CONFIGURATION PRACTICES OF SERVICE TECHNICIANS

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The increasing need for interactive and configurable technologies in the field of industrial refrigeration seems to push the direction of research towards gaining a better understanding about both the practice of and tools for configuring. In this paper, we present three vignettes of configuration practices based on ethnographic studies of service technicians in the field of industrial refrigeration. To further expand our understanding about the complexity of technician's work and configuration practice, we incorporate both design and participatory approaches where we expose, challenge and reframe our understanding about users through engagement with their experiences and elaboration of work. In this way, we have gained new ways of looking and talking about the practice of configuration.

INTRODUCTION

In simple terms, product configuration can be described as an activity to make changes or adjustments to a product for it to function in a specific way. For example, in setting the channels for a newly bought television, one configures the ways the various stations are organized according to his/her preference. In an industrial setting, configuration deals with advance systems, involving complex configuration of hundreds or even thousands of parameters.

In a larger picture, this complexity is also influenced by the socio-technical relations among the key players of configuration practices and between their practices and work environment. In our research, we focus on configuration practices of service technicians who maintain industrial refrigeration systems in supermarkets. We are interested in viewing configuration from the perspective of the service technicians, who deal directly with the system alongside interacting with other technicians, other service professionals, and the customer. In this way, we pay attention to the intricate process of configuration in relation to the issues dealt with by technicians in the field of refrigeration system maintenance and configuration technology development.

THE USEC RESEARCH

The USEC (User Supportive Embedded Configuration) project is a collaborative effort between 3 universities and 4 industrial partners that have a common interest in researching the technology of embedded configuration. Our research in this project focuses on investigating current configuration practices and identifying possible ways to improve.

Embedded configuration is one of the approaches to solve complex system configuration. It involves automation of product interaction, where to a certain extent the user no longer needs to set every single parameter of each product in the system.

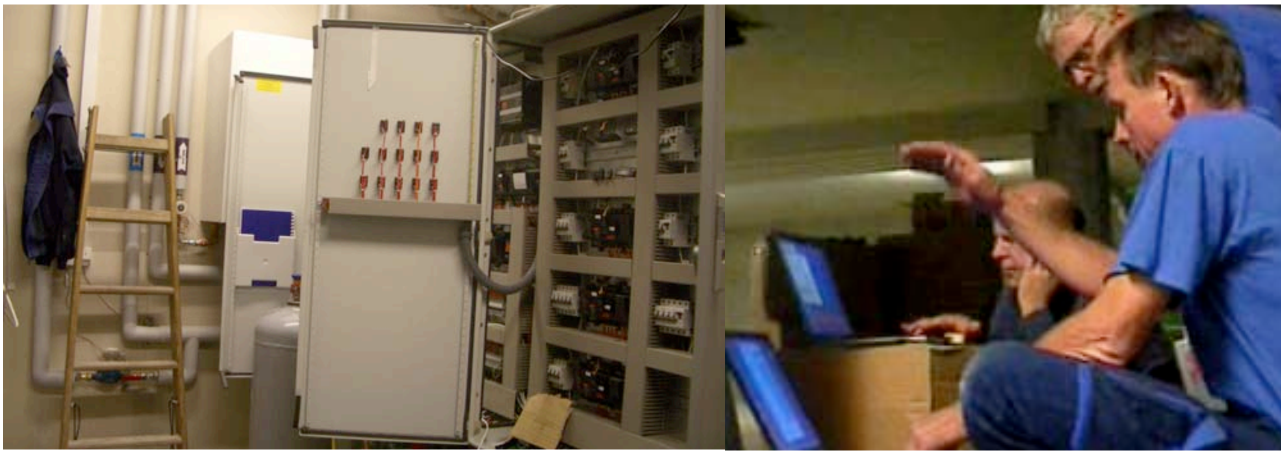

Figure 1 Left: the control cabinet in the control room. Right: Preben, Lars and Karl working with their laptops just outside of the control room

The rules and knowledge of configuration, in this case, are distributed and embedded in the products (instead of given or activated by users). The idea behind this embedded-ness is so that user can efficiently configure a system within less time and with minimal error.

Previous studies in the field of industrial configuration (Hadzic 2004, Mortensen 2000, Subbarayan 2005) have looked at the aspect of intelligence and robustness of product modeling and configuration algorithms. These studies address various issues regarding the inner workings of the configuration software and the relationships that can be established among components of an industrial system. However, there is still a lack of understanding about the ways, in which these knowledge and rules are composed and activated by users in the real world. How do users configure a system?

THE FIELDWORK

We have studied the practice of configuring refrigeration in 9 field sites in Denmark, Australia and Indonesia to obtain a broad overview of what the process involves. Using an ethnographic approach (site visits varied 1 day to 1 week) and video documentation we have studied installation, configuration and a major Danish refrigeration reconfiguration practices of technicians.

Figures 2 In the field of industrial refrigeration, most equipment, manufactured by a manufacturing company, are not sold directly to the customers (shop owners). They are sold to cooling contractors, who would provide the system together with their maintenance service to the customer

In the case of industrial refrigeration, maintenance service is given not directly by the manufacturing company. Instead, shop owners as customer deals with local cooling contractors who in most cases supply the whole refrigeration system.

In the following, we discuss our findings from the field. The three vignettes are specific events describing the site, technicians, and the practice of configuration. After each vignette, we explain briefly the ways in which we further explored and learned about the practice through design activities. Based on these discussions, we conclude with three design and research implications.

CONFIGURATION VIGNETTES: HOW CONFIGURATION UNFOLDS IN THE FIELD

VIGNETTE 1 - BURNT CONTROLLER

The newly built Netto shop is located in Rødovre, just outside of Copenhagen, Denmark. Though the big sign outside says that the shop is about to open in a week, inside we find nothing is up yet, except for the two yellow island fridges and showcases around the back. Downstairs in the basement we see a different picture. Two green vans marked Vojens Køleteknik are parked near a cramped little room where Preben, Karl, Lars and an electrician can be found, working around the control cabinet (Figure 1). Just by the door, they have made a little workspace with cardboard-boxes as desks for their three laptops, which are connected to the controllers in the cabinet.

As they start up their laptops, Preben and Karl discuss several steps that they need to do that day. Most of these are regarding some parameters that need to be configured uniquely for this shop. Lars who has less experience with the software watches Karl and asks several questions.

Suddenly, the electrician calls them in, telling them that there is a smoke coming out of the cabinet. All three rush into the room and find that one of the AK2 controllers is smoking. They shut the power off and Preben pulls out the top of the smoky controller (Figure 3). He notices a burnt transistor on the bottom part of the controller.

It seems that there was too high of a voltage, which had gone through the controller. Since only one controller is burnt, Preben wonders if the fuse fails to work. Karl, who put the controllers together with the electrician, explains that there is no fuse at all. Preben uses a volt meter to measure the current at the controller and compares the reading to other controllers (Figure 4). "Even though a wire might be connected wrong, and a 230 Volt is sent through, it should not have burnt. Why didn't the other controllers burn?" Preben asks as he examines the controller once again. After discussing more with Preben, Karl takes out the system drawing and discusses it with the electrician (Figure 5). This discussion seems to help Karl to question the wiring that comes from the dairy case, which might be mounted incorrectly. While doing this, Karl seems to know more in detail the links of each fridge, while the electrician tries to recall them from the system drawing.

Karl and the electrician then go upstairs to the shop floor where they try to measure voltages in the dairy case. They find that the cause of the problem is located there. The voltage of two circuits comes in the wrong place, causing a 400V running through the transistor of the burnt controller upstairs. Preben then explains that if they had been able to detect such high current running through the system, they could have avoided such short-circuit. But Preben further explains that this often happens, especially during installing a new system. The way the system is designed prevents them to see all the little things that run in the background. Little details such as wire connections from the controller to the rest of the system is critical, yet the only way to see if they are connected correctly is after the system is turned on: a burnt controller means something is wrong.

What prevents the technicians from seeing all the system?

Upon returning from the site, we wondered if the burnt controller problem could have been prevented if the technicians would first re-check all the wiring of the system before turning it on.

Figure 3 Preben pulling out a smoking controller out the control cabinet

Figure 4 Preben using a volt meter to measure electric current in the control cabinet

Figure 5 Karl and an electrician discussing a wiring diagram in the control room

To us, configuration, as it is now, is practiced in two steps: first is to physically assemble and install the system; and second is to digitally connect the system to the controller using the configuration software.

In one hand, we understand that most advanced configuration is done on the second step, using the configuration software. However, we are curious about to what extent could the two practices be merged, in order to avoid mistakes during installation. If the checking of the first step could be done before or through the second, how would the practice of configuration be different? What would it mean for the technicians to have the two practices merged as one? Is it possible? If not, could the configuration through their laptops make sure that all the connections are done correctly?

To answer these questions, we designed several paper prototypes of configuration interface (Figure 6). In bringing these prototypes to the technicians, we try to expose our understanding about the technician's configuration practice. In doing so, we hope to provoke them to show and talk about aspects of their practice, that sometimes are too detailed or complex to be explained during regular interviews.

The paper prototypes cover an area of the current configuration software. With some technical material in our hands (mostly from controller's manual and discussions about refrigeration systems), we chose compressor configuration as a scenario for the three prototypes. With the three prototypes, a compressor configuration practice can be done in three different ways, but all allow the user to see the consequences of their actions.

The "Compressor Rack" interface suggests connecting the compressors to the controller by moving them onto the compressor rack (which is placed underneath the control cabinet in the real world). The "Tunnel" prototype uses the metaphor of going through a 3D tunnel, which leads user to discover various parameters of a compressor. The "Drawer" interface is more abstract than the previous two. It uses a metaphor of a work desk, which has drawers of parameters for each compressor.

We presented the general idea of each concept to Preben and Karl and provided some tasks as a way to try out the concepts. In general, they prefer the "Compressor Rack" for it is the most similar to the real system that they deal with today. When going over the tasks we provided, Preben explains that the ability to see the status of the connections would help them in locating mistakes. But we also learn that often technicians would need to know not only the status of these connections, but also about how and why they are connected in certain ways. The way they find out about these details is through going out to the plant, checking and discussing them with other technicians and sometimes the shop owner.

COLLABORATIVE SENSE-MAKING OF COMPLEX SYSTEMS

From the first vignette, we can identify several key players in the process of system configuration: Preben, the contractor service technician; Karl, the manufacturer technician; and the electrician.

Figures 6 Top: A designer discussing compressor configuration with service technicians using the "Tunnel" interface prototype. Bottom: an implementation of technician's feedback in the later version of "Photo Diagram" interface prototype

Most of the time, we found the first two players work closer together in dealing directly with the configuration. Working in pairs, *technician duets* share their skills and experience in making sense of the system. While Preben, the manufacturer technicians are often more experienced in working with the software element of the system (most of them have system engineering background), the contractor technicians are more skilled in dealing directly with the physical components of the system (most of them are trained electricians, welders, etc.).

This sharing of skills and experiences is a collaborative effort to make sense of a highly complex system. The process where Preben and Karl investigate the cause of the burning controller is an example of how they share their experiences to make sense of the problem. The discussion between them regarding the problem came up through their actions when checking the controller voltages, reading and mapping the controller, and going upstairs to inspect the wiring at the dairy case. These activities are part of their configuration practice, where through them the technicians engage their body and experiences in making sense of the system.

Figure 7 Brad calling the CPC national hotline to help him with configuring the fan ramp

VIGNETTE 2 - FAN RAMPING PROBLEM

Coles New Market is a supermarket under construction, planned to be open in 3 weeks, in urban Brisbane, Australia. All fridges and other cooling furniture have been assembled and equipped with sensors, valves, and CPC controllers (American brand) by the Frigrite mechanics on site. Brad who has checked the plant a couple of days before explained that he had programmed the controller in the morning for the frost cabinets, as they take time to reach temperature, and Coles want to start storing frozen food. But once the parameter settings are completed, Brad encountered a problem: The condenser fans are controlled by a Danish VLT (variable speed controller), and Brad could not make the main CPC controller ramp the fans properly up and down.

The CPC has a full keyboard placed vertically on the switchboard (Figure 7). Numbers are easy, as they are concentrated in a number field to the right; but letters are more difficult, as you need to jump across the full keyboard. As CPC has no local representative, Brad had earlier called the national hotline and left a message for the supporter to call back. Brad had also mentioned this problem to the shop manager, John. While still waiting for the CPC hotline to call back about the fan ramp problem, Brad starts entering settings for the controllers in the medium temperature system.

Brad: You can say it's a dairy case, and they'll put in rough settings for you. But they are not similar to ours, how we would be running them. They are American. But its good to get you started.

Jacob: Can you copy from one case to another?

Brad: No, I'm not sure, I don't think so. I think I've got to go through and do all that. Once I get my head around this, I think this one (the CPC) is A-OK. Once I get my head around their terminology, how they say things. The off-line programming could be a bit easier, like the Danfoss; it (the screen) is exactly the same as the processor on-site."

There are 6 condenser fans on each rack. Brad explains that two of them cut in or out without ramping, the other four are speed controlled. He knows that the VLT works, but the controller does not send any signal in between 0 and full speed. "There's got to be something in here (CPC controller) that we just haven't done right. That's basically all it is." he explains.

Brad checks and rechecks the cabling and tries to make sense of the programming. He also tries to run the controller on manual operation or with simulated set-points, but nothing seems to work. At some point after lunch, the service hotline returns his call and sends a fax with suggested settings for controller and VLT. Brad carefully enters those; it changes the system function somewhat, but not entirely, as it should. Next, he is back on the phone, but the service support needs to investigate more. They promise to return once they have located the settings from another supermarket that runs the same configuration. Towards the end of the day, Brad still hasn't solved the problem completely, but at least the VLT does ramp the fans up and down now, albeit not in the full regulation range.

What tools do technicians use and how do they help them to configure the system?

In analyzing the above event, we are interested to learn more about the relations established between technicians and the system. From the way Brad refers to the entering of the numbers and settings into the controller, we could see that he considers his role as much more than just working with the controller. That it is the ramping of the condenser fan that he would need to configure, and not to worry too much about the controller. However, Brad's way of handling the situation i.e. calling the hotline for help shows Brad takes this problem as part of his responsibility. He understands that the system relies on the controller and therefore he should be able to interact with it.

Figure 8 Left: Brad and Gerry using pliers and screwdrivers to adjust and check the compressors. Right: Preben and Karl trying configuration mock-ups

Brad mentions that since the controller uses a different terminology, it is a matter of understanding the controller better. Brad's struggle in understanding the CPC's language could mean that the controller can sometimes become a hurdle in their ways to complete the configuration task. We have seen similar cases not only in Australia, but also in Denmark. Contractor technicians in both countries often find it difficult to proceed with the configuration software, since they seem to struggle in making the system to work in certain ways that they have described in their configuration. How can we learn more about the ways technicians use various tools in configuring the system?

In analyzing the use of manual tools such as pliers (and screwdrivers (Figure 8), we could see that the technicians seem to make sense of the system through the direct and bodily interactions with these tools. Challenges and possibilities in interacting with the system are somehow visible and directly experienced through the use of physical tools. In order to investigate further about the relationship between technicians, their interactions with the controllers as their configuration tool, we made three different configuration tool mock-ups that emphasize the use of 'bodily' language as a guiding metaphor in interacting with the controller.

"The Pointer" consists of a joystick and a controller, which can be connected to a technician laptop (where they run the configuration software). By pointing to a certain port, the user would be able to activate and connect it using the joystick. The joystick can be toggled to a compressor, condenser fan, frequency converter (VLT) or alarm. "The Tuning Board" has sliders, which can be used to change the value of certain parameters attached to it. Instead of entering numbers into the controller like Brad did, he would slide the controller knob to ramp the condenser fan. "The Compass" is a controller itself, which has four physical levers that can be used to assign and adjust 4 parameters. Preben and Karl explained that in some cases many of the settings for one shop are a copy from other similar shops. Putting action into the interaction with the controller in this case might be helpful to associate specific configuration to specific setting. We also learn that often technicians would prepare their maintenance service the day before. For Preben, who is often called to help out the contractor technicians, configuration practice involves preparation, because often they work in remote places, and access to support or new parts is limited or impossible. In this way, tools that they prefer to use are those that are easily shared and understandable among different technicians.

CONFIGURATION THROUGH INTERACTION WITH PHYSICAL AND DIGITAL TOOLS

In configuring the system, technicians actively engage their skills and experiences through interacting with both physical and digital tools. When using a screwdriver to configure the network address of a controller, or a set of pliers to loosen a bolt, technicians are involved in a bodily interaction with the system. They use the palm of their hands to feel the compressors, ears to listen to the motors, and eyes to follow the path of wires for example.

Similarly, in interacting with the system through a controller system, technicians deal with numerous kinds of information, which though are represented in digital form, corresponds to the physical and real components of the system (compressor, condenser, evaporators, etc.). Because of this, it is often challenging to make sense and configure the interrelations between the system and the digital tools embedded in the controller.

VIGNETTE 3 - RE-DRAWING THE SENSOR WIRING

The management office of Makro supermarket in Jakarta has just started replacing their analog refrigeration controllers with the newer Danish digital controllers. The Makro shop in Denpasar is one of the first ones to begin after the New Year.

Figure 9 Left: Syamsudin checking the depth of water in the underground waterway. Center: Lukman explaining Syamsudin's drawing to Slamet and Ari. Right: Syamsudin explaining the two walls he found in the underground waterway to the shop technical manager.

On the first day, the three Aneka Froze technicians, Syamsudin, Slamet and Lukman plan to first inspect the system and to check the electricity line. According to Syamsudin, this might take a while since they need to inspect the old document, compare it to the physical installation and note down the differences. Syamsudin explains that the refrigeration system is as old as the shop when it was first installed 9 years ago. There is a possibility that there are some changes to the system sometime during this period and that they were not documented by Makro. Syamsudin as the field supervisor reminds the other two technicians about making a drawing of the present wiring to help them figure out the line for the wires of the new system.

On the second day, the team continues with the last wiring that they need to check: the transducers or multi-sensors installed in the showcases. Syamsudin is concerned with the sensor wiring for the showcases since they are wired from the ground. Different from the cold rooms, the showcases are located in the middle of the shop floor. The wires, which come from the roof, cannot be installed into the shop floor through the ceiling, because it will end up hanging vertically across the room. According to Pak Suwaloka, the shop engineer (the shop technical manager) this would block the shopper's view and make the shop looks cluttered and messy.

This would mean that Syamsudin and his team would use the same wiring path like it is now, which goes from the roof, to outside around the building, into the underground waterway, and up into the shop floor through a drilled hole on the floor. Because of this, Syamsudin asks his team to check the condition of the wires and map the underground wiring. The entrance is a 3-meter deep hole located next to the ladder to go up to the roof (Figure 9). From where they stand, one could see that there is some dirty water in the passage. Since it was knee-high, Slamet and Lukman had to go in there with some rubber boots. They also bring with them some flashlights since there is no light in there. Pak Suwaloka explains that the water is coming from the drains on the shop floor. Some of them are from the refrigeration and air conditioning system.

After Slamet and Lukman return, Syamsudin discusses the wiring of the transducers with them. It seems that Syamsudin is still missing some information on how the wiring is done. He asks Slamet a couple of questions regarding the connections but couldn't make sense of Slamet's drawing. Syamsudin then decides to go down into the underground waterway to re-check the wiring. Once returned from underground, Syamsudin gathers his team and starts drawing a new diagram on a sheet of paper. It turns out that Slamet had spotted the wrong wires. While making a new drawing, Syamsudin also refers to the original system drawing. They then discuss some strategies in going about installing the wires. Pak Suwaloka informs Syamsudin that it might take roughly 2 to 3 weeks for the building contractor to be available to help them drill the wire holes on the shop floor. Syamsudin suggests that they should stick to the plan to wire showcases from underground. But at the same time, he also mentions that there are walls, in between the sections in the underground waterway, which make it impossible to connect the showcases.

Syamsudin explains to the shop operator that with the new controller, they would need to connect the sensor wires from the two show cases that they have. After negotiating some details with the shop operator, Syamsudin suggests to proceed with lining up the wires and replace the smaller parts first. Since the building contractor is not there to decide what to do with the underground walls, they have to wait to connect the parts as a completely new system. For the time being, the system will therefore run with half new and half old refrigeration parts.

How do technicians deal with configuration limitations?

In the third vignette, we can see that the technicians are faced with many challenges that perhaps have not been foreseen before they get to the site. Limitations in the case for technicians in Denpasar range from physical one such as the underground walls and the floor of the shop to the social one such as the expectations for being able to meet the shop's regulations and preferences on appearance and opening hours. These limitations influence the ways configuration is practiced in the field. With experience, Syamsudin seems to pay more attention to several details that regarding the system and the plant with which they are dealing.

Julian Orr, in his study of Xerox field service technicians, mentions that in many organizations, documentation seems to be valued and recognized as "directive documentation" (Orr, 1996:106). According to Orr, The Xerox field service technicians however, tend to use such documentation to keep the customer happy. Documentation, in their case is used to keep the customer assured that the situation is under control (1996:108). Similarly, the thorough inspections and detailed drawing of the plant made by Syamsudin becomes handy for the technicians in negotiating and convincing the shop operator in proceeding with the project, despite the lack of building contractors. Moreover, the drawing in this case is also useful as a way for Syamsudin and his colleagues to orientate around such complex system.

We are interested in finding out further the ways in which the technicians configure as they deal with limitations and challenges that they encounter along the way. How do technicians know the things they know? On what information do they base their configuration decisions? Furthermore, we are interested to find out the ways in which skills and knowledge are developed and nurtured in such practice and community of work.

In order to probe further into the practice of these technicians, we decided to analyze the field material collected from three countries and facilitate a process in which other perspectives and understanding about the configuration practice can be use as a framework to talk about the technicians configuration practice.

Inspired by the Video Card Game method (Buur and Soendergaard, 2000), we prepare three sets of short video clips of technicians working. While trying to focus on having videos that show rich interactions among the technicians and with the system, we also try to prepare video collages with three themes that we could use as a set of comparative frames when talking about the technicians practice. These three themes are:

- The Surgeon: looking and seeing
- The Surveyor: making maps and mapping
- The Archaeologist: memorizing and remembering

The workshop was facilitated at the refrigeration system monitoring center in Denmark, involving two operators who deal with monitoring and reporting system status and failures directly to service technicians. Though these operators do not work directly with technicians in the field, most of then were trained and had experienced as refrigeration technicians. Involving them in the design process had taught us also that they have a unique perspective about the practice of service technicians, which enrich our understanding about the field

After viewing the videos and noting brief observations, each group discusses the similarities and differences between the technician's practice and the three themes. For example, for the technicians map-making is a process of making sense of the system (Syamsudin drawing the underground wiring), while the map is an outcome of such process that can be used in mapping the system in the future.

Figure 10 Top: Designer and monitor operator analyzing video of technicians. Bottom: After discussing several features of the configuration software, the monitoring operator sketches an interface that he would use to configure a system.

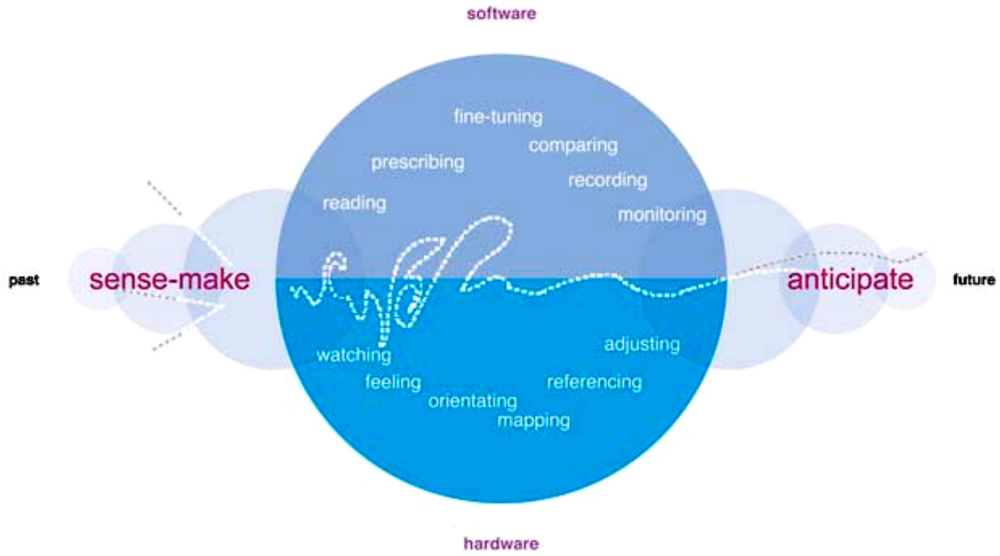

Figure 11 Experience model of configuration practice illustrating the dynamic of activities that are involved in the technician's interactions with the time and tool dimensions. The largest and most centered circle represents a current configuration event.

At the same time, we also learn that in there is a difference between the surgeon and the technician in the way that they anticipate. On one hand, a surgeon would very much depend on a completely secure and careful planning, which sometimes leaves very little room for improvisation. The technicians, on the other hand, work more spontaneously, dealing with sudden changes and at the same time trying to leave traces of their work, as a way to inform future configuration.

CONFIGURATION AS ANTICIPATION FOR FUTURE CHANGES

In configuring refrigeration system, technicians anticipate for changes that happen to the system in the future. This way of thinking ahead is a strategy to not only to prevent the system from failing once change occur, but also to inform the next technicians about the configuration that is carried out at that time. As much as the logged information in the system database is detailed and comprehensive, there are other clues and traces that the technicians would leave behind for the next technicians to make sense of the system.

Douglas Harper, in his study of a small car repair shop owner in rural New York, mentions how the practice of car repairing though may seem an individual, is very much influenced by the "line of action" of others, including the customers (Harper, 1987: 186). In this sense, one can learn that the practice of drawing and mapping, like Syamsudin's should not be taken for granted, for it is influencing the practice of other technician's configuration practice.

DESIGN IMPLICATIONS

Observing and participating in active discussions about configuration practice from and with service technicians, have led us to a current synthesis about the relationships that exist in the practice of configuration.

Configuration is a progressive process of making sense of the system and anticipating for future changes.
It is not a single isolated action, carried out as a task only. Configuration involves a range of activities (watching, reading, feeling, prescribing, etc.) engaging both skilled and novice technicians through different relationships and interactions. In doing these activities, technicians work their ways in such a way that allow them to make sense and respond to the limitations and possibilities that often are out of their control. While interacting with other technicians, shop manager, and customers, they also use both digital and physical configuration interfaces in making changes of the system.

However, it is important to realize that in today's organization, there is a strong push to do almost everything through the digital configuration interface (software-based), which has become the focus of current product development research. Looking for ways to compare the digital tools against tangible and analog tools is crucial in the design process. At the same time, the design of supportive tools should allow technicians to accomplish their tasks, but also nurtures opportunities to develop other skills (motoric and sensorial), which are valued and respected within the community of technicians and in the field of system maintenance.

Configuration tools suffer from conflicting perspectives on the system.
Brad's struggle in making the controller work to ramp the condenser fan might be caused by the fact that the software is designed with a different perspective on the system. Terminologies used in such software might be understood by software engineers, but not by field technicians. The process of designing in this case needs to involve those who use, design and maintain the configuration tools. At this level, designers should generate ways to address the various relations among key players within the practice for which they are designing. Juxtaposing the various dimensions of work, understandings of practice, and key players is a way to model the experience and community of such practice. This model should be used to discuss and negotiate the conflicting perspectives.

Configuration as improvisation: Though the process of configuring may seem unstructured and unplanned, the process of such spontaneous and intricate engagement of skills and experiences is key to configuring such complex systems. Technology in this setting should be designed to support such practice, and not only geared towards the completion of configuration. Interaction with such tools should therefore be designed not only to guide the technicians to one configuration solution, but to help them navigate through an unfolding configuration event and to respond to both social and physical limitations.

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