Facilitating Requirements Negotiation: Modelling Alternatives and Arguments

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ABSTRACT

Co-development aims to ensure the alignment of business processes and support technical systems. During co-development stakeholders need an early understanding of the potential impact of different requirement choices on the enterprise. An early impact analysis understanding is more likely to actively engage stakeholders, highlight strategic options and deliver useful and sustainable systems. However, when multiple stakeholders are involved with differing backgrounds, experiences and frequently competing goals it is inevitable that conflicts occur during the early phases when requirements tend to be opaque. This paper puts forward a conceptual framework for co-development to support collaborative reasoning and decision-making through the modelling of requirements alternatives and arguments, promoting critical reflection, negotiation and discussion.

Keywords

Simulation, scenarios, requirements negotiation, rationale, ontology, modelling, co-development.

INTRODUCTION

The role of Requirements Engineering (RE) is changing, to one in which not only functional and non-functional requirements are considered but also the alignment of business processes with technical systems early in development, through a process of co-development. Co-development reflects exponential growth in information processing (Gantz, Manfrediz, Minton, Reinsel, Schlichting and Toncheva, 2008); enterprise transformation (Rouse, 2005); the changing nature of the economy, which has become global, knowledge-based and networked in nature; increased speed and complexity of decision-making; the acceleration of technological changes and rapid acceptance of computer and electronic communications (Leibold, Probst and Gibbert, 2002).

Loucopoulos and Garfield (2009) suggest the adoption of a designing stance to co-development which involves reflection, exploration, negotiation, compromise and revision. These are the activities in which top class designers tend to engage when considering complex projects in uncertain situations (Gehry, 2004), helping them to work through the problem they are trying to solve (Brown, 2005). During early RE multiple stakeholders are involved with differing experiences, backgrounds and often conflicting goals (Pohl, 1996; Krogstie and Solvberg, 2003; Loucopoulos and Prekas, 2003). Stakeholders frequently change their minds as they wrestle with the problem (Schon, 1983) and their views of requirements can be vague due to the uncertainty of what they want (Pohl, 1994; Ambler, 2006). Negotiation in particular needs to occur between all stakeholders in order to achieve a shared vision of requirements, which addresses their concerns (In and Roy, 2002). Negotiation is defined as a collaborative approach to resolving conflict by exploring a range of possibilities (Easterbrook, 1991). The negotiation task must ensure that the 'right' decisions are made, based on known argumentations and the best alternative is always chosen (Pohl, 1996). Without negotiation techniques, participants often focus on persuading others to accept a ready solution, rather than seeking a new solution that may be acceptable to all (Robinson and Volkov, 1998). There is also little chance the resulting system will accommodate their needs and the project will often fail (Gruenbacher and Briggs, 2001).

Scenarios serve as a means for discussing alternative solutions within systems development, grounding discussions and negotiations on real examples and supporting trade-offs among design alternatives (Weidenhaupt, Pohl, Jarke and Haumer, 1998). Qualitative models used for scenarios have been widely criticised for not enabling extrapolation from the model to the potential behaviour of the system, according to different design options (Loucopoulos, Zografos and Prekas, 2003). More specifically observations, walk-throughs and debating model content do not accommodate model implication comprehension. The simulation of scenarios addresses this problem, by imposing rigorous testing that exposes alternatives to stakeholders (Homer, 1996). Through the use of parameters, inputs and initial conditions, stakeholders' understanding of the world can be enhanced. Simulation evaluation can, however, be challenging, particularly when a large number of scenarios need to be analysed and evaluated, which can potentially lead to confusion and conflicts amongst stakeholders. The lack of tools for tracing reasoning and decisions regarding scenarios can be a hindrance to the process of stakeholder evaluation of alternative futures (Weidenhaupt et al., 1998). Reasoning and decision-making are associated with the very elements that need to be accommodated when taking a designing stance to co-development. Early systems development, leading to the requirements specification, must be traceable to allow an understanding of the requirements themselves (Pohl, 1996). Indeed the life of every requirement must be able to be reconstructed, so that those not involved in the process can understand how and why the requirements specification was produced in a particular way (Pohl, 1996). Communication problems can also occur, as the dynamic settings in which negotiations take place (Berglund, 2005) are not accommodated, which can impact on the quality of elicited requirements (Alexander, 2003). Furthermore reliable data for the construction, testing and validation of models is frequently unavailable (Dash, 1994). Lack of domain knowledge can result in analysts performing poor requirements elicitation and consequently producing requirements specifications of low quality (Kaiya and Saeki, 2006).

This paper puts forward a conceptual framework to facilitate the negotiation of requirements within the context of co-development, through the modelling of alternatives and arguments. This is applied to a case study of electricity liberalisation in the European Union.

A CO-DEVELOPMENT CONCEPTUAL FRAMEWORK FOR MODELLING ALTERNATIVES AND ARGUMENTS

The conceptual framework in Figure 1 addresses the problems that tend to occur with co-development, discussed in the previous section.

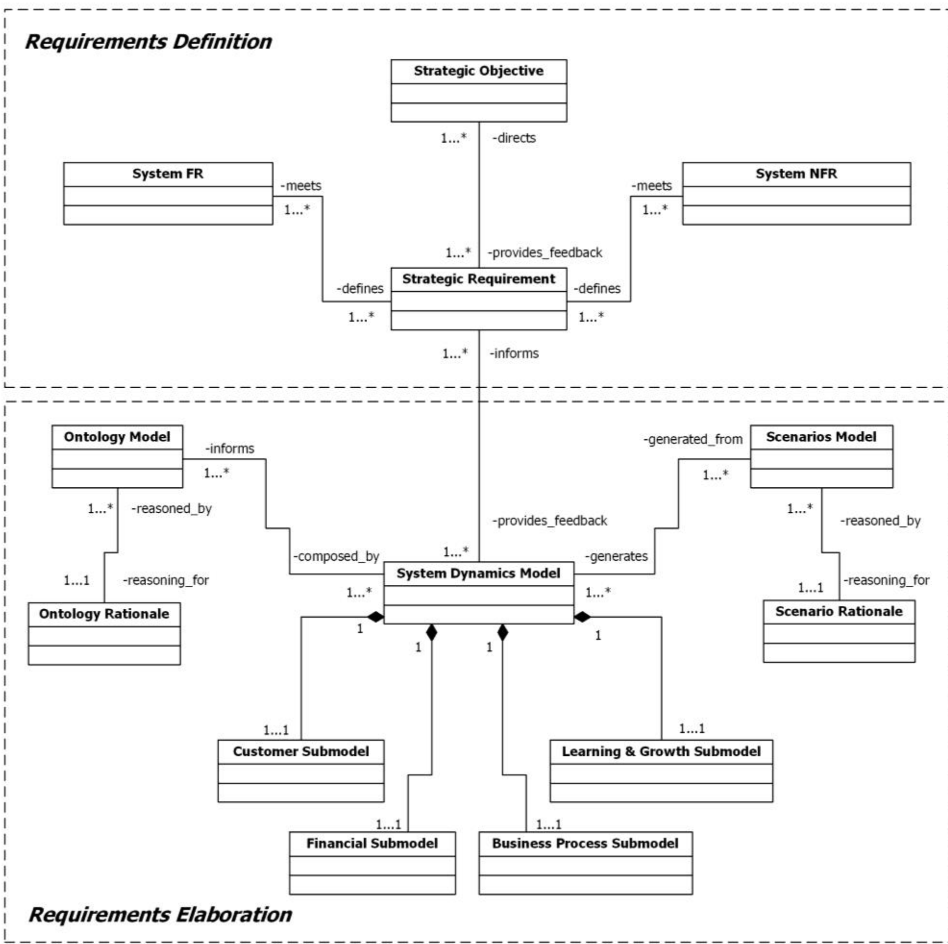

Figure 1. A conceptual framework (Loucopoulos et al., 2009)

Strategic objectives and requirements, together with functional and non-functional requirements, are identified within the *requirements definition* section of the framework. Strategic objectives form the vision for the enterprise and direct the definition of strategic requirements. Functional requirements describe the required functions in terms of what the information system should do, whereas non-functional requirements address the way the information system carries out its functions, such as aspects related to quality. It is considered that a wide range of models, techniques and tools already exist for the definition of requirements. Therefore the framework focuses on *requirements elaboration* as a means for elaborating defined requirements, with a view to aligning the enterprise strategy and requirements.

Requirements elaboration aims to facilitate stakeholder understanding of the potential impact of requirements on the enterprise. An early stakeholder understanding of the impact of different requirement choices on the enterprise is more likely to actively engage stakeholders, highlight strategic options and ultimately deliver useful and sustainable systems that are aligned to enterprise strategy and offer opportunities for influencing this strategy (Loucopoulos et al., 2009). This part of the framework is based on modelling which provides a simplification of reality, enabling a better understanding of the system being created (Booch, 2005) together with the facilitation of analyst-client communication e.g. (Knott, Merunka and Polak, 2000). The System Dynamics modelling methodology (Forrester, 1998; Sterman, 2000; Richmond, 2001) provides the central focus of requirements elaboration. It describes the interaction of the proposed system to the dynamics of the enterprise and facilitates the study, design and management of complex feedback amongst system components. The model is built from strategic requirements and is informed by the ontology model. Areas for improvement can be identified, new ideas tested and an understanding gained of how a system works, without taking any significant risks. The approach reflects the fact that any business strategy is likely to be influenced by different perspectives and encourages the development of four model sub-model viewpoints from the Balanced Scorecard (BSC) (Kaplan and Norton, 1992), namely customer, financial, internal business processes and learning and growth. The BSC enables an organisation's vision and mission to be translated into measurable parameters, which are largely indicators of future performance. Senior managers can visualise whether improvement in one area may be achieved at the expense of another. Through scenario simulation in the scenarios model stakeholders are able to visualise the behaviour over time of different possible requirements futures, according to variations in critical variables, together with determining the most strategically viable alternative future.

The ontology model provides a strategic context for requirements and clarifies semantics and standards. Ontology modelling contrasts to databases, which are less syntactically and semantically rich. Within the conceptual framework the ontology model assists in supporting decision-making and the articulation and negotiation of concepts in the System Dynamics model and, in turn, provides a more informed basis for simulation. It consists of concepts from the enterprise and application domain which are not subjected to differing interpretations. The enterprise domain provides stakeholders with a representation of the as_is business situation. The existing way of carrying out business processes forms a reference on which to base innovations. The application domain comprises standards of best practice which can assist in reducing the subjective nature of System Dynamics modelling noted by Anderton (1989). If knowledge is not structured to inform decisions during RE, it is easy to overlook important details and leave modelling more prone to conflicts, misunderstandings and incompleteness (Garfield and Loucopoulos, 2009). Protégé OWL Full (Stanford Center for Biomedical Informatics Research, 2009) is suggested for the ontology model. It facilitates a high level of expression and enables the direct editing of concepts defined as classes, properties and instances.

Ontology rationale aims to support negotiations by recording stakeholders' assumptions when constructing the ontology model. It assists in clarifying component use within the model to minimise stakeholder conflicts and maximise component traceability, as a mechanism for supporting stakeholders' negotiations. Scenario results can be traced through the use of scenario rationale, assisting stakeholders in their location and management, particularly when there are a large number of scenarios to be analysed and evaluated.

It seems pertinent that a rationale is documented throughout scenario and ontology modelling, as a number of stakeholders with differing backgrounds, experiences and goals are involved in constructing these models (Garfield et al., 2009). Models need to be discussable by stakeholders, address their needs and enable the visualisation of their own and others' perceptions. Rationale modelling provides a way of supporting stakeholder argumentation, providing an organisational understanding, clarity and visibility on decisions. An undefined, unclear rationale is more likely to be associated with poor design (Burge and Brown, 2000), and can lead to assumptions about a model that are conflicting.

Rationale takes the form of collaborative visualised argumentation based on the principles of (Rittel and Webber, 1973, 1984). The basic elements consist of problems and issues that arise in the course of a design, along with pros and cons for each alternative (Shipman and McCall, 1997). This is particularly relevant to the fundamental principles of negotiation, which need to take place in a collaborative environment to assist the elicitation of all alternatives and argumentations (Easterbrook, 1991; Robinson and Fickas, 1994). Moreover the visualisation of negotiation information assists in simplifying the complex and massive negotiation of data (In et al., 2002). An argumentation-based rationale tool, Compendium (Compendium Institute, 2008) is suggested for this purpose. Concepts can be mapped and linked in a straightforward way during collaborative discussions, facilitating stakeholder communication and the clarification of arguments and hidden structures (Buckingham Shum, 1997). In addition the dynamic setting aspect of negotiations e.g. Berglund (2005) can be captured and shared using the real-time facilities.

Figure 2 shows the structure for scenario rationale in Compendium. The nodes denote concepts and are connected via arrows.

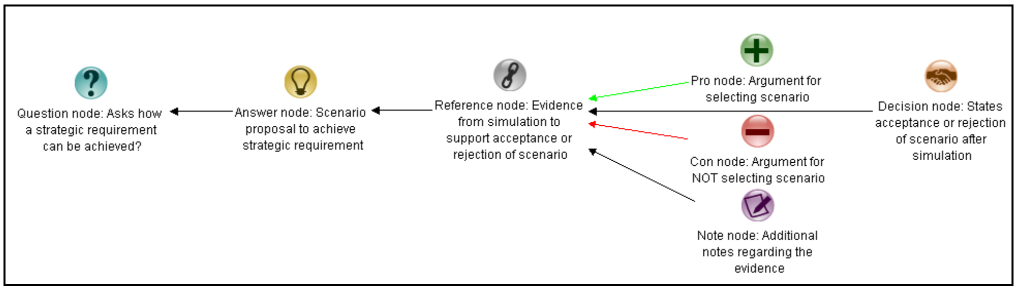

Figure 2. Compendium diagram of scenario rationale structure

Scenario rationale formalisation begins with a question node, which asks how strategic requirement/s can be achieved. In answer to this stakeholders, facilitated by a requirements engineer/s, derive a set of scenarios from the System Dynamics model. These form different ways of achieving the strategic requirement/s (i.e. an information system with associated functional and non-functional requirements) and are denoted by answer nodes. Each scenario is given a reference number and description for traceability purposes. These form pre-conditions (Pohl and Haumer, 1997) which restrict the invocations of a scenario, providing an overall guide for simulation. The number of scenarios to be simulated is not restricted. This supports the principles of the scenarios method, which specifically suggests the conception of all possible futures and the exploration of paths leading to them, thereby clarifying present actions and their possible consequences (Godet, 1987). In order to innovate, various ideas need to be generated, whether bad, dumb and/or wild (Burney, 2006). Following simulation, evidence of the scenarios model is recorded in a document attached to a reference node to support the acceptance or rejection of the scenario. Pro nodes provide arguments for selecting the scenario, denoting simulation results that are an improvement on the as_is situation. Con nodes depict results that do not improve the as_is situation and thus provide a negative argument for the scenario. Any additional information can be detailed using the note node. A decision is made for each scenario, as to whether it is accepted or rejected. The scenario that fulfils all strategic objectives, having all pro nodes, is accepted. Nodes used following simulation form post-conditions (Pohl et al., 1997), which express reasoning and decisions regarding the scenario result.

ELECTRICITY LIBERALISATION IN THE EUROPEAN UNION: A CASE STUDY EXAMPLE

Electricity liberalisation took place in the European Union (EU) from 1996 onwards in response to Directive 96/92/EC (European Union, 1997). The overall goal was to enter the competition market whilst responding promptly and competently to customers' needs and changing market conditions (European Union, 1997). The abolition of protectionism and free movement of goods and capital on a worldwide scale are among the reasons for these changes (ELEKTRA Consortium, 1998a). This case study focuses on the Distribution Business Unit, which is used for transporting electricity on medium and low-voltage distribution systems with a view to its delivery to customers (European Union, 1997).

Business Strategic Objectives and Requirements

Several recent EU Directives encourage innovations in electricity metering. Article 5, Directive 2005/89/EC (European Union, 2006a) and Article 13, Directive 2006/32/EC (European Union, 2006b), suggest the use of real-time demand management technologies, energy conservation together with competitively priced meters that reflect customers' actual energy consumption and time of use. Innovations in this area are particularly relevant at a time of increased electricity prices (Levinson and Odlyzko, 2007). Furthermore metering is important as it is required to calculate customers' bills. Strategic objectives have been identified in conjunction with EU Directives (European Union, 2006a, b) and are shown in Table 1.

Reference No.	Business Strategic Objective Description
SO1	To increase the number of customers
SO2	To increase customer satisfaction
SO3	To increase profits
SO4	To decrease the time for business processes
SO5	To decrease CO_2 emissions

Table 1. Business strategic objectives

Table 2 shows strategic requirements (ELEKTRA Consortium, 1998b) for achieving efficiency within the Distribution Business Unit for the process of electricity metering, as a means of fulfilling the business strategic objectives (Table 1).

Reference No.	Strategic Requirement Description
SR1	Improve metering procedures
SR2	Minimise period to calculate customer charges
SR3	Develop computerised mechanisms for energy metering

Table 2. Strategic requirements

To realise these strategic requirements a number of functional and non-functional requirements are relevant, depending on the type of electricity metering. The strategic viability of the following types of electricity metering is considered as a way of fulfilling the strategic requirements:

1. Continue with the as_is situation, in which meters are read by traditional means
2. Introduce handheld automation
3. Introduce fixed network automation

Traditional metering involves the manual reading of electro-mechanical accumulation meters every three months. The reading is recorded using pen and paper and submitted for data processing. However, this method involves deploying many staff in the field to read meters in areas which can sometimes be difficult to access. The outdated meters pose increased maintenance costs and are difficult for customers to gain an accurate view of electricity consumed. Meters are not tamper proof and in the current climate of increased electricity charges, electricity theft could become more prevalent, resulting in business losses.

Innovations in metering, in the form of fixed network or handheld automatic meter readings (AMR), operating on a radio frequency platform, would enable the automatic transfer of data from electricity metering devices to a central database, reducing staffing levels. Such types of meters can prevent tampering. Automation would provide consumers with the ability to monitor real-time energy consumption in monetary terms, rather than watts of electricity (Brown, 2006). Once the consumer can instantaneously see changes in their energy use, they are more likely to act to reduce consumption (Porter, 2006). Improved electricity conservation would in turn produce cost savings for the consumer, benefit the natural environment but potentially lead to losses in business revenue.

Modelling Alternatives and Arguments

A small part of the System Dynamics model for automated metering is shown in Figure 3. This model is constructed from strategic requirements and influenced by various functional and non-functional requirements. The model is also informed by classes and properties from the ontology model. For example in the case of handheld automation, ‘automated meter travel time’ represents the best practice average time for a meter reader to travel to a customer’s premises.

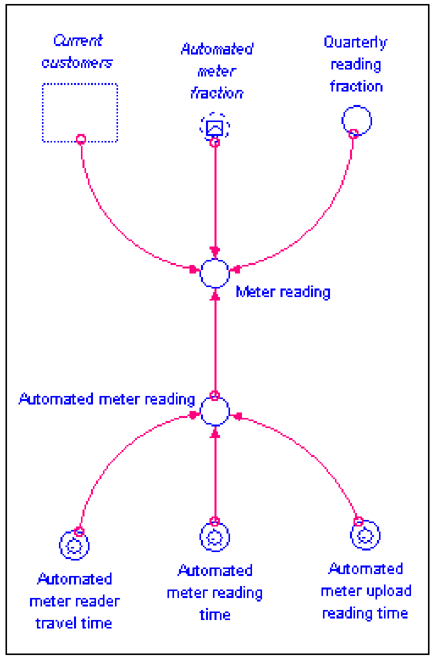

Figure 3. System Dynamics model for automated meter reading

Examples of components modelled within each System Dynamics sub-model viewpoint are shown in Table 3. Each sub-model is interlinked through feedback mechanisms.

Sub-model Viewpoint	Components
Customer	Potential, current, disconnected and reconnected customers and customer satisfaction
Financial	Revenue, costs (e.g. salaries, maintenance) and profit
Internal business process	Meter reading, billing and CO_2 emissions
Learning and growth	Staffing levels, hiring and redundancy

Table 3. Examples of components modelled within System Dynamics sub-model viewpoints

Table 4 shows some examples of simulation assumptions. The investment costs for fixed network and handheld automation include: hardware, software, installation, integration with billing, training and vendor deployment support. Installation of the infrastructure and meters would take place during a five-year period. The implementation of new technologies is reflected in the results over the proceeding five years.

Number of meter readers	1500
Number of billing processing staff	250
Fixed network automation investment costs per meter	€80 (Plexus Research Inc, 2006)
Handheld automation investment costs per meter	€40 (Plexus Research Inc, 2006)

Table 4. Simulation assumption examples

Figure 4 shows an example of evidence for scenario B1.3 in the form of a behaviour over time simulation graph for a 10-year period. This form of evidence, along with detailed statistical data, forms part of the scenario rationale, which is attached as a separate file to the reference node in Compendium. This acts as a basis for reasoning and decision-making together with supporting traceability.

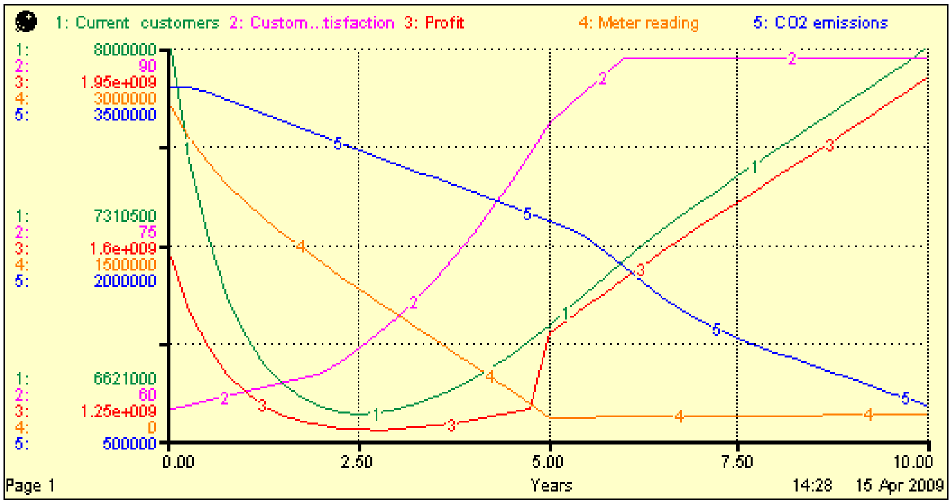

Figure 4. Scenario rationale evidence: behaviour over time for scenario B1.3 – 100% handheld automation

From the *customer perspective*, the initial decrease in customer numbers reflects dissatisfaction with traditional metering and initial disruptions from the installation of new electricity meters, resulting in a reduction in new customer attraction and existing customer retention. Customer satisfaction increases slightly during the early stages of handheld metering. As more meters are installed and customers become familiar with using the service, customer satisfaction and numbers increase at a faster rate.

From a *financial perspective*, initial investments would be required to install and set up the new system. There would be a greater initial setup cost for fixed network AMR than handheld AMR (as indicated in Table 4). There have, however, been shifts in this paradigm, e.g. (Electricity Today, 2007). An increase in customers would increase profits and cost reductions would be realised through a more efficient service, leading to decreased staffing levels.

From an *internal business process perspective*, the total time for meter reading stabilises after the first five years of handheld automation. IT systems would need to be updated to handle large increases in data generated by new meters. This information would have to be cross-referenced with existing systems and stored for up to three years to meet data regulations (Brown, 2006). CO_2 emissions continue to decrease due to reduced staffing levels, resulting from quicker meter reading together with natural improvements to vehicle CO_2 emissions year on year.

From a *learning and growth perspective*, meter reading staffing levels would reduce together with billing processing staff. This would be further pronounced for fixed network automation, as electricity consumption would be transferred automatically to a central computer system, removing the need for meter readers. A small number of specialised staff would be recruited to install the new meters.

The scenario rationale for meter reading is displayed in Figure 5. The degree of metering automation is specified for each scenario (e.g. 50%, 100%). Scenario B1.3 (100% handheld automation) is accepted. It has five pro nodes and therefore fulfils all of the strategic objectives. Strategic requirements SR1, SR2 and SR3, together with the relevant functional and non-functional requirements, are viable in terms of the enterprise strategic objectives, through 100% handheld automation.

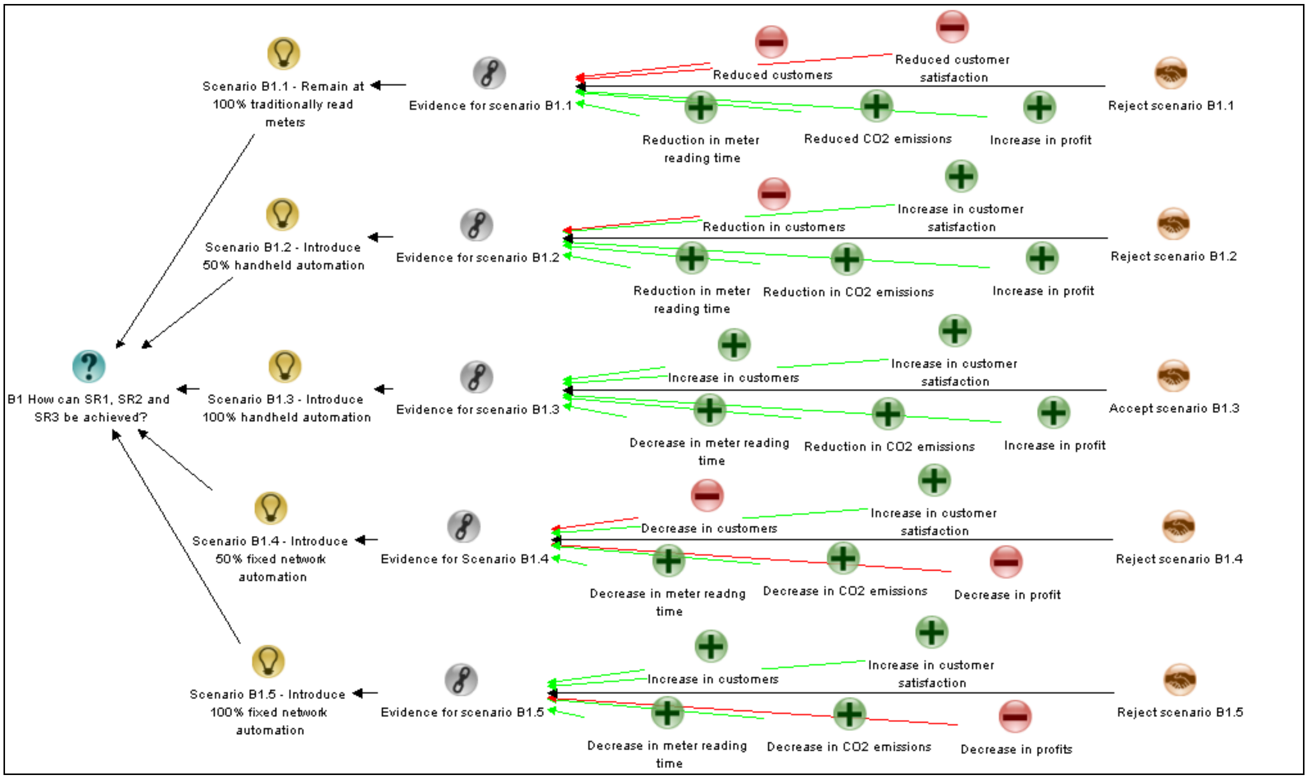

Figure 5. Scenario rationale for meter reading

In summary, the strategic viability of requirements is tested through simulation in the scenarios model following System Dynamics modelling. Scenario rationale enables scenarios to be documented prior to simulation, together with reasoning and decision-making regarding different futures, following simulation. This assists with traceability, a higher level of stakeholder understanding and minimisation of stakeholder confusion and conflicts. The ontology model allows the System Dynamics model to be based on enterprise and application domain semantics and standards, potentially reducing misunderstandings and conflicts and providing a solid foundation on which to base scenarios. Ontology rationale supports stakeholders' collaborative discussions during ontology model building, facilitating the documentation, visualisation and tracing of modelling assumptions.

CONCLUSION

The need for a systematic and systemic way of dealing with co-development aspects is particularly important, as there tends to be great uncertainty about requirements that are often set against a background of social, organisational and political turbulence (Garfield et al., 2009). This paper has put forward a framework for co-development, when multiple stakeholders are involved in negotiating multiple future paths. By facilitating negotiation through the modelling of requirements alternatives and arguments, the understanding of requirements can begin to loose its traditionally opaque nature.

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