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Coherence: an Approach to Representing Ethnographic Analyses in Systems Design

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ABSTRACT

This paper is concerned with how to represent in system design the kinds of features of work settings as reported by ethnographic studies of work. Various researchers and practitioners have found that ethnomethodological analyses of work settings can provide useful insights to the work processes and settings that system design is interested in. Previously at Lancaster, we have examined ways in which ethnography can be used in the design process, and how the results of ethnographic analyses can be presented in such a way as to be useful components of the design process. This paper reflects an effort to approach these methodological issues from a different perspective, by examining how the lessons learned from ethnographic studies can be reflected in the design process itself, and in particular how design artefacts (models, documents, etc.) can express the type of information which ethnographic studies produce.

The paper focuses on how ethnographic analyses can influence the main representational artefact in systems design—the model of the system being developed. We examine how the Unified Modelling Language (UML) for object-oriented design can be used to express information about awareness in cooperative systems

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Coherence: an approach to representing ethnographic analyses in systems design

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Keywords: Ethnography, systems design, awareness, notation, UML

1. INTRODUCTION

The disciplines of Computer Supported Cooperative Work (CSCW) and HCI are both concerned with improving the systems design process so that systems better support the needs of users. In CSCW in particular this has meant involving a turn to the social sciences for insights into how people work together, how work is socially organized and what implications this might have for the design of systems to be operated by several people working together. The group of social scientists most involved in this are ethnomethodologists, who have undertaken a number of studies of work which have examined the nature of cooperative work supported by technology (Harper, Lamming, & Newmann, 1992; Heath & Luff, 1992; Hughes, Randall, & Shapiro, 1992). The enthusiasm for the results of these studies has been balanced by a frustration with accessing and making use of the results in design.

Ethnographers have started to examine the nature of the communication problem that exists between systems designers and ethnographers. The nature of this work has largely been a rethinking of how the results of ethnographers' field work can be presented in such a way as to be useful to system designers (Hughes, O'Brien, Rodden, Rouncefield, & Sommerville, 1995; Hughes, O'Brien, Rodden, & Rouncefield, 1997). The work reported in this paper is trying to approach the same problem from the other direction, by examining how an established system design notation can be used to represent the kinds of information

forthcoming from ethnographic studies. Our approach is motivated by the need to link with the working practices of system developers, and with the notations and tools that they use.

The key concern of this paper, and of the Coherence project in general is to address the problems of applying social analyses in the systems design process and to establish effective communication between the two.

The approach we have taken is to focus on one particular feature of the social organization of workplaces to explore how a standard object oriented notation can be used to represent it. This paper focuses on awareness of work, which has been a feature of a number of ethnographic studies, and how it can be represented in the Unified Modelling Language (UML). A previous field work site was revisited during this work, and the paper is illustrated with examples taken from it.

In what follows, section 2 briefly reviews the contribution that ethnography has made to systems design, and a framework is presented which characterises the various contributions according to the influence of ethnography in systems design. Section 3 reviews awareness in the CSCW literature from a number of perspectives, and argues that there is no agreed model of awareness that can be used here. Section 4 turns to considerations of notation and problems that can exist in their use. Our approach to developing a notation is outlined, and our choice of UML is justified. The three built in mechanisms for extending UML are reviewed, and how UML can be used and extended in order to represent awareness is considered. Section 5 turns to the case study, a small office which was the site of a previous ethnographic study, and a number of examples of awareness in the office are presented, along with their representations in UML. Section 6 concludes the paper and points to further work.

2. ETHNOGRAPHICALLY INFORMED SYSTEMS DESIGN

It is widely recognised that the requirements phase of systems design is particularly problematic (Brooks Jr., 1987; Christel & Kang, 1992; Davis, 1993; Sommerville & Sawyer, 1997). This is for a number of reasons. The elicitation and analysis of requirements is not straight forward. Requirements may be expressed in a number of different ways, come from a variety of sources, and the likelihood of conflicts is high. They also are liable to change throughout the development process, sometimes as a side effect of the process itself as the stakeholders' needs and desires shift when exposed to early prototypes, and so on. This means that the requirements as specified in the project documentation may differ markedly from what is actually needed or expected.

There also exists a much stronger need to get requirements right, as errors in requirements lead directly to systems which fail, either because they do not function as desired, or because they do not match the actual needs of users and other stakeholders. Errors in requirements can remain latent until very late in the design process, and the longer that errors remain uncovered, the more they cost to rectify through work which must be abandoned, and subsequent rework. The motivation, therefore, for spending effort on getting requirements right, is very high.

In the design of CSCW systems, much of the research on requirements elicitation has involved turning to the human sciences, and branches of sociology in particular, in order to improve our understanding and descriptions of the cooperative work which is to be supported. One aspect of CSCW systems which distinguishes them from other computer-based systems is the recognition of the need to support the social organization of the workplace, and the social process through which work is achieved in a collaborative setting. In order to do this, the design process must not only build up an understanding of the social aspects of the system, but also be able to record them in such a way that they can be communicated to other stakeholders, and ultimately feed into the design itself.

The sociological tradition turned to most frequently for this purpose is ethnomethodological ethnography. The early ethnographic studies in the CSCW literature were performed first and foremost as a study of the use of technology in cooperative work settings such as control rooms (Heath & Luff, 1992), research laboratories (Harper, et al., 1992), City dealing rooms (Heath, Jirotka, Luff, & Hindmarsh, 1993), and so on. Consideration of how the reported studies might affect any new technology being introduced into the workplaces would often appear to be an afterthought, and how the use of ethnography might influence the design process in general was seldom discussed, if at all.

More recently, however, ethnographers have directed efforts towards how ethnographic study and analysis can be placed within systems design in a more systematic and structured manner (Hughes, King, Rodden, & Andersen, 1994), and how their techniques might be adapted to make them more amenable to use in the design process through the use of presentation viewpoints (Hughes, et al., 1995) and framework (Hughes, et al., 1997). This work in particular has approached the issue of communicating ethnographic analyses to designers by providing means of structuring the findings from fieldwork. The key benefit that ethnography has to offer design is the rich detailed descriptions of the complex features of the work site, yet this can get lost in the richness of ethnographic record. Work on presenting ethnographic findings in this way attempts to 'pull out' what has been found to be most relevant for design.

The following section examines a number of ways that ethnographic analyses can influence systems design, and presents a framework within which the different approaches can be considered.

2.1 Technomethodology

There are a number of ways in which ethnographic studies have been used to influence the design process. In some cases, it is simply that studies have taken place which have raised a number of issues for the research community to consider. In others, the ethnographers are directly involved in the design process, and present reports on their studies during debriefing meetings with the designers (Bentley, Hughes, Randall, Rodden, Sawyer, Shapiro, & Sommerville, 1992). In others again, the ethnographers are engaged in modifying the ways in which their reports are presented to the design process in order to bring out the specific details of the study that are most useful for design (Hughes, et al., 1995; Hughes, et al., 1997). The latter two positions correspond to the first two ways in which the relationship between ethnographers and designers can operate, according to a recent paper by Button & Dourish (Button & Dourish, 1996) .

In their paper which is concerned with the same issues as we are here, Button and Dourish present three possibilities for how the ethnographer-designer relationship could operate:

- **Learning from the ethnomethodologist**. As in concurrent ethnography, for example (see (Hughes, et al., 1994)), the ethnographer undertakes their study in the workplace, and writes this up. It is through the participation of the ethnographer in the design process, however, where the information is transferred to the designers. The ethnographer may act as a proxy for the users in the field, or for the workplace itself, and can provide feedback to the designers in response to suggestions for changes to the system under consideration. In this case, the ethnographer is engaged directly in the process of informing the design, and in Dourish and Button's terms, the locus of the ethnomethodology (what makes the analysis an ethnomethodological one) is in the ethnographer's head.

- **Learning from ethnomethodological accounts**. In this approach, the ethnographer performs a study of a workplace, and writes it up as before. This time, however, it is the account—that which has been written up—which is passed on to the design process. This is similar to the presentation viewpoints (Hughes, et al., 1995) and

framework (Hughes, et al., 1997), where an ethnographic study is presented in a manner intended for consumption by designers. The locus of ethnomethodology, in this case, is in the account itself.

- **Learning from ethnomethodology**. Finally, in this approach, the design process is informed by ethnomethodology itself. This is unlike anything else covered in this section. Rather than relying on ethnographers to present the results of a study, either themselves or through an account of it, this approach requires the design process itself to be directly influenced by ethnography. In this case, according to Button and Dourish, the design process itself is in some way an ethnomethodological one.

This paper is part of an effort to work from this third perspective, and to examine how traditional systems design methods can be adapted in order to better reflect the concerns of ethnomethodology, and in particular to provide better means of representing the phenomena of interest to ethnomethodology, and to move towards modelling the workplace in a manner that is informed by an ethnomethodological perspective.

We would run the risk of taking on too great a commitment if we were to attempt to explore the whole of ethnomethodology's findings in one attempt. What this paper intends to explore is the feasibility of introducing an ethnomethodological influence into existing system design methods. We therefore wish to focus our efforts on one aspect of this perspective, which we hope will serve to illustrate the utility of this approach. For this purpose, we have chosen to focus on awareness of work, one of the three dimensions which came out of the work on a presentation framework for ethnographic analysis. Not only does this have the benefit of focusing our effort to something more manageable, but awareness is also at present a very popular topic within the CSCW community, with many systems incorporating awareness features, and a number of awareness 'widgets' appearing in the literature. The following section provides some further background on awareness as it has become conceived in CSCW.

3. AWARENESS IN CSCW

Awareness has developed into a very popular topic in recent CSCW research. The origins of its current use can be traced back to the work on media spaces (e.g. (Dourish & Bly, 1992)) and from there to Moran and Anderson's paper in CSCW'90. In this paper, the authors stress the importance of supporting awareness in cooperative systems design in the following manner:

> There is a crucial design principle for any technology that is environmental in the sense that it surrounds people and pervasively impinges on them. Most computer interfaces are designed for people to pay attention to them. But people deal with a complex environment by *not attending* to most of it most of the time. It is important not to saturate people with things they cannot ignore. … On the other hand, people are very *aware* of what goes on in their environment; without such awareness they would feel isolated. The environment needs to be rich with many things (including other people) that *could* be attended to. The environment needs to signal the *availability* of these things by tapping on people's ability to *peripherally* process the non-attended parts of the environment so that they can redirect their attention when appropriate. (Moran & Anderson, 1990) (original emphasis)

So, for Moran and Anderson, awareness is related to the information which we perceive peripherally, attending to it when it becomes necessary for our current activity. This is precisely the type of information provided by media space systems such as those emanating from Xerox PARC and EuroPARC.

Awareness is increasingly referred to in the CSCW literature, in a number of different contexts. There is, however, no real consensus on what awareness consists of. Increasingly, it is becoming considered more narrowly as the collection and presentation of data on activity

by participants in the system—a pale imitation of the peripheral awareness which co-location affords.

The remainder of this section briefly examines awareness as it has been covered in the CSCW literature. The work on media spaces is covered first of all, followed by a review of a number of prototype systems which claim to support awareness, and finally models of awareness and other theoretical considerations are turned to.

3.1 Awareness in media spaces

Media spaces are integrated networks of audio and visual connections controlled by computers between a number of locations, typically individual offices but also connecting open common areas between different sites. What distinguishes them from other similar communication media such as audio and video conferencing is the long-term nature of their use. Media spaces are intended to become part of the environment and used as such.

Probably the best known work on media spaces was conducted at Xerox PARC and Rank Xerox EuroPARC (as it was known at the time) (Gaver, Moran, MacLean, Lovstrand, Dourish, Carter, & Buxton, 1992). Experiments were conducted with shared common areas between geographically distributed labs (Olson & Bly, 1991), on the use of gesture when collaborating through a media space (Heath & Luff, 1991), on the affordances of media spaces (Gaver, 1992), and on systems directly targeted at supporting awareness (Dourish & Bly, 1992). Work elsewhere included systems such as CAVECAT (Mantei, Baecker, Sellen, Buxton, Milligan, & Wellman, 1991), and CRUISER (Cool, Fish, Kraut, & Lowery, 1992; Root, 1988).

The work on media spaces was the first body of research in which awareness was referred to (Moran & Anderson, 1990). The term originally was called peripheral awareness, and was seen as background information which facilitates everyday interaction and collaboration, which we attend to directly when we need to or when it is in our interest to do so, but only peripherally at the rest of the time.

Most papers tend towards an intuitive notion of what awareness is, and any more detailed notion of awareness is hidden.

> "...use of video technology is very similar to the typical awareness activities which occur in a shared physical environment. While sitting at a desk, we are aware of activities going on around us—we hear the sounds of conversations in corridors, see people as they pass by, notice people in offices as we walk down the hallway, and so forth." (Dourish & Bly, 1992)

The media space work then can be seen as the introduction of technology to enable similar affordances for chance interactions, and awareness of events taking place nearby, as those which exist in physical shared spaces. This does not get us any further to understanding awareness for our purpose of representing it in systems design.

3.2 Implementations of Awareness

As the popularity of research into awareness has increased, so has the number of papers on systems which claim to provide support for it. These vary from full systems (or demonstration prototypes) which explicitly aim to explore the support of awareness, through systems which mention awareness as a feature, to toolkits and 'widgets' that are aimed at making it easier for CSCW application developers to incorporate awareness support into their systems. Most of this research concentrates on implementation issues, rather than considering the nature of awareness which is to be somehow supported. They are included here to further illuminate the notion of awareness as it has become construed in CSCW.

The popularity of awareness research means that there is a plethora of systems published recently, but this is not to say that awareness has not been seen as an issue for some time. For example, GROVE (Ellis, Gibbs, & Rein, 1991) provided awareness of others' activity through embellishments of the text in a group editor. Of the recent systems, some claim to have directly addressed awareness in their requirements (Hall, Mathur, Jahanian, Prakash, & Rassmussen, 1996; Sohlenkamp & Chwelos, 1994), whilst others claim awareness as the motivation for their development (Pedersen & Sokoler, 1997; Tollmar, Sandor, & Schömer, 1996). Awareness has become elevated to the status of a system feature to the extent that in Politeam (Mark, Fuchs, & Sohlenkamp, 1997) users are allowed to specify awareness profiles (tantamount to filters) which can themselves be shared.

The breadth of what can be considered as awareness is illustrated with Timewarp (Edwards & Mynatt, 1997) which supports awareness of history, people & time. Other work is more focused on awareness of the activity of other members in a small group. For example, Gutwin, Roseman, & Greenberg (Gutwin, Roseman, & Greenberg, 1996) characterise *workspace awareness* as

> "...the up-to-the minute knowledge a person holds about another's interaction with the workspace [including] ... knowledge about who is in the workspace, where they are working, what they are doing, and what they intend to do next."

They have developed 'awareness widgets', which offer group versions of traditional user interface artefacts such as multi-user scroll bars, as well as graphical indicators of activity.

3.3 Studies, models and theoretical considerations of awareness

In the field of Collaborative Virtual Environments (CVEs), the spatial model of interaction (Benford & Fahlén, 1993) provides a means of reasoning about how aware users in a CVE are of each other, and of the environment in general. The spatial model defines three features for each object in the environment: *aura*, *nimbus*, and *focus*. Focus relates to how much and where one's attention is directed, whereas nimbus is concerned with the opposite notion of the direction and strength in which one's presence is projected. Along with aura, which acts as a bounding mechanism outside of which focus and nimbus have no effect for a given user, the spatial model allows developers of CVEs to manage the computation required to maintain awareness between users. This work has been extended recently to desktop collaborative applications in general (Rodden, 1996).

Another simple model of awareness breaks it down into *modes* of awareness (Fuchs, Pankoke-Babatz, & Prinz, 1995): This is achieved in a two-by-two matrix mapping coupled—uncoupled against synchronous—asynchronous awareness. In contrast with the spatial model, this work simply provides a high-level classification of types of awareness.

When thinking about awareness, it is easy to ignore some of the drawbacks which might exist. In particular, there is a trade-off between awareness and privacy, and also between awareness and disturbance (Hudson & Smith, 1996) . For example, the more one is aware of others' activity, the less privacy they have, and the more potential there exists for one to be disturbed by their activity. This concern did, in fact, become a focus for some of the later work on media spaces (Bellotti & Sellen, 1993).

3.4 Awareness for systems design

As can be seen from the above, whilst awareness as a concept is appealed to in a variety of manners in a multiplicity of systems, there is no universally agreed definition of the phenomenon, beyond what are quite intuitive understandings of it in terms of the type of information and cues which we are deprived of when our communication is mediated by technology. What this means is that for our purposes of understanding awareness in order to

be able to represent it in system design, there is no precise model 'out there' that we can make use of.

Given the above, in combination with the wider context in which the work reported here has been undertaken, we have returned to ethnographic accounts of awareness to drive the development of a notation for awareness in systems design. Ethnomethodology's grounding in the detail of work makes it impossible, for a purist at least, to make generalisations and abstractions from a study. This is, however, exactly what we want and need to be able to do in system design, so a compromise must be reached. We can still, however, make use of the concerns which ethnographic studies have raised in the past in order to ask questions like "what about issues of awareness of work?". This is not saying that the issues exist in every workspace, merely that they can be flagged as issues to be sensitive towards.

For our practical purposes, therefore, it seems to be best to consider awareness as a 'place holder' for contextual information, e.g. about the layout of the workplace, how paperwork is used for purposes other than the obvious of recording and passing on information, how activities are made available and oriented towards other participants in the workplace, and so on. It is clear from the consideration of implementations of awareness above that not all systems will support all aspects of awareness. The challenge for systems design, therefore, is to be able to represent the wide and varied types of information about workplaces, of which awareness is but one. The following section presents the approach we took in choosing a notation for this purpose, and how the notation we chose can be extended to represent awareness in systems design.

4. A NOTATION FOR REPRESENTING AWARENESS IN SYSTEMS DESIGN

The main concern here is to develop a means of representing features of awareness which have been found to be important for the design of systems which are to support the ways in which people in the workplace achieve their work on a day-to-day basis. It is important to note that having a notation will only partially satisfy the requirements for a methodical solution to these issues. For this work to be considered a method in any sense, there must be a process as well as a notation. This paper, however, is only concerned with the latter. The development of an associated process will do more to encapsulate the theoretical perspective of ethnomethodology into a design approach, but the approach must also be able to represent and model the workplace from this perspective. For this reason we are focusing on notation first of all.

Developing a notation is not without problems however. A major concern we have is for our work to be applicable in industry, and for this reason there are some issues with the design and use of notations which need to be considered which influence the approach we have taken, and ultimately the choice of notation to work with.

4.1 Problems with notations

This paper is not the place for an exhaustive discussion of problems with the use and design of notations. Nevertheless, there are some concerns which must be borne in mind when considering the development of a new notation, or extensions to one which already exists.

First of all, we do not believe that it is possible to model reality in its entirety. For every new formalism introduced to capture a particular feature of the world in which we are interested, it is easy to think of ways in which to 'break' it, or to propose situations which are not covered (Bowers, 1992).

Modelling notations can tend to give an impression of 'tidiness' and order concerning what is represented, where no such order exists. Because a situation is presented as a series of boxes

and lines, which do not lend themselves to representing 'messy' aspects of the situation, these potentially highly important features can become hidden. The adage of a picture being worth a thousand words can prove to be a false economy in these cases. Orderliness of another sense can also be read into models due to cultural, but not universal, norms of reading, for example, from top to bottom and from left to right.

We are especially concerned here with modelling and notations as they are used in practice, and so issues of ease of learning and use are of fundamental importance. The ease by which a notation can be learned, and subsequently understood in use as a means of communication about what is being modelled, has a great impact on how successful the notation will be in practice. Extra leverage for new modelling concepts can be gained here by making use of notations which are already widely in use. But there is a danger here if well established notations are used in new and different ways. This can be a source of confusion or, worse still, lead to mistaken perceptions of mutual understanding when communicating via a model.

Bearing all these points in mind, we do not see any advantage in engaging in the development of a new notation which may possess numerous desirable features yet cannot be guaranteed to model all the features of interest in a workspace, nor can it be guaranteed that anyone will make the effort to use it in practice. Rather, we wish to work with existing notations which are already accepted in industry, and examine how they might be used to express the kind of information we are interested in.

4.2 Approach

It is important to note that the approach we are taking is for a particular practical purpose—that of providing means of representing workspaces in a way which ensures that features relating to the coordination of work between people are expressed as richly as possible. At the same time, it is equally important to orient the work towards acceptance by systems designers who are familiar with using structured notations. This paper is not saying that the work of an ethnographer has been systematised in some way, and this is what we are encapsulating in the notation. Making such assumptions for a particular study of a work setting may well be possible, but it would be wrong to assume that these connections can be drawn in general from the notation. For example, we are focusing on how to represent awareness here, but we would not claim that any notation we introduce for describing awareness is the *only* way to represent it, or that it is capable of describing all possible forms of awareness which might be of interest to us.

What we are aiming to provide with this work is affordances for requirements engineers in describing systems rather than restrictions for how they should go about this. So, despite this paper's focus on awareness, and the widespread interest in the subject in the literature, we are not claiming that awareness is something 'out there' which is to be found in any given work setting. Rather, it is a phenomenon which our experience has shown to feature in a number of field studies we've been witness to, and for this reason we believe that a system design method should be able to describe and represent it in some way.

4.3 Choosing a notation: UML

Our choice of notation to work with is primarily guided by our desire to produce work which will be of interest, and ultimately of use, to software engineering practitioners. For this reason, we wish to use as close as possible to industry standard techniques as we can. The choice we have made is to examine how the Unified Modelling Language (UML) (Rational, 1997a; Rational, 1997b; Rational, 1997c) can be adapted to our purposes. UML is a notation for object-oriented analysis and design which incorporates (unifies) what its developers would claim to be the best of three leading object-oriented modelling approaches (Booch, 1994; Jacobson, 1994; Rumbaugh, Blaha, Premerlani, Eddy, & Lorenzen, 1991). It is

currently on the verge of acceptance by the Object Management Group (OMG) as a new standard notation, and is the focus of much attention in the software engineering community.

Whilst UML is not exactly widely established in practice yet, it is being hailed as what will become the standard choice for object oriented analysis and design (Fowler & Scott, 1997). Its foundations, however, are very well established, and the notation in particular is very close to that of OMT (Rumbaugh, et al., 1991), which is itself broadly used in industry.

In addition to its relevance to industry, there is another factor which makes UML a good choice for this type of work, and that is the mechanisms built into the language for making extensions to it. This offers further possibilities for us beyond simply exploring ways in which the notation as it stands can be used to express awareness and other phenomena of interest to us. Also, as the extension mechanisms are built in to the specification of UML, any extensions which we might propose are available to anyone else who makes use of the language with relatively little effort[1]. The following section presents the ways in which UML class diagrams can be extended.

4.4 Options for extending UML

UML has three general extension mechanisms built in which allow users of the notation to define new semantics into the models developed with it. The developers of UML have also made use of these mechanism themselves extensively, for example building in support for the Objectory method (Jacobson, 1994). The extensions to UML are called *constraints*, *tagged values*, and *stereotypes*, and they operate on the UML metamodel[2] in the following ways:

- **Constraints** are used to extend the semantics of the metamodel. A constraint is a condition or proposition which is specified as a relation between elements in a model which must hold true. They work by placing a restriction or condition on a model element, or a collection of them. Some constraints are pre-defined in UML, e.g. the "or" constraint on associations which restricts each instance of an association to only one of the constrained elements (see figure 1). Constraints appear in UML as text strings bounded by braces ({ }).

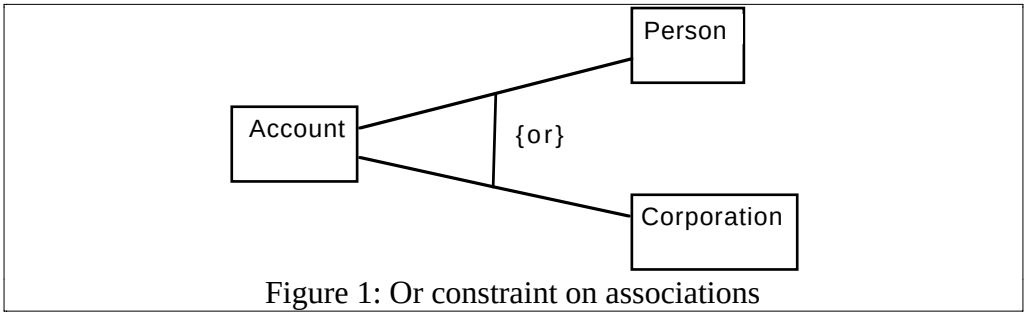

Figure 1: Or constraint on associations

Similar to constraints are **comments**, which are also textual, but not contained within braces. Rather, they are placed within a note symbol (a box with a folded corner, see figure 2) which is attached to a model element, and may contain graphical elements and references to documents in addition to text.

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1 The extension mechanisms all apply to class diagrams in UML, and it is class diagrams that are the primary focus in this paper. There are, of course, other diagrams which will be developed as part of a modelling exercise, and these other diagrams, e.g. use case, activity, interaction, will be looked at in due course.

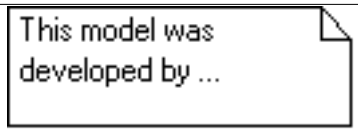

Figure 2: A UML comment

- **Tagged values** are used to extend the attributes of classes in the metamodel. They take the form of keyword-value pairs, and can be attached to any kind of model element. The keyword, known as the *tag*, represents a property that is applicable to one or more kinds of model element. Both the tag and its value are strings, and are enclosed within braces as for constraints. Pre-defined tagged values in UML include postcondition, precondition, and invariant. Figure 3 shows an example of a tagged value.

{author="Joe Smith", deadline=31-March-1997, status=analysis}

Figure 3: Tagged values in UML

- **Stereotypes** are used to extend the classes in the metamodel. The creation of a stereotype is equivalent to the creation of a new class in the metamodel. Stereotypes are denoted by the stereotype name being placed above or in front of the model element it applies to within guillemets (« »). Additionally, stereotypes allow the introduction of an icon to further distinguish model elements of this new type, and this icon can replace the standard notation for the element. Stereotypes have been used extensively in UML in order to extend the notation to cover Objectory classes. Figure 4 provides an example of an Objectory stereotyped class (Objectory classes are of three types: control, boundary, and entity).

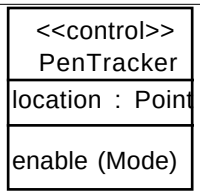

Figure 4: a stereotyped class

4.5 Expressing awareness in UML

Constraints, tagged values, and stereotypes offer a number of possibilities for representing information about awareness in models of systems using UML. At the most basic level, it would be possible to represent a lot of the information provided by an ethnographically informed study in a textual form in a comment. As there is no requirement for comments to be specified in a formal language, and the UML documentation is explicit about the possibility of graphical or pictorial information being included, then comments could include plans of a workspace's physical layout, photographs of items in the workspace of particular interest, or links to reports of observations made, interviews carried out, and so on. This would serve to situate the relevant information in the model (and therefore situate the model in the workplace), yet this would not be achieved in a way which facilitated its influencing the model as far as the definition of classes, relationships, etc. are concerned. In many ways, this is very similar to Button and Dourish's characterisation of design learning from the ethnomethodologist, as it would most likely require the person who had performed the study

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2 The definition of UML (Rational, 1997b) makes use of a subset the UML notation itself. So one has to understand UML in order to understand its specification. It also means that some of the mechanisms which have been used in the development of the notation are also made available to the users of the notation.

to explain its relevance to the design at hand. It is also, however, approaching their second characterisation in that the account of the workplace is recorded in the design itself.

Closer to the second option in their list—design learning from ethnomethodological accounts—would be the definition of a set of stereotypes of awareness classes which could then be instantiated with specific information regarding the system under development. It would be possible to generate a hierarchy of classes of awareness, which in a certain application domain could be extended with experience to cover all the different 'types' of awareness encountered. This is, of course, stretching how much the findings from ethnographic studies can be used generatively. We stress that this is done for the practical purpose of recording information pertaining to a design from a particular perspective of having encountered certain phenomena in a number of work settings, and that it is therefore reasonable to consider whether they exist in others. It is *not* to say that, for example, there will be certain 'classes' of awareness 'out there' to be identified in a given work place.

To reach the third option, of design learning from ethnomethodology, requires more than notation. This is where the process aspects of a method take force, and is beyond the scope of this paper. Our concern here is to explore the design of a notation which could be used in such an ethnomethodologically informed method. The following section considers some options for using UML in such a way, illustrated with examples from a case study.

5. EXAMPLES FROM A CASE STUDY

In order to experiment with expressing awareness with UML in a real setting, we returned to a site which had previously been the subject of an ethnographic study (Rouncefield, Viller, Hughes, & Rodden, 1995). This section presents a brief description of the field work setting, then presents a number of examples of what we would want to broadly classify as awareness in the workplace, and suggestions for how these could be expressed in UML.

5.1 Description of the setting

The setting of the case study used here is the Training Centre Office (TCO) responsible for the operation of a Management Training Centre. The centre is part of a hotel complex situated next to a university, and is administered as a partnership between the hotel and university. The training centre consists of three training suites, each of which consist of three meeting rooms and a larger training room. In addition to the training suites, there is also a computer room and two conference rooms for larger gatherings. The work of the TCO is to coordinate and manage training sessions and conferences booked either through the university or from external clients. Much of this work is concerned with attending to details, of room configurations, catering and accommodation requirements, etc. in particular, and of customer requirements in general.

The TCO is staffed by a manager and four coordinators. A strict division of labour exists, with two coordinators dedicated to internal (university) business, and the other two to external bookings. The hotel coordinators are primarily concerned with future business, handling enquiries and taking bookings for meetings, conferences, and so on. In contrast, the university coordinators, in addition to dealing with telephone enquiries and bookings, also undertake (along with the TCO manager) the day-to-day running of the centre, seeing to delegates' needs while they are there. Much of the work in the TCO takes place on paper, using forms to record enquiries, particular requirements for bookings, and so on. The information technology in the TCO is limited to PCs that are used primarily for word processing (memos, letters to clients, etc.) and a terminal which is connected to the hotel's

reservation system so that the latest details on the number of rooms available on particular dates can be checked if necessary[3].

The most important item in the TCO is the diary, which records all bookings for the various training suites and other facilities, together with hotel requirements for accommodation, catering, etc. Everything is coordinated through the diary pages. The remainder of this section provides a number of examples from the case study, which centred on possible designs for an electronic version of the diary pages.

5.2 The notation in use

This section provides a number of examples of awareness-related issues in the TCO, and provides example fragments of UML models which explore possible ways of representing such information. The first two examples are of different types of awareness in the workplace. The second two are concerned with workspace artefacts and features through which awareness can be seen to operate.

5.2.1 PERIPHERAL AWARENESS

This is the type of awareness typified by the work in media spaces, and is concerned with how we maintain alert to what is happening around us while we work, how we selectively attend to events which may be relevant to our work, and also how we might orient our activities so that others around us can maintain awareness of what we are doing.

The division of labour in the TCO meant that there was little likelihood of a university coordinator needing to maintain awareness of the progress of external enquiries, or vice versa. Similarly, the use of a single paper copy of all important documents, the diary pages in particular, meant that conflicting enquiries could be dealt with on a ‘first-come, first-served’ basis, thus mitigating the need to be aware of others’ work. Nevertheless, the division of labour did lead to one, quite simple, way in which coordinators made use of cues in order to be aware of the source of incoming calls. In a small office with several phones and two lines (one for external only, the other from the university switchboard which could handle either internal or external), it is difficult for someone unfamiliar with the office to know which calls are coming from where, and on which phone. Nevertheless, the coordinators manage to do this by listening to the way in which the phone rings. A ‘normal’ (for the UK) ringing tone in bursts of two rings means that it is an external call, whereas internal calls ring with bursts of single tones. Because hotel and university coordinators typically do not handle enquiries for each other, this means that they can ignore phone calls for the other side of the business. This can be modelled as a constraint on a relationship as below in figure 5.

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3 What the coordinators tend to use for this purpose, however, is a daily printout from the hotel of availability for the following 12 months. The terminal was only turned to for very large bookings, or situations where the hotel is close to full capacity.

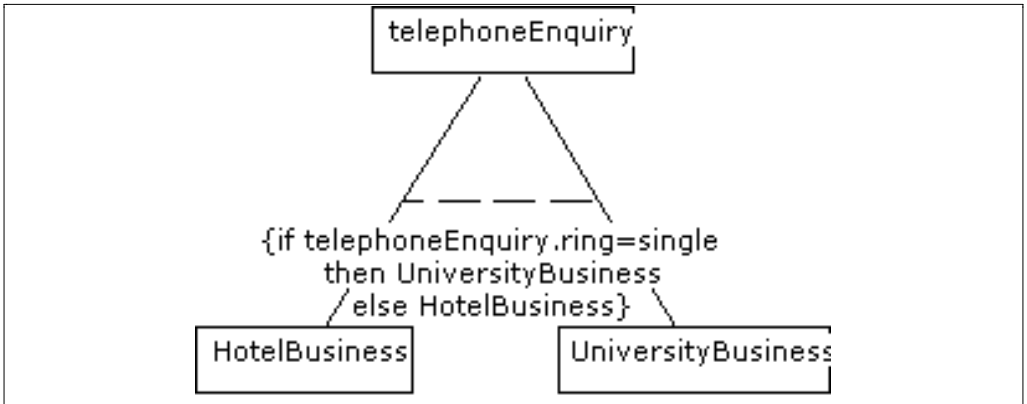

Figure 5: using a constraint to illustrate peripheral awareness information

5.2.2 AWARENESS OF HISTORY

Awareness of history is another type of awareness that has been referred to in the literature. In the TCO, this is manifest in a number of ways. We have already mentioned how the affordances of paperwork assist coordinators in returning to their activities following an interruption, and also how annotations are used to indicate future events which may affect their business. Another area of the work in the TCO where history is a factor is in dealing with existing customers. They try to ensure that a particular customer is dealt with by the same coordinator whenever it is possible. This means that when a telephone enquiry is made, the customer may need to be transferred to a different coordinator. One of the reasons for doing this is to spread the load between coordinators so that no one coordinator has to deal with a disproportionate number of 'awkward' customers. As far as the customers are concerned, this policy means that they get a familiar coordinator who, over time, comes to know their particular preferences, special needs and so on. For example, a coordinator might specifically ask a customer if any of their delegates are vegetarian, because the last time they booked there was one.

The issues bound up with this type of awareness are very similar to those in the field of organizational memory, and in fact the TCO has a system in place which could be characterised as an organizational memory system. Whenever they take an enquiry, if the customer is not immediately familiar to the coordinator, then a check is made to see if there has been any previous business is customer. If so, the coordinator can check to see if there were any problems or special requirements at that time, and can then check back with the customer to see if they also apply to this enquiry. The coordinators feel that this allows them to provide a more personal service on the occasions when the customer making the enquiry is not someone who's preferences they are aware of.

What is interesting about this type of awareness is that it is very difficult to distinguish between the two cases outlined above for regular customers and customers with previous business. In the former case, the coordinators rely upon their own memory and knowledge about the customer, whereas in the latter case, they obtain the same information from a file. Of course, the distinction is not a clean one, and there are obviously cases where a coordinator will be familiar with a customer yet still need to consult the files for particular details about previous business. In terms of modelling this in UML, the most obvious approach is to attach a PreviousBusiness class to the Customer class. This class contains a feedback attribute, which for each item of previous business records whether there were specific needs or problems experienced. PreviousBusiness also contains the details for each previous booking made by the Customer. Figure 9 shows this association, along with the use of a stereotyped association «awareness» which represents the Coordinator's knowledge of previous business with the Customer who is making the Enquiry. This does not preclude the possibility that the coordinator may have to consult the filing system on some occasions.

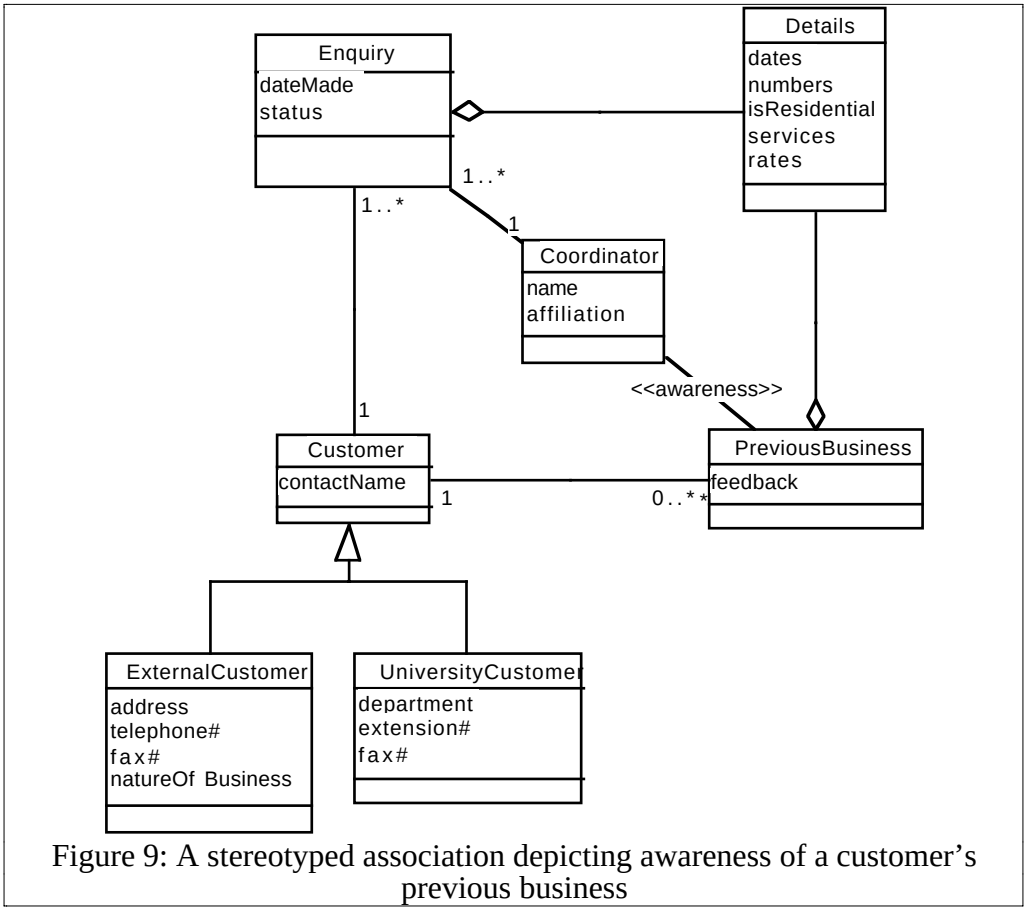

Figure 9: A stereotyped association depicting awareness of a customer's previous business

5.2.3 PAPERWORK

Paperwork is pervasive in the TCO. There is a form for everything from an interest only enquiry which may need following up, right down to detailed day-by-day and hour-by-hour details of catering, staffing, and room requirements. The most important piece of paperwork, however, is the diary. There are a number of interesting features about the diary pages. First they are used as a lock, in that only one person can enter a booking at any one time. An electronic version of the pages would have to implement some means of ensuring that two conflicting bookings cannot be made at the same time (although a lock at this level of granularity would be a very crude solution). In addition to recording information about a booking such as who it is for, what rooms are required, on what dates and times, the diary pages also get used in a more informal way to record information which may be relevant to taking future bookings. For example, holidays of coordinators are entered, and in one case the university graduation week was pencilled in down one margin (important because this could restrict the number of beds available in the hotel for any training centre residential bookings). These annotations are not what the stationery used for the diary pages was designed for, yet paper affords such use.

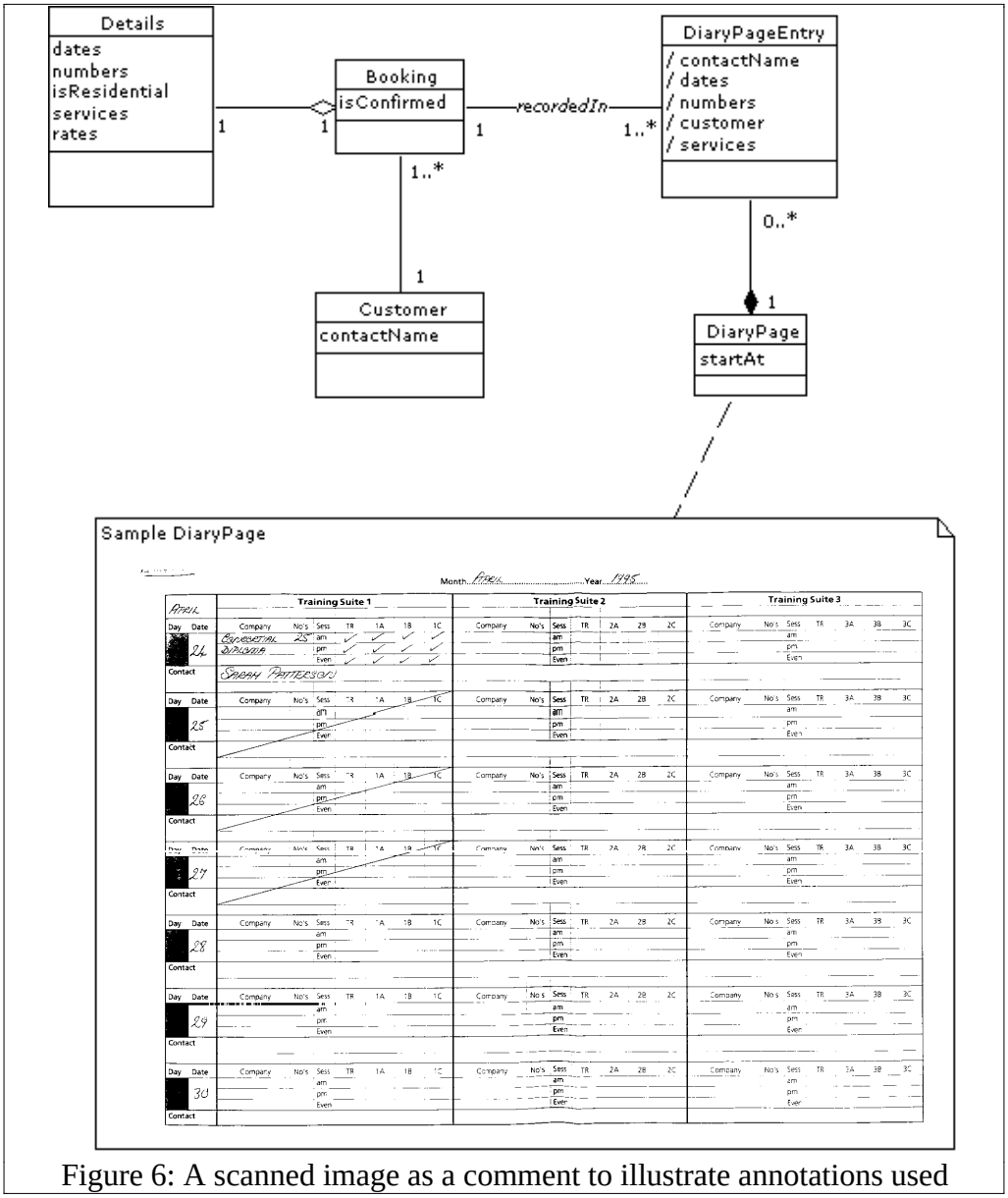

Figure 6: A scanned image as a comment to illustrate annotations used

This sort of information is not straight-forward to capture, and in this case it may be sensible to include a comment attached to the model entry for the diary pages with a scanned image of a sample page in order to record how else the pages are used. Figure 6 shows a note entitled 'Sample DiaryPage' which is attached to the class DiaryPage in a simplified and partial class model of the TCO. In the diagram, a Booking consists of one set of Details, is for one Customer, and is recorded in one or more DiaryPageEntrys. A DiaryPage is made up of zero or more DiaryPageEntrys and covers a period. The attached note provides a pictorial view onto the artefact referred to in the model, in this case a page from the diary.

Another commonly-encountered feature of paperwork is the way in which it makes one's progress in a task available for scrutiny by others. This type of awareness means that it is easy to tell at a glance what was being worked on by someone when they are not present to be asked, and what stage someone is at on the way towards completing a task. In the context of the TCO, where the previous study found that work in the office was frequently interrupted (by the phone ringing, by requests from delegates in the training centre, and so on), this feature of paperwork also means that it is relatively easy to return to work which has been interrupted, after the interruption has been dealt with.

This can be characterised as an awareness of activity in terms of progress made and what the current activity is. If we consider this as a property of paper forms, then it is sensible to model it as an attribute of the class representing the particular form. In fact, the property should be modelled as part of a collection (stack, pile, etc.) of forms rather than an individual form as it is the fact that a form is on the top of a pile that is significant, as well as how many forms are left to be processed in the pile. Furthermore, it is not simply that the forms are in a pile which provides the above affordances, it is also that this is available for others to see.

Returning to the TCO, the construction of a daily timetable is a paperwork-intensive task. The daily timetable brings together all of the detailed information regarding a booking such as catering requirements for special meals, audio-visual facilities required in the training rooms, actual numbers attending, and so forth. All of the forms, memos, letters from the customer, etc. relating to a particular booking are stapled together into one 'pad'. They are then referred to in the production of the daily timetable for that booking. Figure 7 shows another simplified and partial class model describing this, featuring a stereotyped awareness class called ActivityAwareness which acts as a place holder for the awareness information described above.

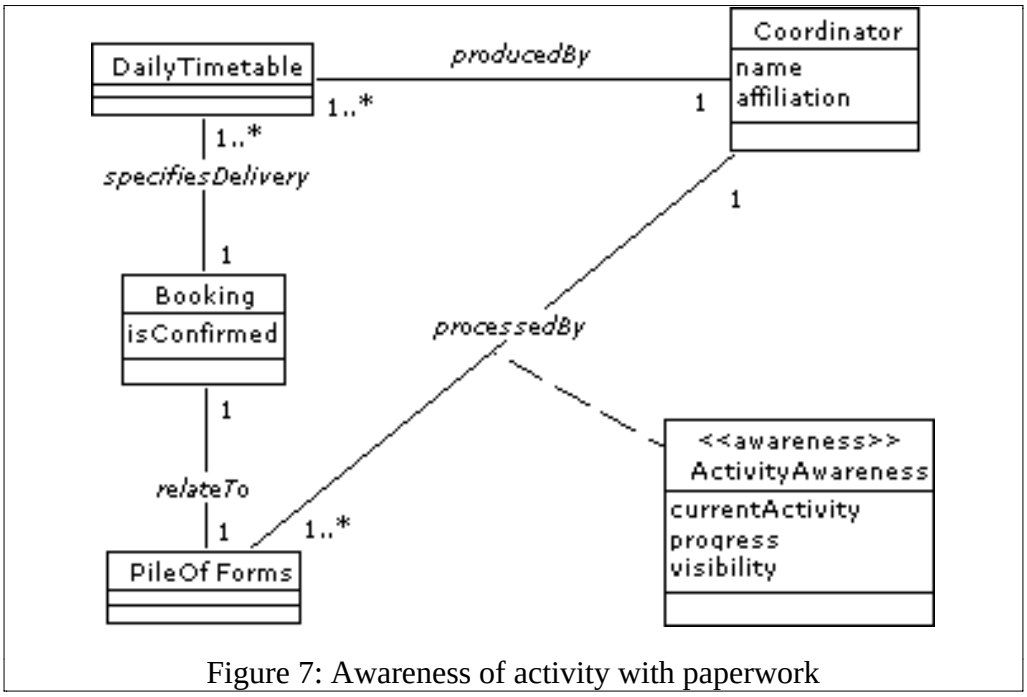

Figure 7: Awareness of activity with paperwork

The ActivityAwareness class is actually an association class, i.e. it describes the processedBy relationship between a Coordinator and a PileOfForms. One PileOfForms relates to a single Booking, and how one Booking is delivered is specified in one or more DailyTimetables, which are produced by one Coordinator. It is possible to envisage a hierarchy of awareness classes which can be used in a similar way to describe other types of awareness as it is encountered.

5.2.4 BUSINESS RULES

The handling of enquiries is one of the most frequent tasks performed by coordinators, yet at the same time it is incredibly complex to specify in terms which match how the task is actually performed. Process diagrams exist which provide the 'official' view of how the task is performed, yet in actual fact the steps are very seldom followed precisely, and not all the steps are specified in sufficient detail. One of the complexities of the process is due to a business constraint which , although not written down anywhere, is adhered to quite strictly. The constraint is concerned with the balance between hotel and university business, and basically states that only one of the training suites each day will be sold to 'day delegates' (i.e. a booking with no requirement for hotel accommodation). If this rule were to be broken,

there is a possibility that the hotel could be left with many empty beds for the days concerned. Conversely,. the staff at hotel reception endeavour to keep a certain number of beds free so that training centre bookings requiring accommodation are not turned away, thus leading to under-utilised training centre facilities. This cooperation between the two businesses operates despite the fact that they have separate profit margins and targets.

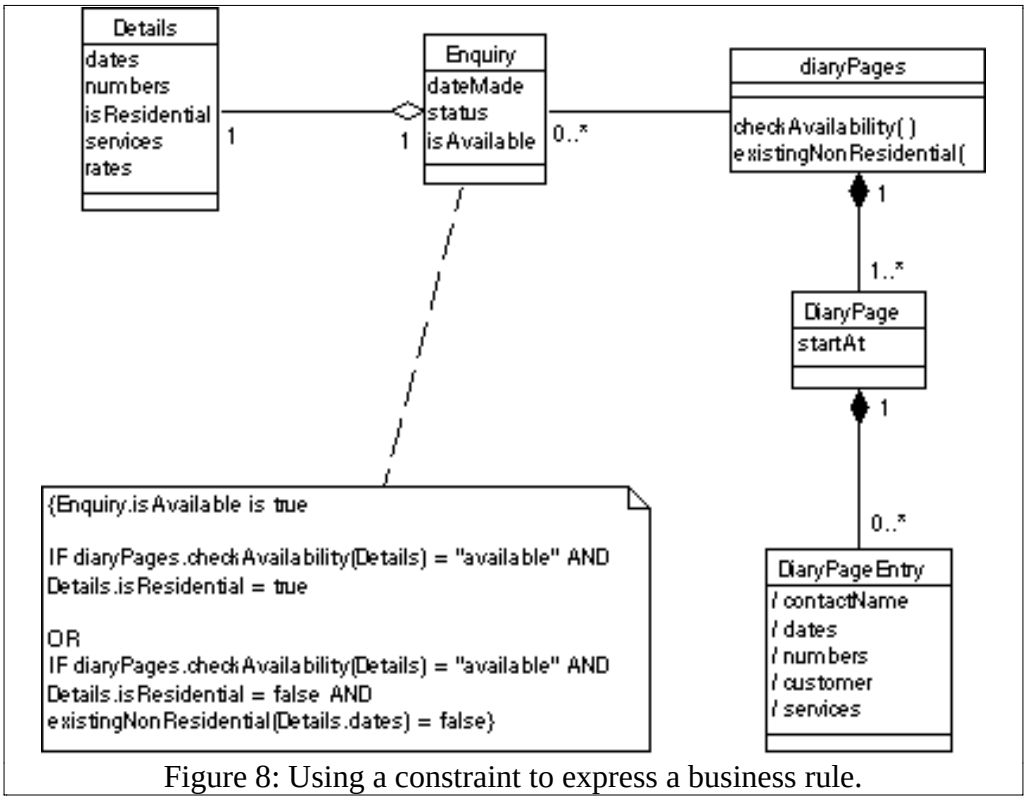

Figure 8: Using a constraint to express a business rule.

When checking availability in response to an enquiry, the diary pages are therefore used not only to make sure that the required facilities are available at the requested dates. They are also checked to ensure that if the enquiry became a firm booking it would not contravene this rule. In doing this, coordinators may suggest changes to the customer such as shifting a non-residential booking forwards or backwards by one day in order to avoid a clash with another existing booking. Skilled coordinators are able to tell at a glance from the diary pages where bookings have been made around which other bookings will be difficult to accommodate. So, the task of checking availability and subsequently agreeing a booking is further complicated by the need to allow for other bookings which may be made at some point in the future. Representing this type of awareness is certainly not straight forward, and is approaching problems related to modelling the skills of individuals. The business rule can be expressed as a constraint, which could be attached to the Enquiry class, which determines whether an Enquiry can be converted into a booking. Figure 8 presents such an arrangement, using a semi-formal language to express the constraint. The diagram also illustrates the structure of the diary pages.

5.2.5 SUMMARY

This section has presented a number of possible uses of UML to express awareness in class diagrams. What is clear from this is that the extension mechanisms that are built into UML can be used to record the type of information that is typically produced by ethnographic studies of work. We can say this with confidence because the facility for including any sort of information in a comment means that if all else fails the model can include detailed textual and graphical depictions of the workplace in such a way as to convey the desired information. This would not achieve the desired goal of building this into a model in a way which improves the translation from ethnographic material through to design models and ultimately

implementations of systems. It does, however, at least provide a mechanism for recording this information in the same place as the rest of the system description, rather than requiring designers to expend effort in looking elsewhere.

The use of stereotypes appears promising, and should ultimately lead to the facility of a 'palette' of ethnographically informed classes which can be used where appropriate in designs. Again, it is important to stress that this should not be viewed as a template of social phenomena into which all work settings can be fitted. Rather, this work will lead to options for designers that they can use as and where they apply for the particular system being developed to support work in a particular setting.

6. CONCLUSIONS AND FURTHER WORK

This paper has presented a way of using UML for expressing information about awareness of work. The motivation for doing this lies in the problems of communicating the findings of ethnographic analyses of work to systems designers in a form that they can readily make use of. Previous efforts to address this problem have been concerned with altering the way that ethnographic studies are performed, or the way in which their results are presented. This work has not been unsuccessful, but it still falls short of fitting in with the day to day practice of systems designers. We have addressed this issue by making use of a notation which systems designers will be familiar with, at least in its use of well established concepts of object oriented design if not the particular semantics of the notation.

We did not want to develop yet another new notation which could end up never being used. Rather, we chose to work with UML which at writing is well along the process towards acceptance as an international standard. Not only is it standard in this sense, but it is also built from three of the leading object oriented notations, and so can claim compatibility with a large section of the market. Furthermore, for our purposes there was no need to depart radically from what the notation has already built in. This further improves the likelihood that our work can be of use to practising systems designers.

UML appears to be flexible enough already in order to support the representation of ethnographically informed requirements. Any problems experienced with describing awareness in the TCO case study were more of the nature of understanding exactly what awareness *is*, rather than how to represent it. In many ways, this is indicative of the dangers of choosing a phenomenon from one or more specific ethnographic studies and then going and looking for it in others. Despite our success with using UML's extension mechanisms to represent awareness in this case study, there may be cases where it is advisable to attach comments to models that include detailed fieldwork material where available. Models often require clarification with comments, and if relevant detail from fieldwork is available, it can assist in this. Including parts of the detailed account will also serve to situate the rest of the design. Another advantage of including this information would be improved traceability, especially if the comments can be referred to, and they include sources of information (people, documents, etc.).

In terms of further work, one area which we intend to examine is that of design patterns as developed by the architect Alexander, and also the software patterns community which his work inspired. This offers the potential of building up a set of design building blocks for commonly occurring features of work. The software patterns community is potentially a very fruitful avenue of enquiry because of their close links with object oriented design in general and with the UML in particular.

The importance of process in design methods has already been stressed. The notation may adequately represent anything we may want it to, but on its own it will not be successful or useful in practice. What a process will provide is guidance for how to make use of the notation. A major motivator behind much of this work is the opportunity to communicate

what we have learned from working with ethnographers to practising system designers in industry. Some of this can be achieved through publishing accounts of our experience, but the ultimate goal is to enable designers to use the ideas themselves. In order to achieve this, we cannot assume that users of our notation and process will have the same background and education as the social scientists with whom we have worked. We therefore need to somehow build in some of these influences into the process itself. Whilst this process is not yet developed, it is likely to take the form of guidance along the lines of "when looking at work places where several people are in close proximity, pay attention to issues of awareness of work", or "when considering the function of paper forms, examine how they are annotated in the course of the work" and so on. Just as we wanted to avoid the production of yet another notation, so the same applies to methods. Developers are even less likely to expend the effort involved in learning a new method, and so we must direct our efforts to process guidance that can be used alongside existing methods. As this work progresses, however, more specific guidance can be included which relates to particular types of work settings, or even tailored to particular methods. This can happen at several levels, from general additions to the method as more ethnographic studies appear which point to other features of work, to users of the method extending it themselves as they build up experience in particular application domains or business sectors.

In summary, this paper is the first step towards the development of a systematic approach to social analyses to influence systems design. The first step has been to explore how the results from social analyses can be represented using a system design notation. This paper has demonstrated our approach to this issue through the use of UML applied to representing awareness of work in a small office.

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