Towards a Requirements Formalism in Procurement

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ABSTRACT

This paper looks at the case for including a Use Case model as part of a Request for Proposal (RFP) during the process of competitive tendering for a new IT system. Customer organisations suffer from the perceived problem of writing tender documents that contain ambiguous requirements, which in turn may render guesswork the calculation of an accurate price and delivery schedule. The process described in this paper looks at ways in which Use Case modelling can be undertaken by the customer organisation to improve IT procurement. Applicable to both bespoke software development and Commercial Off-the-Shelf (COTS) evaluation, the potential benefit from the adoption of Use Case modelling in procurement are explored. Use Case modelling has generally been an activity undertaken by analysts after commercial contracts have been agreed. This is partially due to the complexity and time-consuming nature of producing Use Cases, and partially due to the confusion that surrounds their representation. In this paper, a minimal Use Case representation, suitable for the purpose of procurement, is proposed.

Use Case modelling suffers from a lack of guidance that allows a set of Use Cases produced for the same purpose to be represented at the same conceptual level. There is tension between the Jacobson philosophy that defines Use Cases as being oriented strictly around the user and the broader hierarchy of Use Case goals approach, introduced by Cockburn. This paper seeks to bring both approaches together and show that while Use Cases have the primary function of representing users' requirements, there exists another dimension of Use Case applicability focused on serving the needs of all project's stakeholders.

1. INTRODUCTION

Typically Use Cases have been developed after the procurement function has finished. They are undertaken during funded work by the successful supplier's analysts. This model of procurement delays any Use Case representation until after a supplier has been chosen. This paper advocates a revision to the procurement model whereby the customer retains control of the problem statement by virtue of producing and distributing a Use Case model with the Request for Proposal (RFP).

The proposed customer benefit of retaining problem statement ownership through Use Case representation is primarily as a means of demonstrating verifiable requirements in an unambiguous way. Ambiguous requirements and scope creep are two major problems in IT procurement. This is amply demonstrated by the experiences of the government in the UK. Of the 24 projects reviewed in [1] 54% expressly mention poor requirements definition as being a contributing factor to the projects failure. Because of this, a recent Cabinet Office report [2] makes it clear that it is strongly recommended that all requirements of a project must be captured between customer and supplier in an unambiguous manner before any commercial contract is signed. The report goes further and specifically recommends that no requirement should be accepted after the contract has been agreed. The reason for this being straightforward; requirements that are added after the contract is signed are referred to as scope creep, and scope creep is identified as a major factor in project failure.

With a considerable amount of evidence that the cause of IT failure has its origins in IT procurement failures, there is an argument for reassessing the procurement model and considering changes that specifically address the highlighted issues. The process typically begins with a RFP or 'Invitation to Tender' (ITT) being published by the customer. (The term 'customer' is used to represent the owner of the future system, or the organisation that agrees commercial terms.) This is a difficult document to write in an unambiguous manner relying primarily on a list of requirements that typically begin with the words 'The system shall…'. Requirements lists are flawed. For instance, they are open to interpretation, they are unstructured, they describe concepts at different conceptual levels, do not lend themselves to creating connections between requirements, and are hard to verify as being unique. Use Cases are a way of improving matters by representing requirements in a more intuitive graphical manner that has gained widespread adoption. Use Case models were developed primarily to represent requirements from the perspective of the user. They are not routinely used during procurement. There is an *up-front* cost associated with producing Use Case models, that customers may be unwilling to meet, however this paper argues that it is more efficient for the customer to produce the first Use Case model within the context of the overall procurement process. A system that is more comprehensible is more likely to attract interest from qualified suppliers and result in more high quality bids (responses from suppliers proposing a solution). Bids received are all based on the same specification, the same problem statement, and therefore are more directly comparable. Without the customer owning the problem statement they are in a weak position to judge proposed solutions. The issue of ambiguity in requirements and subsequent requirements creep are better served by preserving a separation between problem and solution. Arguments arise between customer and supplier over these subjects that on occasion require resolution in court proceedings[3]. When the customer is responsible for the production of the Use Case problem statement they are producing a commercially relevant document that serves as proof of the customer's

intention. The objective of Use Case modelling for procurement is to ensure a representation that strictly adheres to a statement of the *problem* domain without making any reference to a possible solution.

This paper is organised to first demonstrate the context in which use cases are normally found, and in section 2 to present evidence of their recent adoption in as a tool for the improvement of the procurement process. In section 3, use case modelling is briefly described, before sections 4 and 5 describe aspects of use case abstraction intended to approach a formalism for the production of use case models intended to aid procurement. In section 6 the distinction between use cases that represent the *problem* and those that represent the *solution* is made plain.

2. USE CASES IN PROCUREMENT

There are a number of high profile recent examples of public sector organisations being aware of the central role that use case modelling can play in system procurement. Although not including use case models within the body of the RFP, a growing body of public organisations in the United States make explicit mention of the fact that a use case model will be a mandatory element of any successful tender. This includes the States of Illinois, Ohio, California, and Louisiana, in systems ranging from the provision of a system for the support of child welfare [4, 5], the administration of welfare payments [6], and aspects of the management of legal proceedings [7].

Although use cases may have a recognised role in systems procurement, there is little evidence to suggest that Use Cases are being employed by customers as an integral part of their RFPs. There may be several reasons for this. Customer organisations may lack the skills to represent their requirements in Use Case models. One way to overcome this obstacle is to work with third parties. When Infraco BCV, a subsidiary of London Underground Limited, wanted to replace the ageing automatic driving equipment that pilots trains on the Victoria Line in London they worked with the independent consultant, Ian Alexander, to adopt an approach that minimised risk which they characterised as ‘right first time’ procurement [8]. After conducting interviews and workshops a use case model was developed and included in the RFP. The process of developing the use case problem statement is reported to have taken one month. Use cases were captured at the level of ‘operational goals’.

A high degree of satisfaction with the adopted approach from BCV (the customer) was reported. The supplier who won the contract found the requirements clear. No substantive challenges were raised at the system requirements review. Alexander suggests that anyone wishing to follow this approach must adopt the general principles of Systems Engineering from the outset. He further reports the process of developing the Use Case model had the advantage of causing additional requirements to be identified, thereby allowing a more complete requirements specification to be constructed prior to the contract being let. Alexander makes explicit reference to the importance of requirements being captured in order to ensure the eventual commercial contract is legally enforceable.

3. USE CASE MODELLING DESCRIBED

Software systems fulfil requirements. A requirement is something a computer program does for a user. In Use Case modelling, a Use Case is a representation of that requirement and users are portrayed by actors [9]. An actor is a role a user may play. A Use Case is a description of a sequence of actions that a system performs to yield an observable result to an actor [10]. Typically, a Use Case has a basic (normal) flow of events, a set of alternatives, and a set of exceptions. Use Cases do tangible work [calculate result, generate new object, change object state…] [10]. A Use Case is a contract specifying an object interface in detail. Actors may provide contracts that involve many Use Cases [11].

Use Case modelling is part of the Unified Modelling Language (UML) 1.3 [12]. Rational Corporation are responsible for the Rational Unified Process (RUP), that describes a software engineering methodology based on the UML [13]. The RUP is heavily influenced by Jacobson's Object Oriented Software Engineering (OOSE) methodology [14]. The sub-title of the book 'a Use Case Driven Approach', makes clear the importance of Use Case modelling to the method.

With time and resources scarce it is not possible to employ the entire Use Case modelling process. Most of the work, as RUP specifies, belongs in the software engineering methodology itself. It is important that the initial Use Case model should be relatively simple and quick to capture and that it is sufficiently well formalised to be of utility. To judge its utility it is necessary to understand the purpose to which it will be put. An initial Use Case model in a RFP is intended as a specification of requirement that can itself be transformed through a supplier defined process for the purpose of estimation, and in the event of success, as the first artefacts in the build.

4. REPRESENTATION OF DETAIL IN USE CASE MODELLING

There is agreement in the literature that Use Cases start off with low levels of detail that is gradually augmented [9, 15, 16] as the system progresses. Couple this with Jacobson's statement that "the set of all Use Case descriptions specifies the complete functionality of the system" [14] and what emerges is a coarse grained picture of a complete system. As each Use Case progresses through its lifecycle it acquires more detail thereby causing the picture of the system as a whole to come into sharper focus. The lifecycle of a Use Case progresses through a series of states until it is complete. Each Use Case starts as a primarily graphical artefact and progressively acquires further elaboration through semi-formalised text that describes, for instance, its preconditions, main success scenarios, and exceptions.

Kulak and Guiney [9] propose a hierarchy of detail through which Use Cases proceed starting by being developed to what is termed a façade level of detail. The purpose of the façade iteration is to create placeholders or Use Case names and short descriptions characterised as including minimal detail. The steps in creating façade Use Cases are:

- create a problem statement
- identify existing documentation and intellectual capital
- get the project sponsor's view point (project champion)
- identify and characterise the users
- identify the actors
- produce graphical Use Case representations

The level of detail provided in a Use Case is dependent on the lifecycle stage of the project. During procurement, façade Use Cases are developed. After a Use Case has been developed as a façade, it is verified for correctness before progressing to acquire further detail. In the façade stage a Use Case is primarily a graphical construction. The remaining stages of enhanced detail, according to this scale, are filled, focused and finished. The engineering methodology is iterative allowing for other models to be produced to complement the Use Cases at various levels of their development. Such models include the domain object model, the analysis model, the design model, the implementation model and lastly the testing model [14].

During procurement Use Cases should be at the façade level. One method of ensuring the initial Use Case model is abstracted at the appropriate level is to concentrate on producing a statement of the problem rather than being proscriptive with respect to the solution.

5. REPRESENTATION OF GOALS IN USE CASE MODELLING

Cockburn describes a different Use Case abstraction from that of the level of detail. Use Cases can be represented at different levels of abstracted goals. They exist on a goal centred scale, ranging from ‘very high level’ to ‘too low’ [very high summary, summary, user-goal, sub-function, too low]. The choice of *sub-function* as a possible classification option might better be termed *sub-goal*, which is the terminology adopted in this paper.

If Use Cases can be represented on a hierarchical goal-based scale, it is not correct, as Jacobson states, that Use Cases are always expressed in the language of the user [14]. Only at the level of *user goal* are Use Cases expressed such. Jacobson intended that Use Cases should be described at this level in order to focus attention on the fact that they were primarily intended for the benefit of users. When a Use Case is intended to primarily benefit a stakeholder other than the user, it is appropriate to change the language of their representation to reflect the actual stakeholder. The choice of level and therefore language depends on the audience for the Use Case model. The audience is taken from the set of all the stakeholders primarily broken down into the customer, the users and the supplier.

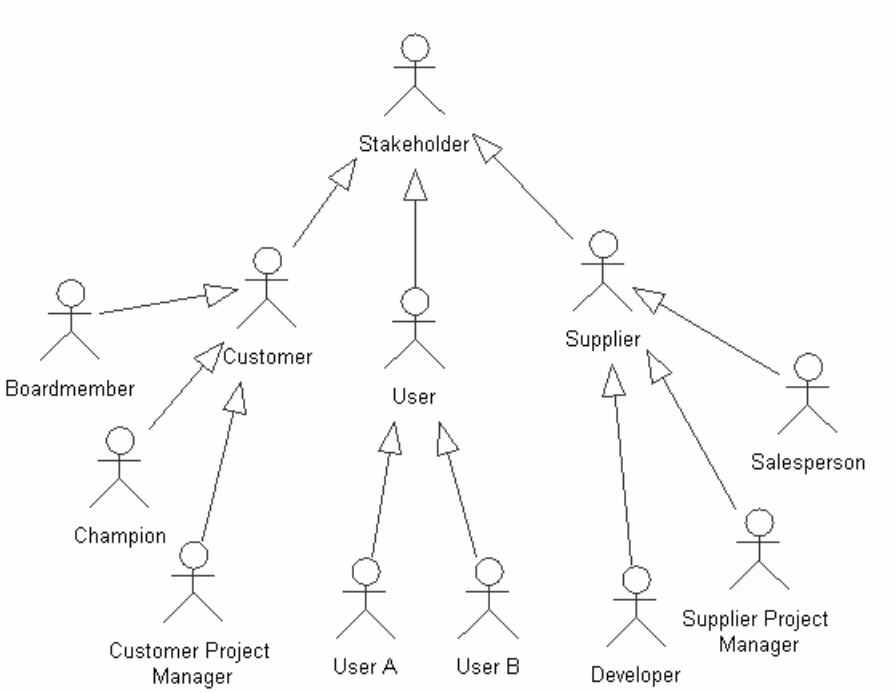

Fig. 1: Typical stakeholder specialisations useful in identifying the audience for a specific Use Case model. During procurement, models may be produced to support commercial negotiations; for the benefit of the Customer organisation, and the Sales function within the Supplier organisation.

In Fig 1, Customer is specialised by Boardmember, Champion and Project Manager. Supplier is decomposed into Sales staff responsible for competing for new business (and keeping the customer happy), Project Manager, and the developers who will physically realise the system should the contract be won. This diagram illustrates the array of stakeholders involved in the provision of a new information system. Although the requirements of the various Users are paramount in defining system functionality, it is clear that Use Case models may have a very wide audience. In the same way that the author of a new novel may have a particular audience in mind, so may the Use Case modeller.

This does not fundamentally contradict the notion that Use Cases are expressed in the language of the user, in the sense that there is one dominant level, and that level is the *user goal* level. Other levels are greater or lesser abstractions. The same Use Case can be shown on the same model at different goal levels.

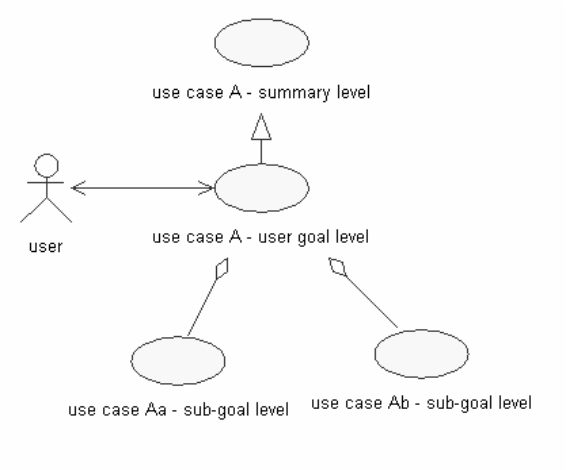

Fig. 2: A Cockburn style Use Case structure. The user interacts with the Use Case at the 'user goal' level. Use Cases higher up the hierarchy are at the summary level, aimed at particular stakeholders (Fig 1). Use Cases lower in the hierarchy are decompositions, depicted associated through aggregation rather than employing the more controversial <include> or <extend> UML Use Case association stereotypes. There is evidence to suggest these stereotypes are among the most confusing aspects of Use Case modelling [17] and are omitted in favour of aggregation associations (whole-part associations).

*Note that where the same Use Case is depicted over more than one goal level, the actor always interacts at the **user goal** level. Where only **summary** use cases are shown, the actor interacts at this level.*

According to Evans, [15] the Use Case should contain only those elements essential to understanding by the reader. Evans makes reference to the "provision of detail consistent with the current level of abstraction but without being so minimalist as to be misleading". This gives a clue as to how the goals of the stakeholders could inform the abstraction used in the model. Jacobson is clear on his instructions that Use Cases should be developed according to the language of the *user*. This could be usefully extended to state that Use Cases are developed in the language of the diagram's audience. Doing so seeks to provide a rationale that reconciles Jacobson with Cockburn. This is important because it accepts the other levels of Use Case goal which evidently do serve a purpose, albeit not necessarily one defined in the *user's* language.

6. SPECIFYING GOAL DRIVEN USE CASES IN THE PROBLEM STATEMENT

It is possible to characterise Use Case goals as being either problem or solution oriented. Use Case models intended for consumption within the customer organisation, and as a prelude to procurement should be problem oriented.

Ideally the initial Use Case model is constructed within the customer organisation to gain internal support and a project champion. The diagrams used to illustrate the points made in this paper are taken from the domain of the travel industry, specifically a travel company that sells package and customised travel to the public. The choice of which levels are used is dependent on the size and scale of the customer organisation and of the project.

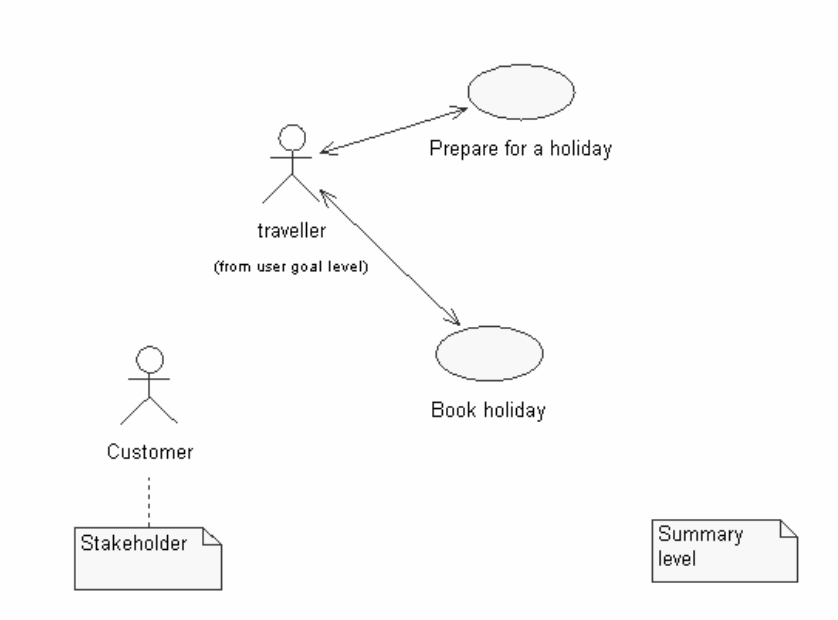

Fig. 3: A Use Case model at the summary level. Here the Customer stakeholder is shown, for whom this diagram is primarily produced. Where 'user-goal' Use Cases are not shown, the actor interacts at the summary level; as in this example.

It is likely such a diagram would be produced in the early stages of the procurement process where the project is seeking to secure a champion or boardmember approval. As a Use Case is refined according to the goal hierarchy process it becomes less abstract until it stands as a, more or less, unambiguous statement of a requirement to which a solution is desired. The process by which Use Cases are transformed has the effect of making them increasingly more concrete and specific.

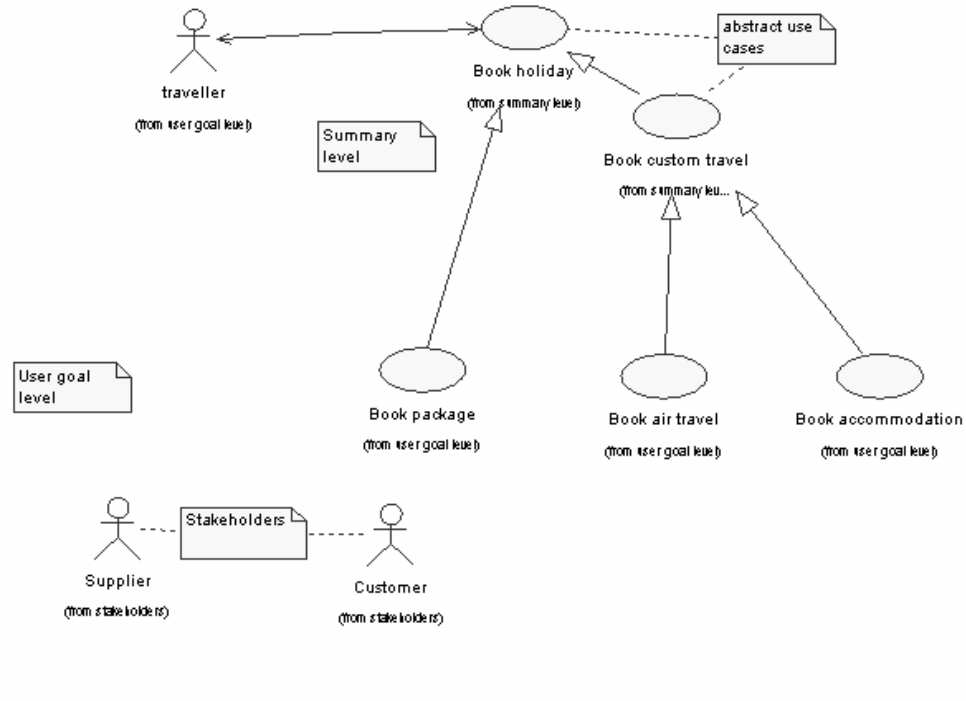

Fig. 4: Problem statement Use Case model at the 'user goal' level. This diagram helps the model specifier to verify user requirements. Summary Use Cases are classified as abstract and subsequently specialised as 'user goals'.

A diagram that depicts Use Cases at the level of summary and user goal is useful to canvas preliminary agreement internally prior to the production of the final problem statement model for inclusion in the RFP.

The decision regarding whether to include sub-goal level decomposition of Use Cases in an initial Use Case model is on balance preferable to omitting them. Sub-goal Use Cases are useful in that they may reduce the number of assumptions made by suppliers tendering to build the system which in turn leads to a simplification of the process of comparison. A model decomposed to the sub-goal level is sufficient for the purpose of inclusion in a RFP that stands as an unambiguous statement of the requirements; being accurate but lacking in precision. A Use Case model built for this purpose must show the legacy systems on which the new system is dependent as these interfaces are material to the effort required to deliver the new system.

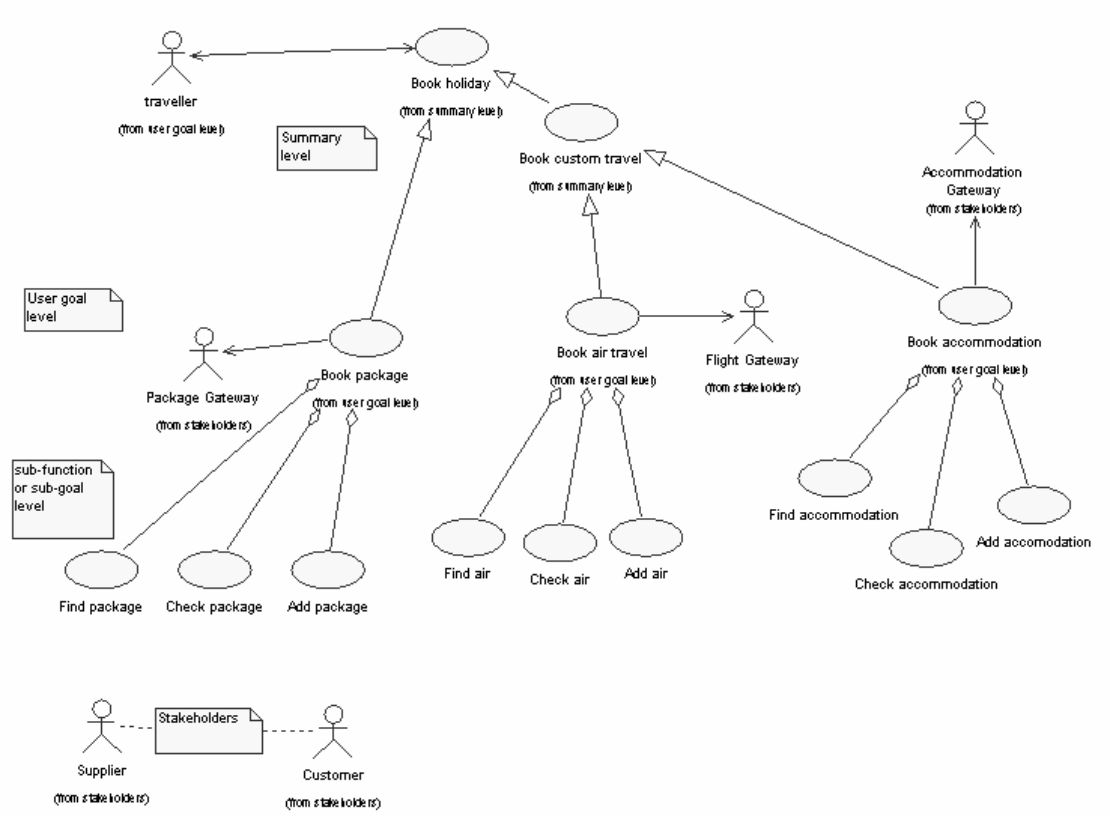

Fig. 5: Problem statement Use Case model at the sub-goal level. The concrete specialisations are broken out using aggregation associations. Interfaces to legacy systems (Gateways) are shown as associations to secondary actors.

This diagram provides an adequate level of detail for inclusion in a RFP. It need only be produced once yet represents utility to many potential suppliers. A supplier understands from this diagram that the business wants to commission a system to interface through to an airline gateway that can provide a booking service.

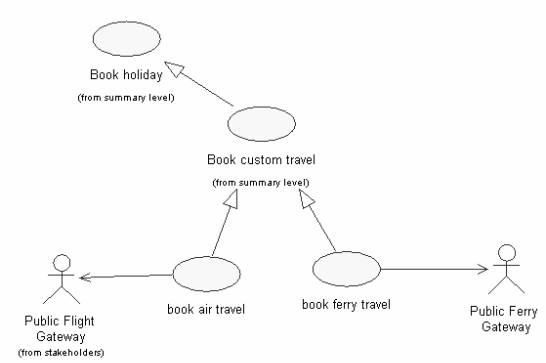

Fig. 6: Higher level Use Cases are, to some extent, insulated from changing requirements, allowing further specialisation to act as a mechanism for the management of 'requirements creep'.

If in the fullness of time it transpires the customer also has the requirement to allow ferry bookings, it is clear from this diagram that the ferry functionality is outside what was originally envisaged. This is important because it allows the stakeholders to agree what functionality is new, and to manage 'scope creep' in a responsible fashion. At least at the summary goal level the design is insulated from this type of change. Should they be necessary it is obvious where they belong given that a hierarchy of functionality has already been established.

7. SUMMARY

One of the major problems in Use Case modelling is deciding on the correct 'level' at which to represent requirements. The debate rages around the inclusion of either too much detail, or too little and the necessity to represent a set of Use Cases at the same degree of detail in order to ensure a 'homogeneity of expression'. The same system can be described at different levels of detail to satisfy different objectives of different stakeholders. Every stakeholder has some responsibility for ensuring the project to supply a new system is successful. Use Case modelling has different, inter-related, axis of abstraction. On one axis, Use Cases model the same functionality at different levels of detail. On the other axis is the abstraction of composition whereby Use Cases are modelled using the techniques of object orientation; aggregation and inheritance. Sub goal Use Cases are primarily decomposed for the benefit of the development team. The decision on how each Use Case is decomposed depends on there being a stakeholder whose goal is served by the decomposition.

Alexander has suggested that the inclusion of Use Case models in RFPs improves the procurement process [8]. This paper seeks to demonstrate that it is easier to contemplate the inclusion of use case models when the appropriate level of abstraction is adopted that limits the degree of detail and which adopts a goal hierarchy appropriate to the representation of the problem and which serves the needs of the relevant stakeholders.

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