Making Things Work: Dimensions of Configurability as Appropriation Work

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ABSTRACT
In this paper we discuss configurability as a form of appropriation work. We suggest that making technology work requires an awareness of the multiple dimensions of configurability carried out by numerous actors within and outside of the organizations in which new technologies are introduced in efforts to support cooperative work. Through discussion of the introduction of a wireless call system into a hospital, we provide an overview of these dimensions – organisational relations, space and technology relations, connectivity, direct engagement, and configurability as part of technology use and work - and we suggest that in increasingly complex technological and organisational contexts, greater attention will need to be focused on these dimensions of configurability in order to make things work.

Categories and Subcategories
Design, Management, Theory. C.5 COMPUTER SYSTEM IMPLEMENTATION; D.2.10 Design; K.6 MANAGEMENT OF COMPUTING AND INFORMATION SYSTEMS; K.6.1 Project and People Management; *Systems analysis and design;* K.6.3 Software Management (D.2.9) *Software development*.

General Terms
Design, Experimentation, Human Factors, Theory.

Keywords
Appropriation work, configurability, organization, health care, work practice, physical environment, cooperative work.

1. INTRODUCTION
Our intention in this paper is to advance discussions about configuration work, which we address here in relation to system configurability. We look at system configuration as embedded in larger contexts of organizations and the physical environment. Hence, configuration is not only a set of processes involving the technical environment, but also organisational relations, space-technology relations, as well as people's connections to other people, to other places, and work materials.

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We develop this perspective by looking at a relatively simple technology – a wireless call system. Making this technology work required interventions in the organisational and physical environment, many of which had not been thought out in advance and were not necessarily well planned or aligned. This brought us to think about configurability as not always and primarily requiring changes of the technology itself but of the environment in which it is embedded. An additional motivation for this perspective is that "computing environments in the future will be populated by a rich and diverse set of devices and networks, many of them integrated with the physical landscape of space and artifacts." [7]

We start by briefly introducing the concept of appropriation work and provide an overview of configurability, which we discuss in relation to the notions of customizability [2] and tailorability [29]. We then introduce the wireless call system case, showing how making the system work required actors to engage in configuring several dimensions of the environment. We introduce the notion of configurability support, which stresses issues such as transparency, accountability, and 'smooth flow of work' [9]. By examining varied activities that constitute aspects of configurability (such as fitting an application to a particular setting, getting an integrated system to work, and so forth), more nuanced dimensions of appropriation work are rendered visible. We suggest that as systems become increasingly complex, the likelihood that they will be used successfully will increase if, during design processes, attention is directed towards the organisational and spatial dimensions of system configuration, and the activities that constitute these dimensions. We conclude by looking at configurability as cooperative work.

2. BACKGROUND
In the 90s there was a marked interest in the tailorability of systems [12, 20, 32, 31]. Researchers started looking at people in companies who worked as 'user-designers', customizing software to the needs of users, and at end-user programming. Trigg and Bødker [29] in their study of tailoring at the workplace (tinkering, translating, gardening, as it is called by others [20]) identified a wide variety of tailoring skills: from building/modifying buttons, to writing macros, to programming on the PC, manipulating otherwise 'invisible' codes. On the one hand, the work of tailoring was seen as 'construction work', with the aim to adapt off-the-shelf software to an increasing variety of use patterns. On the other hand Trigg and Bødker identified bounded variety within a company as a goal of tailoring. Much of the tailoring work they observed had to do with defining, sharing, and distributing 'standards' (forms, macros) within the organization.

The interest in tailoring has continued and has been closely connected to the notion of appropriation work. Pipek [24] describes appropriation as a collaborative effort of end users to make sense of software artefacts in their work context. Besides activities undertaken to configure the software to fit into the technological, organisational and individual work context of the users ('tailoring'), there is a larger area of technology-related communication, demonstration and negotiation activities aimed at establishing a shared understanding of how a software artefact works and what it can contribute to the shared work context. The mutual shaping of the technology and organisational contexts resemble an ongoing design process that end users perform largely without any involvement of professional developers.

Another term that is often used is *customisation*. It denotes activities that are necessary to make a device or system function in a particular environment, down to very small details that matter to users. Many systems are designed for a certain degree of customization, offering specific features [2]. Dourish [11, p. 1] sees appropriation as similar to customisation, but as "concerning the adoption patterns of technology and the transformation of practice at a deeper level" .

Many authors stress the social nature of this process. For example, Ackerman et al. [1] argue that for users to appropriate technology they must both understand its capabilities and have scaffolding mechanisms for collectively discovering, structuring, iterating, and promulgating practices that enable the technology to become a 'resource'. Nardi and Miller [21] stress the sharing of customizations and modifications.

Recently, this discussion has gained an additional dimension, reflecting increasing numbers of devices in our everyday environment and fuelled by the development of the attendant notion of ubiquitous computing. Central to this discussion is the fact that technology today is increasingly being introduced in a 'piecemeal fashion'. The question then is how to support users not only in tailoring one specific piece of software but to enable them to accomplish different combinations of artefacts and media, from mobile phones to TV-sets, projectors to microwave ovens. Newman *et al* [22, p. 148] argue "that systems should inherently support the ability of users to assemble available resources to handle their tasks. In a world of richly embedded and inter-connectable technologies, there will *always* be particular combinations of functionality for which no application has been expressly written." They introduce the term 'recombinant computing,' which builds on tools (protocols and techniques) and interfaces for making components interoperable.

The studies of appropriation work in its different forms focus on "users making sense of technology and making it relevant to the practical circumstances of *their* everyday lives" [26]. Appropriation work in this reading is about users actively integrating technology into their actions, reinterpreting or even modifying/tailoring it; and it is strongly connected to the notion of unforeseen or unanticipated use. For example, Henderson and Kyng [14] distinguish between different degrees of appropriation that require different levels of expertise regarding the supporting technology - choosing between predefined alternatives, constructing new artefacts from existing pieces, and reprogramming the artefact. Eglash [13] defines a continuum of tailoring or customising activities, ranging from reinterpretation to adaptation and reinvention. In much of what has been written to date about appropriation work, the focus of attention is on the technology and those of its features that enable users to adopt and adapt it, fitting it into their working practices. There is an architectural perspective which looks at the flexibility of software systems or artefacts as an enabling key feature; and there is a user interface perspective which asks how to develop tailoring environments that provide users with simple enough concepts and interfaces.

Our research seeks to enrich these perspectives by looking at the broad range of things that need to be "reconfigured, repurposed, and incorporated" [11] when users appropriate a technology into their work practices; it extends discussions about continuing 'design in use'. This not only involves redesigning aspects of the technology but requires reconfiguring organisational relations, work materials, as well as aspects of the physical environment. Hence, we are less interested in understanding how to support configurability through attributes of the technologies themselves then we are in supporting configurability - and hence cooperative work - by focusing on how people make the technologies work within a particular social and physical context.

3. DIMENSIONS OF CONFIGURABILITY

In earlier work we discussed two different but complementary cases – the *mixed media case* (architectural design work) and the *wireless call system case* (hospital work) – and it is through their juxtaposition that we arrived at a perspective on configurability which takes account of the environment in which technologies are placed as a whole [5]. When we briefly refer to the *mixed media case* here, which has been described elsewhere [7], it is to clarify relevant aspects of the history of our concepts, some of which were directly inspired from observing how students of architecture constantly configured and reconfigured their environment of space, artefacts, and media. This enriched our understanding of configuring as an activity required to make technologies work in the *wireless call system case* in a Canadian hospital, which we will analyse in this paper in detail.

The first three of the dimensions of configurability we identified – configurability of organizational relations, of space and technology relations, and of connectivity – have to do with aspects of the environment into which technologies are appropriated. The other two dimensions – configuring as direct engagement and configuring as part of technology use/work – capture salient aspects of *configurability support*. This echoes Pipek's notion of *appropriation support*, which he sees as an essential perspective based on "a new understanding of the collaborative dimension of tailoring along the ties that motivate or enforce user collaboration in tailoring activities" [24, p. 87],.

Configurability of organizational relations: We see configurability as being intricately linked to the fact that in an evolving environment the boundaries of activities are continuously moving. Often the decision to use new technologies in a particular work setting is undertaken specifically to serve as a catalyst for altering or re-configuring work practices. While this fact may be purposely built into learning situations (such as in the architectural students case), it may be ignored, hence poorly supported, in other cases (such as the wireless call system case). Local adaptation and configuration may be at odds with core organizational requirements. Hierarchical organizational relations and the multiplicity of stakeholders may deter configurability. Our conclusion from this was that *configuring organizational*

relations is an important resource in supporting highly configurable technologies.

Configurability of space and technology relations: Rodden *et al* [26] discuss configurability in relation to two organisational features of interaction: placement – how to take account of the local spatial organization of activities; and assembly – how to facilitate the configuration and reconfiguration of artefacts and media. Different tasks may require different spatial set-ups – people may need to be able to configure their workspace and the equipment they need with ease (this has implications for the design of the space and the artefacts that populate it). Different tasks may require different configurations of hardware and software, input and output devices, and so forth. For example, we observed how being able to configure a work environment for a diversity of uses - from solitary work to group discussions, performing, presenting, and building models - forms an integral part of design work [7].

Configurability of connectivity (of people, places, materials): Configurability also is to do with the possibility for people to arrange and re-arrange their connections to other people and to particular places, taking account for example of a varying spatial organization of activities or of changing patterns of availability. Often technologies are introduced to reduce time and space constraints in a complex organisational environment, and in doing so, to improve connectivity of people in varied locations to one another. Configurability also may refer to a capacity for assembling and re-assembling work materials (e.g. patient information) so as to shift perspective, gain a particular point of view, support specific activities, and so forth.

Configuring as direct engagement: Configurability is closely connected to issues of transparency and accountability. In the *mixed media case*, architectural students' direct, bodily engagement with artefacts turned configuring into a (publicly) visible, and hence accountable, activity. The fact that they used barcode technology as a single interaction mechanism rendered their activities easy to understand and transparent. We also could see that the potential of physical interfaces (in this case barcodes on posters, models, and other parts of the physical environment) reach beyond 'mere embodiment'. They provide people with the means for producing configurations that change spatiality, interactivity, and physical landscape in ways that can be shared with others.

Configuring as part of technology use/work: Providing organisational resources for configuring as part of everyday work practice is another challenge. In some work environments, such as the architectural design class, configuring is part of the pedagogy, with students being asked to continuously transform and 're-program' familiar settings. *Configuring* was encouraged, and was hardly distinguishable from proper *use*. In other work environments configuring requires additional work, may require interventions by specialized personnel, may be disruptive of the flow of work, may result in break-downs, and so forth.

4. THE WIRELESS CALL SYSTEM

We illustrate aspects of configurability here in relation to the introduction of a wireless call system in a hospital. Fieldwork for the hospital wireless call system case began in the spring of 2003, when a new building opened at a large Canadian Hospital [3]. A new call (or paging) system was introduced that could be configured to work with a range of devices, from intravenous pumps to electronically equipped beds. Initial plans called for the introduction of a wireless call system at the time the new building opened, however a decision to delay introduction was made amidst the many other changes that were introduced at that time.

Our initial period of fieldwork included a period of intensive field data collection in 2003 during which time we observed the initial introduction of the new call system. Subsequent periodic observations occurred throughout 2004. When plans were announced to pilot test a wireless implementation of the call system late in 2004, researchers assumed an active role that included helping plan the pilot while simultaneously collecting data and supporting the implementation of the wireless call system field test, which began in March 2005 [5]. Following intense data collection that began with planning the pilot implementation in January 2005, regular data collection continued through May 2005, with subsequent periodic visits to the field.

The wireless call system is made up of a combination of telephone console, coloured lights, wireless phones, and 'alarms' that can be triggered in different places (patient bed, bathroom, and so forth), or can be connected to different devices, such as beds or intravenous pumps. It was hoped that the wireless handsets would help quiet the ward by replacing audible alarms that all could hear with alarm calls heard only by staff. The system (in principle) supports varying physical landscapes of alarms and displays, which, if connected with the wireless mobile phone system, can be accessed from any place on the unit.

Figure 1: Telephone console

4.1 Planning

Space on the hospital unit needed to be reconfigured in order to support the use of the wireless call system. When the building opened, a place had to be designated for the main phone console to sit. It had to be both near a telephone line and accessible to staff so they could answer and shut off alarms. When the wireless handsets were introduced, staff also had to be able to access the phone console at the beginning of shifts to program their phones.

A place for storing the wireless devices when they were not in use needed to be created, as well as a place for charging handset batteries. These tasks required the cooperation of building maintenance staff who had to mount storage bins for the phones on a hallway wall, chosen because it was both near the unit's team base, and was in a staff (and hence less public) area of the unit (where the handsets would be less prone to theft). The wireless handsets posed other challenges in terms of the local spatial organisation of activities and placement. For example, the staff had to have a convenient way to carry the wireless handsets around the unit. The handsets were larger than cellular phones,

and would not easily fit into pockets. A decision to give staff shoulder bags for the phones was met with resistance by some staff because this solution drew attention to body parts (large stomachs, breasts) some preferred not to emphasize.

The location of the wireless handsets also presented challenges in cases where a staff member had to enter a room where a patient had an MRSA precaution (an antibiotic resistant infection that could be easily spread). Normally staff entering rooms with an MRSA precaution "double gown" - they cover themselves completely (with a head cover, gown and pants over whatever they are wearing, gloves, etc.) prior to entering an MRSA room, and they remove this second set of clothes immediately upon exiting from the patient's room, and deposit the second set of clothes in a hamper just outside the room. Staff were unsure about whether they should leave the handsets in the hallway when they entered an MRSA room, or take the handsets into the room and clean them afterwards. It was eventually determined that the phones should be left outside the room, or certainly not answered while a staff member was tending to an MRSA patient.

Placement of the wireless handsets within the designated storage location visibly reflected some of the decisions that were made about how the new wireless call system would be used. Handsets to be used by patient care aides (PCAs) (orderlies) were set aside from those used by nurses, because the different jobs performed by the two groups required different handset programming.

4.2 Implementation

Among the reasons that the wireless handsets were introduced was to reduce the amount of time staff spent looking for other staff when calls came in. In the absence of the wireless call system, nursing staff and doctors often were waiting for information (lab results, x-ray results, a call from a specialist). Often when the call came in, the staff member for whom the call was intended could not be easily located (for example, because the staff member might be in any of their patient's rooms, a supply area, etc.). The wireless call system made it possible to reconfigure the ways that people were connected to one another within the organization (e.g., clerical staff would not have to leave their desks to locate staff; staff would engage in less "telephone tag") and between the hospital and world beyond the hospital.

Numerous decisions needed to be made about how the system would be set up - a task that was hampered by a lack of documentation about what was possible. The process of customising the wireless call system involved getting both individual components of the system to work (the paging system and the wireless local area network), and getting each of the components to work effectively as part of the larger system. Most of this work had to be carried out by technicians. Decisions made initially during component set up sometimes needed to be altered when individual components were brought into an integrated network. Recognizing this, the project group convened to implement the wireless call system included staff from the hospital's voice services department (who managed the wired phone system), the information management and information systems department (who were responsible for the implementation overall, as well as design and implementation of the wireless network), representatives from the unit such as the unit manager, some nursing staff, and a representative from the practice group.

At the beginning of each work shift each staff member had to configure the handset they would use for the day. This entailed linking the rooms/beds they had been assigned to to the handset they would carry for the day (if they were nurses), and determining which staff member would serve as their backup for calls that went unanswered during breaks and busy times. There was resistance among some staff members to deciding who would serve as backup for breaks at the beginning of each shift, because prior to the introduction of the wireless handsets, negotiations about backup coverage during breaks had occurred in the moment. Hence the wireless handsets in a sense interrupted the ways that staff members were accustomed to interacting with one another.

At the end of each shift, staff had to clear their room assignments from the phone at the console, remove the batteries from the phone and place them in the battery charger, and place charged batteries in the phone for the next shift. Finally, they had to wipe down the phone and return it to its storage location for use by the next shift.

On the first day of the pilot one of the nurses signed out her telephone and turned it on. Immediately it began ringing. The display showed a room number to which the phone had not been assigned. The call was cancelled but the phone continued to receive these phantom calls throughout the day. Over the next few days this happened several times to other staff. We listened to complaints, noted the time, phone, and room numbers involved, and double-checked that phones were correctly assigned on the console at the nursing base. The phantom calls were not taken very seriously by the vendor representative who said they would probably disappear again, but eventually he was forced to check the system's software logs. He found an error in the configuration which made the system attempt to call the phones up to one hundred times if calls had been forwarded to a handset while it was turned off (as happened frequently when staff took breaks).

Three weeks into the pilot, the phones suddenly stopped working during a night shift. Recognizing the problem, staff divested of the phones and returned to old work routines, relying on the older call system. The problem turned out to reside in an interface unit which connected the application server to the wireless phones. While preparing for the pilot, the vendor had used a demo version of the software for this interface, which he had inadvertently left when the pilot went live. When the software license for the demo expired after precisely one month of use, the phones lost their Ethernet connection. As the Patient Services Manager (PSM, or head nurse) said: "Good thing we kept the old system in place."

4.3 Support

The vendor representative, who was knowledgeable about the telephones, was in charge of the training sessions, and staff in the hospital's voice services department configured the phones, which consisted of programming a number of features (such as how long a phone went unanswered before the call was transferred to a backup) and assigning various functions to specific keys. Several keys and displays were available which could be assigned functionality, but not all keys were used in the configuration chosen, and the vendor was not entirely sure what certain keys did. During training, staff learned little about the telephone consoles or handsets that went beyond the repeated instructions to remember to complete the "staff sign-on" procedure at the beginning of the shift. Although the vendor emphasized that the

wireless phones were "precisely the same as before" in terms of functions, their use in practice turned out to be confusing.

From the beginning, the vendor indicated that the system was quite flexible and could be configured to suit the preferences of the ward. However, referring to the configurable options early in the planning process the PSM commented that "we don't know what we don't know yet". The system manual reflected the narrow focus of the training sessions in its limited presentation of the possibilities for configuration. It contained only a minimal description of a subset of the functionality with which the system was equipped. Like the training sessions, the manual did not convey to users the range of possibilities for configurability of the phones or of the paging system. To make good use of the configurable options it was necessary to have some knowledge about the system's properties and configuration options. The PSM's comment suggested that staff on the ward did not have such knowledge and perhaps did not even want it.

On the one hand staff had little patience with technical detail and just wanted something that 'worked'. Indeed, staff visibly tuned out when any technical information was offered. To deal with this problem the manual (created by the PSM and voice services staff mainly by cutting and pasting excerpts from manuals that had been written by users at other facilities) offered only a bare minimum of information. This complexity reduction strategy seemed sensible since a detailed manual was unlikely to be consulted - even the short and simple manual was never opened during our observations (although it could have been helpful on plenty of occasions). Had staff consulted the short manual more often, the limited information about system options it contained would have limited the possibilities for effectively configuring the system to suit the needs of the ward, and deterred staff from grasping the potential of the system.

In spite of the vendor's insistence that the wireless phones were identical to the older nurse call system, staff clearly did not understand in which sense the old and new systems were the same. Staff failed to recognize the supposedly well-known functions from the older system because that system had never been used as the vendor or the IT-department expected it would be. They had envisioned the system as a tool for improving communication between staff and patients, because it allowed staff to respond to patient calls directly via the handset, which it was hoped would eliminate delays while staff were located to take calls. However, in practice, staff generally responded to patient calls by turning off the alarms via either the console or handsets, and going to the patient's room, rather than responding via the phone. In practice the call system was used only as an alarm, rather than as an intercom system as had been anticipated.

On the ward, nobody seemed to know why the call system had originally been configured with just the kinds of alarms that were in use, and that staff did not realize the configuration could have been otherwise. This became apparent through discussions about the 'bed-out' alarm, which was probably the most frequently heard alarm on the ward. It was activated each time a bed was unplugged from the wall, for example because the patient was being moved in their bed to another part of the hospital, or because bed sheets were being changed. Since the original nursing call system was installed with this feature activated, the stoic response was to quickly shut the alarm off each time it rang. Although nobody on the ward knew why the alarm was there in the first place it was taken as a small nuisance to be dealt with, rather than a potential reason to query about other options for configuration. After two years of rushing to turn off the bed-out alarms each time they sounded, staff were exhilarated to realize that this alarm could be configured so that it did not ring through the wireless handsets.

5. CONFIGURATION AS A RECIPROCAL RELATIONSHIP

Our case illustrates the different dimensions of configurability we have outlined. Furthermore, it shows how the activity of configuring engages a reciprocal relationship, between the technology that has to be made to work and organisational as well as spatial relations. Technology contributes to the configuration of work and the organization, and organizational relations are also a requisite to successful configuration of the technology.

Configurability of organisational relations: The wireless call system case involved mainly intraorganisational relations (although configuring may also affect relations between organisations). It highlights how a relatively simple technology requires what in ANT (Actor Network Theory, for example [10]) is called an alignment of multiple heterogeneous actors, from maintenance personnel, voice services and information management and systems to management staff at the unit level, and workers. Standardising a call system across organisations would explode the density and complexity of those relationships.

One of the intentions for introducing the wireless call system was to alter organizational relations (e.g., improving nurses' responsiveness to patient needs). Ironically, the complexity of

- the technological environment - the elements of the call system that were in the walls such as plugs for devices (e.g. beds), and wires to carry the signals those devices generated, the connection of that infrastructure to a local area network, as well as a hospital wide phone system and a wireless computer network
- the organisational and actor networks required to support the system - vendors, the IT and voice services department, end users with little time to learn complex new systems, etc.
- the web of social relations that brought all those parties together

constrained possibilities for system configurability. Only as the pilot progressed, did the implementation team increasingly make the roles that various groups needed to play in order to support the system explicit.

We can also see the element of reciprocity here. The way the technology reconfigured organisational relations was clearly dependent on those relations. For example, the wireless call system was introduced to reduce the amount of time staff spent locating other staff. This also required the organisation to clarify whom to call in case of technical problems (e.g., the IT department or the voice services department); and creating transparency about accountability was clearly a prerequisite for the system to be integrated.

Configurability of space and technology relations: We can look at the interplay between space, objects, and human actors as assemblies of temporary and short-term events which emerge through ongoing practice, and are perceived as shared experience

by the actors within the practice [18]. So what constitutes place is a complex totality of social engagement with other people, use of artefacts, information, and lived experience. The wireless call system was introduced with an intention of altering space and technology relations. Place is experienced space, and we can see this clearly in the fact that nursing staff did not take advantage of all aspects of the time-space compression – spatialisation [19] – the wireless call system offered to them. Staff neglected to use the wireless system feature that allowed them to turn off alarms remotely and communicate with patients via the handsets, and instead they turned off alarms (via either the handsets or main console) and went to patients' rooms to interact with them. Although we remain uncertain about exactly why nurses seldom responded to patient calls via the handsets, we do know that patient contact and visual assessment are important aspects of nursing care, which are not supported as effectively via telephone as they are in person. Though the wireless handsets accommodated time-space compression, the practice this afforded interrupted place based activities (such as visually assessing patient status). This example suggests that place—understood here as experienced space—should play a significant role in the configurability of space and technology relations.

We can also see how the physicality of the place affected the placement of the main phone console, of the wireless handsets, battery chargers, and so forth. The placement of devices not only took into account the local spatial organization of activities (e.g., the chosen storage location was away from the public area of the unit), but also reflected the social relations of those activities (the difference in the nurses' and care aides' jobs, which necessitated that their handsets be programmed differently, and that they be set apart from one another spatially).

In fact, the particular u-shape of the new hospital building played a role in determining on which unit the wireless call system was pilot tested. This particular unit was chosen for the pilot because shortly after moving into the new building they had introduced walkie-talkies to help overcome the inability to maintain visual contact due to the physical layout of the ward. Also, as staff could not see from which wing an audible alarm was coming, an auxiliary visual alarm system had to be installed.

Configurability of connectivity: As we saw, the wireless call system was intended to reduce time and space constraints associated with care delivery in a complex team environment, and in doing so, to improve connectivity - of patients to staff, and staff in varied locations to one another. Part of what the system did was to alter the role played by the unit clerks who no longer had to physically leave their desks in search of staff when a call came in. Rather they could transfer calls to the wireless handsets. In addition, the wireless handsets made it possible for staff to contact other staff members, for example a nurse could request assistance from a patient care aid without having to go to a central location to use a pager. This suggests that reconfiguring connectivity also alters movement in space.

We already pointed out that the wireless system made it possible for patients to page the nurse assigned to their room, thereby providing a direct spatial link from bed to the location of the nurse, but that nursing staff seldom responded via the wireless handsets. Put simply, space matters, and in some cases, proximity is an important aspect of work and technological substitutes for proximity may not be appropriate. Although configuring connectivity in certain ways may be possible technically, a failure to recognize the significance of place in work practices may mean that envisioned configurations of connectivity are not realised in practice. Similarly, new configurations of connectivity may emerge as a result of technical possibilities.

Another interesting example of how the wireless call system supported the configuration of connectivity was evident in staff interactions with patients who desired increased connectivity with friends and family. Although staff were not supposed to let patients use their wireless handsets to make calls, staff frequently allowed patients to use the wireless handsets as wireless phones to call outside of the hospital, perhaps lessening the burden on staff of patient complaints that few pay phones existed in the new hospital building, where use of cellular phones is also banned.

On the one hand, the wireless call system supported new patterns of connectivity on the unit (e.g., between staff in different parts of the hospital, between patients and their families). On the other hand, although the connectivity feature between bed and nurse had been designed, a lack of reciprocity when the initial call system was introduced – the call system lacked a project champion at the time of its introduction because it was seen as similar to the existing system and was also embedded into the walls – resulted in a failure to utilize this feature as intended.

6. THE NEED FOR CONFIGURABILITY SUPPORT

In addition to those activities that are required to spatially accommodate new devices in a particular environment, to make them work on a day to day level (e.g., programming the handsets prior to shifts), getting individual components of a system (such as the paging system) to work, and getting those components to work as part of an integrated system, other activities such as direct engagement of users, and the possibility to engage in configuring as part of ongoing work (without having to interrupt the work, having to call for help, and so forth) are also important, and can be thought of as a form of configurability support.

Configuring as direct engagement – transparency and accountability: Designing environments so that users can develop an understanding of their choices, receive feedback about the implications of their interactions with the system, and so that their actions are available and understandable to others, is a huge task. In physical space, bodies and artefacts are put into relations that are meaningful in themselves and suggest particular interactions. Our direct engagement with artefacts and the direct feedback provided by their features become part of the shared resources for coordination and expression in cooperative work arrangements [e.g.15 and 25]. Hence, direct, bodily engagement with artefacts may help make configuring a (publicly) visible, and hence accountable activity. The wireless call system implementation provides an illustration of why accountability and transparency are important elements of direct engagement of end users in configuration activities. The call system lacked transparency from the onset. Staff who had been working with the call system prior to the wireless pilot were often confused about which lights meant what, and a lack of bodily engagement with the call system prior to the wireless implementation likely contributed to a lack of bodily engagement once the wireless pilot was underway. Possibilities for configuration of the wireless call system were shrouded in a lack of transparency about the range of configurable

features. As the wireless system was introduced, its configuration was made identical to the pre-existing call system in order to ease the transition, although nobody knew why it looked like it did in the first place, or whether the way it had initially been implemented was useful. One can point to a lack of transparency about the technical part of the system. Thus there were poor manuals that documented only some system features, and the IT department, telecom services and the vendor were each only familiar with a limited set of the configurable attributes of the system. But the problem of opacity relates just as much to the organizational side of the equation, as neither vendor nor hospital representatives had any idea about how the original call system had been used in practice. The simultaneous technical and organisational opacity left the envisioned magic of the wireless call system unrealised.

Configuring as part of technology use/ ongoing work: Although in some contexts, such as the mixed media case [5] configuring is part of ongoing work, our analysis of the wireless case suggests that it may not only be an important feature of making technology work. as in many cases it has to be considered a prerequisite set of activities required to make technology work. What is often called ready at-handness [16] or smooth performance of work [17] may be evidence that successful configuration at multiple levels has occurred. This has partly been argued by Dourish [11] who maintains customization to be a feature of all collaborative work practice, as the features of setting and artefacts around which work practices are organised are constantly reconfigured. We can see that this is not the case in our example where configuring and reconfiguring is not an integral part of the flow of work. In contrast, the wireless call system example illustrates that configuration activities occur not only within the work group for whom a system is designed but also requires the alignment of other actors that are often off-stage. Hence, configuring always requires additional conscious effort that reaches beyond the immediate users of the technology. As technologies become both more complex and more disruptive – less continuous with preexisting technological systems and more inclusive of other people, places and organisations – successful use of technologies will in all likelihood need greater attention to aspects of configurability that go beyond the intended user group. Hence, we end our discussion by suggesting that a further disaggregating of the notion of configurability will improve 'design in use'.

Our work suggests that there is a need to further unravel different levels of configuration and the contexts in which configuration takes place. Configuration is influenced by both technologies and work contexts, each of which have affordances and constraints. The nature of the work undertaken may influence the extent to which work practices can be altered (e.g., design work can be altered considerably, while hospital work may not be). Options for configuring systems differ and reflect affordances and constraints of both the technologies and the social organization of work.

7. FURTHER DISAGGREGATING CONFIGURABILITY

Configuring the wireless call system occurred within a complex organization and it involved different internal stakeholders as well as external stakeholders (e.g., the system vendor). It may involve different levels – technical (system, component, device) and organizational (ward, IT department) units and so forth - and happen at different stages of the system development and implementation process. Each type of configuring requires a specific set of skills, depending on the activity and attention to different resources necessary to successfully carry out configuration in relation to each particular type or dimension of configuration. The main argument is that configuring is never simply just one rather self-contained thing but involves different levels, either simultaneously or consecutively, with each of these levels involving organisational, spatial and/or connectivity issues.

- *Placement* - configuring takes account of the local spatial organization of activities (described in detail above).
- *Assembly – configuring artefacts and media*: This is an activity that takes place as part of ongoing work but requires some preparation. At the beginning of each work shift each staff member had to configure the handset they would use for the day. This entailed linking the rooms/beds they had been assigned to to the handset they would carry for the day, and determining which staff member would serve as their backup for calls that went unanswered during breaks and busy times.
- *Appropriation in the use context*: Customizing the length of time the wireless handset rings before going to the backup nurse is an example of a restricted set of features to be adjusted by end users; another one would be varying the colour of different types of alarms (associated with the patient bed, the patient's body, the bathroom, and so forth). This may happen from time to time to adjust for changes of work practice, staffing level and so forth. In the hierarchical environment of the hospital unit, engagement in this level of customisation was restricted to management staff, who sought input from representative users. Enacting this particular feature required that a vendor representative alter software, and, although this work could have theoretically been undertaken by hospital staff, in the case we observed it remained under the control of the vendor.
- *Fitting the application to a particular setting*: Customising the sign-on and sign-off process to different devices (the unit's computer, its wireless phone system console). This is an activity that takes place at implementation, involving the vendor, technical staff and users. It usually requires some programming (tailoring). In an environment where each implementation integrates a slightly different constellation of devices together with the specifics of what is actually possible in a given setting determined by a myriad of factors, little or no documentation may exist about the exact scope of customisation that is possible.
- *Getting a component system to work as part of an integrated system*: Setting up the phone consoles at the unit desks and setting up the wireless LAN. This is part of the initial equipment set up or modification required as multiple components are integrated. Most of this work would be carried out by technicians. Decisions made during component set up may need to be altered when individual components are brought into an integrated network.
- *Getting an integrated system to work*: An example would be getting the wireless network on the ward to interface with the wired phone system. This happens at the pre-pilot or pre-implementation level, with technicians, IT staff and gatekeepers for component systems solving the complexity or messiness of particular implementations.

- *Creating a sustainable structure for implementation, use and configurability*: Integrating technological components in new ways can pose challenges to existing roles, and can both alter and introduce new patterns of responsibility and accountability. This included clarifying who followed up with problems related to batteries; and defining responsibilities as well as options for staff in case of problems and breakdowns in the wireless call system case. The examples of phantom calls and the call system breakdown related to an expired software license illustrate the need for sustainable structures for implementation, use and configurability. The resolution of both problems required assigning responsibilities and accountabilities amongst distributed and heterogeneous actor-networks, and communicating such accountabilities to staff. A failure to create sustainable structures for implementation, use and configurability can lead to poor uptake or rejection of a technically feasible system.

The dimensions and levels of configurability described so far are interconnected and can be thought of as occurring within multiple, interconnected, domains, which we have tried to visualize in Figure 2. As we suggested in the beginning of the paper, most discussion about appropriation work, (other than Ackerman et al. [1] which refers to social scaffolding or Orlikowski [23] who deals with the organisational domain), centers on the technical dimensions of configurability as well as the user and use domain. Our disaggregation of the multiple dimensions of configurability locates each aspect of configurability in a complex web of interdependencies, all of which must be aligned to configure connectivity, often the central focus of computer-supported cooperative work systems.

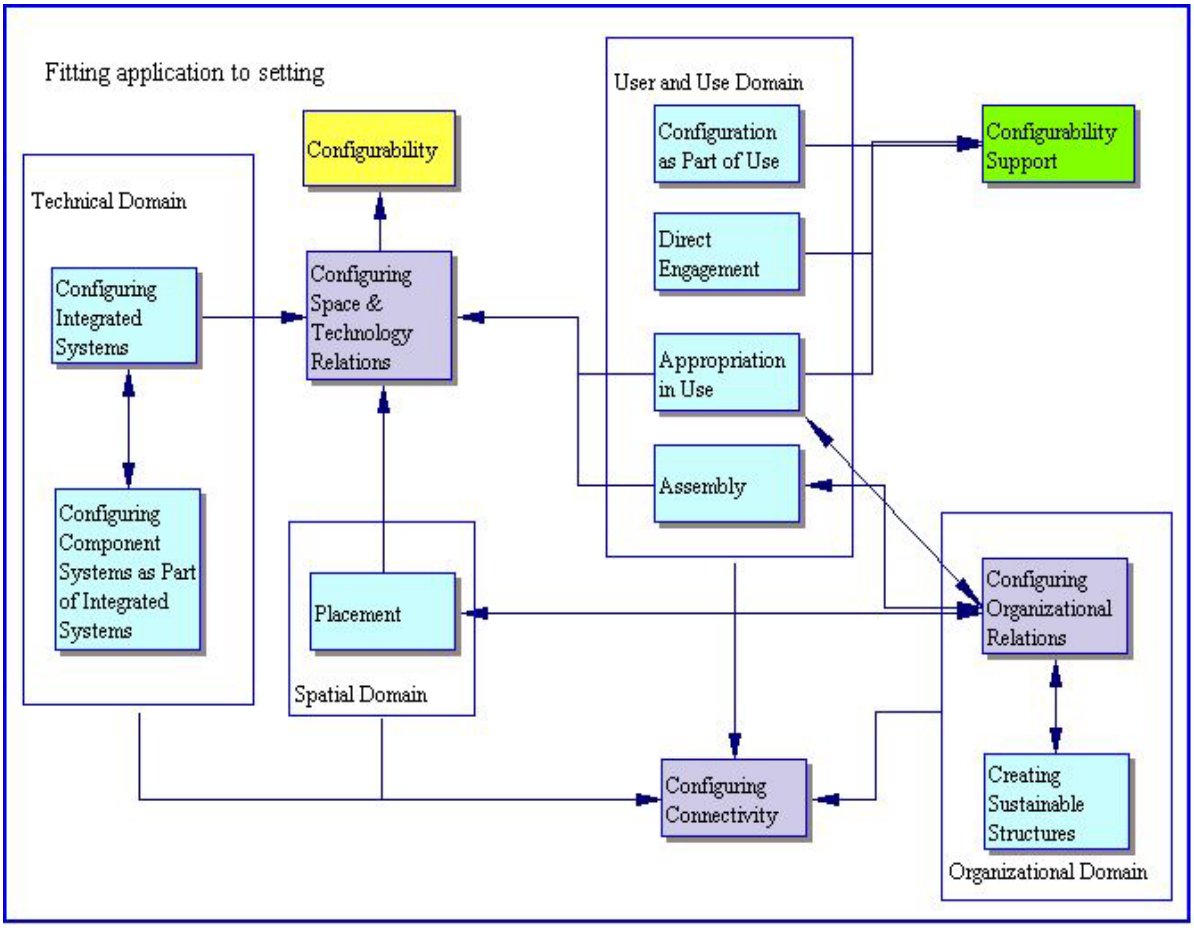

Figure 2: Dimensions and domains of configurability

8. CONFIGURING AS A COOPERATIVE ACTIVITY

Configuring systems to work together and offer users a seamless use experience requires that configuration occur on numerous levels, outlined above. Each type of configuration involves different constellations of actors who come together in different groupings, governed perhaps by different interactional norms or relations, which must be addressed or accounted for in efforts to sustain highly configurable systems.

The social and organisational aspects of technology appropriation have been addressed by many CSCW researchers. Orlikowski's work [23], among the most influential, looked at the appropriation of Lotus Notes, arguing that technologies may offer options to improve work processes that have not been foreseen. Bower *et al.*'s study of workflow systems [9] uncovered a range of social and organisational issues that need to be taken into account when a technology is introduced. Wulf and Mark [33] show how new organisational conventions are developed as a consequence of a technology introduction. In all these studies the focus is on the

way in which the technology can be mapped onto user needs and on flexibility as a much needed feature of it. Our case is about altering the social context rather than the technology itself. This is not because the wireless call system is inflexible but because attention to social detail is required to support its flexible attributes. Configuring these social details is much more critical to the functioning of the technology than configuring the system itself. It is almost a prerequisite to configuring the technology and making it work in the social context of the hospital.

Our study stresses the relevance of the physical environment for making the technology work. Space matters, and in several ways. Much of CSCW research is dedicated to how to support spatially distributed work but less to how space-technology relations have to be designed in order to make this happen, with a few exceptions. Bardram and Bossen talk about mobility work in hospitals and the need of "the achievement of the right configuration of people, resources, knowledge and place" [6, p. 137]. Our case stresses placement issues – where the different parts that make up the technology are located, their physical at-handness. It shows how the loss of visual relations in the building [28] may impact both work practice and the technological configuration, and draws our attention to the fact that time-space compression is not always a good substitute for proximity.

Dourish [11] sees customization as a characteristic of all cooperative work, because the features of the setting and the artefacts around which working practice is organised are continually "reconfigured, repurposed and incorporated into the way in which those practices develop" (p. 2). While this is true at one level – and smooth integration of the wireless call system into everyday work practices may be an example to the point - more conscious and deliberate activities are required to make a technology work within an organisational and/or work context. This is to do with two features of the hospital environment which have been stressed by Schmidt [27] – complexity and the distribution of control. Schmidt has argued that "the relevant perspective from which to analyze the complexity of cooperative work is not something which can only be determined arbitrarily or subjectively … is a researchable issue: what is the relevant perspective, the relevant level of abstraction, etc. to a competent actor 'in the natural attitude' of a given line of action has to be determined empirically" [27, p. 350]. In fact the complexity that needs to be considered in the wireless call system case is far greater than the simple technology would let us assume. It is a nice illustration of the complexity of cooperative work. Connectivity may be and often is a primary goal of computer support but as our case shows its achievement is contingent upon other dimensions of configuration, like placement and assembly, appropriation in use, integrating the system, and so forth.

Acknowledging the systemic character of the wireless call system and the social context in which it is embedded is a prerequisite to successful configuration work. This can be seen in the case of the phantom calls where the level of technical complexity (in terms of components involved) and of social complexity (in terms of social relations amongst different groups of workers – female workers, male technical support, and so forth) made it impossible for any single individual to identify the problem and find a solution on their own. The case of the phantom calls also confirms that "in fact, it seems as if the more intricate the interdependencies and the more distributed the control, the more demanding and difficult the alignment, coordination, integration of the cooperative effort and the stronger the reluctance to collaborate" [27, p. 342]. Moreover, it is not only that configuration work requires articulation work, we can look at it as an additional or 'second-order activity', which proceeds through alignment, coordination, and integration, thereby contributing to 'making work work'.

8.1 Conclusion

Through our discussion of the introduction of the wireless call system, we have outlined a framework for thinking about the complexity that accompanies increasingly configurable technologies. Drawing on a rich history of scholarship concerned with appropriation work, configurability, customizability and tailorability assisted us in extending our understanding of configurability. We suggest that there are several aspects of configurability which, when addressed, can enhance design efforts undertaken to support cooperative work. The first three dimensions of configurability we identified – configurability of organizational relations, of space and technology relations, and of connectivity – have to do with the environment into which technologies are appropriated. Configuring as direct engagement and configuring as part of technology use/work – capture salient aspects of configurability support which we suggest is an important aspect of realizing the goals of configurable technologies and systems used to support cooperative work.

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10. REFERENCES

[1] Ackerman, M., Halverson, C., Erickson, T., and Kellogg, W.A. (in preparation). *Resources, coevolution, and artifacts: Theory in CSCW*.

[2] Andriessen, J., Hettinga M. and Wulf V. Evolving Use of Groupware. *Special Issue of the Journal of Computer Supported Cooperative Work* 12 (2), 2003.

[3] Balka, E. and Kahnamoui, N. Technology trouble? Talk to us! Findings from an ethnographic field study. *Proceedings of the Eighth Conference on Participatory Design: Artful integration: interweaving media, materials and practices* – Volume 1. Toronto, ON, July 27 – 31, New York, NY: ACM Press, 2004.

[4] Balka, E., Kahnamoui, N. and Nutland, K. (In press). Who's in Charge of Patient Safety? Work Practice, Work Processes and Utopian Views of Automatic Drug Dispensing Systems. *International Journal of Medical Informatics*.

[5] Balka, E., Wagner I. and Bruun Jensen. Reconfiguring Critical Computing in an Era of Configurability. *The Fourth Decennial Aarhus Conference Critical Computing- Between Sense and Sensibility*, Aarhus, DK, ACM, 2005.

[6] Bardram, J.E. and Bossen, C. Mobility Work: The Spatial Dimension of Collaboration at a Hospital. *Journal of Computer Supported Cooperative Work* (2005) 14, pp. 131-160.

[7] Binder, T., De Michelis, G., Jacucci, G., Matcovic, K., Psik,

T.and Wagner, I. Supporting Configurability in a Tangible Augmented Environment for Design Students. *Personal and Ubiquitous Computing* 8, (2004), 310-325.

[8] Bossen C. and Dalsgaard P. Conceptualization and appropriation: the Evolving Use of a Collaborative Knowledge Management System. *The Fourth Decennial Aarhus Conference Critical Computing- Between Sense and Sensibility*, Aarhus, DK, ACM, 2005.

[9] Bowers, J., Button, G., Sharrock, W. Workflow From Within and Without: Technology and Cooperative Work on the Print Industry Shopfloor. *Proceedings of the Fourth European Conference on Computer-Supported Cooperative Work*, September 10-14, 1995, Stockholm, Sweden, pp. 51-66.

[10] Callon, M. The Dynamics of Techno-Economic Networks. In: R.Coombs, P.Saviotti and V.Walsh (eds.) *Technological Change and Company Strategies*. London, Hartcourt Brace Jovanovich, 1992, 72-102.

[11] Dourish, P. The appropriation of interactive technologies: Some lessons from placeless documents. *Journal of Computer Supported Cooperative Work* 12/4 (2003), 465-490.

[12] Dourish, P. Accounting for system behaviour: Representation, reflection, and resourceful action. In: Kyng, M. and Mathiassen, L. (eds.) *Computers and design in context*. Cambridge, MA, MIT Press, (1997), 145-71.

[13] Eglash, R. Appropriating Technology: An Introduction. In: R. Eglash, J. Crossiant, G. Di Chiro and R. Fouché. *Appropriating Technology: Vernacular Science and Social Power*. University of Minnesota Press, 2004.

[14] Henderson, A and Kyng, M. There's no place like home: Continuing Design in Use. In: J. Greenbaum and M. Kyng (eds) *Design at work: Cooperative Design of Computer Systems*. Hillsdale, NJ, Lawrence Erlbaum Ass.,1991, p 219-240.

[15] Hornecker, E. *Tangible User Interfaces als kooperationsunterstützendes Medium*. PhD. Thesis. Published electronically at Elektronische Bibliothek, Staats und Universitätsbibliothek Bremen, July 2004.

[16] Jones, M. C. and Twidale, M. B. Anchoring appropriation: facilitation by example,. In: Y. Dittrich, P. Dourish, A. Mørch, V. Pipek, G. Stevens, B. Törpel (Eds.). *International reports on socio-informatics* 2/2 (2005), International Institute for Socio-Informatics: Bonn, 42-46.

[17] Karasti, H. Increasing sensitivity towards everyday work practice in system design. PhD Thesis, Department of Information Processing, Oulu University, 2001.

[18] Linde, P. and Wagner, I. (in preparation). Metamorphoses of objects and the place for design. Submitted journal paper.

[19] Mosco, V. *The Political Economy of Communication: Rethinking and Renewal*. Thousand Oaks, Sage (1996)..

[20] Nardi, B. A. *A small matter of programming: Perspectives on end-user computing*. Cambridge, Mass. and London, MIT Press (1993).

[21] Nardi, B.A. & Miller, J.R. Twinkling lights and nested loops: Distributed problem solving and spreadsheet development. *International Journal of Man-Machine Studies*, 34/2 (1991), 161-184.

[22] Newman, Mark W., Jana Sedivy, et al. Designing for Serendipity: Supporting End-User Configuration of Ubiquitous Computing Environments. *DIS2002*, London, ACM, 2002.

[23] Orlikowski, W. *Evolving with Notes: Organizational Change around Groupware Technology*. Technical Report (IFSRC No. 314-95), MIT, Sloan School of Management, Cambrigde (MA), 1995.

[24] Pipek, V. *From tailoring to appropriation support: Negotiating groupware usage*. PhD thesis, Oulu University. Available at http://herkules.oulu.fi/isbn9514276302/ (verified 20 June 2005).

[25] Robertson, T. The Public Availability of Actions and Artifacts, *Journal of Computer Supported Cooperative Work* 11 (2002), 299-316.

[26] Rodden, T., Crabtree, A. et al. Between the Dazzle of a New Building and Its Eventual Corpse: Assembling the Ubiquitous Home. *DIS2004*, Cambridge, Mass, ACM (2004), 71-80.

[27] Schmidt, K. Cooperative Work and Coordinative Practices. Contributions to the Conceptual Foundations of Computer-Supported Cooperative Work (CSCW), Submitted Thesis, IT University of Copenhagen, 2006.

[28] Tellioglu, H. and Wagner, I. Work practices surrounding PACS: The politics of space in hospitals. *Journal of Computer Supported Cooperative Work* 10/ 2 (2001), 163-88.

[29] Trigg, R. and Bødker, S. From Implementation to Design: Tailoring and the Emergence of Systematization, In: *Proceedings of CSCW'94*, Chapel Hill, NC, ACM (2004), 45-54.

[30] Wagner, I. and Balka, E. Supporting Configuring as Appropriation Work. In: Y. Dittrich, P. Dourish, A. Mørch, V. Pipek, G. Stevens, B. Törpel (Eds.). *International reports on socio-informatics* 2/2 (2005), International Institute for Socio-Informatics: Bonn, 71-78.

[31] Wulf V. "Let's see your Search-Tool!" - Collaborative use of Tailored Artifacts in Groupware. *Proceedings of GROUP '99*, ACM-Press, 50–60.

[32] Wulf, V. and Golombek, B. Direct Activation: A concept to encourage tailoring activities. *Behavior and Information Technology* 20/4 (2001), 249-63.

[33] Wulf, V. and Mark, G. The Emergence of Conventions within Processes of Integrated Organization and Technology Development, In: *Proceedings of the 7th International Conference on Human Computer Interaction* (HCI´97), August 24 - 29, San Francisco (CA), Elsevier, Amsterdam 1997, 293-296.