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Abstract

In this paper we argue that traditional information systems design and development is implicitly informed by a certain deliberative theory about the nature of purposeful activity. However, we examine other theories of activity that lead us to challenge this dominant model. This work-in-progress report reinterprets a number of existing case studies from the literature and provides a preliminary account of a new case study in order to demonstrate that successful operational systems in time-constrained environments often do not exhibit those characteristics that are the hallmarks of the deliberative approach. These systems are better discussed in terms of routines and situated action. Finally, we make some preliminary observations about the significance of this for Information Systems.

Keywords

Theories of activity, Routine activity, deliberative activity, situated action.

1. Introduction

The design of information systems is informed by both our implicit and explicit views on the nature of purposeful activity. Activity can be viewed in different ways. The theories of deliberative action and situated action, to be defined in the next section, have already been discussed in the literature (Norman 1993,Simon 1979, Suchman 1993, Agre 1997), with the former having become our "folk theory" of activity, continually put forward as the basis of planned organizational action (Johnston, 2001). However, we present examples of other types of socio-technical work systems that challenge this dominant model and suggest that an alternative theory of activity co-existing with situated action, may explain these systems better than the deliberative approach.

Particularly, we explore the idea that within some work systems we encounter routines, which are those forms of work that occur repeatedly and may form the whole or a subset of the tasks required to achieve a goal. In these work systems, routines, together with explicit and expedient structuring of the environment enable efficient situated activity in (sometimes) highly pressured settings. These routines seem to occur because certain environments and situations allow their development.

Specifically, we concern ourselves with the idea that while routines are regularly incorporated within socio-technical work systems, information systems design to date does not adequately accommodate this form of activity. We suggest that routines are problematic for the dominant deliberative model because such a model does not accommodate situational, ephemeral or reactive activity - but rather presumes that activity, and the environment in which it is performed, is fixed. We argue that the study of routine activity is important in highlighting the notion that where different kinds of activity exist different information systems design and development approaches are required.

To begin, this paper will discuss prevailing theories of activity. Next we examine routine situated activity, using two sources – case studies from the literature and a new case study. As research in progress, the latter, a small manufacturing information system, is intended as the first case-study investigating socio-technical systems which include routinised work, with additional case studies being part of future work. Finally we will explore the idea of using this theory of agency explicitly in information systems design.

2. Alternative Theories of Activity

In the deliberative theory of agency (Simon, 1979) an agent acts in a goal-directed way by building and maintaining an abstract model or representation of the world and applying deductive processes to this representation to determine action. This process results in a list of actions (a plan) which, when executed, achieve the goal. For individual human action this model is supposed to exist in the mind (Norman, 1993): for computer-supported group activity this representation takes the form of a computerized data-model.

A good example of a system designed using the presumptions of the deliberative model is Manufacturing Resource Planning (MRP II) (Wight, 1981). MRP II is a computer-based approach to manufacturing operations control. MRP II embodies the deliberative model in a very literal way (Johnston, 1996). A computerised master production schedule represents the company-wide production goal. This is processed against a product structure database that describes how raw materials and bought components can be converted into saleable items. The current availability of products is checked against an inventory database and, by purely deductive means, schedules for buying and assembling component parts to meet the master schedule are produced and handed to operators for execution. MRP II shares the assumptions of the deliberative theory, namely, that

systems should represent the environment in which the system acts in terms of external, independent and objective entities, properties and relations.

Below we examine a number of examples from the literature illustrating a variety of information based socio-technical work systems which suggest, however, that some activity is not deliberative and is performed in a routinised manner where actors respond in a situated context, rather than planning and deliberating upon an activity. Suchman defines such situated action as: "what sense we can make of everyday activities (viewing) them as interactions between the acting person and those social and material circumstances in relation to which he … acts"(Suchman, 1993. p.71).

Situated actions are actions that are initiated more or less directly in response to situations encountered by the agent and which depend for their effectiveness upon useful structures in the environment (Agre, 1997). Deliberative actions are initiated by a process of reasoning applied to a symbolic model of the world. All environmental structure is implicitly contained in the world model so that the structuring effect of environments for action is marginalised under a deliberative model. What we see in our examples, however, are that in many systems routines may develop in situated contexts where actors respond to their environment of activity despite having some original deliberative plan of action.

3. Examples

Zuboff (1988), in her research on the computerization of work, studied workers in a paper mill who execute tasks routinely without significant cognitive processing. For example, a worker performing a task repeatedly where they pull two levers described the task as only pulling one lever. "They have built in actions and sensors they are not aware of" (Zuboff, p.60) and carry out the routine activity without thinking while the environment affords it. Similarly, workers complained that they watched a boiler overflow because they were not able to regulate the temperature accurately once the job was translated onto a computer screen, where they were removed from the cues of the task environment. They understood the feel and heat of the boiler perfectly in the physical context and had previously had no difficulty turning the boilers down manually. They easily react to situational cues in a routinised time constrained environment but could not function effectively in a deliberative system that had attempted to "objectify" (Lakoff, 1987) the world and turn it into an abstraction of properties with set values.

Similarly, Wong (2000) describes another situated system for the command and control of emergency ambulances. He describes information "coming from different sources… interleaved with information about different incidents..." which operators need to react to. The operator's environment is not static but we see that they develop routines to deal with the information and allow new inputs from the environment to be assimilated. In the environment Wong describes there are tags such as the "spatial positioning of tickets …(and) tickets that indicate handing over a job to another dispatcher..." illustrating the active use of environmental structure. These environmental inputs reduce the need for cognitive processing and their presence triggers effective routine work practices. In this way the environment is deliberately structured to provide support for routine work.

Earlier work studies of air traffic control systems (Bently, 1992) describe systems where "the division of labour is organized dynamically according to need and does not necessarily follow a prescribed form. Knowledge is (only) expressed on occasions when 'normal and routine' work breaks down." The system generally proceeds with actors responding routinely to situational cues in regard to flight information. Bently's system contains a flight strip which includes some static information such as the flight number and aircraft identifier it also contains dynamic information which is purely situational such as "time over beacon" and current height. The flight strips do not represent

objects with fixed properties but rather important ephemeral cues denoting *situations* to which the air traffic controllers must respond. By contrast, deliberative systems represent *objects* and their properties together with a persistent account of the state of the world over time.

The system in our example is a production control system for a factory of four staff dedicated to the manufacturing of approximately 200 air compressors a year. The production control system features a white board that is a representation of the non-routine aspects of the work system. What is interesting is how little information is represented on the white board and how this is achieved while still maintaining control. In this, we believe the example has a message about how systems developers and designers can reduce the use of explicit representation in information systems.

The factory is designed so that the person taking orders on the telephone in the middle of the factory has full view of all available stock that is hung on a number of shelves lining the walls of the factory. The main components of the system include a white board of open customer orders and the physical parts of the air compressors that, by their construction, implicitly contain information about their own method of manufacture. The information on the whiteboard is minimal and each entry only contains job-specific details such as name of client, and options such as colour, motor size, etc. The system has been designed deliberately in this way to reduce the need to represent things.

Manufacturing commences when the order is received by phone and a line order is added to the white board. The non-standard parts associated with the customer options are checked for availability visually, and if need be, ordered on a one-off basis. The machine assembler then takes a machine base and begins construction, referring to the white board only for order-specific information that is not part of the standard assembly routine.

What is interesting are the things that are not represented as an abstract world-model. There is no information about how to construct the machine: the machine acts as its own "jig" through devices for guiding a tool or part to a specific place, or this ability comes from the tacit knowledge of employees. There is no parts list or inventory system: the availability and quantity of parts holdings are clearly seen on the shelf. The only recorded requirements-related information is in the reference to non-standard choices on the whiteboard. Except for the small amount of information on the white board, "the world (is) its own model" (Brooks, 1991,p.143). The current situation is in fact seen in the view of the stock on the shelf, the number of jobs on the floor, and the state of readiness of those jobs. The recorded information on the whiteboard is largely ephemeral (except for a small amount of recorded information for warranty purposes). If a job is finished it is removed from the whiteboard and the new situation is revealed.

4. Discussion and Conclusions

What we are seeing in the example of the compressor factory is very similar to what both Zuboff and Wong recorded. The workers are reactive and situated, carrying out their work in a routine way, performing a regularly rehearsed set of tasks in an environment where physical indicators, such as the amount of stock apparent from visual inspection and the design of the machine, afford the tasks. In the same way that the spatial positioning of a ticket for an ambulance dispatcher can allow them to carry on the routine of sending out the ambulance, the fullness of a box of screws or the state of a partially constructed machine allow the builder of the air compressor to carry on with the routine procedures that make up the bulk of his work. It is the same type of skill Zuboff described where the environment of the task heavily influences and facilitates what occurs.

In order for such systems to function effectively we see that workers need to develop routines that they are able to perform in conjunction with the structures in the environment. When Zuboff's workers could see and feel the heat of the boilers they were able to control them in a routinised way

without thinking about them. Similarly the workers in the air compressor factory describe feeling in control where they can see the stock, and when the factory is set out in a particular way. This allows them to carry out the procedures that are not recorded on the whiteboard. "Routines exist because people bring a relatively stable set of practices to a relatively stable set of circumstances (Agre, 1997, p.110)". We see this in both the ambulance dispatch system and the air traffic control system where, despite a flurry of activity and fluid environmental inputs, ambulances are dispatched using the same procedures each time and air traffic is controlled using the same basic parameters. Routine activities develop as we recognise the sameness of situations that arise in commonly occurring tasks and the value of regularizing these tasks in order to cope with the new and sudden inputs from, for example, the flight strips. It is important that such systems are routinised and reactive – there is no time to reflect on an abstraction of the real world. In all the systems discussed, little is represented explicitly in the form of an abstract world model. Structures in the environment, such as the positioning of the flight strips or ambulance tickets, make up that gap.

Information systems have traditionally represented everything abstractly, whereas we see in the cases that all that requires abstract representation is what is not included in the routine. Systems based on a deliberative model, however, assume that all system components are represented abstractly as objects and relations between objects and assume that when we act we are continually translating between the abstract world of models and plans and the real world in which the task actually takes place. Systems informed by the deliberative theory, which employ this cumbersome and 'lossy' translation (Johnston, 1996, Agre, 1997), are unlikely to provide appropriate support for time-constrained activity in certain environments. We argue that systems based on routines, which reduce the need for abstract representation and consequently for this translation, need to be a focus of systems design. Environments, that are structured to provide support for routine work by limiting the amount of required deliberative activity, can facilitate task performance and the smooth running of systems. The implications of this, is that where information systems to support such environments are carefully designed and developed, the need for representation should be significantly reduced.

The way we observe actors in the case studies utilizing the ephemeral aspects of situations may also present opportunities for the more effective use of information technology. Systems developers need to consider how technology can be used to structure an environment to make use of an efficient routine and reduce the cognitive burden on system participants. A proper analysis of the theoretical status of ephemeral representation such as we see in the flight strips and the ambulance system tickets might lead to new ways of employing information technology with new emerging technologies providing novel ways of dealing with this different type of representation.

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