Stefania Castellani, Frederic Roulland, Jutta Willamowski, David Martin (2010):
Mediating helpers for remote service provision.
In Gunnar Stevens (Eds.),
International Reports on Socio-Informatics (IRSI),
Workshop Proceedings of 9th International Conference on the Design of Cooperative Systems - COOP 2010, Aix-en-Provence, France, May 2010
(Vol. 7, Iss. 1, pp. 217-227)

Mediating helpers for remote service provision

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Abstract. In this paper we discuss and introduce a framework for what we propose as a 'class' of CSCW systems – mediating helpers – that can provide assisted remote service provision among different groups of users with differing needs and characteristics. We make reference to two systems we have defined that can be seen as mediating helpers and that have inspired the current definition of this framework. We also describe some links among the mediating helpers framework and other conceptual frameworks, such as boundary objects and intermediary agents and discuss current work that comprises refining the concept and applying it to different domains.

1 Introduction

In the CSCW field a computer system is defined as a set of services that users/actors can use to access/create some resources and perform a task. Whereas a lot of research activities have been focused on defining how the system could enable the coordination or the negotiation between the users when accessing the resources, they do not address well the underlying communication problem encountered by the users, due to the fact that each user has its own conceptualization of the resources available for a service. For instance, tasks previously requiring specialist skills are routinely becoming part of the work of non-specialists in those tasks. It's often when people have to work across organisational boundaries that such differences in expertise are made manifest. This is because those workers often do not have easy access to the resources within the other organisation which could help them address the mismatch of expertise.

Instead of a system assuming commonly predefined definitions of the resources, we suggest that the system can act as a *mediating helper* between the users. In the recent years, we have worked on the design of several systems across different domains of applications, where the provision of a remote service is challenged by the underlying communication problems between users. For each project, our focus was to better address the provision to the users of a common understanding of the problem and resources being manipulated through the design of an appropriate shared representation. Reflections and lessons learnt from these individual projects motivated us to define the mediating helpers' framework. We believe that seeing a system as a mediating helper could be a useful thought framework for designers of collaborative systems involving provision of services across organizational boundaries in order to 1) understand the difficulties introduced by the context of the application and identify the users' needs and 2) explore all the dimensions where the designers can act and propose functionality that would reduce the communications gaps.

In this paper we will first introduce two cases of study and design in the domains respectively of remote troubleshooting of devices and colour management in digital document printing. We will then use these two reference examples in order to present our characterization of a mediating helper and illustrate how it can be used to inform the design of a system.

2 Summary of two design experiences

2.1 Remote collaborative troubleshooting

Office devices, e.g. printers, are often shared resources utilized by a variety of different users with a variety of different skills and abilities. When a user encounters a problem with a machine and cannot resolve it himself, he calls a support organisation for assistance. Users and troubleshooters communicate over the phone working together to understand what the problem with the device is, what the appropriate solution is and how to apply it. As described in O'Neill et al. (2005) and Castellani et al. (2009) a number of difficulties arise doing this work. For instance, users and troubleshooters need to routinely describe parts of the device and give spatial directions or descriptions since users do not necessarily have the technical vocabulary to identify device parts by name and the troubleshooters cannot indicate them directly on the device. The lack of access to the device for the troubleshooters results in effort being devoted to produce instructions and directions without being able to see how they might be appropriately framed to the current circumstances, i.e. status of the device, actions of the users, etc.

In order to help users and troubleshooters to overcome these difficulties and better support their work we have designed and built a collaborative troubleshooting system (Castellani *et al.* 2009) based on the idea of providing users and troubleshooters with a shared representation of the device status and the troubleshooting problem. The shared representation mainly consists of a 3D model of the device and a number of means of interacting with it adapted to the user and troubleshooter roles in the troubleshooting task. The shared representation is presented to the user on the device and to the troubleshooter on his terminal. The representation is linked to the device itself, such that actions on the device are shown on the representation, e.g. if a user opens a door, that door will appear on the representation and the troubleshooter will see it. This is enabled through the sensors that reside on the devices. Reciprocal viewpoints are supported and remote troubleshooters and customers are able to coordinate and co-orient around the representation of the device. Figure 1 and Figure 2 show an example of the viewpoints respectively for the troubleshooter and the customer.

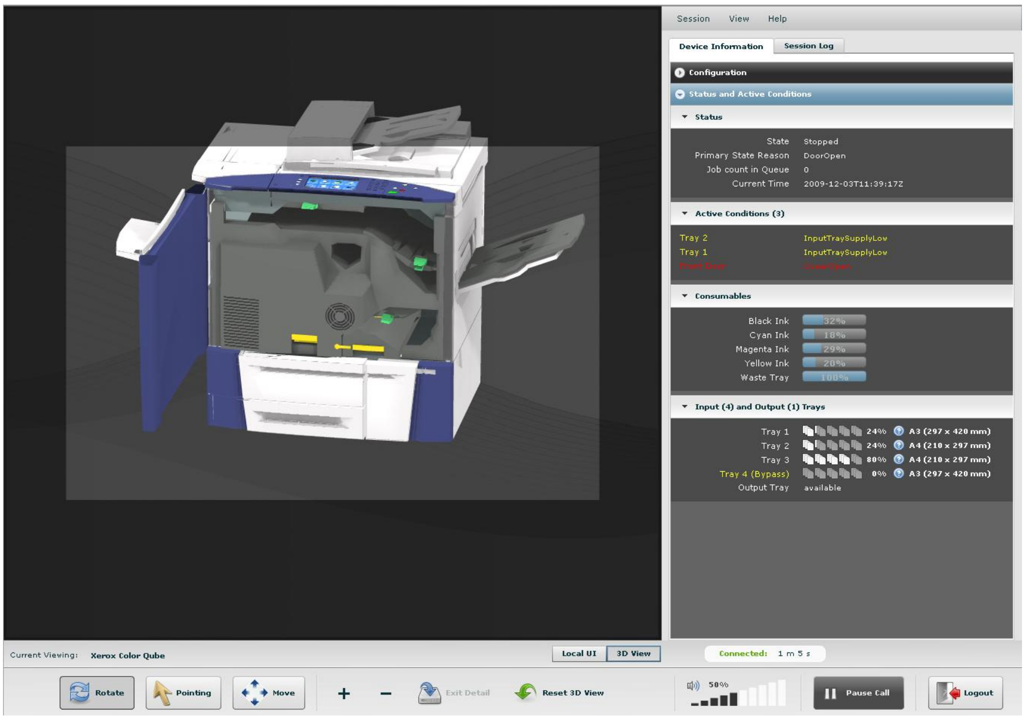

Figure 1: The remote troubleshooter interface.

The troubleshooters' interface includes also information on the operation parameters of the device and a history of past interactions with it. Troubleshooters can view the device representation from different spatial perspectives, to facilitate at-a-glance recognition of problems. They interact with the representation to demonstrate visually actions which should be performed, e.g. lifting a handle and sliding a toner cartridge out of the machine.

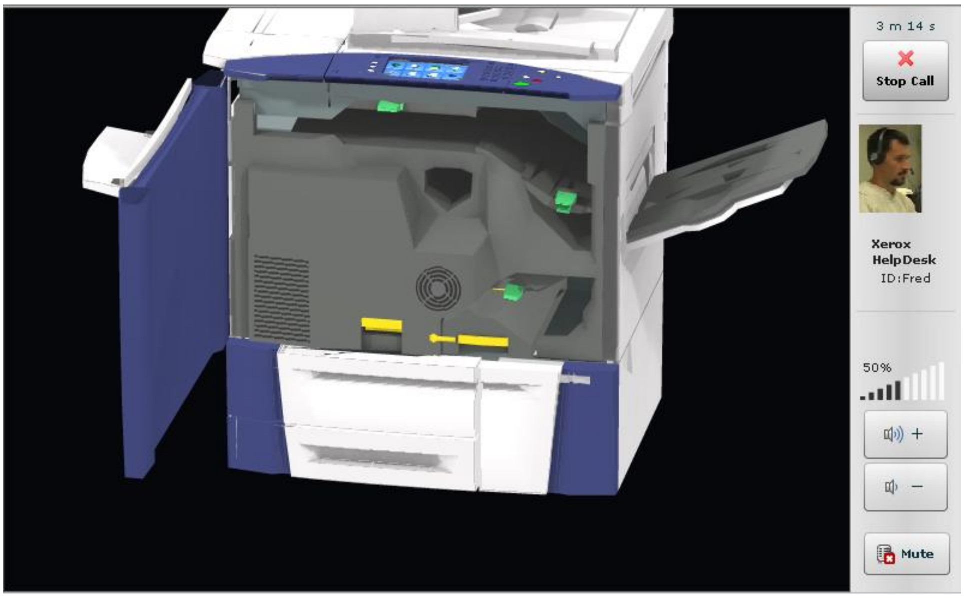

Figure 2: The customer interface.

Troubleshooters can see the actions performed by the customer on the device which trigger sensors thus they can infer, for example, if the customer is following instructions correctly.

On the customer side, the user can indicate device parts to the troubleshooter through the touch screen.

2.2 Colour management workflow

In digital colour production printing workflows designers create documents and submit them for printing to remote printshops. While ideally the document designer would submit print ready files, i.e. files containing the exact and complete specification of the desired target colours, the currently observed workflow usually consists of a significant number of iteration cycles between the document designer and the print shop operator before a satisfying print out is obtained. The reason is that the problem of colour reproduction across various displays and printers is a very complex socio-technical problem that state of the art approaches have failed to solve as explained in Martin et al. (2008) and O'Neill et al. (2008). These studies have in particular highlighted the mismatch between the way document designers think about colours and the way they are handled by colour management infrastructure as a barrier to the creation of documents prepared for being printed accurately. Another issue is related to the fact that the printer operator cannot get any cues of what is the original intent of the designer with respect to colour when the result is not satisfying.

It is along these ideas that we have designed the Print Mediator system (Willamowski *et al.* 2010), which provides support for communication and colour problem detection and correction during print job submission.

The document designer will use the system at the document submission stage to foresee and appreciate potential colour issues when printing the document. Through the review interface shown in Figure 3, the system will assist the designer in either applying immediate colour corrections or in specifying and communicating corresponding requirements to the printer. The printer operator or a pre-press agent will afterwards also use the system to visualize the submitted document together with the requirements added by the submitter and select the appropriate print options depending on the designer's requirements.

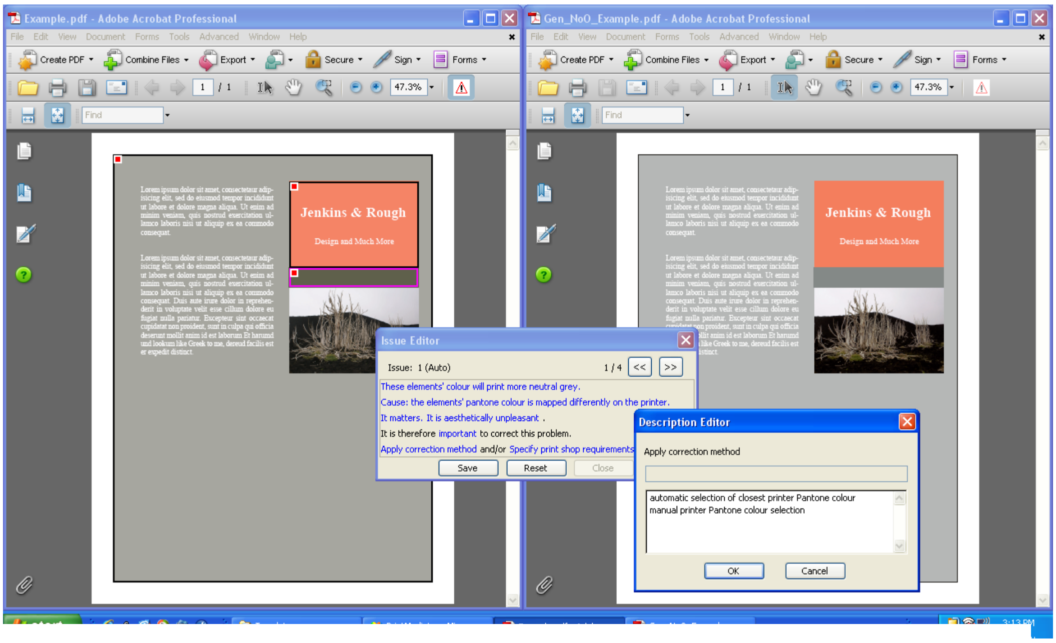

Figure 3: Print Mediator comparative soft proof view with original document on the left and simulated print result on the right.

3 Definition of a Mediating Helper

Although the two systems presented in the previous section differ in terms of services provided, resources being shared and technology being used, they can be seen as two instances of the same abstract class of Mediating Helper systems. A mediating helper is a conceptual view of a system as a mediating technology component whose role is to improve the communication between some users accessing a service by providing a common understanding of the task being performed and the resources being manipulated. A mediating helper can be seen in a very schematic way as described in Figure 4.

A mediating helper incorporates all the service information resources being manipulated by the users. Some of the resources are created during the collaborative activity and some are created by technical editors.

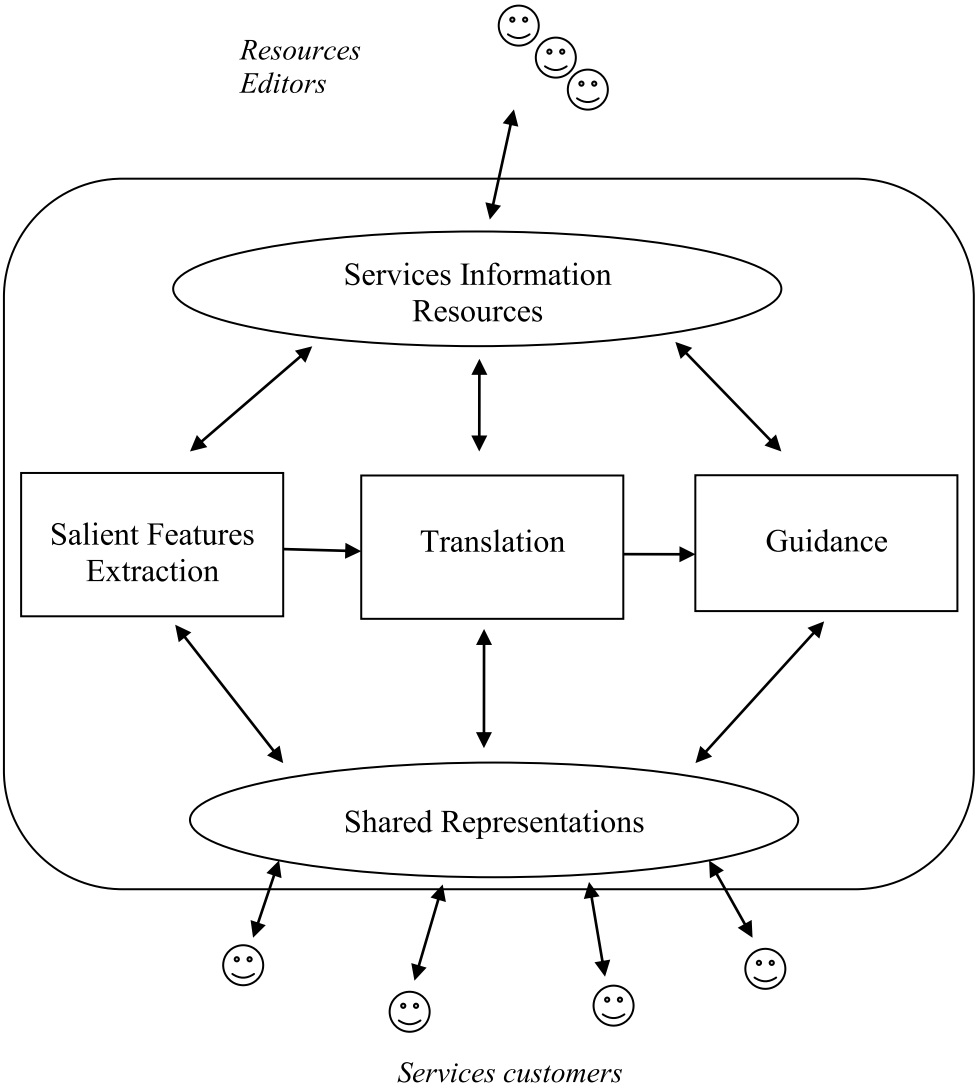

Figure 4: Mediating Helpers components.

The technical infrastructure being used and the way it is configured can be seen as well as part of the resources being manipulated by the users. The resources are made available to the final users of the service through a shared representation. This representation can be of different nature: physical/digital, audio/written/visual content, structured/unstructured. It may be accessed through different user interfaces corresponding to different types of users or roles and show an individualized perspective of it. In order to bridge the resources and the different user perspectives with this shared representation the system must provide some mediation capabilities.

We have identified three levels of mediation that can be provided whatever the nature of the representation. However, the type of technology being used will be very different depending on this nature.

A first level of mediation that can be provided is an extraction of the salient features within a resource. This means extracting from the overflow of information available within the system the pieces that will be of particular use to a group of users or to an individual user at a particular moment of the activity. For example, in a device troubleshooting activity this could be the current or recent error codes that were associated to the component of the device being troubleshooted by the user(s). The extracted features can be provided as such to the end-users so that they can assess more quickly the problem or the situation. However, a further level of mediation is often required before they can be added to the shared representation and used.

A higher level of mediation is to provide a translation between the resources and the users if the users do not have the right level or domain of expertise to directly manipulate the resources (e.g. a machine part illustrated graphically or a fault code translated into a user understandable message) or between two users' perspectives on the same resources (e.g. a designer and a printer).

Finally, the highest level of mediation that a mediating helper can provide is to be able to guide a user in his task or to coordinate several users according to the translation mechanism it uses to interpret the exchanged resources. For example in a device troubleshooting activity, the system may know which actions can be performed given the state of a device component being investigated by the users. It can therefore make the list of possible actions available to the users in order to help them to decide on their next steps. This level implies that in addition to having access to some translated features of the resources, the mediating helper has some knowledge of the domain of the activity in order to assist the users.

4 Characterizing a system as a Mediating Helper

We suggest that the design of a mediating helper can be articulated around the identification of the following points:

- The needs
    - What is the nature of the resources being shared?
    - What are the perspectives of each type of user and how do they differ?
- The proposed solution
    - What is the nature of the shared representation that can be used?

- What can the system do in order to appropriately mediate between these perspectives across the three levels of mediation: extraction of features, translation and guidance?
- What is the technology that can be used to enable the mediation?

These points are interrelated and cannot be answered sequentially but rather through some design iterations. We illustrate below how they relate to the two design cases that we have introduced in section 2.

In the remote troubleshooting case, the **resources** being shared are the status of a broken device and the objective of the system is to help users and troubleshooters to collaboratively move it back to a normal working state. The user of the device can see the device physical status and is aware of the symptoms of the problem but lacks technical knowledge. The remote troubleshooter has the technical knowledge of how the device works and what are the potential causes of a problem but lacks some access to the device status.

In the system that we have designed, the device status is **represented through a shared 3D view** of the device. A semantic model defines the properties of the device that are relevant for troubleshooting and the way they are mapped from the device sensors to the 3D view. Our system **extracts** the status information from the device that is relevant for troubleshooting and **translates** it into the 3D device representation shared between the local user and the remote troubleshooter. The 3D representation is also used to translate name of parts and operations into visual elements that can be pointed and operated to compensate the lack of technical terminology of the end-user during his dialogue with the remote troubleshooter. Finally, the system provides **guidance** in showing to the remote troubleshooter the actions that can be performed on each component of the device. The remote troubleshooter can select among these actions the ones that s/he wants the end-user to try. Another level of guidance is provided by the interaction protocols defined for synchronizing the two views of the representation according to the activity, which allow, for example, coordinating the provision of controlled step-by-step instructions to the end-users.

In the case of the colour management workflow, **the resources** being shared are the document submitted, in particular the colour specifications, and the printer characteristics i.e. the colours the printer can reproduce, the way colours are rendered, and the actual print queue settings modifying the colour rendering process. Furthermore, available colour correction components might be considered as resources. The printer of the document is aware of the printing capabilities but not of the original intent of the document. Reciprocally, the designer has a precise idea of the intended message conveyed by the colour of the documents but do not know what the capabilities of the printers are and what is the best way to obtain an accurate reproduction of the document intent.

The **shared representation** is constituted on one hand by the comparative soft proof view of the document that motivates the designer to indicate and specify apparent colour problems. On the other hand it visualizes the detected colour issues and their current status. The issues and their current status are included in the document and can therefore be exchanged and solved collaboratively between the designer and the print shop operator. From this visualization both users can engage the problem solving process for each issue. Human perceivable colour differences and any colour settings that can explain the cause of the differences are **extracted** automatically by the system. A colour **translation** technology allows the system to describe both the underlying numeric colour values contained in the document and the observed numerical colour differences between the original document and the printed version in natural language. This makes colour and colour differences easier to appreciate for non colour expert human users. **Guidance** is provided during the problem specification and solving process where natural language templates adapt to each user expertise and concerns. This facilitates the required interaction to specify the colour problem, its relevance and the important aspects to consider, and finally enables solving the problem providing an interface to relevant technical colour processing components.

5 Discussion

The shared representations in our mediating helpers framework are related to the "boundary objects" concept (Star and Griesemer 1989). For example:

- "Boundary objects are artifacts that allow information to be exchanged across organizational, team, and other boundaries" (Phelps and Reddy 2009).
- "They contain sufficient detail to be understandable by both parties utilizing the object, although neither party may understand the full context of use by the other" (Star 1989).
- "Their main purpose is to carry information and context that can be used to translate, transfer, and transform knowledge between communities of practice" (Ackerman 2000).

Actually, our shared representations in connection with the service resources for mediating helpers as shown in Figure 4 are close to "intermediary objects" (Vinck and Jeantet 1995). Intermediary objects act as boundary objects but they are also intermediate states of the product when considering the objects as mediators translating and representing the future product (Boujut and Blanco 2003).

Since their definition from Star a lot of work has been dedicated to study the role played by boundary objects in several contexts and domains, e.g. in group collaboration in construction project teams (Phelps and Reddy 2009), collaborative reuse in aircraft technical support (Lutters and Ackerman 2007), cooperation fostering in engineering design (Boujut and Blanco 2003) to cite a few.

Both the concepts of boundary objects and intermediary objects may be mapped quite nicely onto our framework for mediating helpers. This, it can be argued, may be due to appropriateness of fit but it may also be to do with a certain looseness – and even mobility – of definition. We might make a distinction in terms of the fact that we have a fuller description of the framework for mediating systems – (1) they are CSCW systems, (2) our systems are based on the findings of ethnographic studies that allow us to discover, we would argue, relevant user requirements for the shared representation and assistance, (3) so far they have been applied in situations of organization-customer cooperation in definite tasks, and less for knowledge sharing, and (4) we have a more clearly defined framework in terms of task and resources with three possible levels of assistance: extracted features, translation and guidance.

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