Nallini Selvaraj, Bob Fields (2010):
Mediation Role of Boundary Objects in Articulating Common Information Spaces.
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. 228-238)

Mediation Role of Boundary Objects in Articulating Common Information Spaces

Nallini Selvaraj, Bob Fields
Interaction Design Centre, School of Engineering and Information Sciences, Middlesex University, London, UK
n.selvaraj@mdx.ac.uk, b.fields@mdx.ac.uk

Abstract. In this paper we conceptualize the mediation role of common information artifacts in articulating collaborative work. The artifacts are perceived as boundary objects and are characterized as devices for mediating local and global articulation, interpretive articulation, and organizing coordination. This conception is based on Grounded Theory driven qualitative study of collaboration among heterogeneous work communities in the air traffic control work process. Each work community setting in the airport is taken to be a Common Information Space (CIS), with the airport constituting multiple overlapping interdependent CISs. The common information systems comprising the CIS of different work communities act as boundary objects. These act not only as devices for placing information in common across different work communities but also as devices that help synthesize multiple perspectives and establish common enough interpretation of shared information to undertake tasks collaboratively.

1 Introduction

In the field of Computer Supported Cooperative Work (CSCW), research has been undertaken to provide support for articulation of cooperative work through the construction of information spaces, which are viewed as communication or interaction spaces (Schmidt and Bannon 1992). A number of terms have been used

to describe such spaces, namely, shared workspaces, shared information spaces, shared and common communication spaces, and more recently common information spaces (Bannon, 2000). The notion of Common Information Space (CIS) was put forth as an extension of the concept of shared information space by (Schmidt and Bannon 1992). According to this notion, CIS does not represent just a repository of information to which people have common access but also how different people incorporate it in daily usage and integrated it into their work practices by establishing 'common enough' understanding of shared information. Although some scepticism has been raised by researchers concerning the loose definition of this concept, most researchers seem to perceive a value in this notion. For example, (Reddy, Dourish and Pratt 2001) consider it valuable because the concept "*relates shared information to the activities that are conducted over and through the information*" and "*it offers a perspective on how shared information is incorporated into daily work practices*". The notion is still in its early stages of development and more work needs to be undertaken to strengthen its conceptualization. In the CIS literature, cooperative work has been mainly analyzed by focusing on how information represented in artefacts which are common to different work communities have been employed through the work practices surrounding their use. We perceive these common artefacts as boundary objects (Star and Griesemer 1989) and analyze how they perform various mediation roles to support articulation work in a collaborative work setting.

In the next section we briefly present the data collection and analysis method driving this research. Then the field study setting is described in the form of CIS of an airport. The mediation roles played by artefacts common to different work communities are presented next. Finally, the paper concludes by presenting the contribution of this study to the conceptualization of mediation roles of shared representations in cooperative work.

2 Research Background

The discussion presented here is part of an investigation aimed at contributing to the development of the notion of Common Information Space (CIS). The study focuses on collaboration among different work communities in Air Traffic Control (ATC) work environment, particularly in and around the airport. The work communities studied are the Control Tower, Airlines Crew (pilots), Approach Control, and Operations Centre. Field studies have been conducted at a medium sized airport in the United Kingdom over a period of three years. Data was collected through the ethnographic techniques of observation, semi-structured interviews and concurrent protocol conducted with personnel working in the Control Tower and Operations Centre of the airport. This was supplemented with secondary data sources such as photographs, audio recordings of conversations,

technical documents, and literature on the field site. The discussion presented in this paper is based on the analysis founded on Grounded Theory methodology (Glaser and Strauss 1967).

3 CIS of Airport

The airport is characterized by multiple work communities whose physical establishment is considered to be work centers and are placed in a vastly distributed setting. Each work community setting is perceived to be a CIS with the airport consisting of interdependent overlapping CISs (Figure 1). The CISs are heterogeneous with respect to the physical space, social space, and information space.

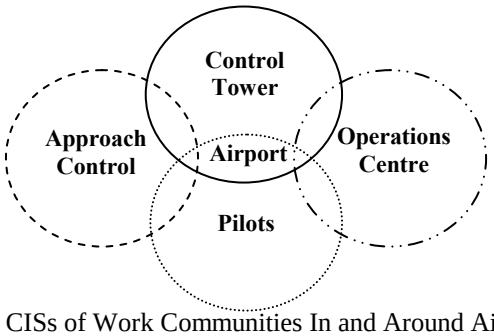


Figure 1. Overlapping CISs of Work Communities In and Around Airport

Among the many work communities residing and functioning within the airport, three central work communities were chosen, they are: the Control Tower, Operations Centre, and Aircraft Pilots. Another work community considered for this study is the Approach Control, which resides outside the airport but is integral to the functioning of the other chosen communities residing within the airport. In this paper, the focus is on information artifacts common to these work communities with the aim of theorizing how they mediate articulation work required to function collaboratively.

4 Role of Common Information Artifacts in CIS of Airport

A framework of the mediation role played by common information artifacts in the CIS of an airport is presented in this paper. Two such artifacts, Flight Schedule Information System and Departure Status Information System, are used to depict the mediation role characterization. These artifacts are considered to be boundary objects and were found to perform various mediation roles based on the practices by which information presented by them was put to use by those utilizing it. The artifacts are characterized as

- Device for Mediating Local and Global Articulation
- Device for Interpretive Articulation, and
- Device for Organizing Coordination

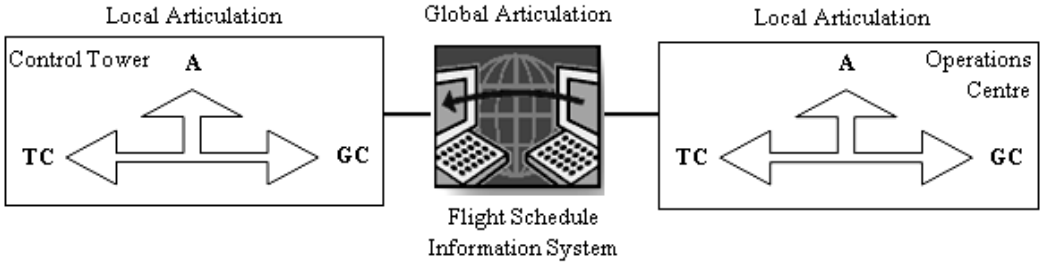
In the ensuing sections each of the above roles is discussed through the concepts emerging from Grounded Theory analysis and illustrated through field data.

4.1 Device for Mediating Local and Global Articulation

The analysis revealed that local articulation is required to coordinate work of individuals within a work community. In addition, global articulation work is needed to manage dependencies among the different work communities and coordinate their activities during task performance. They are not discrete activities and in order to collaborate across heterogeneous work communities in the airport, there is a need to interweave local and global articulation. The following transcript from the field data illustrates this.

> The Assistant has to print the flight strip half an hour before the aircraft has to depart or arrive, put them in strip holders and place it on the corresponding controller's strip racks. For inbound and outbound aircraft, the parking gate number for the aircraft has to be written on the strips. The parking gate number is provided by the Apron Control and is fed into the *Flight Schedule Window* system by them. If the gate number is not available in the system, the assistant has to telephone the Apron Control to find it. She has to check the SLOT time from the *Flight Schedule Window* system and write it on the strip.

In the above transcript, to articulate activities locally within the control tower, the assistant has to articulate activities globally with personnel in another work community, the operations centre, which manages the apron area in the airport. This Flight Schedule Information (FSI) system is a common artefact in that the assistant in the control tower and the ground controller in the operations centre each have their own system through which the two work communities can place and hold information in common (Figure 2). The syntax and presentation of information is standardized in the system, thereby rendering common information representation across multiple personnel.



A – Assistant, TC – Tower Controller, GC – Ground Controller

Figure 2. Flight Schedule Information System Mediating Local and Global Articulation

Three kinds of dependencies are addressed in this scenario. One is the procedural dependency, where the flight progress strips (FPS)[1] (Figure 3) required by the controllers in the control tower are to be provided by the assistant. Also, the gate number (*Stand* [2] in Figure 3) is to be provided by the ground controller in operations centre to the assistant in the control tower through the FSI system.

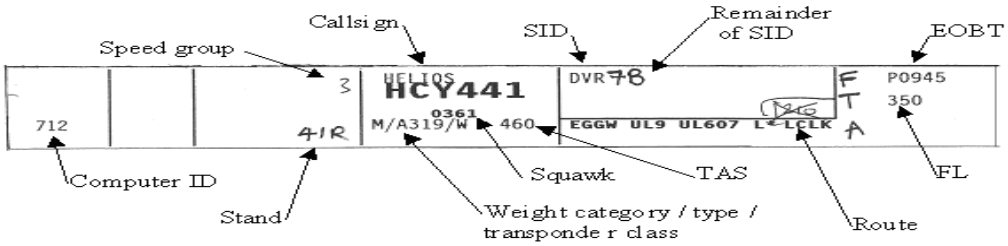


Figure 3. Flight Progress Strip

The task of managing inbound and outbound aircraft by the controllers in the control tower also entails information dependency between personnel. Within the control tower, this dependency between the assistant and controllers is managed by the assistant printing the FPS with information from the Flight Schedule Information System and physically taking it to the controllers to place it on their strip holding bay. The information dependency between the two work communities of control tower and operations centre is managed by the ground controller in the operations centre entering the gate number in the FSI system.

Another dependency to be managed is the temporal dependency. In this scenario it is invoked by the timing of flight strip provision to the controllers in the control tower by the assistant, which is half an hour before an aircraft departure or arrival. Hence, the gate number has to be provided by the ground controller in the operations centre by the time the FPS is printed by the assistant in the control tower. In the event the gate number has not been provided within the required time, the assistant in the control tower telephones the ground controller in the operations centre to obtain the required information.

In this scenario, articulation work taking place within the control tower and between control tower and operations centre is not discreet. The dependencies in the work process necessitate 'meshing' (Schmidt 1994) of local and global articulation work during which the FSI system forms an overlap in the information space of the two work communities. Articulation work taking place within the CIS of the operations centre produces the gate number made available in the FSI system. This in turn is required for articulating activities within the control tower. Thus, the FSI system acts as a device to mediate the local and global articulation work required to manage various dependencies arising during task performance.

---

1 paper strip containing information the controllers need to know about a particular aircraft

2 location in the apron area of the airport where aircraft are parked

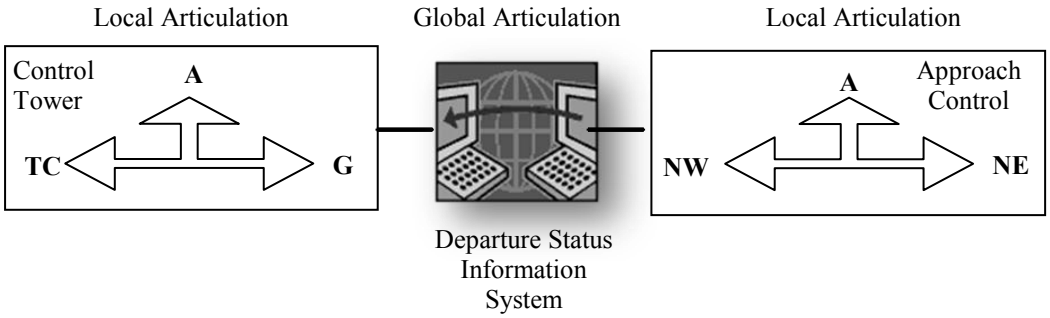
4.2 Device for Interpretive Articulation

One of the main aspects of the notion of CIS is the interpretive component where there is a need to establish common enough understanding of information for communities to work collaboratively (Schmidt and Bannon 1992). An important aspect of this is "Synchronizing Perceptions", a concept derived during the Grounded Theory analysis coding process. Any translation of information placed in common among different work communities is achieved by unfolding the standardization of information representation and adapting it to changing conditions. Since interpretation of common information occurs during task performance, it is relative to the conditions in which task performance takes place. ATC being a dynamic environment, perception of personnel functioning in varying conditions affects the way common information is interpreted and utilized. Therefore, it is vital that sufficiently common understanding of information is established to collaborate efficiently.

The common information artefacts, besides overtly facilitating information sharing also covertly serve other purposes such as revealing contextual conditions, indicating task performance status, and creating situation awareness. This has been revealed during the coding process. An example illustration is the role played by the common information artefact – Departure Status Information (DSI) System – depicted in the following transcript extracted from the interview conducted with the ground controller in the control tower.

> The 'Departure Status Information' screen is used to give messages to the Radar centre as to what state the traffic is in the airport. When I (ground controller) give an aircraft pushback or annotate it with an active sign, the Assistant at the radar centre will put the strip in front of the Coordinator there. When it taxis out to the holding point, our Assistant will then put a hold and again take-off on her Departure Status Information screen. So basically what it is is situation awareness with the Radar centre down the road.

The DSI system is common to personnel within the control tower and between personnel in the control tower and approach control. Each personnel from these two work communities required to collaborate during aircraft departure have their individual DSI system. These systems are linked and facilitate placing information in common across the two work communities (Figure 4). The scenario depicted in the above transcription is that of aircraft departure from the airport. This task requires collaboration among multiple personnel from the different work communities of control tower, aircraft pilots, and approach control. The DSI system provides information about departing aircraft and is represented in the same way across all DSI systems. Personnel in the control tower change information in the system depending on the location of the aircraft during its movement from the stand to the runway. Hence, changes made to this common information artefact reflect change in status of elements in the work environment.



A – Assistant, TC – Tower Controller, GC – Ground Controller, NW - North/West Coordinator, NE - North/East Coordinator

Figure 4. Articulation between Work Communities through Departure Status Information System

The syntax and depiction of information is standardized across these multiple DSI systems to provide a common view (Figure 5). Each row on the screen contains information about a particular aircraft with information representation being similar to that of the paper Flight Progress Strip (FPS). The menu on top of the screen provides options for various functions.

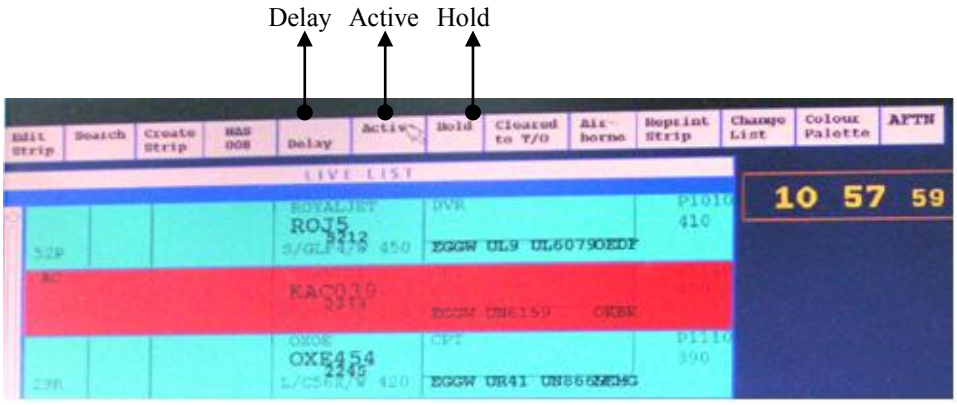


Figure 5. Departing Aircraft Status Information Representation on DSI system

In this scenario, when the ground controller in the control tower has given the departing aircraft pilot permission to push-back from the stand, he annotates the corresponding aircraft information in the DSI system to “active”, which changes the colour (from blue to red) on the system screen. This is reflected in the DSI system of the assistant in the control tower and the radar controller in the approach control. The assistant in the approach control will then print the paper FPS and hand it over to the corresponding controller there.

Then, when the aircraft moves from the stand onto the taxiway and reaches a holding point near the runway, the assistant in the control tower will change the status of the strip in the DSI system to “hold”. This changes the colour of the strip again and gets reflected in the ground controller and radar controller’s systems. In case the aircraft is unable to depart at the allocated slot time after pushback

clearance, the status of the strip in the system is changed to "delay" in which case the assistant in the approach control will remove the strip from the coordinator's strip holding bay. This is illustrated in the following interview transcript with the ground controller in the control tower.

> Delay, if he decided he couldn't go now…if he has got a technical problem or if the passengers haven't turned up, the strips sitting out there now at the Radar Centre (now I've done that), they don't want loads of strips cluttering their bays if they are not going, so if it wasn't anything going I will press the delay button… the assistant would probably go and pick the strip off the display, put it back in the pending bay, to remove the strips off the board because there are a hell of lot of strips down in the Radar because they have a lot of traffic to deal with.

Aircraft information in the DSI system is constantly updated to reflect the changing conditions in the airport. The approach control is spatially separated from the airport and personnel there cannot view aircraft movement in the airport. This system helps overcome the drawback by creating awareness of the state of the departing aircraft across work communities. Based on the information provided by the system, personnel in both work communities can synchronize their perception on the state of the departing aircraft. Updating aircraft departure status through colour coded depiction in the DSI system helps collaborating personnel to achieve common enough understanding of occurrences in the work environment.

4.3 Device for Organizing Coordination

Information presented in the two artefacts – Flight Schedule Information System and Departure Status Information System – are used not only to perform individual tasks but also for collaborating with other personnel. This is because information representation in the artefacts depict various aspects of work performance such as contextual information (status of aircraft departure), decisions made by controllers (give permission for aircraft pushback), and task performance status (aircraft pushback, taxiing, delay). The incorporation of different aspects of work process in the information representation of artefacts allows common information artefacts to function as devices for organizing coordination between collaborating personnel.

For example, the Departure Status Information System mediates temporal relationship between personnel belonging to different work communities. When the ground controller in the control tower highlights aircraft information in the system to "active" or "delay", it triggers an action from the assistant in the approach control. Based on the changes made to this artefact, personnel in the approach control structure their coordination locally such as the assistant placing or removing FPS on the coordinator's deck.

Making changes to common information artefact has various implications for interaction within and across work communities such as triggering, sequencing, and handing over tasks. It not only aids personnel in determining their individual

actions but structures coordination and communication. This is illustrated in the use of Flight Schedule Information System. If the gate number is available in the system, the assistant performs the required coordination within the control tower. If the gate number is not available within the required time the actions performed by the assistant differs. She first obtains the required information from the ground controller in the operations centre by verbally requesting them over the telephone to update the gate number in the system, waits for the information if time permits and then places the FPS on the controller's strip holding bay. Due to the temporal dependency involved in the task performance, if there is not sufficient time to wait for the gate number to be updated, the assistant first prints the paper FPS without this information and hands it over to the controller. She then telephones the operations centre to request the information or waits until it is provided and then verbally gives the gate number to the controller who then writes it on the strip.

5 Discussion

The discussions presented in the previous sections depict how the common information artefacts act as devices that mediate articulation work of personnel from different work communities. The standardization of information representation provides a common language and common frame of reference for personnel from multiple work communities to collaborate with each other. Also, the common information artefacts help people to relate their partial and provincial knowledge. The two artefacts discussed in this paper cater to the varying interests of multiple personnel belonging to the communities of control tower, approach control and aircraft pilot. For example, in the case of aircraft departure, the aircraft pilot aims to depart from the airport within the time slot filed in the flight plan, the ground controller in the tower schedules the aircraft departure in relation to other aircraft waiting to depart and land in the airport, the radar controller in the approach control needs to organize gaps in the airspace surrounding the airport based on the aircraft's departure route and other aircraft movement in the sector. The Flight Schedule Information System and Departure Status Information System mediate the reconciliation of these differing interests.

The common information artefacts present both pre-planned information and dynamic information. Changes made to information representation in the artefacts reflect changes occurring in the work environment during task performance. Personnel holding the artefacts in common are then able to gain perspective of both individual and other's task performance. This is because the artefacts function as "awareness mediators". The use of Departure Status Information System is akin to the way closed circuit television is employed in the Copenhagen ATC centre where it performs similar functions (Berndtsson and Normark 1999). Personnel in the control tower are able to make changes to information representation in the artefact to disseminate up-to-date information about the

conditions of task performance and inform others about the current work situation. The system provides possibility for synchronizing actions by facilitating spatially distributed personnel to oversee the status of other's task performance. This helps the collaborating personnel to anticipate prospective conditions and plan their individual and collaborative work.

The Departure Status Information System in a way acts as the "shared notepad", a label used by (Bentley et al. 1992) to describe the FPS as a public document within the control tower. In this case however, the system is 'public' across communities. It might not permit the same malleability as the paper FPS (Mackay 2000) to make annotations but facilitates establishment of common enough understanding between personnel from different work communities to coordinate their actions. Another feature of the two artefacts is that besides facilitating information dissemination across work communities they also unobtrusively draw attention when required. The artefacts provide possibility for "at a glance" information availability across spatially distributed work communities thereby enabling personnel to oversee each other's activities.

6 Conclusion

The common information artefacts presented in the discussions of this paper are perceived as boundary objects because they capture, transfer, and transform knowledge. They serve to coordinate perspectives and actions of personnel from different work communities by mediating their partial and provincial knowledge. Hence, they are looked upon as mediating devices in the overlapping spaces of different work communities. In the process of exploring information systems common to different work communities we depict how by acting as boundary objects these take on the role of devices for synthesizing different perspectives, planning, organizing, and coordinating work activities across interdependent work communities, thereby uncovering their mediation role in articulating different Common Information Spaces. This paper contributes to the ongoing discussion of mediation roles of shared representation in cooperative work by depicting common information artefacts as devices for mediating local and global articulation, for interpretive articulation and for organizing coordination across heterogeneous work communities.

7 Acknowledgements

We would like to thank NATS, UK for granting permission to conduct the field studies in the airport. We would also like to thank the reviewers of the workshop for their valuable feedback and suggestions.

8 References

Bannon, L.J. (2000): Understanding Common Information Spaces in CSCW. In Proceedings of the Workshop on Common Information Spaces, (Copenhagen, August, 2000).

Bentley, R., Hughes, J. A., Randall, D., Rodden, T., Sawyer, P., Shapiro, D. and Sommerville, I. (1992): Ethnographically-informed systems design for air traffic control. In Proceedings of the ACM Conference on Computer-Supported Cooperative Work (CSCW'92), (New York, November, 1992), ACM Press, 123-129.

Berndtsson, J. and Normark, M. (1999): The coordinative functions of flight strips: air traffic control work revisited. In Proceedings of the international ACM SIGGROUP Conference on Supporting Group Work, (Phoenix, Arizona, United States, 1999), ACM Press, 101-110.

Bossen, C. (2002): The Parameters of Common Information Spaces: the Heterogeneity of Cooperative Work at a Hospital Ward. In Proceedings of the Conference on Computer Supported Cooperative Work (CSCW'02), (New Orleans, Louisiana, USA, 2002), ACM Press, 176-185.

Glaser, B.G. and Strauss, A. (1967): The Discovery of Grounded Theory: Strategies for Qualitative Research. Aldine, New York, 1967.

MacKay, W. E. (1999): Is paper safer? The role of paper flight strips in air traffic control. ACM Transactions on Computer-Human Interaction, 6 (4), 311-340.

Reddy, M., Dourish, P. and Pratt, W. (2001): Coordinating Heterogeneous Work: Information and Representation in Medical Care. In Proceedings of the Seventh European Conference on Computer Supported Cooperative Work (CSCW'01), Kluwer Academic Publishers, 239-58.

Schmidt, K. (1994): Cooperative Work and its Articulation: Requirements for Computer Support. Invited paper for special issue on "Le Travail Collectif", Travail Humain, 57(4), 345-366.

Schmidt, K. and Bannon, L. (1992): Taking CSCW Seriously: Supporting Articulation Work. Computer Supported Cooperative Work (CSCW): An International Journal, 1, 7-40.

Star, S.L. and Griesemer, J.R. (1989): Institutional Ecology, 'Translations' and Boundary Objects: Amateurs and Professionals in Berkley's Museum of Vertebrate Zoology, 1907-39, Social Studies in Science, 19, 387-420.