion of 'usefulness of the artifact' produced. It pursues the idea that Services has a much deeper semantics than the mere reference to a specific category of economic exchange, or the explicit involvement of a human actor in the solution-delivery process. It is proposed that Services refers to the *problem-solving mindset*, which requires service-providers to go beyond the immediate scope of the stated problem, and focus on the 'value' the service offering creates for the actors affected by the problem. The objective of this work is to help enable this mindset both within organizations and the larger society around us.

In doing so, this work questions the dominant approach to design, which considers the artifact produced as a work system, and the usefulness of the artifact as the specific task that the work system helps accomplish. Such an exclusively functional view of design fails to acknowledge the affective states that the artifact invokes at the consumer. Affective states correspond to the internal feelings of the consumer and, if reasoned appropriately, these states can help identify an additional set of tasks that the artifact helps accomplish for the consumer. The ability to situate stakeholders' appreciations as concrete cause-and-effects in the real world increases the likelihood that the stakeholders understand the value proposition of the different solutions, and eventually make an informed decision in specifying the solution of choice.

The contributions of this work can be summarized at two levels. At the conceptual level, it proposes a characterization of the Value concept in terms of the change experienced by the (human) subject of interest. At the engineering level, this work proposes a service-oriented design framework called **TRIBE**. TRIBE acknowledges the embodied nature of human expression, and provides the modeling apparatus required for surfacing the deep semantics of the feelings that a stakeholder experiences with regards to a problem situation. In its effort to connect with the stakeholders at the experiential level, TRIBE employs various visual metaphors to solicit the information required to generate service-oriented models of problem situations. For example, TRIBE employs the peak-and-trough metaphor to help surface the affective states that are invoked at the user by virtue of the experiences that the adoption of a service creates. The peak-and-trough patterns employed in TRIBE are called **Value Frames**.

5.1 Recommendations

From a practical relevance point of view, the primary purpose of this work is to formalize the service-oriented design process such that the activity of service-design is not restricted to some select experienced professionals, rather available as a well-defined process of inquiry that can be executed even by mid and entry-level professionals. This is useful, for example for IT professionals, to augment their capability to engage with the customer during the design phase of the IT solution. Design-oriented engagements are high-end assignments, which require IT consultants to work closely with the customer, and its partners, in co-creating solutions. Some examples of such assignments include, management consulting, strategic consulting, enterprise architecture, and public policy formulation. An important challenge in undertaking these assignments is to be able to facilitate communication between a diverse set of stakeholders. Communication between stakeholders could be impeded due to several reasons – lack of appreciation towards different viewpoints, inability of stakeholders to articulate their feelings, lack of imagination to visualize situations of interest.

Based on the work presented in this thesis, the following recommendations are proposed to professionals engaged in service-design activities:

- Make explicit the focus of the inquiry by identifying the phenomenon of interest, which very often is different from the purpose of inquiry provided by the customer. Taking a Systems view, and making explicit the context that binds the individual components, including humans, technology and material resources, as one unified system will help set the scope of the inquiry.

- While assigning roles to stakeholder, critically reflect on the cognitive groundings of these roles. As a quick check, one can use the four prominent epistemic groundings – historicism, empiricism, rationalism and pragmatism, to verify if the assigned role truly reveals any cause-and-effect relationship relevant to the service being designed.

- Service-designers should pay attention to both the bodily and social being of the stakeholder. Stakeholders should not be modeled as rational thinkers but as embodied beings that experience feelings. Use of patterns like Value Frames will help service-designers reveal the true cause-and-effects influencing the stakeholder.

- To help stakeholders appreciate their role in the success of the service, service designers should synthesize all the information surfaced in visual format, which clearly depicts both, the consumer and supplier, roles for each stakeholder. This will help stakeholders not only acknowledge their obligations but also undertake necessary steps to meet these obligations, for example, issues commonly referred to as change management.

5.2 Going Forward

Going forward, work in the following three directions will be particularly useful in establishing TRIBE and Value Frames as a rigorous framework for service-design.

- **Benchmarking**

The pilot studies conducted so far focused on validating the conceptual model underlying TRIBE and Value Frames. Nevertheless, for the proposed modeling apparatus to be useful in practice, it is important to do an extensive study of how effective it is as compared to existing Requirements Engineering methods, e.g. I* and e3-value. This will require developing a set of key performance indicators (KPI), which are representative of the different types of costs that RE methods entail. From a practical point of view, the adoption of an RE method does not rely only on its ability to surface novel requirements. It is equally important that the method is competitive along other dimensions, for example, economically based on the number of consultants required to conduct the inquiry, or cognitively based on the overhead it demands in understanding the contributing concepts.

- **Visual Semantics Validation**

So far, the pilot studies primarily focused on surfacing affective states based on references to natural language expressions assigned to the four patterns of value creation – Correction, Facilitation, Maturity and Enforcement. These expressions, though fairly indicative, required substantial off-line explanation to convey the different 'nature of change' that each Value Frame reifies. An important extension to the current work will be to go beyond natural language expressions and explore the use of visual and tangible modes of interaction to convey the desired semantics of value creation. One visual approach is the use of peak-and-trough patterns to model value creation at the experiential level. The peak-and-trough based visual patterns though proposed in this work were not validated for their semantics. To do so, one can approach the problem from two perspectives. On one hand, we will conduct experiments to understand the affordances the peak-and-trough metaphor offers to the observer. Affordance is a property of an artifact, which eases the discovery of actions that can be performed as part of the interaction with the artifact [1]. On the other hand, we will explore the space of tangible Manipulatives to devise tangible human interactions that can moderate these affordances - blocking ones, which digress from the intended semantics of Value Frames, and preserving those, which advance the desired semantics. Tangible Manipulatives refers to the interactive environment where physical interactions are employed as a means of learning abstract concepts [2]. To ensure the general applicability of Value Frames across knowledge domains, such an effort will need to undertake experimentation with representatives from diverse backgrounds, including management, technology, governance, and citizens in general.

- **Distributed Cognition**

The problems, whether business or societal, that confront us today are complex, and no single individual can address a real-world problem in its entirety. The services mindset we wish to promote refers to the aggregate cognitive faculty of the system of individuals that work together to co-create value. So far, the work reported in this thesis focused on the cognitive faculty of an individual and how the modeling process can benefit from taking an embodied and situated view of the individual. Going forward, it will be interesting to alter the unit of analysis, from the current individual level to finer levels corresponding to specific cognitive processes within the individual. From a relevance point of view, this will help us understand how cognitive processes interact and what is there relevance to group behavior [3], and for that matter in influencing decision making at an organizational level.

For example, one of the fundamental challenges in realizing a service system is to bridge the gap between the service-conceptualization phase and the service-specification phase. At a cognitive level, each of these design phases is grounded in one of the two basic thought processes available to the human mind. Daniel Kahneman, the Nobel Prize winning psychologist, describes these cognitive processes as System 1 - automatic, affective and heuristic-based, and System 2 - effortful, conscious and rule-based [4]. The service-conceptualization phase is one where the System 1's ability of free-association helps generate new perspectives of the problem-situation. The service-specification phase is one where the System 2's analytical ability reasons these perspectives to extract the information required to engineer the service. A services innovation is an outcome of the successful integration of the conceptualization and specification phases of the design process. For a single-person service system, the physical body of the person acts as the mediating channel between the System 1 and System 2 of the person. However, no such natural means of mediation is available in multi-person service system. Further, the topology of the multi-person service system may itself vary, thereby complicating the aggregation of cognitive processes even more. For example, the existence of specific communication barriers/channels may result in a system-within-system configuration - the *nested service system*, or a set of interconnected-systems configuration – the *networked service system*. In either case, a well-defined services innovation requires an explicit model of how a service system's conceptualization translates into a service-specification.

Independently, there exist theories that inform these two phases of the design process. The theories of conceptualization are descriptive in nature. For example, they describe how the formation of concepts in the human mind is a situated and embodied phenomenon that is grounded in pragmatic considerations as opposed to some pre-defined set of truth-conditions. On the other hand, the theories of specification are prescriptive in nature that employ formal methods and verification tools to ensure the correctness of the specification with regards to some pre-defined domain/process or knowledge model. The central question, though, remains – *can there be an integrated theory for services innovation that builds on these individual theories, and provides a unified framework for formal analysis of the emergent cognitive properties of the system of human actors working together to co-create value?*

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Appendix 1

From Composites to Service Systems: The Role of Emergence in Service Design

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Abstract— **Service Design is an engineering endeavor to enrich some aspect of the real world through a man-made artifact. Systems approach to modeling reality is particularly relevant to Service Design as it seeks to explain reality as a composition of functional observations. Nevertheless, its adoption varies from casual interpretations of interconnectedness to citations of non-deducible causality. To establish Systems approach firmly within the domain of Service Design, it is important to provide an unambiguous characterization of the nature of composition that a Systemic view entails. Further, such characterization should be amenable to the development of a formal framework for specifying Services. In this paper, we take a cognitive approach to composition and highlight the difference between composites as structure-unifying integrated-wholes and composites as emergence-revealing systems. We then translate this characterization into a set of visual semantics for expressing a service-oriented view of observed reality.**

Keywords-compositional hierarchy; behavioral discontinuity; design patterns

I. INTRODUCTION

Unlike the goods-centered model of economic exchange, where goods are seen as "physical embodiments of competence" [1] and are marketed as potential source for benefits [2], services focus on the actual benefits experienced – how the adoption of some man-made artifact enriches the real world [3]. Uncertainties of the adoption process and the tacit nature of consumption context make the information relevant for service design hard to model and, most often, sticky to quantify [4]. Further, as formalized in the Law of Requisite Variety [5], for a design to deliver desired results in a given situation, the design must possess an amount of variety that is at least equal to the variety that the situation can present. As a result, a service designer is required to cast her net wide and try to understand the different facets of the interactions that the phenomenon of interest exhibits with its environment.

A Systems view of observed reality corresponds to levels of abstraction, which best reflect the modeler's view of the interactions between the phenomenon being modeled and its environment. Nevertheless, these levels of abstraction may not always be primary in nature in the sense that they may not correspond to the modeler's first/immediate view of the reality. The modeler explores reality at multiple levels of abstraction – the additional levels being the result of an explicit composition from primary observations. The basis for such composition can vary from casual interpretations of interconnectedness to citations of non-deducible causality. From a combinatorial perspective, an unqualified compositional approach would yield an exponentially large set of composites, not all of which may be relevant to explaining the causal organization of the observed reality. The relevance of an abstraction level in explaining the causal organization of the observed reality can be formalized in terms of the behavioral-novelty that it reveals. An explicit admission of such novel properties as part of the service specification increases the amount of variety embedded in the service thereby increasing the likelihood that the service yields desired benefits.

In this paper, we take a cognitive approach to composition and provide an unambiguous characterization of the nature of composition that a Systemic view entails. The focus is on clarifying the distinction between the two types of composites that are most usually confused and, hence, used interchangeably - structure-unifying composites and emergence-revealing composites. Further, to make this conceptualization of Systems useful for service designers, we propose a set of visual semantics that can help them in expressing a service oriented view of the phenomenon of interest.

The remaining part of this paper is structured as follows: Section 2 presents a survey of the related work – describing, in particular, the cognitive groundings that underlie Systems conceptualization; Section 3 focuses on the organization of observations as compositional hierarchies, providing a characterization of composition that is aimed at identifying behavioral-novelty revealing levels in the hierarchy; Section 4 translates this characterization into a set of visual semantics useful for the early phase of Requirements Engineering. The concepts introduced in this paper are illustrated through an inquiry aimed at enriching the phenomenon of "Bike as a means of transport" through the creation of an IT enabled mobility management service. The example, though trivial at first sight, provides enough richness to illustrate both the challenges that a Systems conceptualization faces and the merits of the approach proposed in this paper. The paper ends with some concluding remarks in Section 5.

II. FUNDAMENTALS OF SYSTEMIC CONCEPTUALIZATION

Systems are an important conceptualization in an inquiry. They correspond to levels of abstraction, which best reflect the modeler's view of the interactions between the phenomenon being modeled and its environment. Nevertheless, the modeler's viewpoint is not formed in isolation. The prior experience of the modeler influences the inquiry through the admission of various heuristics and biases [6]. From a cognitive perspective, the background knowledge of the modeler is organized in her mental space around different cognitive themes, referred to as idealized-cognitive models (ICMs), such as the ones grounded in visual perception, inter-domain communication, knowledge organization, and functional behavior [7]. These models are not mutually exclusive. A first conceptualization benefits from an automatic, unconscious and simultaneous activation of several such models yielding basic-level categories [8]. These categories are basic in that they represent an ontological reification of the innate functional and epistemological view of the modeler.

The basic-level conceptualization, though primary, may not suffice for the purpose of an inquiry. For example, a service-oriented inquiry, which seeks to enrich a real world phenomenon through the creation of some man-made artifact, needs to understand how the observed reality is causally produced. This includes gathering information about both what constitutes reality – the ontological categories observed by the modeler [9], and how these categories interact to functionally produce the observed reality. Basic level categories represent a level of abstraction at which the modeler's observation exhibits maximum correlation with her ICMs. ICMs bring to bear a combination of several perspectives – functional behavior being only one of them. As a result, basic level categories by themselves may not always be adequate to explain the causal production of observed reality. Nevertheless, they present an ideal starting point for the modeler to refine her view by exploring reality at additional levels of abstraction.

Refinement is the process of identifying mappings between different levels of abstraction [10]. Ontological refinement seeks to refine an ontological category, [11], into a set of lower level categories such that the resulting categories contribute to the semantics of the higher-level category. In the context of modeling reality, any ontological refinement is subject to the modeler's assignment of semantics to the mapping between the different levels of abstraction, which, in turn, is an outcome of the invocation of his ICMs and, hence, not exclusively functional in nature.

For example, consider an inquiry aimed at enriching the phenomenon of `<<Bike_as_a_means_of_transport>>` through the creation of an IT enabled mobility management service. The inquiry may start by revealing the following basic level categories: `<<Bike>>` as a mechanical assembly, `<<Road>>` as a friction providing surface for traversal, and `<<Rider>>` as a human capable of balancing and propelling the bike. In an effort to understand the causal organization of these categories, the modeler refines her basic level observations to lower levels of abstraction. Cognitively, the process of refining categories calls for repeated invocation of ICMs, each iteration generating categories with finer details. Given our general familiarity with bikes, one might be inclined to suggest an ontological refinement of `<<Bike>>` that not only identifies its constituent parts but also reveals how these parts can be composed to mechanically assemble the bike. Nevertheless, functional behavior is only one of the several cognitive groundings that motivate ICMs. To ensure the generality of our argument beyond the current exposition, let us assume that the modeler's view is shaped by a combination of ICMs. As a manifestation of this influence, the modeler might see bike as composed of metallic and rubber parts, which in turn are specialized into – bar, clamps, bearings and tyre. Fig. 1 presents a hierarchical depiction of the refinement of the category `<<Bike>>.` Edges tagged *isPartOf* signify decomposition and the ones tagged *isA* signify specialization. The mixed semantics of refinement in this example suggests that not all ontological refinements may lead to purely compositional hierarchies. For instance it is not clear how `<<rim>>`, `<<bearing>>` and `<<tyre>>` come together to form a functional sub-assembly, say wheel, or if there exist any functional sub-assemblies at all.

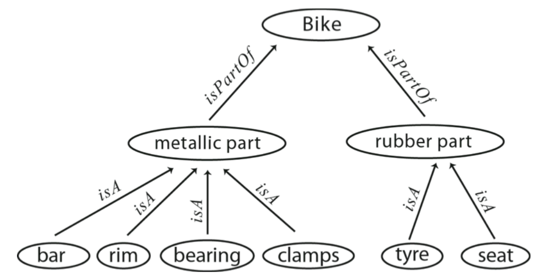

Figure 1. A representative refinement of Bike as a mechanical assembly

Ontological refinement enriches the modeler's view of reality by admitting observations at different levels of abstraction. The expanded set of categories can be reorganized in a way that the composites, obtained by combining one or several of these categories, contribute to some functional aspect of observed reality. The principle of nearly complete decomposition [12], which states that for a given phenomenon of interest, the interactions between the constituent categories are not all of equal strength – some interactions are stronger than the other, suggests that the resulting composites can be structured as a hierarchy. From a combinatorial perspective, an unqualified compositional approach would yield an exponentially large set of composites, not all of which may be conceptually relevant to the modeler, let alone contribute to her understanding of the causal organization of the observed reality. It is, therefore, important that the modeler can distinguish between different kinds of composition and choose the one that is most relevant to explaining the causal organization of the observed reality. Fig. 2 shows a representative compositional hierarchy for `<<Bike>>` with `<<wheel>>` and `<<frame>>` as functional sub-assemblies. It also shows some additional composites, which are either conceptually irrelevant to the modeler or simply beyond the scope of the current phenomenon of interest.

Even in compositional hierarchies where each composite has some functional relevance to the causal organization of the observed reality, there can be discontinuities between the behaviors revealed at different levels of the hierarchy. A behavioral discontinuity refers to the non-trivial deducibility of higher-level behavior from behaviors exhibited at the lower-levels. The occurrence of behavioral discontinuity in a compositional hierarchy is an indication of some qualitatively

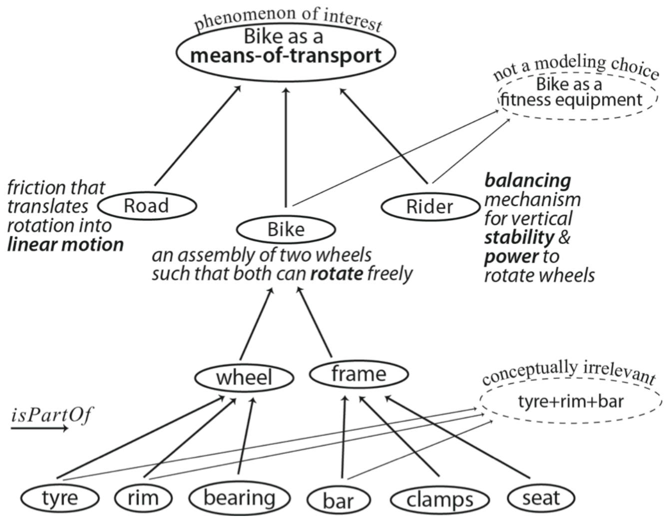

Figure 2. A compositional hierarchy of Bike as a means of transport

novel property of the observed reality - one that cannot be established at any of the lower levels of the hierarchy. The field of Complexity Science refers to such properties as emergent properties and the occurrence of associated behavioral discontinuity as the phenomenon of emergence.

From an informational perspective [13], levels revealing functionally novel aspects of the observed reality are critical to the modeler's understanding of how the phenomenon of interest interacts with its environment. A Systems approach to inquiry emphasizes on identifying levels of abstraction where such novelty occurs. Fig. 2 shows the emergence of *means-of-transport* as a functionally novel property. Here the evidence for the occurrence of behavioral discontinuity is linguistically inspired and rests in the sudden change of vocabulary between the different levels of the hierarchy: rotation, linear motion, power, stability and balance at the lower level and means-of-transport at the higher level. Fig. 3 summarizes the different stages in the deveopment of a Systemic conceptualization of observed reality.

III. The Nature of Systemic Composition

The modeler's view of a given phenomenon of interest is composed of her observations about reality at multiple levels of abstraction. The ontological categories representing such observations can be combined to explain the causal organization of the phenomenon of interest. Nevertheless, an unqualified compositional approach would yield an exponentially large set of composites – the power set of the set of categories. Not all of them may be conceptually relevant to the modeler, let alone contributing to her understanding of the causal organization of the observed reality. It is, therefore, important that the modeler can distinguish between different kinds of composition and choose the one that is most relevant to explaining the causal organization of the observed reality. The following three types of compositions are particularly interesting in our context.

A. Mereological Sum

A mereological sum is a mechanical aggregation of categories, which may or may not have any conceptual relevance to the modeler. Such an aggregation is inspired by an absolute connectionist view of the world where everything is connected to everything with equal strength. In real world some connections are stronger than the others and, hence, any arbitrary combination may not always have noticeable conceptual relevance to the modeler. As noted in [14], an example of a mereological sum can be "Noam Chomsky's left foot, the first act of Puccini's Turandot and the number 3", which from a combinatorial perspective is a perfectly legitimate entity, though it may be extremely hard to find a context to which it can be conceptually relevant. In the context of the bike example, Fig. 2 shows, in addition to conceptually relevant categories like `<<wheel>>` and `<<frame>>`, an aggregation of tyre, rim and bar, which does not contribute to the modeler's conceptualization of bike.

It is important to note that not all aggregates can be organized as a compositional hierarchy. Unlike the absolute connectionist view of equally-strong-association-between-all, hierarchy theory promotes a connectionist view based on the comparative-strength-of-associations [15]. It is this ability to compare the relative strength of aggregation that will allow defining a partial order on the aggregates, thereby organizing them in a hierarchy. Comparison is a cognitive exercise and is only feasible if the subjects have some conceptual relevance to the modeler [16]. Thus, only aggregates that have some conceptual relevance to the modeler can be organized as a compositional hierarchy.

B. Integrated Whole

Integrated-wholes are mereological sums that have some conceptual relevance to the modeler. They represent a composition of categories that is unified under some binding relation [17]. The binding relation is a formal characterization of the conceptual relevance that the integrated-whole holds for the modeler. It is this conceptual relevance that allows the modeler to organize the integrated-wholes as a hierarchy. Hierarchies are defined using a partial order relation based on the relative strength of the part-of relations, aka meronymic relation [18], that produce them and are hence referred to as compositional hierarchies. In addition to the logical properties of transitivity, irreflexivity, and antisymmetry, which define a partial order [19], meronymic relations can have multiple semantic connotations. Three important dimensions along

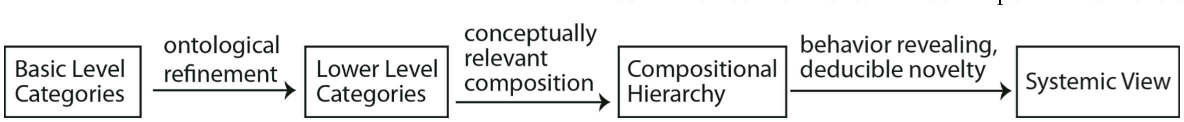

Figure 3. A cognitive perspective of the process for developing a Systemic conceptualization of observed reality

which a meronymic relation can be characterized are – whether the lower-level categories are *functionally* related to the higher-level category, whether the lower-level categories can exist *independent* of the higher-level categories, and whether the lower and higher-level categories are of the same *type* [20].

In the context of specifying an engineering design, which is the end objective of the modeler conducting a service-oriented inquiry, the focus is on understanding the functional behavior as perceived in observed reality. Hence, in compositional hierarchies each lower-level category contributes, in some way, to the functionality of the higher-level category.

The independence of categories corresponds to the conceptual uniqueness of the relevance that an integrated-whole has to the modeler. The existence of binding relation as a formalization of the modeler's focus on some specific aspect of the observed phenomenon and the closure of the integrated-whole under this binding relation together, delineate parts of the phenomenon relevant to the aspect under focus from the rest of the environment. Thus, the hierarchical organization of categories is tantamount to decomposing the modeler's view of the observed phenomenon along different aspects of the phenomenon. Each level in the hierarchy presents a level of abstraction, which reflects the modeler's view of the interactions between the phenomenon being modeled and its environment. Since an integrated-whole is modeled as interacting with the environment, it can be interpreted as enjoying an independence of existence. Thus, meronymic relations exhibited by integrated-wholes are the ones where the lower-level categories are functionally related to higher-level categories and can exist independent of the higher-level categories. Such class of meronymic relations is referred to as component-integral object meronymic class [20].

One interpretation of the type of categories is the newness that it brings to the understanding of the causal production of the observed reality. Nevertheless, not all levels of the compositional hierarchy may contribute to any new understanding of the observed behavior, i.e. the interaction of the observed phenomenon and its environment. The notion of newness can be explained both ontologically and epistemologically [21]. From an ontological point of view, newness is the occurrence of qualitative novelty; say, a property that exists at one level of abstraction but not at any of the lower levels. In the context of compositional hierarchies, like the ones detailed above, the adoption of binding relation as a characterization of integrated-whole might seem to suggest the existence of behavior-revealing qualitative novelty. Nevertheless, the conceptual relevance, which defines each binding relation, can be inspired by variety of considerations not all of which may be grounded in behavioral semantics. For example, a large class of binding relations is based on the Gestalt effect [22], which is the form generating capability of the modeler, particularly with respect to the visual recognition of figures and whole forms. The qualitative aspect of the novelty associated with Gestalt effect is structural in nature and may not necessarily correspond to any new understanding of the behavior.

C. Systems

Integrated-wholes, which exhibit behavioral-novelty, are referred to as emergent [23] and the behavioral-novelty as an emergent property [24] of the integrated-whole. From an epistemological point of view, newness can also be interpreted from the lack of predictability of the higher level from lower levels. Such a formulation of newness aims to categorize integrated-wholes based on the computational hardship involved in establishing causal relationships between different levels of abstraction.

The ontological and epistemological interpretation of novelty can be combined to provide a general framework for characterizing implementable Systems. To recall, we defined Systems as levels of abstraction, which best reflect the modeler's view of the interactions between the phenomenon being modeled and its environment. The ontological focus on distinguishing behavior-revealing novelty from the structure-unifying novelty of integrated-wholes is aimed at identifying precisely those levels of abstraction, which contribute to a better understanding of the behavior of the observed phenomenon. The level exhibiting behavior-novelty and levels below it where this novelty does not exist together constitute a Systemic view of the observed phenomenon [25]. Nevertheless, from a service design point of view, existence of behavior-novelty is not enough. It is important that such novelty can be engineered from the lower level constituents. This calls for an understanding of how the levels below the novelty exhibiting level cause the novelty to emerge. This corresponds to the, above discussed, epistemological view of novelty, which can be framed as the amount of computation required in establishing causality of emergence. Novelty with finite computational demands on establishing its causality from lower-levels is deemed deducible, while open-ended demands on computing causality is considered non-deducible. From a service design perspective, levels of abstraction, which correspond to deducible behavioral-novelty are a more meaningful representation of systems constituting an observed phenomenon as the can be engineered in man-made artifacts. The deducible form of behavior-novelty is referred by many as the weak form of emergence, [26], and the non-deducible form of behavior-novelty as the strong form of emergence, [27]. Table 1 presents four different characterizations of the compositions corresponding to a level of abstraction. Integrated-wholes with only structure-unifying novelty are deducible as they result from the binding relation, which itself is a modeler's construction. As for structure-unifying but non-deducible compositions, they correspond to mereological sums and are, from an engineering point of view, an invalid combination since structure-unifying compositions owe their

TABLE I. COGNITIVE CHARACTERIZATION OF COMPOSITION

Composites	**Ontological** *(Existence of Novelty)*	**Epistemological** *(Nature of Novelty)*
Abstract System	Behavior-revealing	Non-deducible
System (implementable)	Behavior-revealing	Deducible
Integrated Whole	Structure-unifying	Deducible
Mereological Sum	Structure-unifying	Non-deducible

existence to binding relations, which are essentially the cause-and-effect deductions of the modeler from lower-level categories.

IV. Visual Semantics for Service-oriented View

Modeling reality is the first step in an inquiry. It constitutes the early requirements engineering (RE) phase of service design where stakeholders develop and communicate their view of the observed reality corresponding to some phenomenon of interest [28]. While plurality of observations is vital to uncover different facets of the phenomenon of interest, and should be encouraged, it is important that different views can be reconciled into one unified view of observed reality. It is only once a shared view of reality is established that the project can progress and deliver desired results. In the context of IT service design, the RE phase usually results in a service specification document following some standardized structure like the one prescribed in IEEE 830 [29]. Nevertheless, before such domain specific deliverables can be specified, the stakeholders need to communicate to reconcile their views of observed reality.

Visual narratives are one of the most effective modes of communication at this early stage of design. Stakeholders come from varied domains of activity and visual exchange is usually the most inclusive way of communication. Nevertheless, the understanding of visual perception should not be limited to the literal interpretation of seeing as a visual apprehension of spatial gestalts but also as one, which invokes appreciative judgments of quality [30]. Thus visual design should not only focus on the assignment of symbolic descriptions to rules so as to visually register information, but also the processing of such information to enable the construction of meaning. Visual semantics is the phenomenon of externalizing this process through an explicit admission of meaningful visual patterns that enable the invocation of pre-assigned meanings [31].

In this section we propose a set of visual semantics for enabling a coherent service-oriented view of observed reality.

A. Graphical Notation

The concept of integrated-whole is the primary building block in enabling a service-oriented conceptualization. To recall, integrated-wholes are a mapping between reality and the conceptual space of the modeler.

Conceptual spaces, as defined in [32], describe the structure of mental representation at some unique level of abstraction where information from all modalities of experience, such as linguistic, sensory and motor, are compatible [33]. From a cognitive perspective, two other levels of mental representation can be explored to communicate a concept – symbolic level and the connectionist level. Representing a concept at the symbolic level calls for identifying a set of symbols and rules, which govern their manipulation [34]. Understanding a concept is then a combinatorial exercise in symbol manipulation, one that does not lends itself easily to interpersonal communication. Connectionist representations, on the other hand, are high dimensional space of activities where the interpretation of dimensions usually calls for some external measure to reduce them into humanly manageable categories.

Given the overhead involved in understanding a representation modeled at both symbolic and connectionist level, we provide a representation of integrated-whole at the conceptual level. This is an intrinsic approach to representation where the representation exhibits the same relations as what the concepts represent [35], and is hence more intuitive to relate. Integrated-wholes represent a category that is closed under some relation. In a two dimensional space medium like paper, the closure property is represented as a region in conceptual space with its one unique identity. A non-symmetric graphical notation for depicting an integrated-whole is presented in Fig. 4.

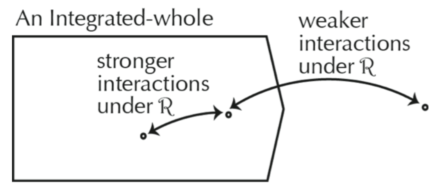

Figure 4. Graphical notation for integrated-whole

B. Design Patterns

Design patterns are named problem/solution pairs, which codify well-established and proven principles of design in a structured format that facilitates their repeated application to new contexts [36]. We adopt the same format of specifying design patterns as the one used in [37] for describing design patterns for software design.

Pattern Name:	*Whole/Composite*
Problem:	How to represent a Systemic view of reality?
Solution:	By making explicit the difference in compositional nature of structure-unifying integrated-wholes and emergence-revealing systems.

A systemic view corresponds to behavior-novelty revealing levels of compositional hierarchy. Nevertheless, novelty can only be inferred by contrasting the information available at different levels. It is not possible only by looking at one level to infer if the integrated-whole constitutes a system or not. It is only when levels are seen in pair that one can identify if the higher level exhibits structure-unifying behavior or emergence-revealing behavior. The pattern *Whole/Composite* is a visual codification of the compositional nature of an integrated-whole. Fig. 5 presents a schema that visually captures the existence of emergent property through an explicit modeling of the process of emergence (ℛ') that reveals some behavior-reveling novelty at a higher level. The tag [W] signifies an integrated whole at a level higher in the compositional hierarchy as compared to the one tagged [C], which reveals the composition of the higher level integrated whole from lower level categories.

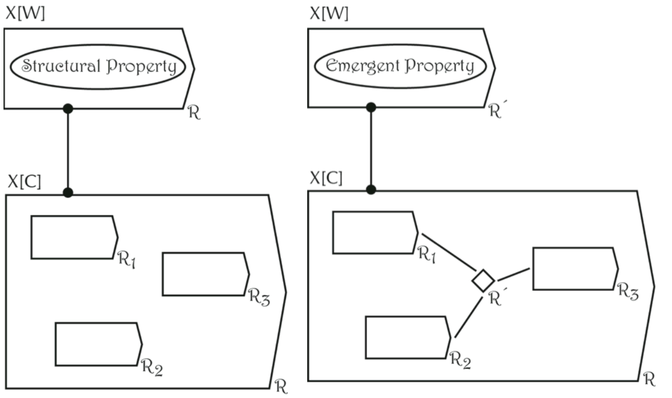

Figure 5. Schema for visual appreciation of Systemic view

Pattern Name:	*Supplier/Adopter*
Problem:	How to represent a Service view of reality?
Solution:	By making explicit the different roles and responsibilities that the stakeholders undertake to realize benefits for themselves.

Service is the process of realizing benefits to the stakeholders of some phenomenon of interest. Benefit is a subjective notion best explained by the stakeholder herself. As a result, to ensure that a service realizes desired benefits, it is important that the stakeholder is included in the designing of the service. For a service to be sustainable, each stakeholder of the service should be benefited in some desired way. This suggests the duality of roles that each stakeholder undertakes as part of the service design. A stakeholder is both a supplier and an adopter of the service [38].

A service view of observed reality should clearly specify the benefits that the service will bring to each stakeholder of the service, and the roles and responsibilities that need to be undertaken/fulfilled to jointly realize these benefits [39]. These roles and responsibilities can be assigned at different levels of the compositional hierarchy. Taking a systemic view of observed reality helps the service designer to identify levels of activities, which, if ensured, can account for the non-trivial aspects of the observed behavior, thereby increasing the likelihood of realizing desired benefits.

From an engineering point of view, a supplier role signifies some responsibility that a stakeholder undertakes towards the production of some aspect of the service leading to the realization of some benefit to some stakeholder. A grouping of supplier roles, assigned at the systemic level, based on the activities that need to be undertaken to realize a benefit for some stakeholder constitutes a Service System. Since each stakeholder benefits from the service, a service-oriented view should reveal one Service System for each stakeholder in the adopter role. Service System can be seen as work systems [40], striving to realize the benefits for some stakeholder. Fig. 6 presents a schema that visually captures the service-oriented view corresponding to the systemic level ℛ'. A complete service description identifies the benefit for each stakeholder of the service and the service systems responsible for realizing those benefits.

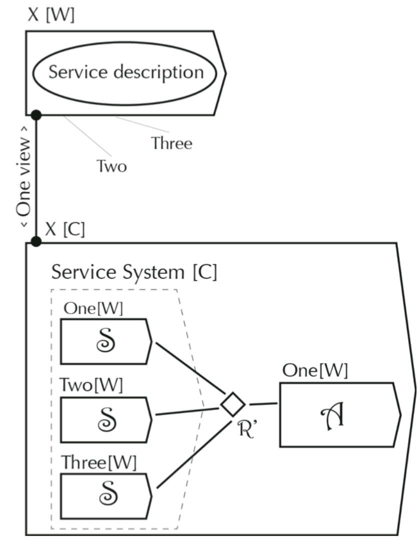

Figure 6. Schema for visual appreciation of Service view
Roles : Supplier 𝒮 and Adopter 𝒜

C. Bike example revisited

In this section we revisit the bike example using the visual semantics presented in earlier sections. Fig. 7 models bike as an integrated-whole composed of all those parts that are permanently connected to each other to give bike its conventional appearance as a mechanical assembly of wheels connected to a frame. The word permanent is to signify extended period of time over which the parts of the bike remain interconnected, as compared to, say, the rider who is connected only while she rides the bike.

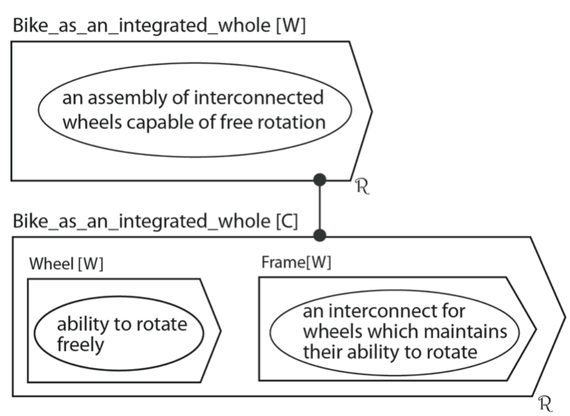

Figure 7. An integrated-whole representation of Bike
ℛ: Temporally extended interconnectedness

Fig. 8 models bike as a system, ℛ', exhibiting the emergent property of rideable_means_of_transport. Since every system is also an integrated-whole, in addition to the emergent property of the system, we will also see some structure unifying property, like all components in physical contact while the bike is in use, including the rider.

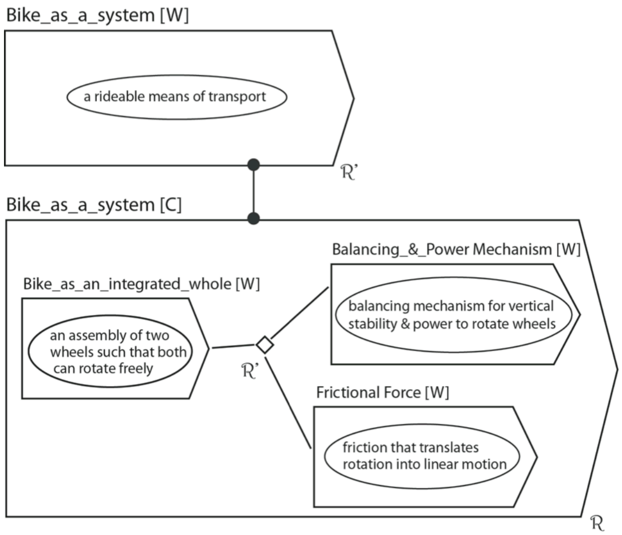

Figure 8. A Systemic representation of Bike
R: Temporally limited interconnectedness; R': Means of transport

Fig. 9 models the service-oriented view of bike. It identifies the stakeholders of bike-as-a-means-of-transport as the Bike Manufacturer, who mechanically assembles the bike; City municipality, which provides ride-able roads; and Ms. She, who rides the bike. All these stakeholders receive some benefit from the Bike-as-a-system. This is captured in service description – Bike manufacturer makes profit by selling bike to Ms. She who uses it as a means of transport by riding the bike on city roads provided by the City municipality for citizen wellness. Each stakeholder then sees the system of Bike-as-a-means-of-transport as providing some service to it. Service systems formalize this view through the grouping of supplier roles for each target benefit. A service-oriented view thus includes multiple views; one for each of the stakeholders - revealing how the benefit they desire is going to be produced.

V. Conclusion

Systems is a theory of observation. It empowers the modeler to identify aspects of reality that reveal behaviorally novel aspects of the phenomenon of interest. Systems approach to modeling reality is particularly useful in identifying the design requirements for services. Service Design seeks to influence aspects of reality through the creation of man-made artifacts and a systemic conceptualization of reality can help the service designer in identifying non-trivial aspects of reality, which, if preserved, would increase the likelihood that the service delivers desired benefits. This paper is an attempt to make explicit the cognitive process of developing a systemic view of reality. Such an explication can help the modelers to make a conscious effort to look for novelty in the observed reality. We also present a set of visual semantics that can aid the service designers in the development and communication of

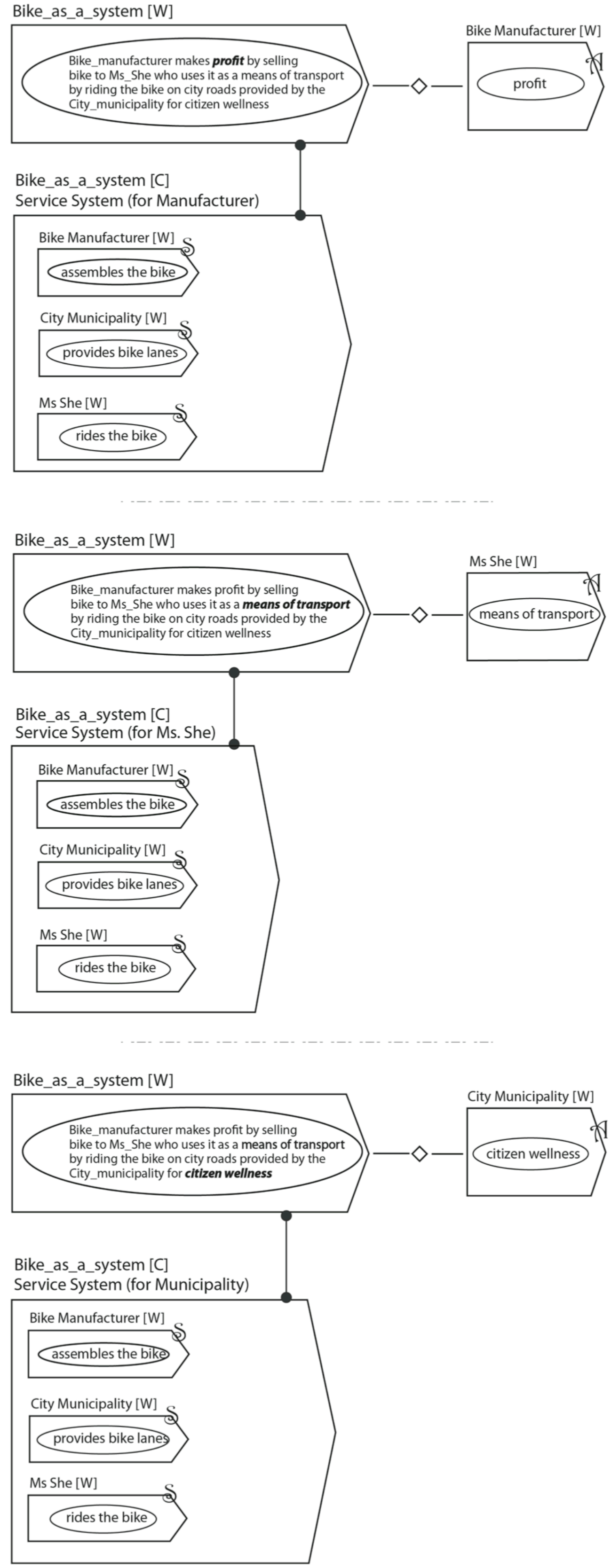

Figure 9. Service-oriented views of the system Bike as a ride-able means of transport

a systemic view of reality during the early phase of requirements engineering.

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Appendix 2

A Cognitive Reference Based Model for Learning Compositional Hierarchies with Whole-Composite Tags

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Keywords: Service design, Part-whole relations, Situated conceptualization, Linguistic markers, Digraph analysis.

Abstract: A compositional hierarchy is the default organization of knowledge acquired for the purpose of specifying the design requirements of a service. Existing methods for learning compositional hierarchies from natural language text, interpret composition as an exclusively propositional form of part-whole relations. Nevertheless, the lexico-syntactic patterns used to identify the occurrence of part-whole relations fail to decode the experientially grounded information, which is very often embedded in various acts of natural language expression, e.g. construction and delivery. The basic idea is to take a situated view of conceptualization and model composition as the cognitive act of invoking one category to refer to another. Mutually interdependent set of categories are considered conceptually inseparable and assigned an independent level of abstraction in the hierarchy. Presence of such levels in the compositional hierarchy highlight the need to model these categories as a unified-whole wherein they can only be characterized in the context of the behavior of the set as a whole. We adopt an object-oriented representation approach that models categories as entities and relations as cognitive references inferred from syntactic dependencies. The resulting digraph is then analyzed for cyclic references, which are resolved by introducing an additional level of abstraction for each cycle.

1 INTRODUCTION

A compositional hierarchy is the default organization of knowledge acquired for the purpose of specifying the design requirements of a service (Saxena and Wegmann 2012). A service seeks to influence aspects of reality through the creation of man-made artifacts. A compositional hierarchy organizes the categories observed in reality in a hierarchical manner such that the categories at the lower level contribute to the behavior exhibited by the categories at the higher level. Knowledge that reveals the composition of some observed behavior by identifying its constituent categories is, in general, useful for engineering purposes. Furthermore, a hierarchical organization of such knowledge, structures the constituent categories based on their relative strength of interactions (Simon 1962). The resulting levels correspond to the different aspects of the composition, which can either be tagged as novelty revealing composites or simply structure enforcing composites. Novelty is a subjective notion that resides in the ability of the observer to discern a conceptualization into coherent, though connected and possibly overlapping, regions in semantic space. In the context of compositional hierarchy, levels exhibiting novel properties signify strong interdependence among the descendant nodes. The inseparability of the conceptual relevance of such descendant nodes suggests that these nodes should be modeled as a unified-whole wherein the individual nodes can only be characterized in the context of the behavior of the descendant set as a whole. For an artifact to deliver desired results in a given situation, the design of the artifact must possess an amount of variety that is at least equal to the variety that the situation may present (Ashby 1964). An explicit acknowledgement of the existence of such unified-wholes as an integral part of the observed reality helps ensure that the properties associated with the unified-wholes are preserved in the target service, which, in turn, amounts to adding variety to the service specification, thereby increasing the likelihood that the service yields desired benefits.

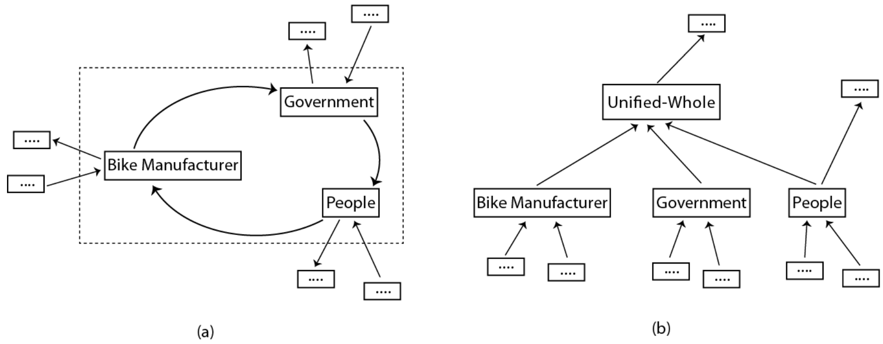

Figure 1: A compositional hierarchy extracted from the sample text $\mathcal{T}'$ depicting the notion of unified-whole as a set of strongly interdependent categories.

For example, consider the following sample text, $\mathcal{T}'$. The interdependencies between the categories occurring in this sample text and the corresponding compositional hierarchy are depicted in figure 1.

$\mathcal{T}'$: *Bike manufacturers are increasingly engaging with people to identify new bike designs. The demand for bikes has gone up. More and more people are now riding bikes. The government has improved the infrastructure by adding dedicated bike lanes for riding the bikes. People feel safe in bike lanes. Government is also encouraging bike manufacturers to increase their production by subsidizing their operations through tax waivers and easy loans. More and more people riding the bike results in a healthy society, which, in turn, lowers the cost of health care for the government.*

Large amount of information about various aspects of the real world is available as natural language documents. In the context of service design, the socio-economic narrative that is most relevant for modeling the real or intended behavior of the participating actors, both human and otherwise, is very often embedded in vision papers, policy guidelines, surveys, and field-study reports (Zarri 1997). Conventional means for learning compositional hierarchies from such unstructured natural language text, interpret composition as an exclusively propositional form of part-whole relation. Propositions define a conceptualization as a set of truth-conditions that are evaluated to ascertain if a conceptualization holds in a given context. For example, a part-whole conceptualization represented in propositional form as *part (wheel, bike)* is considered decodable from a given text if and only if the text contains the natural language expression 'wheel is part of the bike'.

Nevertheless, not all information encoded in linguistic utterances may lend itself entirely to truth-conditions based decoding (Wilson and Sperber 1993). In addition, the utterance may also contain information that is not analytically relevant to the proposition, yet equally important in invoking the perceptual experience associated with the meaning of the utterance that the proposition seeks to model. For example, to infer from the sample text T that the categories - Bike manufacturer, Government and People contribute to each other's behavior and, hence, constitute a unified-whole is quite challenging. The text contains no explicit mention of the unified-whole or any semantic relation that can be mapped to the semantic primitives of a part-whole relation (Winston, Chaffin et al. 1987). As a result, it is difficult to devise linguistic markers that can be used to extract such implicit compositional information based on purely propositional forms of part-whole relation.

A situated view of conceptualization (Barsalou 2009) is grounded in the perceptual experience that is associated with a category. In the context of natural language processing, it models information contained in a linguistic expression as not localized in some fixed, predetermined lexical pattern but as distributed across different aspects of the various natural language expressions constituting the discourse (Langacker 2008). The basic idea is to adopt an experientially grounded approach to conceptualization and model composition at a pre-conceptual level - as an embodied pattern of cognitive reference, (Rosch 1975) (Tribushinina 2008). Cognitive reference provides a generalized interpretation of composition as an interaction between two categories such that one category serves as the reference for understanding the other and that this reference has some cognitive appeal to the observer. The under specification of the conceptual relevance of the cognitive appeal is intentional as it allows to admit all possible aspects of the behavior that a category may exhibit.

From a natural language processing point of view, dependencies between different syntactic categories provide a natural means of extracting linguistic evidence for cognitive references. For example, prepositions represent a syntactic category that can be viewed as a semantic relation between a structure that precedes it, e.g. a verb, or a noun-phrase, and another one that follows it, e.g. a noun-phrase (Saint-Dizier 2006). Similarly, we can also interpret the verb relations and attributive relations like modifiers as evidence for cognitive referencing. In the case of verbs, we get greater specificity by also acknowledging the semantic role assignment done by parsers (Jackendoff 1987), (Fillmore 1968), (Dowty 1991).

We adopt an object-oriented representation (Sowa 1984) approach that models categories as entities and relations as cognitive references inferred from syntactic dependencies. The resulting digraph is then analyzed for cyclic references, which are resolved by introducing an additional level of abstraction for each cycle. Mutually interdependent set of categories are considered conceptually inseparable and assigned an independent level of abstraction in the hierarchy. Presence of such levels in the compositional hierarchy highlight the need to model these categories as a unified-whole wherein they can only be characterized in the context of the behavior of the set as a whole.

2 CHARACTERIZING COMPOSITION

Linguistic utterances encode two basic types of information – information about the state of affair it describes and information indicating various speech acts it intends to perform (Wilson and Sperber 1993). The first type of information is explicit in the sense that the state of affairs described in the utterance can be decoded directly from the various lexical and syntactic constructs used in the utterance. The second type of information is implicit, for example, expressions of subjectivity, which need additional knowledge support to be inferred. In this section, we present two characterizations of composition – the proposition based characterization, which operates at the linguistic level and the experientially situated characterization, which operates at the pre-linguistic level.

2.1 Propositional Approach to Composition

Propositional form of conceptualization is rooted in the logical tradition, which defines a conceptualization as a set of truth-conditions that are evaluated to ascertain if a conceptualization holds in a given context. In the context of natural language processing, truth-conditions correspond to the occurrence of the linguistic marker associated with the proposition. For example, a part-whole conceptualization represented in propositional form as *part (wheel, bike)* is considered decodable from a given text if and only if the text contains the natural language expression 'wheel is part of the bike'. The linguistic marker here is a lexical pattern comprised of named entities *wheel*, *bike* and the copula verb, *part*. The proposition cannot be decoded from any other natural language expression, for example, 'wheel is attached to the bike', or extended to part-whole relations between other categories, for example, 'roads are required to bike', unless additional truth-conditions are associated with the proposition. For the three expressions mentioned above to be decodable as a conceptualization of part-whole relation, the following truth conditions need to be specified as three separate linguistic markers: *part (NE, NE), attach (NE, NE)* and *require (NE, NE);* where NE stands for named entities. Existing information retrieval methods try to minimize the false negatives associated with proposition based concept extraction by expanding the set of linguistic markers used to define the truth conditions of the proposition being decoded. Various automatic and semi-automatic schemes have been developed to identify linguistic markers corresponding to the different lexical and syntactic divergences (Dorr 1993) that the linguistic interpretation of the proposition may undergo. A widely used algorithm for extracting semantic relations through the use of lexico-syntactic patterns is described in (Hearst 1992).

From a knowledge organization point of view, logic based modeling of semantic relations help to structure the concepts in ways that permit automated inference making and is hence widely popular. As part of this modeling tradition, the part-whole relations limit composition to include only those interactions between categories that can be characterized along the following three dimensions – whether the categories are functionally related to each other; whether the categories can exist independent of each other; and whether they are of the same type (Winston, Chaffin et al. 1987). The primary motivation to identify these semantic primitives of part-whole relations is to maintain transitivity as an invariant across all occurrences of part-whole relations in natural language use. Transitivity is an important logical property, in addition to antisymmetry and reflexivity, that underlies much of the inference-making in hierarchies, for example, query expansion (Nie 2003). These semantic primitives are often used to further improve the performance of decoding part-whole relations from natural language text by generating linguistic markers from some widely used keywords that convey the meaning associated with the semantic primitives underlying the propositional interpretation of part-whole relations (Girju and Moldovan 2002), (Khoo, Chan et al. 2000). For instance, 'cause' as a keyword for functional dependence, 'component' or 'part' as keywords for independence of existence and 'such as' or 'for example' as keywords for similarity of type. These keywords are then used to identify lexico-syntactic patterns either manually or semi automatically often with the aid of lexical knowledge bases like WordNet (Miller 1990).

2.2 Situated Approach to Composition

Traditionally the focus has been on propositional forms of knowledge thereby disregarding related information readily available within the language domain, for example, expressions of subjectivity and linguistic expressions outside the proposition (Narrog 2005). One way of interpreting implicit experiential information is to view them as encoded in semantic relations that do not have an explicit mapping to the semantic primitives associated with part-whole relations. As a result they cannot be decoded directly but can only be inferred from the larger context in which they occur. Very often this context may be distributed across several sentences.

Cognitively, conceptualization is situated (Barsalou 2003). It is the reenactment of a combination of prior experiences that together simulate a perceptual experience in the form of a situation - experienced or imaginary. A simulated situation captures only one of many possible aspects of a category observed in reality. Diverse aspects of a category may get simulated across different situations. A situated view of conceptualization is an experientially grounded view of conceptualization and, in the context of language, it models information contained in a linguistic expression as not localized in some fixed predetermined lexical pattern but as distributed across different aspects of the expressions constituting a discourse (Langacker 2008). The basic idea is to adopt an experientially grounded approach to conceptualization and model composition as a pre-conceptual embodied pattern.

Simulating perceptual experience from these modal states is then an exercise of inferring and/or composing a situation. The multi-modal experience that the situation represents is reenacted at the different modal systems thereby simulating an experience of being in that specific situation. Such multi-modal simulation based model of conceptualization highlights the situated nature of concepts and is referred to as situated conceptualization (Barsalou 2009). Such situation specific inferences are, in principle, motivated by the theory of situation semantics, where logical inference is optimized when performed in the context of specific situations (Barwise and Perry 1983).

2.2.1 Cognitive Reference as an Embodied Pre-linguistic Structure of Composition

A pre-linguistic structure of conceptualization refers to the organization of knowledge at a level of abstraction that is higher than the linguistic level, where organization is limited to explicitly stated propositions. The knowledge available at such higher levels of abstraction is experiential in nature, with both explicit and implicit information encoded in the linguistic utterance contributing to the perception of the experience. Various cognitive constructs have been proposed to motivate the organization of knowledge at the pre-linguistic level. These include the notion of force dynamics (Talmy 1988), image schemas (Lakoff and Johnson 2003), construals (Langacker 1987), mental spaces (Fauconnier 1994) and reference point constructions (Langacker Ronald 1993).

Amongst these the notion of cognitive reference point (CRP) construction lends itself naturally to the modeling of composition at the pre-linguistic level. CRP is the cognitive act of referring one entity by invoking another (Rosch 1975). A CRP models composition to include not only propositional forms of part-whole relation but any relation, distributed or local, that establishes a link between two categories such that link has some conceptual relevance and is asymmetric in nature. The asymmetry requirement of the link restricts the interpretation of CPR to only those relations, which clearly distinguish foreground information (focal category) from background information (contextual category) and protects it from the risk of degenerating to any meaningful relation between categories. Meanwhile, the under specification of the conceptual relevance of the cognitive appeal is quite useful for modeling composition as it allows to admit all possible aspects of the behavior that a category may exhibit.

2.2.2 Interpreting novelty from circular cognitive referencing

The notion of novelty can be explained both ontologically and epistemologically (Bunge 2004). From an ontological point of view, novelty is said to occur only when there is explicit knowledge about a new category and adequate information to verify the associated novel property using some truth-conditional formulation. In the context of this work, we follow an epistemic interpretation of novelty as patterns of association, which only indicate the occurrence of novelty and provide no additional information that could help reify the ontological status of the indicated novelty.

Cognitive reference provides a generalized interpretation of composition as an interaction between two categories such that one category serves as the reference for understanding the other and that this reference has some cognitive appeal to the observer. As a result, mutually interdependent set of categories are considered conceptually inseparable and assigned an independent level of abstraction in the hierarchy. Presence of such levels in the compositional hierarchy highlight the need to model these categories as a unified-whole wherein they can only be characterized in the context of the behavior of the set as a whole.

3 APPROACH

Instances of cognitive reference from text can be interpreted from dependencies between lexical elements in a sentence. The fundamental notion of dependency is based on the idea that the syntactic structure of a sentence consists of binary asymmetrical relations between the lexical elements of a natural language expression (Tesniere 1959). Dependency types commonly used in dependency parsers include surface-oriented grammatical functions, such as subject, object, modifiers, and a set of more semantically oriented role types, such as agent, patient, and goal (Nivre 2005). Semantic roles are theme revealing relations that express the role that a noun phrase plays with respect to the action or state described by a sentence (Jackendoff 1987), (Dowty 1991). When these roles are defined exclusively in relation to the sub-categorization frame of the verb they are referred to as case roles (Fillmore 1968).

We use the Stanford dependency parser for English language text (de Marneffe, Maccartney et al. 2006). Following the terminology used in the Stanford dependency manual, a dependency relation holds between a governor and a dependent and is represented as: `dependency(governor,dependent)`. Each dependency connection, in principle, links a superior term and an inferior term. The superior term receives the name governor and the inferior the name dependent. The superior/inferior characterization for a pair of words is based on different morphological, syntactic and semantic considerations. In the context of this work, the interest is more to characterize superior/inferior from a cognitive reference point of view – superior as the one in the foreground (focal) and inferior as the one in the background (context). The background word contributes to the understanding of the word in the foreground. As mentioned in (Langacker 1994), the structural syntax based dependency framework and the cognitive reference framework have substantial similarity. The acknowledgement of the underlying similarity encourages us to re-interpret dependency relations between lexical items from a cognitive reference perspective.

The Stanford dependency manual (De Marnee and Manning 2011) lists 53 grammatical relations. Table 1 lists the dependencies considered in this work and their re-interpretation as focal and contextual categories.

Type	Syntactic dependency	Cognitive reference
Verb	*obj(A,B), agent(A,B)	A(focal), B(contextual)
	*subj(A,B)	A(contextual), B(focal)
Preposition	prep*(A,B)	A(focal), B(contextual)
Attribute Modifiers	amod(A,B)	A(focal), B(contextual)

Table 1: Interpreting syntactic dependencies as cognitive references.

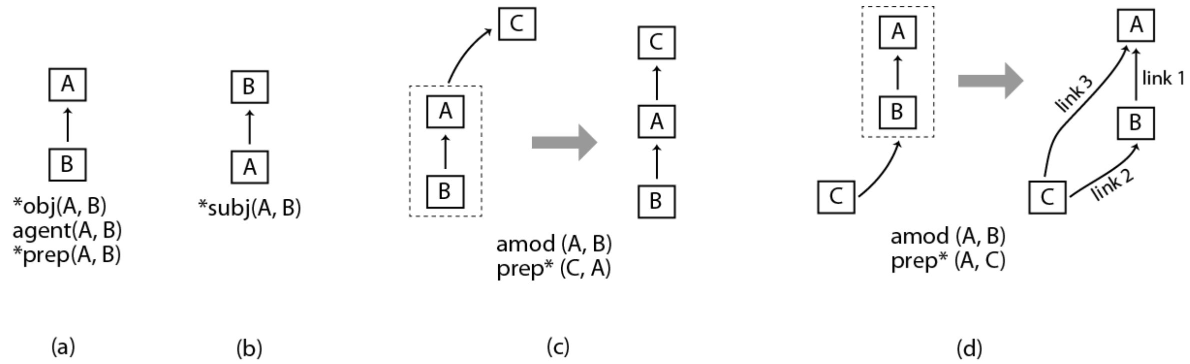

Figure 2: A visual depiction of the mappings from syntactic dependencies to cognitive reference

Most dependencies can be interpreted directly as a cognitive reference link, with the governor as the focal category and the dependent as the context. For subject dependencies, it is the other way round: governor as the context and dependent as the focal category. This is due to the interpretation of verb as a link between its different arguments – the object qualifying the meaning of the verb and subject being qualified by verb as providing the context in which the subject is being referred. A visual depiction of the cognitive reference links inferred from syntactic dependencies is provided in figure 2. A special pattern resulting from a combination of attributive and prepositional dependencies is worth mentioning. The case where the focal categories are different, e.g. figure 2(c), the combination of attributive and prepositional qualifiers can be organized as a uni-path hierarchy, which can be seen as context refinement. The case where the focal categories are the same results in a multipath-hierarchy as the focal category can be interpreted in multiple contexts, figure 2(d).

Consider the following sentence:

S: *The government has improved the infrastructure by adding dedicated bike lanes for riding the bikes.*

The dependencies generated by the Stanford parser for S are depicted as a graph in figure 3. This visualization is obtained using a freely available plug-in, DependenSee, from the Stanford natural language processing group website (Group 2012). It is important to note that the cognitive reference point relation links lexical elements with binary asymmetrical relations as a result each sentence can be depicted as a directed acyclic graph, DAG. As explained earlier, the only semantics associated with this link is encoded in its direction – the source being the constituent category and the destination the focal category. The DAG depicting the cognitive reference links embedded in the sentence S is shown in figure 4.

The DAG for each sentence in the text is merged by only admitting one node per category. Conceptually this amounts to making explicit the implicit connections in the text. The resulting graph is directed but not necessarily acyclic. The cycles in the digraph correspond to interdependence between categories. The digraph representing the cognitive references between categories described in $\mathcal{T}$ is shown in figure 5.

The cognitive reference digraph is then analyzed for cycles by identifying the strong components of the digraph. A strongly connected component of a digraph is a maximal set of vertices in which there is a path from any one vertex to any other vertex in the set (Tarjan 1972). The algorithm used to identify the strongly connected components of the digraph is due to KosarajuSharir and described in detail in (Sedgewick 2011).

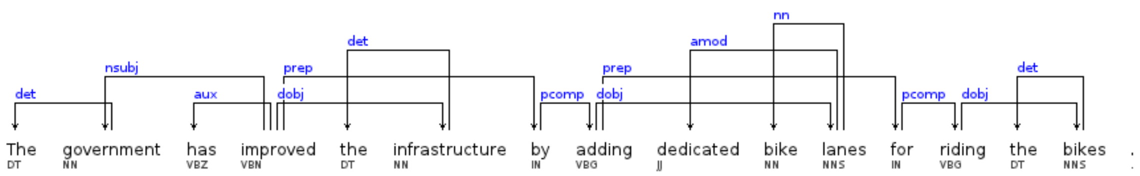

Figure 3: Dependency graph visualization of S

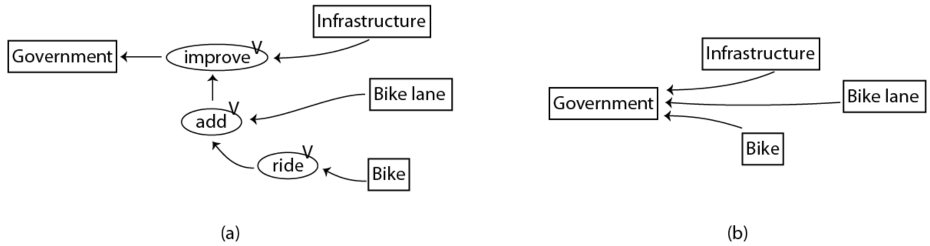

Figure 4: Cognitive reference graph visualization of *S*

4 CONCLUSIONS

Data mining is defined as "…the analysis of (often large) observational data sets to find unsuspected relationships and to summarize the data in novel ways that are both understandable and useful to the data owner" (Hand, Smyth et al. 2001). Nevertheless, efforts to find unsuspected relationships from data and their use in formulating new hypothesis should not be interpreted as the absence of any initial hypothesis, which in the first place guides one to find such unsuspected relationships. For example, the use of distributional hypothesis that assumes terms to be similar to the extent to which they share similar linguistic contexts (Harris 1968). In this case what is unknown is the nature of similarity and its relationship to different patterns of linguistic context. Communicating this work to the data mining community is equally relevant as it presents a cognitive model of composition, which can be used as a starting point for developing new data mining schemes realize this model in a computational setting.

The primary purpose of this work is to suggest an alternate conceptualization of composition and show how it can be more rewarding by making it easy to identify novel aspects of observed reality. From a relevance point of view, the work was motivated based on its usability in a very concrete

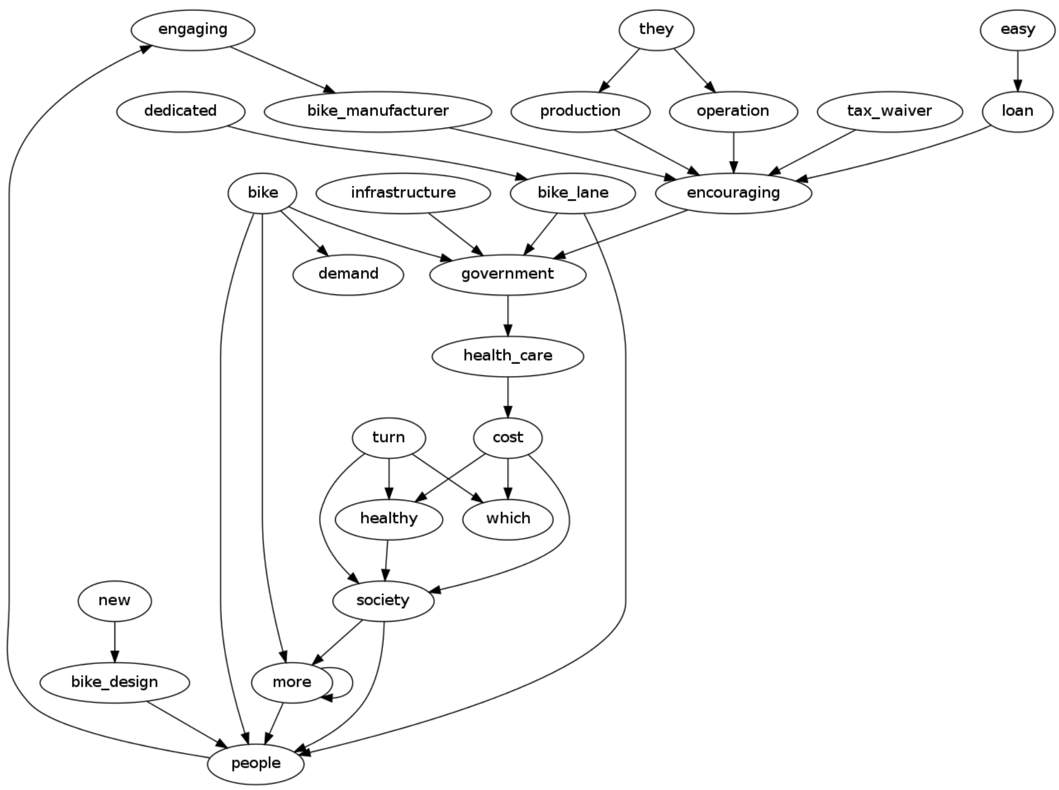

Figure 5: Cognitive reference revealing digraph visualization of $\mathcal{T}'$

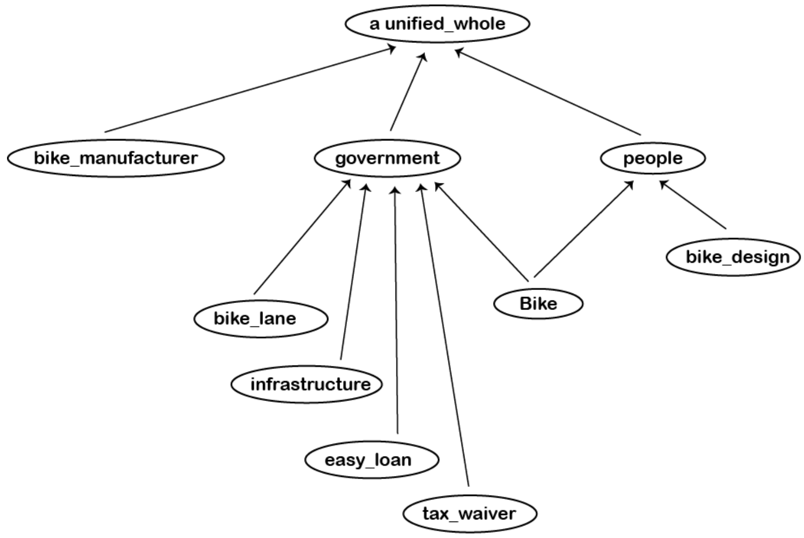

Figure 6: Compositional hierarchy representation of $\mathcal{T}'$ depicting integrated-wholes

domain that of service design specification by linking novelty to the notion of requisite variety, thereby making service design conscious of the need to anticipate the operating environment conditions and account for them by including enough flexibility in their design. The current exposition is, however, limited in its scope to only identify the existence of novelty and not to provide any conceptual interpretation of the novelty of the unified-wholes.

An important future work in this regard is to apply this model of extracting compositional hierarchies to diverse text samples and study the extent to which it is able to detect cognitive reference cycles. Based on our experimentation, there could be situations where the cognitive interdependence may not be detectable as a complete cycle and some threshold based connectivity measure might help further reduce the false negatives associated to identify unified-whole in compositional hierarchies.

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Appendix 3

A SYSTEMIC DESIGN OF REGULATION ENABLING ONTOLOGY

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Abstract: The deregulation of economies has re-created the need for regulation. From a Systems perspective, the unbundling of large monolithic industrial setups into smaller independent companies results in the dissolution of high level management structures which, in the pre-deregulated era, had the overall control of the end-to-end delivery process. In the absence of such holistic oversight mechanisms, deregulated industries remain vulnerable to systemic failure. Industry regulators need to go beyond the usual concerns of price, quality, and access, and invest in methods that capture the interactions between the different stakeholders in an industry. It is the understanding of the individual interactions that can help piece together a holistic view of the industry; thereby allowing the regulator to devise well informed interventions. In this paper we model industry interactions as a multi-party value realization process and take a Systems approach in analyzing them. Every value realization is analyzed both at the industry level and at the level of stakeholders within the industry. The design patterns that emerge from this whole/composite view of value realization form the basis for formalizing the concepts required to analyze the working of an industry. An explicit specification of these concepts is presented as Regulation Enabling Ontology, REGENT.

1 INTRODUCTION

The deregulation of economies has led to the unbundling of large, vertically integrated, monolithic, industrial monopolies into lean, efficient and more focused entities with the freedom to develop upstream and downstream interconnections (Baldwin & Cave, 1999). Network Industries (Shy, 2004), such as electricity, telecommunication, transportation, posts, gas and water supply, are most representative of such restructuring. From a management perspective, such unbundling results in the dissolution of the high level management structures which, in the pre-deregulated era, were responsible for the complete end-to-end delivery process. A deregulated industry is, instead, composed of multiple smaller management structures, each restricted in scope to some specific aspect of the overall industry. For instance, the deregulation of Electricity Supply Industry (Zaccour, 1998) led to its restructuring along functional lines. Separate companies emerged for generation, transmission and distribution of electricity. These companies have independent management structures, each responsible for their part of the industry and interacting purely on an economic basis. The absence of a holistic industry wide management structure makes deregulated industries vulnerable to systemic failure. Modern regulatory systems need to go beyond the usual concerns of price, quality, output and access, and invest in schemes that capture the interactions among the stakeholders of the industry. Understanding these individual interactions help piece together a holistic view of the industry, thereby allowing the regulator to devise well informed interventions that can ensure the sustainable development of the overall industry.

Industries are composed of multiple stakeholder groups: the companies that supply certain goods or services, the individuals that consume them, the government that facilitates these transactions and the environment that provides the necessary backdrop for these interactions. Any interaction within an

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industry can be reduced to an instance of the multi-party relation that exists between these four stakeholder groups. The plurality in relationship and the diversity in stakeholder beliefs that underlie these relationships make the effort of developing a holistic understanding of an industry even more challenging.

To address these challenges, we invoke the notion of value and model every relationship in an industry as a set of value realization processes. Value is a qualitative concept and, thus, well suited for an interdisciplinary discourse. Taking a Systems perspective, we analyze the value realization process both at the industry level and at the level of individual stakeholders within the industry. Two important design patterns emerge from this whole/composite view of value exchange: any value created in an industry has an associated supplier and adopter, a supplier of one set of value is an adopter of some other set of value. These design patterns form the basis for formalizing the concepts required to explain multi-party relationships in an industry.

This paper is an attempt to provide an explicit specification of these concepts as ontology. The ontology will provide regulators with a standard representational vocabulary with which they can document the material and information interplay between the different stakeholders of an industry. It is the abstraction of industry specific configuration details as shared pan-industry concepts that will facilitate the knowledge-level communication among the community of regulators, thereby enabling more effective and speedy sharing of regulatory best practices. Section 2 provides a brief overview of Systems thinking approach and presents a Systems perspective of the de-regulated electricity supply industry. Section 3 explores the notion of value in greater detail and introduces the concepts of resource and feature as building blocks of the value realization process. Section 4 describes the Regulation Enabling Ontology, REGENT, in detail, highlighting the different design choices that were made during the development of REGENT. Section 5 instantiates REGENT for the Urban Household Electricity Industry and, as an example, demonstrates its effectiveness in establishing regulatory oversight. Section 6 presents some related work in this field. The paper concludes with future work directions in Section 7.

2 A SYSTEMS PERSPECTIVE OF INDUSTRY

A Systems approach to understanding the relationship between the stakeholders of an industry allows taking a holistic view of the industry and analyzing how these relationships influence one another in the context of the overall well being of the industry. This is particularly useful for deregulated industries where management structures only exhibit knowledge about local relationships and the relevance of these relationships to the entire system remains largely unexplored. For a regulator to act as a true custodian of the industry, it is important that it has the complete knowledge about the different interactions that occur in an industry and the bearing these relationships may have on the overall working of the industry. To further illustrate the affect of deregulation on the overall management of the industry, we use the visual semantics of SEAM to analyze the evolution of Electricity Supply Industry.

SEAM is a set of Systemic Enterprise Architecture Methods (Wegmann, Julia, Regev, & Rychkova, 2007) that exploit the principles of General Systems Thinking (GST) (Weinberg, 1975). GST advocates that the component parts of a system can be best understood in the context of relationships with each other and with other systems, rather than in isolation. An important way to fully analyze a system is to understand the part in relation to the whole. SEAM represents any perceived reality as a hierarchy of systems. Each system can be analyzed as a whole [W] - showing its externally visible characteristics or as a composite [C] – showing its' constituents as a set of interrelated parts. When applying SEAM to an industry, two main aspects are analyzed: (1) How different stakeholders cooperate together to achieve some common objective; these groups of stakeholders are referred to as value network, VN. (2) How these value networks interact within an industry; these interactions are referred to as Multi-Party Relationship, MPR. The visual syntax of SEAM includes block arrows for systems, annotated ovals for externally visible properties, diamonds for relations, simple lines for active participation to a relation, dashed lines for pseudo participation to a relation and rounded end-point lines for emphasizing the identical nature of modelling elements.

Figure 1 presents a SEAM depiction of a pre-deregulated Electricity Supply industry. The four prominent entities that engage in the activities of this industry are the Electricity Supply Company (ESC), Electricity Consumer VN, Government VN and the Environment VN. When viewed as a whole, the ESC [W] exhibits the overall responsibility of maintaining an end-to-end supply of electricity –

from generation to distribution. When viewed as a composite, the ESC [C] reveals its' constituent subsystems. ESCs can have different architectures. Nevertheless, for these subsystems to work as a viable whole, each ESC has some form of management subsystem (Beer, 1985) that oversees the end-to-end delivery process.

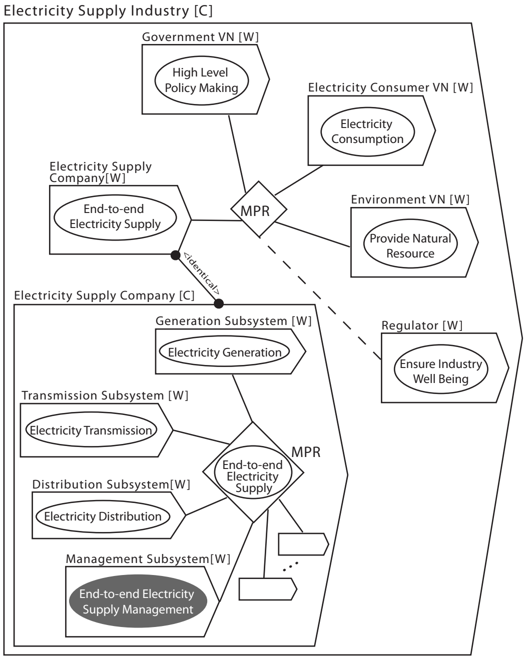

Figure 1: Pre-deregulated Electricity Supply Industry.

Figure 2 presents a SEAM depiction of a deregulated Electricity Supply Industry. The vertically integrated ESC of the pre-deregulated era stands unbundled into independent Generation, Transmission and Distribution Companies. The presence of multiple such companies constitutes competition, and provides the Electricity Consumer VN the choice to buy electricity from one Generation Company, get it transmitted through some other Transmission Company and receive the end supply service from yet another Distribution Company. These three companies when put together represent the Electricity Supplier VN. From a management perspective, each of these companies is controlled by an independent management subsystem which is strictly limited to its' part of industry operations, e.g. generation, transmission or distribution. Unlike the pre-deregulated era, there exists no end-to-end electricity supply management system that can be held responsible for the overall delivery of the supply.

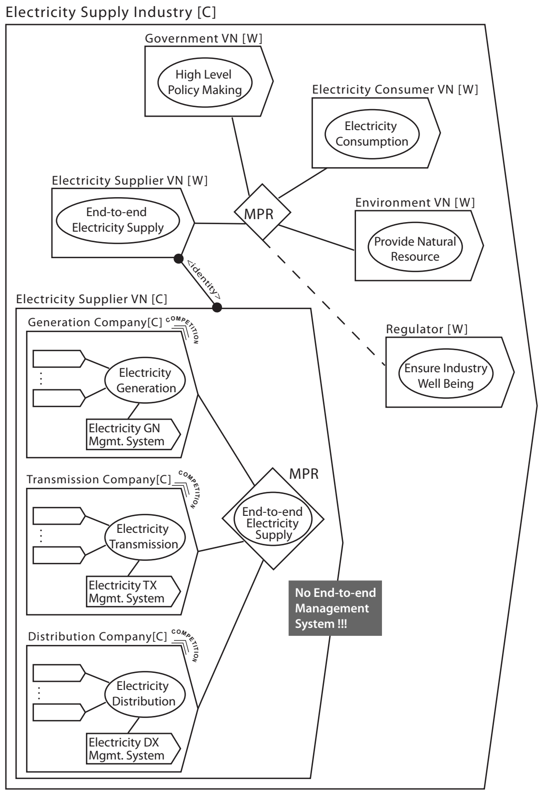

Figure 2: Deregulated Electricity Supply Industry.

3 THE RESOURCE-FEATURE-VALUE TRIUNE

An industry is a complex composition of diverse stakeholder groups. Suppliers are primarily concerned about issues related to market share, profit and return-on-investment; consumers are concerned about cost, availability, reliability and ease-of-use; governments are concerned about collective welfare, institutional relevance and political indispensability; and the issues of interest from an environment point of view include habitat and climate related ecological concerns. To realize the benefits of Systems approach in analyzing the different facets of an industry, it is important to first identify a unifying concept that can act as a generic platform for the interdisciplinary discourse required in an industry. In this paper we exploit the notion of *value* as the unifying concept and treat the above mentioned stakeholder concerns as context specific manifestations of the value concept.

Based on the analysis presented in (Ramsay, 2005), we define value as the tangible or intangible effect accrued by a stakeholder through the consumption or trade of a service or good. The notion of value is at the heart of MPR modeling. Stakeholders aspiring for a common set of value are grouped together as a VN. MPR models industry interactions as a value realization process between VNs. VNs exchange resources, material and information. Any resource addition to the VN affects the stakeholders of the VN either in a favorable way, realizing positive value, or in an unfavorable way, realizing negative value. Figure 3 depicts MPR as a bi-directional value realization process between the different VNs in an Electricity Supply Industry.

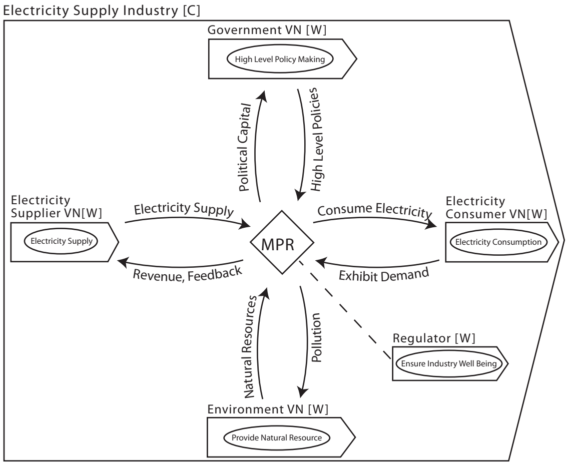

Figure 3: Bi-directional value realization in MPR.

Value is a subjective notion, dependent exclusively on stakeholder perceptions. An effect welcome by some stakeholders may be completely rejected by others. For example, time based electricity pricing schemes where a consumer can pay less for off peak electricity usage is perceived by many as a positive value as it provides an opportunity to reduce electricity bills by shifting workloads to low cost off peak durations. For others this may not be a welcome change as it results in increased night time activity in the neighbourhood. As a result it is desirable to explicitly specify the context in which a value is created, delivered or consumed. We accomplish this by introducing the concepts of resource and feature.

We follow the definition given in (Barney, 1991), where *resources* are defined as "... assets, capabilities, processes, and information" in control of the stakeholder. Thus resource can be considered as the contribution an individual stakeholder can bring to a VN. *Feature* on the other hand is a composite attribute which exists only at the VN level. Based on the resources available with the different stakeholders of a VN, the VN may exhibit different properties. These properties emerge from the different combinations between these resources, and are known as the features of the VN. For a given industry, an MPR identifies the different resources available with each VN, the set of possible features that may emerge from them and the value these features may bring to the other VNs. The same is presented in Figure 4. The use of the term enterprise in the figure is a more formal way of referring to stakeholders constituting a VN. The resource, feature and value concepts coupled with the GST inspired whole-composite view of value exchange guides our ontology design activity. Two important design patters emerge from this combination.

D1. *For every value created in an industry there exists a supplier VN and an adopter VN*

D2. *Each VN in an industry acts as a supplier of one set of value and an adopter of another set of value*

Supplier and adopter are roles assigned to VNs while analyzing MPRs. The supplier role signifies ownership of resources required to create/produce and deliver the services or goods. The adopter role signifies ownership of resources required to consume the service or good thereby realizing the value advertised through the features of the service or good.

Design Patterns have their genesis in the field of architecture where they were first proposed as an

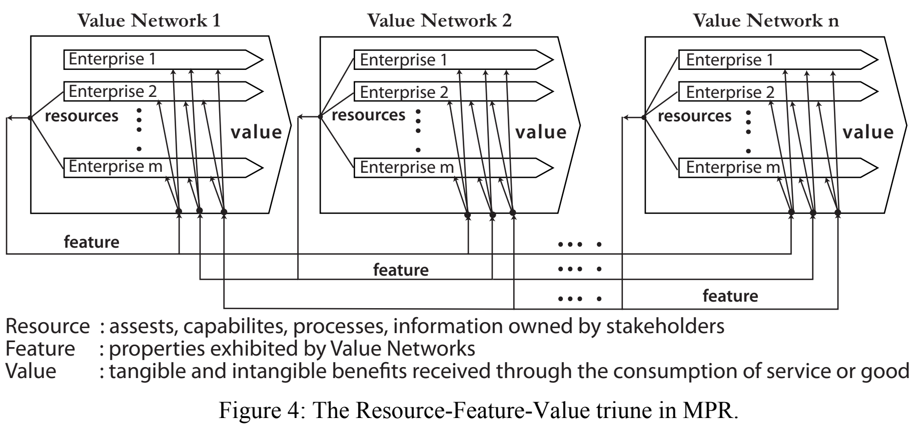

Figure 4: The Resource-Feature-Value triune in MPR.

architectural concept by Christopher Alexander (Alexander, 1979). These were later adopted in software engineering, and are defined as an artifact in the form of a construct, a model, a method or an instantiation, which is general enough to be reusable in solving commonly occurring problems (Gamma, Helm, Johnson, Vlissides, & John, 1995). In this paper we use these two design patterns as the basic constructs for formally specifying the knowledge required to formulate an overall understanding of any industry.

4 REGENT: A REGULATION ENABLING ONTOLOGY

As defined in (Gruber, 1993), ontology is an explicit specification of a shared conceptualization. It is aimed at formalizing a specific view point that enables/enriches the discourse on some aspect of interest in the real world. The purpose of REGENT is to enable the discourse on industry regulation. Formalization of the concepts that constitute an industry and the relationships that hold among these concepts provides a common vocabulary with which regulators can represent their understanding of the industry. Such a standardized way of documenting information is particularly useful in promoting knowledge-level communication between the different industry regulators.

Various ontology languages exist to represent these concepts and relationships. The most prominent of these is OWL (W3C, 2004). It is developed by the World Wide Web Consortium and consists of individuals, properties, and classes. Individuals represent the objects in the domain of interest, properties are binary relations on these individuals, and classes are interpreted as sets that contain these individuals. Our reference to concept and relationship maps to the notion of class and property in OWL. Individuals are instantiation of concept. OWL has three sub-languages: OWL-Lite, OWL-DL and OWL-Full. The expressiveness of OWL-DL falls between that of OWL-Lite and OWL-Full. It is based on Description Logics (Baader, Calvanese, McGuinness, Nardi, & Patel-Schneider, 2003) which are a decidable fragment of First Order Logic and are thus conducive for automated reasoning. For this purpose we use OWL-DL as the language for specifying REGENT. The development of REGENT was done using the ontology development tool, Protégé (Stanford Center for Biomedical Informatics Research, 2010). The visualizations presented in this paper have been created using the OntoViz graphical plug-in in Protégé. In the following, we present our design choices for REGENT.

REGENT has two top level classes: `IndustryConcept` class and `ConceptSpacePartition` class. `IndustryConcept` is the foundational class for all the concepts in an industry. It is based on the Resource-Feature-Value triune detailed in sub-section 2.3. `ConceptSpacePartition` is the class which subsumes the different viewpoints that can be useful in analyzing the set of concepts detailed in the `IndustryConcept` class.

4.1 The IndustryConcept Class

The `IndustryConcept` class formalizes the concepts of resource, feature and value. Figure 5 presents the taxonomy of the `Resource` class. The `Resource` class has two subclasses: `Commercial` and `Operational`. This refinement of the `Resource` class is a manifestation of the design pattern D2. As depicted in Figure 3, every value realization is a bi-directional process. We exploit the dual nature of VN, i.e. the simultaneous role of a supplier of one value and an adopter of some other value, to classify the resources available with a VN. From an industry perspective, a product or service creation process has two parts – the operational

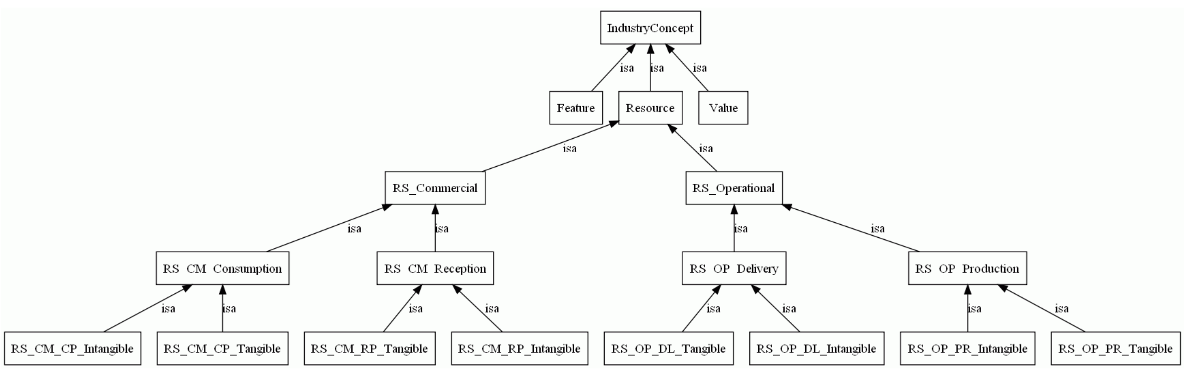

Figure 5: Taxonomy of the Resource class.

process of bringing the service or good into existence and the commercial process of making it tradable (Smith, 1904). The operational process is related to the supplier role of VN; the supplier has complete control over this process. On the other hand, the commercial process is related to the adopter role of VN. It is aimed at making the service or good conducive for consumption and, thus, requires taking an adopter perspective. Accordingly, the set of resources in an industry can be divided into two – the ones required to realize the operational process, the `RS_Operational` class, and the others required to realize the commercial process, defined as the `RS_Commercial` class.

We can further refine this classification by exploiting the insights of the supplier and adopter process. At the supplier end, bringing a service or good into existence entails two aspects – production and delivery. For instance, in the Electricity Supply Industry it is not sufficient for the electricity to be generated at the generation units, it is equally important that it is available at the prospective location of consumption. Operational resources that contribute towards the production of the industry offering are categorized as the `RS_OP_Production` class while the ones that contribute towards the delivery of the industry offering are categorized as the `RS_OP_Delivery` class. At the adopter end, realizing the benefits of the offering entails two aspects – reception and consumption. For instance, the complementary nature of electricity requires the availability of electrical appliances to consume electricity. Commercial resources that contribute towards the consumption of the industry offering are categorized as the `RS_CM_Consumption` class while the ones that contribute towards the reception of the industry offering are categorized as the `RS_CM_Reception` class. Finally, based on their cognitive orientation a resource can be further classified as tangible and intangible. The leaf nodes of the taxonomy presented in Figure 6 refine the higher level `RS_CM_*` and `RS_OP_*` classes as `RS_*_*_Tangible` and `RS_*_*_Intangible` subclasses.

Figure 6 presents the taxonomy of the `Feature` class. The `Feature` class is a manifestation of the design pattern D1. As argued in (Ramsay, 2005), we do not treat value as an intrinsic characteristic of a product or service, and hence do not subscribe to the value chain metaphor (Porter, 1985) which is often interpreted to suggest that a value can be moved from the supplier to the adopter. The notion of supplier and adopter in D1 is to highlight the role of VNs in supplying resources that lead to the realization of some value at the adopter VN. Nevertheless, connecting resources directly to value will bypass an intermediate composition level where resources from different enterprises within a VN come together to define artifacts with some potential value content. This concept of composition is concretized in the `Feature` class. Features can, thus, be viewed as the potential value of a combination of one or more resources of a supplier VN. This potential value gets transformed into realized value when the adopter VN consumes the underlying artifact i.e. the industry offering. Thus feature and value differ only in the context of the observer. Feature expresses the view of the supplier of his product or service and value is the view of the adopter of the consumed product or service. This difference is captured as property constraints and is further detailed in Section 4.3.

From a taxonomy point of view, interpretation of features as potential value results in similar refinements of the `Feature` and `Value` classes. The taxonomy of the `Feature` class is presented in Figure 6. We posit that the `Value` class has a similar taxonomy tree hence do not present it separately. The following discussion on the specificities of feature refinement applies equally to the value concept.

The `Feature` class has two subclasses: `FT_Utility` and `FT_Warranty`. Utility and warranty are two concepts publicized as part of the Information Technology Infrastructure Library (ITIL) (OGC, 2007), developed by the UK's Office of Government Commerce (OGC) for Information Technology Services Management. Utility captures the functionality offered by a product or service and is informally interpreted as 'what the industry offering does'. On the other hand, warranty is the promise that a product or service will

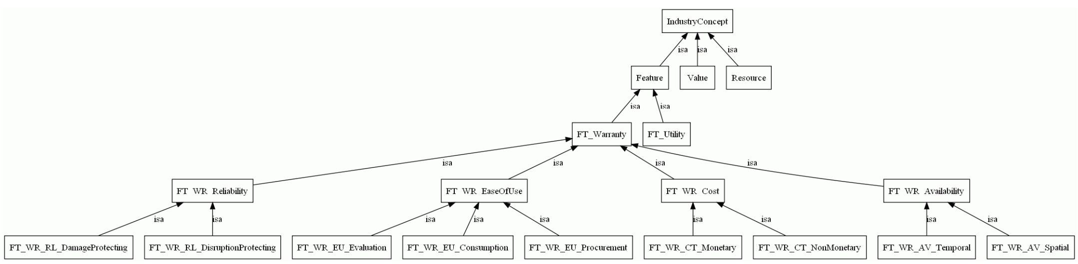

Figure 6: Taxonomy of the Feature class.

meet its' agreed requirements, informally interpreted as 'how the industry offering is done'. In the Requirements Engineering field, these are often termed as the function and non-functional requirements (Gause & Weinberg, 1989).

The utility of a service or good is usually well understood. It is the warranty aspect that is open to interpretation and is hence further refined. A warranty can be related to the availability, reliability, ease of use and cost of the service or good. The `FT_WR_Availability` class represents the attributes that capture the readiness of the service or good to be consumed by the adopter. The readiness can be both temporal, `FT_WR_AV_Temporal` class, and spatial, `FT_WR_AV_Spatial` class. The presence of electricity supply at the time and place of consumption will constitute the temporal and spatial availability of the service provided by the ECN. The objects of the `FT_WR_Reliability` class represent the appropriateness of the service or good for consumption. Appropriateness can be achieved by ensuring safeguards against disruptive failures, the `FT_WR_RL_DisruptionProtecting` class, and damaging failures, the `FT_WR_RL_DamageProtecting` class. For instance, the use of surge protector equipment can protect against slight variations in electricity supply but a line breaker would be required to stop the supply in the event of very high variations in supply. The `FT_WR_EaseOfUse` class represents the (in) convenience of evaluating – `FT_WR_EU_Evaluation`, procuring - `FT_WR_EU_Procurement`, and consuming - `FT_WR_EU_Consumption`, a product or service. The `FT_WR_Cost` class captures the attributes that define the cost of the service or good. The cost can be interpreted both in monetary, `FT_WR_CT_Monetary`, and in non-monetary terms, `FT_WR_CT_NonMonetary`.

4.2 The ConceptSpacePartition Class

The taxonomy of the `ConceptSpacePartition` class is presented in Figure 7. As the name suggests, this class creates a partition on the set of concepts represented in the `IndustryConcept` Class. A partition imposes a certain view of the industry. The `Enterprise` subclass partitions the various concepts in an Industry along the well established boundaries of legal ownership and undertaking. For instance every resource in an industry is owned by some enterprise. `Enterprise` subclass is the default

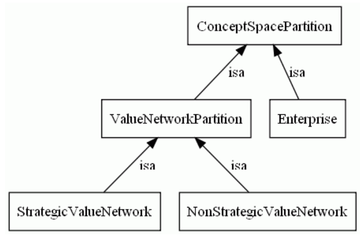

Figure 7: The Taxonomy for ConceptSpacePartition Class.

partition of the objects represented by `IndustryConcept` class.

The `ValueNetworkPartition` subclass is a manifestation of the Value Network concept in SEAM. It relies on the default `Enterprise` class imposed partition on industry concepts. More specifically, the `ValueNetworkPartition` subclass partitions the various concepts in an industry along the common intent of the enterprises where these concepts originate. It is important to note that the absence of an explicit intent is also a commonality and, hence, can form a valid partition of the Industry concepts. As a result, the `ValueNetworkPartition` class is further sub-divided into `VNP_Strategic` and `VNP_NonStrategic`. The strategic subclass refers to a partition that is based on some maximizing something – profit, welfare, power, etc. By contrast, the non-strategic subclass is blind and has no objective, no preferences, and no foresight, for instance the Environment (Birchler & Bütler, 2007).

4.3 Property Constraints

The properties that bind the different concepts in REGENT are depicted in Figure 8. Properties in OWL are binary relations constraining the interaction between any two classes. For any property connecting an object o1 to object o2 an inverse property can also be specified which connects object o2 with o1. In the following, we discuss these properties on a class by class basis. For the sake of clarity, words starting with upper case alphabet are class names and the same when written in lowercase represent objects of that class.

The objects in the Resource class are constrained through two properties. 1) The *hasOwner* property mandates that each resource is connected to some enterprise. To ensure the uniqueness of this relation we limit the property to have a single value i.e. each resource has only one owner. In OWL this is accomplished by setting the property characteristics as functional. The corresponding inverse property that connects an enterprise to its resources is the

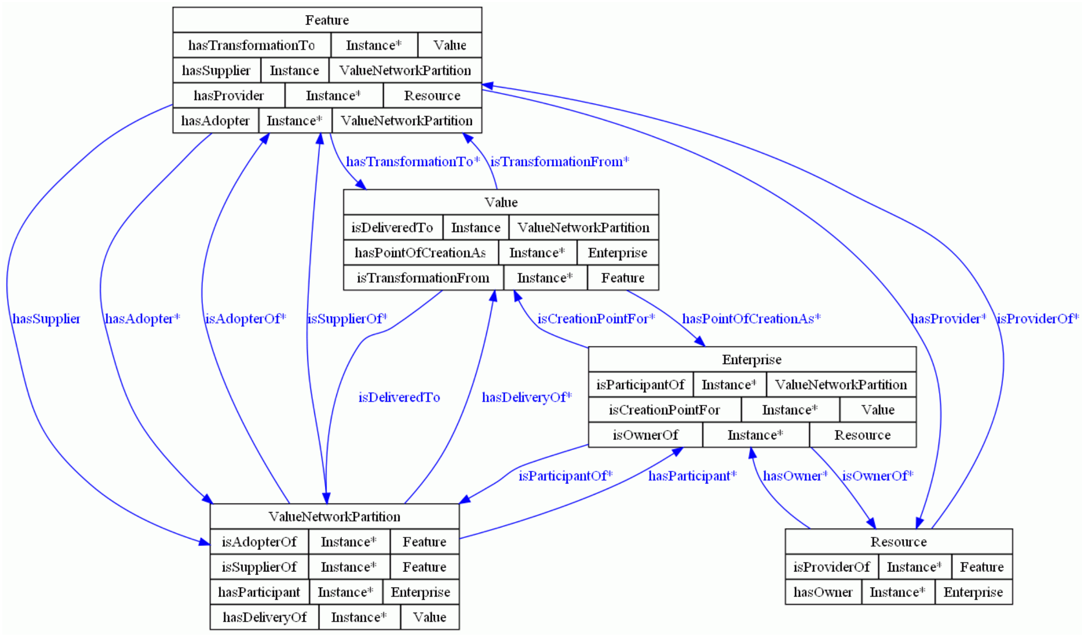

Figure 8: A visual representation of properties constraining REGENT concepts.

isOwnerOf property. The one-to-many nature of this relation is visually represented with an asterisk (*). An enterprise can own more than one resource. 2) The *isProviderOf* property links a resource to the feature it contributes. The corresponding inverse property that connects a feature to its constituent resources is the *hasProvider* property. Both of these properties represent a one-to-many relation – a resource can enable more than one feature and a feature can be enabled by more than one resource.

The objects in the Feature class are constrained through four properties. 1) The h*asTransformationTo* relation specifies the values that are realization of the features. The corresponding inverse property *isTransformationFrom* specifies the features that constitute the value. Both of these relations exhibit multiplicity – multiple features can aid a value creation and multiple values can be enabled by a feature. 2) The *hasSupplier* relation specifies the supplier value network for a feature. This is a single value relation which restricts each feature to have a unique supplier. The same is imposed by setting the functional characteristic of this property. The corresponding inverse property, *isSupplierOf*, is a multi-valued relation. A value network can be a supplier of more than one feature. 3) The *hasProvider* relation is already discussed above. 4) The *hasAdopter* relation specifies the adopter value network for a feature. The corresponding inverse property, *isAdopterOf*, specifies the set of features that a value network adopts. Both of these are multi-valued properties – a value network can adopt multiple features and a feature can be adopted by multiple VNs.

The objects in the `Value` class are constrained through three properties. 1) The *isDeliveredTo* property specifies the value network where a value is realized. This is a single value property; a value is closely associated to the perception of the consumer and, is hence, unique to the value network. We do this by setting the functional characteristic of the property. The corresponding inverse property, *hasDeliveryO,* specifies the value that a value network consumes. 2) The *hasPointOfCreationAs* property specifies the precise enterprise which consumes this value. Again, consumption is unique to an enterprise; hence, this property is a single-valued function. The corresponding inverse property, *isCreationPointFor*, identifies all the values that are consumed by an enterprise. This is a multi-valued property. 3) The *isTransformationFrom* property has been detailed earlier.

In addition to the properties exhibited by the Feature, Resource and Value class. There exists an additional relation between the objects of the Enterprise class and the objects of the ValueNetworkPartition class. The property *isParticipantOf* identifies the value network to which the enterprise participates. To highlight the fact that an enterprise when part of two value networks does so in different roles, we model this relation as a single-value property – setting its functional characteristic. The corresponding inverse property, *hasParticipant*, is a multi-valued property and identifies all the enterprises that are members of a VN.

5 THE CASE OF URBAN RESIDENTIAL ELECTRICITY SUPPLY

In this section, we use REGENT to provide a systematic view of the Urban Residential Electricity Supply Industry (URESI). Details about the URESI were gathered from various reports (US Aid, 2007) (Malaman, April, 2001), best practices (OECD, 1997), guidelines (Queensland Competition Authority, 2001), national regulations (GOI, 2002) and personal communication with Industry representatives. The later was done through a consultation meeting, 'The Role of IT in Regulatory Governance', held on December 05, 2009 at TATA Consultancy Services Ltd., Lucknow India.

We begin by identifying the different stakeholders in a URESI. Stakeholders with common objectives, or lack of objective, are grouped into same Value Network. Four VNs emerge from this exercise: The Economic Value Network (ECN) that represents enterprises with primarily economic motivation, Social Value Network (SCN) that represents enterprises with primarily social motivation, Environmental Value Network (EVN) that represents non strategic enterprises and Government Value Network (GVN) that represents the collective welfare as the overriding motivation. The enterprises constituting the ECN are Generation Company, Transmission Company and the Distribution Company. The enterprise constituting the SCN is the Urban Household. The enterprises constituting the ENV are Climate and Habitat. Climate represents the macro level aspects of the environment while habitat represents the micro level aspects of our immediate surroundings. ECN and SCN are generalizations of the Electricity Supplier Value Network and the Electricity Consumer Value Network mentioned in the Sections 2 and 4.

5.1 Resource Identification

For each of these VN, we take a commercial and operational view of the value exchange and identify

Table 1: List of Resource identified in URESI.

TAXONOMY			ID	VN	ENTERPRISE	RESOURCE LIST
Commercial	Consumption	Intangible	r1	ECN	Generation Co	MarginalCostBasedGenerationStrategy
			r2	ECN	Generation Co	MarginalEmissionBasedGenerationStrategy
			r3	EVN	Habitat	AuditoryHumanSense
			r4	EVN	Habitat	OlfactoryHumanSense
			r5	EVN	Habitat	TactileHumanSense
			r6	EVN	Habitat	VisualHumanSense
			r7	EVN	Habitat	GustatoryHumanSense
			r8	GVN	Ministry of Power	AuthorityReinforcement
			r9	GVN	Ministry of Power	InformationReinforcement
			r10	GVN	Ministry of Power	OrganizationReinforcement
			r11	SCN	Household	UsageBehavior
		Tangible	r12	GVN	Ministry of Power	TreasureReinforcement
			r13	SCN	Household	AssistedLivingElectricalAppliance
			r14	SCN	Household	BulkChargingElectricalAppliance
			r15	SCN	Household	ClimateControlElectricalAppliance
			r16	SCN	Household	HeatingCoolingElectricalAppliance
			r17	SCN	Household	HomeOfficeElectricalAppliance
			r18	SCN	Household	LightingElectricalAppliance
			r19	SCN	Household	MotorDrivenMiscElectricalAppliance
			r20	SCN	Household	PersonalUseElectricalAppliance
	Reception	Intangible	r21	ECN	Distribution Co	BillCollectionCapability
			r22	ECN	Distribution Co	BillGenerationCapability
			r23	ECN	Distribution Co	BillTransmissionCapability
			r24	ECN	Distribution Co	SupplyRepairCapability
			r25	ECN	Distribution Co	SupplySupportCapability
			r26	GVN	Ministry of Power	PublicOpinion
		Tangible	r27	ECN	Distribution Co	Cash
			r28	ECN	Distribution Co	Credit
			r29	ECN	Distribution Co	ExternalCounter
			r30	ECN	Distribution Co	InternalCounter
			r31	ECN	Distribution Co	LightMaintainenceEquipment
			r32	ECN	Distribution Co	HeavyMaintainenceEquipment
			r33	ECN	Distribution Co	InternetAsCommChannel
			r34	ECN	Distribution Co	Phone
			r35	ECN	Distribution Co	SnailMail
			r36	EVN	Climate	Air
			r37	EVN	Climate	Land
			r38	EVN	Climate	Water
			r39	GVN	Ministry of Power	Election
			r40	GVN	Ministry of Power	Nomination
			r41	SCN	Household	Identity
Operational	Delivery	Intangible	r42	EVN	Climate	ProcurementFeasability
			r43	GVN	Ministry of Power	Campaign
			r44	GVN	Ministry of Power	MoralSuasion
			r45	GVN	Ministry of Power	Propaganda
		Tangible	r46	ECN	Distribution Co	AutomaticSwitch
			r47	ECN	Distribution Co	MannualSwitch
			r48	ECN	Distribution Co	ConventionalMeter
			r49	ECN	Distribution Co	SmartMeter
			r50	ECN	Distribution Co	SinglePhaseLoad
			r51	ECN	Distribution Co	ThreePhaseLoad
			r52	ECN	Distribution Co	UndergroundCable
			r53	ECN	Distribution Co	OverheadCable
			r54	ECN	Distribution Co	OilTransformer
			r55	ECN	Distribution Co	FerroTransformer
			r56	ECN	Transmission Co	HighVoltagePowerLine
			r57	ECN	Transmission Co	LowVoltagePowerLine
			r58	ECN	Transmission Co	VeryHighVoltagePowerLine
			r59	GVN	Ministry of Power	Grant
			r60	GVN	Ministry of Power	Loan
			r61	GVN	Ministry of Power	Tax
			r62	GVN	Ministry of Power	Rebate
	Production	Intangible	r63	GVN	Ministry of Power	Authority
			r64	GVN	Ministry of Power	Information
			r65	GVN	Ministry of Power	Organisation
			r66	SCN	Household	SpendingStrategy
			r67	SCN	Household	WorkloadCharacteristics (Batch/Interactive)
		Tangible	r68	ECN	Generation Co	BioWastePlant
			r69	ECN	Generation Co	CentralisedPlant
			r70	ECN	Generation Co	CoalPlant
			r71	ECN	Generation Co	DistributedGenerationPlant
			r72	ECN	Generation Co	GasPlant
			r73	ECN	Generation Co	HydroPlant
			r74	ECN	Generation Co	NuclearPlant
			r75	ECN	Generation Co	PetroleumPlant
			r76	ECN	Generation Co	SolarFarm
			r77	ECN	Generation Co	TidalUnit
			r78	ECN	Generation Co	WindFarm
			r79	ECN	Generation Co	VariableOutputPlant
			r80	ECN	Generation Co	FixedOutputPlant
			r81	ECN	Generation Co	LargeCapacityPlant
			r82	ECN	Generation Co	SmallCapacityPlant
			r83	EVN	Habitat	BioWaste
			r84	EVN	Habitat	Coal
			r85	EVN	Habitat	Gas
			r86	EVN	Habitat	Hydro
			r87	EVN	Habitat	Nuclear
			r88	EVN	Habitat	Petroleum
			r89	EVN	Habitat	Solar
			r90	EVN	Habitat	Tidal
			r91	EVN	Habitat	Wind
			r92	GVN	Ministry of Power	Treasure
			r93	SCN	Household	MonthlyLoad
			r94	SCN	Household	MonthlyBudget

the tangible/intangible resources that aid the production/delivery of the VN offering and the reception/consumption of the counter offering from other VNs. These resources along with the related Enterprise and Value Network are listed in Table 1.

In the case of ECN, the Generation Company provides fuel specific generation plants (r73-83) as tangible resources for the production process. The Distribution and Transmission Companies provide the necessary network, both large area and local area, to transport the generated electricity to the prospective place of consumption. The elements of these networks (r51-63) represent the tangible, delivery related operational resources in ECN. To enable the return path, the Distribution Company makes available different Billing plans (r27-31), Collection modes (r32-35), Communication channels (r38-40) and Maintenance Equipments (r36, 37) as tangible resources for receiving the revenue and information (feedback) flow. The accompanying intangible resources for this purpose include billing, repair and support related capabilities (r21-25).

The information resulting from this feedback is consumed by Generation Companies in fine tuning their generation strategies, for instance operate the generation units in the increasing order of marginal production cost or in the increasing order of marginal emission (r1, 2).

In the case of EVN, the Habitat provides the different kind of fuels such as Gas, Coal, Nuclear, etc. (r88-96), as tangible resources for the production process. On the delivery front, EVN provides an intangible resource in the form of ease of procurement of natural resources. It is the procurement feasibility (r47) that allows a natural resource to be available as a fuel in the electricity production process. To enable the return path, the Climate makes available air, land and water (r41-43) as tangible resources for receiving the pollution that results from the electricity production process. The pollution is finally consumed as a displeasing benefit through the five human senses (r3-7), which act as the intangible consumption resource.

In the case of GVN, policy making exploits the following four resources available with any government institution: information (Nodal), power (Authority), money (Treasure) and management (Organization). The NATO concept was introduced by (Hood & Margetts, 2007) and has since been widely used to study the working of governments. The information, power and management (r68-70) represent intangible and money (r97) represents tangible, operational resources for producing high level policies. To deliver its policies the government uses various social and economic instruments (r48-50, 64-67). It receives the benefits of policy making through election, nominations and public opinion formation (r26, 44, 45). Any political capital thus accrued is encashed by reinforcing (r8-10, 12) it resources for further policy making.

In the case of SCN, the demand for electricity at an Urban Household is a combination of its load requirements and the willingness/capability to pay. The tangible resources that produce this demand include the household monthly budget and monthly load (r98, 99). The corresponding intangible resources include the spending strategy and the

Table 2: List of Feature identified in URESI.

TAXONOMY			ID	VN	FEATURE LIST
Utility			f1	ECN	ElectricitySupply
			f2	EVN	ElectricityFuel
			f3	GVN	HighLevelPolicy
			f4	SCN	ElectricityDemand
Warranty	Reliability	Disruption	f5	ECN	TimeToRepair
			f6	ECN	GenerationFromRenewable
			f7	GVN	NoticePeriodForNewPolicyAdoption
			f8	SCN	BackupSupport
			f9	SCN	IncomeStability
		Dmg	f10	ECN	ApplianceProtectionInsurance
			f11	GVN	PolicyReviewOption
	Availability	Spatial	f12	ECN	ConnectionTransfer
			f13	SCN	ResidentialStability
			f14	GVN	UniformityInPolicyAcrossSupplyRegion
		Temporal	f15	ECN	FrequencyOfInterruption
			f16	ECN	DurationOfInterruption
			f17	EVN	RenewableFuelSource
			f18	EVN	NonRenewableFuelSource
			f19	GVN	FrequencyOfPolicyChange
			f20	SCN	PaymentTimeliness
	EaseOfUse	Evaluation	f21	GVN	Command&Control
			f22	GVN	Reward&Penality
			f23	SCN	LoadVerifiability
			f24	SCN	IncomeVerifiability
		Procurement	f25	ECN	DistanceFromGrid
			f26	ECN	DistanceFromSource
			f27	ECN	InitialCostOfConnection
			f28	ECN	InitialTimeToConnection
			f29	ECN	IndividualContract
			f30	ECN	CommunityContract
		Consumption	f31	ECN	EaseOfBillPayment
			f32	ECN	EaseOfServiceSupport
			f33	ECN	VariableLoadSupport
			f34	GVN	UniquenessOfInterpretation
			f35	SCN	TimeOfDayInSensitiveConsumption
			f36	SCN	TimeOfDaySensitiveConsumption
			f37	SCN	TimeOfWeekInSensitiveConsumption
			f38	SCN	TimeOfWeekSensitiveConsumption
			f39	SCN	TimeOfYearInSensitiveConsumption
			f40	SCN	TimeOfYearSensitiveConsumption
			f41	SCN	LoadVariance
	Cost	Monetary	f42	ECN	FixedSupplyTariff
			f43	ECN	QuantityBasedSupplyTariff
			f44	ECN	TimeofUseSupplyTariff
			f45	ECN	FrequentTarrifVariationUnknownApriori
			f46	ECN	OccassionalTarrifVariationKnownApriori
			f47	GVN	ComplianceCost
			f48	SCN	CostSenstivityOfWorkload
		NonMonetory	f49	ECN	ToxicWasteOutput(emission)
			f50	ECN	WasteDisposal
			f51	EVN	CarbonIntenseNaturalResource
			f52	EVN	CarbonNeutralNaturalResource
			f53	GVN	ComplainceOutcomeOnTrade
			f54	SCN	QualitySensitivityOfWorkload

consumption characteristic (r71, 72). In an urban setting, there are no extra resources required to make this demand visible to the ECN, as a result there are no delivery related resources listed for SCN. Nevertheless, this is not always the case. In a rural setting, the economic prospects of serving an isolated demand may not be too attractive. Very often, in these situations, the GVN lends its resources to deliver such demands, aka Universal Service Obligation. On the commercial front, the SCN obtains a connection using its identity as the resource to guarantee the intent of upholding the terms and conditions. The household identity (r46) is thus the tangible, reception oriented commercial resource of SCN. Finally, the different kind of electrical appliances (r13-20) in the household and the usage behaviour (r11) of household members act as the tangible and the intangible resources required to consume electricity.

5.2 Feature Identification

Every VN in an industry contributes some service or good to other VNs in the industry. As described in Section 2.4.1, a VN offering can be detailed along the utility and warranty dimensions. Table 2 lists the utility and warranty details of the VN offerings in the Urban Residential Electricity Industry.

The utility of ECN is to provide electricity (f1) for residential purposes. For the electricity supply to be useful, it provides a set of warranties related to the temporal (f15, 16) and spatial availability (f12), dollar (f42-46) and non-dollar costs (f49, 50), ease of use (f25-33) and reliability (f5, 6, 10).

The utility of ENV offering is to provide natural-resources (f2) required for electricity generation. These natural-resources can either be provided in perpetuity (f17) or only for a limited period of time (f18), with little (f52) or significant (f51) ecological impact, thereby constituting the warranty of the ENV offering.

The utility of SCN is to exhibit demand (f4) for electricity. Demand includes both the expected load and the willingness/ability to pay. The temporal sensitivity of consumption (f35-40, 48), the specificities of the expected electrical load (f23, 41), tolerance to qualitative variance (f54) and the payment guarantees (f9, 13, 20, 24) are the warranties that detail the utility offered by the SCN to other VNs in the industry.

The utility of GVN is to provide the high level policy (f3) framework that guides the industry in the desired direction. These policies can be evaluated for their suitability of implementation - command & control (f21) or reward & penalty (f22). A simplified (f34), sensitive (f7, 11), stable (f19) and uniform policy regime (f14) limits the industries' cost of compliance (f47) and results in the industry growth (f53).

5.3 Value Identification

Every VN in an industry receives some value in return to his contribution to the Industry. Value can either be positive or negative, solicited in the case of strategic VNs or unsolicited in the case of non-strategic players. Table 3 lists the utility and warranty of the different value created in the Urban Residential Electricity Supply Industry, the VNs that adopt these value and the enterprises in the adopter VN where these value are realized.

The utility of the positive value realized at the ECN is profit (v1-3). To accomplish this, the Distribution Company tries to forecast demand (v8), inform policy makers about its requirements (v12), exploit the need of consumers for electricity (v18) and ensure continued flow of revenue (v19). On the transmission front, the spatial diversity of demand (v14) creates more business opportunities for the Transmission Company. Continued availability of fuel (v17) for electricity generation is the primary warranty for a Generation Company. All the ECN enterprises bear the transaction cost (v29-31) of doing business under some policy regime.

The utility of the negative value realized at the EVN is pollution (v4, 5). At the micro level the pollution can lead to a variety of displeasures (v34-38) to the inhabitants of a certain geographical area. At the macro level pollution can manifest itself as undesired alterations to climate (v39-41).

The utility of the positive value realized at the SCN is the comfortable living (v7) of household members. The household convenience is maximised by ensuring safe & continued operation of electrical appliances (v13, 21) and giving the household complete freedom of the financial (v33) and social aspect (v16, 23) of electricity supply. Simplifying the interactions between the household and the service provider (v28) also brings added comfort to the household. In certain situations, specificities of the supply network may impose restrictions on the use of some types of appliances (v10), for instance heavy load motors on single phase connections.

The utility of the positive value realized at the GVN is to ensure collective welfare of the society by accumulating political capital (v6). Achieving

Table 3: List of Value identified in URESI.

TAXONOMY			ID	VN	ENTERPRISE	VALUE LIST
Utility			v1	ECN	DistributionCo.	Profit
			v2	ECN	TransmissionCo.	Profit
			v3	ECN	GenerationCo.	Profit
			v4	EVN	Habitat	HabitatPollution
			v5	EVN	Climate	ClimatePollution
			v6	GVN	MinistryOfPower	PoliticalCapital
			v7	SCN	Household	Comfortable Living
Warranty	Reliability	Disruptio	v8	ECN	DistributionCo.	Demand Foresight
			v9	GVN	MinistryOfPower	ElectricitySupplyIndependence
			v10	SCN	Household	RestrictionOnTypeOfAppliance
		Damage	v11	ECN	DistributionCo.	PlanningOpportunity
			v12	ECN	DistributionCo.	OpinionSharing
			v13	SCN	Household	SafeOperationOfElectricalAppliance
	Availability	Spatial	v14	ECN	TransmissionCo.	SpatialDiversityOfDemand
			v15	GVN	MinistryOfPower	CapitalInvestmentInTransmission
			v16	SCN	Household	EaseOfResidenceChange
		Temporal	v17	ECN	GenerationCo.	ContinuedAccessToFuel
			v18	ECN	DistributionCo.	ContinuedDemandForElectricity
			v19	ECN	DistributionCo.	ContinuedRevenueInflow
			v20	GVN	MinistryOfPower	CapitalInvestmentInGeneration
			v21	SCN	Household	ContinuedOperationOfElectricalAppliance
	EaseOfUse	Evalu	v22	SCN	Household	RestrictedChoice
			v23	SCN	Household	ChoiceOfElectricitySource
		Procu	v24	GVN	MinistryOfPower	UniversalAvailabilityOfSupply
			v25	SCN	Household	InitialPayment
		Consump	v26	GVN	MinistryOfPower	CapitalInvestmentInDistribution
			v27	GVN	MinistryOfPower	MinimumQualityofSupply
			v28	SCN	Household	CommercialConvenience
	Cost	Monetory	v29	ECN	GenerationCo.	TransactionCost - emission, distributed generation
			v30	ECN	TransmissionCo.	TransactionCost - infrastructure expansion
			v31	ECN	DistributionCo.	TransactionCost - service delivery
			v32	GVN	MinistryOfPower	FairPrice
			v33	SCN	Household	OpportunityToReduceMonthlyBill
		NonMonetory	v34	EVN	Habitat	AuditoryDispleasure
			v35	EVN	Habitat	GustatoryDispleasure
			v36	EVN	Habitat	OlfactoryDispleasure
			v37	EVN	Habitat	TactitoryDispleasure
			v38	EVN	Habitat	VisibleDispleasure
			v39	EVN	Climate	AirPollution
			v40	EVN	Climate	LandPollution
			v41	EVN	Climate	WaterPollution
			v42	GVN	MinistryOfPower	EnvironmentalStandardComplaince
			v43	SCN	Household	InconvenienceOfReschedulingHouseholdWork

Table 4: Resource-Feature-Value mapping in URESI.

VALUE	FEATURE
v8	f23, f24, f41
v9	f6, f17
v10	f33
v11	f7
v12	f11, f53
v13	f10, f54
v14	f25, f26
v15	f14, f19, f21, f22, f34
v16	f12
v17	f17, f18
v18	f35-40
v19	f9, f13, f20
v20	f14, f19, f21, f22, f34
v21	f5, f8, f15, f16
v22	f29
v23	f30
v24	f20, f25, f26
v25	f27
v26	f14, f19, f21, f22, f34
v27	f5, f15, f16, f28
v28	f12, f31, f32
v29	f47
v30	f47
v31	f47
v32	f42-46
v33	f44-46
v34	f35, f44, f48
v35	f49-51
v36	f49-52
v37	f49-53
v38	f25, f26
v39	f49-51
v40	f49-52
v41	f49-53
v42	f49, f50, f52
v43	f44, f48

FEATURE	RESOURCE
f5	r24, r31
f6	r68, r73, r76-78, r83, r86, r89-91
f7	r9
f8	r14
f9	r94
f10	r46, r49, r52, r55, r58
f11	r9
f12	r22
f13	r41, r43
f14	r9, r10
f15	r46, r49, r52, r55, r58
f16	r24, r31, r46, r49, r52, r55, r58
f17	r83, r86, r89, r90, r91
f18	r84, 85, 87, 88
f19	r9, r10
f20	r21-23, r94
f21	r63-65
f22	r63-65, r92
f23	r13-20, r93
f24	r41, r43
f25	r69
f26	r71
f27	r48, r51
f28	r25
f29	r21-25
f30	r21-25
f31	r21-23
f32	r25
f33	r50, r51
f34	r8
f35	r14, r19, r67
f36	r13, r18, r67
f37	r17, r20, r67
f38	r13, r67
f39	r19, r67
f40	r15, r16, r67
f41	r67
f42	r22
f43	r22
f44	r1, r22, r49
f45	r1, r22, r49
f46	r1, r22, r49
f47	r12, r59-62
f48	r66, r94
f49	r2, r68, r70, r72, r74, r75
f50	r43-45, r59-62
f51	r84, r85, r88
f52	r83, r85-87, r89-91
f53	r43-45, r59-62
f54	r13, r17, r20

independence in electricity supply (v9) through increased investments (v15, 20, 26), making electricity available for every one (v24), ensuring minimum quality standard of supply (v27) at a fair price (v32) are important warranties of electricity supply that affect the consumers at large.

5.4 Establishing Regulatory Oversight

Table 4 presents the mapping between the different members of the Resource, Feature and Value set. This mapping exploits the property constraints detailed in 2.4.4. In the interest of space, here we only elaborate the realization of auditory displeasure (v34) as a negative value created at the Habitat by the introduction of time based pricing scheme in the electricity supply industry.

Balancing the supply and demand for electricity is central to the proper functioning of an electricity grid. The demand, however, tends to exhibit time sensitivities with more electricity required during specific times of the day or year, for example increased lighting requirements during the night and higher climate control needs during peak winter/summer season. In the absence of efficient large scale electricity storage techniques such variability in demand can only be met through flexible generation capabilities. Not all generation units support variable output. For example, nuclear power plants must be run at close to-full capacity at all times whereas production from other sources such as wind and solar, though inherently variable in nature, remains hard to predict. Further, the cost of electricity production varies from one type of generation unit to another. Generation Company operates these units in an increasing order of marginal costs (r1). Thus increased generation required to meet higher demands (peak hours) results in a higher per-unit cost of electricity. Similarly, during periods of low demand (off-peak hours) generation units with high marginal costs are cycled down resulting in a lower per-unit cost of electricity. Installation of smart meters (r49) allows the Distribution Co. to extend its billing capability (r22) and help the ECN introduce time of use (ToU) electricity pricing tariffs (f44). ToU presents economic incentives to enterprises in ECN and SCN

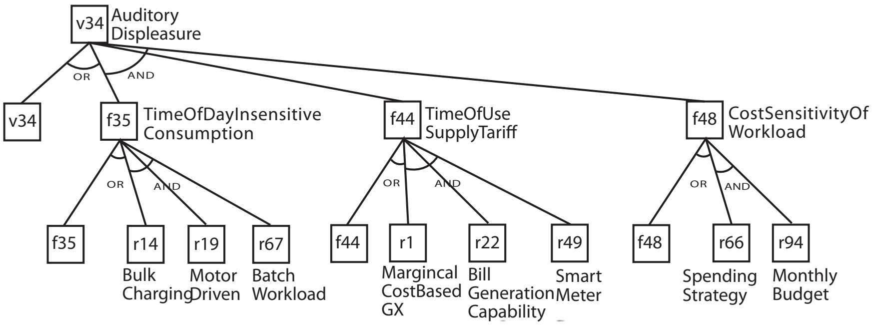

Figure 9: Monitoring auditory displeasure.

alike. Electricity suppliers can increase profits by charging a higher per-unit cost during peak hours and consumers can minimize their bill (f48) by moving their time insensitive workloads (f35) to off-peak hours when the per-unit cost is low. The sensitivity of households to electricity bill is a function of their monthly budget (r94) and spending strategy (r66). Any attempt by households to move electricity workloads to off-peak hours is limited to the rescheduling of time insensitive workloads (f35) which in turn depends on the availability of requisite electrical appliances (r14, 19) and batch oriented workload characteristics (r67).

The temptation to move workloads to hours of low overall activity, e.g. night time, may result in increased noise levels during odd hours leading to the realization of a negative value of auditory displeasure (v34) to surrounding neighborhoods, the habitat. Use of REGENT to formally represent the value realization process exposes the industry concepts that enable it and the relationship these concepts have with the real world. Industry regulators can use this knowledge, for instance, to clearly identify the different industry elements that need to be monitored so as to track the realization of a given value of interest. An AND/OR graph depicting the value realization process for auditory displeasure (v34) is depicted in Figure 9.

6 RELATED WORK

The role of ontology in formalizing the concepts in a knowledge system is well established. In the context of industry, ontology development has primarily focused on formalizing the domain specificities. The concepts and relationships that occur between entities from different domains have not attracted much ontological attention. E3 value (Gordijn & Akkermans, 2003) is one of the few attempts to study the value exchange between the stakeholders in an industry. It is, however, restricted to analyzing the economic exchange between companies active in an e-commerce business. Some ontology development has also been recently noticed in understanding regulation, for example IPROnto (Delgado, Gallego, Llorente, & García, 2003) which presents a formalization of the concepts in digital rights management. In the Electricity industry power quality measurement related ontology has been presented in PQONT (Küçük, Salor, Inan, Çadırcı, & Ermis, 2010).

7 CONCLUSIONS

REGENT enables an explicit specification of multi-party relationships in an industry by formalizing the concepts that influence the realization of stakeholder value. A systematic representation of industry knowledge will expose any deficiencies in regulators' understanding of the industry, thereby assisting the regulator in developing a holistic view of the industry. REGENT is an important first step in our larger effort of developing a knowledge system for the regulation of utilities.

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Responsibilities Undertaken

2009 onwards:
- Research Assistant at the Systemic Modeling Laboratory, School of Computer and Communication Sciences, EPFL Switzerland.

2004 – 2009:
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2001-2003:
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1995-1999:
- Undergraduate student in Computer Science & Engineering at the Institute of Engineering and Technology, Lucknow India (Graduated with honors)

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List of Publications:

1. A Situated and Embodied Approach to Service Design, Hawaii International Conference on System Sciences (HICSS), Hawaii, USA January 6-9, 2014. ***(accepted for presentation)***

2. On the Situated Semantics of Service Systems, IEEE International Conference on Service Oriented Computing and Applications (SOCA), Hawaii, USA December 13-16, 2013. ***(accepted for presentation)***

3. A Situated Approach to Systems Based Modeling of Services, IEEE International Conference on Systems, Man, and Cybernetics (SMC), Manchester, UK October 13-16, 2013.
4. A Cognitive Reference Based Model for Learning Compositional Hierarchies with Whole-Composite Tags International Conference on Knowledge Discovery and Information Retrieval (KDIR-IC3K), Vilamoura, Algarve, Portugal 19-22 September 2013.
5. From Composites to Service Systems: The Role of Emergence in Service Design, IEEE International Conference on Systems, Man, and Cybernetics (SMC), Seoul, South Korea October 14-17, 2012.
6. A Systemic Approach to Multi-Party Relationship Modeling, Communications in Computer and Information Science, CCIS, vol. 272, p. 241-257, 2012.
7. Saxena A., Wegmann A., A Developing World Perspective on the Design of Wireless Enabled Humanitarian Relief Services ", International Conference on Wireless Technologies for Humanitarian Relief (ACWR), Amritapuri, Kollam, Kerala India, December 18-21, 2011.
8. Saxena A., Wegmann A., A Systemic Design of Regulation Enabling Ontology", International Conference on Knowledge Engineering and Ontology Development (KEOD/IC3K), Valencia Spain, October 25-28, 2010.
9. Saxena A., Wegmann A., "A Systemic Approach to Establishing Regulatory Oversight", Regulation in the age of Crisis, Third Biennial Conference of the Standing Group on Regulatory Governance of the European Consortium for Political Research, University College, Dublin, June 17-19, 2010.
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14. Saxena A., "Case for an Adaptive Security Framework for wireless-adhoc networks", Wireless World Research Forum 12, The Convergence of Digital Industries, Toronto, Canada, November 2004.
15. Papitashvili V., Saxena A., Petrov V., and Clauer R., "VGMO.NET: Realization and testing of a virtual global magnetic observatory", Geospace Environment in Near-Real Time: Science and Technology2003 IAGA/IUGG General Assembly, Sapporo, Japan, June 30-July 11, 2003.