AN ACTIVITY THEORY ANALYSIS OF RFID IN HOSPITALS

Daniel E. O'Leary

University of Southern California, 3660 Trousdale Parkway, Los Angeles, CA 90089-0441

oleary@usc.edu

Abstract

Although there have been many proposed applications of RFID in hospitals, few of those applications have received sustained use in hospitals, to-date. As a result, this paper investigates the use of RFID in hospitals in an emerging application, that of using RFID as part of the prescription process, including pharmacists generation of the prescription and nurses' administration of the medicine. Using activity theory we generate activity templates for pharmacists, nurses and the hospital to investigate the introduction of RFID.

We find that the introduction of RFID involves changes in the activities, as measured by changes in context variables, not just changes in technology. We find that the RFID – based approach eliminates substantial "medicine" slack. Further, using activity theory we also find that the activity design for using RFID facilitates "technologically insulation" of pharmacists and nurses, from each other and doctors. Finally, we find that such "digital specification" of activities likely leads to fewer error, and constrains action, limiting inappropriate use of prescription drugs.

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KEYWORDS: ACTIVITY THEORY, RFID, HOSPITALS, DIGITAL SPECIFICITY, TECHNOLOGY INSULATION, ACTIVITY THEORY ORGANIZATION AGGREGATION, ACTIVITY THEORY BEFORE AND AFTER, TECHNOLOGY ELIMINATED SLACK

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1. Introduction

Many intriguing potential uses have been suggested for **r**adio **f**requency **id**entification (RFID) in hospitals (Collins 2004). As a result, RFID has been highly touted as an integral part of the hospital of the future (e.g., Furher and Guinard 2006). Unfortunately, there are far fewer implementation stories (e.g., Baker 2005, Halamka 2006, 2007b) than there are potential applications. Further, there have been a number of concerns that "RFID implementation is not moving fast enough" (e.g., Young 2006a). Accordingly, this paper investigates one hospital RFID application that has received recent attention within the context of a theoretical framework in order to anticipate some of the potential opportunities and limitations of that application. Specifically, this paper investigates the impact of introducing RFID into hospitals, in the emergency room processes of prescribing and administering prescription medicines to patients.

This analysis is done using a theory-based approach to analyze a case application. In particular, this application is investigated using "activity theory" as a basis of analysis. As its name suggests, activity theory is based on an analysis of activities in which people participate. Activity theory provides a rich set of context variables that can facilitate deep insights into the particular activities. Although originally developed as a psychological approach, the focus of activity theory has centered on taking into account the "context" on which the activity is based, rather than treating the technology independently.

1.1 Purpose and Findings

This paper applies activity theory to facilitate the analysis of the introduction of RFID technologies into hospitals, and the corresponding impact of those technologies on those organizations and their processes. The approach allows us to garner insights into the impact of RFID after its introduction, and in contrast to the use of previous technology and supporting processes. In addition, this approach allows us to investigate the different groups (e.g., pharmacists, nurses, etc.) affected by the introduction of the RFID, and how the introduction of the technology facilitates alignment with the overall organization.

The use of activity theory to analyze the introduction of RFID into a hospital organization leads us to three key insights and evaluative bases. First, the RFID-based approach appears to potentially eliminate particular kinds of organizational slack. Using RFID, medicines can now be specifically assigned so there is no "slack" medicine. Second, the RFID-based approach facilitates what I call "technology insulation" between different groups of actors, including nurses, pharmacists and doctors. The technology insulates the users groups from the actions of other groups. For example, nurses are limited in their set of actions because of and by the use of the technology. Third, the analysis finds what I call "Digital Specificity": Prescriptions are specifically prescribed by doctors, and a prescription must be specifically generated by a pharmacist and that specific dosage must be administered to specific patient by a nurse, whose identification also is captured. The technology drives the activities and workflow with digital specificity as to who does what when.

In this paper, we also advance the use of activity theory to include disaggregation to different homogeneous groups and consideration of both input (pharmacists and nurses) and output (patients) activity groups. Further, we consider the resulting alignment that we find between the different groups in their use of RFID in this hospital setting.

1.2 Outline of This Paper

This paper proceeds in the following fashion. Sections 2 and 3 outline general RFID hospital applications and lay out the case study area that is the focus of this paper. Then sections 4 and 5 provide a review of activity theory and discuss how activity theory can be used to analyze organizations. In sections 6, 7, 8 and 9, I discuss pharmacists, nurses, the entire hospital, and the alignment between different groups, based on activity theory. The final section provides a summary of the paper, discusses the paper's contributions and briefly analyzes some extensions.

2. RFID Hospital Applications

Starting in the early 2000's there were a number of proposals for the use of RFID in hospitals (e.g., Hendrickson 2004). RFID was identified in many news stories worldwide as a technology component that would facilitate some type of activity, such as control of hospital assets or prescription drugs.

As an example, RFID has been proposed as a basis *to track the location* of almost everything found in a hospital, including doctors, patients, pharmaceutical stocks and medicines, and medical hardware (e.g., Hendrickson 2004, Caffrey 2005, Godinez 2007). With location information, would come the ability to provide greater security and control of those people or things being tracked. For example, Godinez (2007) describes another system that could be used to control medical supplies inventory that automatically captures who removes an item.

Fixed asset control seems to be the application of RFID that has gathered the greatest level of actual application. For example, in a survey by CIO, asset tracking was found to be the most frequently used application and the application most likely to be adopted. Further, Halamka (2006, 2007) notes that there has been some success, particularly associated with the use of active RFID tags on hospital assets. RFID is being used to prevent the abduction of infants (e.g., Sullivan 2005 and Pullar-Strecker 2007). Infants can be tagged with RFID ankle bracelets, and unauthorized movement can be determined and authorities can respond to unauthorized movement. Unfortunately, there have been few stories about full-fledge implementations other than tagging infants and assets.

However, an approach that seems to be gathering additional attention is one described in Wessel (2006), who notes that RFID could be used to decrease the rate of medication errors. RFID tags could be applied to sealed packets of individual medication. Patient, location and pill count could be captured as the dosage leaves the pharmacy, and recaptured when they arrive at the patient location. Nurses then could scan employee identification information when they administer the prescribed medication. Digitally the activities can be well-structured and controlled.

3. Research Approach and Case Analysis

Unfortunately, we cannot examine the entire spectrum of either users or activities in a hospital, as they relate to RFID in this single paper. Accordingly, we focus on the specific case of the emergency room and the process of prescribing and administering medicines. Further with the introduction of technology, the nature of activities can change (e.g., Hammer 1990), so the discussion and analysis are not just aimed at the technology level, but also at the organizational impact of the introduction of the technology.

As a result, we will focus on a particular case application, and a particular set of activities that include RFID as part of prescribing and administering patient medication needs. There has been a substantial amount in the practical literature about the set of activities discussed in this paper. That literature and discussion with practitioners provided the basis of this case discussion and analysis. Because there is more literature about Jena Hospital' application, than any other hospital, that will be our focus, however, our primary concern is the application in general. Jena Hospital proposed using RFID throughout the activity of providing patients in intensive care and other departments with prescription medications. For the interested reader, two short videos of the process are available at SAP (2006 / 2007) that summarize and document the overall activity. In addition, there are a number of papers, including Wessel (2006, 2007), Specht and Laslo (2006) and Specht (2007). In addition, a closely related version of the same process was implemented at Pittsburgh's St. Clair Hospital (e.g., Young 2006b), among others.

3.1 Initial Design – Medication Prescription

The approach proposed at Jena University Hospital is one of the few that apparently makes use of RFID throughout the process. As with virtually all information technology implementation projects, the initial version of the activity, ultimately changed from the version initially proposed. In its earliest version, Wessel (2006) describes the beginning of preparation for one potential new version of the activity of pharmacists filling a prescription in a hospital (numbers added to facilitate discussion)

1. After treating patients, doctors will prescribe medication … by typing an order into the hospital's computer system.
2. This order is transferred to the in-house pharmacy, where the correct medication dosage is then prepared for each patient.

3. Before the prescribed antibiotic leaves the pharmacy on an automatic transport belt, the pharmacist will apply an RFID tag to the sealed packet of an *individual dose* of medication (italics added).
4. In addition, the box transporting the bottles – as well as containers holding multiple items – will be tagged. (Items put in the box are automatically scanned)
5. Portal readers … will read the tags as the medication leaves the pharmacy. …

This revised activity structure is substantially different than a classic activity associated with pharmacists, prior to the introduction of RFID. Historically, for pharmacists, the activity has been defined as up through step 2, but no mechanisms existed to digitally ensure the capture of information about the administration of a particular prescription. However, with RFID now it appears that the activity of the pharmacist has been expanded to these other activities to ensure capture of additional digital information, and issuance of the medicine to the labeled patient.

3.2 Prototype Implementation – Medication Prescription

Since the "Initial Design," of the RFID-based process, listed above, Wessel (2007) provides a slightly different version of the activity. First, instead of conveyer belts, in the revised systems robots deliver boxes of medication to the appropriate locations in intensive care. RFID tagged medicines are put into boxes that also are tagged, and the tagged boxes are put onto tagged carts that are delivered by the robots to nursing receiving stands (figure 1).

Second, since conveyer belts were not used, and the fact that using portals was apparently expensive and less flexible, hand held readers were implemented, rather than portals. As noted in Wessel (2007), it would have been too costly to use a network of conveyor belts and generation multiple portals that would have been needed in intensive care. In addition, it would have been difficult to generalize the approach and test, to the rest of the hospital, beyond intensive care.

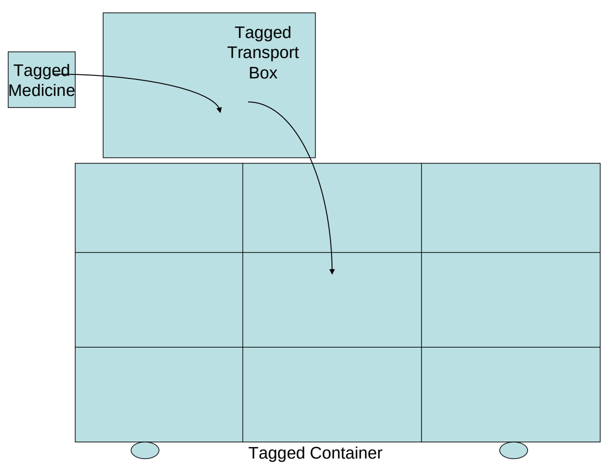

Figure 1 - Medication Transportation

3.3 Administration of the Medication

In any case, after the medications have been transported to nursing, the nursing staff picks up the medication box when it is needed. Individual packets of medication are administered by the nurses. The medication is scanned and digitally linked to the specific patient in intensive care. Patients RFID bracelets are scanned to establish identification information of the patient. (At Jena hospital, no patient history is kept on the RFID tag, instead, the information is on hospital servers, enhancing potential privacy.) Then, the nurse scans their own RFID badge to capture information about who administered the medicine. In a similar manner, at St. Clair Hospital, Young (2006b) notes that nurses felt that the RFID tag in their badge speeded and facilitated the process, over bar codes and manual approaches.

3.4 Alternative Approaches

A closely related technology based approach is that of using bar codes on the prescriptions, rather than RFID. Many see the bar-code approach as the most economically feasible at this time for this process (e.g., Halamka 2006, 2007b) and Young (2006), that the cost of using RFID for the prescription process would be "exorbitant." Further, as seen in Gruman (2007), bar codes can be used at different parts in the process, rather than RFID. For example, some hospitals use bar codes on patients, nurses and medications, while others use bar codes only on medications. In general, RFID tags are more costly, yet, many feel that bar codes scanning slowed down the process. As a result, nurses in Pittsburgh preferred the RFID approach (Gruman 2007).

However, a key concern is that bar-codes can be circumvented (e.g., Young 2006b), as opposed to RFID tags which are linked to the individual item level. For example, with bar codes, empty containers and partial or full unused containers can be scanned, since the medicine may be the correct medicine for the patient. But with RFID a particular dosage must be associated with a single patient.

3.5 Hospital Setting: Intensive Care vs. Other Hospital Settings

As might be expected, there are some advantages and disadvantages of implementing medication dispensing using RFID in intensive care, as compared to other settings. Intensive care settings are likely to have greater resources available, e.g., there likely are more nurses to ensure intensive care capabilities. However, since it is intensive care, there are more likely to be critical and emergency situations where there is limited time to manually scan a bar code or an RFID chip. One can imagine that during a true emergency that taking time to scan a recalcitrant tag would be impractical.

4. Activity Theory

Activity theory is concerned with doing and activity (Nardi 1996b, p. 7). Activity theory proposes that human activities cannot be understood without examining and understanding the role of context in everyday life. Recently, e.g., Sierhaus and Clancey (2002), activity theory has received attention in some computer science applications.

Activity theory is a theory-based approach that has its origins in psychology. In particular, activity theory resulted from the efforts of Russian psychologists trying to develop a psychological theory based on Marxist philosophy and thinking. Historically, activity theory was initiated by the Russian Psychologist Lev Vygotsky in the 1920's and 1930's. His work is summarized in Vygotsky (1978). That work was extended by S. L. Rubenstein, A. N. Leontjev (1978) and others.

4.1 Activity Theory Templates

Although activity theory was founded by Russians, perhaps its most active researchers have been from Scandinavia. In particular, one of the key sets of structures used to explain activity theory was developed by Engestrom (e.g., 1987), who generated generic templates for activity theory that have found wide spread application, and are used in this paper. The primary template is summarized in figure 2. In the following discussion, we will analyze the diagram and each of its components in greater detail.

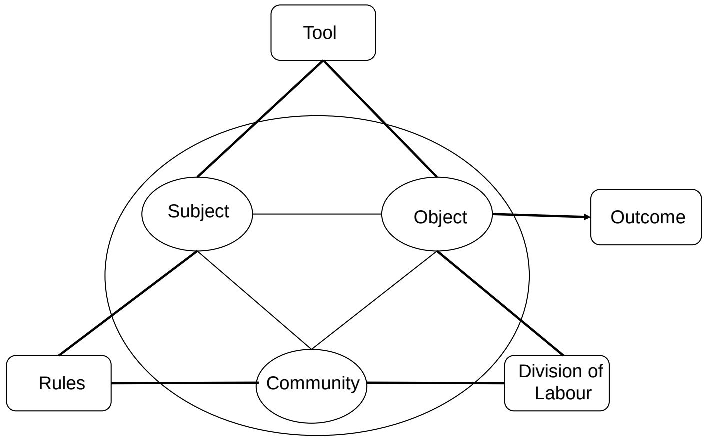

Figure 2 -Structure of an Activity (Engestrom 1987)

4.2 Activity

The main object of study of activity theory is human work activity. An activity is a form of "doing" directed to an object (e.g., Kuutti 1996). Activity theory uses the notion of an activity as the basis and unit of analysis. An activity is motivated towards transforming an object into an outcome (Barthelmess and Anderson 2002). Activities have an object and transformation of the object motivates the existence of the activity (Kuuti and Arvonen 1992). Accordingly, Bedny and Harris (2005, p. 130) define an activity as " … a goal directed system where cognition, behavior, and motivation are integrated and organized by a mechanism of self regulation toward achieving a conscious goal."

Activities may have more than a single step. As a result, there may be more than one activity and each activity can be made up of a number of related tasks. Accordingly, the analysis can be broken down to the task level in order to generate more detail. However, there are no firm barriers as to what is a task or activity. Further, activities may or may not be independent of each other or sequentially related.

Kuutti (1996) offers some examples of activities, including a software team programming a system for a client. Clancey et al. (1998) note that activities can include reading mail, going to workshops or answering phone calls, so the notion and detail of activities can be very general. Articulation of the detail of the level of activity can vary based on the analysis.

4.3 Object

The object of an activity is that which is modified and explored by a subject, according to the goal of the activity (Bedny and Harris 2005). Objects can be material things. Engstrom (2004, p. 6) defined an object as " … a heterogeneous and internally contradictory, yet enduring, constantly reproduced purpose of a *collective activity system* that motivates and defines the horizon of possible goals and actions." As seen later in the paper one example object is "useable knowledge." An object in the hospital setting is to get accurate and complete medicine to the patients.

4.4 Outcome

The outcome of an activity may or may not be one that accomplishes the object or goal, if there is one in the representation. A simple example of an activity is that the patient gets complete and correct medication in a timely manner.

4.5 Subject

A subject typically is a person that undertakes an activity. Subjects are people in different roles (e.g., blue collar workers and white collar workers) that transform materials and use information. Subjects are part of a collective effort, and do not exist in a vacuum. An example set of subjects are pharmacists, while another are the nurses that administer the prescription.

4.6 Community

Community refers to all of the people involved in the activity, for example, not just pharmacists and nurses. If the activity relates to a system, then the community will relate to the specific activity and its location in the life cycle of the system. For example, a system in steady state use will have a particular organizational community that includes those putting data into the system and those responsible for maintenance of the system. A system in design and development can be a largely different community from a system in steady state, and include others from the community, including designers and top management from functional areas.

4.7 Tools

Tools can be either physical or mental tools (Kaptelinin et al. 1999). Tools shape the way that people interact with reality. In addition, tools are shaped by the experience of other people who have tried to solve similar problems, and thus tried to make the tool more useful or efficient. Ultimately, the use of tools is an evolutionary capture and use of knowledge that influences not only external behavior, but also the mental functioning of the individual.

Tools are both enabling and limiting (Kuutti 1996). On the one hand, tools provide the subject with enhanced capabilities. On the other hand, tools restrict interaction "to be" from the perspective of the particular tool being used. Some example tools include computer systems, scanners and even spreadsheets, depending on the level of detail of concern in the analysis.

4.8 Rules

Rules refer to any guidelines, codes, heuristics or conventions that guide activities and behaviors. Rules can refer to what it means to be a member of the community. Rules also can refer to production rules for the activity. Rules can be established at the particular organization or by outside agencies, e.g., any group that is a part of the community.

4.9 Division of Labor

Division of labor refers to balancing activities and parts of activities between different people and artifacts. Division of labor also refers to the hierarchical structure of organizations that support the activities. As an example, generating and administering a prescription for a patient requires the coordinated efforts of doctors, pharmacists and nurses.

4.10 Example

In one of the most complete and clearest discussions of applications of activity theory, Collins et al. (2002) addressed the issue of documenting solutions to customer problems within Hewlett – Packard, focusing on the knowledge authoring activity. They had found that support knowledge about application software had become more difficult to capture in a reusable way because the software had complex dependencies on contextual and environmental variables that were unique to each customer. Ultimately, they argued that their results could be used to provide input for tool requirements and authoring, and to provide value by aligning customer support and knowledge authoring tools. Their discussion of the issue was based around the activity theory element. I have summarized some of their findings in an activity theory template in figure 3, below.

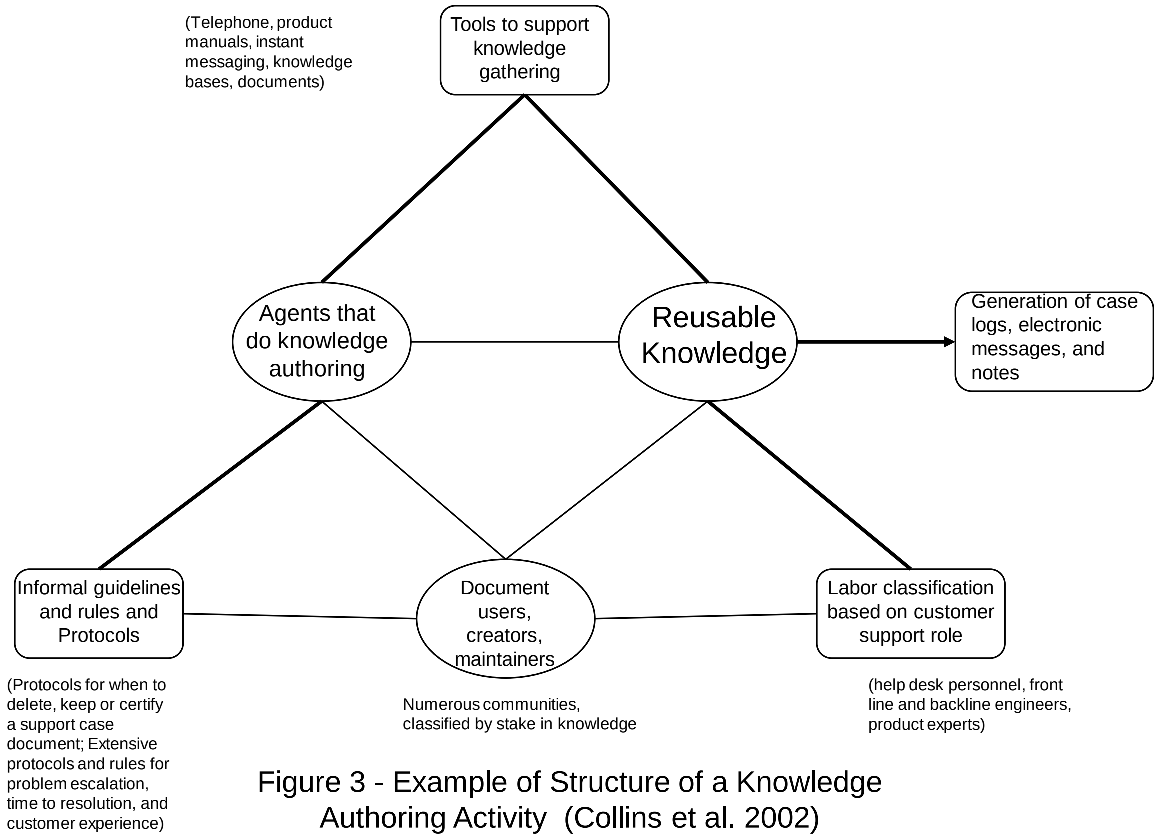

Figure 3 - Example of Structure of a Knowledge Authoring Activity (Collins et al. 2002)

5. Use of Activity Theory Analysis To Investigate RFID in the Emergency Room

Activity theory templates drive our choice of variables and analysis. In addition, to the basic activity theory template, we will use three extended uses of that theory: Before and After (technology introduction) Activity Theory Analysis, Homogeneous Group vs. Aggregated Activity Theory Analysis, and Inputs vs. Outputs.

5.1 Before and After Activity Theory Analysis

We can compare activity contexts, both before introduction of the new technology and then after introduction of the new technology. This before and after comparison, can provide us with insights into the introduction of the technology into hospital settings and how the change in technology influences the context of activities. In particular, we will consider how the introduction of RFID influences the activities and their context components.

5.2 Homogeneous Group vs. Aggregated Activity Theory Analysis

It is difficult to try to generate the perspective of the organization as a whole because there are so many different heterogeneous views. As a result, in order to account for an entire hospital, using activity theory analysis, generally requires generating and aggregating multiple views.

A priori it is not easy to establish what level of detail should be investigated in an activity analysis. We typically analyze groups that perform the same activity of interest. Because they are performing the activity, there is a degree of homogeneity about the groups, e.g., nurses or pharmacists, in an emergency room-based activity. However, we also need to consider how multiple groups involved in an activity, interact with other groups or at least what are related groups to ultimately perform the activity.

Activity theory analysis can start with the entire hospital and then examine disaggregated groups that aggregate up to the totality of the hospital. These considerations are illustrated in figure 4, below.

Activity theory does not provide for any formal combination rules or disaggregation rules. There is no mechanical combination of templates or template factors. Ultimately, the level of analysis depends on the analyst.

After generation of the templates for different groups, there can be an investigation of the “alignment” or consistency between the different views generated. For example, we can be concerned with whether the activities under “Pharmacists” or “Nurse” are aligned with those under “Entire Hospital.”

How might we see alignment in figure 4? As an example, consider the alignment between objects, such as doctors, nurses and pharmacists. We can ask are the objects of the groups for the activity, in alignment with each other? If they are not then the performance of the activities with one group can be at odds with another group.

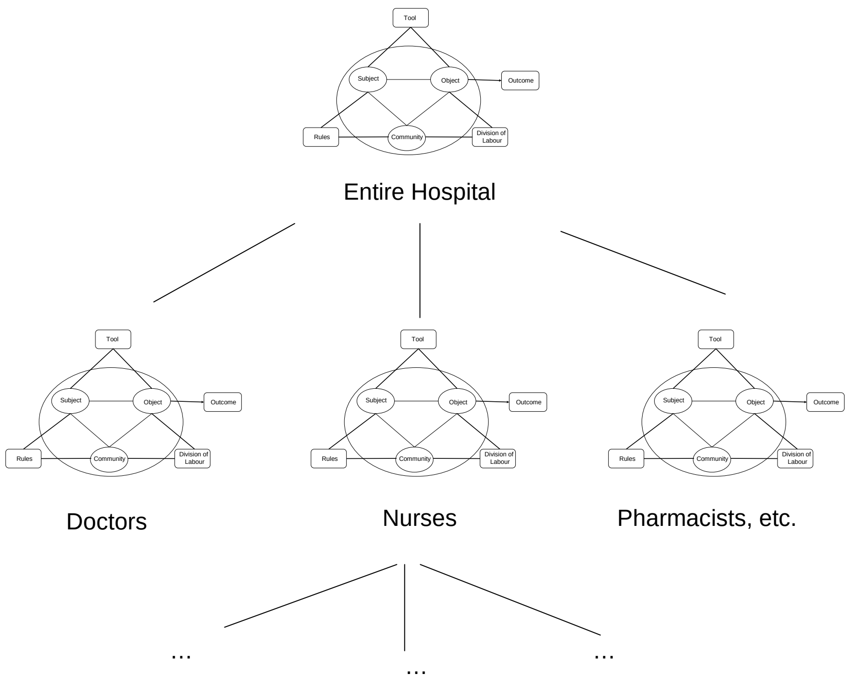

Figure 4 - Aggregated / Disaggregated

5.3 Input Groups vs. Output Groups

As another generalization of activity theory we can focus on the groups that perform the input or production factors, such as pharmacists or nurses. Alternatively, in the case of the hospital setting that we can consider, analysis of outputs that requires investigation of the patient’s point of view. We can investigate both inputs and outputs and analyze their alignment.

6. RFID and Activity Theory: Pharmacists as Subjects

Consider the context of the pharmacists as subjects. We can examine the initial state and then the impact of the change for each item in the activity theory template.

6.1 Object

Prior to the introduction of RFID, the object of the pharmacists likely was to fill a prescription correctly and in a timely manner. For example, in Scheckelhoff (2006), it is noted that "… the role of the pharmacist (is) in reviewing medication orders for accuracy and completeness."

However, given this new activity definition in the "Initial Design," discussed above, the object apparently would need to expand that role. Although correctness and timeliness would likely still be concerns, the pharmacists would take on a new role associated with controlling the dosages and medications through their use of RFID. Now the pharmacist also is charged with correctly packaging the medication to include patient identification tags that facilitate accuracy and completeness. This suggests that an important extension would be to find a way to embed the tag into the dosage without employing an extra step, of embedding the tag on the label, limiting the extra work by further reengineering the process.

6.2 Community

ASHP (2006), the primary U.S. support group for hospital pharmacists, "urged the FDA (Food and Drug Administration) to Keep Bar Coding a Priority, while supporting RFID." However, they supported the use of RFID by groups other than pharmacists for more accurate shipment of goods from manufacture to pharmacy. As a result, the group of hospital pharmacists in particular hospitals may not fulfill a complete commitment to RFID technology.

The introduction of RFID (and bar coding) into the activity of providing patients prescription medicines likely expands the community. Before RFID, the community was pharmacists. After RFID, the community expands to include technology personnel to deal with RFID consideration, security personnel (e.g., Scalet 2007), packaging personnel, transportation personnel and others. Accordingly, the community becomes more diffuse, and less potentially focused, resulting in differential objectives.

6.3 Tools

Ironically, the "Initial Design" approach, discussed above, does put an additional control concern in the process: Is the tag the right tag? Generating a new step of putting the tag on the package introduces another level of uncertainty: Does the tag correspond to the prescription. One approach that evolved during the year between the initial design and the prototype was the ability to *print* RFID tags, potentially eliminating the concern of the extra step of labeling and then putting a tag on.

Next assume that the pharmacists mislabeled the medication. Unfortunately, in this case the RFID chip would provide additional evidence generated by the technology, substantiating what is actually a mislabeled medication. As a result, the RFID chip may ultimately tell the nurse, erroneous information. Thus, there can still be errors, even with human intermediaries, because of their ultimate dependence on the technology and the human's implementation of the technology.

6.4 Rules

In the United States, the Food and Drug Administration, has asked the industry for a "drug pedigree system" that is preferably electronic. They recommend that each "package" have a unique identifier. Again, the limitation is that the identifier is in the package, so the identifier is ancillary to the medication.

However, at this time, there is not a requirement to use RFID. However, if RFID becomes the norm and pharmaceutical supply chains employ standards for RFID, then that can mitigate potential conflicts with existing RFID tags and facilitate use throughout the supply chain.

6.5 Division of Labor

The division of labor seems to change with the new activity definition. For example, some may argue that the pharmacist also is becoming a "packager," now charged with making sure that the package has an RFID tag on it. The duty of the pharmacist seems to have been extended, to getting the appropriate medicine dosages generated, tagged and transported, up to the point that the boxes are placed on the container departing the pharmacy area. However, division of labor within the aspect of generating the individual dosage is clear and limited to the pharmacy. As a result, with either version of the system, the pharmacists are technologically insulated from doctors and nurses.

7. RFID and Activity Theory: Nurses as Subjects

After laying out the pharmacist portion of the activity, and apparently getting buy-in from pharmacists, the head of electronic data processing division of Jena Hospital noted (Wessel 2007) "we are curious to see how the new system will be received by the nurses, but we are very optimistic after positive pretests with the head nurse." Correspondingly, the second group in our activity analysis is the nurses.

7.1 Object

Historically, one concern of nurses is that the appropriate medication is dispensed to the correct patient at the correct time. Another object of nurses can be the elimination of errors (e.g., Specht and Laslo 2006). With RFID, those are still objectives.

7.2 Community

As with the pharmacist, the implementation of the technology, whether it is bar-coding or RFID, broadens the base of the community to include those involved with the technology, diffusing the homogeneity of the community, from just nurses to technology support groups. As the homogeneity decreases, the likelihood of a need to pursue multiple objectives increases, potentially resulting in less focus on the original object.

7.3 Tools

As noted by Barlow (2006) "Med error reduction can only be achieved if the nurse is willing to use the handheld scanning technology with each med administration. If it is difficult to scan the bar code, the nurse may feel the extra effort is unjustified. However, when the RFID tag is (used) … the scanning process is effortless and the nurse becomes fully willing to adopt the technology. This then saves patient lives, reduces liability, and reduces costs." In addition, as noted by Young (2006b), "Nurses appreciate any time savings and convenience that can be applied to their workflow." Accordingly, it appears that RFID tools are seen as providing benefit by the nurses, improving and facilitating the prescription administration process.

7.4 Rules

Work rules need to be established, including some aimed at making sure that the technology works appropriately. For example, at Pittsburgh's St Clair hospital, the hospital had to determine the appropriate reading distance for the RFID scanners, and determined that was 2.5 inches, a distance built into their work rules for using RFID (e.g., Young 2006b). Unfortunately, rule generality and implementation can be critical, since such rules that are too specific may be difficult to implement, but rules that are not specific enough will have difficulty being implemented.

7.5 Division of Labor

Nurses would be responsible for the movement and administration of medicines from the point in time that the transport boxes were received in the intensive care department. As a result, to a certain extent the technology and design of the nurse's activity insulates them from both the pharmacist and doctors, as part of the workflow. They are insulated from the pharmacists because they cannot administer the prescription, until it is delivered, and from the doctors, since the nurses cannot obtain prescriptions until they are prescribed.

If the medication has not been delivered, then either it has not been prescribed or it has not been processed by the pharmacy. Even if patients are in pain, nurses would not be in a position to provide prescription drugs. Accordingly, the nurses are limited, through technological insulation, from what they can do for patients, since there is no slack.

Finally, a recent concern is that nurses have been found stealing prescription drugs (Weber and Ornstein 2009). As a result, a concern is to limit the slack drugs that might be misappropriated. Since each dose is individual and each is generated for a particular patient, there is no slack medicine in the system. As a result, nurses also would be limited from appropriating prescription medicines for their own use, likely resulting in less theft, and ultimately greater control by the hospitals over prescription medicines.

8. RFID and Activity Theory: Output – Patients as Subjects

In order to account for the entire hospital as the focus of the activity theory analysis, generally requires either aggregating multiple views, trying to take the perspective of the organization as a whole or focusing on a system output (e.g., patients). Some of the key concerns can include the following.

8.1 Subject and Activity

Although we have focused on nurses and pharmacists, at some level the key subject of concern to the hospital is the patient and the activity is the treatment of the patient at the hospital (e.g., Specht and Lasio 2006). As that activity is broken down into its component pieces the focus can be on the different sets of roles that we have examined earlier, such as pharmacists and nurses.

8.2 Object

Specht and Lazio (2006b) note " … we want the RFID system to have the right drugs dispensed to the right patient in the right dosage about the right route at the exact time we have scheduled it for." As they also note, patents' safety is important, but also shorter stays save the hospital money, which is facilitated by the right dosage of medicines at the right time.

As an alternative object, much of the motivation for the system at Jena hospital (Specht and Lazio 2006) was aimed at reducing the errors in medicines administered to patient. However, a focus of the activity design is on making sure that patients don't get the wrong medicine does not ensure that they get all of the medicine that they are required to get. There needs to be reconciliation between those medicines issued and whether or not the patient was administered the medicine.

8.3 Community

If the subject is the patient then truly many different communities are affected, because patients come from many communities. Further, if the subject is the patient, then the patient community is very heterogeneous. Heterogeneous communities are difficult to manage because of the different concerns and objectives of each group. In order to mitigate this as part of the analysis different groups of patients, e.g., by disease, could be made.

8.4 Tools

The integrated design of the activity using RFID (and/or bar-coding) apparently speeds the prescription administration process and works to mitigate errors. Key groups appear to buy-in to the use of RFID. For example, RFID speeds and facilitates the nurses' activities. However, an important concern is the extent to which the tools dominate the process and nurse and pharmacist actions. There should be a concern that over dependence on the technology tools does not override human judgment. For example, mislabeled drugs may be spotted by experienced and knowledgeable human actors.

8.5 Rules

Internal and external work or activity rules for all groups, including the patients must be adhered to. That is why, for example that the design at Jena Hospital did not put any information on the RFID chip, so that privacy of the patient could be protected.

8.6 Division of Labor

The activity of making sure that the patient gets the right medicine at the right time ultimately requires integrated efforts of at least four groups, as seen in figure 5, below. Medicine must be requested, the prescription must be filled, it must be transported from the pharmacy to the intensive care unit, then it must be administered. The technology has been used to facilitate a decomposition of those efforts, through what we have called technology insulation that appears to provide substantial control that results in isolation of potential errors.

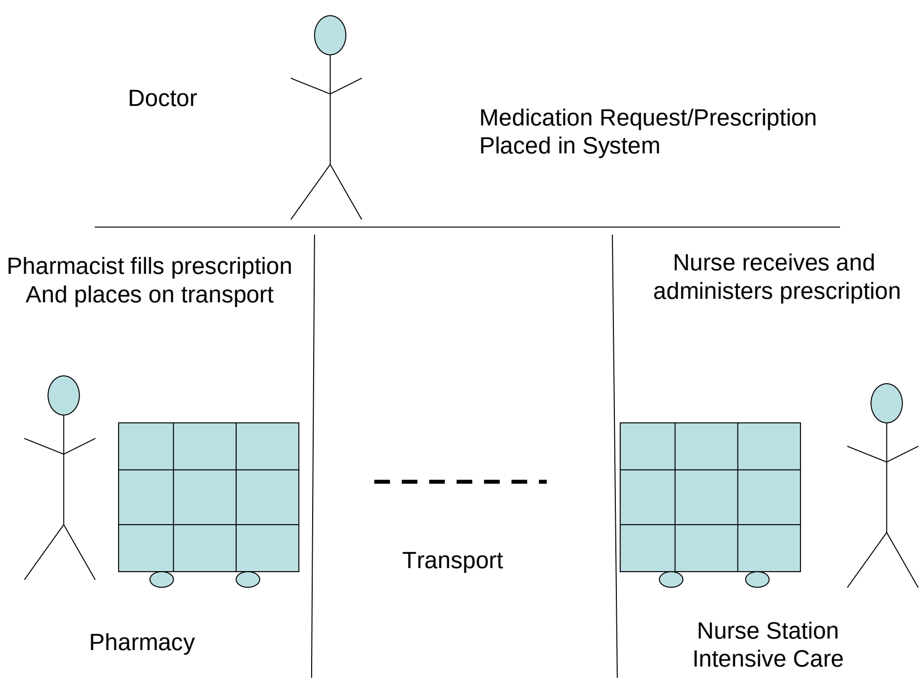

Figure 5 - Borders for Controls

8.7 Outcome

The key performance indicators for the overall process and individual activities are likely to be the number of errors in medication administration, both in time and medicine. However, ironically, unless something goes wrong at the patient level, the existence of medication errors may not be determined.

As seen in figure 5, the approach used by St. Clair Hospital and Jena Hospital appear to decompose activities of medication request generation, filling and enabling transportation of the prescription, transportation, and receiving and administering the prescription into independent activities.

The design of activities used in the entire prescription process provides limited, if any, slack in the system, and provides greater assurance that a specific dosage is administered to a specific patient. A single dose of each medication is generated to meet the individual needs of a patient. If RFID is used then that single dose can only be used for a single patient. Even if bar codes are used, one of the few ways to generate any (medicine) slack in the system would be simply to not give patients their dosage. If the system reconciles prescribed and actual dosages, such discrepancies would be rapidly noticed, particularly if time is built into the administration system. As a result, RFID also is likely to be able to limit misappropriation of the drugs for personal use.

In addition, as noted above, the technology makes each segment virtually independent. We have labeled this as technology insulation, because technology is facilitating insulation or independence of each group of subjects (pharmacists, nurses and doctors). But it is also "digital specificity" since each activity and sub activity now must be executed at a particular time by a particular person to a particular patient.

9. Alignment Between Groups and the Hospital

After information has been gathered for each of the appropriate groups and templates have been developed, then we can examine the extent to which the individual groups and the hospital in aggregate are in alignment/consistent with each other. As we *briefly* examine each of the components it is easy to argue that the groups and the hospital's activities generally are aligned in this case, largely because their objects are consistent.

9.1 Activity

The prescription generation and administration activity is clearly a critical function of meeting the needs of patients, and thus the need for this activity is aligned across groups and with the enterprise. However, quality is needed in each activity leading to the administration of the medicine. Errors by any group will limit the effectiveness of the entire hospital experience by the patient. Building RFID into the process facilitates building quality in and limiting errors and potential for theft.

9.2 Object

The individual objects elicited in this discussion for nurses and pharmacists are consistent with overall hospital, in that by accomplishing their objects, the object of the hospital can be facilitated. As seen in figure 5, the segmentation of the different groups effectively generates digital and actual borders between the groups, accordingly, the individual objects must be consistent with the overall hospital for there to be alignment.

9.3 Community

Communities of each group are but subsets of the hospitals' community. However, it is important to note that the groups are not stand-alone groups independent of the hospital. Further, the resulting heterogeneity between groups ultimately can impact the ability of the hospital to accomplish the overall objective. Diffuse groups are likely to have differential objectives, that may not be aligned.

9.4 Tools

The same set of tools are being used by each of the groups individually, and the hospital as an integrated system. In particular, the prescription is gathered from the doctor straight into the computer and used by the pharmacist and nurse to get the right medicine to the right patient at the right time. RFID is used to gather patient and nurse information to make sure that the appropriate information about the subjects is gathered for the system. Either RFID or bar-coding is used to mark the prescribed medicine. As a result, the tools play an important role in driving the activities.

9.5 Rules

Ultimately, the rules associated with each of the groups must be accounted for by the hospital and aligned with hospital policies. For example, privacy concerns in this case led to not putting any information other than patient identifier information on the RFID tag. As a result, no private information was placed on the tag, and only was available at the server level where the hospital could provide substantial security and not depend on RFID tag security for privacy.

9.6 Division of Labor

As we have seen in this investigation, for this process design, the division of labor appears aligned between the hospital and the individual groups. Each group performs a clearly specified set of activities that clearly provides specified actions that need to be done to accomplish the object. Each groups' activities are relatively independent, yet linked to the next group. For example, if one group introduces errors into the system, those errors are likely to propagate. However, the digital borders can limit errors by specifying activity for the relatively independent group.

10. Conclusion: Summary, Contributions and Extensions

This last section briefly summarizes the paper and its contributions. In addition, it discusses some extensions.

10.1 Summary

This paper started by noting that although there have been a number of proposed uses of RFID in hospitals, that the number of actual implementations has been limited. As a result, there was an interest and a concern in examining an application that appeared to be gathering interest as an implemented application. This paper presented activity theory as a basis to examine the issue, using both before and after a technology activity theory and aggregated – disaggregated activity theory. The paper generated and discussed activity theory templates and context for pharmacists, nurses and the hospital.

The RFID-based approach focuses on getting specific dosages to specific patients at specific times. This investigation found that the RFID-based design of activities lead to very limited slack (medicines) available in the system, since each medicine dosage could only be used for a specific patient. In addition, we also found that the approach lead to a "technology insulation" for each of the groups (doctors, nurses and pharmacists) from each other. We also found that the resulting structure was one that likely generated alignment between the groups and the overall hospital needs, particularly in light of what was labeled as digital specification.

10.2 Contributions

This paper introduced the notion of analyzing the activity theory context, before and after the introduction of a technology, RFID, in a hospital setting. It also illustrated how activity theory might be used to facilitate overall analysis of an activity or set of activities, using before and after a technology activity theory and aggregation – disaggregation activity theory. In addition, the paper illustrated that three key concepts emerged from that analysis: limited slack, technology insulation and digital specification. In addition, the activity theory analysis here generalized the analysis from just the inputs to include consideration of outputs, in this case, patients.

Further, as we analyze the templates and resulting concepts, we might note that it may be too easy to allow the technology to dictate what should be done when. Throughout, the technology-based process does not require that the actors have substantial intuition. This may be good news and bad news. On the one hand, as long as the technology-based solution is appropriate and error-free, the system provides a rapid and high quality solution. However, if errors are introduced at any point in the process then, user intuition and care would be critical to finding any errors or quality difficulties, and the consequences could be severe if such intuition is not used in emergency room prescription systems.

10.3 Extensions

This paper can be extended in a number of directions. Perhaps the most apparent extensions could be the analysis of alternative subjects and their corresponding activities, both before and after the introduction of RFID. For example, those affected by RFID include doctors, administrators, accountants and others. However, the effect is less than those that we have investigated above

In addition, the approach could be used to examine other technologies or other activity theory context variables, such as changes in rules, changes in community, changes in division of labor and other issues.

Further, although we focused on key concepts (slack and technology insulation) we could have also focused on analysis of improving the design. One potential limitation of the designs generated by the hospitals is that potentially there is no reconciliation between the generation of dosages of medicine and whether that medicine was actually used. That is, the focus appears to be making sure that there are no errors for medicines given, but there does not seem to be a focus on making sure that patients get all of their medicines.

In addition, the way the initial design process was laid out did not fully leverage computer-based intelligence over the activity. For example, as the medication leaves the pharmacy in the last step, additional checks can be made to ensure if the medicine is appropriate for the patient and does not interact with other medicines.

Finally, this same approach could be used in other industrial settings where there is a valuable asset that must be handled by a number of homogeneous different groups. For example, this approach might be extended to settings where the assets involved are cash, gold or precious medals.

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