From description to requirements: an activity theoretic perspective

Phil Turner and Susan Turner
School of Computing
Napier University
Edinburgh, Scotland
+44 131 455 4675
Email {p.turner, s.turner}@dcs.napier.ac.uk

Julie Horton
Department of Computing and Mathematics
University of Northumbria at Newcastle
Newcastle-upon-Tyne, England
+44 191 227 4236
Email: julie.horton@unn.ac.uk

ABSTRACT

This paper demonstrates how activity theoretic concepts can be used in conjunction with an ethnographically informed approach to derive requirements on a work situation. We present a case study based on a series of collaborative design episodes, the structured description derived from it and show how a preliminary set of contextually-grounded requirements on supporting the design process can be created.

KEYWORDS

Activity theory, ethnography, requirements, contextual analysis, WWW.

INTRODUCTION

Investigations of work have taken many forms, ranging from cognitive analytical approaches, for example, task analysis (Benyon, 1992; van der Veer, Lenting and Bergevoet, 1996) to variations on contextual analysis and participatory design (e.g. Bødker and Pederson, 1991; Holtzblatt and Beyer, 1996; Beyer and Holtzblatt, 1998), and ethnographic enquiries (e.g. Bentley *et al*, 1992; Hughes *et al*, 1994; Benford *et al*, 1997) to mention but a few. Unlike those methods which rely on formal and semi-formal tools, the ethnographic approach relies on the researcher immersing him/herself into the work. However, a consequence of this immersion is that the resulting data is both copious and unstructured, but more than this, as Randall and Bentley (1994) have observed, the data by its very nature resists formalisation. While agreeing with this position, we believe that it is possible to provide a structured description of the work which may lend itself to a variety of uses including requirements definition. To achieve this, all that is required is a powerful, richly descriptive organising framework with links to the systems design process. We propose that activity theory is one such suitable framework and this is an attempt to *operationalise* its use. However more than just structuring the data, an activity theoretic perspective provides fresh insights into the processes and organisation can be had. Examples of such insights are discussed later in the paper.

A BRIEF INTRODUCTION TO ACTIVITY THEORY

Activity theory is a body of thought which has been found relevant not only to psychology and education, but more recently in the understanding of work in organisations and several other fields. It developed from the ideas of the Russian psychologist Vygotsky (1896-1934) and his successors. More recently, Engeström (e.g. Engeström, 1987; Cole and Engeström, 1993; Engeström, 1995) has extended these ideas to include a model of human activity and methods for analysing activity and bringing about change.

The basic unit of analysis in activity theory is the human activity. This can be described as a system whose components include those who carry out the activity, the tools and concepts used, the object (or objectified motive – this concept encapsulates the motive for the activity and the object of the work) the community in which it takes place and the rules (or praxis) governing the conduct of that community. While activity theory is a dynamic and evolving body of thought, it is clear that an activity is the central concept and acts as a nexus having both an internal structure and a broader contextual setting. The issues of an activity's internal structure and contextual setting are returned to in more detail later, but first applications of activity theory are briefly reviewed.

Applications of activity theory

There are numerous examples of the application of activity theory to the analysis of work, play and a wide variety of processes as diverse the invention of writing (Nicolopoulou, 1997) to drama games with six-year-old children (Brostrom, 1999) and the working of a law court (Engeström *et al*, 1997). While the emphases of the studies vary from one from another, there are the recurring themes of learning, culturally-mediated human activity, social-mediation and so forth. However, recently researchers have adopted activity theoretic concepts for the modelling of work, CSCW and HCI (e.g. Kuutti,

1991, 1996; Bardram, 1997, 1998a, 1998b; Bødker, 1991 and Nardi, 1996 among others). These are discussed in the next section.

System applications

At present there is no systematic way of interfacing activity theory with existing systems analysis or design methodologies. Nonetheless, activity theory has been successfully exploited in a variety of heterogeneous ways to inform systems design. For example, Bødker (1996) has applied activity theory to the analysis of applications for the Danish Labour Inspection Service. Her work explored the potential for reshaping technology in use, and activity theory concepts were used as a means of situating a video-based analysis of the system in its historical context. Here analysis of contradictions also identified problems with mediating artefacts. Similarly Christiansen (1996) studied computer use in police work using an Activity Theory framework. An activity typology was developed, artefacts matched to activities and users of the artefacts interviewed and observed. Key success factors in the adoption of an artefact as a mediating tool in an activity could then be identified, but the transition to systems design is not explicit. The utility of the activity theory concept of 'object' is illustrated by Nardi (1996) in a retrospective analysis of presentation software, showing how this distinguishes between superficially similar user tasks. A rather different perspective is taken by Heeren and Lewis (1997) who integrate the hierarchical levels of human processes (intentional, functional and operational) with media richness theory, claiming to provide insights into task/media fit for distributed communities.

Bardram has demonstrated the application of further aspects of activity theory in a series of related studies concerning the design of hospital administration systems (the SAIK project). The first of these (Bardram 1997) identifies the role of plans as artefacts in an activity. Plans are realised according to situational context by actions. Implications for tool design are identified, specifically that workflow tools should support the situated nature of planning, and take into account that actions may be polymotivated, serving both the execution of the work itself and its organisation and accountability. The analysis in Bardram (1998a) demonstrates the use of 'Work Activity Scenarios' from requirements through design to evaluation and training. The scenarios are structured according to a checklist derived from activity theory. Contradictions and co-ordination/cooperation mechanisms are also analysed and inform design work, together with a detailed description of core activities and relationships between them. Finally an activity theoretic analysis of different levels of collaboration is provided in Bardram (1998b) – after Engeström's *et al*'s analysis of court procedure - distinguishing between co-ordination (the routine flow of work), cooperation (in which actors actively balance and integrate their actions) and co-construction (where the community re-conceptualises an entire activity). Again recommendations are made for design to support each of these modes and movement between them.

Finally, our work complements that of Kaptelinin and Nardi (1997) on their 'Activity Checklist'. The checklist is described as 'a practical tool to provide guidance and structure for empirical work that takes account of context in design and evaluation'. We have organised our data and the emergent requirements a little differently, but it is quite clear that our approaches are congruent.

A further link to systems development

Within the activity theory canon, change to activities arises from the incompatibilities, conflicts or opportunities, known as contradictions (also called *breakdowns*), that can exist both within and between activities. These may lead to the formation of new activities or the cessation or transformation of existing ones. Figure 1 is an illustration of Engeström's (1987) classification of the four levels of contradiction which may occur. Those found within a single node of an activity are *primary* contradictions; those which occur between nodes are *secondary*; those between an activity and a new form of that activity with a "culturally more advanced" object are *tertiary*; and those between different activities are *quaternary*. (The structure of the 'triangle' itself is discussed later.)

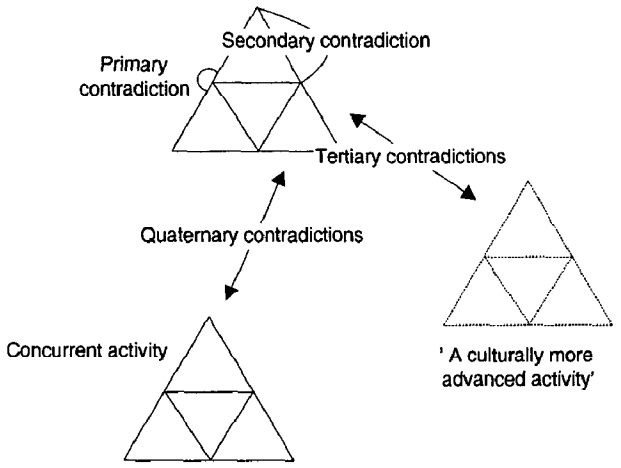

Figure 1

The role of the 'culturally more advanced activity' which is co-constructed with the stakeholders is reminiscent of Checkland's use of 'relevant systems' (Checkland, 1981). These are described as being relevant as they reflect the values and beliefs of those involved. However activity theory's treatment of contradictions is somewhat different in that it is arguably more systematic and more thorough. As we will demonstrate later, they can be examined (or generated) by considering each activity node in turn for all four varieties of contradictions.

In conclusion

In contrast to most of these studies, it is our intention to operationalise the use of activity theoretic concepts rather confine ourselves to a high-level descriptive use which is

characteristic of many studies. We now turn to the work study.

THE SOFTWARE DESIGN WORK STUDY

The work setting for this is a software house, TTM Ltd (which is, of course, a pseudonym) and the data we present is in two forms, foreground and background. The foreground data (which is the focus of this work) comprise a video record of a series of design meetings which a particular team of three software designers held as a part of their project work at TTM. The background data are as follows.

TTM Ltd

Background knowledge of TTM is drawn from the first and second authors who were working there[1] (on a completely unrelated project) at the time of the study. Thus, while it is fair to say that the authors were immersed in the organisational culture and working practices at TTM, it should also be noted that data from the designers' day-to-day working were not recorded in as much detail as the video record.

TTM was involved in both commercial and research and development (R&D) work, with much of the latter being supported by the European Union's Framework programmes. TTM was organised into three divisions (commercial, information technology R&D and telecommunication R&D) each with a divisional manager. The technical workforce of approximately 50 people was supplemented by administrative and sales staff. Working practice was quite informal despite the company being ISO quality accredited. Project teams ranged in size from as little as one person up to perhaps five or six. Each project team had a project leader (or manager – depending upon the size or importance of the project or the seniority of the assignment staff) who reported to a departmental manager. At any time TTM might have had 10 or so research projects of which Mallard was a very typical example.

Mallard

Mallard (again a pseudonym) was a European-supported, consortium of multinational companies working collaboratively to improve the visualisation of evolving software products by providing an integrated development process and supporting tools.

This case study concerns the work within the local team at TTM who were responsible for designing a configurable graphical animation workbench for the visualisation of specification and design notations. At the time of the case study, a specification had been completed and the team were working on the high level design of the animation tool: the output of this phase was a design document for use by the wider consortium. In many ways Mallard is typical of both collaborative projects and the way in which research was undertaken at TTM.

[1] The first author for 5 years, the second author for two years.

The video record

As already mentioned, the study focusses on a team of three software designers (the Mallard project team) comprising the project manager (Roger) and the team members (Peter and Matt). The team had worked together on the project for some weeks. All were experienced software designers.

Work during the two weeks of the video study comprised periods of individual work interspersed with team meetings. The team's desks were located close together, in part of a large open-plan office, allowing frequent informal communication between team members, particularly Matt and Peter. However, prolonged whole-team discussions tended to disturb other people, so these were held in a meeting room and provided the data for this study. This small meeting room was equipped with a large table and chairs and two unfixed whiteboards – plus our video camera.

Five Mallard design meetings were video-recorded and form the basis of the ensuing analysis and discussion. The team was questioned briefly after each meeting to ascertain the general purpose of the session, its conclusions and the consequential actions. A transcript of each tape was made. In addition to the intensive analysis of the meeting record, each team member was briefly interviewed at the end of each working day to establish what tasks he had been engaged upon, and what communication he had had with other team members.

The camera was positioned to take in the whiteboards and the team members as they sat around one end of the meeting room table. Apart from an early meeting (not recorded) which the second author attended for familiarisation, no extra persons were present during meetings except when changing tapes.

The use of representational media

At the start of the meeting a number of different artefacts may be observed. The whiteboard is used in three modes: (i) as a display of design elements which had already been developed, either in an earlier meeting or by an individual in preparation for a meeting - individuals might add material to the whiteboard before the others arrived, or transfer it from notes during the meeting, explaining as they drew; (ii) as an exploratory tool for sketching out new ideas and modifying old ones; and (iii) as a bridging mechanism between two temporally separate parts of a design meeting.

Printed documents, both formal project documents and individual work-in-progress, sometimes with annotations made in document reviews outside meetings, are used for reference to specifications and to earlier versions of the design. Of the five meetings analysed three included the current design document itself as a main topic of discussion. However, as well as providing a basis for discussion, documents were also an important workspace for the individual's own active design work. Individual notebooks/pads were also used for comments and notes. These were often very detailed and sometimes provided a

shared resource for activities after the meeting. Analysis of the data shows a rapid sequence of switches in focus between media. While individual copies of documents, and of course notebooks, were by default private, occasionally their owners would move them to the public arena to amplify an idea. At the end of the meeting the resources reverted to their status of records, either to serve as a basis for the next stage of individual or team work, or to be transformed into more permanent design documentation as working papers, or eventually, official project documents.

AN ACTIVITY THEORETIC ANALYSIS

At the centre of the structured description of the work study is the activity 'triangle'. This is a creation of Engeström's (1978, 1987) who has been responsible for extending the graphical representation of an activity to recognise that it occurs in the context of a community, praxis (formal and informal rules) and a division of labour. The nodes on the new 'triangle' effectively act as points of interface with the larger issues in activity theory such as an activity's cultural-historical lineage; the role of transformation, learning (described as the zone of proximal development by Vygotsky - Vygotsky, 1978) and the internalisation – externalisation dialectic. Thus an activity is a *nexus* with an internal structure and a location in a cultural-historical continuum wherein it developed and evolved. Figure 2 illustrates these relationships.

The structured description

Implicit in the production of an activity theoretic structured description of work are the questions 'for whom and for what?'. Answering these questions, we have adopted the perspective of deriving a set of requirements for computer support for the designers in the Mallard project at TTM in both team meetings and in their parallel working. Our intention, as discussed earlier, is to demonstrate that activity theoretic concepts can be used to structure and organise the wealth of ethnographically acquired data, thereby achieving a greater understanding of the processes and dynamics of a work situation; and, to use *contradictions* to guide systems design. However neither of these aims can be realised with a linear series of textual descriptions. An activity is a highly interwoven system which necessarily requires a non-linear representation. Using the medium of hypermedia, specifically a web-based approach, we have been able to produce such a description. Of course this approach it not particularly novel, having been used by a number of researchers including Kyng (1995) and Cockton (1998) in the management of requirements.

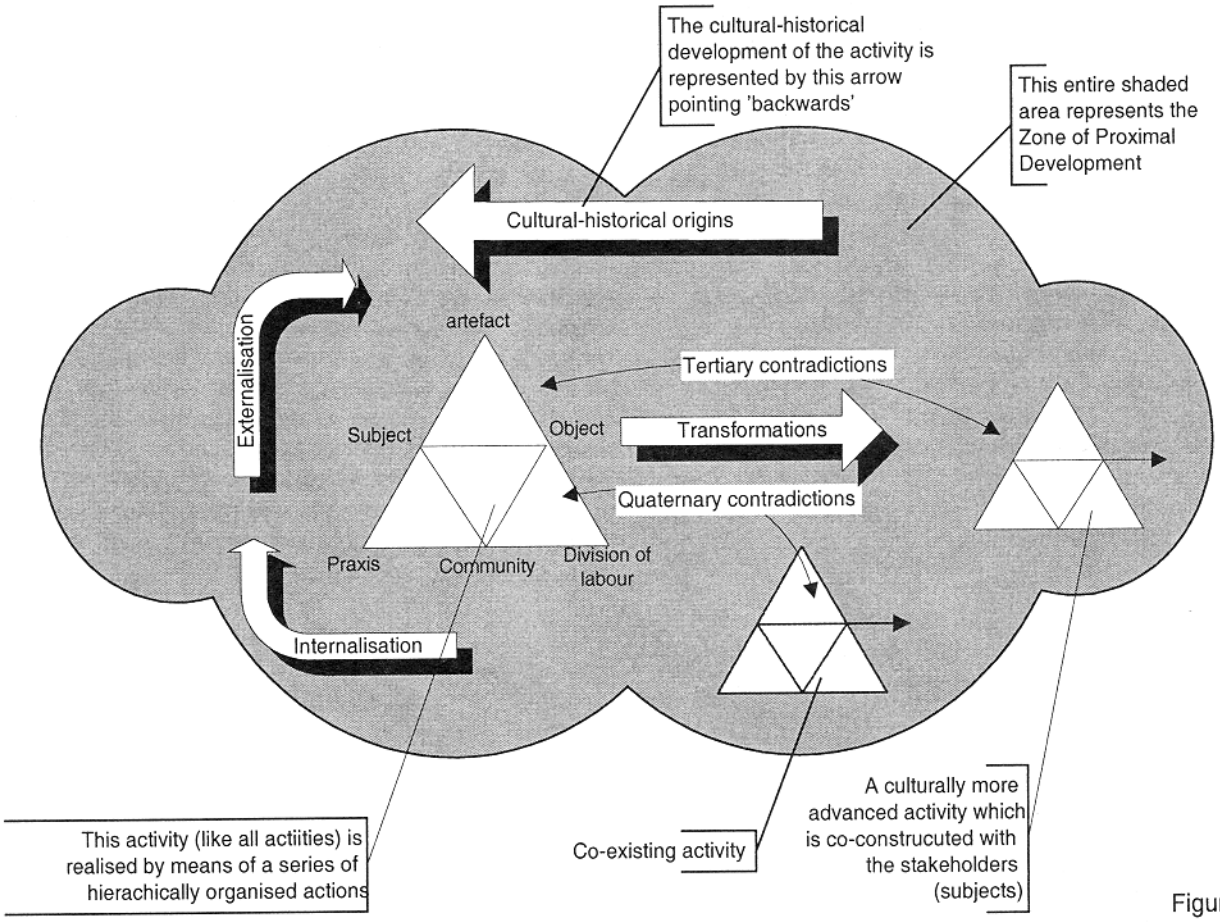

Figure 2

The anatomy of the structured description

Figure 2 is actually an illustration (as this is clearer than an equivalent screenshot) of the image map used as a 'front-end' to the web-based system we have created to hold the structured description of the design work. (Callouts have been added to indicate the principal points of entry into the structured description.)

The Mallard activity

The nodes of the central activity are populated with textual descriptions of which the following examples are paraphrases. Each node is also linked to a table of contradictions – which are discussed in detail later.

Object

The object of the activity (at the overall project level) is 'to improve visualisation of evolving software products by providing an integrated development process and supporting tools' – as described earlier – with an output of a set of such software tools.

Praxis

This is, perhaps, the most complex part of the description. Firstly there are the formal rules governing the consortium as a whole embodied in such devices as the project contract, the collaboration agreement and the European Union's own abundant rules and regulations. In an organisation such as the EU there are inevitably many contradictions which, while they could run to volumes, are not our immediate concerns.

We now turn to the informal rules governing the project. Unusually, the consortium had a significant shared history of co-working, and many of the rules governing the ways in which consortium meetings were held and informal contact between partner companies and had arisen from the ways in which the earlier project had been run. (Mallard was a follow-on project from an earlier successful collaborative Esprit project which involved all of the Mallard consortium.) Thus the informal praxis was very much a product of the consortium's shared cultural-history. Any technological innovation at TTM would be required to fit with these existing practices. Indeed the Mallard consortium had set a variety of project-wide measures and protocols to ensure (or at least increase the probability of) efficient co-working.

Artefacts

These were wide ranging and again had their origins with shared history of the project partners. The artefacts varied from such things as word-processing standards (i.e. MS Word 6), document templates, coding standards, email protocols / clients, hardware and software platforms (i.e. Sun Sparc architecture, the Solaris OS, and the GNU C++ compiler), software version control (standard SCCS).

The internal structure of the activity

An activity is realised by a set of actions. Unlike the central activity itself, these are directed at achieving a goal (as distinct from the overall object). In this case the consortium-wide project achieves its object by dividing the technical work among the members of the consortium (*cf.* division of labour, as above), effectively assigning them an individual goal or set of goals. These goals are in turn realised locally by means of a series of actions. We have identified a range of such actions (local to the work at TTM). These are 'updating fellow team members', 'discussing design options' and 'recording the design'. We discuss two of these in some detail beginning with the first of these. Figure 3 is a screenshot from an action page which structures this material.

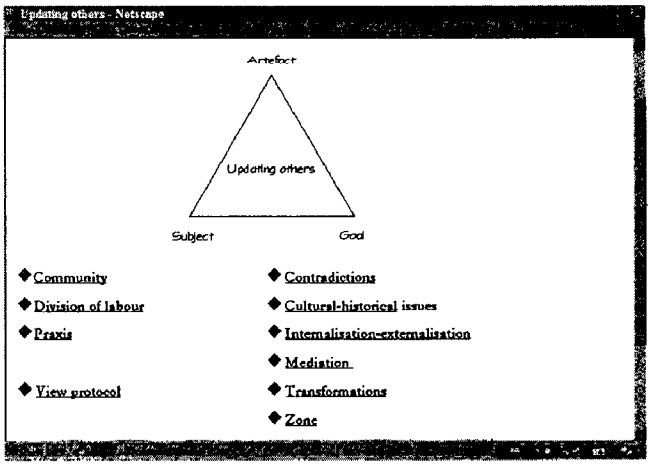

Figure 3

Action I: Updating fellow team members.

Between meetings the Mallard team at TTM worked independently to develop parts of the design. Sometimes this resulted in the production and distribution of short working papers, otherwise ideas were captured in notebooks or drawn up on the whiteboard just before the next group session. Even if a paper had been circulated it was not always read in advance of the meeting. Such independent work therefore resulted in the meeting action which we describe as 'updating fellow team members'. Updating occupied a substantial proportion of meeting time. Typically, each person in turn would stand up and verbally brief the others, using any or all of the range of artefacts identified, indicating the current focus of the argument with explicit verbal reference or gesture. While updating was in progress, the speaker would not generally be interrupted. Comments and questions usually waited to the end of a segment of exposition[2].

[2] Occasionally in the protocol fragments the word *indistinct* will appear in italics. This is a reference to a break in the transcript where what a speaker has said cannot be determined.

Roger pointing at the white-board as he speaks.	OK. I thought I'd pretty-print that [laughter]. Probably haven't lost too much that was interesting. Construction on the left hand side but I've left a little bit of space around construction because we may well end up breaking it down [Peter: mm hm] into models of state, configuration type things, [Peter: yeah] [Matt: yeah]. Control, well yes, control, scheduling's permeating all layers as a result of some of the things we've said [Peter: mm hm] user model, value, evaluation of value, only goes up as far as the abstract model, I haven't taken that through [Peter: yeah] and then there's execution events whose flavour changes as we go up [Peter: yeah] and everything else whose flavour changes, we really ought to

Protocol fragment 1

While (apparently) listening, other team members might make notes or consult other materials. Thus having made praxis, community and division of labour explicit we turn to the operational elements of the action itself. Protocol fragment 1 has Roger using the whiteboard, notes and other documents to update his co-designers with his latest ideas for his part of the design. This is done informally with his co-designers waiting to comment until he has finished each part of his ideas.This action has ultimately the goal of creating a common understanding which can be seen from the murmurs of agreement or acknowledgement (depending on the tone of the mm hm) from those being updated.

Action II: Discussing design options.

As an example of continuing design work, we next have Roger, Matt and Peter discussing the element mapper for the design animator. The same range of media are involved in this action as in the last but here the emphasis is on building on and extending existing knowledge. Ideas (design options or alternatives) are suggested, debated and decisions made or implicitly deferred. The whole tenor of the group work is one of informality with little or no apparent structure. Protocol fragment 2 shows that the argument draws upon a shared understanding of past states of the design, as well as developing ideas further.

Matt	Wouldn't this idea you were talking about beforehand ... *indistinct*... Couldn't you have a monitor within the animator which says, I want monitor operations on this element map, particular kinds of operations on this element map which might be connected with events.
Peter	I think that sounds a bit confusing and complicated actually. I thought what we were talking about before was we had an event coming in here, the abstract user model would take it, it would do things to its own state and then pass it on. So the sort of thing you've got going up is a *indistinct* value object in its own right, or possibly.... I thought that's what we were talking about.

Protocol fragment 2

Having established the common grounds from which to proceed the team works together to agree a design decision (protocol fragment 3). Again Roger is observed pointing at parts of the design on the whiteboard and gesturing towards the working papers to suggest a design alternative. As already noted, the praxis in this action is much closer to 'brain-storming' with the designers frequently interrupting each other: the make-up of the community and division of labour are unchanged.

Peter	That's true actually.
Roger pointing at the design documentation	And we ought to be also actually mapping values into a stable form.
Peter	So we could possibly have it on the element map in that form, convert element or something like that.
Roger	Yeah, OK
Peter	Ok, I'm convinced. So the animator talks to that

Protocol fragment 3

The zone of proximal development

This co-working also facilitates learning and within activity theory, learning (or development) is centrally important and is, of course, socially mediated. For Vygotsky this is the zone of proximal development, which he defines as,

> *The distance between the actual development level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers.*

Vygotsky, 1978

The spatial metaphor in the above quotation is mirrored in the real world as a zone or field to which an individual belongs which may be populated by experts, tools and other cultural artefacts. Protocol fragment 4 illustrates Roger's use of the whiteboard to help in his explanation of his proposal. Here we find a situation in which the concept of a zone of proximal development can be used to explain co- or mutual learning. Protocol fragment 4 shows the murmurs of agreement while Roger is talking (updating the team) slowly decline until a pivotal question is asked by Matt, "So part of the information in the filter will be the thing that is using that filter?". Roger tries to continue his updating by clarifying his previous statement, but the tone of the meeting now switches from updating to evaluating design options, again evidence of mutual learning. This action continues until Roger ends the process with "Pass. It might be".

Roger	... You have a number of mappers [Peter: mm hm], say from the kernel model you have a number of interested parties [Matt: mm hm] and the kernel doesn't care what those interested parties do with the information, [M: mm hm] but one of them could be mapping up to the user model, to do some filtering; one could be writing a Petri net level execution block for debugging, turning it into ASCII as it went and filtering some things out so it could be a debug type thing. [Peter: mm hm] Another filter or another thing could be ... probably not the animation because there's a different level of communication with that but it could do any number of things and the kernel [Matt: mm hm] doesn't care what they're doing ...
Peter	and the kernel spits out all its events
Matt	I thought it would be
Roger	*indistinct* interest and doesn't care what they are
Matt	So part of the information in the filter will be the thing that is using that filter?
Roger	Well ... the filter's actually in the mapper, you know. It's the mapper and the mapper uses the filter but you have more than one mapper ... more than one thinger listening to the kernel.
Peter	So is the filter a separate thing to the mapper?
Roger	Pass. It might be.

Protocol fragment 4

Mediation and transformation

Vygotsky (1978) has argued that human actions are mediated by tools. In the activity model, this is shown in the relationship between subject and object. The tools are usually described as instruments or artefacts and are used in the transformation of the object of the activity. Using these concepts of mediation and transformation, we can now focus on those parts of the design meetings which are concerned with transforming (i.e. extending, improving and so forth) the state of the design which is the goal of the action. Re-examination of the corpus of meetings data show that this transformation proceeds along a number of different dimensions. These are:

Distributed	-	Centralised
Provisional / Ephemeral	-	Decided / Persistent
Local artefact	-	Boundary object

It is very likely that other interpretations of the data are possible and other dimensions identified but, as will be seen, these prove to be useful.

The Distributed – Unified dimension

This transformation also affords the opportunity to examine the role of internalisation and externalisation. This dimension is usually taken to refer to external actions being internalised (or such things as mentally rehearsed plans being externalised) but here we take it to mean something more akin to distributed cognition. As the overall design process is distributed across space and time, individual work and team design meetings, the resulting design is necessarily distributed across multiple media. These media include, as already noted, not only physical realisations (such as notebooks) but also speech, gesture and in the minds of the designers. A consequence of this is that these multiple representations must be transformed into a centralised and unified form as the basis of an agreed understanding. Subsequently, of course, this unified, centralised representation does again become re-distributed across media. Protocol fragment 6 illustrates part of this process showing a design representation distributed between project documents and the whiteboard.

Peter gestures at document looks at whiteboard	Right. All I'm thinking about here is in some way you've got to define a given set of events, and when you've got those events, what the animation is. I mean, OK you might define it in terms of these frames things – whatever, who cares. [Roger: laugh] Somehow you've got to handle that and you've got a set of rules to work out what you're going to do. [Roger: mm hm]
Peter gestures at document	The more composite the events get the more complex that set of rules is and the more you're going to have. [Roger: mm hm] So there's a balanced trade-off between the granularity of the event structure if you like and the complexity of defining animation rules.

Protocol fragment 6

The transformation process to a unified representation can be seen in protocol fragment 8 below.

Provisional – Decided

This dimension refers to the transformation of the design from a provisional stage to one which has the agreement of the team. Hand-in-hand with this process is the change in media from the ephemera of whiteboard, speech and gesture (protocol fragment 7) to the more persistent medium of a designer's notebook (protocol fragment 8). At this early point in the meeting Roger is outlining a design proposal which is quite deliberately rough. The provisional nature of his proposal can be seen in those parts of protocol fragment which we have underlined.

Roger Yeah structure... but it's using the same information whereas ... we'll look at the words later. I think this may be more precise or a subset of it.

Matt Are these two circles on the way up? Or have you deliberately done them on the way up. You indistinct the values, but you need to know what elements those values map to.

Roger Well, that's that. Sorry, that was meant to be up and that was meant to be down. [Matt: right] So what I'm about to do, perhaps I'll do this in a different colour. I mean this is not decent syntax there's something like that giving us that [Peter: yeah] [M: mm] and on the way back down I assert we, basically we can say, you know, its a Chinese Restaurant, 3 number 7s [P: yeah] but I guess we can say in principle that it's an element idea [Peter: yeah] that gets mapped, we're not interested in values.

Protocol fragment 7

As the meeting progresses this part of the design crystallises and is recorded.

Roger So this means - I'd like to record somewhere that this functionality belongs in one particular place or another, or perhaps it should be in the text associated with the abstract user model. Could we agree that's where it should be? Does that seem sensible?

Protocol fragment 8

This process is typical of the design transformations not only in this but in all other design meetings observed. However it should be noted that the design process is essentially in parallel, with different parts of the design at different stages of maturity at any particular time.

Local - Boundary Object

This dimension is concerned with the transformation of the design in moving it from an artefact local to the design team to one for external consumption by the wider project. Such transformations result in the creation of boundary objects. A boundary object (Star, 1989) is a shared object of working, such as a document or file, which crosses the boundaries of different workgroups and as such acts as a vehicle for communication about work. Protocol fragment 9 shows the team presenting their design–as-boundary-object in the best possible light for the project consortium.

Roger Well, we can just say at the moment that we've made an assumption, but we are aware it is an assumption and requires validation or whatever. [Peter: yeah] They won't even have thought about monitors in that sense.

Peter *Indistinct* languages

Roger But it's breakpoints generalised, among other things.

Peter Lots of other things.

Roger But we won't tell them about all those. [laughter]

Protocol fragment 9

Roger, towards the end of the meeting, organises the making of a meeting record. He is referring to the work the team has done on the whiteboards. The record is not just for the team themselves, but forms the basis for co-working as a boundary object.

Roger OK. I'll record all that. What I'd actually like is for somebody not only to record that right hand one but draw it on some tool or even on a piece of paper that we can photocopy, but without any further refinement or thought so that it's a shared record. [Peter: yeah] I think that one's an important one because this on the route there we might have to come back to at some point. Peter: mm hm] & then on Monday we have to make some definite plans for actually wrapping this up and getting it into a document to send out on Wednesday I think. Right. It's going to be a rush job but I have to have something. I have to be able to talk about this and make decisions with people at the meeting, which is unfortunate, because it would be nice to involve the team on that but I think we need to have something in writing to give them ample preparation time. And the sort of thing we can have, it can start with the five layer thing we've got here, perhaps six with the meta-model.

Protocol fragment 10

In summary

As can be seen from this brief treatment of the central activity, the context in which it operates and its component actions, a variety of requirements present themselves in a fairly *ad hoc* manner. However what is required is a systematic treatment of requirements which we address in the next section.

THE LINK TO SYSTEMS DESIGN

Contradictions at the activity level

A contradictions-driven approach to requirements is potentially highly systematic, in that one could work through all of the permutations of primary, secondary (and so forth) contradictions. Such considerations are not confined to the components of the work system in isolation, for example substituting computerised for manual records or changing task procedures, but facilitate treatment of how changes interact with other aspects within and between activities. As we have already described, contradictions are not to be viewed as negative as they may equally be seen as opportunities. We now describe two examples of contradictions and the

requirements which arise from them at the activity level, followed by further examples at the action level.

Example requirement 1: Not getting together
As with most European projects, Mallard held frequent technical management meetings and as may be observed in protocol fragment 10, Roger notes that "*I have to be able to talk about this and make decisions with people at the meeting, which is unfortunate, because it would be nice involve the team ...*". Clearly Roger would have liked to involve Matt and Peter in the overall project meeting but for practical and financial this was not possible. This breakdown is indicative of a primary contradiction at the division of labour node with a presenting requirement for the provision of something like video-conferencing. Interestingly we can observe an interaction between this underlying contradiction and cultural-historical aspects of the project. Mallard was a follow-on project the partners had many years of shared history and this shared would have facilitates the uptake and use of technology as such video-conferencing.

Example requirement 2: Email
As we have just noted, the Mallard project partners had a shared history during which a range of artefacts had been agreed and subsequently prescribed so that any innovations in this domain would have to comply with these pre-existing standards or, as it happened, be required to co-exist with them. At the time of the study TTM were moving from Internet email on a Unix platform to Microsoft™ email. These two systems should have inter-worked, but differences in the way they handled attachments and distribution lists required the local Mallard team to operate both systems in parallel. Here the presenting requirement is to resolve this difficulty.

Contradictions at the action level

Primary

Primary contradictions are those which occur within a node. During the updating action, for example, we can observe a contradiction between the artefact used by individuals to progress their individual work – typically the personal notebook - and that used to communicate such work to the rest of the group – typically the whiteboard. The contradiction suggests that a new artefact which supports the sharing of notebook pages could avoid the need for time-consuming transcription. Considering the wider aspects of this part of the work, however, it becomes clear that the design of such a tool would need to take into account an aspect of praxis - the norm that one's notebook is private to oneself - and the way in which the step-by-step drawing of a diagram may facilitate mutual learning.

Secondary
A good example of a secondary contradiction – between nodes – lies with Matt's role. It can be observed from the video record that Matt tended to speak less than the other two, but was the group's primary note taker. Analysis of the time spent talking by each person reveals that he spent significantly less time contributing to the design meetings than Roger and Peter, probably as a direct consequence of minute taking. The contradiction is here is between the object of progressing the design and the way in which work is divided between the team in such a way that Matt is unable to contribute fully. The consequential requirement here is for less demanding meeting capture software, again designed with full consideration for the whole work activity.

Tertiary
To model tertiary contradictions it is necessary to propose a culturally more advanced (or new) activity. Effectively, this is what we have done in suggesting the changes described immediately above. The consideration of such changes against current work practice (for example) uncovers tertiary contradictions such as the mismatch with privacy norms and its consequential requirements on design previously identified.

Quaternary

These are contradictions between concurrent or co-existing activities, or in this case actions. In the design meetings there are frequently two or more actions running more or less concurrently which need some measure of coordination. Episodes of updating are interrupted by attempts at further design development. This occasionally has the observable consequence of someone being interrupted before an explanation is concluded. It can be seen from the protocol that had the updating action been allowed to run its course, the development work which interrupted it would have been unnecessary. Here the requirement seems to relate to meeting practice, perhaps to a need for slightly more formal turn-taking.

DISCUSSION

We have made a case for using activity theory to organise unstructured ethnographically informed data and demonstrated how this data can be held in a web-based system. We have also shown that requirements on the work situation can be systematically elicited and generated by way of contradictions. Such an approach both ensures that requirements remain attached to the context of work and provides an accessible, organised resource for later stages of analysis and design. It thus contributes to the collection of tools for moving from activity theory to systems design practice which are now beginning to appear in the literature.

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