The Meeting Journey: Supporting the Design of Interaction Within Co-located, Collaborative Device Ecologies.

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To David Benyon

(1954 – 2018)

i Authorship Declaration

I, Aurélien Ammeloot, confirm that my thesis and the work presented in it are my own achievement.

Where I have consulted the published work of others this is always clearly attributed. Where I have quoted from the work of others the source is always given. With the exception of such quotations this dissertation is entirely my own work.

I have acknowledged all main sources of help.

If my research follows on from previous work or is part of a larger collaborative research project, I have made clear exactly what was done by others and what I have contributed myself.

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ii Abstract

The combination of personal and Bring Your Own Device (BYOD) technologies with augmented "smart" spaces designed for collaborative work offers new design challenges for the HCI community. This thesis looks at how BYOD technologies can integrate with such spaces in the context of cross-channel collaboration, from a user experience (UX) perspective. In addition to this, the work looks at how BYOD technologies can replace smart spaces entirely and form space-agnostic collaborative device ecologies.

A series of qualitative empirical studies were undertaken that led to the development of the concept of a meeting journey. The meeting journey is an abstract representation of the different steps, tools and activities undertaken by users in the context of a co- located collaborative activity aimed to inform the design of such systems. The meeting journey helped define a series of design principles for collaborative device ecologies.

Whilst the longitudinal aspects of collaboration have been well covered by work in the area of Computer Supported Collaborative Work (CSCW) and supported by a number of commercial products, the UX of co-located ad hoc meetings have not. Such meetings are still characterised by difficult and awkward interactions due to different technologies, levels of computer literacy and processes.

The concept proposed to improve the desirability of collaborative device ecologies following the design principles previously defined is based on a hybrid approach, built on an extensible framework nicknamed “OIL”. The sharing activities specific to ad hoc collaborative meetings are delegated to a consistent user interface, whilst the ecology retains a platform-agnostic philosophy as to which applications and devices are used by the participants.

The final part of the thesis relates the development of a proof-of-concept hybrid system inspired by OIL, and its evaluation using desirability metrics. This leads to a discussion of the possibilities of extensions to the proof of concept, including support for more steps of the meeting journey, a broader set of functionalities, and a broader range of issues such as security and data ownership.

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iv Publications

Ammeloot, A., Benyon, D. and Mival, O. (2015) 'Design principles for collaborative device ecologies', *Proceedings of the 2015 British HCI Conference on - British HCI '15*, New York, New York, USA, ACM Press, pp. 255–256 [Online]. DOI: 10.1145/2783446.2783598.

Ammeloot, A. (2015) 'Supporting the Meeting Journey', *Proceedings of the 2015 International Conference on Interactive Tabletops & Surfaces - ITS '15*, New York, New York, USA, ACM Press, pp. 463–468 [Online]. DOI: 10.1145/2817721.2820988.

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1 Introduction

1.1 Introduction

The past few years were a vehicle to changes in the way we interact with computers. It can be argued that Weiser's (1991) vision of technologies "(weaving) themselves into the fabric of everyday life until they are undistinguishable from it" has not yet materialised, however latest developments in the domains of mobility and form-factors (smartphones, tablets), cloud computing, the Internet of Things (IoT), and big-data informed intelligence have been a major shift from the workstation-centred approach to computing that has been common from the onset of personal computing. Analysts and specialised journalists often use the term *Post-PC era* to designate this shift. In the workplace, the term "Bring Your Own Device" (BYOD) has been coined to designate people increasingly bringing their own smartphones or tablets in corporate environments. Corporate environments are also increasingly distributed or relying on telecommute and telepresence, which pushes technologists to rethink collaboration, both co-located and distributed. In the meantime, there has been an active research and commercial activity in the domain of "smart" rooms, multi-touch interaction and large surface computing.

The convergence of BYOD technologies and new forms of interaction led a specific branch of research in interactive meeting rooms. Interactive meeting rooms are environments providing computing equipment and room for BYOD technologies to support interactive and collaborative work. There are examples of such meeting rooms in the literature (Bardram, Gueddana, et al., 2012; Bragdon et al., 2011; Wigdor et al., 2009). At Edinburgh Napier University, there are three examples available: small study pods for students equipped with a large screen, meeting room C50 equipped with a very large screen and teleconference equipment and the (now defunct) ICE room, which was completely augmented with interactive screens. These spaces, when used, are instantiations of *device ecologies* (Coughlan et al., 2012; Loke, 2003) i.e. a collection of devices (e.g. computers, tablets), in a specific environment (e.g. a workroom, a study space), that have an established relationship towards each other. Those devices play a role in a collaborative scenario and are "aware" of each other's existence, whether this awareness is literal and supported by technology, or the relationship is established by the users'

workflow. The *ecology* metaphor is reinforced by the fact people can - and do - bring their own devices when using them to work together, introducing a form of *technological diversity*. It is no accident, considering the meaning of the metaphor, that the term *device ecosystem* has also been used (Terrenghi et al., 2009). Device ecologies can be mapped from a very lightweight, ad-hoc form (e.g. a laptop and a smartphone in a coffee shop) to very site-specific implementations (e.g. smart devices in home automation).

The Oxford Dictionary of English defines collaboration as "the action of working with someone to produce something". The convergence of BYOD and collaborative work is a factor leading to many scenarios where device ecologies are formed, either completely ad-hoc or in connection to equipment available in rooms.

Figure 1 staged mock-up of a collaborative activity in the ICE Room at Edinburgh Napier University

1.1.1 Research Motivations

The initial motivations for this PhD project come from over a year's work as a research assistant in the CID and informal observations of people using the ICE.

The room has been in use by staff members since its launch, however its actual patterns of use have been very different from the interaction mock- ups the team has been producing in its design stage (Figure 1). Users of the ICE have been favouring a BYOD approach, reserving the room's screens for presenting content from their laptops or connecting to videoconferences.

This opens up questions about the design of interactive spaces for collaborative work and the integration of BYOD technologies within those spaces, as detailed in the following section.

1.1.2 Research Questions

Based on informal observations and a study of literature available on the topic of collaborative spaces and multi-user interfaces, a set of research questions were drawn out. They are as follows:

- What is the influence of digital support technologies and toolsets for people working in co-located, multi-device ecologies on collaborative activities' user experience (UX)?
    - What tools do people use?
    - What activities do they perform?
    - What framework can help inform the understanding of collaborative device ecologies in order to work on UX impact?
- Building on the knowledge of the first question, what is its value and benefit to those designing and facilitating the implementation of these tools in the future?
    - What design principles can be drawn from the exploratory research?
    - What design and technical approaches can be taken to implement part or all of the design principles?

1.1.3 Research Aims and Objectives

The two research questions above identify two distinct research aims. The first question's aim is to explore the domain of collaborative, co-located, multi-device ecologies and list the impact it has on user experience. Two research objectives will help measure this:

- At first, the thesis will seek to identify the activities and tools in use by users of co-located, collaborative device ecologies.
- Next, it seeks to create a design tool helping to inform and support the future design of such device ecologies.

The second research aim is to identify the benefits to design and implementation practitioners uncovered in the exploratory work. It includes the following objectives:

- Proposing a set of design principles that can help support issues uncovered in the first research aims.
- Proposing one potential implementation that seeks to implement those design principles.

1.2 This Thesis

This thesis is structured into a series of key chapters:

- A literature and methodology review (Chapter 2) will assess past work on the topic of smart meeting rooms, multi-user interfaces, device ecologies and other collaborative activities. It will also cover a number of theoretical frameworks relevant to the area of research and a review of different methodological approaches. This PhD project is not a project about methodology; however, an awareness of different research methods is necessary to inform methodological choices to meet the research objectives.
- The first empirical chapter (Chapter 3) seeks to answer the first research question. It consists of multiple exploratory studies with users of co-located device ecologies at Edinburgh Napier University. It is essentially of a qualitative nature and leads to the creation of the meeting journey, i.e. a tool to represent the different actors in a co-located device ecology scenario.
- The subsequent chapter (Chapter 0) seeks to offer a partial answer to the second research question; it mostly reports a qualitative focus group study seeking to stimulate and generate design principles for collaborative device ecologies. Additionally, it compares some software that existed at the time of the study and reports on a pilot that sought to try metrics for a later evaluation, but this study lead to the generation of additional ideas.
- The last chapter (Chapter 5) is empirical for its most part and consists of the design and evaluation of a prototype implementing most of the design

principles. Additionally, it offers a short positional statement on a possible technical approach to implement such a concept.

- The final chapter is a discussion of data findings, the value of contributions to research and general community, as well as an inventory of future directions of work.

1.2.1 Conclusion

This thesis positions itself in the domain of practical HCI. The main three contributions are the meeting journey, the design principles, and the concept of a hybrid system. This thesis does not position itself as a work of research in the domain of HCI theory or HCI methodology.

The coming chapter is a literature review and methodology review.

2 Literature and Methodology Review

2.1 Introduction

This chapter is a review of available literature on the subject of interactive spaces and multi-user interfaces. Due to their interdisciplinary nature, these topics are at the intersection of a breadth of subjects, including Ubiquitous Computing (Ubicomp), Computer Supported Collaborative Work (CSCW), Human-Computer Interaction (HCI) and more specialised technical domains such as surface computing.

The first part of this chapter focuses on existing work in the domain of interactive rooms for collaboration. Then, it reviews existing works in the domain of multi-user interfaces, among which multi-touch technologies, which have an important place in some instantiations of interactive spaces. Finally, the chapter covers theoretical frameworks relevant to the design of collaborative device ecologies.

2.2 Interactive Collaborative Spaces

This PhD project originated from informal observations of users in a live interactive meeting space located at Edinburgh Napier University: The Interactive Collaborative Environment (ICE). Although it will depart from the domain slightly, some background about the subject is necessary to understand some of the underlying issues.

2.2.1 Early Works

The notion that computing would get away from the traditional mouse and keyboard and Window, Icon, Menu Pointer (WIMP) metaphor goes back to more than two decades. In his article, Weiser (1991) introduced the term *Ubiquitous Computing* (Ubicomp). If the most commonly accepted notion of Ubicomp is more focused on mobile and embedded technologies, the notion of computing adopting different form factors and integrating the everyday environment is relevant to the concept of the interactive rooms. For example, at Edinburgh Napier University, the ICE is equipped with an interactive table-top and a digitally augmented wall-whiteboard that retain their primary functions of table and wall. The computing

element is hidden from plain view and those devices can retain their functions of table or wall, even if the technology is not operational.

Research in early surface computing, more especially multi-touch interaction, has its roots in the 1970s and 1980s. However, it is DiamondTouch (Dietz and Leigh, 2001) that can be identified as the first fully-functional multi-user table-top interface. DiamondTouch is a table fitted with a capacitive touch interface, capable of distinguishing n-point touches with its grid of electrically conductive material located underneath an insulating layer. This capacitive multi-touch technology is commercially available today, essentially in smaller formats. Apple's iPhone™ and iPad™ are widely known examples of capacitive multi-touch. DiamondTouch, however, required the fitting of a projector above the table, which aside from making its installation complex, also caused hands and objects to cast shadows on the user interface.

Research in interactive meeting rooms has also been active since the 1990s. An early example, Roomware (Streitz et al., 1997, 1998) Roomware 2, (Streitz et al., 2002), was part of the Smart Future Initiative at the Fräunhofer Institute. It is based on Streitz's idea of cooperative building. The idea that collaborative meetings still use analogue technologies as opposed to computers and desks, drove them to design several projects including a digital wall (DynaWall), an interactive table, and chairs embedding small tablet computers. They also make use of sensors so the underlying software architecture, called BEACH, can be "aware" of the different devices available and their current setup.

Streitz and his colleagues introduce the notion of *passage*, establishing the relation between the virtual and the physical level. A similar notion called *access point* will later be established by Rogers and her collaborators, with a focus on surface collaboration (Yuill and Rogers, 2012; Hornecker et al., 2007; Rogers and Lindley, 2004).

Figure 2 Roomware (Streitz et al., 1998)

The National Institute for Standards and Technologies' (NIST) *Smart Spaces* project started in the late 1990s (NIST.gov, 2016). The philosophy of the project was more focused on the context-awareness of smart meeting rooms. The envisioned rooms would implement a large number of sensors, video and audio capture devices, as well as technologies such as face or speech recognition. The bulk of their research was toward the establishment of standard tools and formats to deal with the large amount of data associated with the capture of meetings in smart spaces. The project generated a large number of technical publications until 2009.

These early works demonstrate an ongoing interest in the field of Ubicomp and surface computing. However, it was not until 2007-2008 that mobile and multi-touch technologies were made widely available commercially. Apple's iPhone (Apple Inc, n.d.) and Microsoft's original Surface™ were made available in 2007.

2.2.2 2007 onwards: commercial Implementations

The period encompassing 2006-7 can be established as a turning point in the commercial availability of touch-enabled mobile devices and surface computing. Han's paper and TED Talk (Han, 2006) were among the earlier examples of demonstrations of the capacities of multi-touch interfaces in their modern form. He founded Perceptive Pixel, one of the first modern commercial manufacturers of large multi-touch displays. It is also in 2007 that Apple presented the first iPhone™ and Google introduced the Android™ (Google, n.d.) platform. Until that

date, smartphones were mainly a niche product targeted at business customers. Microsoft also introduced its first table-top interface, Surface™ (Bowden, 2017), in 2007. However, Surface™ was not a commercial success. Its small coffee table format made it a niche product, not adapted to a realistic work setup. Other manufacturers such as the Finnish Multitaction (Multitaction Ltd, n.d.) started around the same time.

Following the success of the iPhone™, Apple launched the iPad™ in 2010 (Apple Inc, 2010), bringing the same multi-touch technologies into a 10-inch tablet format. Microsoft launched its own portable tablet in 2012, called Surface™. The previous table-top product was rebranded PixelSense™, following the takeover of Han's Perceptive Pixel the same year.

2.2.3 The ICE at Edinburgh Napier University

The ICE (Figure 3) was a remarkable instantiation of an interactive meeting space launched in 2010 at Edinburgh Napier University. Originally a testing platform, it was used as a real-world meeting room for generic tasks until 2016. The ICE was the first phase of a wider project, exploring the possibilities of augmentation of traditional workspaces by technology, either for co-located interaction, or a hybrid mix of co-located and remote collaborators. The ICE generated a lot of publicity with its blog (Mival, n.d.), a news broadcast (BBC News Scotland, 2010) and coverage in specialised press.

2.2.3.1 Design Philosophy

In their paper, Benyon and Mival (2012) describe the five design principles of the ICE as:

"Be people not technology led.
Be design not engineering led.
Design for simplicity, elegance and joy.
The end product should be fun, productive, engaging and effortless.
Robustness and ease of use above all else."

Figure 3 a photograph of the ICE, Edinburgh Napier University's interactive meeting room (2010-2016, from The Future Interactions Group [http://www.futureinteractions.net/])

The Centre for Interaction Design's (CID) team of designers favoured an approach where the way people work drive the technology, rather than the opposite. This led to some design choices, e.g. the table was designed at worktop height, in opposition to commercial products like Microsoft's original Surface™, which was designed as a coffee table and met very little commercial success in enterprise. The edges of the table were carefully considered to be wide enough to accommodate laptops or notepads, without interfering with its interactive surface. Based on the principle that people like to use whiteboards and flipcharts in meetings, the walls of the room were designed as augmented whiteboards, with special software that can keep track of changes. The table and walls retained their original functionality. If switched off, the table could be used like any conventional piece of furniture. One of its requirements was to be watertight to support potential coffee or beverage spillages. The whiteboard-walls, if used with conventional markers, would fill their purpose, unlike some electronic counterparts that only allow interaction with special hardware.

Figure 4 the Crestron™ interface for the configuration of the ICE. On the left, the zones as input sources, on the right the output screens.

Most of the computing hardware was hidden from plain sight within the walls of the room, which acted as maintenance cabinets. Initially the room was equipped with four Apple Mac minis™ and a Mac Pro™ supporting triple boot, later reduced to three computers. A Crestron™ automation system (Figure 4) was located near the entrance and controlled the configuration of the room.

2.2.3.2 Previous Works on the ICE

The ICE was presented and discussed in several workshops about blended interaction and collaboration (Jetter et al., 2013; Benyon and Mival, 2012). The project's publicity also generated a series of collaborations with the industry, including major clients like in the domain of oil & gas, pharmaceuticals, and ICT (Mival, n.d.).

The room was the ground for several student projects. Two related MSc projects were conducted in 2010 in the context of news publishing, multimedia stories were built collaboratively from the table, aimed at being consumed on multiple media, such as the web, phones or tablets. One project focused on the multi-touch interface while another investigated existing electronic publishing solutions for the end product.

In 2013, a student worked on a multi-touch, multi-user environment to support character sheets and geographical progress for the role-playing game Dungeons and Dragons.

The main focus of those dissertations was the design and development of surface applications, using the ICE as a deployment platform. They did not study the room as an instantiation of a multi-screen collaborative ecology.

2.2.4 Other interactive meeting spaces

Wespace (Wigdor et al., 2009) was a room project in cooperation between Harvard and Mitsubishi Labs. Wespace is a meeting room with a large wall display and a large multi-touch table. Wigdor and his colleagues worked in collaboration with a group of astrophysicists and examined their workflow through an extensive ethnographic study. They identified four phases in the group's workflow when they are working on a research publication: proposal preparation, data reduction, data analysis and write-up. From their ethnographic data, they retained the following requirements for the room: provide a shareable display, allow the use of laptops, maintain interactivity of existing applications, retain user control over data, support egalitarian output and provide a record of the meeting. The room has to cater for different individual practices and existing bespoke software written by the group.

The authors of Wespace refer to a system called IMPROMPTU (Biehl et al., 2008) used to share existing application windows across multiple devices, but it won't allow for multi-touch input. Instead they developed their own solution: a server running the table and the wall, as well as lightweight clients based on VNC to share the content of laptop screens on the wall. They also developed tools, including a layout manager and an overlay Application Programming Interface (API) for the image coming from laptops. Their evaluations based on quantitative and qualitative data bring out the following guidelines:

- make the process win-win
- set expectations
- let participants take ownership of the process

The latter point, about retaining ownership of the process will inform one of the design principles in Chapter 0.

ReticularSpaces (Bardram, Gueddana, et al., 2012; Bardram, Houben, et al., 2012) is a project by Bardram et al. applying *Activity-Based Computing* (ABC) to an interactive smart space. The space provides a digital wall, table-top and mobile devices. The project's software offers a unified user interface, distributed over all different types of devices. The space does not give access to standard applications and follows a high-level approach specific to ABC. ABC is covered in more detail in a later section of this chapter (2.6.4).

Code Space (Bragdon et al., 2011) is another example of smart space, developed by Microsoft Research in Redmond. Code Space is a room equipped with a wall-mounted surface and a set of Kinect™ cameras.

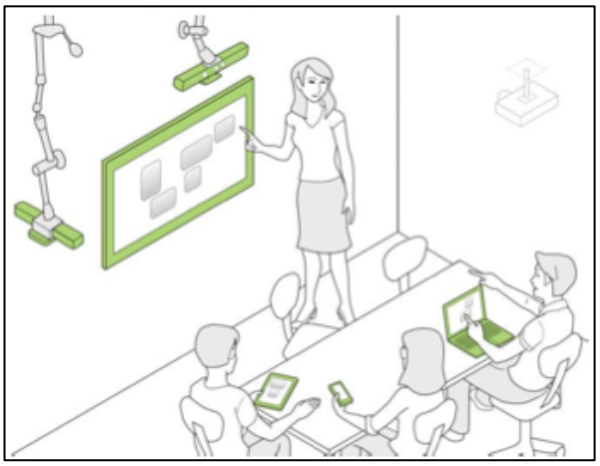

Figure 5 Code Space (Bragdon et al., 2011)

Bragdon et al's paper studies the cohabitation of touch and gesture interface within an ecology of mobile devices to support specialist meetings of developers. The philosophy of the project is to "address many of the democratic access and sharing problems developers face today". The study looks into making interaction with the surface from a distance possible, by the tracking of hand gestures and mobile devices, with a focus on social acceptability of gestures. Their user evaluation is generally positive.

2.2.5 The notion of 'device ecology'

Coughlan et al. (2012) use the term *device ecology* to describe a set of distinct devices used by multiple users with a common goal (definition in 1.2). The term was previously coined by Loke (2003). The term has a connotation in connection with the natural world. It refers to biodiversity and interdependency.

Coughlan and his colleagues conducted a study of device ecologies applied to learning activities. Their setups include laptops, a table-top interface and a large projected screen. They make note of the main focal character differences between the table, projector and laptops and produce a large quantity of qualitative data relative to focus and transitions. The authors stress the importance of providing niches with different levels of focal character to accommodate different styles of collaboration, including individuals and sub-groups. This could for example be instantiated in different user interfaces, form factors, seating configurations etc based on the granularity of what is being worked on.

2.2.6 Specific vs. Generic activities

Each of these examples offers different insights on the design and implementation issues for collaborative device ecologies. Bragdon et al. or Coughlan et al.'s examples provide sensible guidelines for the design of such spaces; however, they are limited to very specific activities, i.e. scientific meetings and learning. The same issue applies to Code Space, focusing on groups of developers in a major software company. Also, the authors describe their evaluation as pilot study that may not be generalisable. ReticularSpaces is built upon a pre-existing framework (2.6.4) for the support of collaborative activities, that will be reviewed further in this chapter. However, it also focuses on a specific activity (developer meetings) and their UI approach, which removes access to applications completely, has not been evaluated in comparison to a more traditional desktop / application approach. These examples offer a wide range of designs and approaches to collaborative ecologies, for a fairly narrow and specialised range of activities. There is a lack of comparative studies of these different approaches applied to a broader range of activities.

2.3 Surface Computing and Multi-User Interfaces

There have been a lot of publications related to Surface Computing since 2007. The ACM conference on Interactive Spaces and Surfaces (ISS) is a major publication vehicle in the field, but works are also regularly published in more general HCI conferences like CHI, or journals like ACM's Transactions on Computer-Human Interaction (TOCHI).

2.3.1 Collaboration with surfaces

The community has had a vibrant interest in collaborative surface computing for years. Larger surfaces are good vehicles for larger multi-user interfaces and can enable collaboration. In 2004, a few years prior their wider commercial availability, Rogers and Lindley (2004) published an empirical study on the subject of collaboration around large screens. They compared horizontal and vertical surfaces in the context of a collaborative scenario involving tourism and problem solving; they found out that participants were more likely to collaborate around a table-top due to the increased awareness of other people's actions. The interactive screens used a Mimio™ pen as a pointing device, as multi-touch technology was not yet commercially widespread. A more recent study by Yuill and Rogers (2012) this time including multi-touch technologies, also identifies awareness of others' actions as a key mechanism for the design of multi-user interfaces. This will be discussed further in (2.6.2).

Many case studies of collaborative table-top systems have been published in recent years. uEmergency (Qin et al., 2012) uses an interactive table to manage emergency response situations. Zancanaro et al. (2012) designed a system called Negotiation Table using co-narration to resolve conflicts in the context of the Israeli-Palestinian issues. Re-Collision (Tozser et al., 2012) is a study of a table-top interface in use within a forensics and collision reconstruction police department. Although a tabletop alone would not constitute a device ecology, their role in collaborative scenario could potentially be central to a broader ecology environment.

There has also been research in the domain of arm embodiments, materialising other people's arms on screen when users of a table-top are distributed across

multiple locations (Doucette et al., 2013; Genest et al., 2013; Genest and Gutwin, 2012). These are more relevant when participants are remote and need to be materialised.

2.3.2 Surfaces in public settings

There is a body of research available regarding surface computing in public settings. An early study by Hornecker (2008) consists of a table-top computer in a museum in Berlin. Aside from a few usability issues, visitors generally engaged with the table as a medium. However, few discussed their engagement with the actual educational content offered by the table. CityWall (Peltonen et al., 2008) was an experiment with a digital wall in Helsinki that highlighted interaction conflicts associated with large, shared, interactive surfaces. Those territorial conflicts also appear in Marshall et al.'s (2011) table-top day planner installed in a tourist information office in Cambridge. To tackle those territory issues, Klinkhammer et al. (2011) worked on an adaptive multiple-single-user interface in a museum setting. Their table-top made use of a tracking system to detect users and a set of eight speakers connected to different channels.

Although co-located device ecologies are in private settings, issues highlighted with multi-user tabletop interactions can be relevant to their design, if such technology is included in a setting.

2.3.3 Common ground between public and private surfaces

Most of these studies focus on collaboration around a single device, typically a table and do not integrate the notion of device ecology. However, design principles from these publications can be retained. Even if surfaces do not suit all tasks that can be performed in collaborative device ecologies, they offer qualities for certain tasks, like those requiring real time visualisation and manipulation of data by more than one person.

2.3.4 Integrating surfaces to device ecologies

Mobisurf (Seifert et al., 2012) opens up to the notion of device ecologies by adding personal mobile devices to a single surface and studies the integration of personal

portable devices and fixed surfaces to perform collaborative tasks within a household. This example brings the research in surface computing to the area of device ecologies. In this example, the transfer of data between the smartphones and the table are supported by a technology called PhoneTouch (Schmidt, 2010) based on optical discrimination between finger and phone touches. BEMViewer (McGrath et al., 2012) explores the transition between decoupled (tablet) and coupled (table) collaborative work in the context of the visualisation of large datasets.

2.4 Other Technologies and Interactions

2.4.1 Proxemic and gestural interfaces

This section covers other available forms of interaction that could have a place in an interactive collaborative environment.

Greenberg, Ballendat and their colleagues have been working on the notion of *Proxemic Interaction* (Greenberg et al., 2011; Ballendat et al., 2010) in recent years. In his book *The Hidden Dimension*, Hall (1966) defines proxemics as the "the interrelated observations and theories of man's use of space as a specialized elaboration of culture". Research in proxemic interaction seeks to understand how to integrate the distance, movement and orientation of users towards technology as part of the interactive experience. Greenberg's group at the University of Calgary has been working on various proxemics setups influencing the experience of digital surfaces. Marquardt (Marquardt, 2013) previously chaired a tutorial session on proxemics and surfaces at ITS'13.

Greenberg et al.'s work especially highlights how proximity to different endpoints can be used to identify users, authenticate and potentially adapt the user interface to different scales of interaction.

2.4.2 Wearable computing, augmented and virtual reality

Wearable computing is a booming market. So are augmented reality and virtual reality. When this research project started, the Apple Watch™ and its main competitor Android Wear™ were not the established products and brands they are now. The hype around the now defunct Google Glass has faded away and it is now

marketed as a niche product. Oculus VR (Facebook, n.d.), Google VR (Google, n.d.) are exploring virtual reality (VR). Apple has announced a strong focus on augmented reality (AR) in iOS 11 with ARKit (Apple Developer, n.d.).

These now mainstream technologies are not yet as commercially widespread as mobile devices and surfaces, however their influence on working practices and meeting environments are to be monitored. This thesis does not review the years of research and publications that lead to these commercial products being made available, however it is a possibility that they will be introduced in the working environment eventually.

2.5 Groupware and other CSCW works

Researchers in the area of Computer-Supported Collaborative Work (CSCW) also show a growing interest in new forms of interaction supporting collaborative work, albeit with a more theoretical approach. Two forms of groupware have been discussed in the field and are relevant to the multi-device ecologies: *Single-Display Groupware* (SDG) and *Multi-Display Groupware* (MDG). Stewart et al. (1999) came up with the notion of SDG to designate shared multi-user interfaces. This notion was discussed before the wider availability of large interactive surfaces and studies were still conducted using multiple mice and keyboards up until recently (Wallace et al., 2009).

MDG is used to designate collaboration distributed over multiple devices as opposed to SDG. Wallace et al. studied the appropriateness of SDG over MDG on various scenarios which pointed that SDG was more suited to the general awareness of a situation where MDG was more appropriate for the conduct of individual tasks. Some HCI studies mentioned previously were published in conferences relevant to the area of CSCW (Doucette et al., 2013; Genest et al., 2013), indicating that the delimitation between both areas of research can be rather fluid when the research focuses on the domain of interaction in the context of collaboration.

Hybrid device ecologies can be defined as a form co-located MDG as many devices can have an individual focus, however the presence of a table-top of multi-user

surface, like in the ICE, has a potential to turn those spaces into hybrid MDG/SDG applications.

2.6 Theoretical Frameworks

This section will look at published theories and frameworks relevant to the domain of collaborative device ecologies. Some available literature makes use of the ICE, but other publications offer a more general view on issues related to the design of systems supporting collaboration or multiple users.

2.6.1 Blending Theory

In *The Way We Think*, Fauconnier and Turner (2002) introduced the notion of *Conceptual Blending* as a creative process. In their field of linguistics, they describe *Blending Theory* as the creation of new mental domains, called *blends*, from the blending of two domains sharing characteristics with a third, generic, domain (Figure 6).

In *Designing With Blends*, Imaz and Benyon (2007) establish a relationship between Fauconnier and Turner's theory and modern HCI and Software Engineering. In HCI, they cite the example of computer windows as a blend. Computer windows mix the characteristic frame of windows traditionally found on buildings, with a set of computer-specific characteristics, such as a list of files, a scroll bar, resize buttons or a title. Both spaces share the common concept of "looking at something".

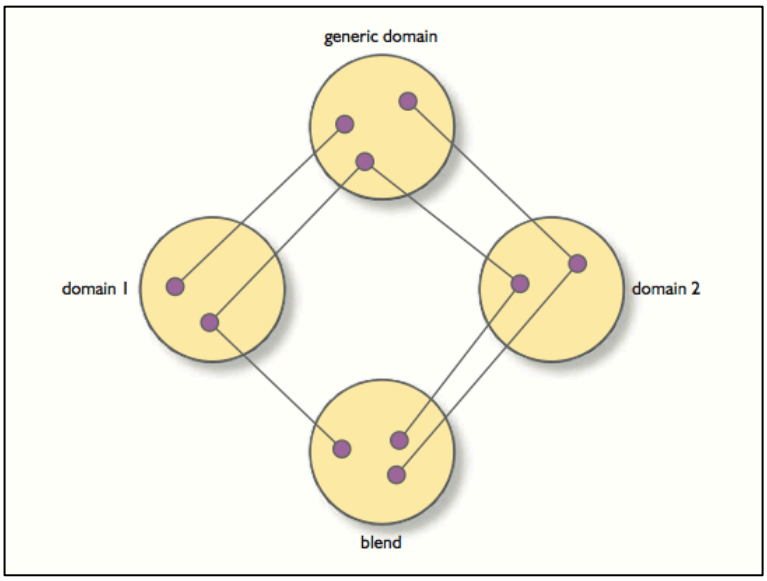

Figure 6 Blending theory, from (Benyon and Mival, 2015)

Benyon and Mival (2015) describe the ICE as a *blended space* (Figure 7) and offer a framework for the design of collaborative blended spaces. The ICE was also previously featured in two workshops on Blended Interaction and Collaborative Spaces, in Capri (Jetter et al., 2012) and Paris (Jetter et al., 2013).

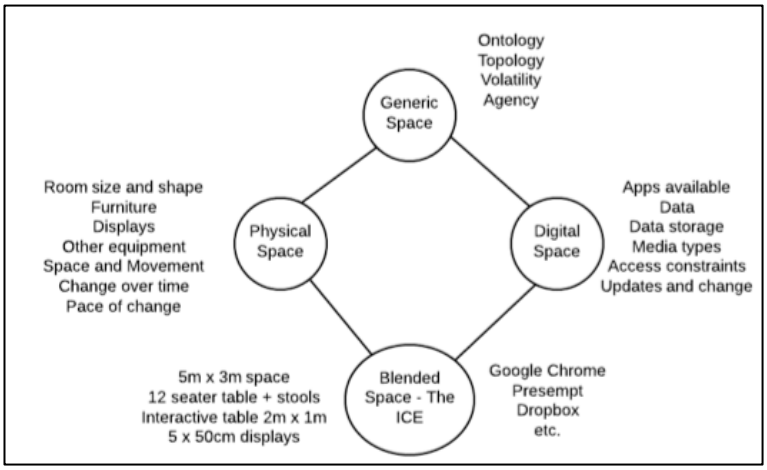

Figure 7 The ICE as a blended space (Benyon and Mival, 2015)

Blending theory applies well to the design of the ICE, which is augmenting existing features of a room with technology, however, is does not translate well for other examples of spaces supporting collaborative device ecologies. More conventional spaces, like meeting rooms or the study pods at Edinburgh Napier are not driven by the notion of augmentation and instead offer a clear separation between technology and space.

2.6.2 Mechanisms for Collaboration

In their 2012 paper on multi-user interfaces, Yuill and Rogers (2012) introduce three main mechanisms for the design of multi-user interfaces: *awareness of others, control over interactions, and availability of information*. The paper presents three different collaborative case studies, each of which is deployed in two different versions, using separate or shared controls and different levels of constraint. The authors stress the importance of those three mechanisms in a non-prescriptive way, leaving the final decision to designers and their requirements. However, the case studies of these publications are all centred on shared interfaces: a table-top, tangibles, and augmented toys. They do not integrate the notions specific to multi-device ecologies, such as the different focal points identified by Coughlan et al. (2012) or issues arising when foci and information are transitioned from a device to another.

2.6.3 TACIT

Benyon and Mival (2015) drafted the TACIT Framework for the design of interactive collaborative environments. TACIT stands for *Territoriality, Awareness, Control, Interaction and Transitions*. This Framework was developed at Edinburgh Napier University, from the observation and experience of using the ICE.

TACIT maps well with multi-device collaborative ecologies. Territoriality is a key issue when several people collaborate with the same space. It covers the physical territoriality conflicts as much as the separation of private and shared information. Awareness of others' actions is key when working together in a shared space as much as working apart before putting things together in a meeting. Control designates the process by which people decide to control shared technology. Whether someone is in charge, or people use a democratic or synchronous process. Transitions, according to the authors, applies to the digital/analogue transitions in the ICE as a blended space and act like Rogers' notion of entry point. But the notion of transition can also be applied to the transition of foci from private screens to shared outputs. The notion of Interaction is interesting as it maps to the way people interact with each other as well as technology. However, as per the current

literature, there is not just one way to design the interactive experience of such spaces.

Although both these frameworks offer relevant principles for the design of collaborative environments, it seems TACIT maps out better with the issues relevant to multi-screen instantiations of collaborative device ecologies. They both, however, offer no support for the broader continued activities that accommodate sessions of co-located collaboration.

2.6.4 Activity-Based Computing

Bardram (2005) offers a framework for distributed collaboration in Ubiquitous Computing named *Activity-Based Computing* (ABC). ABC is an evolution of traditional task management in the context of desktop computers towards a more abstract, goal-driven management of activities, to which several services and sets of data are associated.

Bardram defines activities over three dimensions:

- *Task and Material,* i.e. a task that needs to be accomplished and the data necessary to accomplish this talk.
- *Time and Space*, i.e. the activities are persistent over time and can be performed in a distributed manner over many devices.
- *Users;* activities are collaborative by nature. The awareness of others' actions is key to understanding the state of an activity.

ABC implementations already generated many practical case studies and publications (Houben and Bardram, 2013; Voida and Mynatt, 2009; Bardram et al., 2006), however it is ReticularSpaces (Bardram, Gueddana, et al., 2012; Bardram, Houben, et al., 2012) that is notable for bringing the concept of ABC to an interactive collaboration room. ReticularSpaces embraces the concept of ABC fully and removes access to applications altogether, requiring the development of a completely bespoke user interface. The approach seems to have a limited deployment ability in a world that adopted many industry standard applications for business or creativity.

2.6.5 McCullough's Places

ABC offers a high-level view on computing task management by encapsulating them in activities. However, activities in Bardram's definition are very specific and it seems a more generic classification is needed to define different types of activities that can take place in the ICE. In his book *Digital Ground*, McCullough (2004) defines eleven types of activities and their associated places at work:

Deliberating (places for thinking)

Presenting (places for speaking to groups)

Collaborating (places for working with others)

Dealing (places for negotiating)

Documenting (places for referencing resources)

Officiating (places for institutions to serve their constituencies)

Crafting (places for skilled practice)

Associating (places where businesses form ecologies)

Learning (places for experiments and explanations)

Cultivating (places for stewardship)

Watching (places for monitoring)

For example, many activities observed during this thesis project, that took place in instantiations of collaborative spaces, could be identified as deliberating, presenting, collaborating or documenting. They are usually a combination of several of those and some activities, like the collaborative creation of a document or presentation can fall in more than one category (i.e. deliberating and crafting).

2.6.6 Design tools

The notion of customer (or user) journey is a more recent addition to the collection of representations available for interaction designers (Howard, 2014; Teixeira et al., 2011). A user journey is a representation of all the ways a user – or customer – will access a service. These different access points to the service are called touchpoints. The main design challenge is to design such touchpoints to provide a coherent user

experience. Take the example of train travel. A person may be made aware of a promotional offer for travel watching a television advert. They can then browse the train operator's website on their desktop computer to choose different dates and seats and leave it there. A few hours or days later, then can finalise the transaction using a smartphone app and pick up their ticket using a ticket machine at the station. These different touchpoints can be both digital and physical.

Patrício et al., (2011) recommend drawing up a list of touchpoints in order to create a service blueprint. This representation is sequential. It works in theory but in reality, few users will follow the perfect sequence defined by designers. The next chapter in this study will focus on identifying the different activities and touchpoints in the context of technology-supported collaborative meetings.

Benford et al., (2009) developed the notion of trajectory and also developed a framework for the design of complex "cultural applications". The work is influenced by the domain of interactive arts, but it does mention the notion of "hybrid ecology" with a meaning similar to Loke's (2003) device ecologies.

2.7 Methodologies

This section is a brief review of a research methods relevant for this thesis. The research questions lead to three different phases: investigation, design, and evaluation. The next few pages will explain which methods will be selected for pursuing the research project. This chapter does not seek to explain the methodology in detail, as this is described in more detail in relevant chapters. This chapter is more like a high-level rationale of the methodology used.

2.7.1 Ethnography

The first study used a form of *ethnographic* observation (Lazar et al., 2017a), e.g. an observation of real-world users of rooms such as the ICE or alternatives. The idea was to obtain data showing situated actions (Suchman, 2006) where the influence of the environment is shown on human-machine interactions. Initially, this was meant to be the pilot for a larger-scale study involving industry contacts, however

as access issues arose this became a small set of data used to frame a subsequent study in a more controlled academic environment.

An issue with ethnography can be of an ethical nature, with consent more difficult to obtain from all individuals involved. Institutions may have a procedure of *assumed consent* for such situations, involving the listing of participants and a risk assessment of the implications of the study. In the case of this specific thesis, the main point of interest was how the devices were used, not what was actually discussed at meetings. The procedure of assumed consent was followed, and the assessment showed that confidentiality and data protection risks were negligible. However, a number of approached individuals still refused to take part in the observations.

2.7.2 Semi-Structured Interviews

The follow-up study of the initial observations is using two methods of qualitative data gathering and analysis. Firstly, it is using a model of data collection called *semi*-structured interview (Lazar et al., 2017b) which follows a loose structure of high-level questions and follow-up, more focused questions. However, it allows for the researcher to get off script to discuss specific points more in-depth.

The data analysis stage of the second study followed a structure informed by Strauss & Corbin's Grounded Theory (Lazar et al., 2017c) using the following structured:

- Transcription of the collected data into a textual form.
- Open coding, i.e. coding interview "nodes" with a number of themes identified as they are being coded.
- The codes used in open coding are then named and grouped into a set of coherent categories.
- Another pass of coding on the data, with the themes in mind, allows for a more comprehensive and thorough coding.

More strict interpretations of grounded analysis require other passes of coding (transversal) however in the case of this study the themes were used to constitute the main backbone of the meeting journey. This methodology is useful when

analysing a set of data without a strong hypothesis or premise, however the result can be affected by a researcher's own bias.

2.7.3 Focus groups

The main study that led to the drafting of the design principles used the same data analysis method as above, however, the data was collected with the help of two focus groups. The focus groups were recruited among a cohort of postgraduate students with some literacy in the domain of Human-Computer Interaction and Interaction Design. This is a deliberate action to obtain articulated opinions on a number of specific problems that were presented.

2.7.4 Designing a hybrid solution

The hybrid solution tested in the last study was informed by a number of different steps informed by standard design techniques such as user-centred design (UCD). A first step involved building a number of proto-personas and writing scenarios. Real-world users encountered in the studies leading up to the design phase were synthesised into personas. It also involved writing a collaborative scenario involving a number of activities, part of the meeting journey. The idea was to use the scenario for a more controlled observation of users experimenting with technology in a room equipped with technology forming a device ecology.

The personas and scenarios formed one part of the design process for the ecology, the other part was formed by the design principles and data obtained by a comparative analysis of different systems. The concept of hybrid system is described in chapter 6, as well as some wireframes representing user interface ideas.

2.7.5 Evaluating

The evaluation of the hybrid system, described in chapter 6, was the object of a within-subject experimental design. The aim was to get 8 pairs of people perform a number of tasks which were part of a scenario involving research of information,

creation of artefacts (presentation) and exchange of data in the context of a collaborative device ecology.

The data collection process in this context can prove to be challenging. One viable option available to gather user impressions about a system is to use a *think aloud* approach (Lazar et al., 2017a) where users express their personal impressions about the system whilst using it. The issue is that this is more difficult to implement with more than a single user.

Another challenging aspect of the data collection process is usability data. Measuring the time taken to perform tasks, or other elements such as the number of errors, can be fairly straightforward in a highly controlled environment. It proved something fairly simple to implement using a video camera when the baseline was established, however it was more difficult with the software prototype – deployed on a MacBook Air™ and an iPad mini™. To what extent should users' movements and actions be restricted in order to get appropriate camera angles? Screen recording software made the capture of the laptop simple, but the iPad proved problematic.

Eventually, as the usability data proved problematic and think aloud was not deemed suitable, the focus of the evaluation ended up being on a more experiential angle. Two metrics were used for the user experience data on the evaluation: quantitative data in the form of an adapted Attrakdiff (Hassenzahl et al., 2015) questionnaire augmented with an informal process of qualitative data collection. The idea behind Hazzenzahl's questionnaire is to measure the attractiveness of a system on three different aspects: pragmatic qualities, which focus on the practical sides of a product, and hedonic qualities, focusing on stylistic and pleasurable qualities. The questionnaire uses *semantic differential scales*.

2.8 Conclusion

This chapter reviewed relevant literature available about interactive rooms, multi-user interfaces and applicable theories for the design of collaborative device ecologies. The diversity of work and technology already available is evident. However, some lessons can be kept from the studies:

- Most co-located collaborative device ecologies are designed with a specific activity, workflow, or process in mind. In that respect, the ICE was a notable exception.
- There is research to be done covering more ad-hoc setting and looser processes, as more flexibility in the use cases of the rooms designed can make them more attractive to implement.
- Examples favour a high-level bespoke user interface; however this is not always compatible with the requirement of more 'generic' users.
- A broad range of technologies already exists, which can support interaction in device ecologies.

3 Exploratory Studies: The Meeting Journey

3.1 Introduction

The literature review highlights gaps in the knowledge of collaborative interactive systems. For a start, there is a large body of literature on interactive spaces and smart rooms. Most examples cover forms of collaboration that involve a rigid process e.g. (Bardram, Gueddana, et al., 2012; Bragdon et al., 2011; Wigdor et al., 2009). A focus on looser work processes and more ad-hoc collaborative scenario opens more possibilities of coverage for different applications of technology in the collaborative workplace, as well as additional challenges.

The early stages of work consisted in observing a number of meetings held in the Interactive Collaborative Environment (ICE) or other venues adapted for multi-screen, cross-channel interaction scenarios. This was followed by a second study, interviewing users of the ICE and students working as groups in interactive study pods. This body of data helped identify the activities and tools in use by users of a number of co-located device ecologies, leading to creation of the meeting journey. The meeting journey is a mind-map-like tool helping to support the understanding of given collaboration scenarios in a bid to design technological solutions.

This chapters aims to provide answers to the first research question:

- What is the influence of digital support technologies and toolsets for people working in co-located, multi-device ecologies on collaborative activities' user experience (UX)?
    - What tools do people use?
    - What activities do they perform?
    - What framework can help inform the understanding of collaborative device ecologies in order to work on UX impact?

The first two empirical studies aim to understand the tools and activities angles. The meeting journey is a framework proposal to address the last point.

3.2 Study 1: observations and classification of device ecologies

This initial small-scale study took place in Spring 2013, over the course of a few weeks. The general idea of the study was to observe and report a number of meetings taking place in instances of collaborative device ecologies available on site at Edinburgh Napier University (ENU). This chapter will report four examples and will seek to establish a model to identify activities and technologies in use in those types of meetings. Meetings observed took place mostly in ENU's Interactive Collaborative Environment (ICE) with the exception of one instance, where a conventional meeting room was set up with a number of PC workstations for the occasion.

3.2.1 Methodology

This study uses observations and note-taking. The observation methodology does not make use of a formal ethnographic approach; it was initially a pilot for a larger ethnographic project in a corporate environment which was cancelled because of access issues. However, the observations still provide useful data with a sufficient granularity of information to categorise toolsets and activities used in the meetings.

The observations were captured in situ by handwritten notes, then summarised electronically using a note-taking and diagramming tool (when relevant). The observations focused on the use of devices rather than the content of the discussions.

When reported electronically, the activities were classified using McCullough's (2004) classification as reviewed in section (2.6.5).

The electronic hardware was classified whether it falls into the *Bring Your Own Device* (BYOD) category or not. The definition used for BYOD in this thesis is one of a personal device (e.g. laptop, smartphone, tablet) brought into a collaborative environment by an end user and which is made use of for working purposes. Whether the device was purchased and configured by the employer or the user can be relevant to the discussion about configuration and security, however the general

approach of this thesis is one where the non-BYOD devices belong to the room and BYOD devices are brought into the room.

The software used does not follow a specific classification, however there is a link between the activities performed and the applications in use.

3.2.2 Example 1: EU coordination action project

3.2.2.1 Description

ENU hosted an EU-funded Coordination Action Project in Interaction Design (IxD), which aimed to identify key issues and coordinated a key research community in an emerging topic. The main project coordinators were located within ENU's IxD research centre. Other partners, academic or industrial, were spread over different European countries.

This meeting was a 2hr launch meeting for the initiative, hosted in the ICE, and including remote participants taking part in a group videoconference.

3.2.2.2 Meeting information

- Location: ICE
- Number of people on site: two, coordinators of the project.
- Number of people connected remotely: three, in different parts of Europe. The teleconferencing system is GoToMeeting™ by Citrix (LogMeIn Inc, n.d.)

3.2.2.3 Identified activities:

- Deliberating: participants made decisions about upcoming events, such as a summer school or a publication agenda.
- Presenting: participants present the current state of affairs to each other using the videoconference system.
- Collaborating: participants shared information and links to each other. At a point, there were two conversations going on simultaneously. One was a

verbal exchange from the room to a remote participant whilst another was an instant messenger chat from the room to another remote participant.

- Documenting: One of the participants used their iPad™ to look for Internet information and shared the content using GoToMeeting's Internet chat. She also used the feature to take minutes of the meeting.

3.2.2.4 Technologies:

- BYOD: an iPad™, an Apple MacBook Air™, an iPhone™.
- Non-BYOD: the main wall screen in the ICE, used for the videoconference. This is identified as a non-interactive shared interface.

3.2.3 Example 2: Remote Progress Review

3.2.3.1 Description:

Progress Reviews (RD6) are semi-annual meetings held for every PhD student at ENU. They involve the student, their director of studies and other supervisors, as well as their panel chair, which holds the role of an external observer of the student's progress.

Figure 8 PhD progress review in the ICE

While the majority of students are working on-site, a handful of them are actually living remotely due to personal circumstances. A typical meeting can last from 30 minutes to an hour.

3.2.3.2 Meeting information:

- Location: ICE
- People on site: three. The director of studies, the second supervisor and the independent panel chair.
- Remote: one. The student located remotely.

3.2.3.3 Identified activities:

- Presenting: the student has to write a short report, which is read by the panel ahead of the meeting. They have to summarise their progress for the previous 6 months and answer questions from the panel chair about the risk contained in their following 6-month plan.
- Deliberating: the members of the panel fill in a progress review form and make a decision whether the student is allowed to proceed with their research and target degree.
- Collaborating: the decision is a group decision, with a strong input from the Panel Chair.

3.2.3.4 Technologies:

- BYOD: none, people brought pen and paper.
- Room: the main screen, used for videoconferencing using Skype

3.2.4 Example 3: School Exam Board

3.2.4.1 Description:

Edinburgh Napier University's module boards take place every trimester. Chaired by the head of school, the boards' purpose is to review the grades obtained by students for every module. If necessary, the teaching conditions are discussed, and

moderation is applied to the grades. The results of individual students are not discussed there, but at the programme boards instead.

3.2.4.2 Meeting information:

- Location: room D40, Merchiston Campus Edinburgh Napier University.
- People on site: about 20. The head of school, chairing the meeting. A school administrator taking minutes, another administrator controlling the information displayed on the screens.
- Module leader and teaching staff, either sitting at a monitor or in the back of the room.

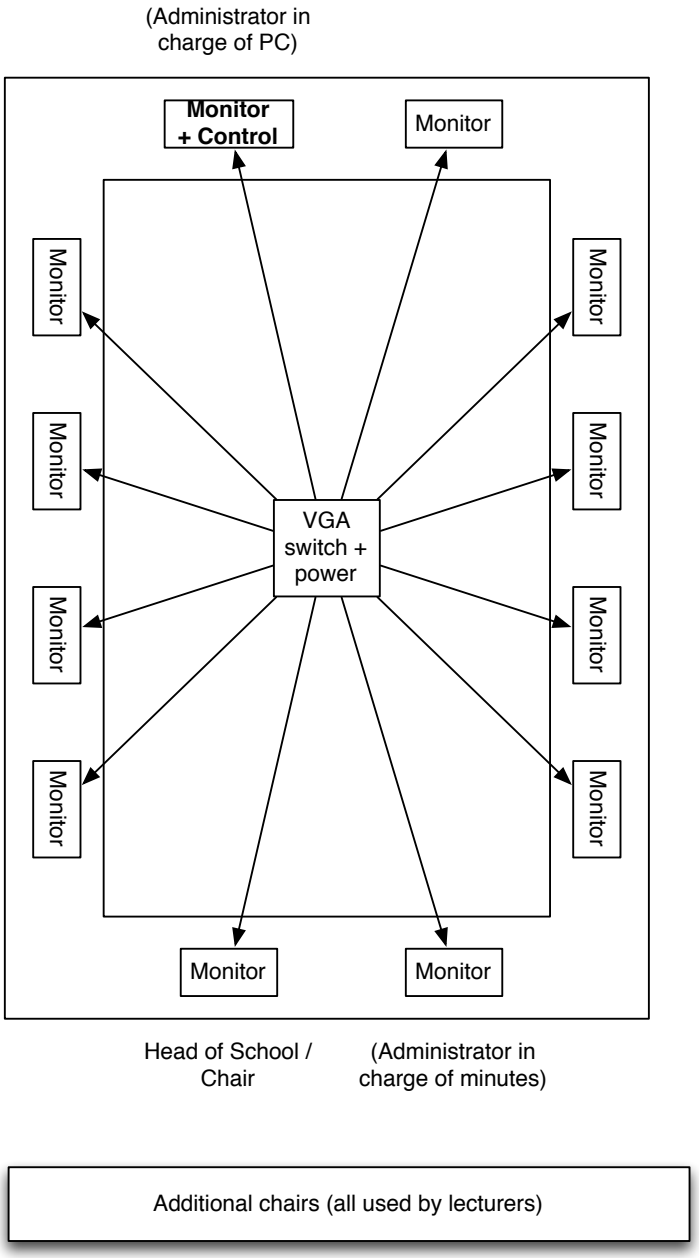

Figure 9 Room Layout for Example 3

This meeting is interesting because it takes place in a generic meeting room set up with a bespoke setting of devices for the purpose of this meeting only.

In order to present the figures and statistics, a set of 12 monitors connected to a single computer is installed around the table. Only one person has control over the computer.

3.2.4.3 Identified activities:

- Presenting: module leaders present their results, statistics, student feedback and other issues to the head of the school. They are supported by the spreadsheet featuring the statistics.
- Deliberating: each decision is open to debate amongst the head of school, the module leader and other senior staff present in the room. The decisions can consist of accepting module results as they are or operate some moderation on the results under certain circumstances.

3.2.4.4 Technologies:

- BYOD: Some teaching staff brought their laptop or tablets, but these devices were not playing a specific role in the collaboration.
- Non-BYOD: The room had a bespoke setting of personal monitors located around the table. All the displays were connected to the same computer and a single person was in control. People sitting at the back could hardly see the information on the displays.

3.2.5 Example 4: Digital Tourism Conference Call

3.2.5.1 Description:

The ICE holds regular conference calls to discuss potential research or commercialisation projects. One of those calls took place to discuss a potential digital tourism project with a trust located in the Scottish Highlands. At Edinburgh Napier, the people involved in digital tourism projects are usually the same involved with the ICE, therefore they have a level of expertise in using the room not necessarily shared with other staff members.

3.2.5.2 Meeting information:

- Location: ICE

- People on site: five. The director of the research group usually involved in digital tourism projects; the person in charge of business development in the research institute; the organiser of the meeting, senior research fellow; a lecturer in touch with a group of students forming a mobile development business within the university's incubator; a researcher previously involved in the development of digital tourism mobile applications.
- Remote people: one. The person in charge of the trust.

The people involved in this meeting are:

- The director of the research group usually involved in digital tourism projects (D). The person brought pen and paper to take notes.
- The person in charge of business development in the research institute (B). The person brought pen and paper to take notes.
- The organiser of the meeting, senior research fellow (O).
- A lecturer in touch with a group of students forming a mobile development business within the university's incubator (L). The person brought a laptop and an Android Smartphone.
- A researcher involved in the development of digital tourism applications (R). The person brought an iPhone™.
- The person in charge of the trust, via videoconference, present on screens displaying zone 2 (2).

The application in use for the conference is GoToMeeting™ as it allows the sharing of multiple displays.

3.2.5.3 Identified activities:

- Presenting: the first phase of the meeting was to demonstrate previous works developed by the research institute remotely to the person in charge of the trust.

- Deliberating: the second phase of the meeting is the discussion of possible future collaboration with the research institute.

3.2.5.4 Technologies:

- BYOD: An Android smartphone and an iPhone™, used for mobile software demos. A laptop used to film the demos via its webcam.
- Non-BYOD: the main screen in the ICE, used for the videoconference. The conferencing software used was GoToMeeting™, which was connected to ICE's main webcam and the laptop's webcam when the demos were running. Two people brought pen and paper to take notes.

3.3 Initial classification of device ecologies

The observations highlight a distribution of spaces, portability of technology, and the ability to share the interfaces. Technologies can be distributed among private and public places, brought by the users or provided as part of a space (room, pod, public setting) and either provide personal or shared interfaces (Table 1).

Table 1 Classification of collaborative ecologies

	Public Space	Private Space
Pure BYOD	Ad-hoc setups of laptops, iPods etc. e.g. library open plans, coffee shops etc.	Ad-hoc setups of laptops, tablets, etc. e.g. study rooms in the library
Hybrid	Generally non-applicable to work scenarios. Although non-collaborative examples exist: e.g. interactive ad boards with QR codes etc....	The ICE (in practice) ReticularSpaces (Bardram, Gueddana, et al. 2012) Coughlan et all's educational setups (Coughlan et al. 2012) Study pods in the Library Meeting rooms e.g. C50

	Public Space	Private Space
		Bespoke settings e.g. module board WeSpace (Wigdor et al. 2009), Code Space (Bragdon et al. 2011)
Pure "Non-BYOD"	None identified for work scenarios however examples exist in literature in other contexts (e.g. (Hornecker, 2008))	The ICE (in theory). Yuill and Rogers' examples of multi-user interfaces (Yuill & Rogers 2012).

The literature and observations show that many examples of collaborative ecologies are actually a mix of BYOD technologies and technologies provided as part of a private, controlled space dedicated to work. These spaces are hybrid collaborative device ecologies, in opposition of the completely ad-hoc setup of devices in a room or an office.

3.4 Study 2: interviews and meeting journey

The first study was an exploratory set of observation figuring out how spaces are used and how what technology can be deployed. However, it was also necessary to approach users of such spaces in order to further understand the way they are being used and what sort of work their users usually undertake. To do this, the next study consists of interviews of five groups of students working in study 'pods' available at Edinburgh Napier (Figure 10), as well as five key members of staff who count among the regular users of the ICE facility.

These pods provide a shared PC and screen and are designed to allow students to engage in collaborative activities. In addition, four members of academic staff engaged in extended interviews about their use of two purpose built collaborative environments ('smart spaces'). One of these was the Interactive Collaborative Environment (ICE) at Edinburgh Napier – a purpose-built room with five interconnected PCs and multi-touch table. The other (Room C50) was a more traditional meeting room seating 8 – 10 people with a meeting table and large TV

screen connected to a PC offering connections for BYOD devices via HDMI and VGA.

3.4.1 Methodology

Undergraduate students were approached randomly in the campus Library during a busy time of coursework completion. Some groups were too busy and rejected interview requests, however five groups were happy to cooperate. The members of staff approached were selected among frequent users of the ICE and the more standard meeting room, C50.

Figure 10 A Study Pod at Edinburgh Napier University's Merchiston Campus

The staff and student interviews were recorded and transcribed in text documents. Their subsequent qualitative analysis is a simplified process informed by grounded theory (Lazar et al., 2017c). Once transcribed the interviews were analysed in several passes. The first pass of analysis consists of reading the transcripts and extracting the main themes by coding relevant citations and references. The next phase consolidates the extracted themes into a set of categories, making the second pass more manageable. The second pass of analysis consists of coding the transcripts based on the themes extracted previously. A third pass focuses on the comparison of themes and ideas leading to a theoretical framework.

3.4.2 Qualitative analysis

The total length of the transcribed interviews was approximately 7000 words (including questions) that led to the creation of 24 different nodes at the open

coding stage. These are listed in Table 2 with the number of times a theme was mentioned (sources) and the total number of references (refs), i.e. the different interview transcripts included in the data set.

Table 2 themes extracted from the interviews at the open coding stage

Themes	Sources/ occurrences	Themes	Sources/ occurrences	Themes	Sources/ occurrences
Activity	6/12	Analogue	2/3	B.Y.O.D.	6/26
Capture	2/4	Cloud Drive	1/1	Communication	4/5
Content	4/5	Content Sharing	5/14	Control	2/3
Device Sharing	3/6	E-mail	1/2	Location	6/8
Longitudinal Activity	6/8	Mark-up	1/1	Parallel Activity	6/25
Room Booking	6/25	Physical Drive	1/1	Scheduling	7/19
Screens	2/6	Screen Sharing	6/25	Setting Up	2/3
Table-top	1 / 2	Tools	7/26	Tracking	4/7

The 24 themes can be consolidated into three broader categories: activities, scheduling and tools. Activities include the main meeting activities of screen sharing, content sharing, discussing and presenting. The concept also encapsulates long-term activities, such as follow-ups after a meeting and preparation for further meetings. There are also concurrent activities such as when members of the group work on different tasks in parallel. Scheduling refers to the tasks associated with the organisation of meetings, e.g. checking people's availability, rooms, even setting up the environment. Tools are referring to the hardware and software technologies in use to perform the activities.

3.4.3 Category: Activities

Analysis of the codes highlighted the longitudinal nature of the work undertaken both by groups of students and members of staff. Two student groups were

working on semester-long group projects while three others were working on group presentations assigned over a few weeks. Activities result in more than one meeting, e.g.:

"Twice a week usually"

"Every week in study pods "

"We started off a couple of time a week, but over the last couple weeks it became more like a daily thingy"

Similarly, staff members used the ICE or C50 primarily for follow-up meetings on longitudinal projects (industry collaborations, PhD supervisions etc.).

The main references to tasks encountered on the conversations are:

- Screen sharing (6 sources, 25 references)
- Content sharing (5 sources, 14 references)
- References to parallel activities (i.e. groups breaking out and performing different tasks, 6 sources, 25 references)
- Communication, including telepresence and video-conferencing (4 sources, 5 references)
- Mark-up of documents (1 reference) and Capture of analogue notes (2 sources, 4 references).

3.4.4 Category: Scheduling

Scheduling, as a broader thematic node, refers to the merging of the following nodes from the open coding phase: scheduling, location, and room booking. This results in 31 coded sentences from 7 sources. The remarks highlighted under this group of nodes give an indication of the variety of frequencies, schedules, tools and motivations for picking a space. In the case of the students, the main motivation for picking up the pods was the presence of a large screen enabling multiple people sitting around and discussing ideas. This sort of facility can also be provided by other spaces, such as private study rooms or meetings rooms. Some groups

mentioned the fact you don't need to book the pods or the unavailability of study rooms as a reason for picking them up:

"they don't need to be booked"
"We got kicked out of the group rooms"
"we could only book one for an hour today, so we just took one of those"

Scheduling happens in advance through some form of communication. The members of staff invariably mentioned email, whilst the students mentioned making use of more informal and modern means to communicate, essentially Facebook™ conversations or SMS. The room booking for staff members happens through the university's Outlook™ system. The study pods do not need to be booked and if students wish to book a study room, they need to address a Library member of staff.

3.4.5 Category: Tools

Under the main "tools" category, the following sub-categories come across as the most coded:

- References to B.Y.O.D. technologies (6 sources, 26 references)
- Screens (2 sources, 6 references)
- Content (e.g. files, sources, 4 sources, 5 references)
- Analogue technologies (2 sources, 3 references)
- Other technologies such as e-mail, networks drives, table-tops, USB drives etc. have a low amount of mentions (1 or 2).

The BYOD comments highlight how much the use of people's own devices is favoured over the use of the computers put at the users' disposal in meeting spaces. For some it is about the consistency of use between their usual work environment and their meeting environment:

"my laptop has my stuff there and it has my apps as well therefore whatever comes across, I can quickly open my favourite app and

do my work"

"I've got everything here. I've got saved links as well. I save a lot of links from the internet. It's more convenient.".

For others, it is because the laptops are complementary to the technology at their disposal, e.g. if they have to break out in sub-groups to work on different task:

"Usually it's not connected because we need to work on different interfaces at the same time."

"Basically we've been using the big screen as the group and the laptop is for individual work. Others also bring their laptops"

However, as the participants were concerned, one group of students and one member of staff did however not bring any BYOD technology to the meetings. For example, in the scenario of PhD progress reviews, the ICE Room is used as a support to emulate a life-size telepresence conversation. The participant explained they were not bringing technology other than what they would bring to a face to face conversation (notes, pen etc.).

The large screens were deemed one of the most useful features of the spaces by virtually all participants. The main use is that of a single, shared, large screen for collaborative work, because it enables collaboration across different participants:

"Everyone can see"

"We picked that as opposed to the other computers that aren't in pods because it's enabling that, yes"

"In the computer lab we'd all be working sided along the way rather than as a group; and we'd all be crammed in around the screen"

Large vertical screens enable collaboration (Rogers and Lindley, 2004) but what makes the difference in study pods is the ability to create an ad-hoc setting of multiple devices and collaborative configurations, with little or no hassle.

Another use of the large screen was for its telepresence quality in the context of a remote video call:

"experience is much more one of intimacy in the ICE because the person you're speaking to is life-size".

The possibility to have multiple screens, more specific to the ICE room, was also mentioned several times as an advantage.

3.5 The Meeting Journey

The diversity of activities and tools gathered from the interviews and initial observations highlights the needs for systems designers to understand those points for a given design scenario before envisaging possible solutions. One of the first proposals of this thesis is a tool called a meeting journey. More precisely it is a mind-map representation of the tools and activities of a meeting; the meetings are part of a more longitudinal set of activities and consist of phases such as scheduling, preparation, dissemination of information etc. Although the focus of this thesis is on the meeting itself, it is not necessarily inappropriate to include those in the meeting journey representation.

There is a similarity with the notion of a customer journey (Teixeira et al., 2011) as the tools can be the touchpoints of a given activity. The meeting activity is not dissimilar to a service as it has a form of persistent state and can exist beyond the constrained time boundaries of the in-situ meeting. Some of the students interviewed worked on university projects and alternated between meetings and work in different situations. Some of the academic researchers included the meeting in a broader process. Some had not formalised a process at all. Before the meeting, people need to create or locate relevant content, during the meeting they need to find, select, and share with other people. After the meeting people need minutes, updated content, and an action list.

The choice of a mind-map for the meeting journey comes from the different levels of granularity: the first level can represent the broad steps relating to the meeting's place in a longitudinal activity. The second level highlights the activities undertaken for each broad step. Finally, the third level represents tools currently in use to support the meeting journey, whether they are existing sets of software or hardware (Figure 11).

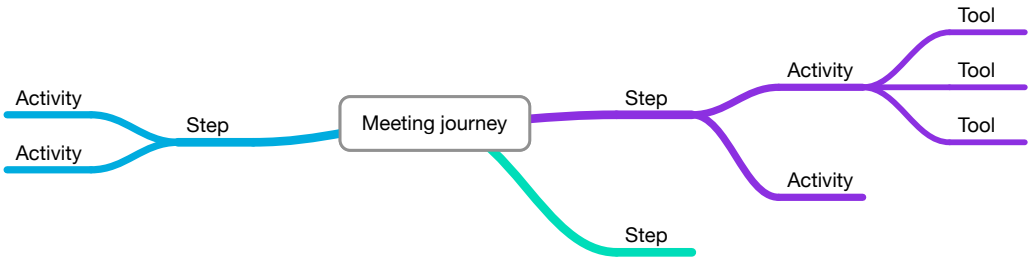

Figure 11 how meeting journey mind-maps are represented

Once mapped with the data following the tree structure, the meeting journey looks like a mind-map representation as per Figure 12; this figure is a first attempt at producing a generic meeting journey. It comes from mapping the observation and interview data with the mind-map structure proposed previously. In this first attempt all the activities gathered from the data are treated at the second level, however by looking more closely, it is interesting to note that some notions at level 2 actually overlap some level 1 steps:

- The idea of longitudinal activities itself is what the nodes at level 1 represent. It is therefore redundant.
- The notion of having plenary sessions in opposition to breakout sessions is interesting as it can actually map those two types of work sessions: the meetings, and the work done apart. Therefore, from the moment a meeting is taking place in the same room it can be considered a plenary session and therefore merged with the notion of “activities at meetings”. By the same token, breakout sessions can now be a branch of the meeting journey, even if the focus of the study will be on supporting the meetings.

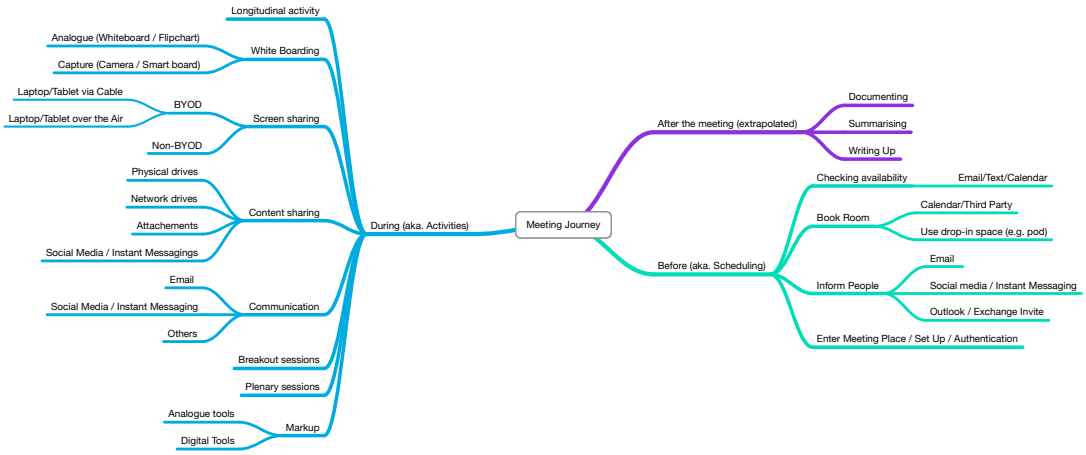

Figure 12 the first meeting journey (from the data)

A consolidated meeting journey may look like Figure 13 (next page):

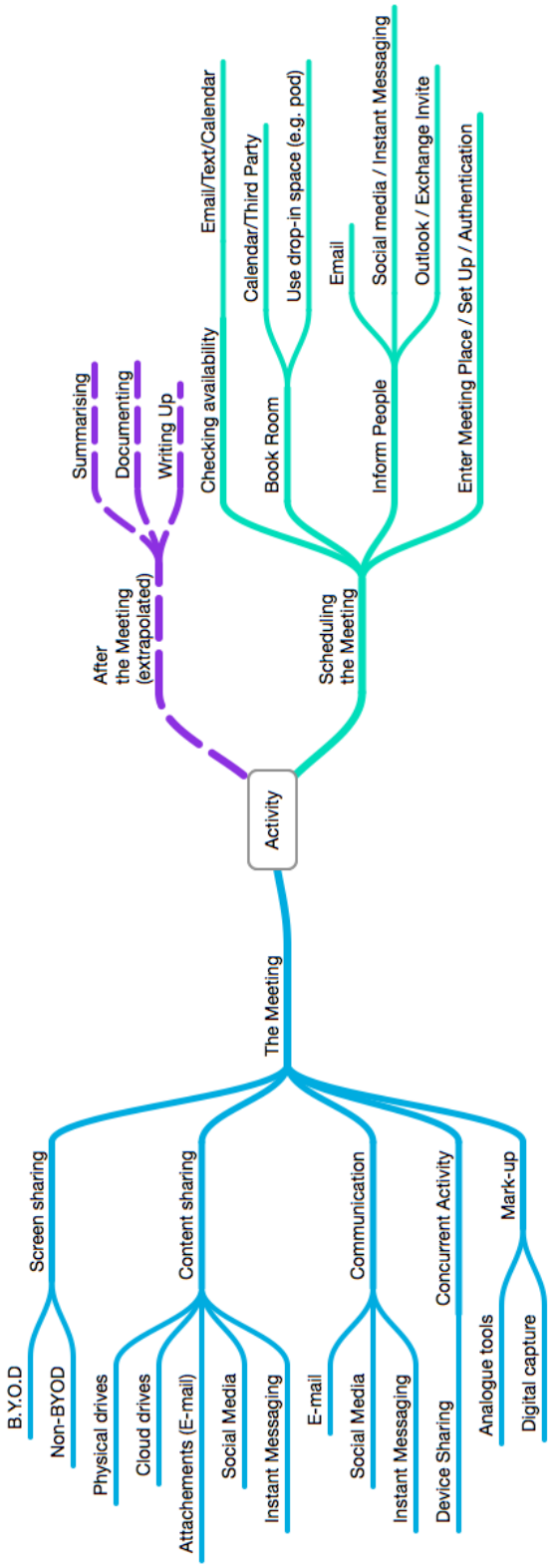

Figure 13 The meeting journey mind map – a non-sequential representation of the touch points

The main limitation of the mind-map representation is perhaps the lack of a clear sequential aspect that can be found in customer journeys used in service design, or other frameworks such as trajectories (Benford et al., 2009). However, the main reason to retain a mind-map format is the ability to retain different levels of granularity. The example in Figure 13 is a consolidated "generic" meeting journey based on a composite of the different meetings observed and the interviews conducted as part of the empirical study. Different scenarios and use cases may lead to the need for additional levels of granularity, e.g. if a situation requires to distinguish between several ways to authenticate users, or if different variations of several tools or platforms are being used.

3.6 Conclusion

Those two studies highlight the diversity of activities undertaken in co-located, collaborative device ecologies. A caveat of the studies would be the recruitment, which was target to academic users. However, the diversity of activities would be easily replicable into enterprise or business scenarios, as presenting, deliberating, or researching can be considered fairly generic and transferable activity types.

The main take-away from the first study is the breadth of BYOB technologies used by workers in environments such as The ICE. No scenario presented a reliance purely on the technology embedded in the room. One scenario, the programme boards, was clearly an outlier as it followed a clear process, however the other scenarios were more generic and less codified.

Third-party tools such as Facebook Groups™, Google Drive™ or even physical sharing were used to compensate the lack of supporting technology offered by spaces such as the ICE or the study pods to underpin the exchange of information inherent to collaboration. Some users still used HDMI cables to connect their laptops to screens due to the lack of interoperable screen sharing tools.

The focus of the next chapter will be to generate design guidelines to support the common interactions in such meetings; one major influence of these early studies will be to give the subsequent empirical work a more specific focus on the matters of content and screen sharing.

4 Leveraging the Meeting Journey: drawing design principles for co-located collaborative device ecologies.

4.1 Introduction

The previous chapter had two aims: identify technologies and activities involved in a set of scenarios implicating the use of co-located, collaborative device ecologies and offering a possible tool for designers: the meeting journey, which is a mind-map representation of steps, activities and tools involved in a given scenario. The aim of the meeting journey is to support designers or facilitators in the process of creating of deploying collaborative device ecologies.

The present chapter's aim is to leverage the meeting journey itself and explore different possible ways to support the design of co-located device ecologies.

A first aim of the chapter is to draft a number of design principles for the design of ad-hoc co-located device ecologies: an initial focus group study was conducted in a process of ideation and discussion to cover a number of ideas and requirements for such device ecologies. The first section will explain the methodology and qualitative analysis performed and what draft design principles have been produced.

The second aim of the chapter is to come up with a conceptual proposal for a way to support the design guidelines previously drafted for the implementation of future device ecologies. The second half of the chapter will report on a brief comparison of existing software tools in light of the design principles, followed by a user study conducted in Edinburgh Napier University's (ENU) Interactive Collaborative Environment (ICE) with an aim to generate ideas for an implementation approach.

4.2 Focus group study

This first study's aim is to generate design guidelines and principles to support design and implementation of device ecologies. A specific focus on a narrow band of activities has been picked the study:

- The study focuses on the meetings themselves. The longitudinal aspects of collaborative tasks would fall within the remit of Computer-Supported Cooperative Work (CSCW) studies independently of the interaction design considerations specific to co-located collaborative device ecologies.
- The activities at the meetings can vary, so do tools. Rather than interfering in a business-specific aspect of the meetings, the study will focus on a number of tasks that would appear more mundane at a first glance but however from the data in Chapter 3, those surrounding issues are prevalent in most scenarios: content sharing, and to a lesser extent, screen sharing.

A first step taken was to formalise the acts of content and screen sharing using flow-diagrams representing the different actors (people and machines) and their interconnection. For example, content sharing has been broken down into a number of user-level steps:

- User 1 locates a content to share on device 1 and initiates sharing
- Device 1 sends a sharing request to device 2
- Device 2 informs user 2 of the request, user 2 accepts or declines
- Device 2 informs device 1 and sharing proceeds or not
- When content has arrived on device 2 appropriate acknowledgements are displayed on devices.

The process above is aiming to be technology agnostic. In technical terms there would be a number of application and transport protocols dealing with the networking issues, however these are outside the scope this study. For the remainder of this thesis networking is considered a black-box.

The flow diagram on Figure 14 is an attempt to represent the steps described in the above bullet points.

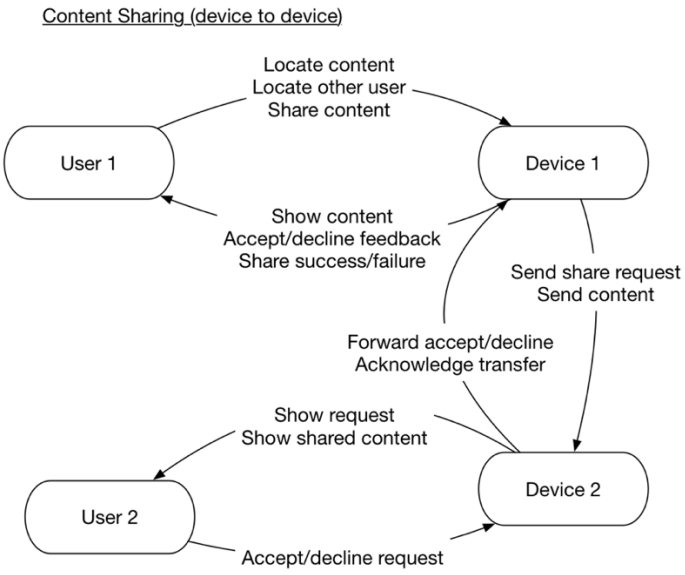

Figure 14 Steps involved when sharing content

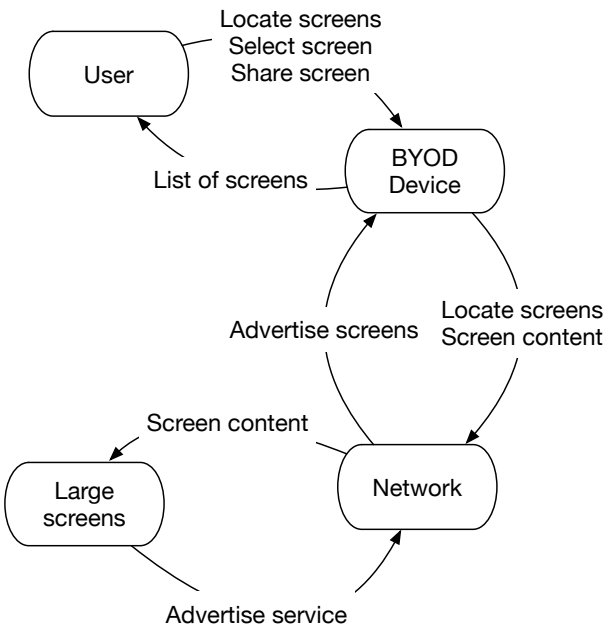

Figure 15 screen sharing data-flow diagram

Figure 15 illustrates describe the process of screen sharing. They do share a common base. To share content, it first has to be located. Both sharing content and screens include the issues of locating contents and devices. Sharing screens also involves locating other devices, as users need to choose a target screen or TV to perform the activity. There are more specific issues involved in screen sharing that can be looked at, but it doesn't involve locating content. The study will

therefore focus on the task of sharing content with a view to re-use some of its principles towards the actions involved in screen-sharing.

4.3 Methodology

The study consists of the qualitative analysis of focus group interviews; the methodology for analysis is a simplified approach informed by the stages of grounded theory analysis, similar to the previous study described in Chapter 3. The main aim of this methodology is to quickly generate concepts and ideas from the data that was collected. Once generated, the concepts can later be used as a baseline for further empirical work.

The steps taken for the study are the following:

- At first, the focus groups are interviewed together for a duration of 45 minutes. They are being shown different existing or hypothetical user interface examples focusing on the steps the study is aiming to help design. The interviews are captured on video media with an audio backup.
- Then, the interviews are transcribed in a written form, for analysis. The granularity of transcripts is quite low-level, keeping hesitations, interruptions or laughter in the text. However, non-relevant discussions are kept away, as well as parts of the text that are marked an inaudible during the transcription process.

Both groups interviewed are mature MSc students taking a Human-Computer Interaction module at university. Both groups were interviewed during a two-hour afternoon practical class. The first group consisted of four people: two male and two female participants. The second group consisted of three people: two male and one female participant. Two of those were not native English speakers but still highly proficient.

The protocol for interviewing the groups consists of six stages:

1. Introduction: the group is introduced to the researcher, the concept of collaborative device ecologies, the meeting journey, and the broad ideas of the research.
2. Consent: participants are asked to return signed consent forms.
3. Participants are being shown the mind map of the meeting journey and the researcher explains the broad ideas and concepts.
4. The participants are shown different screenshots of interfaces for content and device location and transfer on desktop and mobile platforms. A large majority of the screenshots are taken on Apple macOS or iOS operating systems; however, a lot of them represent generic desktop situations that can be easily replicable on Microsoft or Linux operating systems. Then they are asked the following questions as a conversation starter: What works for you? How do you find and identify content? How do you find and identify the device you are working on? (Appendix C)
5. Open comment section, supported by showing videos of two gesture-based applications: Air Link (Chen et al., 2014) and the now discontinued application Bump (Lieb, 2013).
6. The aim of the last act is to open the discussion on forms of interaction outside the classic desktop and mobile paradigms.

The first group's recorded interview lasted 40 minutes, which generated a 4,600-word transcript. The second interview lasted 36 minutes and generated 3,200 words, giving a whole body of approximately 7,800 words.

4.4 First pass of open coding

The first pass of open coding of both interviews lead to the creation of 26 themes, divided as such:

- Group one: 23 themes, for which 84 unique codes were marked up for a total of 104 codes including those falling in several themes. The average length of each code is 25 words and 46% of the document is coded.
- Group two: 20 themes, for which 59 unique codes were marked up, for a total of 72 codes (some codes can be coded over several themes, e.g. a comment about changing the way the Finder displays files based on a

certain context can fall into both “Preview” and “Context”). The average length of each code is 28 words and 52% of the document is coded.

Table 3 Themes after first pass of open coding

Themes	Sources/ Occurrences	Themes	Sources/ Occurrences	Themes	Sources/ Occurrences
Abstraction	1/1	Awareness	2/10	Choice	1 / 2
Clutter	1/11	Complexity	2/4	Configuration	1 / 2
Context	1 / 2	Convenience	2/9	Ease of Use	2/8
Efficiency	2/12	Familiarity	2/8	Identification	2/9
Information	2/11	Integration	1 / 2	Mess	1 / 1
Mistakes	2/10	Need	1 / 1	Platform Agnosticism	1 / 1
Preview	2/19	Repetitiveness	2 / 3	Search	1 / 6
Session	2/15	Subjective Remarks	2/11	Technology	1/6
Traceability	1 / 2	Usefulness	2/5		

The first pass led to a broad number of concepts which can be consolidated into broader themes for the next phase of analysis.

The inference between the codes, the themes and categories will be illustrated with quotes in the last part of this study report, describing the design principles.

4.5 First Consolidation and second pass of coding

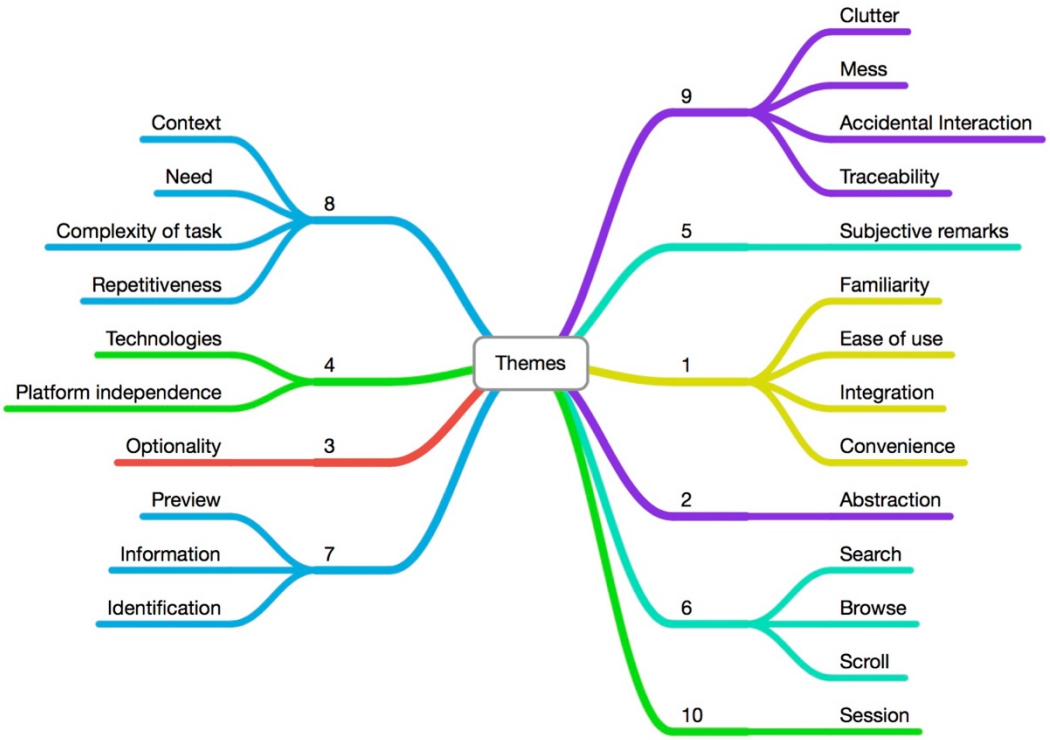

Figure 16 The grouped themes

The themes were consolidated into 10 more abstract unnamed categories which will evolve into named categories (Figure 16). At this stage, the categories were kept unnamed in order not to pre-empt the future themes of the analysis. They were given numbers instead. They were grouped by semantic proximity, e.g." Search", "Browse", and "Scroll" all relate to methods of locating content. They were grouped together.

This new nomenclature forms the basis of the second stage of coding, where each interview is analysed once per theme, aiming for a more comprehensive level of coding.

The second pass of coding, with pre-defined themes, lead to the following quantification:

- Group one: 87 unique codes were marked up out of a total of 140 codes.
- Group two: 70 unique codes, for out of a total of 114 codes.

- Codes for each theme are unevenly distributed, however the whole interviews do not consistently talk about the same themes.

4.6 Categories

By identifying themes and grouping them into categories, it now possible to extract a number of axes of design recommendations. The next stage is to identify and name the categories however a number of adjustments had to be made along the way:

- The themes in category 1 are generic and high-level and are therefore discarded.
- Category 2 contains themes related to user interface abstraction (i.e. high-level).
- Category 3 is about the choice and optionality of user browsing interfaces. Its themes are now grouped with nodes from theme 7 under" Presentation".
- Category 4 is about platform integration and agnosticism. It is now 'Platform Agnosticism'
- Category 5 contains mostly subjective comments that are not necessarily exploitable for design principles.
- Category 6 is about browsing and searching.
- Category 7 is about previews, identifications and information. It now falls under the 'Presentation' and contains the nodes in theme 3.
- Themes in category 8 are reshuffled. "Context" moves into the "Abstraction" theme, as abstraction covers the need to adapt the quantity of information to a certain context. Configuration becomes a theme.
- Out of the themes in group 9, traceability, mistakes, accident become another category: accountability. Clutter is now linked to presentation.
- Category 10, session, remains so.

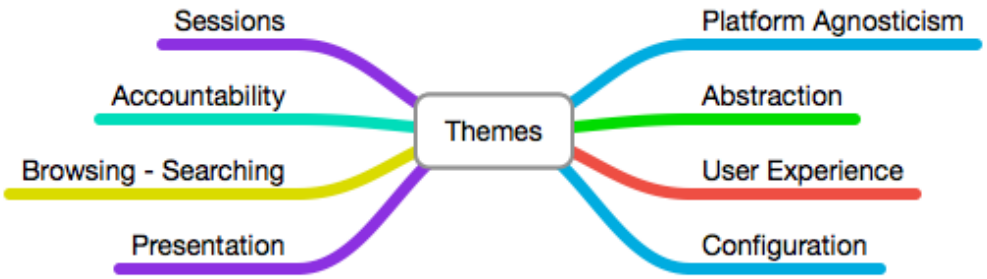

Figure 17 Renamed and consolidated categories

There are now 8 high level categories (Figure 17). Each category can be the starting point of more prescriptive design guidelines. Some categories can be merged:

- Session and Accountability are clear categories which can be expanded later.
- The quotations from the Browsing/Searching, Presentation, Integration themes tend to highlight users having strong preferences in the way they use technology. This leads to creating an umbrella category on the theme of *user preferences*.
- Abstraction, i.e. only showing what is necessary, is a theme in itself.
- The configuration comments tend really talk about ease of configuration; a suggestion for this is "plug-and-play".

Post merging the five high-level design guidelines are the following:

1. Support a form of session (Sessions)
2. Make the user actions traceable and make errors recoverable. (Accountability)
3. Do not interfere in users' preferred platforms and presentation options. (Browsing – Searching, Presentation, Platform integration)
4. Automatically curate users, assets, and devices relevant to the context of the collaborative session. (Abstraction)
5. Provide a "Plug-and-Play" approach to configuration. (Configuration)

4.7 Design Principles

4.7.1 Support a form of session

Enable an activity or workflow for people to join. If users are logged in and assets are available in a repository, it is easier to constrain the general workflow to a set of pre-existing file system and network boundaries. When shown the Mac network browsing screen shot, one user suggested:

> *'Why not have everyone in the meeting log in? And that group of login is managed somehow, so you get past that need to search every time you wanna [sic] find somebody in the room.'*

Make authentication transparent. This is a useful way to filter out unwanted users and devices. How to authenticate is open to options and evaluation. The traditional user ID and password combination is ubiquitous, however now modern technologies allow for the identification of users using mobile devices and fingerprint (e.g. Near Field Communication, TouchID). One suggestion was to connect a device to the room, physically:

> *How about something where, you're sitting around the table and you're "plugged into" the end of it. You know?*

Two participants also mentioned the use of webinar, which is also centred around the idea of a session. Having a common session to join is a key staple of collaborative work. If students now use social networks like Facebook to share content collectively, in the past it would have been Google documents, Skype, Microsoft Messenger, or ICQ. These systems are convenient as they offer a continuous stream of n-way conversations and attachments, unlike, for example, group email where it is necessary to always use the" Reply-all" function and mistakes are frequent.

Session transparency should not be at the detriment of security. One user expressed her concerns about having unknown users visible on AirDrop just by the fact they are in close proximity to your device:

> *A few screens back, you had [..] Oli's device that showed up? Do you know him? Or does he happen to be next door? [...] does that*

mean they can see you as well? So, there's potential there for. . . mess?

Other users expressed concern when shown more novel ways to interact and broadcast information by using gestures (Air Link and Bump):

I can see a lot of potential for mistakes as well... Inappropriate sending of... things.

A user clearly mentioned that the risk of accidental interactions is lower when connected to a session:

If we were in a room like this and I wanted to share something just with you with a gesture like this [mime] that would be great, but there would be some kind of limit, or you'd have to start a sharing session or something.

It appears that sessions are a key element to a successful support of activities in collaborative device ecologies however security is essential. The increasing amount of high-profile cyberattacks and security vulnerabilities over recent years makes security an underlying priority for all the design principles. To an extent every principle described in this chapter needs to be implemented with security in mind.

4.7.2 Accountability

Keep a history of users' exchanges. Being able to trace actions taken by users in a history is a key requirement to ensure the system provides accountability and also the ability to erase accidental edits, if a collaborative system offers such a facility. An interviewee commented:

'I just really want it to be really easy, and also traceable. You know like you sent an email you can say "I totally sent that to you", whereas if not it can be a bit odd "did I? did I share with the right person? Are we sure we did that?" all these sort of things'

Emails do keep a copy of a message in a 'Sent' box, and all instant messaging applications keep a history of the whole conversations, including the attachments

that circulated. On the other hand, a system like Apple's Airdrop™ does not provide a history. It is more difficult to trace what has been exchanged.

Accountability could also offer the possibility to roll back and cancel any unwanted actions. Collaborative editing software and version control repositories (Subversion, GIT) all offer the ability to trace who made changes to a document and roll back such changes if they happen to be an issue.

Rolling back is already commonplace in collaborative applications, and similar ideas should be applied to the support of real-time collaboration with multiple devices. Some collaborative services offer traceability and history (Google Drive, Dropbox) for remote collaboration.

4.7.3 Non-interference

This principle is deeply woven into the philosophy of BYOD. *Bring your OWN device*. The idea of bringing one's own device goes hand in hand with bringing one's own platform, application, and preferences.

4.7.3.1 Browsing vs Searching

Provide a way to locate files by path, or search files by metadata. There are two approaches for locating files on modern computer systems: browsing and searching. To be efficient, browsing requires files to be properly organised within a file system hierarchy. Searching does not require filing files as thoroughly, but it requires an index and metadata about the file type, name, and content need to be well documented. The browsing approach is based on file-hierarchy whilst the searching approach is based on metadata.

The responses in the interviews about the using search ranged from not very often to the main way of looking for content, e.g.:

> *I usually know where well where my things are so I don't use search that much'*
>
> *vs.*

'Q: Are you organised? A: Yes, but if you search, it's faster

It must be noted that the strategy of only searching drew criticism from one commenter, e.g.:

> *we were forced to use the search, but to be perfectly honest, and it was annoying rather than useful.*

File search interfaces can show results in the form of a list or icons, but on more modern they can categorise their results on a more abstract metadata level. If looking for music, it can be a song name, an artist name etc. Or it can be a sentence indexed inside a text file.

4.7.3.2 Presentation of Information

Consider users with different preferences: list, icons, grids etc. The interviews suggest that people have various preferences about how data is presented when they are looking for content on a filesystem. The reactions of participants were extremely variable, whether they were shown icons, lists, columns views, or lists with previews.

One advantage of listed views is their ability to display a lot of information on little screen real estate, e.g.:

> *That's why I always use lists, because you don't need to scroll. The first thing on a list view, that you get, is often the date, the date of creation and that sort of thing. It's quite handy if you wanna [sic] know "what have I done recently, what's older stuff?"*

A disadvantage is their cluttered aspect, that a user described as "overwhelming". The same user admitted having a more visual approach to looking for files, preferring icons by far:

Well it looks a bit confusing, it's kind of overwhelming. There's a lot of stuff filling a small amount of space.

Provide content previews. A concept that was broadly appreciated by users was the "Cover Flow" view on the Apple Finder. Apple's view presents a 3D effect, but it is the concept that people seemed to like: a list view, and a large preview. This seemed like a compromise between the quantity of information and the quality of the previews.

Well it gets over the problem of "what is that file?" "What does it represent?" you're getting a much bigger view. this but this one gives me a combination of both: being able to identify clearly, but […] because there's a list as well, you're able to scroll through more volume

Use appropriate tools so users know what they are looking at. When browsing, let them know where they are. Breadcrumbs (called "Path Bar" on the Apple screenshots) were generally deemed useful by the participants:

'I use breadcrumbs a lot on websites, I don't know about people, but I find it quite useful to know where I am.' '[…] it's useful – I find it useful. I like to see where I'm at. Especially if you are in complicated directories.'

4.7.3.3 Platform agnosticism

Make sure you provide clients for most major platforms. If the personal computer market of the 1990s was dominated by Microsoft Windows, it is no longer the case in 2017. Google and Apple have become two major players in the market of Smartphones and tablets. One interviewee:

'You need to be cross-platform. You want everyone to be able to participate.'

It is necessary to find ways for people to connect to a collaborative environment that is not exclusive. Apple's Airplay and Airdrop may be easy to use, but they are solutions that apply to Apple products only.

4.7.4 Abstraction and automatic curation

Do not show unnecessary files. The need for a higher level of abstraction is mentioned by the group on several occasions. One user is using an example based on his experience of downloading films and email attachments:

'Hmm document files, but generally in the downloads folder you have all the email downloads. When you see an email, you download the attachment that time and then you re-download it. You don't need it there. You have the same file many times'

This can generally be applied to the support of collaborative activities. It is not necessary to have access to an actual file in a file hierarchy if it can be available as part of a selection of relevant assets. One user:

'As much as I can I try to set up a "Favourites" folder, and then as try to locate inside that folder.'

As much as possible, provide a way for users to gather their documents in a shared folder, or use available metadata such as tags to identify which content is relevant to the session.

Do not give access to the whole network. Users need a more humanly understandable way to know who they are sending content or sharing screen with. Corporate networks are usually very large, and the visibility of other computers is based on families of IP addresses.

It would be metaphorically easier to identify if it were not network names. To me, I just look at that and I think "Dah".

All devices have network names or IP addresses. Sharing content to a device should not go through the process of using a network name or an IP address. There needs

to be a way to curate which devices and users are relevant. Instead of giving access to the enterprise's whole Active Directory, have people join a session specific to the activity they are working on. Instead of giving access to the whole corporate network, technologies such as Bluetooth and local ad-hoc networks can be used to create a hardware-based proximity "shroud".

Locating a device or a screen through with a certain level of abstraction requires the handling a large amount of metadata: what is a friendly name for the device? Does the system know who is the owner and who is user currently logged in? If not, as a fall back, is there a way to represent the device in its physical form rather than its more abstract IP address? Apple's macOS does this, if other Macs are connected to the network, it represents them with an icon reflecting the exact model of Mac computer. Can this type of metadata be made available on a broader type of platforms in order to make the user experience easier?

4.7.5 "Plug-and-Play" Configuration

Provide activity presets for configurations. An example of systems that currently complex to set up is the ICE. It is configured via a video and audio matrix controlled via a Crestron system. The system offers full flexibility as to which screen displays which source etc., however some combinations are rarely used. Configuration is a necessity and can be time consuming. One interviewee:

> *'you want it to work easily and efficiently well. you don't want to spend half the meeting setting it up'*

4.7.6 Discussion

The draft principles previously discussed give an indication of a direction of travel for the design of future co-located device ecologies. However, they need to be handled with a number of caveats.

They need to be evaluated against several implementations to be refined, most likely more implementations than within the scope of this research project. Additionally, their validity beyond the parameters of this study would also need to

be tested: although the focus group method was chosen for its ability to generate ideas quickly, there is a risk of biased requirements.

A number of additional considerations did not appear prominently in the study, e.g. security considerations, data governance etc, but they do need to be addressed in the context of a live system that would potentially handle sensitive information, as can be commonplace in an enterprise environment.

4.8 Gap Analysis

After establishing the meeting journey, the next step was to analyse a selection of existing software packages against the activities of the meeting journey and the design principles to establish what possible gaps are present in a current offering of collaborative software.

The selection of software was based on a mix of tools easily available in a corporate environment or some commercial software solutions used for tasks (like screen sharing etc.)

Table 4 software packages studied in the gap analysis

Name of Package	Publisher	Purpose	Similar products
Airdrop	Apple Inc.	Wireless device-to-device file transfers	Pushbullet
AirPlay+ AirServer	Apple Inc. + App Dynamic	Wireless screen sharing to an AppleTV or a PC equipped with AirServer.	Miracast, Chromecast.
Skype	Microsoft	Video conference, VoIP, and instant messaging client.	Google Hangouts, Apple Facetime + iMessage etc.
Solstice	Mersive	Multi-screen sharing server	Clickshare etc.

The data was gathered into two spreadsheets summarising the points reviewed in the checklist. A number of points can be identified:

4.8.1 Sessions

There are different ways to join sessions: a username and password combination, open sessions or invitations. Solstice offers different other options: password, passcode or approval handshake.

With the notable exception of Airplay and Airdrop, most reviewed packages enable a form of collaborative session. Sessions for real-time collaboration are already in place, however they generally don't support the notion of longitudinal activity, in the sense that Activity-Based Computing did (Bardram, 2005). Unlike ReticularSpaces (Bardram, Gueddana, et al., 2012) previously, this study's goal is not to replace applications and processes but instead to provide software facilities to support the use of current applications and processes in the context of real-time, multi-channel collaborative ecologies.

4.8.2 Abstraction

Most internet-based products studied (GoToMeeting, Skype etc.) have a user-centric interface, i.e. they connect users rather than devices. For example, when one is using Skype to initiate a screen-sharing session or a file transfer, this happens from a user to a user. Users can be connected to the service using different devices (e.g. mobile, PC) at the same time and the user interface is agnostic to that fact. Airplay and Airdrop use a device-centric approach; however, they follow clear naming conventions.

A recommendation would be to keep using a user-centric approach for the identification of other devices, and only use the device names in case of ambiguity. The reviewed applications follow this logic, however one dimension is not considered: they all give access to full file and operating systems. Alternatively, the applications could be "guided" to only have access to the assets, documents and devices relevant to the activity. Users could bypass this restriction only if they really need to. This could be supported by the longitudinal collaborative session previously discussed, which could point applications to a certain set of documents, users and devices without altering them or the processes in use.

4.8.3 Configuration

The reviewed packages offer different networking approaches:

- AirPlay and Solstice require the configuration and opening of specific firewall ports to allow network traffic to flow. This can be a problem in some corporate networks where security policies are to close all ports at firewall level. These systems can be deployed in specific environments with their own sub-networks, such as meeting rooms, however it is less easy to create ad-hoc deployments of those technologies if there are corporate-level firewall restrictions.
- AirDrop offers a different approach: it detects nearby devices based on their Bluetooth signal. It then creates a one-off Wi-Fi connection between those devices to perform a file transfer. It was possible to transfer a file between a Mac and an iPhone even though the former was not connected to a Wi-Fi network. It was connected to the network via Ethernet instead. Miracast (Wifi Alliance, n.d.) is using a similar system to enable screen sharing sessions.

Users should not have to deal with networking considerations other than connecting their devices to a Wi-Fi or wired network. Bypassing the network completely is not a good idea, however, as it may cause issues with access to enterprise resources or the internet. One of the recommendations would be to create breakout sub-networks in spaces designated for collaborative work using device ecologies, however if this is not possible, another alternative is to make use of technologies that can use standard network ports as much as possible.

4.9 Second study: idea generation

This second experiment was designed with several aims in mind:

- Capture and observe the working practices of a group using a multi-device ecology with a specific task in mind.
- Gather comments and generate ideas of what could support the use of a collaborative device ecology.

- Run a pilot on metrics for future evaluations.

Two groups of people collaborated on in the ICE on a constrained scenario that involved a breadth of activities as well as content and screen sharing.

4.9.1 Methodology

4.9.1.1 Focus on sharing

As discussed in the previous chapter, the observed gaps in the initial studies were about the support of screen and content sharing with the device ecologies. For that reason this study will essentially focus on those two tasks (Figure 18) and scope out other issues that are more business-specific.

For the rest of the study, the main focus will be on the following activities:

- Sharing content, i.e. the design challenges connected with the location of contents, other users, other devices and methods to transfers those contents (Figure 19).
- Sharing screen, i.e. the design challenges surrounding the location of other screens, their connectivity, and controls (Figure 20).

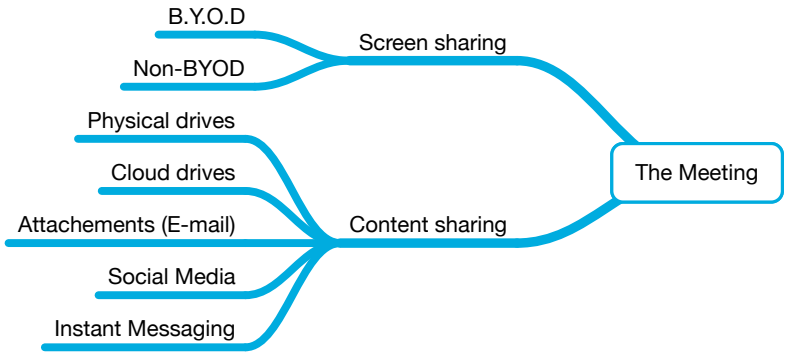

Figure 18 The meeting journey (focus on sharing)

Among the design principles, the focus of the research is on the following:

- Sessions
- Abstraction

- Configuration.

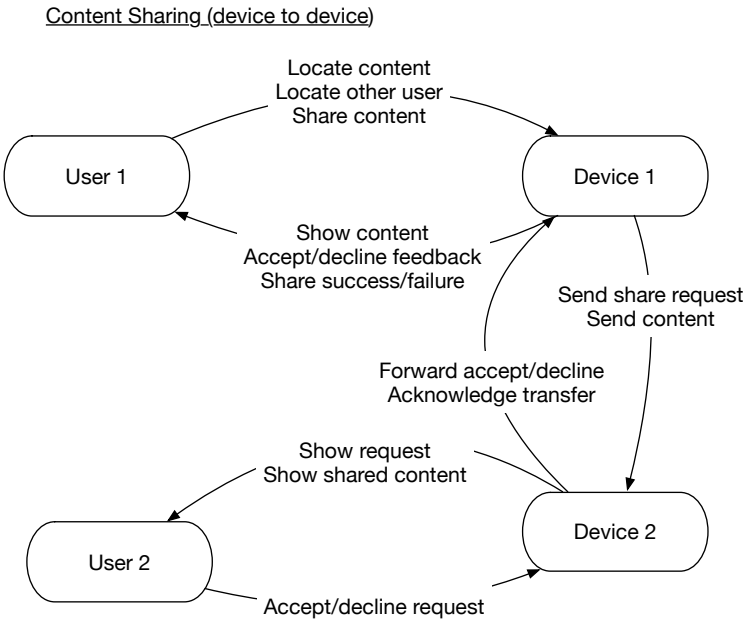

Figure 19 Content sharing data-flow diagram

In order to support activities, it is important to understand them in a form that is broken down into actors and steps. The representation chosen below is a variation on data-flow diagrams; this format was chosen over others (e.g. UML use cases etc) for its technology-agnostic approach.

The current process of content sharing (one-to-one) is based on tools similar to Apple's AirDrop™ or the process of transferring files in an instant messaging application akin to Skype: a user wishes to send content to another; the other must accept the request before the transfer is initiated.

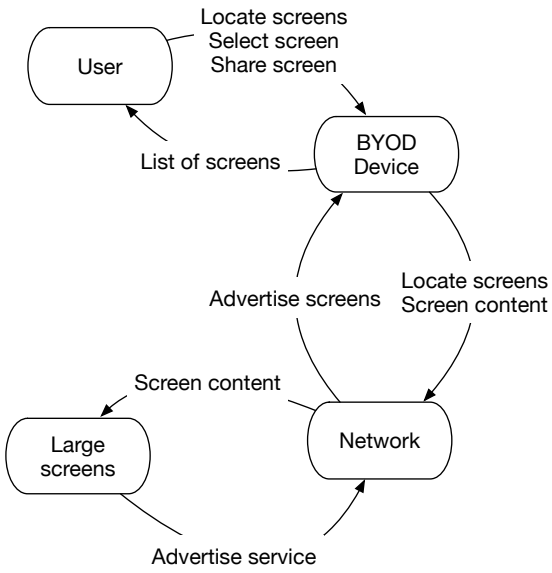

Figure 20 Screen sharing data-flow diagram

Figure 20 describes the functional process of connecting a device to a wireless screen using a sharing protocol similar to AirPlay™ or Solstice™.

4.9.1.2 The scenario

People were given the following fictional brief, which is a simplified version of a scenario which at the time had been drafted the design process of a prototype which is reported in chapter 5:

"You were commissioned by the Scottish Government to create a new marketing campaign highlighting the modern aspects of Scottish tourism and cultural life. Your focus will be on contemporary / modern art."

Groups were given a number of resources to start their research online (web links, documents, place names) and a time limit of 20 minutes to perform the following tasks:

- Research the subject given in the brief.
- Brainstorm some promotional ideas (e.g. a mobile application, a website)
- Set up a short presentation using PowerPoint or equivalent and start presenting it on the screen using the means at hand.

This brief was designed as it covers a number of aspects of the meeting journey:

- Participants have to research data and create a presentation: use of third-party software.
- Participants have to gather data together: content sharing.
- Participants have to brainstorm ideas: use of whiteboard, notes etc.
- Participants have to rehearse their presentation: use of screen sharing.

The sessions were captured on video from two different angles. Also, participants filled an evaluation questionnaire and answered a few open questions after the end of the session.

4.9.2 Metrics

The questionnaire designed to evaluate the user experience was informed by Hassenzahl's AttracDiff2 (Hassenzahl et al., 2015), which is a tool to measure the desirability of a product. The reason this approach was chosen was to provide a subjective evaluation metric for individual components of the device ecology's experience. The complexity and different pathways of interaction with the different devices and functionalities of an ecology like the ICE makes quantitative usability testing more difficult to control. The discussion (Chapter 6) will cover alternative research methodologies that could have been used.

The questionnaire is based on the use of semantic differentials on a set of qualitative adjectives (Appendix D). The adjectives used in the questionnaire reflect different aspects of the product's user experience: its pragmatic qualities, i.e. if the product is perceived as useful and functional, and its hedonic qualities i.e. how the users perceive the system in terms of style, pleasure and character.

The questionnaire was populated with pairs of opposite adjectives. Some of these adjectives were extracted from the AttracDiff2 questionnaire, others come from a body of data acquired when interviewing focus groups in a previous study that led to the design of the meeting journey. A balance of pragmatic and hedonic qualities was kept in line with the AttracDiff2 however, like the latter, the questionnaire used for this study did not pursue the same distinction between stimulation and identity as the same level of granularity was not sought in the pilot. The questionnaire ended up having 21 pairs of adjectives. Positive and negative

adjectives were distributed randomly among the left and the right-hand side of the scales in order not to create a positive or negative bias among participants.

An evaluation grid was used for content sharing and screen sharing. At the time of evaluation, a side note was added to the questionnaire to identify which means were used for either activity. Additionally, a grid was also provided to evaluate the means to connect to the room however in the later studies this step had to be assumed so data was not retained.

4.9.3 Study Results

Two groups of three people cooperated in the ICE for controlled collaborative sessions of a duration of 20-25 minutes. The participants were asked to bring their own devices, but there were backup devices provided if they were unable to: a Microsoft Surface Pro™ hybrid laptop-tablet running Windows 8.1™ and a Nexus 7™ tablet running Android.

Aside from the participants' own technologies, the room provided:

- 2 x 2 touch-enabled screens (mirrored) connected to computers running Windows 8.1
- Its own Wi-Fi Network,
- A Dropbox account and shared folder set up for the session,
- The possibility to mirror via Airplay to the screens,
- Whiteboard markers, post-it notes, a USB stick and a VGA cable.

4.9.3.1 Group 1

Table 5 describes the composition of group 1.

Table 5 composition of group 2

Participant	Technologies brought	Tasks and comments
P1, female, PhD student	None, used the MS Surface Pro	Used the whiteboard for brainstorming. Created the slides. Could not AirPlay them.
P2, female, PhD student	Own laptop	Used PowerPoint to make her own slides, used email to transfer to P1.
P3, female, administrator	Own laptop	Used PowerPoint. Used AirPlay to present.

Group 1 decided to split the work by having each person researching a theme and producing two slides. The slides were put together on a main computer: one person gave her slides to the group leader via USB, the other via email.

Figure 21 Group 2 used USB and email to transfer content

Figure 22 Group 2 brainstormed using the walls as a whiteboard

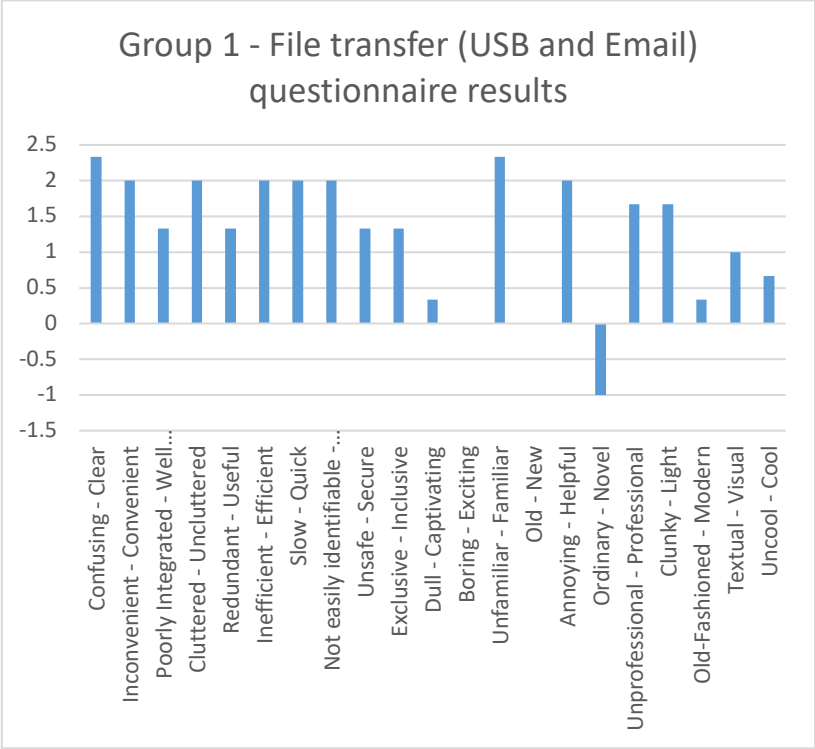

Figure 23 File transfer (USB and Email) questionnaire results

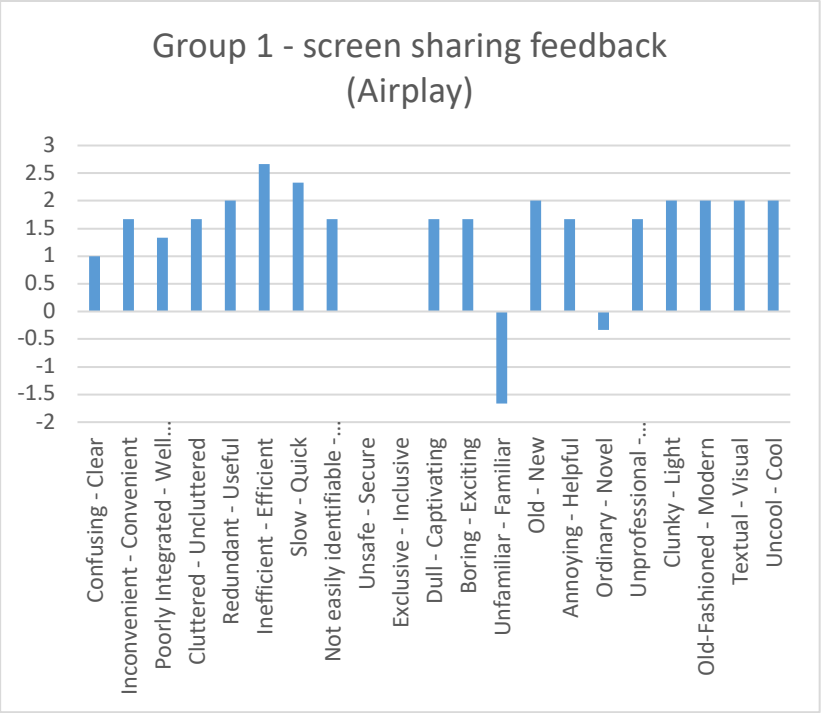

Figure 24 screen sharing feedback (Airplay)

Interestingly, the combination of USB drives and email attachments scored quite positively with the participants, with the exception of novelty. Even though the group seems to acknowledge it did the job efficiently, it fared neutral – low positive on hedonic qualities such as modernity, excitement, and integration.

For this session of screen sharing, the group used Airplay. It scored quite low on the familiarity and just under neutral on the novelty scale. It scored neutral to low positive on the integration, security, inclusiveness and clarity scales. The rest of scores were generally positive, however the result's significance needs to be taken with some caution, they only establish a sort of baseline.

During a short debrief after the sessions, participants left some open comments on the technology. The necessity to have a common file repository was highlighted by one person and acknowledged by the whole group. One person mentioned they found the environment (the ICE) very novel but wouldn't know how to make use of it, stressing her unfamiliarity with Airplay screen sharing.

4.9.3.2 Group 2

Table 6 describes the composition of group 2:

Table 6 composition of group 2

Participant	Technologies brought	Tasks and comments
P1, female, graphic designer	None, using Nexus 7	Researching material, switches from tablet to wall screen halfway.
P2, male, English teacher	Own laptop	Making the slides.
P3, male, software engineer	None, using Surface Pro	Researching material and running the presentation over AirPlay™

Group 2 used Dropbox for the data transfers. Participants using laptops accessed Dropbox via the its web interface, whilst the participant using the main large screen had the Dropbox client installed on the machine. This has influenced comments made by participants. One of the participants never used Dropbox before and required help from someone else.

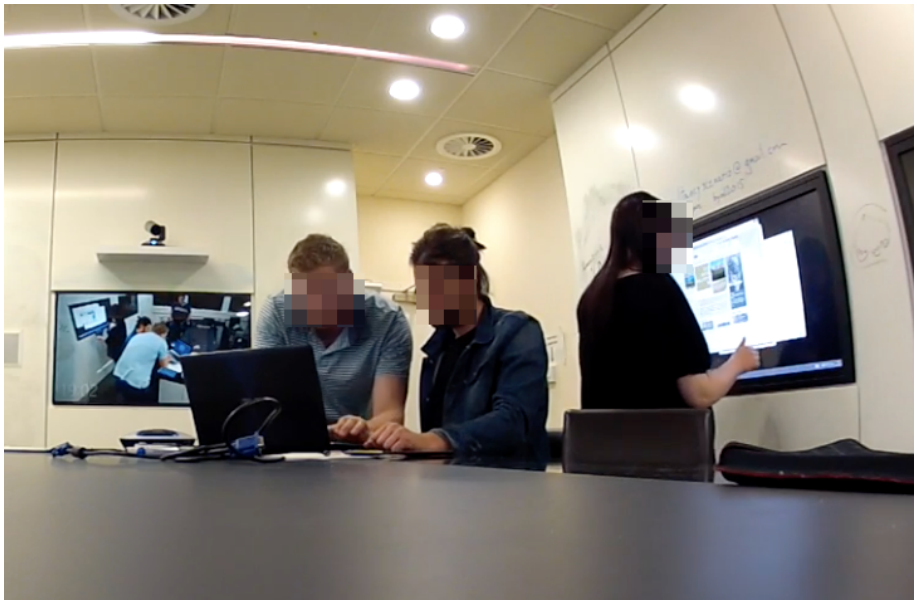

Figure 25 Two participants helping each other setting up Dropbox

P3 had the AirPlay screen sharing on for the whole session. He just ran the presentation from Dropbox in the end.

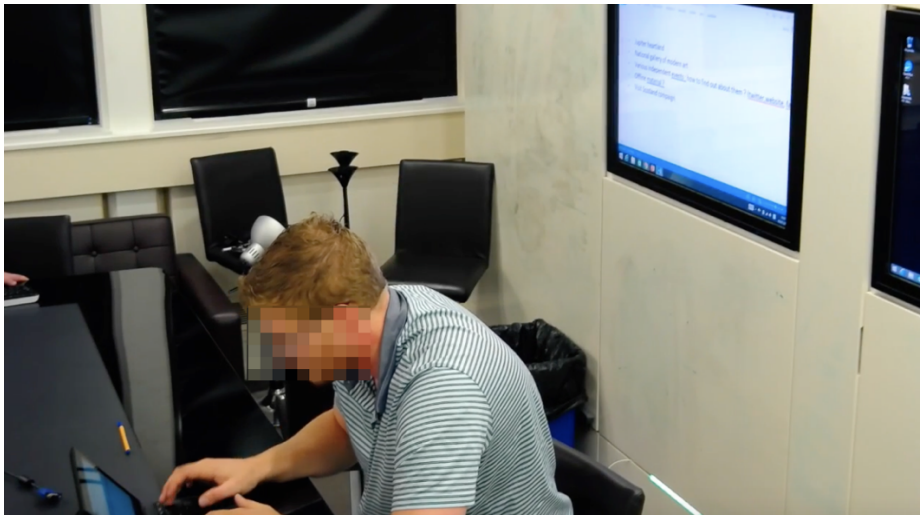

Figure 26 P3 mirroring his screen behind him, for other people to see

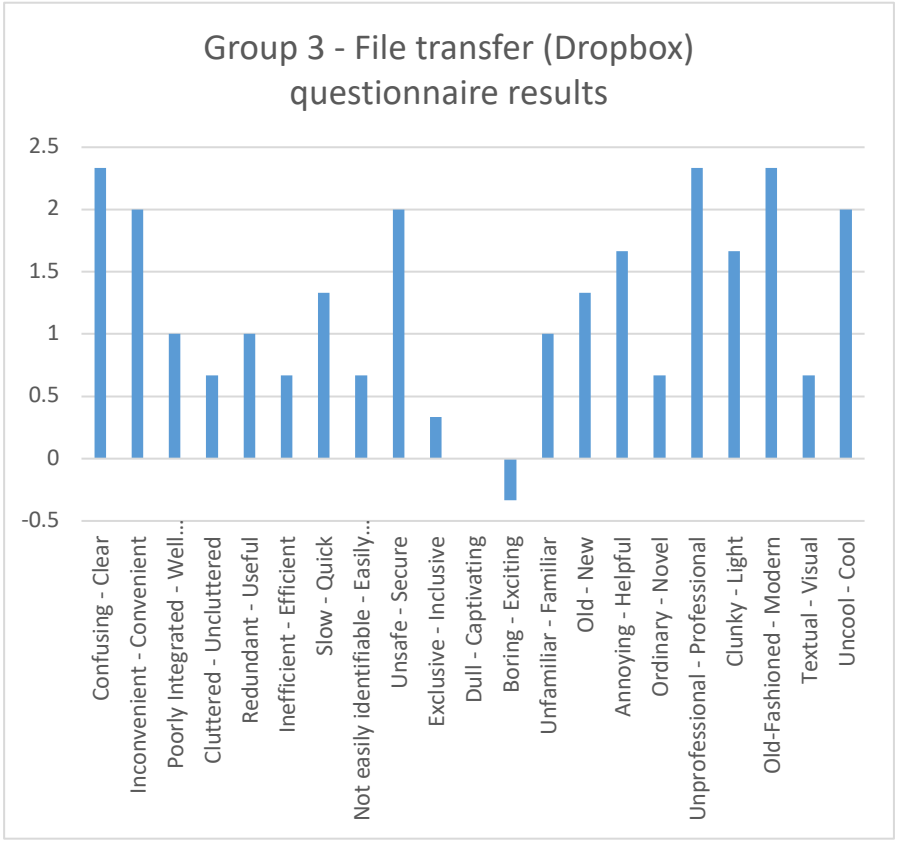

Figure 27 File transfer (Dropbox) questionnaire results

Although participants considered it did the job efficiently, Dropbox scored quite low with group 3 on a range of points: clutter, efficiency, inclusiveness, novelty. However, two participants were using it on the web and one of them was unfamiliar with the technology at all.

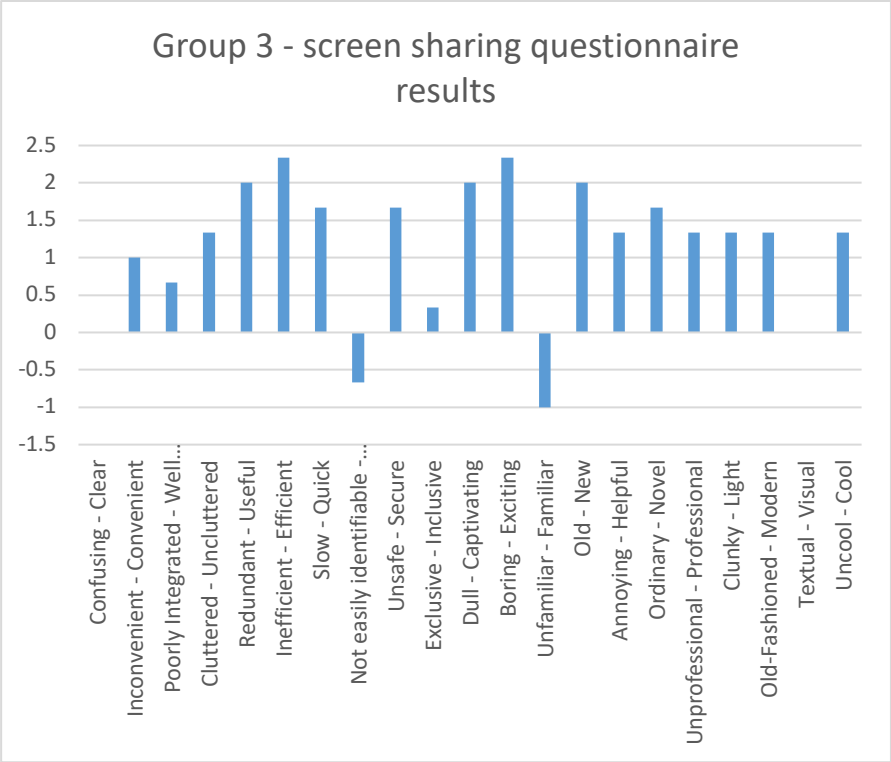

Figure 28 Group 3 - screen sharing questionnaire results

The group highlighted a lack of clarity, identification, and familiarity on the use of AirPlay™. In this precise group Airplay was used on Windows using third party software, a step that is not necessary on an Apple platform.

In further discussion, the group highlighted that although Dropbox was a very good tool, it is cumbersome to set up or join for a person that is not already acquainted to a meeting room or group's internal process. A strong suggestion was made to support a "one-click" way to join the room, e.g. by getting everything ready on devices when joining the Wi-Fi network. The participant, who happens to be a software developer, also highlighted that technologies such as Bluetooth would now enable people to be authenticated with a physical artefact rather than signing-in with a username and password combination, however no additional commentary was made about security implications.

4.10 Discussion

All participants in the study managed to perform the task expected from them, however the discussion highlighted that a lack of familiarity and information about the technologies available to share content and screens was an obstacle to making

use of the facilities in a manner that took advantage of the more technologically advanced collaborative tools. The participants came from different backgrounds, had different working processes, tools, and preferences; they found a common ground using physical drives, Dropbox, etc., but it required explaining and setting up.

On the basis of these observations and previous studies, this thesis positions itself for a hybrid approach when designing co-located collaborative device ecologies. The definition of a hybrid approach is the following:

- Users join a session when accessing the technology of a room or space. Or if the set-up is ad-hoc, users can create a collaborative session. This also supports the idea of session highlighted in the design principles.
- Once the session is joined, users can keep using their agreed tools and follow their agreed process (non-intervention).
- The only additional software in use would be an application acting as an assistant or agent and facilitating interoperability and offering a software common ground for tasks such as content and screen sharing. It would point out to the relevant other devices or content and automate some of the tasks that it facilitates if it runs on an interoperable platform. Failing that, it can offer documentation and help to overcome the lack of familiarity with the room environment.
- Additional considerations for accountability, security, and automatic configuration can be made however the complexity of those does not make room for further considerations in this thesis. They will be discussed as future work in Chapter 7.

4.11 Conclusion

This chapter explored requirements and design considerations for co-located collaborative device ecologies. It offers a set of five design guidelines to support systems. They present a number of limitations but helped inform the idea of a *hybrid* approach to support of multiple devices in a collaborative context.

The next chapter will report the design and evaluation process of a prototype of apps supporting the *hybrid* approach and a position on technological and engineering considerations for their implementation.

5 Implementing a meeting journey: proposal of a design approach and prototyping of a set of apps to support meetings.

5.1 Introduction

In the previous chapters, the meeting journey was proposed as a tool to analyse collaborative scenarios (Chapter 3) and a set of five design principles were also produced to design collaborative interaction in co-located device ecologies (Chapter 4).

This chapter is an attempt to take the design principles further, by proposing a possible technical approach for the implementation of the design principles (first half) and implementing and evaluating a small-scale functional prototype of a software toolset supporting a given scenario (second half).

The first half will focus on a conceptual design for an optimised-interoperability layer (OIL). The name was light-heartedly coined because its aim is to "smoothen the frictions" of collaboration in device ecologies. It is a proposal for an approach that could be implemented either in the form of middleware or drivers that considers devices for what they do rather than what they are.

The second half is focusing on the evaluation of a software prototype, including a macOS and an iOS tool meant to be an iteration of how OIL could support the sharing of files and screens for a given use scenario. It is important to stress that OIL remains at the stage of a concept, whereas the prototype was implemented using a number of underpinning pre-existing internet-based technologies that merely simulate how OIL would support some of these issues at a local level.

The evaluation will use a refined version of the methodology of chapter 4 to measure the overall desirability of the prototype.

5.2 Proposal: An Optimised Interoperability Layer

5.2.1 Philosophy: a hybrid approach to device ecologies

One of the design principles elicited in Chapter 0 is about minimal interference in users' choices. This, in a way, rules out a high-level "meta" user interface as per some literature examples (Bardram, Gueddana, et al., 2012; Bragdon et al., 2011), as those are more suited to scenarios with a more formalised process that the more ad-hoc device ecologies which are the focus of this thesis.

Any proposed approach in a new system would leave users almost complete freedom of choice when it comes to tools, limiting any additional software strictly to the management of a meeting sessions and/or the support of common sharing tasks. In a scenario of ad-hoc collaboration, no formal process has been defined by users. In a group, a number of users may be using Microsoft Office™ to create their documents, sometimes edit them collectively using a cloud tool like Google Drive. Some users may be using a Linux distribution, rendering access to commercial software more difficult. The device ecology should remain agnostic to the applications in use; if tool incompatibilities are detected, it may offer some users an accessible alternative to ensure people work with compatible tools.

This approach, named hybrid in the context of the project, can be deployed across a same user's access points, e.g. a user can be editing a paper on a laptop using Microsoft Word in full screen. In the meantime, the same user's smartphone can be used as the interface from which they control the relationship between the laptop and the rest of the device ecology, e.g. the visibility of certain files with other users, or the connection of the laptop to a wireless screen sharing protocol.

Another reason for the choice of a hybrid approach over a high-level interface is also a matter of ease of deployment. ReticularSpaces works because the people using the space all belong to the same professional group and share a number of processes in common. In a scenario where a guest collaborator is joining such a group, it may be too costly in terms of time or money to bring their technology on par with the very specific set of software used by the main group. A hybrid approach allows the guest user to join a collaborative session with their own tools.

The device ecology would analyse which tools are present on the guest's devices and offer a compromise to ensure interoperability with the main group.

To do this, it is important that devices speak the same language when joining the device ecology. A solution for this is the deployment of a compatibility framework, describing the generic capabilities and specific compatibility issues inherent to each device wishing to join the ecology.

5.2.2 An extensible framework called OIL

Devices creating or joining a collaborative ecology need to talk to each other and be aware of each other's generic capabilities and specificities.

Generic capabilities encapsulate a comprehensive number of information about their nature, such as:

- Their type, e.g. room hardware, mobile devices, wearables, etc.
- Their form factor, e.g. small pocket devices, medium-sized laptops, large collaborative screens. A starting classification for form factors can be taken from (Terrenghi et al., 2009).
- Their mode of input, e.g. touch, mouse and keyboard, gestures.
- Their operating system, e.g. Windows, macOS, Android.
- The type of functionalities they can provide, e.g. presentation software, screen sharing, storage.
- Their output capacities, e.g. sound, screen, haptics etc.

However, generic capabilities encompass a breadth of heterogeneous devices running different platforms. A Linux platform will not, for instance, be able to access Microsoft Office; however, it will be able to access Office documents using other applications. An Apple device will not be able to mirror its desktop using Miracast, it will however be able to use a different technology such as AirPlay™ or ChromeCast™. This is where the more specific descriptors of compatibility play a role, mapping the generic capabilities to more technology specific applications and technologies.

In the framework, each device identifies itself with its name and owner. It contains a set of generic capabilities. Each generic capability contains set of technological descriptors.

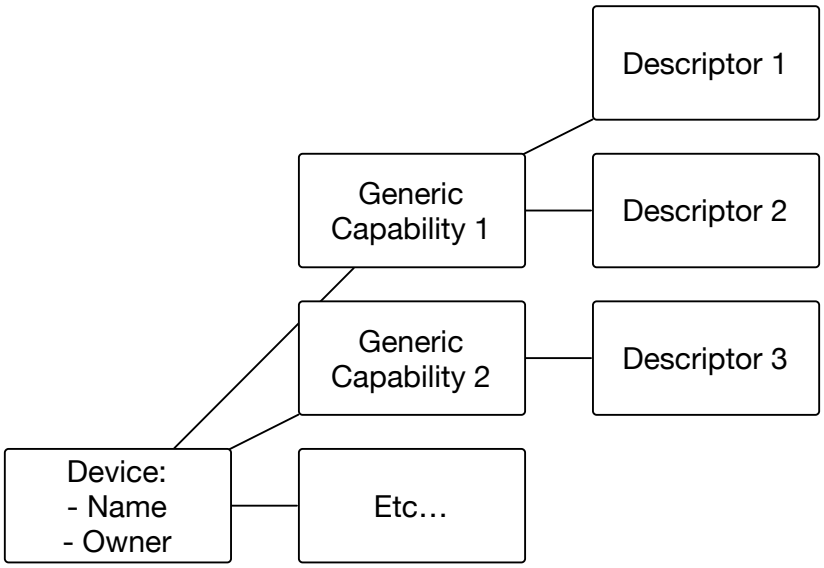

Figure 29 Extensible framework hierarchy

5.2.3 Infrastructure

The design for a hybrid system consists of two layers: infrastructure (OIL) and user interface. Those two layers could work together in order to help supporting the device ecology.

One design principle for the support of ad-hoc collaborative scenarios is the idea of sessions. Sessions are already a cornerstone of existing forms of collaborative software (ref: Solstice, GoToMeeting) and although they are not a new idea, they are an essential feature to delimit the scope of a device ecology amid the context of a meeting journey.

In the context of a smart space, sessions can be running on a local machine acting as a server. Users join sessions when located in-situ, their devices being by their presence on the local network, or by their proximity to the space, or both.

In the context of an ad-hoc collaborative device ecology, sessions can be created on the fly by a first device. Their existence is maintained as long as one device or more is present in the ecology, in the same fashion as an ad-hoc wireless network. The presence of the device that initiated the session is not essential to the

persistence of the collaborative ecology, allowing a form of "plug-and-play" approach to joining and leaving a device ecosystem.

The OIL infrastructure could consist of a device acting as a server managing a session. There are two scenarios of use:

- Users are joining a room where a computer can act as a permanently installed server
- Users are creating an ad-hoc ecology, in which case the first device to initiate will act as a server, until the end of the session, or until it leaves the session and passes the server responsibility to another device.

Each client device contains a generated set of descriptors, using the format described in the generic framework. There are multiple descriptive languages that can support such a descriptor (XML, yaml etc).

In a scenario where two laptops connect to a meeting room (ICE like), this can be as in Table 7:

Table 7 an example of ecology descriptors

Device	Generic attributes	Specific attributes
Room Screen	46in Multitouch Video-conference Wireless sharing Windows Platform	Windows 10 Skype AirPlay (third party) and Miracast
Laptop 1	12in. screen Linux Presentation software	Ubuntu LTS LibreOffice
Laptop 2	13in. screen Apple Mac Presentation Software Wireless Sharing	macOS 10.14 Keynote AirPlay™

Additionally, the identifiers should provide whether actions are automatable or not; if not they should provide clear human-readable instructions how to perform the tasks manually. The descriptors should be able to provide alternative software solutions.

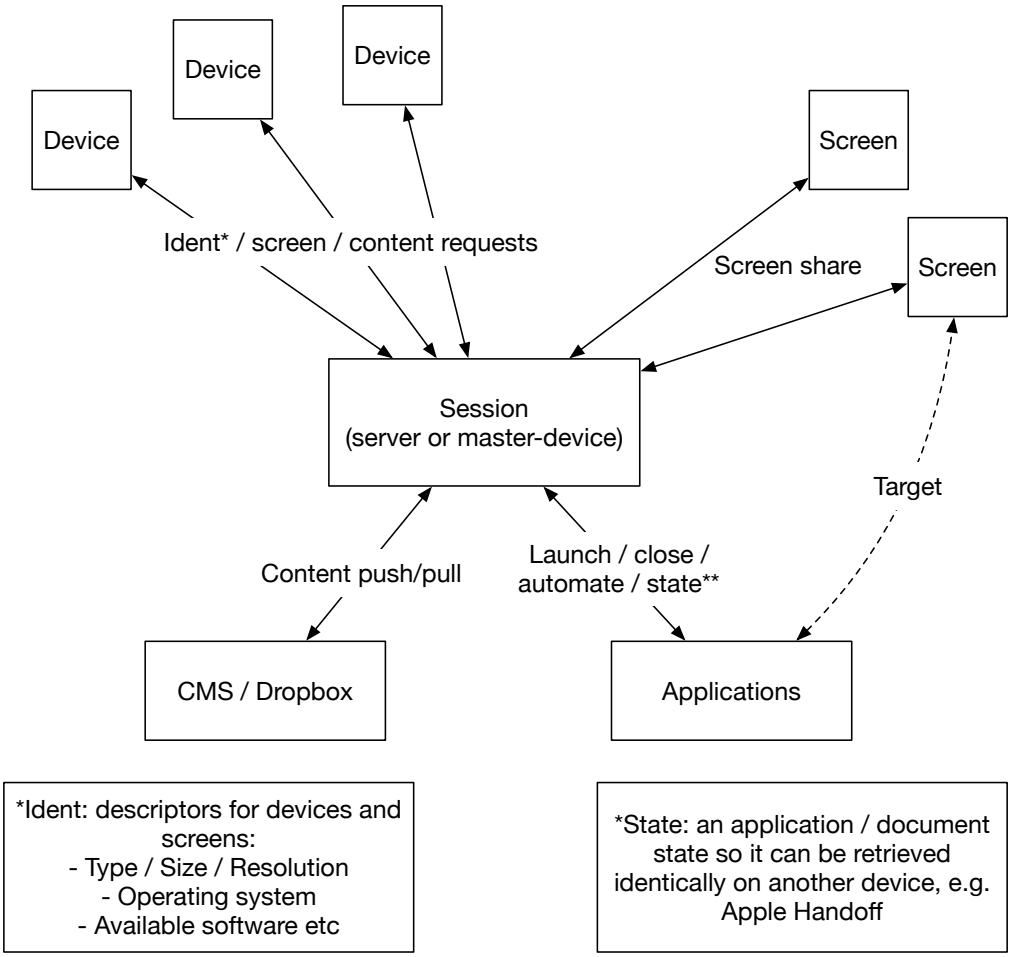

Figure 30 High-level functional description of the interoperability layer

The server acts as a session manager, it allows the following functionalities:

- Joining or leaving the session
- Publishing the different devices and their capabilities
- Managing a common set of files and assets using a content management system; it can be a simple shared folder, a cloud storage system or a more complex system to be determined.

- Acting as a proxy delivering the appropriate network identifiers and addresses, so devices needing to connect to each other can do so directly; alternatively, if an incompatibility between protocols (e.g. AirPlay vs Miracast) or it appears to be impossible to automate an action (e.g. screen sharing) it will deliver clear instructions for users to do this manually.

5.2.4 Discussion

The OIL proposal is not implemented in the scope of this research project due to its considerable technical ramifications. Additionally, it does not exist in a vacuum. It touches notions of middleware that exist in the domain of automation (Toschi et al., 2017), the Internet of Things (IOT) such as generic enablers (Brogan and Thuemmler, 2014).

In the domain of Ubiquitous Computing, Modahl et al. (2004) have reviewed a number of low-level building blocks and technologies. Network auto-discovery technologies include Apple's open-source Bonjour (Apple Developer, n.d.).

5.3 Design process: a prototype

At this stage the conceptual proposal for the hybrid approach/OIL has been leaving the interaction aspect and user interface aside. This thesis section aims to make a proposal for a possible way to implement the user interaction by creating a couple of applications that help support a number of collaborative tasks in an OIL scenario.

5.3.1 Background brief

The design process of the application followed a number of steps present in user-centred design, involving the creating of a scenario and a number of basic personas. The previous chapter made a mention to a consultancy and art scenario. This is another iteration for it:

A consultancy team were commissioned by the Scottish Government and Visit Scotland to create a new marketing campaign, aimed for the rest of the UK and

Europe, which highlights the modern aspects of Scottish tourism and cultural life, in contrast with the usual stereotypes. The campaign will focus on the following points:

- *Contemporary art and performing arts*

They were requested to take part in a brainstorming session to review different possibilities and banks of content available, in order to generate a 20-minute presentation to your clients, i.e. the Scottish Minister for Tourism and the Executive director of Visit Scotland. That presentation will be given in front of the minister, the executive and civil servants in the Scottish Government's building at Victoria Quay, Leith. They are expected to come up with a social media campaign and a mobile app idea.

5.3.2 Personas

To support the brief and scenario, a number of personas were created; those personas are informed by the background of a number of participants in the earlier studies however names and additional personal information has been made up.

5.3.2.1 Nicola, 34, Graphic designer

- Nicola has an honours degree in Graphic Design she obtained after school and an MSc in Marketing that she got in her late 20s.
- Most of her previous experience was as a freelancer.
- She has been working in the company for a year now, mostly in charge of graphic design for marketing campaigns.
- Nicola's initial desire to do this job was motivated by beautiful printed books and magazines. However, she adopted the digital revolution of web and eBook publishing in the past decade, albeit slightly reluctantly.

Technology profile:

- A 15in Retina MacBook Pro, provided by work, that she brings home on a daily basis.
- An iPhone 5S
- An iPad mini, that she always carries in her messenger bag, to read the news and play Candy Crush saga on the bus.
- Born in the early 80s from a middle-class background, Nicola was in contact with computers from an early age. Her first internet connection was in 1997,

when she was 16. Although she did not own a laptop for her early unit years in the late 90s, she got her first one very soon after that.

Personal Life:

- Nicola is single and lives in a shared flat in Central Edinburgh.
- She's a huge user of Netflix, Facebook, and Spotify.

5.3.2.2 Euan, 40, Project manager and chief executive

Background:

- Serial entrepreneur with a technology / academic background
- Has experience with start-ups and spin-offs
- Set-up the communication / tech consultancy in the last two years

Technology profile:

- Can afford the latest gadgets and likes to show them off.

Personal life:

- Lives in suburban Edinburgh with two young children and a pug

5.3.2.3 Karolina, 28, Web and Mobile Developer

Background:

- Moved to the UK from Poland in 2004 for work, enrolled in a university a couple of years later, where she graduated with a software engineering degree.
- Has experience in mobile and web development.
- Works on consultancy project,

Technology profile:

- "Digital Native" and early adopter.
- Windows PC laptop
- Android phone

Personal life:

- Lives in Edinburgh with partner
- Loves hiking and mountain biking

- Collects vinyl records
- Is involved in a local branch of a women in STEM group

Helen, 49, PA to Euan and general administrator for the consultancy company

Background:

- Helen comes from a temp/admin background
- Has been working with Euan for a long time

Technology profile:

- Self-described "technophobe" although she has been working with a computer for the past 10 years

Personal Life:

- Married, suburban, two teenage boys

5.3.3 Scenario

Tender call received – creation of a meeting

Helen receives the tender call and discusses the potential interest of the consultancy with Euan. Euan decides to include Karolina and Nicola in the project and creates a new activity, which links the calendar tools within the agency with a project management tool and a repository for assets and different pieces of work. After circulating the tender and checking everyone's availability, Helen schedules a meeting in the agency's augmented space for the next two weeks.

Before the meeting: background research

The participants to the meeting are actually doing some background research to come up with ideas for the brainstorming session. Webpages and assets are saved to popular tools such as Dropbox, Evernote, Pocket, or Pinterest with the appropriate metadata and tags, so they can be retrieved by the activity automatically.

The Meeting(s)

The team are entering the space and taking seats around the table. They carry the following technology:

- Nicola: laptop (work), iPhone
- Karolina: laptop (work), phone
- Euan: iPad (work), phone
- Helen: laptop (work)

The room detects the devices present in the room using Bluetooth and a number of security credentials – and wirelessly triggers the opening of a pop-up window on Euan (project leader)'s computer, asking to confirm if this is the brainstorming meeting scheduled for that specific date. Euan confirms and authenticates using his Phone's TouchID.

The room's underpinning infrastructure configures the screens. A screen sharing system similar to Solstice is accessible and access is given to the assets and metadata that were gathered by the team in the previous phase.

Nicola is the first to speak. She's presenting her findings about the contemporary music scene and possible partnerships with venues using the material she's saved on Pocket and Pinterest. Because the content has the correct metadata or tag, the room's server was able to "scrape" it from her account and gather it in a repository accessible to all members of the activity. Nicola is presenting contents on a larger screen wirelessly from her laptop using Airplay. In the meantime, Euan is able to look at the content of the folder from his iPad and mark up the various images and media Nicola has gathered.

Helen is taking minutes of the meeting on her own laptop, which are saved into the common repository.

Karolina is giving her own talk about what she found under the contemporary art category. She can also connect to the wireless screen, which can support multiple simultaneous sources. The large display now shows both Karolina and Nicola's

screens. Euan proceeds to hide Nicola's screen, which is no longer relevant, from public sight using a menu on his device.

In the meantime, Euan is building a draft presentation slideshow from his iPad, using PowerPoint and Dropbox. He uses the media presented by the girls and integrates the ideas discussed as a group to the slides.

5.3.4 Meeting Journey

In addition to the personas and scenario, a meeting journey extracted from the pilot in (Chapter 4) can help break down the different steps, activities, and tools involved in the scenario.

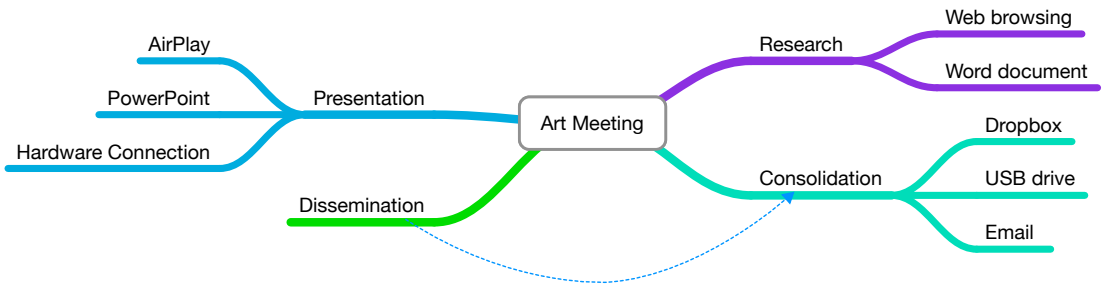

Figure 31 meeting journey for the consultancy scenario

The steps are research, consolidation of data, presentation of findings and dissemination of the meeting results. Dissemination and consolidation involve information sharing and can therefore be considered as two iterations of using the same tools. Presentation involves screen sharing.

5.3.5 System specification

The scenario described previously could be supported by a set of applications on users' devices that would manage the underpinning generic tasks inherent to the use of a collaborative multi-device ecologies:

- Authentication (session)
- Simplified access to room screens for sharing (abstraction)
- Simplified access to other devices for direct content sharing or access to shared repositories.
- Automatic curation of relevant content and applications (abstraction)

5.3.6 User interface

Ideally every device on every platform should run a native client but, falling short of this, they could accesses the ecology via a web interface. Mersive's Solstice (Mersive Technologies Inc, n.d.) in Figure 32 offers an interesting approach: when entering a room, instructions on how to join a session using a web-browser are displayed. This directs to a webpage where clients can download the native client on their Apple or Microsoft device.

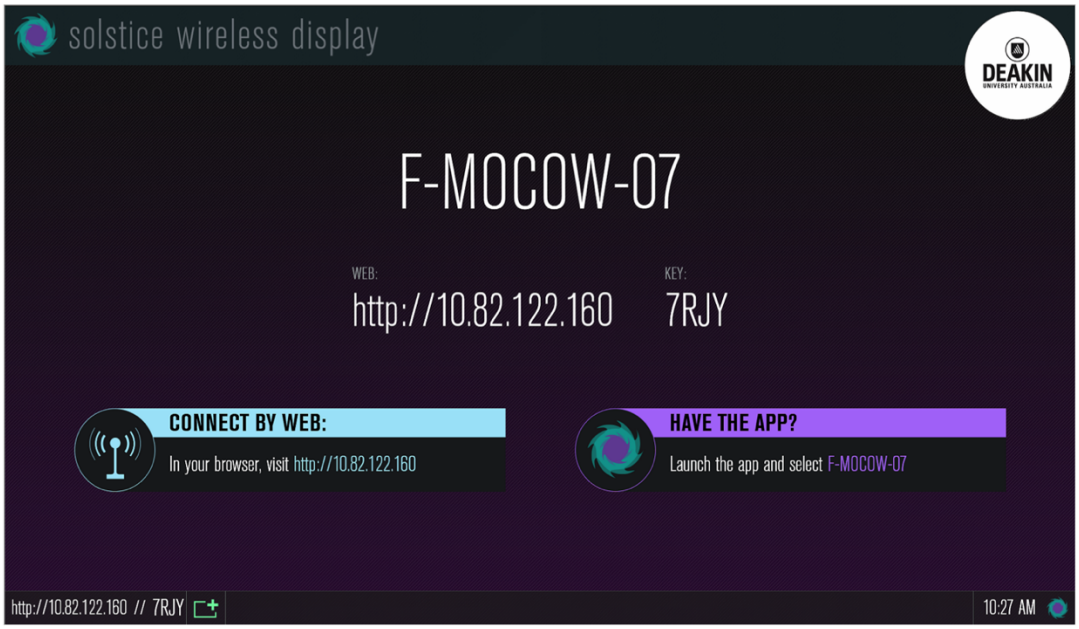

Figure 32 The instructions to join a Solstice session using a web interface

This leads to a user interface where devices can be added or removed from the session (Figure 33 top left); users can either approach an action using a task-centric interface (Figure 33 right) or a device-centric interface (Figure 33 bottom left).

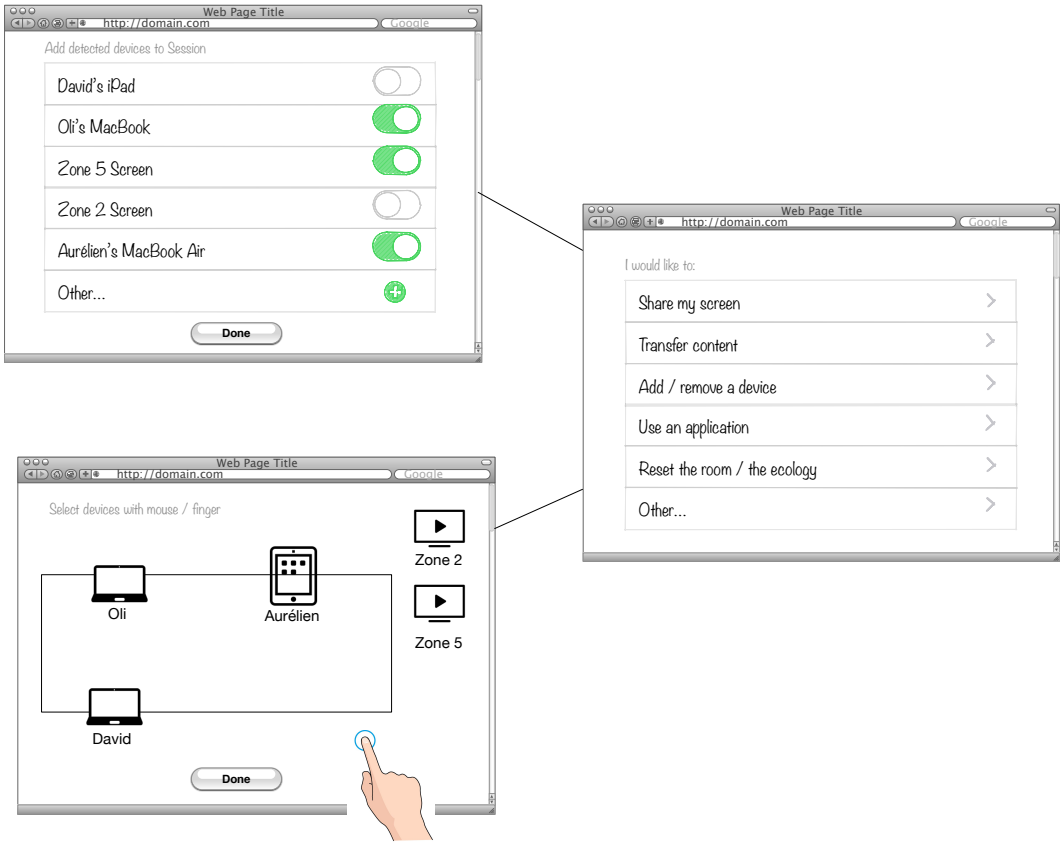

Figure 33 a schematic wireframe of the interface to add devices (top left), select a task (right), or select a device before performing actions (bottom left)

The actions offered depend on the generic tasks and capabilities offered by the devices. It relies on the framework to identify and list those capabilities and actions. It is important to stress that the use of the hybrid interface is not actually compulsory beyond the connection to the ecology. One of the interests of such an approach is to offer guidance for the collaborative actions, however expert users can still use the operating system and its standard approach if they wish.

Figure 34 shows an example where wireless screen sharing is supported using Airplay™ and another where the user is notified to use an alternative means if they want to share their screen (e.g. a cable, a different software package etc.).

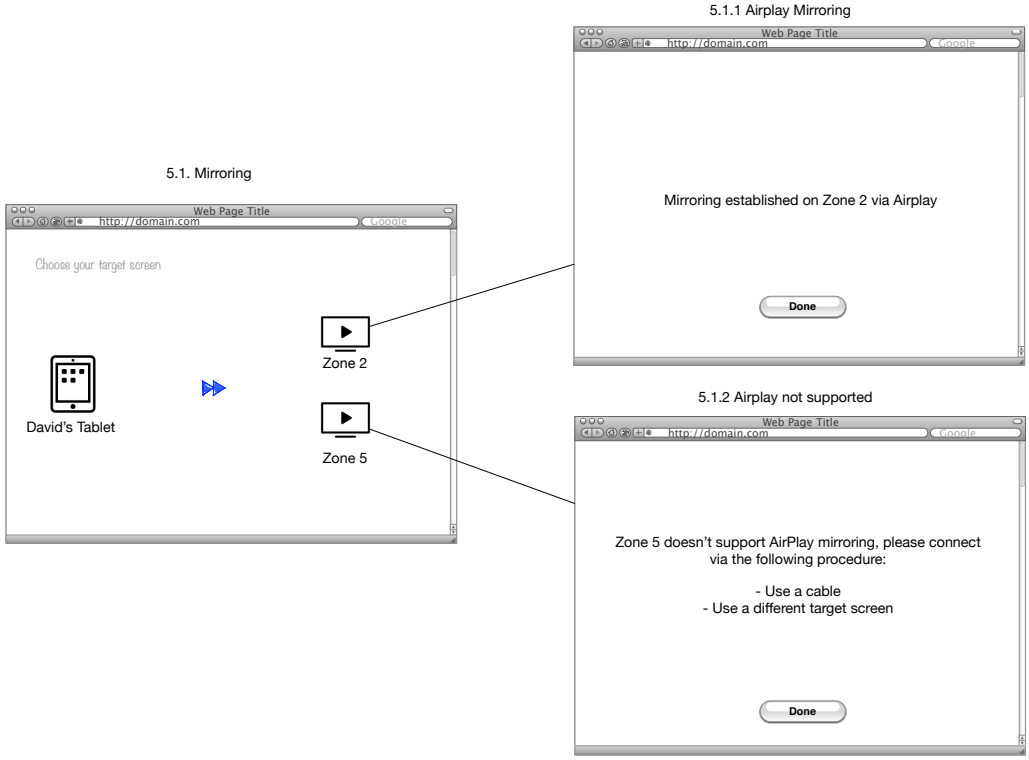

Figure 34 An example of screen sharing interface for the hybrid system

5.3.7 Actually implemented prototype

The software prototype itself was a simple implementation of the following:

- A macOS client application supporting content and screen sharing with the other devices in the session.
- An iOS (iPad) client replicating the same functionalities.
- An iOS plugin allowing file sharing from any other application.

The focus was primarily about implementing the functionality and not about the aesthetic design of the application. File sharing was simulated using the iCloud protocol. Screen sharing was implemented using an open-source implementation of Airplay using a Python script.

The applications were developed in Objective-C and targeted to run on Mac OS X 10.11 and iOS 9 respectively. The choice of Apple platforms was made because of the easy availability of iOS devices (iPad mini) however there is no reason not to

have made an iteration available on Windows or Android platforms other than the availability of platforms.

5.4 Focused evaluation of existing solutions

The following study aims to establish a user-experience baseline before conducting a comparative evaluation of a prototype of the hybrid system

5.4.1 Methodology

For this phase of experiment, participants were asked to create a presentation like in the above scenario in pairs. The participants were acting in two roles:

- Role 1 was given a laptop with standard web browsing software; participants in this role were asked to research images on the theme of contemporary art in Scotland.
- Role 2 was given a MacBook Air equipped with Microsoft Office(tm); participants in this role were asked to build a short presentation with the materials collected by Role 1. Subsequently, they were asked to present on a large screen in the venue.

In an aim to take individual usability measurement, the activity was broken down into a set of individual 'atomic' actions, performed by two people, as follows:

- Role 1:
    - Transfer images with the help of a USB drive.
    - Transfer images with a cloud service (Dropbox)
    - Transfer images using email attachments
- Role 2:
    - Present on a large screen using a VGA cable
    - Present on a large screen wirelessly using Apple's Airplay Mirroring
    - Broadcast the presentation to the rest of the group using Dropbox
    - Broadcast the presentation to the rest of the group using email attachments.

After a brief introduction to the study protocol, each participant chose their role and got started. The work was usually completed within its 15-minute time limit, occasionally people had an extra two or three minutes to complete the slides.

Once the work was completed, participants were asked to answer an evaluation questionnaire, designed using semantic differential scales. The adjectives used in the scales are split in two categories, informed by the work of Hassenzahl's Attracdiff2 (Hassenzahl et al., 2015) desirability metrics. A first category of adjectives covers the pragmatic qualities of the products, such as its perceived ease of use or efficiency. The second category of adjective cover the hedonic qualities of the product, such as their attractiveness or style. The adjectives are listed in (Table 8)

Table 8 pairs of adjectives used for the semantic differential evaluation

Pragmatic Qualities	Hedonic Qualities
Clear / Confusing	Dull / Captivating
Convenient / Convenient	Boring / Exciting
Well / Poorly Integrated	Familiar / Unfamiliar
Useful / Superfluous	Old / Modern
Inefficient / Efficient	Annoying / Helpful
Quick / Slow	Professional / Unprofessional
Unsafe / Secure	Ordinary / Novel
Exclusive / Inclusive	Uncool / Cool

The choice of adjectives is mixing some of the standard Attracdif2 set of qualities, with other adjectives occurring in the data set of interviews and focus groups covered in previous chapters. The adjectives were represented as the extremes of a seven-point scale, users are invited to tick the box closer to their subjective perception of the system, e.g. Table 9.

The negative and positive adjectives were distributed randomly on the left and the right, in order to avoid questionnaire bias. The full grid is available in Appendix 4. Participants had to fill a grid for each atomic task they had to perform.

Table 9 example of answer grid for the semantic differentials

	Strongly			Neutral			Strongly	
Efficient		X						Inefficient
Slow					X			Quick

5.4.2 Participants

The participants were recruited among academic staff and students of a university computing department. Eight groups of two people, a total of 16, took part in the experiment. They were aged 20 to 46 and equally distributed between male and female.

The design of the study is within subject, i.e. participants will run the focused tasks once with pre-existing software and then, after two months, will perform the same tasks again with the software prototype.

5.4.3 Data

The data of 16 participants was then split into two groups: eight participants who took part as *role 1* and 8 participants who took part as *role 2*. The seven-point scale of semantic differentials were then coded into numeric values. The adjectives were rearranged so that the positive adjectives represent a score of 7 and the negative adjectives represent a score of 1. The time taken to perform actions was also recorded in the first phase of the study. Adjectives were grouped as pragmatic and hedonic qualities (e.g. Table 10).

The means and standard deviation of the consolidated pragmatic and hedonic qualities are subsequently calculated and visualised.

Table 10 an example of how the data was coded into statistics software (partial example only)

Participant No.	Time	Clear	Convenient	Integrated	Captivating	Exciting	Modern
1	10	5	6	5	6	5	6
4	21	7	7	6	7	7	7
6	12	7	7	7	7	7	7
8	12	5	5	3	5	6	6
9	11	6	7	7	6	6	7
12	37	7	7	7	7	7	7
13	11	7	7	7	7	7	7
15	20	6	7	7	7	7	7

5.4.4 Base data

There is actually very little difference between the result returned for the two screen sharing methods; they both returned similar means in the medium-high range and deviations in the lower range (within the parameters of this study).

Table 11 questionnaire results for screen sharing applications

	Airplay	**Cable**
Pragmatic Qualities	5.7 (σ = 1.75)	5.7 (σ = 1.35)
Hedonic Qualities	4.42 (σ = 2.05)	4.3 (σ = 1.8)

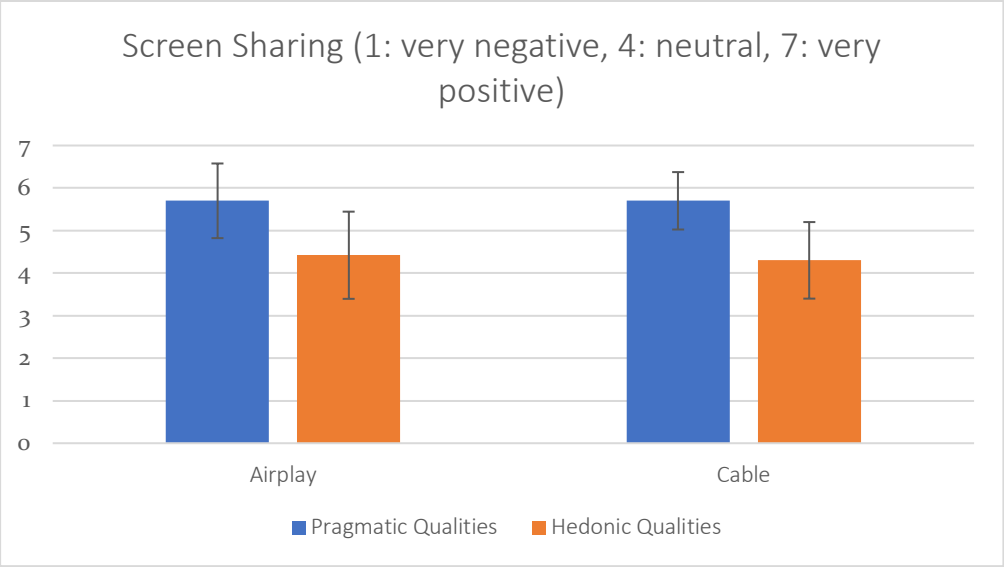

Figure 35 Comparative results: Airplay and Cable

Results show both methods rate medium-high to high on pragmatic levels, rather neutral so on hedonic levels; there could be improvements to make on the

VGA and Crestron score very similarly to Airplay despite containing more steps to perform the task: plug in, go to the Crestron, change the video input from the current zone to VGA etc.

Table 12 File sharing results

	USB	**Dropbox**	**Email**
Pragmatic Qualities	4.71 (σ=1.93)	5.7 (σ=1.6)	4.47 (σ=1.8)
Hedonic Qualities	4.2 (σ=1.76)	5.29 (σ=1.58)	4.28 (σ=1.82)

When file sharing using Dropbox got a generally more consistent feedback on both qualities than the other two methods. In contrast, file sharing with USB and E-mail got a more neutral feedback and both pragmatic and hedonic qualities appear in a similar result bracket (neutral).

5.4.5 Evaluation of the prototype

Participants were recalled a few weeks later to evaluate the prototype. However not everything went to plan, and four participants did not participate again. This

will influence the statistical results and therefore the study results should be taken with caution.

The questionnaires were followed-up with a short discussion with the participants.

5.4.6 Data and discussion

The Semantic differential data was coded in the same manner for this session of data collection as it was in the previous round.

Table 13 Results, including the app

	USB	Dropbox	Email	App/Task	App/Device
Pragmatic Qualities	4.71 (σ=1.93)	5.7 (σ=1.6)	4.47 (σ=1.8)	4.88 (σ=1.72)	4.7 (σ=1.8)
Hedonic Qualities	4.2 (σ=1.76)	5.29 (σ=1.58)	4.28 (σ=1.82)	4.65 (σ=1.69)	4.46 (σ=1.78)

The first result is actually underwhelming in comparison with some methods for sharing content used previously, such as Dropbox. It scored more neutral on the pragmatic aspects and neutral to positive on the hedonic aspects.

The task-driven interface for file sharing scored slightly better in comparison with the device-centric interface, but significantly lower than Dropbox in the first pass of data collection.

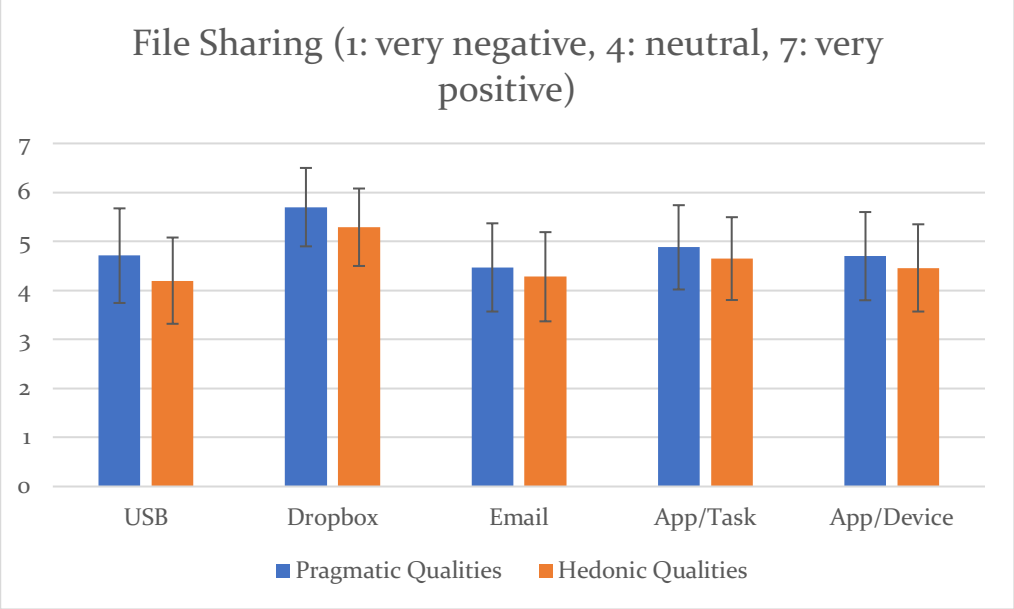

Figure 36 Comparative results for file sharing, including prototype

5.4.7 Additional discussion and caveats

Interestingly, in conversations with the groups who repeated the study with the prototype, a majority of them, with some reserves, confirmed preferring having a system than none. The attractiveness figures show a slight preference for Dropbox sharing over the app, however discussion with participants appears to slightly contradict this; if not the implementation in place but at least the idea of a system has its appeal..

One participant said the prototype made "more sense" than the "mess" presented in the first study. But also stressed the familiarity of the process can bypass the need for a system. In the context of this study the ad-hoc aspect of the meeting is important, in which case there would not necessarily be a precise process in place.

Another one, a cyber-security student, shared the same opinion about bringing meeting management functionalities in the form of a system, but highlighted that it would have been useful to have an idea how the security concerns were dealt with; these are out of scope in this context but will be discussed in Chapter 6.

"It is fine but what is the advantage of this approach over, let's say, Google Documents?" was asked by another person. This can also be discussed further, there is a need to bridge the gap between heterogeneous tools or increase the interoperability of existing tools.

Aside from the small sample size, several interpretations of the results can be discussed. Does the large gap of time left between both studies explain how users used the semantic differential scales differently? They could genuinely think the prototype improves their experience and not fill the questionnaire consistently with the first trial. A repeat study with a larger sample could help chase these ambiguities.

Another possibility is a phenomenon of confirmation bias during the interviews. Caution was taken to randomise the order of adjectives in the questionnaires in order to avoid such a bias, however there is a possibility that users sought to confirm the hypothesis that the system would make their experience better when verbally asked about it.

Finally, the prototype itself was static and non-scalable. The experiment would only simulate a hard-coded session with 3 devices: an iPad, a laptop, and a large screen. The user interfaces were left in the bare, default aesthetic appearance of iOS and macOS applications. Another study with a more finished prototype might, again, provide with more significant results.

5.4.8 Conclusion

This chapter explained the idea of an interoperability layer for collaborative device ecologies. It positioned the underlying concept of a layer supporting a set of generic and specific capabilities for different devices put together in an ecology. This led to the design of a hybrid system for the support of collaborative device ecologies, implementing the basic simulated functionalities of screen-sharing and file-sharing, approached via two different routes: the selection of *an action first, then a device*, and the selection of *a device first, then an action*.

The targeted evaluation of the prototype generated mixed results. When looking at the qualitative desirability data, there is no evidence of an improvement over some existing systems, such as Dropbox. However, users seem to have seen an improvement in the overall experience when they were asked their overall impressions about the concept and prototype.

The significance of the quantitative results needs to be treated with caution; therefore, it seems that although the initial idea was well received, it needs further evaluation using a more scalable system and more contemporary user interface metaphors.

6 Discussion and Conclusion

6.1 Introduction

This discussion chapter aims to conclude this thesis by analysing how the research findings answer the research questions posed in the introduction chapter.

Its first section will reassert the research questions and findings of this project and connect each of the findings to the element of the research questions it aims to answer. Each finding will be carefully contextualised and caveated to avoid extrapolations beyond the scope and parameters of the research performed as reported in the previous chapters.

The second section will extract the two main contributions from the set of findings and discuss them in relation to other existing research and projects in the field of HCI and Informatics in general.

The third part of this chapter will act as a conclusion to the thesis by drawing a list of detailed considerations for future research work in the area.

6.2 Research Questions

As per the introduction chapter, the research questions are:

- What is the impact of digital support technologies and toolsets for people working in co-located, multi-device ecologies on collaborative activities' user experience?
- What is the value and benefit of leveraging the aforementioned impact to those designing and facilitating the implementation of these tools in the future?

The first research question is of an exploratory nature. It is necessary, in order to generate a useful contribution, to understand a baseline of real-world uses of collocated multi-device ecologies; this leads to a further line of questions:

- What tools do people use in collocated multi-device ecologies?
- What activities do they perform in aforementioned ecologies?
- What framework can define the tools and activities and inform their design?

The second question is meant to lead to a contribution for an audience of user-experience designers and facilitators alike. It sounds abstract however it can be broken down into a number of more precise and focused deliverables:

- What design principles can be drawn from the exploratory research?
- What design and technical approaches can be taken to implement part or all of the aforementioned design principles?

The next section will now look at the different studies and findings and map them to the research questions to establish how they contribute to answering them.

6.3 Discussion: Exploratory Work

There are two initial exploratory studies. The first one is a set of observations of actual use cases of multi-device co-located collaboration in device ecologies. The second one is a set of semi-structured interviews of undergraduate students collaborating in publicly accessible 'study pods' located at Edinburgh Napier University's Merchiston Library.

6.3.1 Findings

What these two studies contribute to the thesis are answers to two parts of the initial research questions: what tools are being used? And what activities are being undertaken? The data collected is of a descriptive nature and provides a breadth of various activities and tools in use. The activities identified match those in McCullough's (2005) classification: collaborating, deliberating, documenting, and presenting. These four generic classifications can encompass what activities have been observed and provide an answer.

Additionally, the observations and interviews provided an insight about the tools utilised by users of collaborative device ecologies. It highlighted the gaps in the existing systems, that users mostly plugged by using third party strategies, such as cloud drive providers, or even social media platforms. The variety of hardware and software in use will answer the question about tools, and further inform the meeting journey.

6.3.2 Caveats

The first immediate caveat is the university setting, which can focus the breadth of activities to more intellectual and academic ones, as well as the nature of

participants to a more educated percentile of the population. It is therefore important to keep in mind that the results of this research project are valid within these parameters and there may be limitations as to how they scale up to other settings. Another limitation comes from the methodology of the observation phase, which is of an informal nature, limiting the results to a description of tools and activities rather than a more in-depth analysis of user interactions that would be generated with a more formalised ethnographic approach.

However, the caveats above notwithstanding, the studies generated a valuable body of descriptive data which informed the generation the meeting journey.

6.4 Discussion: The Meeting Journey

The meeting journey did not result directly from a dedicated study. It is, however, a tool derived from the search of a convenient way to represent the results of the study described in (Chapter 3). It builds directly upon the findings of the initial exploratory studies.

6.4.1 Findings

McCullough (2005) offers a way to classify the human activities. Similarly, Yuill and Rogers (2012) or Terrenghi et al. (2009) offer classifications for different types of multi-user interfaces for the former, or screen form factors for the latter. In contrast, the Meeting Journey is a tool to represent the activities, tools and potential issues of a given type of co-located, multi-device collaborative ecology scenario. In that sense, it does offer an answer to the research questions about a possible framework to represent a collaborative scenario in a co-located, multi-device ecology.

6.4.2 Contribution Value

The Meeting Journey is one of two main contributions of this thesis. This tool could be used by designers and facilitators alike to understand the base parameters of a collaborative device ecology based on users' activities and tools. Therefore, the Meeting Journey is not really a journey as such. It maps tools and activities. It extrapolates the phases pre and post-meeting.

User journeys can result in prescriptive or non-prescriptive user experiences alike. For example, a large number of non-expert computer systems use a very prescriptive and constrained approach to accomplish tasks. Some commercial products such as the ones sold by Apple™. are examples of such experiences meeting a large commercial success. In the context of multi-device ecologies, Bardram et al.'s *ReticularSpaces* (2012), building upon Activity-Based Computing (ABC) is another such example of prescriptive user-experience. The application layer is supplemented by a task-oriented interface altogether; someone who wants to join an ABC-based system needs to comply to a certain set of software, hardware, and a certain process, making it difficult to support more spontaneous, ad-hoc types of collaborative use scenarios.

Such a prescriptive approach would ultimately be counter-productive to ad-hoc device ecologies, as the overheads required to get hardware and software in conformity with said approach, as well as the learning curve of the processes and superseding user interfaces, would be incompatible with the possibility to quickly set up an ad-hoc collaboration environment for more informal scenarios such as the ones covered by the multiple studies in this thesis.

This Meeting Journey contribution is in contrast non-prescriptive. The angle of the contribution is that of a map identifying the different paths that can be taken by a user of collaborative systems. Teams can demonstrate different levels of computer literacy, technical expertise, or both. The chosen approach is to offer different access points (Figure 37) to the meeting instead of a streamlined sequential journey. These points can be related to user journey touchpoints (Teixeira et al., 2011) or access points (Yuill and Rogers, 2012; Hornecker et al., 2007).

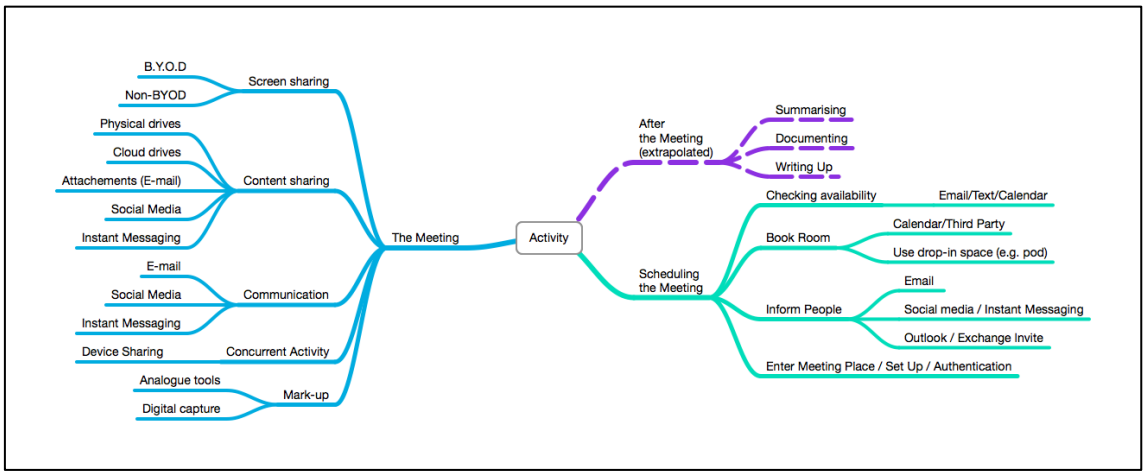

Figure 37: a Meeting Journey example; this one is a composite of the studies in chapter

By exposing a certain lack of uniformity, the Meeting Journey highlights gaps in the systems and how that people plug those gaps. The meeting journey exposes the meetings for what they are: bare combinations of users, software, hardware with no common unifying technology. In the scenarios observed, users make use of third-party services to unify their experience: Google Drive™, Dropbox™, even Facebook™ private groups in the case of students. It is up to designers to build upon the meeting journey to create either a user experience that provides a unified interface, or on the contrary facilitates the cohabitation of a diversity of platforms in the same room. The position of this research thesis is the latter, as explained in the results of the next study.

6.5 Discussion: Focus Group Studies and Design Principles

The initial exploratory studies and the Meeting Journey's main aims were to provide answers to the initial research questions, whose aim was to sample, identify, and map out the tools and activities related to the use of collaborative multi-device ecologies. The follow-up research questions are focusing on a value – a take-away – for practitioners and facilitators of such device ecologies.

6.5.1 Findings

The design principles stem from additional qualitative data analysis of two distinct groups: professional regular users of Napier's Interactive Collaborative Environment (ICE) on one hand; specialised Human-Computer Interaction students on the other. The first group is relevant for it regularly uses an actual

room design to facilitate multi-device ecologies. The focus groups were recruited in a logic of idea-generation with a future potential to build a set of requirements for a support system. The two groups of HCI postgraduate students, were exposed to the notion of a meeting journey and shown a set of user interface captures to give feedback on.

Qualitative analysis of the interviews and focus groups led to the drafting of design principle covering the following five themes:

- Sessions
- Accountability
- No interference
- 'Plug-and-Play'
- Automatic curation

The next section will discuss the contribution value of these themes. Those principles do provide a possible answer to the research questions aiming to leverage the understanding of tools and activities used in collaborative multi-device ecologies.

6.5.2 Contribution Value

6.5.2.1 Sessions and automatic curation

The issue is to find a "sweet spot" between leaving all devices to their default software configuration and leaving no room for user freedom whatsoever. Hence, the idea of supporting collaboration using a.

There are different definitions of the word session, from the wording used in website development to persistent games. This thesis' idea of session is something at the same time persistent and decentralised.

A collaboration session has to be persistent. It needs to exist beyond the simple instance of a meeting. The files needed for the work needs to be available previously; the work produced by different collaborators needs to stay available afterwards. Persistence means the persistence of data and the persistence of collaboration. In terms of data persistence, existing reliable cloud or enterprise-

based solutions can support the issue of collaborations already without a need to "reinvent the wheel". As for data accountability, similar systems already offer the possibility to edit documents simultaneously, keep track of the changes. This sort of functionality is supported by Google Drive™ or version control services such as GIT.

Persistence of session is more akin to the way ad-hoc Wi-Fi network are currently implemented. Feeney et al.'s approach to Spontaneous Networking (Feeney et al., 2001) described how such networks could be implemented on an infrastructural viewpoint, in 2001. The idea of collaborative session would build upon this idea of spontaneous networking and take it to a level of spontaneous collaboration. In spontaneous collaboration, it is the management of collaborative sessions and the curation of collaborative content which is independent from a centralised infrastructure; however, spontaneous collaboration does not – and maybe even cannot – be based on a purely independent and ad-hoc approach. Are people members of the same organisation? Maybe then, they are connected to the same corporate Wi-Fi network. Are the group of students working together in a coffee shop? Maybe they depend on the coffee shop for internet access. Internet access is prevalent in working environments. To the amount of corporate, academic, even public Internet access points, there is a now the possibility to connect to the internet using mobile devices as a "Hotspot", therefore creating a centralised Wi-Fi network based on a 3G or 4G internet access.

The idea of spontaneous collaboration can rely on centralised infrastructure; however, it is the creation and perpetuation of sessions that should be, or appear to be, decentralised and ad-hoc. A number of devices, by their sheer physical proximity and / or belonging to the same network infrastructure, should be able to perpetuate and even resume a collaborative session, even if the original device that got the session started is no longer present.

Making the assumption that access to the internet is going to be available at most times, the tasks of data persistence, collaboration on documents, and accountability can be delegated to reliable and robust third-party solutions.

6.5.2.2 Little to no Interference.

The principal belief that led this thesis, when it started, was that smart meeting rooms would be an enabler of collaborative activities. Combining data and the general trend of device sales pointing towards Mobility, the focus quickly shifted towards a more flexible, BYOD approach, and more spontaneous collaboration scenarios.

The idea of not interfering, or only very little, with the users' initial preferences comes from the interviews with users. Data described in chapter 0 would tend to point towards users preferring a highly individualised approach to their work environment. Users can have a relationship and a preference to a certain platform, a certain way to present information, a certain way to organise their files. In a way, this is not compatible with producing a single, unified user-interface for all devices collaborating in the same room. This would lead to several issues:

- How much flexibility should such a system offer?
- If such a system were to offer such flexibility, why would users use this instead of their current favourite file explorer, web browser, word processor etc.?

The idea of this design principle is to enhance the experience without disrupting the user's browsing and organisation habits, or to a minimum.

The use of a full-on layer of abstraction beyond applications cause a number of issues. First of all, an issue with its deployment. Take ReticularSpaces (Bardram, Gueddana, et al., 2012) or WeSpace (Wigdor et al., 2009) for example: the amount of development work necessary to build a production quality task-driven interface, compliant with Activity-Based Computing (ABC) or not, is considerable for a single type of platform. Possible scenarios can involve not only laptops and digital walls, but also tablets, smartphones, wearables, or connected objects.

In a traditional approach to software development there would be a need to develop a new environment for each platform, learning the platform's programming interfaces, fixing bugs for more platforms, updating clients for more platforms, creating additional clients when new platforms emerge.

However, the software world offers cross-platform environments. Java SE is one of them, however its success in terms of deployment for client applications is very limited. Popular modern platforms are Android, iOS, macOS and Microsoft Windows.

Recently, the power of web browsers has increased dramatically, and modern versions of Google Chrome™, Safari™, or Firefox are able to run increasingly fast and responsive user interfaces based on the HTML5, CSS and JavaScript. Google's ChromeOS™, running on its increasingly popular series of laptops ChromeBook, is essentially built upon web technologies that manage to increasingly mimic and even surpass the performance and finish of native desktop and mobile applications. This thesis favours a hybrid approach based on native third-party applications, however there is also a field to explore in the domain of truly responsive (i.e. from wearable to very large walls) interfaces based on web technologies, which can adapt to not just different formats of screens, but also different types of shared interactions (simultaneous collaboration on a table-top, multiple-single users on a wall etc.).

Responsive web technologies therefore may address the issues of the scalability of a single user interface for a unified collaborative environment, however the second issue is not necessarily resolved.

6.5.2.3 Plug-and-Play

The empirical studies did not cover the notion of plug-and-play configuration. Like authentication or security, they would rely on a more complex technological solution. The suggestion of using the proposal of optimised interoperability layer (OIL) is made and could answer some of these considerations.

6.5.3 Caveats

As discussed in the relevant chapter, the recruitment of participants presents a risk of biased requirements, it would be therefore necessary to prototype a broader diversity of systems following the design guidelines and evaluate them to validate them. It is therefore recommended to consider the validity of the design principles within the parameters of studies presenting similar recruitment conditions.

Additionally, some issues are not discussed such as cyber-security and they should be taken into consideration when implementing a real-world system.

6.6 The concept of OIL and the prototype

The idea of OIL was conceptually proposed to cover specifically the issues that were the focus of this thesis, however there are already technical solutions published in the domain of the Internet of Things (IOT) or Ubiquitous Computing as covered in 5.2.4. so as far as a middleware solution is concerned this would need to be thoroughly investigated in future works.

The prototype evaluated in the final empirical chapter did not result in data showing a higher desirability overall in comparison with the technologies already available in the room. Dropbox scored higher on average with a narrower standard deviation.

The questionnaires did not return the result that was hypothesised; however additional comments from participants indicated that it might be a direction to explore further. Additionally, there are other caveats to the study; the prototype's functionality was very limited, and its user interface was very 'vanilla' i.e. using the default appearance settings of the operating systems without a specific effort into their appearance. This could also influence the ratings on attractivity.

As such the study is more valuable as a testbed for further studies than as a standalone piece of research.

6.7 Conclusion and Future Work

The main two contributions of this thesis are the meeting journey and the design principles. Their contribution value is essentially for designers and creators of co-located, collaborative device ecologies; the former is useful for the analysis and requirements gathering stages. The second is useful for the design stages.

The concepts of OIL and the prototype for the hybrid approach are, on the other hand, proposals of how the design principles could be applied and implemented. Alternative arrangements could be implemented and evaluated.

6.7.1 Refinement of design principles

With the caveats of the design principles in mind, a matter of priority would be to further evaluate them against different variations of systems supporting different collaborative scenarios. Each scenario would take place in a different space, would comprise of different activities, contain different variables.

This would lead to the instantiations of different user interface / user experience models. Targeted usability testing can be used as well as desirability metrics.

6.7.2 Ownership and Authorship of Data

Additional questions arise about the ownership and authorship of data. These go in pair with the matters of accountability. Collaborative editing tools such as Google Drive do offer the ability to simultaneously edit the same documents, with the risks of conflicts and collisions among different users.
Similar issues would arise among users of a co-located, collaborative device ecology. Collaborative groupware does offer a unified user interface; Microsoft's most recent efforts to unify the UI in its Office 365 tool among different platforms (PC, Mac, mobile) is remarkable; however how could similar issues be dealt with in a more heterogenous ecosystem of devices and software? If, for any reason, a group does not wish to rely on third party vendor infrastructure for security or data governance issues, what solutions could be deployed? Nextcloud (Nextcloud, n.d.) is an open-source, self-hosted alternative to Dropbox, and is currently deploying collaborative tools. SOLID is another ongoing project, launched by Tim Berners-Lee (Inrupt, 2019), looking into alternative solutions for data ownership.

6.7.3 Security and Scalability

Notably, security issues and their impact on user experience have been outside the scope of this PhD project; they deserve to be investigated thoroughly. Two angles of research can be held: local access and remote access.

Authentication issues need to be investigated; not all security and authentication measures have the same efficiency and impact on user experience. A systematic review of those measures followed by a comparative study of their UX impact is

one angle of research. Another angle of interest would access limitations of devices to networks, as most of the research assumed the network to be a working “black box”.

Finally, the impact on user-experience, usability and performance of the scalability of collaborative device ecology is an additional axis of additional investigation.

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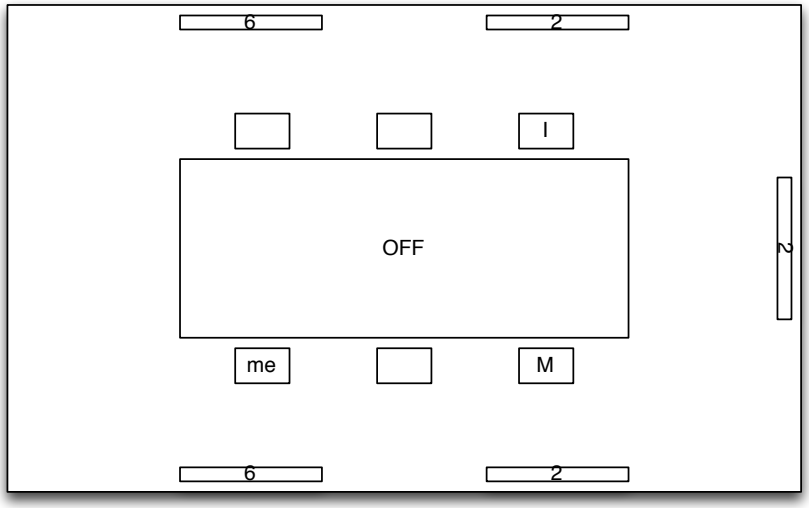
Appendix A Initial Observation Data

This appendix contains a selection of observation data. The selected examples are "EU project coordination meeting" and "University exam result board". The data is presented in the form a vignette, containing meeting details, a few photographs, and a transcript of actions observed during the meeting.

Theme:	EU Project
Place:	ICE
Date:	21/2/2013 9.45am
Participants:	IH, MS, Remote participants
Room setup:	I setup the room, lights full on, sound 60%

Layout of Room



Notes

We arrived at room at 9.45am. IH used the room's equipment for the whole duration of the meeting, exclusively using the wireless keyboard and screen.
Starting the conference caused some difficulties, as GoToMeeting requires the creation of a session, sending an email to all participants. First IH needed to reach the password, which was changed recently. GoToMeeting's built-in mail client is not set up in the ICE, which required IH's login to the university's webmail and copy/paste the invitation text to everyone. Getting people to connect to the meeting took about 15 minutes.
The quality of the link with one of the participants was quite bad, which required him to use his computer / webcam for the visual aspect of the teleconference, but use his phone to get the audio to work.
The onsite participants were quite aware of my presence and some "think aloud" moments occurred from IH, about the unfamiliar aspect of the computer setting in the room.
A lot of multi-tasking took place during the meeting. IH using her iPad and MS using his laptop. IH used GoToMeeting's chat window to keep notes of what's being said, but at some point also has a conversion with the Italian side via text-chat whilst MS was discussing a different topic with the Croatian side using voice and video. At some point IH used Google on the main screen, to which MS said "I can't see them anymore". She resized the window down.
The point where "everything was said" was reached 4 times, before the actual end of the meeting; something new came up everytime and the actual end time ended up 18 minutes later.

9.45am
IH:

- Not using touch at all.
- Not finding the login for GoToMeeting
- Initially set up the room with lights on "3" and blinds closed:
- Kinemote keeps appearing on the screen.

10am

- MS remembers the password was removed from the whiteboard for security reasons.
- Meeting due time

10.05am

- GoToMeeting started
- MS is reading email addresses of attendees from his laptop to IH. IH writes those addresses on paper. She uses the invitation template from GtM, logs into her staff account on zone 2, pastes the template in a new message from Outlook Web and sends the email to the attendees. She seems to struggle reading on the screen as she needs to lean forward to see what's written. She's exclusively using the mouse/keyboard from her seat, not using the touchscreen at all.

10.07am

- Meanwhile, GTM emits a regular beep, waiting for attendees.
- IH is thinking aloud: the experience is stressful on an unfamiliar computer where the email is not set up etc.

10.10am - IH: "I don't know how Oli does it normally."
10.12am - IH checks the webcam angle. She's unhappy, gets up, and tries to aim the webcam slightly differently.
10.13am

- First attendee (P1) is live online from Croatia.
- Audio check, volume is too low. They look for the setting.
- MS "We'll just all have to speak loudly".

10.15am

- *I helped with the volume, up to 60%*
- P1 hears his own echo.

10.16

-Kinect window appears.

- The enlarge the GTM window.

10.20

- M and P1 discussing the normal agenda. Meanwhile, IH is multitasking with her iPad.
- M takes notes on paper mostly, and masked very little use of his laptop.

10.23 - an iPhone keeps receiving notifications in the background of P1, this confuses
10.24 - IH multitasking with iPhone
10.27 - IH is emailing a missing person from her iPhones
10.28 - M is texting the missing person.
10.31 - Kinect reappears. Some ghost touches on Zone 2.
10.32

- Regular "click" sound in the speakers.

- IH opens Chrome with the email page, and closes it promptly.

10.33 - IH and M decide to stop waiting for the attendees and keep going on with the agenda.

10.35 - Kinect window over everything

10.37

- P2 comes in, live from Italy
- Sound test. He hears MS but there is a long lag.
- I am introduced as a PhD student to the remote participants.

10.38

- Bad audio lag issues with P2
- P1 leaves the frame

10.39

- P1 is back
- IH is still multitasking

10.40 - IH passing iPad to M, showing something on screen. They collaborate around the iPad, which however appears tiny on webcam.

10.45 - Some remote windows error sounds are audible

10.47

- IH is Googling someone full screen on zone 2
- M is confused by the lack of video feedback of P1 and P2 and says it aloud.
- IH reduces the window size and sends a link to P1 and P2 via the GTM chat window.
- Some ghost touches on the cell.

10.51

- P2 muted himself (video and audio)
- No comment by anyone about this

10.59 - P2 reappeared. He's using the phone to connect to the conference audio instead of his computer.

11.03 - P2 types something on his phone keypad, this is audible from the ICE.

11.04 - Accidental opening of "Room Control" (Ghost touch?). IH closes it.

11.06 - IH types what is being said in the chat box (in order to keep a written trace?)

11.07 - *I set the air-con a bit warmer*

11.09 - Absent attendee from Denmark texts MS to excuse himself.

11.14 - Video issue with P2's stream

11.15

- IH mentions the end of the meeting.
- A date for the next meeting will be scheduled later.

11.20

Parallel conversations:

- M with P1 via video
- IH with P2 via chat.

11.24

- MS is multitasking with his laptop.
- Kinemote appears again.

11.25

- Second call for the end of the meeting.
- P1 keeps going.
- P2 has been very quiet on audio/video for the whole meeting.
- Next meeting to be scheduled mid-March?

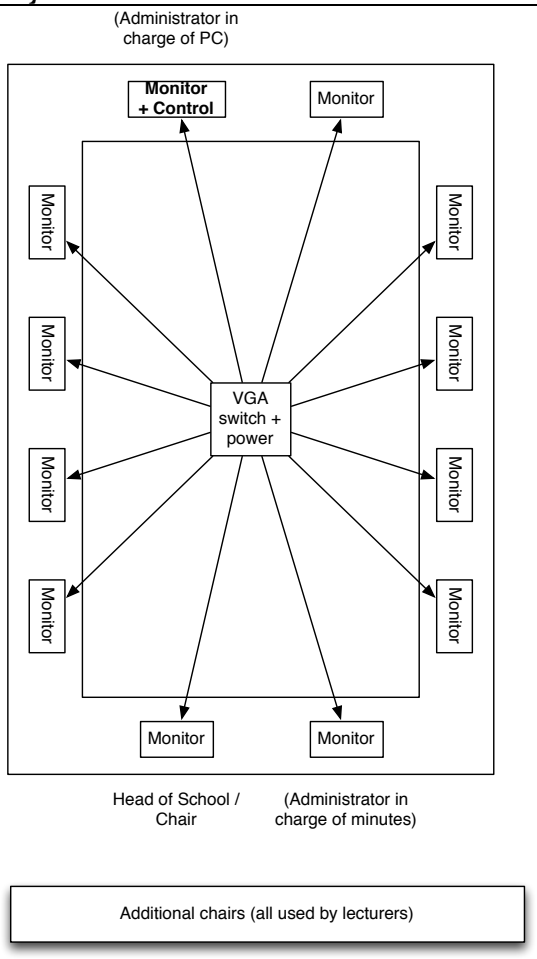
11.27
- Third call for the end of the meeting
- P2 starts talking

11.29
- IH still uses the GTM chat in parallel. P2 keeps talking.

11.33
- Fourth call for the end of the meeting.
- Attendees greet each other. Actual end.
- It takes a couple of minutes for IH to close GTM completely.

Theme:	**Undergraduate module board**
Place:	**D40**
Date:	**28/05/2013**
Participants:	**Faculty administrators, Module leaders**
Room setup:	**N/A**

Layout of Room



Notes

Started 9.35.
It started with the minutes of the previous meeting for about 5 minutes. Then we the board went along all the results and statistics per module. The module leaders were commenting on different matters, such as marks distribution, student feedback.

The head of school chairs the meeting and a faculty administrator shows the relevant electronic documents on all screens via this distributed network of VGA cables. There is a global spreadsheet with the agenda and summarised stats; each module has its own detailed spreadsheet for marks.
Per module discussion time can vary, it's around 10 minutes at level 7. At level 8, it can be significantly longer because of many issues discussed.

Appendix B Transcripts: interview guidance sheet, student and staff interview data

Understanding Collaborative Practice with Technology

Guidance sheet for group interviews, based on ABC – TACIT principles
Aurélien Ammeloot
Version: 1.2
20/02/2014

Group:
Location:
Date:
Amount of people:

(template http://www.crpspc.qc.ca/Guide_entretien_versionWEB_eng.pdf)

Activities / Journey

Key questions	Additional questions	Clarifying questions
What are you doing?	**What is the scope of your activity?** **Its duration?**	**Can you expand/clarify?**
How often do you meet?	**For how long?**	
How do you choose the location? The time?	**Any constraint for the location of the time?**	
Do you also spend time working apart?	**What ratio?**	

Technologies

Key questions	Additional questions	Clarifying questions
What technology do you bring at the meeting?	**Why do you bring? …**	**Can you expand/clarify?**
What equipment of the room/pod do you use?	**How do you use it?** **What advantage do you see using it?**	
What applications do you use when you collaborate?	**To produce?** **To communicate?** **To organise?** **What type of documents and assets do you use?**	

Interview transcripts
Student Group 1:

Number of people: 3
Digital Media Students, 3rd Year
Group Project

Male, 27y/o, role not documented, "expert" user, uses laptops, smartphone applications, tablet several hours a day, never uses large surfaces / tables.
Male, 20y/o, role not documented, "expert" user, uses laptops several hours a day, smartphone apps daily, never uses tablets and large screens/tables weekly or less.
Male, 20y/o, role "creator", "expert" user, uses laptops, smartphone applications several hours a day, never uses tablets or large surfaces.

They had one laptop connected to the screen.

Interview:

What are you doing?
Working on a group project, making the art for a game. Working with programmers who will make the game
How often do you meet?
Every week in study pods. The reason is they don't need to be booked.
Does the screen play a role in your choice of the pod?
Certainly helps but we could use laptop screens.
You're all creating a game, do you brainstorm or review other people's work?
We discuss each other's work. It's not really brainstorming (other guy: yeah more like go home, research and discuss here).
Do you share those ideas before the meeting?
Sometimes we have Skype meetings or we send it to each other using Facebook.
Do you use any wikis or collaboration tools then?
Google Docs, to create documents online.
What type of documents?
We can write a story here, talk about our next presentation. Everyone can make changes, we can see the changes others have made. Easier than word docs.
Any difficulties when sharing those docs?
No, just one click. Or you can set so, you just have a link you can paste anywhere.
Do you work on any documents separately that you eventually need to share?
Yeah we work on Maya files, 3D files.
All of you?
Yes.
Do you have any form of hierarchy?
(misunderstood question) x. As they're linked they'll automatically be updated.
Do you keep track of people working on different assets, changes etc?
Mmmm we kinda just started (laughs). We're gonna have to do something like that. It's not been an issue as we haven't created a huge amount so far.
When you're meeting, basically you're meeting with one laptop. What do you do with the large screen?
Well we do sometimes use the PC so someone can write something else.
So you use them separately sometimes?
Yeah

Do you need to transfer information from one to another?
No it's usually separate documents, doing something different. Someone might be taking the minutes, like earlier.
But you don't have a specific use case for multiple screens, other than that?
Not really, it's mostly easier for everyone to see when we're working on something like an asset.

End of recording.

I forgot, how do you schedule the meetings?
Facebook mostly… and the time is whenever people are free.

Student Group 2:

Pod 5
21/02

What are you doing?

Putting up a presentation about cars. For SACI, product design & graphic design, design business. This is about cars, we have to look at the target market.

Is this a one-off?

We're probably going to be working with other people after this. It's just a one-off.

How often do you meet?

We've had three classes and one meeting outside the class (the first).

How long do you plan to meet today?

For the next two hours (girl: until the presentation *giggles*)

How come you picked this place?

It's quiet. And you can plugin a laptop and everyone can see what you're doing. We can't sit round as a group in the Kilby.

Is it important for you that people can see what you're doing?

Everyone can see the same thing instead of crowding around the laptop. Everyone can make comments about what needs to be changed.

Is there one person in charge of the laptop?

(girl: it's my laptop!)
It's me but [other girl] had to summarise what she was doing and used the laptop herself.

Would you work differently if you were somewhere that doesn't have such a big screen?

Yeah. In the Kilby we'd all be working sided along the way rather than as a group; and we'd all be crammed in around the screen.

How do you connect to the screen?

HDMI cable.

You're not using any cloud sharing?

No we put stuff on Facebook. We've got a Facebook group for this group.

Do you work apart? On your own?

Oh yeah (guy: we all do our own bit and the we bring it all together to this meeting).

Did you ever use another way to share the information to that screen? Network drive? USB pen? Drive?

Girl 1: No, I don't think there's any other way no?
Girl 2: Here's a computer
Girl 1: Oh! No... It's easier with the cable.

When you're working apart, do yiou have a way to be aware of what other people are doing?

We just put it on Facebook.

How much do you need to be aware of what people are doing?

We all have set tasks, so they don't overlap anyway.

Again, when you're working apart, how important is it for each of you to have your own private territory? Your own stuff?

Girl1 :It's not really that...
Girl2 : No....
Not from each other... but I guess if we're doing non-work related, that'd be our own thing.

What software do you use?

(1 person: I use Google Drive)

Do you use it together on this project?

No we use word.

How do you share you work?

Save it and upload the file to Facebook.

Why did you bring the laptop instead of connecting to the provided computer?

I've got everything here. I've got saved links as well. I save a lot of links from the internet. It's more convenient.

And about meeting now? What guided your choice of this time?

(giggles from all the group)
Last minute really...

Student group 3:
Pod 5
6/3 15.30
3 People

What are you doing?

We're doing a presentation for pre-cognition in a module. School of Life Sciences (3rd year)

This presentation, how long is this project going on?

We started 2 weeks ago, it's been assigned since the beginning of the semester. The deadline is next Wednesday.

How often do you meet?

Twice a week usually.

How long?

A long time. 3 to 4 hours.

Do you work apart?

Yeah we have to read a lot of articles so when we bring it all together it's easier to flow. Not today but before the first meeting we had to read articles and prepare arguments for the presentation.

Why do you meet here? Do you usually meet here?

Usually it's study rooms, but we could only book one for an hour today, so we just took one of those.

Any constraint, like a lecture before or after you meet?

No, well not today but previously we had lectures before.

So I see you bring laptops and you use the screen. Do you connect your laptop to the screen or do you use the other computer?

Sometimes we do when we have to write something. Usually it's not connected because we need to work on different interfaces at the same time.

Apart from the laptops, do you bring anything else?

Phones, but we don't use the phone for the work.

What do you think the advantage of that screen is?

Everyone can see.

What applications do you usually use?

Word, Internet, Powerpoint.

How do you communicate?

Facebook to each other and texts.

How do you organise your meeting?

FB, and when we see each other during class.

What types of documents do you work with?

Word, PDFs, PPT

Do you keep your own information private until you meet? Or do you share?

Depends, when we have questions or not.

How do you share?

Facebook (giggles)

What do you send on Facebook?

the paper, links, websites, general information, questions.

Do you feel the need to keep stuff private until a certain point?

No, because at the end it's all gonna come back here. We actually need to share a lot, that's why we spend so much time together.

How easy is it to share on facebook?

Easy, we don't share all documents but once we meet we bring hard copies of the documents, have a read through.

How do you get feedback from other people? Do you mark up documents?

Yeah we just highlight them, write notes. On paper.

So you don't exchange comments when you're working apart?

No, usually we just attach a question to a document, like "on that paragraph, what does that mean?" "what do you guys understand?"

In the message then, not in the document?

Not in the document, no.

So, when you're together, when you're working on different machines, are you aware of what other people are doing?

Yeah usually. We try to share the task. If two people are working on the same thing, it's kind of counter-productive.

Do you need a lot of awareness? Do you have to be constantly aware?

Not constantly as long as we know what we're doing. We know our friends; we know they're working on a specific part of what we are doing at the moment.

Do you need any tools for that, or do you just do that?

No yeah just talking.

Who's in control of the main screen?

At the moment she is, because we have our machines.

But is there one person controlling, or do you take turns?

No, whenever someone wants to show something they just take the mouse.

How do you ensure the information from the laptops can end up on the screen?

P1: Facebook. We upload to Facebook and then get back from Facebook (on the screen).

P2: Or now, if we need something just now we connect it to the screen and show.

P1: Or USB sometimes.

P3: I email stuff to myself all the time.

P1: I prefer Google Drive but it's just to save the articles I want to save.

Student Group 4:

3.30 24/03/14
Two girls G1 and G2. G1 is doing most of the talking. I differentiate them when necessary
10 minutes.

So just remind me, you're in the school of
Built environment

What are you doing right now?
We're doing a group presentation for a planning and development class.

How long does this span over… one week? Two weeks? More?
Hmmm well it should have been longer but we had a week to do it. We've only been yesterday and today.

How long do you meet every time?
Today we've met for… 5 hours? (checks) Yeah five today and yesterday was away… 3 hours. 7 'til 1.

Seven in the morning?
No, seven in the morning til one in the evening (NB: she did say 3 hours, doesn't match).

And the deadline is?
Tomorrow.

Why did you pick this place? Do you usually pick this place?
We got kicked out of the… group rooms (laughter).

Does the large screen guide your choice of picking the place?
No. Well it's good because it's a big one so we can work together. (blank) We picked that as opposed to the other computers that aren't in pods because it's enabling that, yes.

What technology did you bring with you?
G1: I brought my laptop.
G2 shows her phone. *Do you use it for the work?* G2: no.

Are you the only person using the laptop or do you share?
Uh, we've been sharing the laptop as well.

Do you take turns? Do you have a democratic process?
One of us uses the big screen, one of us uses the laptop.

Is the screen connected to your laptop or are you using it independently?
We're using the computer.

Okay so you're multi-tasking.
Yep, one each.

Do you work apart or only together in those sessions?
It's a bit of a combined… sometimes we're working apart and sometimes together. At the moment we're together.

Can you quantify?
We don't usually have group work. It's usually individual courseworks.

But for this task?
Just for this specific module, yes.

What applications do you use?
As in… Microsoft? PPT, Word, Excel.

What kind of documents and information do you exchange when you're working as a group?
PDFs, planning regulations, p,anning frameworks, things like that. Usually PDFs.

And how do you organise the meeting?
Facebook, we have a group. There's two more people in this group, they just left for work.

So everybody posts their bit on Facebook?
Yes and when we meet we put it all together.

--

When you work together, do you like to keep your information private until a certain point, or do you not mind people being able seeing what you're doing.
G1: I don't mind.
G2: I get embarrassed, in case it's not right. In case it's wrong.

So you need to keep your own space?
G2: Yeah I don't like people watching.
(to G1) what about you?
G1: I don't really mind, but I like to see what everyone else is doing 'cos I'm a bit of a… of a…
G2: a bit nosey
G1: a bit of a perfectionist so I wanna know what everybody in the group's

Do you have a role in the group, like a group leader?
G1: We don't really have roles.

How easy is it for you to keep things private?
G2: Not really that easy because (name) usually wants to see (giggle).
Would you like a system helping you keep things private?
G2: No, I just want… personal thing, you know…

Do you have any conflicting interactions when you work together, like on the same document or the physical space? Or sharing the screen with more than one person? Does it ever happen?
G1: Arguments?

No, conflicting interactions, you're trying to do things at the same time and it gets mixed up.
G1: That's why we brought the laptop. Just in case, if that is a problem.

Are you usually aware of what other people are doing?
G1: If I wanted to be aware, I would. I'd find out.
G2: (laughing)
G1: You know what would happen (giggle).

So how much awareness do you need?
G1: Basically I want to know everything. (laughs)

What do you use for that? FB? Do you check?
G1: Hmmm well yesterday I just had everyone report to me.

G2: I suppose (name) is the leader.
G1: I'm the leader, but not specified. Without the name. I won't say I'm the leader, I will say I'm a perfectionist.

(jokingly) You can do a PhD then if you're a perfectionist. You'd work alone.

And when you're working apart?
G1: Obviously I can't know until we're working together. They could send me the documents if need be, but if they're with me I'll have a look at what's happening.

How do other people react to that? Do they protest?
G1: They do not get a chance to protest (laughs).

How do you usually interact with each other?
As a group we interac† through FB, then through FB we organise meetings. On FB we keep logs of what's been happening.

How do you make transitions between the laptop and the screen?
Basically we've been using the big screen as the group and the laptop is for individual work. Others also bring their laptops.

Up to how many laptops can you get in a meeting?
I've never tried but about 3?

How do you pass your information to that screen?
Drives, sticks, but we also send to the FB conversation as well.

No tools like Google drive or Dropbox?
No, not for this group.

Thanks for your time.

Student Group 5:

Group 5 transcript

Pod 1
26/03
2.30pm

What are you doing?
We're doing a project for a management module

What school?
SEBE

Why do you work in this pod?

Basically it's a group project, we're all doing on one computer. There's a big screen, we can all see it.

That's important for you to have a big screen?
Well yeah it's easier than a small screen and if we surround it's easier to [work it off?] (sic)

What's the scope of this project?
It's a semester project, 3rd year.

How often do you meet here?
We started off a couple of time a week, but over the last couple weeks it became more like a daily thingy.

How long usually?
A few hours. Quite a long time usually.

Do you have any constraint for the time/place you meet?
No, usually just after lectures.

How do you work? Only together or sometimes apart?
We mainly work together, sometimes we'll do a little part and bring it, but mainly together.

What technologies do you usually bring?
Mainly phones. We usually only bring USB sticks and use the screen here.

What type of apps?
Word, Excel

Any specialist app?
No not for this project, no.

How do you communicate?
Mainly texts.

No FB? Email?
No just texts

Do you keep information private until a point where it needs to be shared?
We'll all open on sharing. As soon as someone brings something it's put on the table.

Do you have a main person using the technology in a meeting?
Do you have a democratic process?
Do you take turns?
He's usually using it. He's the expert. [I can… use computers]. He's a fast typer. He's fast at using the computer, faster than we are.

When working together, do you have conflicting interactions?
On documents?
In the physical space?
Accessing the room/pod's technology?
How do you resolve conflicting interactions?
No not really. If they wanna look something up, I'll do it for them.

And working apart?
We've been writing our own files and we put them together by copying and pasting into a main one.

Do you use any collaborative system? Google drive? One drive?
No, just memory sticks.

Are you aware of what others are doing in meetings?
How much awareness do you need?
Sometimes someone's on their phone, you wanna get off it. It's not a big issue. Happens sometimes. Happens to him in the corner, he's always on his phone [**nb: if that was a joke it was a proper deadpan delivery**]

How do you interact with each other?
We're all mates, for a few years. It's not like we work with people we've never worked with before, where it's more formal. We're very informal because we're all mates.

You use sticks, nothing else?
No

Staff 1:

AA: Ok ……. interview 31st of March. So we are going to talk hypothetically because we're not actually in real life you're not actually doing something but… what do you usually use the room for?
[redacted] I use it quite a lot for meeting with clients who do innovation vouchers if C50 isn't available.
AA: OK you use C50 first and…
[redacted]: I would tend to yes
AA: what's the reason for the choice, one room rather than the other?
[redacted]: I think C50 I think is… the table is easier to sit round and also the big screen is easier to operate, to use to play a laptop and show people stuff.
AA: So, let's say if you're in the ice you use mainly the big screen as well?
[redacted] I try to, but it's really not big enough because the screens are behind you, people need to turn round away from each other to look at them so you can't actually speak to them at the same time as you're looking at stuff. So it actually makes it quite difficult to talk to people.
AA: how do you usually configure the ice then, if you're in the ice and you've got those 4 screens at the sides and this one…

[redacted]: yeah I would tend to just get them all up and plug a laptop in and connect the laptop.
AA: so you try to mirror on every screen?
[redacted]: yeah probably, yeah. Mainly because, I think if the screen here was bigger, everyone could look at it but it's actually quite small.
AA: yeah the same, ok. Yeah I know, I think back in the day it was the largest you could find and…
[redacted]: and I think the problem is the table, I mean ideally the table would work, you could plug in a laptop or something and use the table as something to show people stuff but I think the table's actually quite difficult to get working and get the stuff you want onto it.
AA: On the screen?
[redacted]: On the table.
AA: Yeah ok, displayed on the table.
[redacted]: Yeah so ideally you would have it on the table, you'd have documents and things you'd be able to slide them over to people and turn them round and show people stuff but I've never actually managed to get it to work
AA: OK, how would you do that, do you think you there should be an easy way to upload content there or just plug it in on physical media?
[redacted]: yeah I think, or if you could just access your H drive, if you could log in yourself and access your…
AA: staff H drive?
[redacted]: staff H drive or whatever so you could pull the files that you want to look at onto it and then share them and discuss them, or show a video or whatever you wanted to do, yeah.
AA: Who are the other people usually, like external clients, so they're members of…??
[redacted]: Usually external clients yeah, well usually there'll be myself maybe Roger or Sharon who are internal, maybe Elaine Wood and you'll have your people from outside and if I'm working with a developer they'll be there as well.
AA: OK. Do you have any meetings with other like members of the school or the institute for more collaborative like brainstormings or creation or…
[redacted]: Yeah again, I would tend to use C50, the whiteboards in there seem to work, it's got the paper things. I think the whiteboards in the ice lab they don't seem to work.
AA: the digital capture?
[redacted]: yeah.
AA: yeah it's yeah… in truth it's disconnected at the moment because of a USB power issue but…
[redacted]: yeah. But also I guess the location of the actual surface that you can write on seems to be to the side and narrow it's not a big space that you could actually do stuff on.
AA: Yeah
[redacted]: So yeah, I mean it's a nice idea to have and I do use that kind of thing when I'm in brainstorming with folks in C50. But it seems to work better there for some reason, in C50.
AA: OK, is there a capture in C50?
[redacted]: well, there's no capture you just, well you just take a photograph
AA: OK. OK is it the flipchart or no, a whiteboard?

[redacted]: there's a flipchart there's also the whiteboard and often it's easier just doing it on the whiteboard it's snappier and then you can share it afterwards.
AA: yeah. Yeah, it's easier. What technology do you usually bring when you're having a meeting in either room?
[redacted]: a laptop and a few coloured markers.
AA: OK do you use your laptop to display content on the screen or do you use the equipment that's in the room like connecting to your H drive or Dropbox?
[redacted]: so I'll connect my laptop to one of the screens and I'll probably use google drive or that kind of thing from my laptop if that's what you mean?
AA: OK, yeah you don't use the computer provided in C50 or provided in the ice room?
[redacted]: No I usually, I mean in C50 Skype's not actually installed properly, you can't use it on the computer that's there.
AA: do you use it in the ice?
[redacted]: again it actually works better just using your laptop I think and skyping with the laptop you get a better quality audio and stuff.
AA: oh right OK that's fair enough coz some people use the ice mainly for skyping coz actually that's one of the things that works best so I was wondering…
[redacted] I've not tried that for a couple of years but initially it didn't seem to work
AA: it's only installed on one screen, Screen 2.
[redacted]: Right OK
AA: It's only there because that's the only machine with a…
[redacted]: Is it installed on this one?
AA: Yeah this one, that's the only machine with a webcam. So you can get a fairly lifesize image but again, any feedback is good for me so that's interesting. What type of documents to you usually bring in these meetings?
[redacted] there'll be Word documents, there'll be pdfs, there'll be videos, there'll be webpages…
AA: Any code, any code demonstrations?
[redacted]: yeah we will kind of run demos, so again your laptop you just run it from your laptop.
AA: Yeah because there's, the space doesn't have a visual studio or anything like this. Who's usually leading the meetings, are you the person in charge of the technology or are there many people using the technology, taking turns or…?
[redacted]: Usually I would probably be in charge of setting it and maybe if we've got developers they'll be in charge of demonstrating different things if the companies come along with their demos as well they'll load it up.
AA: so it's more than one person, you don't have conflicting interaction on the machine like sometimes somebody needs to use the machine and the other one is using it or… those questions are very generic they can apply to break-time collaboration or they may or may not match what we are talking about (can't hear end of this)
[redacted]: I mean certainly for C50 it's quite easy to plug in a different laptop and swap over.
AA: oh you can plug in 2 machines.
[redacted]: you just swap them over fairly easily
AA: doesn't the ice do that?
[redacted] Um because the screen's, I think because the screen here isn't big enough it's actually difficult, yeah, I find C50 a lot easier

AA: OK. When you're working, do you tend to keep your information private until a certain point when it needs to be shared or are you more open for people seeing the drafts or your work in progress?

[redacted]: so the internal team, so myself and the developer, keep things open and then we'll ?? it to the company when we feel it's the appropriate time and then we'll agree with the co when to release it to the funders. So you've got kind of 3 levels of interaction, you've got myself with my developers, you've got myself and developers with the company we're working with and you've got myself, the developers the company and the funders. So you've got kind of 3 levels of release of information.

AA: yeah release and openness and so do you think it's necessary? are there motives behind that maybe confidentiality or…?

[redacted]: I think when you're talking with your developers you're brainstorming and you're looking at the pros and cons of things and whereas if you (???) it to the clients you want to be more, come across more assured of what you're doing and you've looked at the different options and you're recommending something with them so you probably wouldn't go through that brainstorming so much, you would in some circumstances but there are things that you would do at the developer part that is training them up and getting them to the level that you want them to be at so you wouldn't bring the client in on that, on these kind of discussions and things.

AA: Yeah makes sense

[redacted]: And again there are things that the client might want to discuss with you and brainstorm with you before going back to the funders on what the decision's been so, yeah

AA: Ok that's interesting, do you have any way to keep track of, do you need a lot of awareness of what other people you're working with are doing maybe? Do you keep track or are you more trusting or do you have set meeting or milestones to keep track or…?

[redacted]: Yeah so with the developers I work with I probably have a weekly or fornightly meeting with them, I'll also get them to keep stuff on maybe google drive and code in using an SVN for one project so that they're checking stuff out and they keep… It's fairly light touch but they'll do a little report each week on how many hours they've spent on it and what they've done coz we need it anyway for filling in the claim sheets for their expenses so it makes more sense for them to do it as they go along and that gives us the info to put into the reports, our quarterly reports of whatever we're doing.

AA: And what about the external clients do you have a way, do you need some awareness of what's happening, coz I guess in innovation vouchers you have to match time and work and…

[redacted]: yeah innovation vouchers aren't so bad but I've got other ones who've got a technology strategy board produce line?? which is a 9 month project and there are quarterly meetings with the funders so you need to keep more of a track you've got to kind of what packages and keep track of the stuff so again email and dropbox is fine for keeping track of that.

AA: yeah ok so there's no specific way to look at what they're doing or look at their check out or their comments on ???? or something.

[redacted]: no because we're doing separate things with them so it's not really collaborating on the actual code with them it's more us producing code that they'll then take (can't hear end of this)

AA: OK so collaboration happens here or happens there but then it's (can't hear end of this)
[redacted]: there are different kinds of collaboration and then integration of things, basically.
AA: Uhuh. OK that's good. Couple of other questions, I've covered those aspects ???? What tools do you use, what do you use to set up the meetings?
[redacted]: Usually outlook
AA: Outlook?
[redacted]: Yeah
AA: Yeah? Even with the clients do you use…
[redacted]: Just Outlook
AA: Outlook. OK, that's OK. Well that's good that's kind of the info I needed.
[redacted]: Good
AA: Well, we'll see where it takes us. Thanks …. for your… (cuts off)

Staff 2:

AA: So what are you usually doing when you're meeting in the ICE?

[redacted]: Right so there's three of us, there's three PhD supervisors, meet together in order to talk to our PhD students who are doing a PhD remotely in Abu Dhabi. We can't meet them face to face obviously because of the geographic distance so the ICE is the ideal location and space in which we can actually see them and talk through their PhD work.

AA: And why is the ICE ideal, instead of an office or a more conventional meeting room?

[redacted]: You got the big screen. If you were sitting doing it on Skype at a laptop or a computer, it's not nearly. The experience is much more one of intimacy in the ICE because the person you're speaking to is live-size for start, on a computer screen they wouldn't be live size so on that screen it's much more like being there in person.

AA: So this idea of intimacy is guiding you to pick this place rather than another?

[redacted]: Yeah

AA: So what else do you use in the ICE, do you use any other technology that's available?

[redacted]: I think we… Yeah when it was first being set up we did use it with Oli as well, looking at the RLS website. Looking at a literary app at one point, I think, but it was quite a while ago now, four years or so. It was quite handy for having different pages of the website at the same time, that you could look and see how it worked.

AA: On multiple screens?

[redacted]: Yes.

AA: And what did this give you rather than having more than one window on a single screen?

[redacted]: It meant you could compare and contrast, things like that. We were looking at other things, it wasn't just the website – I'm sorry I can't remember – but I know we did use it for various purposes and we could look at – we were looking at the city of Edinburgh for some reason as well – I think the literary app.

AA: The literary app?

[redacted]: We were thinking of doing an app for this… oh it was with Serkan, a literary tour a virtual tour of

AA: Okay, did that become the City of Lit – no that's a different project from?

[redacted]: It became the trail, yeah.

AA: Okay that's not the topic anyway. So how often do you meet?

[redacted]: Not often really, maybe three or four times a year for each student?

AA: Three, four times… for how long usually?

[redacted]: ¾ of an hour or so,

AA: Outside these meetings do you have some form of remote collaboration with the other supervisors?

[redacted]: Uh with the students, yes, we exchange emails on a regular basis, commenting on work, passing back comments on work, arranging time to meet for example.

AA: So if I understand, the ICE is for supervision meetings, or for supervision and RD[1] meetings?

[redacted]: That's right, progress reviews, it's most important for progress reviews because in that circumstance you want to have a supporting environment for the student; we can do it via email but email can be misinterpreted and come across in the wrong way. When you're talking face to face, I think your meaning comes across much more readily.

AA: Okay, so what… do you bring your own technology in those meetings?

[redacted]: Do I bring my own technology to the ICE? No.

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[1] RD (Research Degree) meetings are Napier jargon for PhD progress reviews (4-months, 6-months, 1-year etc. e.g. RD4 RD6)

AA: No, you only use the room's. Do you use any form of application?

[redacted]: No, just Skype,

AA: Okay, do you exchange any for of document before or after that?

[redacted]: Yes we exchange the RD[2] forms obviously, send them electronically to students and they put an electronic signature on the forms and send them back to me.

AA: Okay. How do you apply an electronic signature?

[redacted]: I don't have an electronic signature myself but the students do. And they just put it on the documents and then send them back, electronically.

AA: Okay. I'm going to ask another set of questions, they might seem a bit out of touch, or not. We'll see because I'm actually evaluating a framework, about different key points with your collaborators. We'll see, they might be relevant or they might not. That's what I'm trying to find out.

[redacted]: Okay

AA: Okay. In the context of those meetings, do you keep information private until a certain point when it needs to be shared?

[redacted]: Occasionally, perhaps, if there is something I want to speak just to the student, about, or if there is something I just want to talk about with the supervisors, without the student in our hearing.

AA: Do you need to do that often?

[redacted]: No.

AA: How easy is it to keep things private?

[redacted]: Well we just have a private conversation face to face, outside of the ICE.

AA: Outside of the ICE, I guess because the student is in Dubai, Abu Dhabi, sorry.

[redacted]: That's right. Maybe Dubai actually, I always forget.

AA: Not here anyway. Do you have any conflicting interactions when you work together, with your colleagues?

[redacted]: No that's fine.

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[2] Standard documents associated with the RD meetings.

AA: How do you share the ICE for instance, is there a person using the computer, are you taking turns?

[redacted]: We talk very much as we probably would in a one-to-one face-to-face situation. We're sharing the questions, I tend to lead because I'm the director of studies and the panel chair, if he has any comments to make, he's usually very good. He takes notes of the meetings and things like that.

AA: The panel chair is acting as a… well takes minutes.

[redacted]: Yes.

AA: You have no conflicting interactions on the physical space, documents, this sort of things?

[redacted]: No.

AA: You're not producing something?

[redacted]: No.

AA: You work on the form?

[redacted]: Yes, but I do that on my computer.

AA: It's not actually like you're working on a project or build a presentation and so on?

[redacted]: No.

AA: Are you aware of what other people are doing in the meeting?

[redacted]: Well we're just sitting there listening to what the student has to say and then responding, and asking our own questions, we're not doing things, apart from the panel chair who's making notes.

AA: So would you say you need to have a certain awareness, or you don't?

[redacted]: Not really, because everyone's focused on the task in hand, which is talking to the student.

AA: How do you use the technology, apart from setting up Skype, do you do anything else?

[redacted]: No

AA: So you wouldn't say there's an issue of control of the technology with three people?

[redacted]: No, because we haven't really used it like that for those sessions.

AA: You set up and you're talking

[redacted]: Yes.

AA: How do you interact together, with your students and your colleagues physically present?

[redacted]: Well we try to sit one opposite each other so we're all facing the screen and looking at the student. And I can speak to them around me as necessary.

AA: Okay. So what do use to ensure the information you're bringing into the meeting – whether it's an RD form or feedback – reaches the technology present in the room?

[redacted]: Well we don't use. What do you mean?

AA: You might have an RD form or some notes, how do you make sure it reached the technology? You can be using the cloud, or talking to the microphone.

[redacted]: Well we would just talk to the microphone.

AA: You use the space as some sort of proxy to see the student and hold the conversation

[redacted]: That's right

AA: It's something you could hold arund a table basically.

[redacted]: It's like a virtual meeting room, I will have the RD form with me and it can be signed by the supervisors there and then. And I can send one sheet to be signed by the student. And for them to agree the summary of the meeting which I'll type up afterwards.

AA: Ok.

Staff 3:

AA: ….. , 24th March, C56. So when you're in the ICE, what are you usually doing?
[redacted]: I'm meeting with external clients and we may have presentation, or maybe not but just using it as a meeting room.
AA: As a meeting room, OK do you use any of the technology in the ice?
[redacted]: Yes if there's something in this particular meeting if there is something that requires a screen, for example a presentation we would connect to that screen and use it as a presentation.
AA: what do you mean connect, do you connect a laptop or do you bring some…?

[redacted]: I either connect my laptop or I download a presentation and display it on the screen
AA: what do you do most of the time, laptop or…?
[redacted]: I would say more laptop.
AA: more laptop?
[redacted]: more laptop.
AA: How easy do you find it to connect your laptop in the ICE?
[redacted]: It was OK until I got the Mac which it was more difficult but now I found a way so that I can connect the Mac as well.
AA: which way?
[redacted]: with the proper adaptor, like the thunderbolt to VGA
So you do it physically not over over the air or over a cloud service
Not over the air I don't even know if I can do it over the air.
OK that's interesting. How often do you meet, do you have a regular group of collaborators you meet there?
No it's only if we happen to have a meeting and the C50 room is not available then we would use the ICE.
So you use it as a back-up to C50
[redacted]: Exactly
AA: How do you use C50? In the same way?
[redacted]: How *often?*
AA: How do you use it?
[redacted]: As a meeting space, the same thing it's got a screen and therefore we can meet there.
AA: And you also connect to the screen?
[redacted]: Yes
AA: So you use both indifferently in the same way?
[redacted]: Yes
AA: What type of applications do you use?
[redacted]: Probably presentation but maybe we have some video maybe we can browse the web or design something
AA: OK. So you're mostly for presentations you don't use any of the rooms for collaborative work or…
[redacted]: No it's mostly one way.
AA: It's mostly one way so for example clients
[redacted]: With external clients, yeah
AA: (Just external clients)
[redacted]: In the past we used it for productive collaboration and so on but only a few times over the past 3 years or so.
AA: Did anything go wrong?
[redacted]: Mm?
AA: was there a reason you stopped using it?
[redacted]: No it was mostly that we don't do many collaborative meetings
AA: Ok
[redacted]: And again c50 is better even for this because there is a screen, the table is better, the seating area is more comfortable compared to the ICE room
AA: OK
[redacted]: So the ice room will be used only if there are far too many people or for some other reason.

AA: OK so comfort. So what technology do you bring apart from the laptop when yo're using the ICE?
[redacted]: Mostly the laptop
AA: Mostly the laptop?
[redacted]: Yeah
AA: Does anyone else usually bring, I don't know, an iPad?
[redacted]: I haven't seen, no, I don't think so
AA: and why do you bring the laptop instead of, let's say, using the technology available in the room?
[redacted]: Because my laptop has my stuff there and it has my apps as well therefore whatever comes across I can quickly open my favourite app and do my work.
AA: OK and the apps you use might not be available…
[redacted]: Exactly, so for example there is no visual studio in the ICE room and even if there was how would you use it with the screens like this if you want to quickly prototype something let's say you can't really.
AA: OK so in your meetings sometimes you prototype
[redacted]: Yeah well very rare occasion, but it could be OK you're collaborating to produce something you may want to prototype something or you may want to draw a box diagram… how would you do it in ICE room? Well maybe it's possible but it's much faster if you use your favourite app on your favourite laptop which is probably much faster than the computers in the ICE room.
AA: OK. Do you exchange any form of documents before the meetings or after the meetings with the people involved?
[redacted]: Not really, possibly, depending on the situation but not really.
AA: So you're using that for meetings that start when you enter the room and stop when you leave. Do you have a preparation period or…?
[redacted]: Very small, no not really.
AA: I'm going to ask you questions now I'm going to try to ??? questions that may or may not seem relevant to the subject. I'm actually trying to evaluate if they're relevant or not because that's a qualitative framework that David and Olly have been working on for a while. So don't be alarmed if that seems completely out of the blue. Do you keep your information private until a point when it needs to be shared in these kind of meetings or collaborative scenarios?
[redacted]: Yes, yes while I'm working on something I don't like having drafts circulating around if this is what you mean
AA: Yes, among other things.
[redacted]: Yes I like to share at the desired point not sooner
AA: how easy is it to do it, let's say your laptop is connected there, do you ensure everything is on before the meeting or do you sometimes need a private space during the meeting?
[redacted]: Yes
AA: Yeah? How do you…?
[redacted]: No I don't, no
AA: No you don't?
[redacted]: No
AA: There's no…?
[redacted]: You mean a private screen?
AA: Yes
[redacted]: No, well the Mac can do it because he sees the ICE room as a projection screen.

AA: ok so you're not mirroring
[redacted]: and it extends its setup to the projection, whatever it is.
AA: so extending instead of mirroring you've got your private space this way
[redacted]: Yes exactly, if I need private space which I don't think is likely, anyway.
AA: OK so you need it before the meeting but not at the meeting.
[redacted]: Yes, yes when I'm producing the document but during the meeting, what could you do that you need private space?
AA: Are you the only person using the computer or do other people use…
[redacted]: Other people as well
AA: OK, the laptop?
[redacted]: They have their own laptops.
AA: They have their own laptops? Do they also connect to the ICE room?
[redacted]: Yes, and that's the advantage of the ICE room compared to C50 that everybody can connect and have their own screen.
AA: so do you connect different laptops to different screens?
[redacted]: Yes
AA: Ah that's…
[redacted]: We've done this a few times
AA: Is it easy to do, or do you have any…?
[redacted]: no it's fine, it's straightforward?
AA: how do you do that?
[redacted]: we connect it
AA: you connect it and you set up in the room?
[redacted]: Yes
AA: Do you have any issues sometimes?
[redacted]: Mmm, yes sometimes but most of the time it's fine maybe some cable is missing or something like this but… we've done it a few times. You kind of need to know what you want to do and make sure the equipment is there before the meeting. Once you have that, it's straightforward.
AA: How do you book the ICE, do you use the outlook system?
[redacted]: The what?
AA: How do you book the ICE?
[redacted]: oh with outlook, in the past I was booking it through Olly but now…
AA: we've changed now. When was the last time you used it because I was looking at people using it…
[redacted]: yeah it was with you, the last time was with you, I sent you an email and you told me, you can book it through outlook.
AA: no, but the last time you actually used the room for a meeting was a long time ago.
[redacted]: Yeah
AA: OK, that's fine. Do you have any conflicting interactions with other people in the ICE, on let's say, the same space, the same screen, the same documents.
[redacted]: No
AA: Because the purpose of your bookings are for presentations and meetings?
[redacted]: No, we have booked alone so what sort of…
AA: No, in the room, the people present in the room, the other people
[redacted]: No because there are many screens so anybody can project what they want, right?
AA: Uhuh, so everybody has got their own space

[redacted]: Kind of, yes.
AA: You're not sharing a specific space when you're in that room
[redacted]: No
AA: But in C50 it's different
[redacted]: C50 has only 1 screen, therefore you need to make a decision on who's presenting.
AA: How do you usually interact with your colleagues when you're in the room?
[redacted]: Discussion and maybe some small presentation or some small diagram which we discuss
AA: OK, um, so how do you make the transition from your personal data, your personal computer, personal space to that presentation area
[redacted]: Because if it's a presentation then I have prepared the presentation and it's always what you want.
AA: Do you use the cloud service at any time?
[redacted]: No, which cloud service?
AA: I don't know, like…
[redacted]: Dropbox?
AA: Dropbox or, One Drive
[redacted]: Yeah I use, I use all the time
AA: do you use them when you're using those rooms?
[redacted]: not, uh, I wouldn't want to… I think I've done it once, I think I've done it once, but I don't remember, to be honest. I do not really need once I walk in there with my laptop. The presentation is on my laptop so there's no need to download it from dropbox. It's very good that it *is* there, tho, yeah I know, that I can do my meeting there regardless if my laptop is not working, if the cable is not there I can use dropbox and get the presentation from there.
AA: But you haven't used it.
[redacted]: Mm, don't really remember, maybe once.
AA: OK, and the other reason you choose the ICE, maybe use it for day conferences and…
[redacted]: We used to, in the old…
AA: either room, actually
[redacted]: Many years ago, we were trying to meeting with collaborators who were based in London and we were using the ICE room weekly, but then we found out that most of the time, well not most of the time, many of the times, the ICE room was not working properly, one way or another, the Skype was not working, this was not working, that was not working, so we got bored of this and we started using C50 which is more contained and easier to troubleshoot and so on…
AA: ok, what do you mean easier to troubleshoot?
[redacted]: if the cable is not working, then you can see the cable and you can find out why it's not working.
AA: ???
[redacted]: So many times we have called Olly or you to fix something. It was 10 second fix but…
AA: So you book through outlook, do you also organise the meetings through outlook or…?
[redacted]: Yes, yes.
AA: even with external people?
[redacted]: Yes

AA: OK

[redacted]: it could be both with external, but locally I book with outlook and externally I send an email and say the meeting is there.

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Staff 4:

AA: What are you usually doing in the ICE or in C50?

[redacted]: So, I have two main uses of the ICE. I play a support role, when Oli Mival is introducing the whole subject of interactive collaborative environments to major corporate clients, and having had the privilege of participating to five or six of these, from time to time I will encourage Oli to demonstrate another aspect of the digital capability that the ICE brings to business situations and enhances the effectiveness of work experience, beyond simple video-conferencing. That's my prime reason for being in the ICE.

AA: So it's taking part in demonstrations of the ICE?

[redacted]: I take part, but rather it's I'm aware of some of the digital assets, I can use a few, uh, and so I use sometimes the surface computing – table – Also with these clients. There's something about getting them to engage with the actual table, to make them aware of how the various display screens are controllable, and can be used to present a wide collection of materials from bring your own devices to perhaps things that they have brought in. So the people leave those meetings with Oli, both understanding, if you like, the technology the human benefits, which I'm focusing on, but also one of the things that Oli does very well is use the ICE room, not to talk about the product, but to talk about how you develop a solution to an organisation's needs, based on understanding the users' needs, their different environment and their use of technology and their needs, their outcomes.

AA: Do you use it for?

[redacted]: Secondly, I use it for meetings, sometimes those are up simply because there is pressure on rooms, sometimes I very deliberately use the ICE room because, of all the meeting spaces of the university, it speaks to innovation, and new ideas, and whilst I'm leading them – I'm not there to demonstrate the ICE – I often leave them feeling that they're part of this innovative environment and I think we can do a lot more with the ICE room, to that end, but I'm not a technologist, and you need far more collaboration around the ICE than I feel there is at the moment.

AA: Collaboration in

[redacted]: Between academics, so for example, a person who should be making far more use of the ICE room is Jessie Kennedy, Robert and Allan, in the visualisation team, because you could take then different screenshots from the analysis they're doing so we (inaudible) then you could use the ICE for this progression, and also people then who are working on the data could interact with it all. Equally, Bill Buchanan

in the area of cyber security could both use the ICE room to demonstrate to people in London some of his skills and traning, but also I feel, through doing that, promote the ICE indirectly to the police forces of the world, and I also think that the very nature of cyber security, you have five or six people minimum working to protect digital assets, and if they were in the ICE environment they would see each other's screens, just because of the sheer physical size of them and the way it's organised. The way they could share data on the surface, whilst still having their own desktop or screen access to one device, you could facilitate I think much more collaborative working and reach decisions, and get greater teamwork than at the moment.

AA: When you're having those meetings, that you're leading, not the demonstrations. Do you use any of the technology that's available in the room?

[redacted] So, we have used, as you know, the Skype, because of the large sized screen, we have occasionally used it for looking at different screenshots and websites when we wanted several people around to be able to look at it and just play. Nothing. Because I'm not an expert, and I've not invested enough time to use the ICE room I go in there typically supporting Oli. Otherwise it hasn't been something I have invested time in.

AA: These like conventional meeting but you use the ICE to support being in an innovative environment,

[redacted]: Absolutely,

AA: That's a unique approach, let's say. Those meetings, do they have some sort of scope, are they part of something larger?

[redacted]: So, they're all about business collaboration, so for example we had somebody come in who wants to use either Google maps or "One source" maps as a means to create a business called "everything past" where as a filmmaker and historical researcher she has come to realise that the scope to ?? adding a pin using the geolocation capabilities of the map, information about the history of a place, of a location, using obvious just url links to that address, where you as an interested researcher, thinks "what happened at 1 charlotte square" then if somebody just put in some information you can go away and find it. This is a historical place-centric Wikipedia. Using the ICE and just having a map of the world and being able to bring in some bits of internet page work, we just gave a greater sense that everything is possible. Somehow, the ICE and the atmosphere just creates that sense, that "aura".

AA: The atmosphere, like the physical atmostphere.

[redacted]: Less the physical atmosphere per se, because that is of poor quality, more the screens, the things you can see, I think it's very good that sometimes the screens are left on and then tracking the sources of social media and twitter activity. We were showing some other aspect of usage of the web on a global scale. And those simple images help create this aura. Now the actual physical room isn't in the best

of conditions, but the atmosphere in the room, and the sense of what it conveys, is so different to every other room.

AA: Would you say, would you find the ICE as being some sort of digital territory, or physical territory?

[redacted]: Ah interesting question, I think I'll come straight to this point. It is clearly a physical space, but when you go in it is the sense, precisely, that it conveys of a digital territory, which is without boundaries, has so many more abilities, but it's also the fact that you can very practically use it to show - at least depending on your abilities as a user – some of the capabilities that makes it that special spott.

Aa: Okay. Did you use the table for that specific project?

[redacted]: Yes. I have often spoken to clients – as an example, a rather trivial one but nevertheless quite important – Oli was meeting with Logica CGI and they were looking for these consultancy expertise to design and build an innovation centre for them, using all the themes and concepts that he's developed through the ICE project. And as an instance of the inspirational nature of the space, I simply highlighted that if you write on certain parts of the wall, the information is digitally captured and you can share it. Now that wasn't apparent from being in the room, when we were using things, but the fact that it can be done which is very pertinent to innovation types of laboratory activity – which you have a small number of people in the company involved – and the woman (???) could realise that possibility was there. I think purely because of that sense of digital space, there's no evidence of that beyond people's handwriting on some of the walls.

AA: Do you keep your information private until the point when it needs to be shared, or are you more open?

[redacted]: I keep it private unless it needs to be shared.

AA: Yes, do you need to do that or is it something you don't appreciate? Sending your drafts maybe?

[redacted]: Uh, (abr) it is sometimes for confidentiality, sometimes it is for… particularly when we have customers in these meetings I'm always keen to listen to the customers and not coming forward with too much of our information. There is a behaviour, to supporting that.

AA: How do you keep it private, do you bring your own technology?

[redacted]: I bring my own notes, I also bring a tablet.

AA: Do you sometimes need to make a transition from the tablet to the equipment in the ICE or in C50?

[redacted]: Yes

AA: How do you do that?

[redacted]: How do I do that, I usually call up – through the ICE – my drive here, so I call up [redacted]'s personal files, bring the information up on to the screen, so that people can see it.

AA: So from your network drive, your account, not from your tablet.

[redacted]: No

AA: Ok so that's some sort of cloud or physical network drive.

[redacted]: Yes

AA: You don't use USB sticks or network screen sharing?

[redacted]: I have used USB stick on one occasion, for a presentation.

AA: Do you have a process when you make the transition, when you're leading those meetings, to make the transition between this physical space to this mixed physical and digital space? Like a certain order in which you bring apps up or

[redacted]: No, uh, I am such an infrequent user, and my instances of use have been specific, so the USB occasion I had a presentation in a draft form, I thought "oh how should I do this?" so I listened to people and said "here's what I've done" put the USB stick in (???) now I haven't done that kind of thing.

AA: Who's usually in control of the technology, is this you? Or do you leave your clientsto have a good

[redacted]: It's rarely me who's in control, I would say in 99% of cases it's an academic, who's present, who knows sufficiently how to use the ICE.

AA: Ok like a research group leader or something like that?

[redacted]: Yes.

AA: Do you have any form of awareness of what other people are doing? Or is this usually…

[redacted]: That's usually fairly transparent, that's one of the things I like about the ICE, when Oli or who else, Brian Davison,you can see them just here bringing things up, so no.

AA: So maybe this transparency is the nature of these meeting, business meetings, conversations rather than collaborative creation?

[redacted]: Yes, correct, it is the sole reason that I'm using the ICE.

AA: Anything else to add?

[redacted]: I've got several comments. First comment is the ICE is the only tangible manifestation of the capabilities of SoC and it's no surprise that when you bring business clients in, they can see that some really bvery practival sold there. First thing. It just gives that sense of innovination, thirdly, it's underused and it comes back I feel to a number of colleague perhaps not wanting to embrace it, see its potential "oh that's what they do, they do this, we do that" I don't know how you break that down here, because it's a deep seated cultural mindsety of academic teams. "We work over here, you work over there and we're not gonna try what you do to help us". Teamwork is not very evident.

AA: Ok. Anything inherent to the ICE maybe, it's difficulty of use?

[redacted]: Difficulty of use? I possibly a lot of people say that. Bill says it doesn't work, I don't think that's true, and I've said others perhaps tried occasionally and not made progress and therefore they don't invest time.

AA: do you have any suggestions?

[redacted]: Absolutely, I think if I was a dictator here I would be having minimum monthly "lunch and learn" "discussion groups" or "get togethers" and I would encourage these to be delivered through the ICE, providing support as necessary to enable people to use and experience and learn themselves.

AA: It's more about getting people to know the space rather than something than need to be changed itself.

[redacted]: Yes.

Appendix C Focus Group protocol and transcript

Device Ecologies Focus Group

Aurélien Ammeloot
December 2014

Background

- Room C78 is an Interactive Collaborative Environment
- Launched in 2010, the room has been used as a conventional meeting room and an experimental platform since
- http://vimeo.com/30126381

Background

- We call the ICE a multi-screen device ecology. It is a closed and private environment.
- Similar collaborative setups exist or can be created on the fly, e.g. a group of students with laptops and tablets in a collaborative study room. It is an open and private environment.
- Public environments exist, e.g. the large screen in Merchiston's foyer.

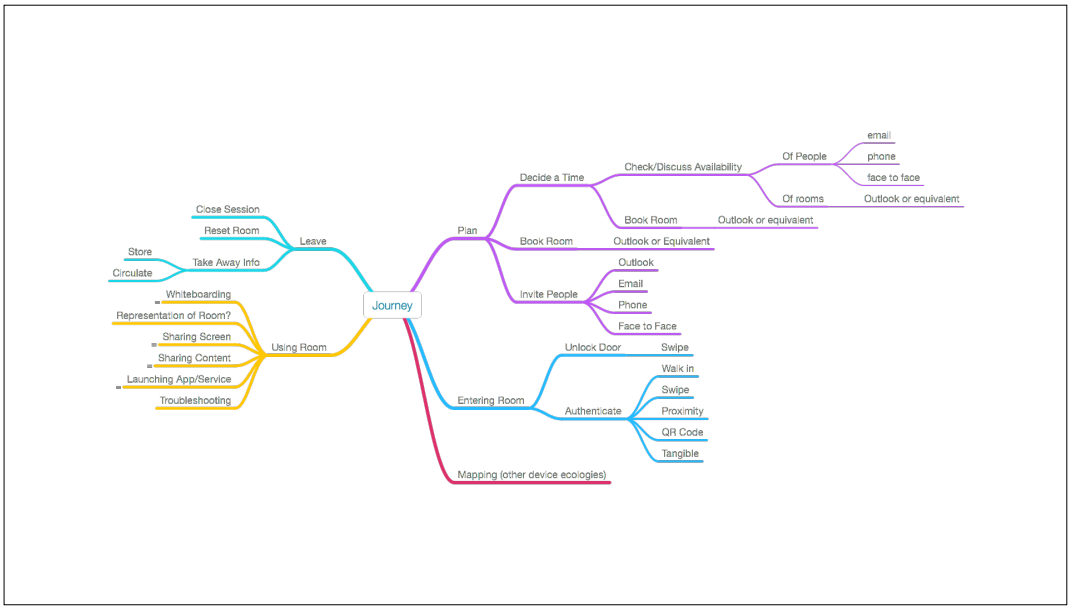
Study Pod, Edinburgh Napier, GuardianWitness, 2013

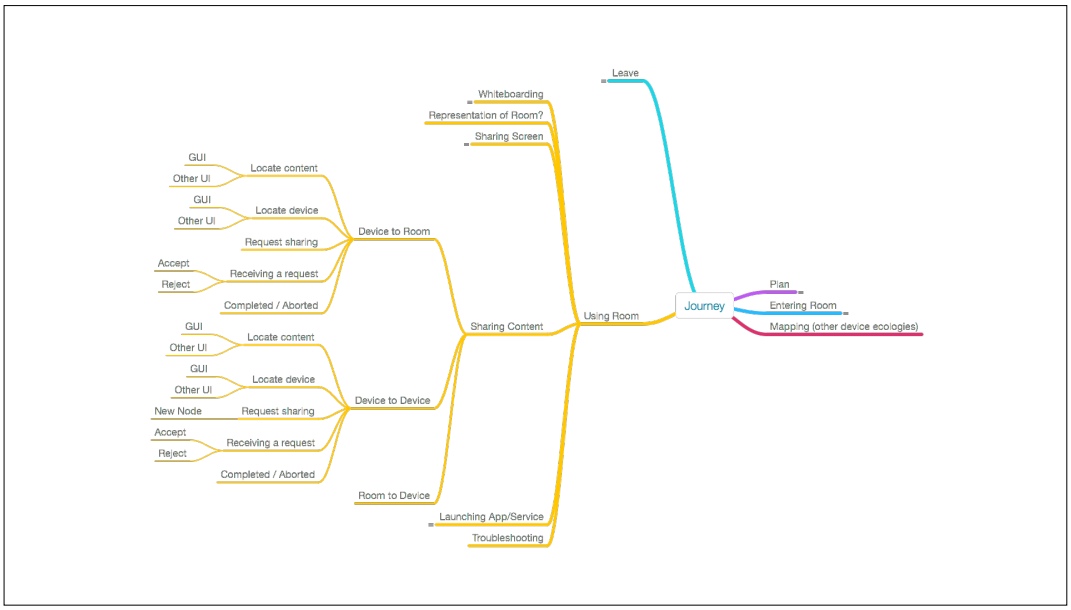
Today's Session

- You will be shown different existing user interfaces and asked to openly discuss what you think about them.
- The session will be captured on video and recorded on audio.
- Data will be anonymised and you will not be identified in any subsequent publications.
- Although this study does not present any trigger warning, you may leave and withdraw at any point if you wish so.

Please return signed consent forms

The Meeting Journey

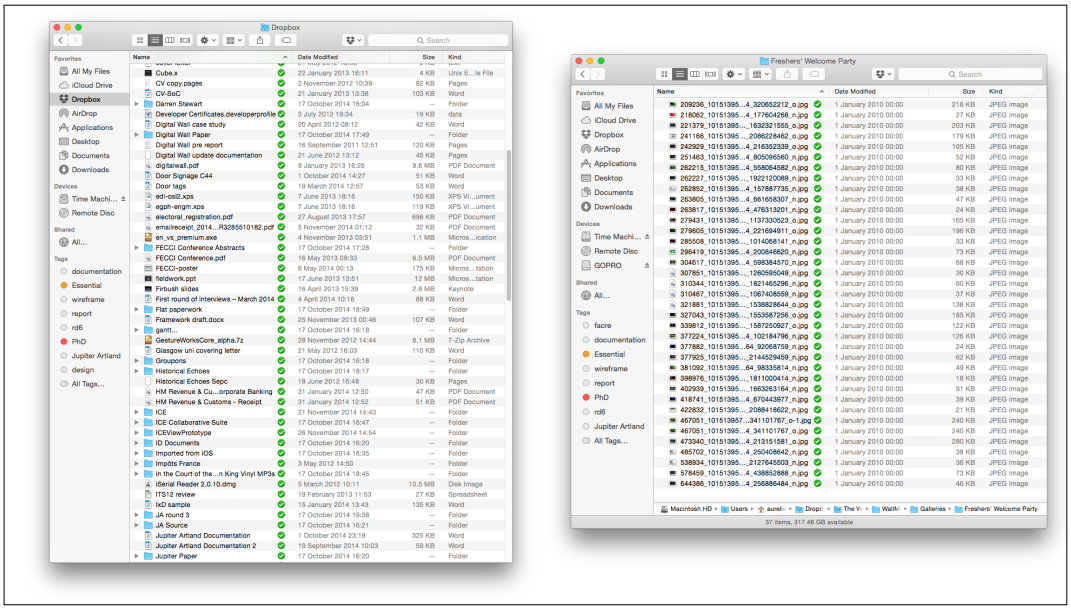

Journey
Plan
Decide a Time
Check/Discuss Availability
Of People
email
phone
face to face
Of rooms
Outlook or equivalent
Book Room
Outlook or equivalent
Book Room
Outlook or Equivalent
Invite People
Outlook
Email
Phone
Face to Face
Entering Room
Unlock Door
Swipe
Authenticate
Walk in
Swipe
Proximity
QR Code
Tangible
Mapping (other device ecologies)
Leave
Close Session
Reset Room
Take Away Info
Store
Circulate
Using Room
Whiteboarding
Representation of Room?
Sharing Screen
Sharing Content
Launching App/Service
Troubleshooting

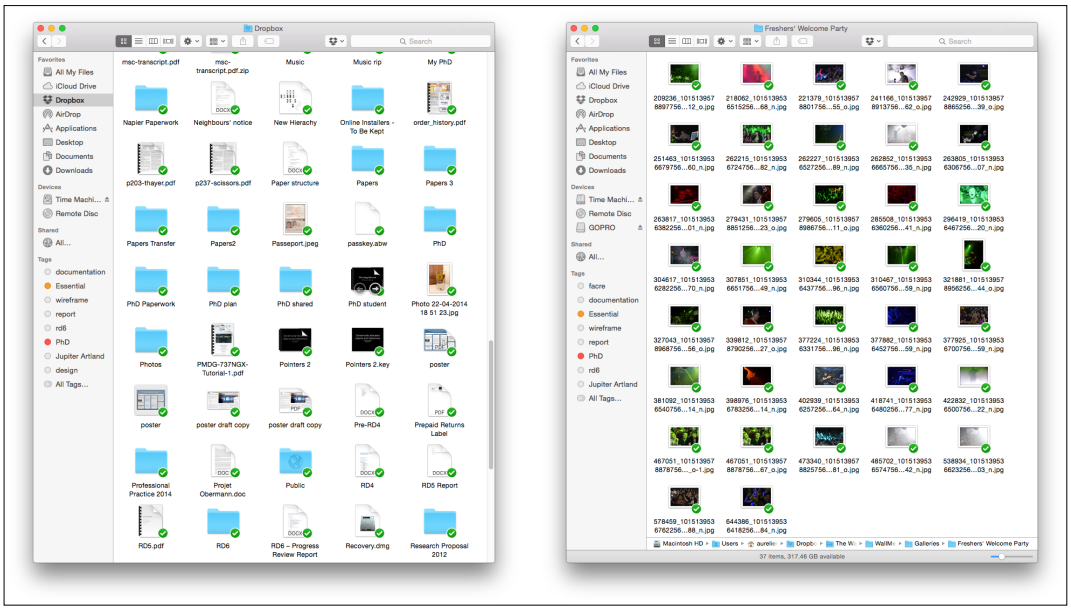

Journey
Plan
Entering Room
Mapping (other device ecologies)
Leave
Using Room
Whiteboarding
Representation of Room?
Sharing Screen
Sharing Content
Device to Room
Locate content
GUI
Other UI
Locate device
GUI
Other UI
Request sharing
Receiving a request
Accept
Reject
Completed / Aborted
Device to Device
Locate content
GUI
Other UI
Locate device
GUI
Other UI
Request sharing
New Node
Receiving a request
Accept
Reject
Completed / Aborted
Room to Device
Launching App/Service
Troubleshooting

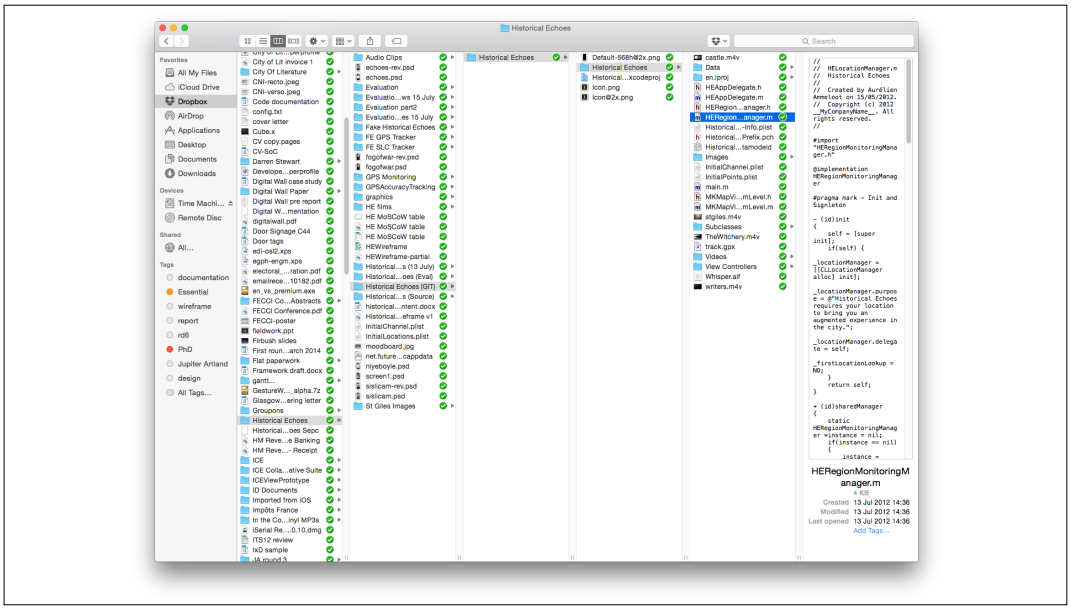
Locating Content

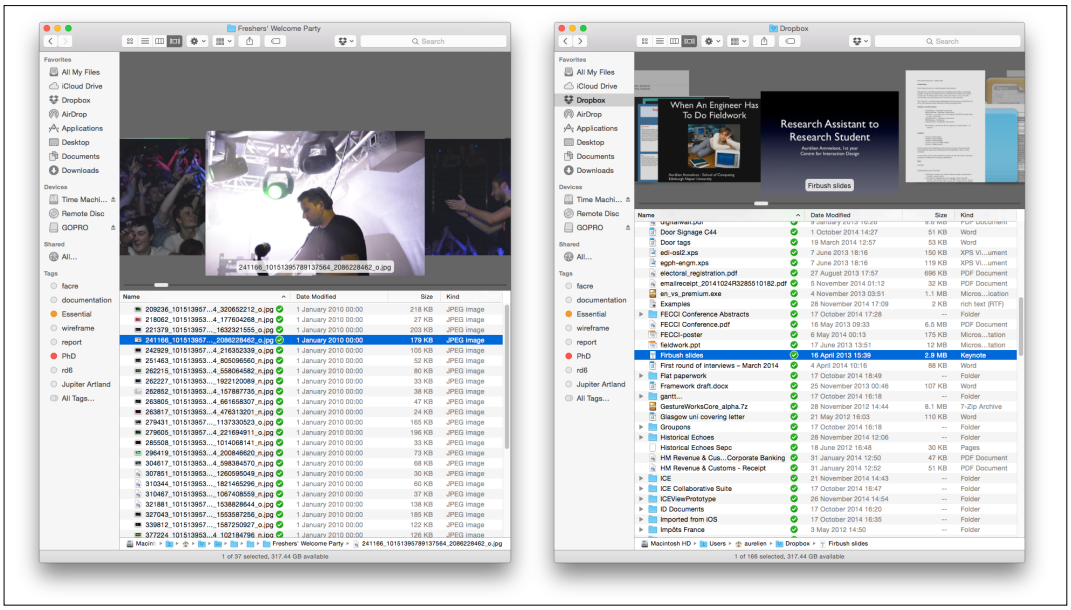
Locating Content

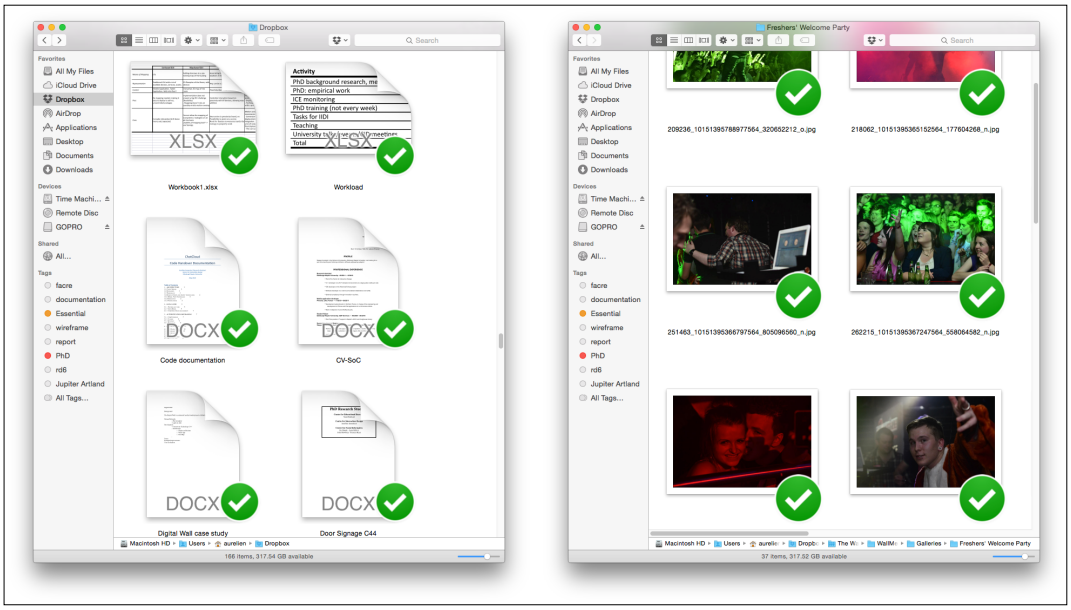
- On the following examples, try to think
  - What works for you?
  - How you find and identify content?
  - How do you find and identify the device you are exploring content on?







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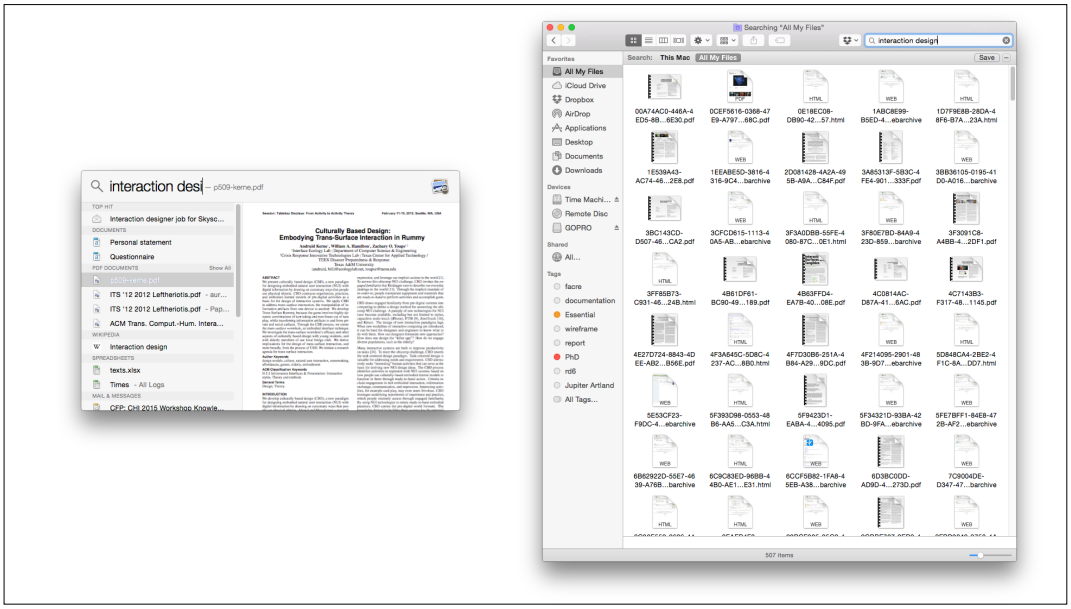
Workbook1.xlsx
Workload
Code documentation
CV-SoC
Digital Wall case study
Door Signage C44
Freshers' Welcome Party


interaction desi
Culturally Based Design:
Embodying Trans-Surface Interaction in Rummy
Searching "All My Files"
interaction design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Dropbox
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Bookshop App
Bookshops_source
C
Case study
Case Study Tech.xlsx
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City of Lit
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City of Lit invoice 1.pdf
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Favorites
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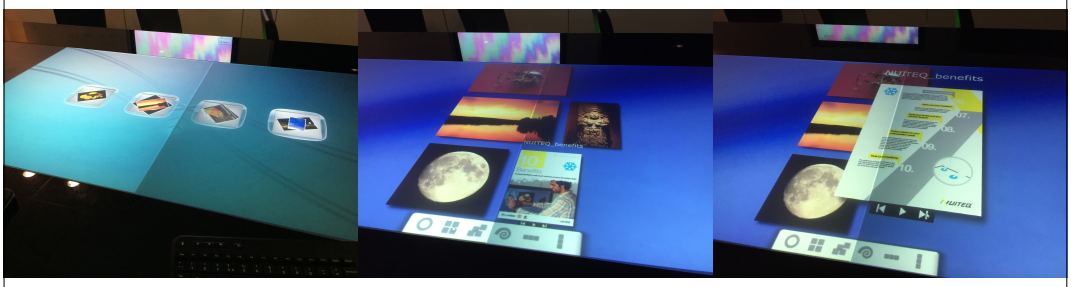
March 2010
January 2010
July 2009
April 2009



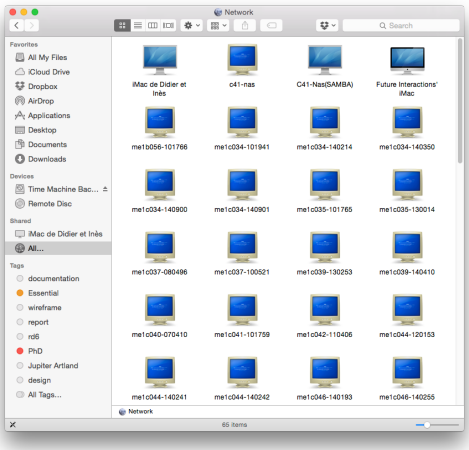
Locating Content

- Do you know any other methods?

Locating Devices

Locating Devices

- On the following examples, try to think
  - What works for you?
  - How you find and identify devices?
    - Nearby? Remotely?


Network
Search
Favorites
All My Files
iCloud Drive
Dropbox
AirDrop
Applications
Desktop
Documents
Downloads
Devices
Time Machine Bac...
Remote Disc
Shared
iMac de Didier et Inès
All...
Tags
documentation
Essential
wireframe
report
rd6
PhD
Jupiter Artland
design
All Tags...
iMac de Didier et Inès
c41-nas
C41-Nas(SAMBA)
Future Interactions' iMac
me1b056-101766
me1c034-101941
me1c034-140214
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me1c035-101765
me1c035-130014
me1c037-080496
me1c037-100521
me1c039-130253
me1c039-140410
me1c040-070410
me1c041-101759
me1c042-110406
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me1c044-140241
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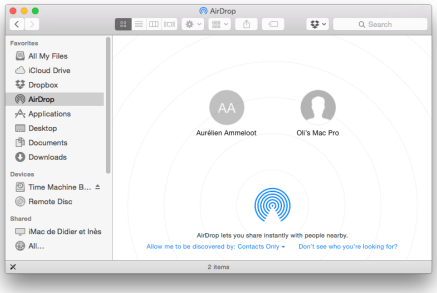
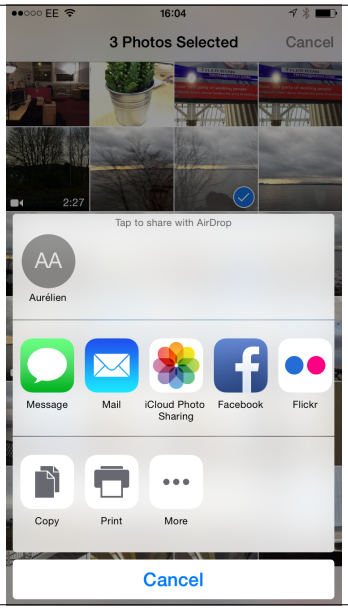
me1c046-140255
Network
65 items


AirDrop
Search
Favorites
All My Files
iCloud Drive
Dropbox
AirDrop
Applications
Desktop
Documents
Downloads
Devices
Time Machine B...
Remote Disc
Shared
iMac de Didier et Inès
All...
AA
Aurélien Ammeloot
Oli's Mac Pro
AirDrop lets you share instantly with people nearby.
Allow me to be discovered by: Contacts Only
Don't see who you're looking for?
2 items

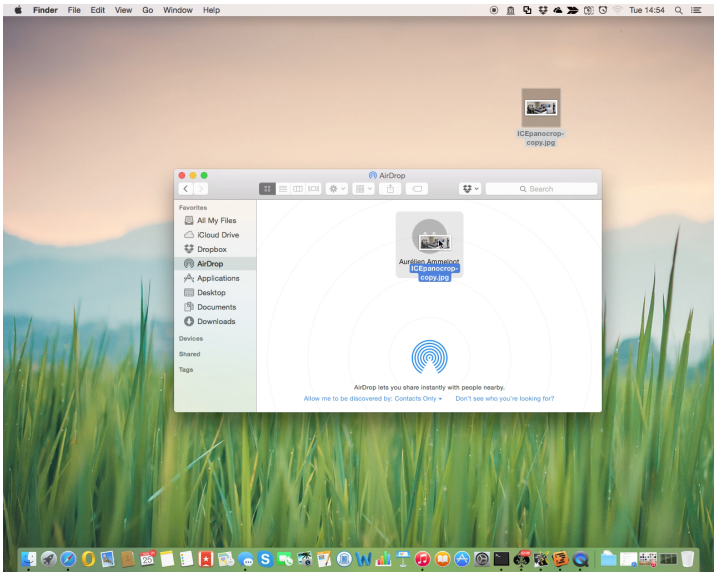

EE
16:04
3 Photos Selected
Cancel
2:27
Tap to share with AirDrop
AA
Aurélien
Message
Mail
iCloud Photo Sharing
Facebook
Flickr
Copy
Print
More
Cancel


OneDrive
All files are up to date.
OneDrive
This PC
Documents
ZONE 5
Pictures

Locating Devices

- Do you know any other methods?

Sharing content


Finder File Edit View Go Window Help
Tue 14:54
ICEpanocrop-copy.jpg
AirDrop
Search
Favorites
All My Files
iCloud Drive
Dropbox
AirDrop
Applications
Desktop
Documents
Downloads
Devices
Shared
Tags
Aurélien Ammeloot
ICEpanocrop-copy.jpg
AirDrop lets you share instantly with people nearby.
Allow me to be discovered by: Contacts Only
Don't see who you're looking for?


micro
4GB
cruzer

Consider also

- Email attachements
- Dropbox, One Drive, Google Drive etc.
- Attachements on Facebook Chats

Open discussion

- From the previous elements, discuss what could work for you
  - In a multi-device ecology?
  - To share information from your private device to a public screen?
  - To recover information from a public screen to your private device?

Available Examples (videos)

- AirLink - https://www.youtube.com/watch?v=fnFUv2v7Gbg
- Bump (discontinued) - https://www.youtube.com/watch?v=XkXNte4mzRc&spfreload=10
- Cisco Telepresence - https://www.youtube.com/watch?v=ChwLYS-N56Q

Thank You

Informed Consent Form

Device Ecologies Focus Groups

Edinburgh Napier University requires that all persons who participate in research studies give their written consent to do so. Please read the following and sign it if you agree with what it says.

1. I freely and voluntarily consent to be a participant in the research project on the topic of user experience in device ecologies to be conducted by Aurélien Ammeloot, who is a PhD student in the Edinburgh Napier School of Computing.

2. The broad goal of this research study is to explore different ideas of user interface to use in collaborative device ecologies. Specifically, I have been asked to discuss different user interface ideas, which should take no longer than 45 minutes to complete.

3. I have been told that my responses will be anonymised. My name will not be linked with the research materials, and I will not be identified or identifiable in any report subsequently produced by the researcher.

4. I also understand that if at any time during the session, I feel unable or unwilling to continue, I am free to leave. That is, my participation in this study is completely voluntary, and I may withdraw from it at any time without negative consequences.

5. In addition, should I not wish to answer any particular question or questions, I am free to decline.

6. I have been given the opportunity to ask questions regarding the procedure and my questions have been answered to my satisfaction.

7. I have read and understand the above and consent to participate in this study. My signature is not a waiver of any legal rights. Furthermore, I understand that I will be able to keep a copy of the informed consent form for my records.

_____

_____

Participant's Signature Date

I have explained and defined in detail the research procedure in which the respondent has consented to participate. Furthermore, I will retain one copy of the informed consent form for my records.

_____ _____

Date: 5/12/14
Location: ICE
-
Participants MSc Students (Design Dialogues)
Left to Right
P1: male
P2: male
P3: female
P4: female
I: interviewer

Loading content

Dropbox, list

P1: From a distance, it's maybe hard to see anything.

I: You can get closer if you want.

P3: I think that what's quite nice about this kind of thing is that it's very familiar. It looks exactly… I have a PC rather than a Mac but it looks exactly the same as your other folder. So it's rather integrated with what I work with.

I: So it's familiarity.

P3: Yes.

P1: I've been using Windows 8 OneDrive, to put files into the cloud, and I find it quite integrated with Windows… as long as you don't mind Windows of course, I don't think there's any cross-platform…

I: I've got a few screenshots of it later on; we can discuss it later if you want?

P1: Yeah, yeah. Dropbox, I don't use that much.

I: It's not about Dropbox, I mean it's just a normal window… let's say if you compare this to this. [Dropbox icons], this view (icon), to this view (list). What would work better for you? You can speak freely about what would work better; I've deliberately chosen a full folder of different things.

P1: The first thing on a list view, that you get, is often the date, the date of creation and that sort of thing. It's quite handy if you wanna know "what have I done recently, what's older stuff?" Whereas if you go to the folder view, you know, you're getting icons and stuff so it's easy to read, but you don't get as much information.

I: What do you mean by "easy to read"?

P1: Mmmm… well maybe it's easy to identify, maybe read is not the right word… "I recognise that picture, I recognise that"

I: OK

P4: Yeah personally I find that one on the left (icons) much easier to deal with than (I switches to previous slide) … than that, yeah.

P3: (pointing at screen) I think, for me, that I would like… if I'm looking for a file, I would like to use this one [list] as you see, like (P1) you say particularly, which one's the most recent one, whereas if I was looking for a photograph, that second one [icons] you can actually see the photographs. That's when I prefer to use that format.

I: OK

P3: Because you can see which photograph it is, because you know, the names don't really mean anything (P1 nods).

[Some additional explanation from interviewer about the screenshots being platform agnostic]

P4: I think, if I can just add, about the icon view… You can have it sorted in date order; you could have in date creation order. I just think it's easier to deal with because of the white space between the items. When I see… Maybe it's just me, when I see a list I just think [overwhelmed gesture].

P3: Feels like it's quite a personal thing.

I: What would you call a list then, too… too?

P4: Too "busy"

I: Too busy? [Back to icon view] is it not busy here?

P4: Mmm, less busy [all laugh]. The first one to me looks quite… "Heavy", sorry my adjective's not great. But the list view is too… difficult to sift through, difficult to filter through.

I: What about where you are? There's one here, which has a path bar, one which doesn't. Is it something you find useful? In theory or in practice?

P3: What do you mean a path bar?

I: At the bottom, on the right hand side, you can see where you are in your hard drive. On the other, on the left, you can't.

P1: I use breadcrumbs a lot on websites, I don't know about people but I find it quite useful to know where I am. So on a file system as well it's probably pretty useful.

P3: Yeah, I find it useful, too.

P1: Yeah

I: So, you actually need to know where on your file system you are most of the time.

P3: Yeah

I: And on your phone, do you know where you are? I know on the iOS you usually don't.

P3: I do, on the Android, yeah.

P2: Sometimes you don't certainly need to know where you are.

P4: To be honest, the kind of stuff I use my phone for, I don't go down that type of file paths, file systems that long.

P3: For work, I have quite complicated file paths of boring different things (laughs).

[Switch to column view]
I: What about this kind of representation of where you are, here is deliberately exaggerated to fill the whole screen, any comments on that?

P1: I [*feel very able?*] to fill the whole screen, then why not yeah. It's fairly logical.

P4: I like this, I have to say, but it's because I've been using Macs for years, so it's just familiarity.

P3: And I don't really use Macs, so I don't like this really, mostly because it looks a little unfamiliar. I'm sure I can find stuff if I needed to, but it's not… I don't instinctively like it, you know.

I: What about this? [Cover flow] This one is also typical Apple, but it's mixing a preview and a list of files.

P1: That's good

P2: Yeah

I: And showing pictures on one side and documents on the other, do you have any comments?

P2: I like that [P1 nods] [P3 nods]

P1: Well it gets over the problem of "what is that file?" "What does it represent?" you're getting a much bigger view.

I: Do you have any comments on the appropriateness, depending on the content. I know some people are mixed when it comes to pictures, documents, in this specific case?

P3: I think I do look for files and pictures in different ways.

I: Yes?

P3: And so, if it was a very [text] file, we'd have to see a very [text] file in a small way. It's easy to see with pictures, which is which, whereas if you have a lot of boring Word files, it would be harder to see them quite small, I think.

I: So it depends what type of files, then? Here you have a PDF with text and two presentations, and they're rendered differently.

P3: So, you can see which is which for the presentation but it's harder to see which is which if you have a collection of PDFs or Word documents, you know.

I: Okay, any other comments on this one?

P1: I supposed, rather than a view, maybe a title? Would that help if it flashed up? [P3 nods]

I: There is a title actually in the white box here

P1: I just meant a title in a preview, as a way of seeing it. You wouldn't necessarily be able to recognise a word file from the arrangement of the paragraphs, but perhaps if you had a title flashed up, in large letters, in the preview…

I: Do you mean the name of the file? Or the first line of the document?

P1: Could be the filename, could be first line.

I: Scraping the first line of the document and showing it in the preview?

P1: Yeah

I: That's an idea I can look at.

P4: Yeah that would work for me as well, that would make more sense than, let's say that's a word documents on the right there, it would be more recognisable I think.

[Switching to large icon view]
I: And what about large representations? That's the last one I'll show you for the desktop.

P3: It only works if you have a small number of things to look through, doesn't it? (P1 nods) I'm often looking for a large number of things.

I: What about the intrinsic quality of the document. There's a previews of Word and Excel documents here, how useful is that for you?

P1: You could certainly start to read text on these icons, if you had them on a laptop, you would be able to get them into a bit more detail.

I: And media?

P1: Well the pictures are reasonably identifiable.

P4: I suppose it's the point here, to be identified; it's not the quality of the picture.

P1: I suppose the key issue here, is being able to find things reasonably efficiently and quickly?

I: Yes, we're locating content; the idea is you wanna transfer content to somebody.

P1: Yeah, as I said if I look at those I would say, "Oh that looks like a concert I went to" it's reasonably recognisable.

I: Any preference for the Desktop so far? Any general consensus?

P1: I like that one [large icons]

P2: I prefer this one [cover flow]

P1: I like that one too

P2: Because I think it gives a combination of both. As (p3) said the last one depends on the volume of content that you're looking for, I may have a greater clarity to identify but may take longer so to find what you're looking for. Whereas this but this one gives me a combination of both: being able to identify clearly, but because there's a list as well, you're able to scroll through more volume

P1: That's how a lot of email clients tend to work as well, actually, the view and then the preview.

P3: I like this one too, but I actually like the pictures to be on the right rather than on top.

I: That's the Windows approach I believe?

P3: Yeah probably, because that's what I'm used to.

I: Well certainly on Windows 7, I see what you mean. But it's the same idea, except it's vertical and has no visual effect.

P3: Yeah.

[Interviewer switches to spotlight view]
I: Right, do you search much?

P3: Yes.

P1: Not that much for files, only if I'm really lost. If I can't find in the structure, I'll do a search, but I usually try to find it in the tree before.

P2: As much as I can I try to set up a "Favourites" folder, and then as try to locate inside that folder.

I: [to P4] do you search much? On the Mac?

P4: No, not really, when I worked yes but as a student, not so much.

I: I know some people tend to file everything and some don't they prefer to search

P3: We had a boss who was a bit like that, [everything was scattered], we were forced to use the search, but to be perfectly honest, and it was annoying rather than useful.

[Switching to iPhone views]
I: Same sort of interface, but on a phone, same Dropbox, files on the left, pictures on the right.

P1: I think the alphabetised approach works well on the very top level, like Windows 8, you'll have an alphabetised list on the apps page, but I think as soon as you get a large file structure, having ABC becomes less… useful, I mean having a label for each letter. If you've got a small number of files, it's quite a good way to find them.

I: This list has got a search as well

P1: Oh yeah, you've got on the right. Well, it can be useful.

I: I know this is the Dropbox app, it doesn't show previews for documents, only media. What if documents were showing this way?

P4: Again, I don't know how useful this would be, I mean, an A4 page… scorched down to the size of one of these icons? To me, you know that's counter intuitive, I think. If it was a title, possibly, a keyword maybe?

I: What about a larger surface, maybe?

P4: Even then, I think, I don't think I would like it, but again I can't speak for everyone.

[Now showing Snowflake media browser]
I: That's the table you're sitting around, when it's working, that's a file browser, from left to right, there's folders, media inside the folders that you can reposition in different ways, here is a PDF you can read. This is multi-user, multi-touch. I just cannot demo it right now because of a technical issue.

[a couple of minutes of dialogue with clarification]
P2: How many instances of that can run on the table?

I: More than one

P2: Okay that's what I'm trying to understand

P4: How editable are documents?

I: It's just a file browser / viewer. We're just looking at ways to locate the content.

P4: Is that a menu bar at the bottom?

I: Yes it's a menu bar

P4: So, yeah if you're familiar with those icons, then maybe

P3: Yeah it's maybe a bit unclear what the icons would be.

I: Okay they mean the icons are organised as: a circle, a grid, scattered around, a spiral, lined up…

P1: This is quite an interesting question whether you're trying to display them on a wall or on a table. If you're on a table the interest is to share, and collaborative, whereas on a wall, on a public space, everyone's doing their own thing, they're looking at what they need to be looking at.

I: That's the main difference between this place and the big screen downstairs.

[Quick chat about the difference between the ICE and the large screen in the foyer]

P1: I think we're getting the gist of it

P4: I think it's not overly complicated; really we get 3 images and one with some text? Looks simple enough.

[One drive]

I: That's OneDrive on Windows 8. It turns out to be practically empty. What do you think?

P4: They're quite easy to locate

I: What do you think of this representation? This flat, abstract representation for folders and files?

P4: It just looks a bit old-fashioned to me. Clunky, too.

P3: [inaudible]

P1: There's a lot of screen real estate used for a white background, it's not as exciting I suppose. [Laughs]

P4: It just looks like an Atari game from 1984 [Laughs]

[Actual interactive demo of OneDrive on touchscreen]
P4: I think with Windows 8, they're just trying to copy Apple but it's not as pretty. It's easy to find something

I: You think they copy Apple?

P3: Uh

P4: Yeah

I: I tend to think it's a slightly different direction, but okay.

P3: I think the way that it's flat, rather than the usual 3D element, doesn't make you feel like something comes out of it, you know what I mean? Because it's flat it just looks like a box.

I: Yes

P3: If it had anything coming out it might look like it's full of things.

P1: Yeah

P3: It's a container for a thing but it doesn't have a feeling of that sort of "fullness".

P2: Yeah if you had more sense of depth you might feel like there's more places to go.

I: One last question about locating content? Is there any elephant in the room, anything I missed, anything you can think of, other methods of locating content.

P3; [about windows 8] I think there's a lot of space for how you want to customise your own folders. There's no way to give them a different colour. Like "all the green folders have to do with work" or all the other folders are about home things or whatever, I could put like a picture in front of the folder to remind me what this is.

P1: Something interesting about Windows 8 is that when you log on, your desktop goes with you, travels with you. That idea of customisation not being something you have to setup every time, you just log in and then that's your identity.

I: Authentication, you find your desktop wherever you go, it's kind of replicating what you already have in the enterprise networks.

P1: Like Napier, for example.

I: Yes like Napier, you log in anywhere and find your own desktop. But it's a fairly new thing I would say with the cloud

P1: Certainly for a home PC

I: Do you like that?

P1: I think, if you get over with any sort of problem with having your data on the cloud, I think it's convenient, it makes sense.

I: What if you, let's say, have a desktop computer and laptop and you use them for different things?

P1: Ah…

I: I know, I'm using my desktop for development, video encoding, video editing, and my laptop mostly for writing text, what do you think, if everything is replicated from one to another?

P1: Mmm, well I think, for example, if you take the OneDrive example, you can always organise your folders in a "home" and "work" fashion, and you might want to do something on your laptop that otherwise you do on your desktop. I know I do, sometimes.

[Switching to locating devices]
I: Yep. Anyway, now we're gonna look at locating devices, that's going to be shorter. Locating devices and transferring content. I'm gonna show you a few other screenshots, most of them are from the Mac or the iPhone, but the network one for instance is easily replicable on a Windows PC. You found your content, now you want to transfer it to your colleague that might be across the room using another device, let's look at this.

[Reminder of the main questions]

[Showing OS X local network browsing]

I: First of all, this is Apple, this is the network. I click here and it's all the machines on the network. Don't forget, you want to send something to somebody.

P1: there's not much differenciation, the icons don't tell you anything, it's just the text underneath them.

P4: and it's really hard to differentiate

I: That's the Napier Network, they all have these generic names "Merchiston-something"

P3: [inaudible] some sort of standardised naming format [inaudible] you know everybody's got their first name or surname so that you, you could find them.

I: But we're all in this room, for example, we're 5 people working on a collaborative presentation and I want to send you something, how does that interface work?

P3: There would only be 5 pictures on here so you know it's one of the five people here, it that it?

I: I don't know [laughs] technically, we're in a room that's inside a corporate network at napier as well so if I connect to the network with one of these computers I could see all of this, too.

P1: Why not have everyone in the meeting log in? And that group of login is managed somewhow, so you get past that need to search every time you wanna find somebody in the room.

P4: You could log in, not as yourself, but as a participant to the project or something, I don't know what it's called.

I: A session?

P1/P4: Yeah

P1: Because I wouldn't want to have to go through every single user here.

[Airdrop]
I: this is Airdrop, do you know Airdrop, who's using macs here? [all shake head – P4 probably never used airdrop]. You've got two machines nearby, using Bluetooth, they recognise each other, and here you see, that's my office mac, I can see the Mac next door (Oli) and I can see my phone. If I want to send something I just drag and drop. How do you identify? How does that representation work for you, in terms of nearby devices.

P3: It's okay but in a meeting environmenet, I fell like okay, so we're in a meeting, and I wanted to share with all four of you, I wouldn't like to drag and drop to all four of you. Do you know what I mean?

I: Okay

P3: I would find that, too much hard work

P4: Yeah

P3: Not [inaudible] but a bit of hard work

[Switching to airdrop interface on iPhone]
I: Same tech, except it's represented on a phone. In that case it's my phone seeing my computer. So it shows my user name, because it is my user logged into my computer, but it doesn't say it's my Mac. Same here [back to previous screenshot] it doesn't say it's my iPhone

P3: It can get confusing if you [inaudible]

[Ondrive interface]
I: Onedrive, apparently you can switch between the machine and the cloud
[no comments]

[Crestron]
I: I was thinking about that, we're in a meeting room, why not a map? That's not an actual map of the devices in this room. I just took a picture of the control system there, it's just a technical way to manage the screens in this room. As you can see, it's using a map metaphor with circles and tags where 'something happens'. How would that work if those were devices? The devices you bring into the room?

P1: So you would be able to tell from the icon: that person sitting there, therefore it must be there?

I: Yeah for instance

P1: Right

I: That's the concept

P1: Yeah, the thing is, if you're in a meeting you wanna get moving quickly, y'know if that was a quick way to find a user and say "okay we can start now".

P4: It depends what kind of person, how they interpret the information, some people find this quite difficult, not knowing what you're facing. You know, some people turn things around in their head and don't have a sense of direction. I'm not sure that's for everyone.

P3: I quite like it, but I can see it being being difficult. In a room, I can see… there's a thing over here "is that your thing?" [giggles]

P4: How do you know what exact person is supposed to be working on the device that's sitting there?

P1: You'd have to ask [inaudible] [all laugh]

I: Any other thing?

P1: There's near field, but I don't know how…

I: NFC?

P1: Yeah

I: That's for very very close exchanges

P1: right

[Back to airdrop]
I: That's roughly the same, as it's using Bluetooth, it's within a few yards' range. Near field is a few inches.

P3: How about something where, you're sitting around the table and you're "plugged into" the end of it. You know? [inaudible]

P1: Ha

P3: I'm just thinking about more ideas

P1: I just… at least with near field you have to be physically doing that [push gesture] so you're sure that's the right person. You know, that's one way of looking at it.

P4: A few screens back, you had… Oli's network is it? Oli's device that showed up? Do you know him? Or does he happen to be next door?

I: Well I do know him, but I may or may not know him… actually this is filtered [back to airdrop – mac] you can restrict to your email contacts. But if somebody's not in my contacts I can take it off.

P4: So you can take that filter off and if somebody's next door you can see mor people.

I: Yes

P4: does that mean they can see you as well? So there's potential there for… mess?

[Action of sharing]
I: So that's Airdrop in action actually. I have a picture here on my phone, I choose to see the nearby people, like you said, the other person receives a notification – it's kind of like near field but within Bluetooth range. Would that work for you, or do you know any other way that works better? That's the Mac equivalent, you drag and drop your file on the icon.

P3: Same thing, it feels like it works well one to one. Maybe we can make a group?
I: Like on Skype? With a 3-way conversation? When you send an attachement?

P3: Yeah

[USB stick]
I: What about that? [all laugh]

p1: Well, I mean you've got the fact that you know for a fact you've seen it go into "that" machine [p3 giggles]. That's reliable from that point of view. You can spread lots of viruses around…

I: Other things… email attachements? Cloud drive? Attachements on instant messenging?

P3: [inaudible] at some conference I did this thing where everybody was using this app to take notes directly into dropbox? It was quite cool actually because it …

I: What's the name?

P3: Geo… something. I'll try to figure out, I can email you if you want

I: Okay

P3: So you can take it on a field trip, and everyone can make notes directly into the same Dropbox account. It is quite cool for the kind of "you're making notes to the same place at the same time" kind of thing, which is quite cool.

P4: there is something similar, like the webinar. Technology with Blackboard. It's the same, I was making notes, I was in a group of people who were in different places and who were taking notes at the same time. It was very handy. I don't think… I thkn the administrator had access to all of them, he was able to email the completion of the session etc. That's… quite handy.

I: Do you see anything you would favour? That's more practical to you among the things we discussed earlier? I'll show you a few examples… that's an app from a research lab (Airlink) using gestures
[people watch]

P1: So was that a "many" broadcast?

P3: I feels like [inaudible] coming to us "Oh sorry I didn't mean to… [mimicking gesture] [laughing]

P4: I can see a lot of potential for mistakes as well…. Inappropriate sending of… things.

P3: the app I mentioned is "Fieldtrip GB"

[Bump]
I: this app was discontinued. It's "Bump" I don't know if you've seen it.
[problems setting up]
I: it's a bit cheesy

P4: The overwhelming feeling I get, with things like it, is the overall lack of security. There's just a potential for things going a bit wrong.

P1: the good thing about it, is you can't accidentally do it. You have to decide to bump with you fist.

I: Unlike the previous one?

P1: Yeah you can be swatting a fly and accidentally… I know it sounds ridiculous

I: No it's not. We used to have a Kinect here… you could accidentally make a grotesque gesture and start an application. I know exactly what you mean because a student developed something for his MSc and … well that's what happened sometimes.

P4: I was using using Windows 8 the other day, and I happened to be.. kind of tapping my finger [tapping the table like a trackpad] and my screen changed completely. I was like "What the hell did I just do?" and then I did it again and my screen came back. I had no idea.

P1: Mmm I didn't even realise you did it.

P4: I wasn't really.. I wasn't aware that [tapping] would have any effect.

I: Any other general comments?

P3: I just really want it to be really easy, and also traceable. You know like you sent and email you can say "I totally send that to you", whereas is not it can be a bit odd "did I? did I share with the right person? Are we sure we did that?" all these sort of things [P1 nods agreeing]

P4: also, you want it to work easily and efficiently well.. you don't want to spend half the meeting setting it up. Everyone has to be up to speed with the technology, you know. People have to be trained.

P3: bit I don't think

P1: You need to be cross-platform. You want everyone to be able to participate.

Transcript Group 2
P1: female – non native English speaker
P2: Male
P3: Male – non native English speaker
I: Interviewer

[Locating content]
[Dropbox desktop list]

p2: Well it looks a bit confusing, it's kind of overwhelming. There's a lot of stuff filling a small amount of space.

P3: It would be better if left left picture could be sorted, by the type or the file for example.

I: You'd sort by type of file?

P3: Yeah that would be the first thing I would do.

P1: really?

P3: yeah.

I: How would you sort?

P1: well I have the same interface on my mac, I don't use this view at all, ever. I use the next one along, it has the picture, the three columns and the picture and the date.

I: That one? (showing the icon)

P1: yeah

I: We'll come to it later

P1: I never use that because when I use it I feel like you (p2) I feel like …

P2: it's too much yeah

P1: or I search, on the top bar I'd never actually look down this [list] and try to find a file.

I: Ok, you don't look for a file this way

P1: no

I: So you use the search, what about you? (p2)

P2: yeah all out, I also prefer when the icons are a bit bigger, in rows and columns rather than all listed

I: what about that? [Dropbox desktop icons]

p2: yeah that's more what I'd be used to

p3: I find this awful, I always do the list

p1: [laughs]

p3: always, in windows, because I use windows

i: ok what about you? [p1]

p1: yeah this is better than the last one but again, I wouldn't use it because it takes too long to scroll down the things, and you can't really see it easily, and you can't see inside of each of the individual folder either. Scrolling through it. I like it when you can see the root folder, and you can see inside, the content.

I: Do you need to know where you are? On your filesystem or on the network. Do you need to?

P3: Ah, yeah

I: Do you generally know where you are?

P1: mmh

I: Because on the left it's the default view, on the right there's a bar indicating where you are. I guess this is standard on Windows, on Windows 7 it appears at the top. You use a Mac, right? [p1]

P1: Yeah I use Mac

I: do you have this bar activated?

P1: No, but I don't use this view ever either.

I: But you both [p2, p3] use windows 7 or 8 I guess? [nodding] You have that at the top

P2: I use both, yes.

I: but it's not optional?

P1: yeah

P3: No it's not optional. But it's useful – I find it useful. I like to see where I'm at. Especially if you are in complicated directories.

P1: I don't care, I don't have complicated directories. [all laugh]. We had this battle yesterday when you were using my Mac [pointing at p3 and laughing]. "How can you find anything?"

I: But you search, we'll come to the search later. [Dropbox desktop columns]. What about that, let's say you have a complex directory, that's the multiple columns view. I don't think there's an equivalent on Windows 7.

P3: Yes, there is

I: There's six colums here.

P1: It doesn't matter,

P3: What do they represent

I: (explaining) that's the main folder, where I opened the window. That's the children folder, that's the file I selected and that on the right is a preview of the file and some details. It's an extreme examples but the default is just three colums.

P1: Yeah, I think I have mine at three, usually. What I like – and you can't see it because it's only a screenshot – but when you scroll down, you automatically see what's inside a folder without having to click on it, that's what I like about it. You can just scroll down and automatically the content of the folder shows up in the next column. You don't have to actually look inside, you can automatically see. So, it saves time, in my mind.

P2: [inaudible] I think I would use that

P3: I find it too much, I don't need so much information. For example, since I am in the fourth level of directory, why do I need to know what exists in the first level?

I: Yeah, most people will be at three colums

P1: [to p3] It's like a path. This one's really big, you usually would have it a little bit smaller than that.

[Dropbox desktop coverflow]
i: So here we go, that's the 'hybrid' one. So, that's the Mac version with Coverflow, on Windows you have as colums, you have the files on the left and on the right you get the preview of your image or your document if I remember right. [p3 nods] but it obeys the same concept. So, list and a preview. On this example you have media on the left and documents on the right. Any comments?

P1: Depends what you're looking for. This is only useful if you're looking for an image or if you're looking for something specific, like a small difference between two images but you can't be bothered to open the files to see the difference in the images. It wouldn't be useful if you're looking at documents. It's useful if you're looking at images and you wanna see two that are different, next to each other or something else.

P3: Or when you have different types of files, because it's totally different, image.. I don't know. I find it useful… could be useful. The second screen, the first one? I don't know.

I: The first one – images?

P3: No

I: which one do you find useful, this one? [docs] rather than this one? [images]

P3: yeah

I: I usually get the opposite, that's why. So what is

All: [laugh]

I: No, no, that's good, I want many user perspectives, so why?

P3: Because with one look, you can identify the type of the file, without looking at the list. Here, you have a presentation, then a document, then a file – a folder, something. I don't know. . Well the first one could be useful for - for images. The second one could be useful for, generally navigating and directions.

[Dropbox desktop large icons]
I: Now we look at the same files, in the same folder, still inside my dropbox. Just icons, but this time, big. So you have an idea what's inside. Big.

P2: You'd have to scroll a lot to find what you want, no?

I: ok. But what if I didn't have to scroll?

P1: I think it's quite useful because, again, it's another feature that's quite nice, you can actually see the inside of the file without having to open the file. So instead of knowing that it's a Microsoft document and that the name is "blah blah blah" you can actually see what it's it, you can process it faster, like

I: but can you?

P1: Yeah if I'm looking for like a CV or looking for … I don't know… an Excel file you can see and sort it faster, than just seeing the name of the file. For me anyway, because I do everything visually.

P2: My documents would pretty much get a similar preview, so it wouldn't work that well anyway.

P3: I think that, if you don't need to scroll, yeah it's useful. That's why I always use lists, because you don't need to scroll. [p1 laughs]

I: Ok , actually it's been the same folder, every one of these screenshots was the same folder.

P1: It's nice having that optionality though, that you can choose which view that you use, because I would use all these views but I would all use them in different times and for different purposes. I wouldn't use them all for the same thing. At least, when I'm using my computer, I'd use them all.

P3: I am the same, I have a different view for my folders, well at least the folders that I mostly use. I, for example, for my downloads folder, that is pretty big, I have the list one and

P1: Really?

P3: You can do it in normal Windows

P1: But you have to keep it that way, you can't change it?

P3: I can change it

P1: But for example with this [Mac] you can change it, you can, each folder you can click a button and it changes the view

P3: Yeah you can do on Windows

I: You can do it on pretty much any platform

P1: But can you set a folder, like in one view, all the time

P3: Yes, yes.

P2: Yeah I just have my pictures, in big icons all the times

I: Do you change yours all the time?

P1: Yeah yeah everytime I look for something, I change the view of what I'm looking for

P3: Yeah?

P1: Yeah

[Spotlight search]

I: What about search? Are you guys searchers? Or filers?

P1: Yeah I'm a searcher

P2: I usually know where well where my things are so I don't use search that muj

I: So you have folders, sub-folders etc?

P2: yeah

I: Are you organised?

P1: Yeah, but if you search it's faster

P3: I do not search a lot

P1: If I had to do through a menu, if I had to look into another window to search, I wouldn't bother. But because it's there [pointing at top right] I can do it really fast

I: So what do you think about these views. On the left, the latest spotlight view, on the right a normal search window?

P3: the right screen has exactly what bothers me in Windows, you cannot sort the search by the type of file. I think this is the most important.

I: This window, though [left] does that splits results into categories

P3: I would use the left one

P2: yeah

P3: I use that, I use search a lot, generally because I don't keep files very organised, but for example if I need something in daily life I'm not gonna search
it.

[Dropbox mobile]

I: Same Dropbox, but on the iPhone.

P1: It's okay. It works.

P3: I would choose the second one, because I don't need to scroll, and it's easy to identify a picture.

P1: You're really anti-scrolling aren't you? I don't care about scrolling, because you use it with your finger anyway, it's not like you have to scroll with a mouse, which is more annoying.

[Snowflake table]

i: That's a file browser, but on the table. [+ explanations of interface]

p1: That's really annoying, this looks like a mess.

P2: I'd probably want it in a grid, so it looks as organised as possible.

P3: Yeah, maybe grid. Yeah grid.

P1: It's like you opened a folder on your computer and all the files just went like that [messy gesture]. And then you have to look around inside your screen to… looks like my desktop on my computer now! [laughs] The files just abandoned.

[Onedrive]

I: Have you seen OneDrive on Windows 8?

P3: I never used it yet

I: I'll show you live [showing live on large screen with touch enabled]

P2: I don't like windows 8 at all on a laptop

I: What do you think about the whole flat interface?

P1: I don't like it, I don't like the fact that you can't see where you were. You can't see which folder you're inside.

[Other methods]

p3: Something that I thought about, you could hide tiles of files that you never use, or that you use less. I don't know how it is on a Mac, but on Windows some sorts of file, you never see there. But generally you could abstract it more, you could hide for example in downloads you could hide types of files that are not usually used. Like, what kind of files, subtitle files? You use only once and then you never use it again, but it's still there. Hmm document files, but generally in the downloads folder you have all the email downloads. When you see an email, you download the attachment that time and then you redownload it. You don't need it there. You have the same file many times. More abstraction, that's what I would do.

[Locating device]
[Network view icons]

I: Network, that's the school of computing network, from the mac. What do you think if you want to pass a content to someone?

P2: [you need to know] how a computer is called, so maybe not that easy to send it someone?

P1: most of them have numbers rather than names

I: That's the usual policy on corporate networks

P1: It would be metaphorically easier to identify if it were not network names. To me, I just look at that and I think "Dah".

[Airdrop Mac view]
[Airdrop iPhone view]

I: Another one, that's Airdrop on the Mac and on the iPhone. It's based on Bluetooth proximity, and you see the name of the user, not the name of the machine. You can filter so you can only see your contacts or not.

P2: That's more convenient than earlier.

I: Here's a comparison with the network representation previously. Another thing suggested by the last group was, people could connect to a session, and you would appear in that session. Any comments?

P1: If you were using it in an environment like this it would probably be useful to have like a session, because you know there's a limited number of people who are gonna be using it and they'd all be connected to the same thing, and you could all put files in the same thing. But, in normal everyday life, it would kind of [??]. Yeah it depends on the situation.

I: Other comments?

P3: I would use the second one [Mac].

[Onedrive machine switch]
[Skipped because discussed previously]

[Crestron map metaphor]

i: Or that, just a map of the room? This is taken from the controller there, but these spots here could be devices. They could be your iPads, or iPhones.

P1: What if you moved?

I: It could track you,

P1: laughs

P2: yeah, I like that idea actually

P1: I think it's confusing because you have numbers.

I: It's a hypothetical interface, it could have icons

P1: If it's icons it's alright. It needs something that's identifiable easily.

[Other methods]
[Sharing content]
[Airdrop protocol iPhone]
[Airdrop protocol Mac]

i: Now if you share content. This is spontaneous sharing using Airdrop on the iphone. Here on the mac.

P1: It looks very easy.

I: Okay and that's one to one, what if you wanna share to a big group?

P1: Depends if you can pick more than one person but on the middle screen you could pick more than one.

I: In this case, you currently cannot do that.

P1: If we could then, it would be the same thing.

P2: Yeah same principle.

P1: Or for example you could create a group, I don't know, in uh… there's an app called WeChat you can create a group of people, it has all the individual people, you [??] then you can send everything to the group.

I: Yes, I've got some students I talked to last semester, when they work as groups they use Facebook.

P1: mmm

[Other methods]

I: email attachments, pros and cons?

P1: Takes a lot of time.

P3: also you have a size limit, that's inconvenient.

I: Cloud folders? Dropbox etc?

P1: Eh I like Dropbox, it's pretty useful as you can access things everywhere. You use Google Drive don't you?

P2: Yeah

P3: I think in FB it's always easy, because you don't need to connect with the other person.

I: Yes the comment I heard from a lot of people was "everyone has it"

[USB stick]

i: What about that?

P2: I've used that a lot

I: Do you still use it?

P3: yeah

P1: I almost never use a USB stick

P2: I don't use them anymore but in the past I did.

P1: Same, in the past I used them all the time. Not anymore.

P3: I have like 4 USB sticks on my keyring

P1: Really? I always use Dropbox now. Because, if you have Dropbox you don't need a USB.

P3: Yeah

P1: You just put in the Dropbox and you can pick it up anywhere.

P3: What about big files?

P1: Well yes, you.

P3: You have to wait to upload…

P1: Ah yes, that's that's a pain. Yeah you're right.

P3: And also how many GB do you have in Dropbox for free?

P1: You get four, then you have to pay… depends what you use it for. For example, if I go on holiday, I can put all my photos into Dropbox, so that I don't have to carry around like a million USB sticks and like… hard drives. I put everything on dropbox, and that way I know I won't lose it.

[Open discussion]

i: other comments on this kind of environments?

P1: I think people aren't used to using rooms like this, if I was put in a room like this I don't know if would know what to actually do with

P2: yeah so many screens

P1: It's like, too much, to, I don't know, I would need to see, get ideas how to use it. I wouldn't know what to do.

P3: Yeah there's more screens than… people here. And even, even if it is… full. Still!

[Video examples]
[Air Link]

i: I found that, actually. A way to transfer content from a phone to another using gestures. I don't know if you have an opinion on that.

P3: It's just waving hands.

P1: This could cause loads of accidents.

I: I heard that earlier.

P1: [laughs] I'd be afraid about sending things to people by accident. It's really convenient, I think it would help you if you …

I: That gesture [video] was an example of a broadcast by the way

P1: If we were in a room like this and I wanted to share something just with you with a gesture like this [mime] that would be great, but there would be some kind of limit, or you'd have to start a sharing session or something.

P3: You'd need a special connection.

P1: Yeah it's pretty weird to think that, by accident, you can share something.

[Bump]

i: and there was an app a few years ago, bump
[comments about the ad]

p3: it's not bad

p2: I like it

p1: it's easy

p3: it's great because you don't bump your phone to another phone by accident

p1: yes, but then you have to move to do the bump

p3: yea. But if you are in a session, you can do the other application with gestures.

Appendix D Final study, protocol and questionnaire

Collaborative scenario questionnaire v1.3.1

Thanks for taking part in our study about collaborative work and multiple devices. In order to evaluate the user experience of the functionalities we tested, we will need you to complete a questionnaire. This should not take more than 10 minutes.

For a start, tell us about yourself:

Gender: _____

Age: _____

Profession: _____

English first language? Y / N

Have you worked with other people in your group before? Y / N

Now we will ask you to rate the systems you have used. You will be asked to rate it by picking a choice of two adjectives.
Make your rating by checking the appropriate space, for example:

	Strong			*Neutral*			*Strong*	
Good		√						**Bad**

I found the content transfer using the **iPad plug in**:

Clear								**Confusing**
Inconvenient								**Convenient**
Well Integrated								**Poorly integrated**
Superfluous								**Useful**
Efficient								**Inefficient**
Quick								**Slow**
Secure								**Unsafe**
Exclusive								**Inclusive**

Dull								**Captivating**
Exciting								**Boring**
Familiar								**Unfamiliar**
Modern								**Old**
Helpful								**Annoying**
Ordinary								**Novel**
Professional								**Unprofessional**
Cool								**Uncool**

I found the content transfer using the **device tab**:

Clear								**Confusing**
Inconvenient								**Convenient**
Well Integrated								**Poorly integrated**
Superfluous								**Useful**
Efficient								**Inefficient**
Quick								**Slow**
Secure								**Unsafe**
Exclusive								**Inclusive**

Dull								**Captivating**
Exciting								**Boring**
Familiar								**Unfamiliar**
Modern								**Old**
Helpful								**Annoying**
Ordinary								**Novel**
Professional								**Unprofessional**
Cool								**Uncool**

I found the content transfer using the **actions tab**:

Clear								**Confusing**
Inconvenient								**Convenient**
Well Integrated								**Poorly integrated**
Superfluous								**Useful**
Efficient								**Inefficient**
Quick								**Slow**
Secure								**Unsafe**
Exclusive								**Inclusive**

Dull								**Captivating**
Exciting								**Boring**
Familiar								**Unfamiliar**
Modern								**Old**
Helpful								**Annoying**
Ordinary								**Novel**
Professional								**Unprofessional**
Cool								**Uncool**

I found screen mirroring using the **device tab**:

Clear								**Confusing**
Inconvenient								**Convenient**
Well Integrated								**Poorly integrated**
Superfluous								**Useful**
Efficient								**Inefficient**
Quick								**Slow**
Secure								**Unsafe**
Exclusive								**Inclusive**

Dull								**Captivating**
Exciting								**Boring**
Familiar								**Unfamiliar**
Modern								**Old**
Helpful								**Annoying**
Ordinary								**Novel**
Professional								**Unprofessional**
Cool								**Uncool**

I found screen mirroring using the **actions tab**:

Clear								**Confusing**
Inconvenient								**Convenient**
Well Integrated								**Poorly integrated**
Superfluous								**Useful**
Efficient								**Inefficient**
Quick								**Slow**
Secure								**Unsafe**
Exclusive								**Inclusive**

Dull								**Captivating**
Exciting								**Boring**
Familiar								**Unfamiliar**
Modern								**Old**
Helpful								**Annoying**
Ordinary								**Novel**
Professional								**Unprofessional**
Cool								**Uncool**

USER STUDY

Introduction

Device Ecosystem

Looking at:

- Usability and UX considerations around:
  - *Content sharing*
  - *Screen sharing*
  - *Presentation*
- In a context of cross-channel collaboration.
- Multiple people, multiple devices, at least one large surface. (e.g. here or study room etc).

Scenario

- You are commissioned by the Scottish government to present ideas of an app supporting art-tourism in Scotland.
  - *The idea is to promote the country's more "contemporary" side.*
- You will be asked to
  - *Designate a person in charge of the presentation – this person is welcome to use my laptop.*
  - *One or more people in charge of information retrieval*

Task

- Find two pictures per venue
  - *Jupiter Artland – https://www.jupiterartland.org*
  - *GoMa - http://www.glasgowlife.org.uk/museums/GoMA/Pages/default.aspx*
- Send them to the person in charge of presenting using a USB stick, email, Dropbox.
- The person in charge of the presentation creates a couple of slides
- The person in charge of the presentation presents the slides
  - *Using the DVI cable*
  - *Using the wireless network*
- The person shares the presentation with everyone

Advice

- You can stop any time
- I am the local expertise, if you need to be shown ask me
- Please return consent forms.
- Video starts now.