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Office of the Future

Changes in the physical an digital office

smartOFFICE

Projektnummer 4P00098

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Bakgrund

Kunskap och information tillhör de mest värdefulla tillgångarna i ett företag. Företag har alltid varit fokuserade på att tillhandahålla korrekt information och kunskap till rätt personer, vid rätt tillfälle och helst direkt på begäran (s.k. efterfrågestyrd informationslogistik). På en globaliserad marknad har detta blivit ännu mer artikulerat under senare år eftersom de flesta organisationer konkurrerar på en alltmer kunskapsdriven marknad.

En pågående utveckling av en ny teknologi, som bland annat studeras av glasforskningsinstitutet Glafo i Växjö, är den som bygger på transparent intelligensen eller tryckkänsliga glasytor som den också är känd som. Nya produkter baserade på denna teknologi har många möjliga tillämpningar men projektetet Office of the Future, som finansierats av Smart Housing Småland, har haft som avsikt att fokusera på dess användbarhet och nytta i en modern kontorsmiljö. Deltagarna i projektet är av den åsikten att transparent intelligens, i kombination med affärssystem och semantisk teknik, öppnar upp möjligheter för att skapa en ny informations- och kommunikationsplattform för bättre samordning, samarbete och kunskapsdelning inom företag.

Projektets vision av framtidens kontor är att det är en plats där det känns naturligt för människor att engagera sig i samordningen, samarbetet och kunskapsdelningen av aktiviteter, vare sig det rör sig om ett fysiskt kontor eller ett virtuellt sådant. Under det senaste decenniet har marknaden fullkomligt exploderat vad gäller nya, nätverkskopplade, tekniska enheter. Vi har alla blivit vana vid, och beroende av, smartphones, surfplattor, sociala nätverk, e-böcker, m.m. i våra dagliga liv. Inom en snar framtid kommer många av de verktyg som återfinns i dagens kontor att se mycket annorlunda ut än vad de gör idag. De kommer att vara tryckkänsliga, fungera i realtid, vara allestädes närvarande, vara intuitiva och mycket visuella samt uppmuntra till samarbete på ett sätt som vi inte sett förut. Framstegen inom ny teknik, som transparent intelligens, gör det möjligt att omvandla ett fönster, en vägg, eller en möbelyta till ett mycket snabbt bredbandsnät, en interaktiv yta, eller en display. De nya produkterna, baserade på transparent intelligens, kommer att utgöra perfekta komplement till stationära datorer och laptops. Semantisk teknik är i detta sammanhang en nyckelkomponent för att förstå och tolka innehållet i och strukturerna hos olika typer av data, människors avsikter och deras aktiviteter, genom att uttrycka innehållet och strukturen i en form som är hanterbar av datorer. Den semantiska tekniken gör det möjligt att dra fördel av alla existerande och nya produkter i interaktionen med nuvarande affärssystem, eller mellan enskilda medarbetare, för att på så sätt förverkliga visionen om Framtidens kontor.

Viktigaste resultat

Under hösten 2014 har en förstudie genomförts under namnet Office of the Future (Framtidens kontor) vilken finansierats av Smart Housing Småland. Under förstudien har projektet bestått av följande deltagare: Länsstyrelsen i Kalmar, Pdb (Jönköping), Glafo (Växjö) och HJ/JTH-JIBS (Jönköping). Förstudien har bland annat innehållit genomförandet av en analys av dagens kontor och de dagliga aktiviteter som ett kontor inbegriper. Resultaten från denna analys kommer att ligga som grund för det fortsatta arbetet mot Framtidens kontor. Några av de aktiviteter som analyserats under förstudien har varit: 1) hur arbetar olika aktörer på ett kontor idag, 2) vilka verktyg, metoder och processer förlitar man sig på, 3) vilka IT-hjälpmedel och informationskällor står till kontorsanställdas förfogande idag, 4) hur kan nya hjälpmedel baserade på bland annat transparent intelligens (det vill säga tryckkänsliga glasytor i form av kontorsbord och mellanväggar) inlemmas i de dagliga aktiviteterna för att förbättra, fördjupa och förenkla samarbetet på kontoret, och 5) hur kan man effektivisera arbetet på kontoret med hjälp av alla de olika verktyg som står till buds i form av mobila plattformar, tryckkänsliga glasytor, semantiska teknologier, m.m. Svaren på frågorna 1-3 har främst kommit från intervjuer med personal på Länsstyrelsen i Kalmar och Pdb medan svaren på frågorna 4-5 kommit från analyser av pågående internationella forskningsprojekt. Det samlade resultatet, som inkluderar alla dessa frågor, presenteras i denna slutrapport som bland annat innehåller processbeskrivningar baserade på resultaten från intervjuerna. Ansatsen i förstudien, men även för det fortsatta forskningsprojektet, har varit att besvara Smart Housing Smålands upprop, att *skapa en internationellt ledande innovationsmiljö som, med användaren i centrum, skapar smart boende och hållbar byggd miljö med bas i glas och trä*, genom att fokusera på en specifik del i det moderna samhället som utgörs av kontoret, dess uppbyggnad och funktion. Det fortsatta, utvidgade projektet ligger också väl i linje med Vinnovas program Utmaningsdriven innovation – Informationssamhället 3.0 – Konstellationsbyggande och idéutveckling. En ansökan till detta program avses skickas in i januari 2015.

Fortsättning

Målet med den fortsatta forskningen kring Framtidens kontor är att utveckla en generell plattform som beaktar nya teknologiska landvinningar inom transparent intelligens, nya rön inom informationsbehandling och gränssnitt som ökar användarupplevelsen. Plattformen kommer att implementeras i form av en demonstrator, vilken kommer att utgöra ett exempel på ett reducerat kontor. I demonstratorn kommer att ingå, förutom den nyss nämnda plattformen, olika typer av enheter (t.ex. glasbord med tryckkänsliga kontaktytor), vilka planeras att tas fram under slutet på 2016 eller början på 2017 med avsikten att fungera som prototyp under det framtida forskningsarbetet. Demonstratorn kommer bland annat att bestå av ett förslag på IT-lösning (mjukvara, gränssnitt för ökad användarupplevelse samt en modell som beskriver kontorsaktiviteter och informationsflöden) samt ett förslag till förändrad byggnadsarkitektur vad gäller den fysiska planeringen av ett kontor baserat på utnyttjandet av transparenta tryckkänsliga ytor i form av t.ex. bord och/eller glasmellanväggar. Ett antal artiklar beräknas också produceras kopplade till Framtidens kontor, bland annat inom områdena semantiska teknologier, användarupplevelser och cross-channel informationsarkitekturer. Ett mera långsiktigt mål är att skapa en dynamisk och kreativ forskningsmiljö bestående av aktörer från näringsliv, institutioner, forskningsinstitut och universitet/högskolor.

SMART HOUSING SMÅLAND

Innovationsmiljön drivs och finansieras av

Innehållsförteckning

1 Introduction

Information and knowledge are one of the most valuable assets in organizations. Organizations have always been concerned with providing the right information and knowledge to the right persons at the right time to drive the right business decision, preferably on demand (demand driven information logistics). This project has embraced the advances in the areas of transparent material, information and communications technology, information architecture and user experience design, to map out the path forward to office of the future, providing innovative tools and platform for better coordination, collaboration and knowledge sharing in enterprises.

In the last decade mobile and digital technologies have been expanding into more and more aspects of our life. Today they have enabled us to work anytime and anywhere, changing the notion of both whatever and wherever the office might be. Alongside this, the trend in the tools for work is toward touch-based, real-time, ubiquitous, collaborative, intuitive and highly visual ones. The technological changes open up new ways how information is created, analyzed, synthesized, shared, and put to use. Though they do not define an organization, the technologies becomes the enabler for an organization to define or change how it is organized, as well as how people organize work, collaborate and share.

The pre-study for the project, including studies in both theory and practice, has been carried out during August 2014 to January in 2015. The external project participants, Pdb in Jönköping and Länsstyrelsen in Kalmar have provided real use cases of workplaces for the practical study. Glafo in Växjö has helped with a feasibility study about the potential applications of transparent intelligence for future workplaces. Researchers at HJ-JTH and HJ-JIBS investigated how new technologies for information production, share, and reuse, enact change and contribute to shaping the digital and physical environment of the office of the future.

2 State-of-the-art

The following section outlines a number of areas that have been identified as highly relevant to the initial stages of the project *Office of the Future*. Another reason to choose these areas or topics was related to the former competences and experiences of the involved researches.

2.1 Introduction

Computer Supported Cooperative Work (*Anders Adlemo*, HJ-JTH)
is a multidisciplinary research area that has been around as a concept for about 30 years but having roots in the 1950s. One definition of Computer Supported Cooperative Work (CSCW) is 'computer-assisted coordinated activity such as communication and problem solving carried out by a group of collaborating individuals'. As a research area, CSCW is vast and contemplates such different topics as collaborative work environments, computer-supported collaboration, and knowledge management, just to mention a few. For the continuation of the *Office of the Future* project we plan to further investigate topics such as coordination management, knowledge and expertise management, awareness management, and ontologies as a means of modelling office aspects.

On demand information supply (*He Tan*, HJ-JTH)
is about the ability to acquire the correct information for the correct person at the correct moment and preferably instantaneously, wherever the person might encounter himself or herself, all in a self-explanatory and user-friendly manner. The fundamental aspect that needs to be focused on to realize this on-demand information supply is on management, and especially of three key components, namely *content* (a user is supplied only with correct, pertinent and relevant data), *communication* (a user is supplied with the "correct" *content* without having to consider the technological platform or communication media), and *context* (a user is supplied with information in accordance with the need, position, place, time and so forth).

Enterprise application information (*Vladimir Tarasov*, HJ-JTH)
is about finding the solutions needed for an efficient integration of data sources among involving systems within enterprises and across enterprises, interoperability of heterogeneous systems, connection of legacy enterprise applications, and so forth. A common definition of enterprise application information is "the plans, methods, and tools aimed at modernizing, consolidating, and coordinating the computer applications within an enterprise.

User experience and cross-channel design (*Cajsa-Tora Hermansson,* HJ-JTH*, Andrea Resmini*, HJ-JIBS)
is about the design of the physical and digital workplace from the point of view of behavioral patterns of use and appropriation, of its general user experience and the role that technology might play in making it better (user experience) as our goals shift from performance and usability to satisfying experiences to pervasive cross-channel experiences (cross-channel design).

Transparent intelligence (*Mikael Ludvigsson*, Glafo, Växjö)
is about a technological breakthrough in transparent surfaces, ranging from colored glass used as protection from the sun to invisible interactive interfaces. As for the usage within an *Office of the Future,* where modern architecture glass and other transparent material are going to be used extensively, the possibilities for such surfaces providing additional functions are endless.

2.2 Computer Supported Cooperative Work

Computer Supported Cooperative Work (CSCW) is a discipline that has been around for approximately 25 years. The term Computer-Supported Cooperative Work was coined by Irene Greif who organized the first workshop in 1984. Greif (1988) writes that CSCW is 'computer-assisted coordinated activity such as communication and problem solving carried out by a group of collaborating individuals'. More recently, Schmidt (2011) writes that: 'the development of computing technologies has from the very beginning been tightly interwoven with the development of cooperative work' and that 'over the last couple of decades computing technologies are also and increasingly being developed and used for coordinative purposes'. These computing technologies are often referred to as groupware. The term groupware was defined by Johnson-Lentz and Johnson-Lentz (1981) as computer-based technology that supports social group processes. Hence, groupware research can be looked upon as one of many current areas of research within CSCW.

The following sub-sections demonstrate an overview of different research activities within CSCW and groupware. This list of activities is by no means exhaustive. What they have in common is that that we believe they are important and should be further investigated in the continuation of the *Office of the Future* project.

2.2.1 Coordination management

Coordination mechanisms (CMs) can be defined as any kind of computable construct whose aim is to organize activities performed by a group of actors that are called to collaborate for some purpose or reason (Cabitza & Simone, 2013). As such, CMs can be observed, conceived for and applied in a vast number of coordinative practices in almost every work setting.

One way to deal with the problem of process flexibility (i.e. flexible initiation, flexible termination, flexible selection, flexible reordering, flexible elimination, flexible extension, flexible concurrency and flexible repetition) is to model the process description (Mulyar et al, 2008). In general, the process description is based on pictorial representations that use graphs whose nodes and arcs are interpreted in different ways according to a formal semantics (Cabitza & Simone, 2013). One can observe three main interpretations of the graph: as a flow of activities (i.e. *process-based*); as a path expressing the circulation (or routing) of documents (i.e. *document-based*); and finally, as the unfolding of conversation (i.e. *conversation-based*) steps where activities contents can be defined (Cabitza & Simone, 2013; Wang & Kumar, 2005).

2.2.1.1 The process-based approach

A process is seen as an articulated sequence of activities that business modelers and system designers (when these two categories do not coincide) have preliminarily defined in terms of a network of temporal or causal dependencies, interconnected control structures and task abstractions. Such models are usually described and specified with standard notations that have gained increased diffusion probably due to the promises of seamless interoperability and process automation that their

advocates point out: e.g., BPMN, BPEL and XPDL3, just to name a few of these languages (Ko et al, 1995).

2.2.1.2 The document-based approach

The second modelling approach is based on the metaphor of 'circulation folder' that reflects the usual way in which documents are managed in organizations, especially the more bureaucratic ones, like wide corporations and public administrations (Klöckner et al, 1995). Activities are specified, possibly in a dynamic way, as the series of elaborations that a document can undergo in a specific point of the circulation path so that the receivers can activate the subsequent elaborations (Cabitza & Simone, 2013).

2.2.1.3 The conversation-based approach

The conversation-based paradigm is rooted in the idea that interpersonal communication is a natural way to define the coordination of activities among multiple parties in a flexible and contingent way. This paradigm offers a radical alternative to look for flexibility. For the first time people and their communication capabilities (and not activities or documents) became the main focus (Cabitza & Simone, 2013).

2.2.2 Knowledge and expertise management

Knowledge Management (KM) is a diffuse and controversial term, which has been used by a large number of research disciplines. CSCW, over the last 20 years, has been critical towards most of these approaches, and instead has shifted the focus towards a practice-based perspective (Ackerman et al, 2013). The term *knowledge sharing* takes a perspective in which externalization of knowledge in the form of computational or information technology artifacts or repositories play an important role. The term *expertise sharing* is the capability to get the work done or to solve a problem based on discussions among knowledgeable actors and less significantly supported by a priori externalizations. Both terms connote CSCW's spin on the problem - that knowledge is situated in people and in location, and that the social is an essential part of using any knowledge (Ackerman et al, 2002).

2.2.2.1 The first generation – the repository model

The first generation, based on repository models of information and knowledge, was rooted in documents or computer records perspective (Ackerman et al, 2013). Within CSCW, this had the rubric of organizational memory, although there were many earlier efforts to examine document and information flows. This body of work was concerned with information as an externalized artifact or object, although the information was understood to be within a social context. The work on repository models produced many insights into the social practices around knowledge sharing. The shortcomings of repository models were quickly recognized and empirically investigated both in CSCW and knowledge management practice, and a second generation began to examine tying communication among people into knowledge work (Ackerman et al, 2013).

2.2.2.2 The second generation – the sharing expertise model

A second generation of CSCW studies emphasized interpersonal communications of knowledgeable actors over externalizations in IT-artifacts (Ackerman et al, 2013). The shift away from the repository model ascribed a more crucial role to the practices of individuals engaging in knowledge – or expertise-sharing. Emphasis was on finding an appropriate person. In this second generation, sharing tacit knowledge, including that contextual knowledge that might be required to understand information, became critical. The distinction between 'explicit' and 'tacit' knowledge (Polanyi, 1967) led to the idea that 'making tacit knowledge explicit' could be one of the design goals to associate with IT tools particularly of the 'first generation' (Nonaka & Takeuchi, 1995).

2.2.3 Awareness management

Awareness is a fundamental and critical feature of collaborative work (Dourish & Bellotti, 1992; Begole et al, 1997; Mark et al, 1997; Cadiz et al, 2002; Hill & Gutwin, 2003) that facilitates a collaborative process (Kouzes et al, 1996). Awareness implies that a collaborator needs to be aware of actions and the progress of other collaborators (Begole et al, 1997; Convertino et al, 2004).

Awareness support is an essential part of groupware (Gross, 2013). Groupware is distinguished from normal software by the basic assumption it makes: groupware makes the user aware that he is part of a group, while most other software seeks to hide and protect users from each other (Lynch et al, 1990). Groupware platforms accentuates the multiple user environment, coordinating and orchestrating things so that users can see each other, yet do not conflict with each other. With more awareness technology becoming available, huge amounts of data can be captured and stored. Increasingly the question arose of how to structure awareness information in order to selectively provide awareness information according to the respective users' needs (Gross, 2013).

A groupware platform normally provides some system support to keep participators aware of other collaborators' status. Till date, awareness control has already been enhanced to the extent that the granularity of awareness is customizable rather than forced (Hill et al, 1994), which means that users can control the degree of awareness that they want others to know about their own work. By granularity of awareness, is meant the part of work that a user would like to share with other collaborators (Chang et al, 2005). Whether to keep every user's view consistent throughout the collaboration could constitute a problem. One option is to always distribute to all participants every change of the shared artefact. The other option is to only send modifications to a participant on-demand (Bernier, 2001). Another level of awareness intends to facilitate latecomers' comprehension of the status of the collaboration (Shen et al, 2002).

2.2.4 Classification of CSCW/groupware

CSCW deals with the study of the communication between people to achieve some common task, taking advantage of some kind of technology, i.e. a specific hardware and software dedicated for this task. As every human action, this communication takes place in space and time. Figure 1 illustrates this relation in space and time as defined by Johansen.

		Time	
		Synchronous	Asynchronous
Space	Same	Face-to-face interaction	Asynchronous centralized interaction
	Distributed	Synchronous distributed interaction	Asynchronous distributed interaction

Table 1. The four CSCW quadrants (Johansen, 1988).

From table 1 it can be observed that there exist 16 different combinations that are shown in table 2. However, some of the combinations are not valid, e.g. a system has to be synchronous or asynchronous and a system has to be distributed or not distributed (i.e. 0, 1, 2, 3, 4, 7, 12 are non-valid combinations) (Penichet et al, 2007).

Type	Time		Space	
	Synchronous no=0 yes=1	Asynchronous no=0 yes=1	Same no=0 yes=1	Distributed no=0 yes=1
0	0	0	0	0
1	0	0	0	1
2	0	0	0	1
3	0	0	1	1
4	0	1	0	0
5	0	1	1	0
6	0	1	0	1
7	0	1	1	1
8	1	0	0	0
9	1	0	0	1
10	1	0	1	0
11	1	0	1	1
12	1	1	0	0
13	1	1	0	1
14	1	1	1	0
15	1	1	1	1

Table 2. Breakdown of the four CSCW quadrants (Penichet et al, 2007).

Many other types of classifying CSCW systems have been proposed over the years. One way is to show the relationship between a function, or an application or a system, with the time-space features and with the typical CSCW characteristics: information sharing, communication and coordination (Poltrock & Grudin, 1999, 2005). Table 3 indicates the eight different combinations of CSCW characteristics that are possible, where seven are valid (A-G) and one is invalid (X).

Type	CSCW characteristics		
	Information sharing no=0 yes=1	Communication no=0 yes=1	Coordination no=0 yes=1
X	0	0	0
A	0	0	1
B	0	1	0
C	0	1	1
D	1	0	0
E	1	0	1
F	1	1	0
G	1	1	1

Table 3. CSCW characteristics (Penichet at al, 2007).

Coordination is fundamental in an organization. To harmonize mediums, efforts, and so forth, to realize a common action. Communication could be understood as the process of exchanging information, usually via a common system of symbols.

When combining tables 2 and 3, different IT-tools can be organized and compared as shown in table 4. The result is a classification of different groupwares (Penichet at al, 2007).

Type	Tool	CSCW characteristics			Time		Space	
		Information sharing no=0 yes=1	Communication no=0 yes=1	Coordination no=0 yes=1	Synchronous no=0 yes=1	Asynchronous no=0 yes=1	Same no=0 yes=1	Distributed no=0 yes=1
B-5	Fax	0	1	0	0	1	0	1
B-5	E-mail	0	1	0	0	1	0	1
B-9	VoIP	0	1	0	1	0	0	1
B-9	Chat	0	1	0	1	0	0	1
C-7	Group calendar	0	1	1	0	1	1	1
C-7	Agenda	0	1	1	0	1	1	1
F-7	Forum	1	1	0	0	1	1	1
F-7	Talk	1	1	0	0	1	1	1
F-7	Share point	1	1	0	0	1	1	1
F-9	Video conf.	1	1	0	1	0	0	1
F-10	Meeting room	1	1	0	1	0	1	0

Table 4. Classification of different groupwares (Penichet at al, 2007).

Based on this classification of different groupwares one can ask the following questions to determine what each functionality should achieve:

- Are the users helped to collaborate to attain a goal? Do they share information? Do they work with it?
- Can it be used as a communication method? Are users informed about anything? Do they inform themselves using this tool?
- Does it coordinate processes and persons?
- Is the tool used in real time?
- Is it suitable to use it pre-recorded?
- Is it suitable to use it in the same physical space?
- Can the tool be used in different spaces?

By classifying different groupware tools it becomes clearer what they are capable of doing and what could be done to modify a tool to make it more versatile.

2.2.5 Ontologies

Another field of research related to CSCW and groupware is the use of ontologies to model the behavior and relations between people. Some of the work in this area have been presented by Anzures Garcia et al, 2010; Penichet et al, 2008; Borst, 1997; Garrido et al, 2008; Gómez-Pérez et al, 2004; Gruber, 1993; Guarino, 1995; Hurtado et al, 2007; Within computer science an ontology could be seen as a data model that represents a set of concepts within a domain and the relationships between those concepts. The W3C provides a language, OWL Web Ontology Language, which is designed to be used by applications that need to process the content of information instead of just

presenting information to humans (W3C, 2004). The following subsection outlines a very limited example of an ontology that models a collaborative environment, such as an office, its organizational structure of the office workers, and the collaborations established among them.

Most software applications are used by different users, but not all these users have the same rights, or can use software applications in the same way. A complex application usually needs also a complex variety of final users. However, there are several types of users: users with similar features or users related between them because they share a common goal, etc. This logical structure of final users, classified by means of groups and roles, is an *organizational structure*. The organizational structure of the users is defined according to some other concepts called *organizational items* (group, role, and actor) and some *organizational relationships* among them (play, aggregation, and cooperative interaction). A *group* is a set of individual or collective *actors* which play *roles*. It is a set of *actors* that need to work together and to collaborate in order to reach a common group objective. A *role* can be seen as a set of *actors* that share the same characteristics and perform the same tasks. An *actor* is one or several persons or another external system that interacts with the system to accomplish individual tasks, but they can also interact with each other, through the system, to perform cooperative tasks. In table 5 below is shown some example of organizational items in relation to an office environment. This means that *actors* belong to *groups* depending on the *roles* they play, because *groups* are organized with the *roles* needed to form that *group*. There are no connections among the *organizational items* because they are only examples of *group*, *role*, and *actor* respectively.

Organizational items	*Example*
Group	Economy, sales, marketing
Role	Assistant, administrator, chief
Actor	Bo Svensson, Adam Fors, Peter Holm

Table 5. Examples of organizational items (Penichet at al, 2007).

An *actor* is an *organizational item* linked to the *role* concept by means of a *play organizational relationship*. *Aggregation* makes sense among *groups* and their *roles*, but also with other *groups*. Since *actors* belong to *groups* by the *roles* they play, there are no *aggregation organizational relationships* between *groups* and *actors*. Every kind of *organizational item* can be related to another through a *cooperative interaction*. A *cooperative interaction* means the performance of a cooperative task among several *actors*, *roles*, or *groups* in order to reach a common objective. In short, *play* and *aggregation* relationships define the organizational structure of the users of a system, while *cooperative interaction* specifies the collaborations within such an organizational structure.

When an ontology of an office has been defined, including the organizational structures and interactions among the workers using existing tools, it is important to define a conceptual model where all the previously described terms fit together to constitute a metamodel from which specific models to represent real collaborative scenarios can be instantiated (Penichet at al, 2007). Once a specific model has been defined, it will illustrate all the actors within an office and their internal

relationships and interactions. The model defines a set of terms around the human-computer-human interactions instead of only around the human computer interactions. Thereby, cooperative tasks in a system can be identified, analyzed, designed and, if necessary, re-designed in an intuitive and explicit way (Penichet at al, 2007).

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2.3 On demand information supply

2.3.1 Introduction

Within the past few years the advances of ICT leads to a broad variety of ways to obtain information, i.e. various new kinds of appliances suited for information, coordination and communication purposes. However, this also entails some problems: The variety of available information and information sources often makes it difficult for people to find what they need and burdens them with the laborious task of separating the relevant from the irrelevant. In addition, people are often provided with information at a time it has no value to them. At the same time, people searching for information often do not know where the information they need can be found, receive information that does not meet their requirements or is outdated, and cannot dispose of particular pieces of information at a given point in time. This results in an information undersupply occurring simultaneously with the above mentioned information overflow. The challenge of an accurate and effective information supply is to provide optimizing information supply to information users by ensuring that the users receive exactly the pieces of information they require in the manner that best suits their information demands. An information user can be a single person, a target group, a machine or any size of networked organization [1].

The fundamental aspects that need to be considered to realize this on-demand information supply are [2] :

- Content management: An optimizing information supply ensures that each user is supplied with only that content she really needs.
- Communication management: An optimizing information supply involves various methods of providing users with information via different communication channels. The supplied information is adjusted to the present technical environment of the recipient.
- Context management: A consideration of the entire context of information use is necessary in order to ensure the information supply meets the user demands.

2.3.2 Content management

2.3.2.1 What is content?

Firstly, we clarify the word 'content'. Essentially it refers to something contained in an entity. Compared to the use of the terms 'data' or 'information', content is associated with a container. We talk about the content of a document, content of a web site, or content of the Internet, among others. It is often opposed to other aspects of the container, for example, structure or representation. For example, in an XML document, we can separate content, structure, and one or more external presentations.

2.3.2.2 Structured vs unstructured Information

Today there is more information available to us than ever before. We need deal with information of all kinds: not just in terms of media types like text vs. images vs. voice files, but also in terms of how

structured and thus how readily managed. Structured information is information that is highly defined – like most of the information held in relational databases – and is readily to be processed by a computer program. Unstructured information is the opposite of structured information. Unstructured data does not have a fully defined structure, and most likely will be read and used by humans, e.g. most of the information produced by common office applications (word processors, presentation programs, log data and social media feeds). It is estimated that 80% of business data today is unstructured [3]. Many organizations believe that their unstructured data stores include information that could help them make better business decisions. Unfortunately, it is often very difficult to analyze unstructured data. In addition to structured and unstructured information, there's also a third category: semi-structured information. Semi-structured information is information that doesn't reside in a relational database but that does have some organizational properties that make it easier to analyze. Examples of semi-structured data include XML documents and NoSQL databases. The term "big data" is closely associated with unstructured data. Big data [4] refers to extremely large datasets that are difficult to analyze with traditional tools. Big data can include both structured and unstructured data.

2.3.2.3 Content management

Content management is a combination of strategies, methods, and tools. Organizations are overwhelmed by various kinds of information artifacts, e.g. documents, data, reports, web pages, social media, etc. Regardless of the type of information and where it resides, all organizations need to capture, organize, process and maintain information so that it can be accessed and used when needed [5] (see Fig 1).

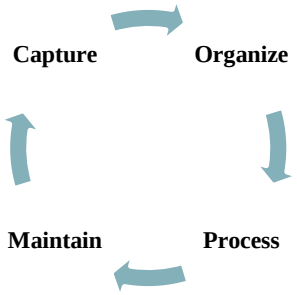

Figure 1. Content Management Lifecycle [5].

Capture The first stage in the content management includes all activities associated with collecting content. An organization must first identify which content it wishes to capture and its range, quality, and depth [6]. In the past, many organizations find that because little systematic attention was paid to content capture, large gaps exist between what they collect and what they need. All too often, content is collected because it might be useful rather than because it directly supports organizational tasks.

Organize Content is useless if it cannot be easily searched or navigated. Organizing content involves indexing, classifying, and linking content and databases together to provide access within and across business units and functions [7]. IT can provide considerable support with it. Organizing content begins with a taxonomy, that is, a systematic categorization of content by keyword or term. Properly implemented, taxonomies can become “the common language that can be shared across the organization, furthering the goals of knowledge management” [8]. A second layer of organization is metadata, that is, information about content and where it is. Metadata is especially important for workflow design, the overall management of content, and for content exchange between enterprises

or different software applications [9]. A third layer of organization is provided by work processes. These processes identify the content's ownership and ensure that content meets all necessary corporate, legal and linguistic standards. They also manage such activities as authorship (which can be separate from ownership), versioning, and access. A final component of organization involves the look and feel of content. Decisions must be made about how internet and intranet content is displayed. Many organizations use standard templates for documents and other information assets.

Process The processing step analyzes content in ways that inform decision-making. Very few firms have yet developed the capability to aggregate, analyze, and use content to make informed decisions that will lead to action and generate business value. Within the technology perspective, development of the software and systems for extracting, manipulating and analyzing data, statistical modeling, and analytical methods is the key to improve content processing capabilities in organizations [10].

Maintain It is by far the biggest challenges in content maintenance. It requires considerable ongoing effort to ensure that it is kept up-to-date. While using technology can achieve some savings, humans play an important role in content maintenance because they must continually assess how well an organization's content is working to meet its needs and these are always changing [7].

2.3.2.4 Relevant research questions in content management

Within the technology perspective, the research concerns the development of hardware, software, and standards for content management in organizational context [11]. The early content management solutions used either technically coarse content storage granularity with very large content units (files, documents) or high granularity with very small content units (data items in databases). The structured document approach introduced the use of schemas for describing the structure of documents and adding semantic information to the content [12]. Recent research on the Semantic Web illustrates the increasing interest in this approach. The research was triggered by the perceived lack of semantic information related to the Internet content. The Semantic Web is intended to be 'an extension of the current web in which information is given well-defined meaning, better enabling computers and people to work in cooperation' [13]. The well-defined meaning is added to the web by means of metadata. The metadata is information about resources either accessible or identifiable on the web. Ontologies are used to express semantic metadata. An ontology formally defines the concepts and their relationships in an application domain [14]. Management of information assets can be remarkably facilitated by the use of metadata. Accordingly, constructions of content models, metadata models and related ontologies have become important in content management. Use of ontology to structure domain concepts can serves as a technical means to link the XML schemas and metadata models, especially to natural language processing. The specification of ontologies for information and knowledge management in organizations and organization networks is an active area of research (e.g., [15]).

2.3.3 Communication management

Today, organizations and their employees and members have access to many communication channels. Some of the possibilities are mobile technology, e-mail, blogs, formal written document, telephone conversation and video conferencing. A challenge is to determine what type of communication channel to use once they have determined objectives and strategies, constructed messages and assessed relevant receivers.

2.3.4 Context management

2.3.4.1 Context definition

Although the importance of context has been often emphasized in different research communities, there is no common definition for this. People usually understand tacitly this concept, but it is found hard to elucidate it [16]. The only generally accepted interpretation is that context represents a key knowledge source in various research fields of computer science. Previous definitions of "context" have emerged in cognitive psychology, philosophy and also in particular areas of computer science, like natural language processing or automatic reasoning [17]. However, since these definitions have proved to be hardly applicable in other computer science domains, numerous context-aware applications define context by enumeration of examples or by choosing synonyms for context. It is important to place more focus on context information itself and acquisition and processing of context than on a clear definition of the concept [18].

2.3.4.2 Context elements

Context information is typically defined by plenty of elements. We can distinguish task requirements, user characteristics, social partners, physical environment, geographical position, etc. Here, we list possible context elements relevant to information supply and their definitions in general. Depending on the scope and purpose of a specific on-demand information supply application only a subset of these elements may be required or some additions may be necessary [19].

Information demand is the most fundamental factor for an accurate and effective information supply. A user's information demand defines what information she wishes to be supplied with and what conditions the information has to fulfill. These conditions may refer to various aspects of information such as its type, age, quality, subject, or contents. Consider, for example, a user who wishes to be notified whenever a new document referring to a particular project is available on her company's Intranet.

User preference The organizational roles, work activities, interests, knowledge background, resources and other attitudes of an information user all belong to the user's context. They may have a great influence on how information supply is to be carried out and what information is to be provided. In addition, they may also affect the communication medium employed for information supply, the delivery time, the number of deliveries, and other elements concerning the execution of information supply.

Time and history Date and time is another fundamental context element. It provides information that answers the question of when a particular situation occurs. In addition to this, historical data about interactions between entities such as a history of past information supplies or of an entity's system usage are important context elements.

Location is particularly relevant for location-dependent information demands. These demands may only just occur with the presence or absence of an entity at one or more locations. In addition, the requested information itself may depend on location.

Environment may both affect the way information is presented to users as well as the selection of information that is to be supplied. Examples of environment are data about the light conditions, temperature, or noise level in an participant's environment.

Nearby people and objects [20] has pointed out that this context element is not restricted to actually present entities; it may also include imaginary companions. They may affect the information is presented but also the information supply.

Further context elements Numerous other aspects that may constitute a context have been identified. The objectives or focus of attention of an entity, or things like communication costs, as well as changes to all of these elements are some examples.

2.3.4.3 Context management

Context management is the heart of an on-demand information supply. It directs both content and communication management. A context management need address the questions [21]:

- How to acquire and gather context information;
- How to represent and store context information;
- How to process context information so that realize an on-demand information supply.

Gathering Context

Context information is acquired from a large variety of context data sources. Some context information, e.g. user preference and information demand can be acquired through user profiling. Based upon a history of previous user actions and input, a general profile with user preferences can be determined. It is clear that this kind of information is error prone and subject to change. Some context information, e.g. time, location and environment, can be acquired by sensors, hardware and systems. This low-level information is prone to measurement errors and can require transformation into conceptually richer information before being usable. Consider information supply in an organization, context information about information use of an individual or a group a large extent depends on the work processes they are involved in, their organizational role and other attributes in the organization. These kinds of context information require interviews with different persons (roles) within an organization, work or information flow analysis, or enterprise modeling. All in all, gathering

context is a non-trivial task. This is not just because context information comes from diverse sources, can be both explicit and implicit, can be dynamic and have a limited validity, but also context information may be incomplete, inconsistent, and/or erroneous [22].

Representing Context

Context information models have to deal with a large variety of context information sources that differ in their update rate and their semantic level. The models should capture the various relationships between types of context information to ensure correct behavior of the applications. As we mentioned above, context information may be incomplete, inconsistent, and/or erroneous, thus it is also important that representation techniques should be able to support both consistency and verification of the model and reasoning techniques. Moreover, since gathering, evaluating and maintaining context information is expensive, re-use and sharing of context information between applications need be considered from the beginning. The existing well-designed context information models should be able to ease the development and deployment of future applications. Therefore, it is natural that the benefits of formal context information representation have been increasingly understood. On the other hand, context, as intended in this report, can be considered as a type of knowledge. The knowledge representation and reasoning technologies are considered possibly appropriate for handling context.

Ontology, as a formal modeling technology, has been studied in the knowledge representation community for 20 years. Ontology-based methods for representing context information will exploit the representation and reasoning power of description logics [22]: a) the expressiveness of the language is used to describe complex context data that cannot be represented by simple languages; b) by providing a formal semantics to context data, it becomes possible to share and/or integrate context among different sources; c) the available reasoning tools can be used both to check for consistency of the set of relationships describing a context scenario, and, more importantly, to recognize that a particular set of instances of basic context data and their relationships actually reveals the presence of a more abstract context characterization.

Processing Context

Processing context depends strongly on the types of context information and the way it is interpreted. The underlying procedures are too specific to be used in a generic scope. Context information, like location, time and temperature, is typically used as a filter to improve the quality of information services, and is hard-coded in the system implementation. Context information about information demand and user preference can be understood as a specific domain of discourse and be used to support tasks in content management, such as information retrieval, extraction and discovery, and information integration. For example, if an information query can be complemented with context information, it will contain more information and will be better specified than a few ambiguous keywords. Information integration can be improved using context and its properties (data quality,

security) as a mediation policy to achieve a higher rate of semantic interoperability between heterogeneous environments (Reddy). Other aspects of processing context need to be considered include changes of context and how the system deals with this dynamics; when context information should be involved in information supply, all the time, user-specific, by request or any other possibilities.

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2.4 Enterprise application integration

2.4.1 Introduction

There always is a need to integration in enterprises. The need is driven by new rules of competitiveness - "collaborate or perish" [1]. From a technological perspective, integration is the melding of heterogeneous and probably overlapping technologies, applications, data and communications into a uniform ICT architecture. The traditional approaches for integration include Enterprise Data Integration (EDI) achieving data integration, and its successor, Enterprise Resource Planning (ERP), providing solutions for integrating business processes across enterprise. However, today enterprise systems still present many limitations in integrating business and cross enterprise business process [2]. One reason is that businesses are often depending on a number of heterogeneous applications and data sources that meet diverse and constantly changing business requirements. Businesses often rush in new systems "of-the-shelf", need customize applications meeting specific business needs, but also rely on legacy applications not always desirable to replace. As a result, solutions are needed for efficient integration of data sources among involving systems within enterprise and across enterprises, interoperability of heterogeneous systems, connection of legacy enterprise applications, and etc. Recently, such solutions are referred as Enterprise Application Integration (EAI). Definitions of EAI literature shift focusing between business and technology. A common one is "the plans, methods, and tools aimed at modernizing, consolidating, and coordinating the computer applications within an enterprise [3]."

2.4.2 Problem dimensions of enterprise application integration

The work on EAI focuses on three issues: distribution, autonomy and heterogeneity:

- Distribution Application or systems are located at different geographical locations (rooms, buildings, cities and even courtiers). They do not share common hardware components, but connected through internet. Proxy services are an established technique for distribution. Applications are decomposed in functionalities and processes presented in the form of services discoverable on network. Services communicate with each other through request-and-reply communication.
- Autonomy includes design autonomy, communication autonomy and execution autonomy. Applications are free to use models, naming concepts, and techniques and so forth, to make its own decision on what it wants to provide to others, and execute in any way it wants to. The feasibility of reducing autonomy by technical means is highly limited. Usually, autonomy can only be reduced in connection with organizational changes [4].
- Heterogeneity occurs at various levels and for various reasons. It is one of the most difficult tasks in EAI. Enterprise applications not only have technical heterogeneity, such as different hardware platforms, operating systems, database management systems, and programming languages, but also content heterogeneity. Content heterogeneity exists when two systems differ in their syntax, semantics and pragmatics,

- Syntax heterogeneity: collaborating systems have different ways structuring data during exchange; i.e., the manner in which data is be codified using a grammar or vocabulary is incompatible.
- Semantic heterogeneity: The meaning of the syntactic elements can be interpreted by collaborating systems in different ways; i.e.; they do not share the same meaning of the data in relation to the entity or phenomena it represents in the real world.
- Pragmatic heterogeneity: Messages sent by a system can causes the effect that is not intended by that system; i.e., the intended effect of the message and its use in a given context is misunderstood by the collaborating systems.

More work has been done on technical heterogeneity than content heterogeneity. Traditional techniques for overcoming heterogeneity are the use of common programming and data models, and similar structuring of information. Domain-specific standards are useful for defining the meaning of information to be shared among dissimilar organizations. Wrappers that provide unified interfaces are an established technique for integrating legacy systems.

2.4.3 Service-oriented architecture (SOA)

SOA represents the latest trend in the development of integration technologies [5]. It enables integration to focus on business-centric services with business transaction granularity, independent from the implementation, and standards compliance. SOA enables organizations to create new applications dynamically to meet changing business needs [6]. Under SOA applications are decomposed into individual functions and processes presented in the form of services. Services are published on network, and can be discovered and used, often through a single, standards-based form of interface. Each of such existing services can be recomposed, reconstructed, and reused to create new applications (see Figure 1).

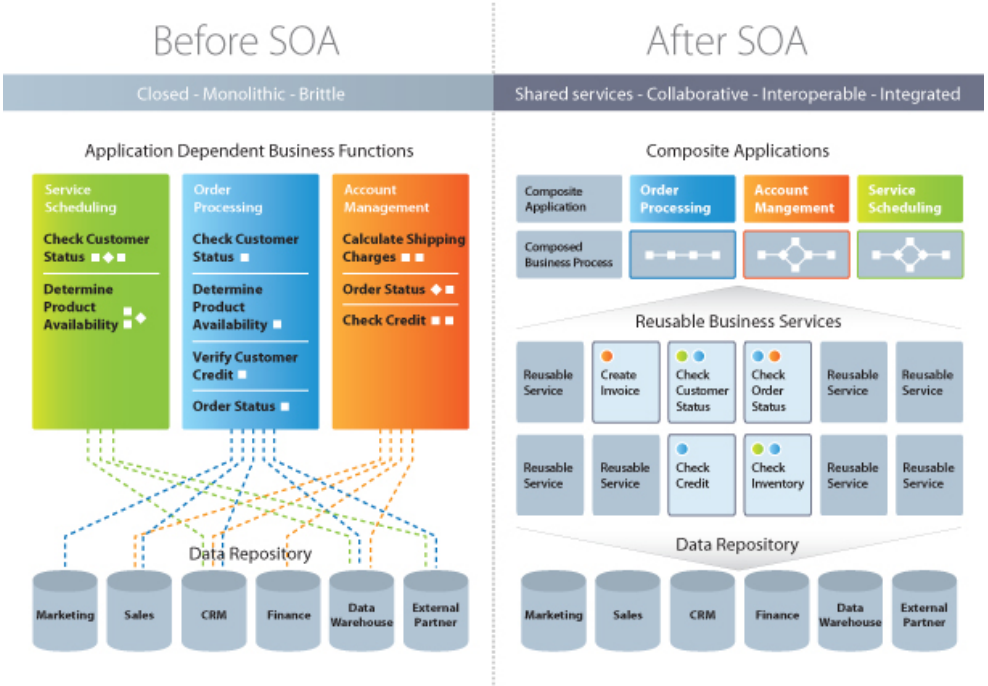

Figure 1. Service-oriented architecture (SOA) solution [14]

SOA is more than an IT solution. It is about describing, building, using, and managing an IT environment in enterprises, focusing on the services it supplies, rather than the technology it employs. When enterprises adopt a service-oriented architecture, they describe their IT investment in terms of modular services, each delivering specific value. A well architected, governed, and managed SOA environment enables enterprises to quickly create, combine, and deploy services so as to respond to rapidly changing business needs. Software development life-cycle methods, such as Service-oriented modeling and architecture (SOMA) [7], have identified key techniques and roles required to effectively analyze, design, implement, and deploy SOA.

2.4.4 Semantic enterprise application integration

Communication between servers is an exchange of information between a sender and a receiver. Information is formulated in some language. Every language is characterized by its syntax and its semantics. The syntax concerns the symbols a language recognizes and the rules which govern how to construct well-formed sentences using those symbols. The current success of EAI depends on the efforts of XML-based EAI syntactic standards [7]. The standards enable collaborating systems to agree on syntax and understand information in communication.

Although XML-based standards enable agreement on the rules of syntax among systems, they do not resolve heterogeneity on semantic and pragmatic level. The semantics of a language fixes the meaning of its expressions (symbols, terms, or sentences). Communication obstructions arise from the fact that sender and receiver employ different languages for representing information internally. In different systems, the languages may have been established in different contexts, for different

purposes and based on different models of domain of interests. As a result it may happen that the same symbol may have different meanings in different languages, or distinct symbols in different languages may have the same or overlapping meanings [8]. This semantic heterogeneity causes serious problems since it is often not clear how to interpret expressions properly in a communication process.

Ontologies are tools specifying the semantics of terminology systems in a well-defined and unambiguous manner [9]. Ontologies are used to improve communication either between humans or computers by specifying the semantics of the symbolic apparatus used in the communication process. It has been well-recognized that ontologies are promising to provide solutions for semantic and even pragmatic heterogeneity. Different applications and systems use different terminology systems but specify semantics using ontologies.

With the growth of the Semantic Web the specification of the semantics of terminology systems using description logic-based ontologies [10] has become popular. Since the semantics of terminologies are specified using logic-based ontologies the mappings from and to each other can often be computed automatically [11]. To enable computer programs to automatically generate transformations between different terminology systems is also the core of the dream of the Semantic Web [12].

2.4.5 Some challenges

The first challenges are the development of ontologies in the context of EAI. Because of the broad range of skills and knowledge required to create an ontology, they are generally slow and expensive to build. Researchers in the area of ontology engineering have contributed many invaluable ontology development methodologies and tools, but solutions are still needed for the bottlenecks, such as knowledge-acquisition and ontology maintenance in ontology development.

Mappings of ontologies are the second challenge. Many diverse solutions have been proposed so far for the area. There is no integrated solution that is a clear success, which is robust enough to be the basis for future development, and which is usable by non-expert users. The challenges includes: high-quality matching results, stability of performance of matching system, discovering missing background knowledge, uncertainty in ontology matching, matcher selection and self-configuration, social and collaborative ontology matching, and alignment management, among others [13].

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2.5 User experience and cross-channel design

2.5.1 Introduction

This section of the pre-study approaches the design of the office space of the future from the point of view of the behavioral patterns of use and appropriation, of its general user experience and the role that technology might play in making it better. We first introduce the concepts of user experience design, information architecture, and interaction design as the relevant fields of research and practice within the scope of the pre-study. Then we discuss the long shift from usability to user experience to cross-channel experiences. Finally, we formalize the idea of the office of the future as a blended space and give account of the major design trends in the area.

2.5.1.1 User experience design

User experience design (UXD or UX) is an umbrella definition that traditionally brings together a number of design- and business-related disciplines into an uneasy tangle where the user is the center of the design process, and technology a supporting partner.

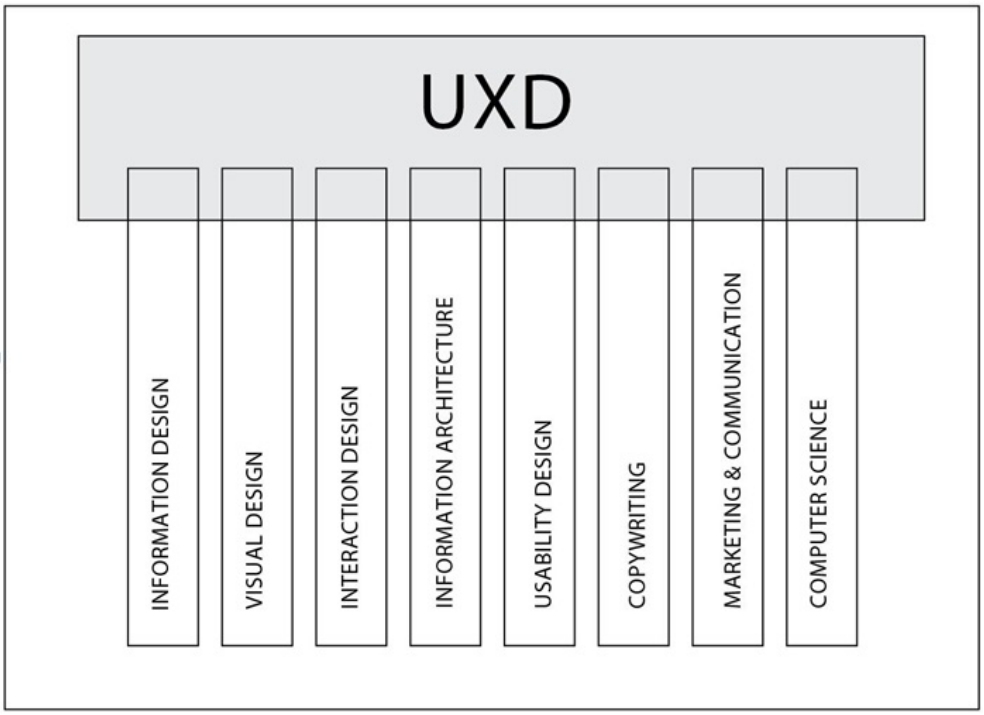

Figure 1. Peter Boersma's T-Model (Hobbs et al 2010).

As Peter Boersma explains in his T-model of UX (Hobbs et al, 2010), it is convenient to think about UXD as a horizontal area of expertise and application that is concerned with the general outcomes of a product or service in terms of user satisfaction and engagement. Below this area, partially overlapping and fully supporting it, are vertical expertise wells that span from visual design to copywriting to business intelligence, information architecture, and interaction design.

If instead of considering a skill- or role-based approach we consider how UXD as a field of practice and research emerges as the result of multiple overlapping areas of concerns that concurrently belong to one or more disciplines, Dan Saffer's own UX Diagram (Fig. 2) provides a rather complete overview.

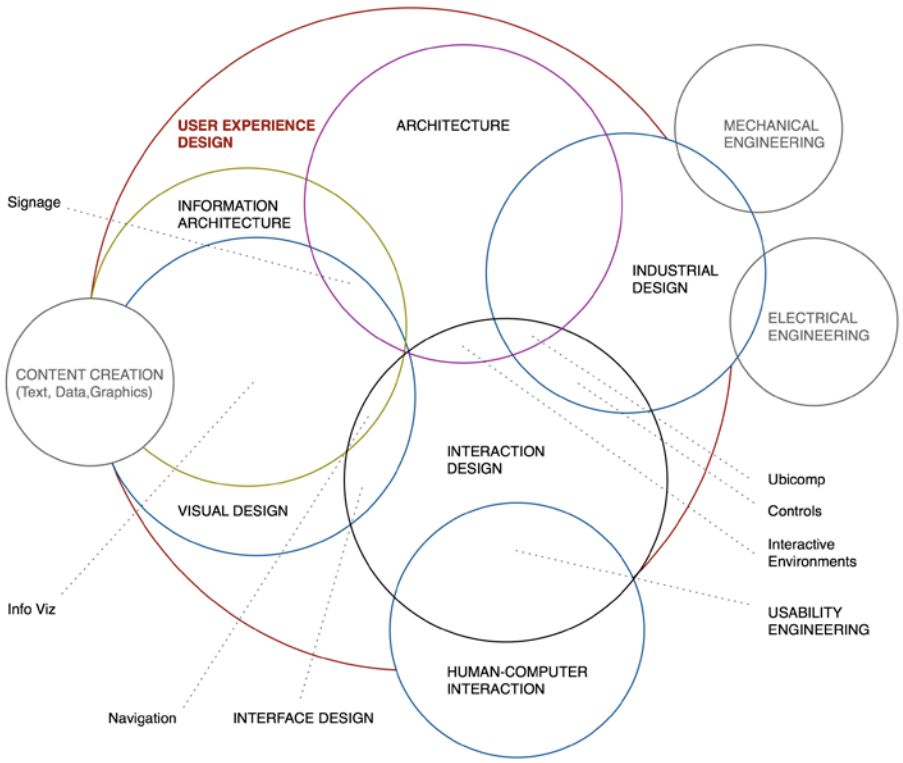

Figure 2. Dan Saffer's UX Diagram.

In this pre-study, user experience design is primarily used in accordance with Boersma and interpreted through the lenses of information architecture and interaction design, these being the two disciplines which respectively structure the conceptual framing that allows use and understanding of an information space and the point-to-point human-system or human-artifact relationships.

2.5.1.2 Information architecture

Information architecture (IA) is a professional practice and a field of studies focused on solving the basic problems of producing, maintaining, and accessing the vast amounts of information available today. The Information Architecture Institute defines IA as the practice concerned with the "structural design of shared information spaces", and while it is common to consider these information spaces vastly coinciding with either websites large and small or mobile applications, and to limit the reach of IA to discussing labels and taxonomies, a more recent expansive interpretation of IA has been

proposed that considers it to be concerned with the "structural integrity of meaning across contexts" (Arango, 2013) and with the pervasive architectures of information that connect activities across channels (Resmini & Rosati, 2011; Resmini, 2014). This latter reframing has moved IA towards the end of the continuum that gravitates close to the macro level where strategy and systems thinking are predominant.

2.5.1.3 Interaction design

Interaction design (IxD) has been around as a full-fledged discipline or field of practice for some 20 years. As a continuation of product design in the realm of software- or information-based artifacts, IxD is concerned with shaping and designing digital products with human behavior in mind, and with solving the specific problems of how human beings interact with technology. As such, IxD aims at creating solutions for both existing and anticipated future problems and is particularly concerned with point-to-point, artifact-centered issues. In respect to IA, IxD gravitates towards the opposite end of the continuum, the one closer to the micro level of punctual and precise interactions.

A large part of the foundational constructs of IxD have their roots in human-computer interaction (HCI) theory and practice: how useful and easy it is for us to use an interface or application, what type of users they are targeted at, what problems might derive from incorrect usage, and so on. Another part of its concerns, for example how enjoyable is to use a software product, how does our relationship with it change through time, are mostly related to the user experience side and harken back to the practice of design.

With the expansion of digital into everyday life, and technology not only getting personal and portable but being embedded in cars, home appliances, furniture, clothing, thus making digital interfaces one of the dominant cultural forms of our time, interaction design has too been constantly extending its area of application.

2.5.1.4 User-centered design (UCD)

User-centered design is a methodology describing a process for the design of products or services that gives the needs and wants of end-users constant attention throughout all phases of ideation and development, as opposed to traditional post-development testing. It is also an ISO standard (Human-centered design for interactive systems, ISO 9241-210, 2010) that has been extensively applied to the design of software and software-related products, and that is generally considered a necessary approach to user experience design in the praxis. Cooperative design, also participatory design or co-design and originally a Scandinavian methodology, is a type of user-centered design process that aims at involving all stakeholders of the project in the design process in order to ensure that the final artifact meets their needs.

2.5.2 From usability to user experience

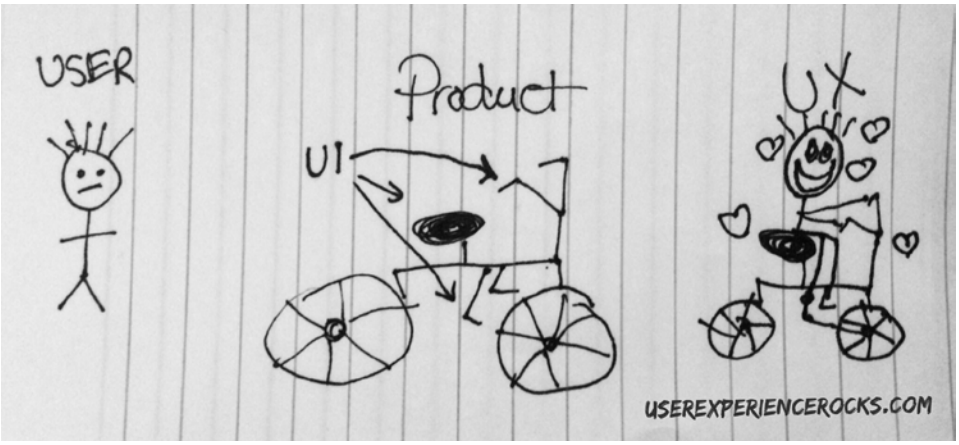

Figure 3. Jennifer Aldrich, UI vs UX. https://userexperiencerocks.wordpress.com/tag/ux-and-ui-bike/

Throughout the '80s and early '90s usability engineering has been the main control point for those who wanted to create human-friendly software. As the Internet moved from research network to mass medium, usability started to be a concern also to those who wrangled information on the World Wide Web. Not only all kinds of software applications needed to be usable, but websites too. As a natural extension of ergonomics or human factors to the world of digital interfaces and interactions, usability tends to aggregate around metrics, measurable goals, and performance. With the gradual maturation of technology, barriers have gradually moved, goals have grown in range and attention has slowly shifted towards the end of the spectrum where "satisfaction", a much more difficult indicator to measure, is prevalent. If the idea is that "great designs should be experienced and not seen" (Spool, 2009), then experience is where most of the value in use resides. Where usability is concerned with objectively measured indexes, user experience introduces an entire array of individual and hard to gauge indicators: the user's perception, emotions, behavior, physical and psychosocial responses that occur before, during, and after use.

As Jennifer Aldrich wrote on her blog (2014) and famously sketched in a doodle for her daughter (Fig. 3), the difference between the two domains can be easily explained if we think about someone who wants to ride a bike. The handlebars, the pedals, the seat, those are elements of the user interface and here usability can provide us with measurements about distances, sizes, degree of resistance, and so on. We tweak these, we get the perfect bike to ride. When we ride it, when we speed down a slope or sweat up a hill, that's the user experience. While the two are clearly connected, they are definitely not the same thing nor obey the same rules or follow the same perspectives.

2.5.2.1 Guidelines and heuristics

Through the years, many base guidelines or heuristics have been pushed forth by both academics and practitioners that establish what makes interactions good, mostly stemming from basic human-computer interaction (HCI) or usability principles, and some of them re-appropriating well-known rule

of thumbs designers have been applying to physical products for decades to the world of digital interactions. Of these, Jakob Nielsen's "10 Usability Heuristics" are probably the most famous:

Visibility of system status: The system should always keep users informed about what is going on, through appropriate feedback within reasonable time.
Match between system and the real world: The system should speak the users' language, with words, phrases and concepts familiar to the user, rather than system-oriented terms. Follow real-world conventions, making information appear in a natural and logical order.
User control and freedom: Users often choose system functions by mistake and will need a clearly marked "emergency exit" to leave the unwanted state without having to go through an extended dialogue. Support undo and redo.
Consistency and standards: Users should not have to wonder whether different words, situations, or actions mean the same thing. Follow platform conventions.
Error prevention: Even better than good error messages is a careful design which prevents a problem from occurring in the first place. Either eliminate error-prone conditions or check for them and present users with a confirmation option before they commit to the action.
Recognition rather than recall: Minimize the user's memory load by making objects, actions, and options visible. The user should not have to remember information from one part of the dialogue to another. Instructions for use of the system should be visible or easily retrievable whenever appropriate.
Flexibility and efficiency of use: Accelerators – unseen by the novice user – may often speed up the interaction for the expert user such that the system can cater to both inexperienced and experienced users. Allow users to tailor frequent actions.
Aesthetic and minimalist design: Dialogues should not contain information which is irrelevant or rarely needed. Every extra unit of information in a dialogue competes with the relevant units of information and diminishes their relative visibility.
Help users recognize, diagnose, and recover from errors: Error messages should be expressed in plain language (no codes), precisely indicate the problem, and constructively suggest a solution.
Help and documentation: Even though it is better if the system can be used without documentation, it may be necessary to provide help and documentation. Any such information should be easy to search, focused on the user's task, list concrete steps to be carried out, and not be too large. (Nielsen, 1995).

More recently, Nielsen's approach has been subject to a second repurposing meant to both simplify and better connect it to the rarefied ideas of "quality" and "experience" that are now forefront. For example, in an article on Medium titled "The Three Laws of Interaction Design" and somehow indebted to Asimov's laws of robotics, Diogenes Brito provides an interesting shorthand to old formulations. It is interesting to note how the focus has somehow moved from "software" to the "computer" itself, in an effort to circumscribe the object at one end of the interaction process. According to Brito,

1. A computer shall not harm your work or, through inaction, allow your work to come to harm.
2. A computer shall not waste your time or require you to do more work than is strictly necessary.
3. An interface should be humane; it should be responsive to human needs and considerate of human frailties (Brito 2014).

In terms of simplicity, to accomplish an action or task, the most aggravating experience you can have with a computer is losing work. Regardless of the practical consequences and the impossibility to exactly recreate bit by bit work which has been lost, the emphasis is on elements of reliability, ease of mind, and experience. Solutions aimed at solving such issues, for example through preserving selections across work sessions or introducing backups and versioning, are trying to solve behavioral problems that are not limited to the single interaction, in strict usability fashion, but that develop and progress through time. This is also the reason why a "computer" should not waste our time or requires us to do more work than is strictly necessary.

It is also noteworthy that the final law stresses "humane" characteristics in software and its being considerate towards human-side errors, misunderstandings, and plain mishandling. The more we move away from the fixed-context computing of the 80s and 90s and the more we consider the constant human-information interactions of today, the more the need to take into account whatever environmental discomfort we might find ourselves in becomes necessary. From screens that can't be read in direct sunlight to smallish buttons we can't press efficiently to the noise of the city preventing some critical notification to be heard, graceful handling of non-optimal interactions is becoming a central element of computing. More information coming our way also means plenty of possibilities for missing cues and making mistakes.

Nielsen based his work on an extensive analysis of commonly found usability problems, but it is not unusual to find formulations that descend from qualitative rather than quantitative analysis, especially as the focus shifts away from performance and ergonomics. Brito's are probably a good example in the field of interaction design, even if clearly relying on Nielsen's, and Peter Morville's honeycomb (Fig. 4) is one of the best known example in the more general field of user experience.

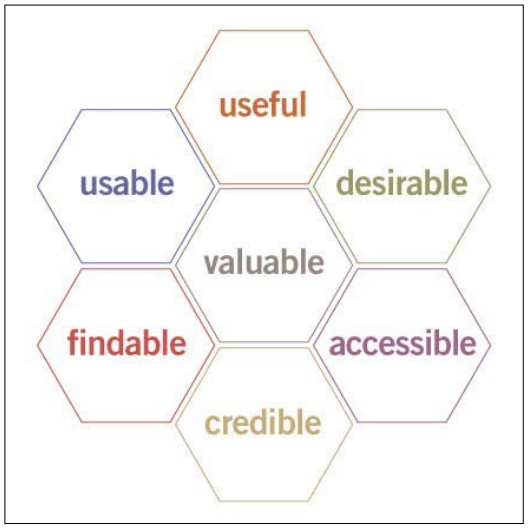

Figure 4. P. Morville's UX Honeycomb.

Morville interprets the elements of the honeycomb as facets and explains them thus:

1. Useful: As practitioners, we can't be content to paint within the lines drawn by managers. We must have the courage and creativity to ask whether our products and systems are useful, and to apply our knowledge of craft + medium to define innovative solutions that are more useful.
2. Usable: Ease of use remains vital, and yet the interface-centered methods and perspectives of human-computer interaction do not address all dimensions of web design. In short, usability is necessary but not sufficient.
3. Desirable: Our quest for efficiency must be tempered by an appreciation for the power and value of image, identity, brand, and other elements of emotional design.
4. Findable: We must strive to design navigable web sites and locatable objects, so users can find what they need.
5. Accessible: Just as our buildings have elevators and ramps, our web sites should be accessible to people with disabilities (more than 10% of the population). Today, it's good business and the ethical thing to do. Eventually, it will become the law.
6. Credible: Thanks to the Web Credibility Project (credibility.stanford.edu), we're beginning to understand the design elements that influence whether users trust and believe what we tell them.
7. Valuable: Our sites must deliver value to our sponsors. For non-profits, the user experience must advance the mission. With for-profits, it must contribute to the bottom line and improve customer satisfaction.

According to Morville, the honeycomb serves several purposes at once but first and foremost it allows advancing the conversation past the restricted goals of usability. Then, it helps people define priorities in a modular way that provides a better fit in respect to the business objectives and constraint. Is it better for a website to be desirable or accessible? Or usable? Morville sees this as a series of trade-offs that need to be made explicit and ultimately depend on a "balance of context, content and users" that is unique to any project.

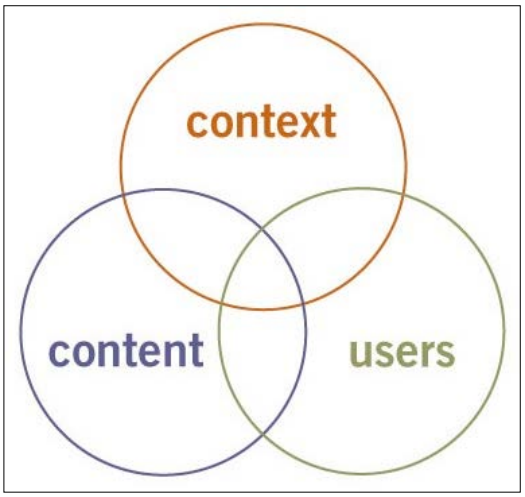

Figure 5. L. Rosenfeld & P. Morville, the 3 circles of information architecture.

That nod to context, content and users connect directly to a preceding elaboration in the field of information architecture, Rosenfeld and Morville introduced their seminal Venn diagram using context, users, and content in "Information Architecture for the World Wide Web" (1998). The circles were meant to illustrate how the design of information spaces requires balancing business goals and context, user needs and behavior, and content.
More recently, Resmini and Rosati's (2011) heuristics for pervasive information architectures are an example of a set of guidelines which have purposefully being rendered abstract and medium-agnostic and that are meant to be applied to information spaces regardless of the way they are effectively rendered through physical or digital: no mention of software, buttons, websites, computers or interfaces is made here.

Place-making: the capability of a pervasive information architecture to help users reduce disorientation, build a sense of place, and increase legibility and way-finding across digital, physical, and cross- channel environments.
Consistency: the capability of a pervasive information architecture to suit the purposes, the contexts, and the people it is designed for (internal consistency) and to maintain the same logic along different media, environments, and times in which it acts (external consistency).

Resilience: the capability of a pervasive information architecture to shape and adapt itself to specific users, needs, and seeking strategies.

Reduction: the capability of a pervasive information architecture to manage large information sets and minimize the stress and frustration associated with choosing from an ever-growing set of information sources, services, and goods.

Correlation: the capability of a pervasive information architecture to suggest relevant connections among pieces of information, services, and goods to help users achieve explicit goals or stimulate latent needs.

Resmini and Rosati consider place-making, consistency and resilience to be grounding heuristics, providing constraints and anchoring points, and reduction and correlation as contrasting processes bringing purposefulness, complexity, and depth.

2.5.3 Cross-channel user experiences

The reason the 5 heuristics for pervasive information architectures are medium-aspecific is that we live in a post-digital world, a world where mainstream access to portable technology and mobile connectivity is creating a new blend that mixes physical spaces with digital constructs. This is the world Negroponte prefigured in his 1998 Wired "Beyond digital" article, a world where digital, "like air and water", is "noticed only by its absence, not its presence" and is the "commercial and cultural compost for new ideas" (Negroponte, 1998).

In this post-digital world, information has moved out of the limited bidimensionality of the screen and into physical space, where it is becoming a pervasive layer we remediate constantly and whose architectures silently create new social and cultural affordances, or remodel and discard old ones.

This shift is changing everything we do. Our perception of the city has been thoroughly transformed by the possibility to instantly access way-finding information on the go via Google Maps. Google Maps and similar technologies have in turn enabled a number of other applications to use geolocation, geographical data and socially-constructed content to give us information on the nearest and best restaurants, or on whether the bus or train is running on time. Our jobs have been profoundly reshaped by instant and mobile access to not only mail, but instant messaging, teleconferencing, and asynchronous collaboration through a number of personal devices that are quickly becoming an integral part of our work routines, in and out of the office or workplace.

Information is also being thoroughly embedded in physical space through ambient appliances, sensors and actuators, or personal devices, augmenting our in-place experience, providing us with cyborg-like forecasting or planning abilities, and adding a variety of in-context individual and social capabilities that run the gamut from the banal to the sublime, from the socially necessary to the commercially superfluous.

Education, healthcare, the practice of governance, and the way we work: all are being transformed. The subtle but momentous change is here clear: we used to consider the Web (and digital) a different, separated world, an elsewhere we could (or should) visit by sitting in front of a computer, an infinite library we could browse through. When we were done, we'd exit the Web, and return to the "real" world. Technology made the desktop computer our interface of choice to access information, with a dedicated place in the house, the office, and the school, and computing was a bounded

activity, both in space and time. Not so today, when "things are increasingly smeared across multiple sites and moments in complex and often indeterminate ways" (Mitchell, 2003).

In the imaginative parlance of science fiction and cyberpunk literature, we pictured our immersion in a world of data and information into the idea of "jacking in" to some digital 3D world. With the possible exception of videogames, it has not simply played out this way in the mainstream: both Microsoft Bob and Second Life have simply failed to capture a sustainable mindshare and market.

In its place, we have "a layer tightly integrated into the world around us" (Institute for the Future, 2009). Information is becoming pervasive, and banal. It's there, producing its effects, extending and reinforcing our focus rather than taking us somewhere else. As Steven Jenkins recently wrote in an op piece for The Guardian (2013), "(p)ost-digital is not anti-digital. It extends digital into the beyond. The web becomes not a destination in itself but a route map to somewhere real".

We are swinging back to the real world, but we are bringing the computers along, and they are restless, smaller, faster, connected: we have created an unexpected, layered and uneven but very real version of what we believed "cyberspace" ought to be. Rather than via cortex-level implants or through sophisticated cyborg apparatuses, people in the 2010s can access "cyberspace" anytime and for any purpose from the privacy of their homes, from the office, a mountain top, and amidst the confusion of airports, bus stations, and crowded streets. And this is done with affordable, run-of-the-mill consumer electronics or ambient devices tapping into the global information network.

Being mobile by itself is not the revolution: it is rather the enabling layer that makes the revolution possible and provides new niches of opportunity. The revolution is in what constant, mobile access to connected and manipulable information allows us to do: how it allows what is digital to modify our use and perception of physical space (Dourish, 2004); how it simultaneously turns distances into semantics (Höök et al, 2003) and reinforces the very idea of being in-context through the use of geolocation and map-based, visual approaches; how it turns passive receivers into wranglers constantly weaving new subjective narratives (Sterling, 2005) in information space.

This is the result of a series of complex socio-technical changes and phenomena of which the most visible and discussed is by far convergence (Jenkins, 2006). Convergence mostly considers the changes happening in the production and consumption of content or information when audiences are treated with narratives that structure their arcs across many different media. Canonical examples of convergence are the Wachowski siblings' Matrix trilogy, whose story arc can only be reconstructed in its totality by experiencing not only the movies themselves, but also the companion videogames, comics, and animated shorts, or the TV-series "Lost", in which elements in the developing plot line were driven by conversations happening on fan-hosted forums where the screenwriters were occasional guests.

Convergence is also connected to a larger cultural shift that has taken us from postmodernism to digimodernism (Kirby, 2009): between the late 90s and the early noughties, "the emergence of new technologies re-structured, violently and forever, the nature of the author, the reader and the text, and the relationships between them" (Kirby, 2009). Postmodernist narrative, which had its primary expression throughout the second half of the 20th century, is author-centered, over-conscious, attentive to intertextuality, prone to pastiches (of styles, times, genres) and overloaded with a sense of self, history, irony, and detachment.

Figure 6. (C. Moore, Piazza d'Italia, New Orleans. Photo: T. Brown, CC 2.0, https://www.flickr.com/photos/atelier_flir/15105496901).

On the other hand, digimodernism (also called pseudo-modernism) "fetishes the recipient of the text to the degree that they become a partial or whole author of it" (Kirby, 2012). If movies such as Quentin Tarantino's "Pulp Fiction" are the epitome of the cultural remix of high and low culture tropes typical of postmodernism, digimodernism is best represented by the deluge of reality TV shows and their cultural derivatives. They express both the rapidly decreasing centrality assigned to the Author and the "visceral, raw, uncut, first-person immersions within what appears to be, legitimately or because of careful directing and editing, the unfolding stream of events" (Resmini, 2013). In this light, postmodernism is irremediably an old media phenomenon concerned with books, films, music, and the television screen. It fundamentally addresses culture as a "spectacle before which the individual (sits) powerless" (Kirby, 2012).

It is easy to see that Twitter, Facebook, Instagram, Path, and any digitally-mediated service that relies on user co-production have no place within the framing of postmodernism. Digimodernist artifacts, on the other hand, "cannot and do not exist unless the individual intervenes physically in them" (Kirby, 2012).

This reformulation rests on a new and different socio-technical landscape that is the consequence of technological circumstances, such as the general availability of broadband and mobile broadband in most of the world (Lomas, 2012; ComScoreData, 2012); economic circumstances, such as the creation of ubiquitous service ecosystems (Norman, 2009; Resmini & Lacerda, 2014) and in the transfer of much control into the hands of consumers-producers (Jenkins, 2006; Kirby, 2012; Resmini & Lacerda, 2014); and social circumstances, as people adopt, use and transform these systems

(Shirky, 2008) and their meanings to serve emergent goals and objectives, thus reinforcing the mechanism (Sterling, 2005).

This blending of physical and digital that results from information ubiquitously seeping into everyday activities is "chang(ing) a fundamental part of our existence: the lenses through which we view and interact with the world", from the most trivial, such as figuring out if a certain local store is open or not, to the ones running deepest, such as how we perceive and think of ourselves.

Information, digitally-mediated, dynamically-updated information, is being embedded into the real world: as a result, our social and cultural practices, our working, traveling, shopping, chatting, or interacting with larger systems such as education or healthcare, increasingly happen in the blended spaces of cross-channel experiences.

2.5.3.1 Cross-channel ecosystems

Originally a marketing term, cross-channel initially identified a modality of service delivery where "a single campaign" was driven "with a consistent message that is coordinated across channels". It was then introduced to information architecture, user experience and service design (Resmini & Rosati, 2011; McMullin & Starmer, 2010) to describe the changes occurring in the design practice in connection with the mass penetration of portable devices, the general availability of mobile broadband, and the expansion of social media patterns into all sorts of digitally-enhanced blended spaces. In its current use, cross-channel introduces a systemic angle to the design of information systems and identifies operative, actionable scaffolding for the co-production and remediation of information, content, and experiences.

A system consists of an interconnected set of elements coherently organized in a structure that produces a characteristic set of behaviors and, through those, its function or purpose (Meadows 2008). In cross-channel user experiences, the primary elements of an ecosystem are channels, goals, and actors. The relationships between these elements are an integral part of the structure of the ecosystem.

Actors bind channels into systems in the pursuit of strategic goals, for example by placing together IMDB reviews, public transportation timetables and seats availability at the cinema to go see a movie. Because of the individual and contextual nature of the process, the boundaries around any such systems are arbitrary: some actors might use a mobile app to book seats while others might prefer to buy their tickets at automated kiosks on site, maybe before dining out.

A cross-channel ecosystem can then be formally defined as "an ecosystem resulting from actor-driven choice, use, and coupling of channels, either belonging to the same or to different systems, within the context of the strategic goals and desired future states actors intend to explicitly or implicitly achieve" (Resmini & Lacerda, 2014).

Within this formulation, a channel identifies a pervasive layer for the transmission of information within a service or product ecosystem. For example, kiosks for booking seats at the local cinemas, or signage on the streets of a city. Individual elements of a channel configure touchpoints. In the examples given above, either the individual kiosk points or the individual signs placed at different locations.

Channels and touchpoints can be configured physically (as in the case of signage or kiosks), digitally (as in the case of a mobile app for booking seats at the movies), or biologically (as in the case of cashiers or traffic assistants).

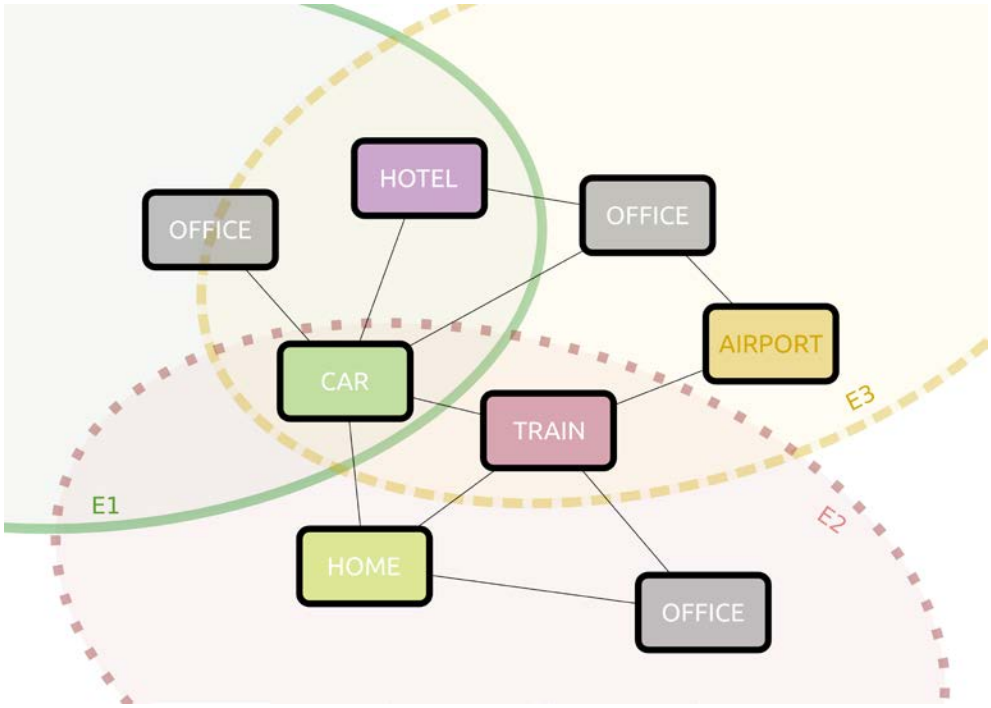

Figure 7. Individual cross-channel ecosystems for "watching a movie" overlapping.

The resulting cross-channel, information-based ecosystem is emergent, free-flowing, and repeatable. The way these pieces are assembled is entirely unpredictable at the beginning, as every actor will act differently. But as these steps that combine products and services, often from different producers and providers, are either mediated by technology or supported by a service process, they are trackable and traceable.

This is why our focus has moved necessarily away from the single artifact, the isolated object of serialized production, to consider the product or service ecosystem (Resmini & Rosati, 2011).

2.5.3.2 From products to services

Personal devices, sensors, actuators, urban appliances, and actor intervention blend individual artifacts into complex ecosystems we access through multiple devices and across multiple contexts in unstable, emergent, individual choreographies.

More and more of what we routinely do every day as part of our jobs or as sociable individuals requires us to move between different media, channels, and environments, with no particular distinction between what is physical and what is digital. We still visit websites, but we also use mobile applications, interact with intelligent devices, and connect with people through a variety of computer-mediated technologies. And we move on and off: as Don Norman explained (2009), any product is

"all about the experience. It is about discovery, purchase, anticipation, opening the package, the very first usage. It is also about continued usage, learning, the need for assistance, updating, maintenance, supplies, and eventual renewal in the form of disposal or exchange." It is the store, a website, an app, updates or reminders via text messages. It is the way we use it, connect it, or get more services online.

Watching a movie might involve a quick look at the local newspaper or website, scouting for reviews on the IMBD app, texting friends to agree on a time and place, buying tickets online and then concluding the experience at the cinema. Or an unexpected obstacle or change of mind could easily turn this into a visit to a local DVD / Blueray rental or to Netflix, and swap the cinema with the living room (Fig. 7).

As spending patterns and interest move from products to services to ecosystems to experiences, focus moves away from technology as a goal to consider technology as a means to personal contact and human-to-human information exchanges: again, "(p)ost-digital is not pre-techno but exploits technology for a civilizing purpose, human congregation and intercourse" (Jenkins, 2013).

2.5.3.3 Characteristics of cross-channel ecosystems

Cross-channel ecosystems usually, if not necessarily, configure a blended space of actions (Benyon, 2012) that straddles across digital and physical spaces.

In the context of the office or the workplace, a possible cross-channel ecosystem could be the result of having to work with a client on the delivery of a revised version of blueprints for a house. Documents, in both paper and digital format, sketches that need digitizing, catalogs, photos, a meeting room, contacts over email and telephone, a calendar, interactions with colleagues and other external actors, the meeting room and ambient and personal computing devices: all or a selection of these are used in order to arrange a meeting, have a meeting, discuss the design, record the decisions, store the new design, and push it along to completion. Some of these activities will take place in the office, some on location, and others through channels which make physical location unimportant, such as mail, the Web, or teleconferencing. Still, they are part of "getting the design done".

As such, the notion of visible seams (Chalmers et al, 2004) between channels, that is, identifiable demarcations helping clarify that a certain part of an experience belongs to a given channel and service or product and not another, is a primary component requiring attention and careful design. Well-crafted seams between the channels work as navigational and experiential aid for actors in the system, and act as place-making indicators. In respect to the traditional silos of multichannel organizational, cross-channel ecosystems introduce:

- a broader and more fitting framing for product and service ecosystems within the current socio-technological climate;
- a more operative, actionable ecosystem set up for participation. Cross-channel is about the co-production and remediation of services rather than simple consumption;
- a change in the degree of freedom that actors enjoy in their use of and navigation across channels within the ecosystem, as actors in a cross-channel ecosystem move from an

appliance to a human agent to a physical store and back at will, in accordance with their needs and wants.

This third point is directly related to how thinking how technology can empower the workplace of the future implies a rethinking of the very idea of the office as a space of action. Cross-channel constructs are eminently systemic and emergent in nature; require a holistic approach, and attention moves to process-oriented, dynamic solutions. Any workplace cross-channel ecosystems instantiates a conversation for action that happens in the blended space that straddles the physical space of the office and its many digital layers, and that connects actors. Mobility, personal portable devices, the constant access to information make in turn both the physical and digital components of the office much fuzzier constructs than they were twenty years ago.

2.5.4 Office space as an interface

In the process of creating any kind of product or service it can be tempting to begin by focusing on the details of the design that are most familiar and can be handled most easily. With digitally-mediated activities, this usually leads to designing up from what a certain technology allows or what a certain platform suggests could be done, laying out an interface, promoting or discarding certain types of interactions, say speech, even before the problem space is clearly understood.

In the case of the office workplace, such an approach may result not only to be terribly short-sighted, producing uneven results because of its inherent lack of user-centered-ness and favor or immediate feasibility, but also in the simple substitution of behavior- of activity-related issues with technology-related problems.

Consider how unpredictably any office workflow, such as for example the chain of events that leads from an email received to a design delivered in our previous example, configures a series of complex activities carried out across channels in blended space, that might involve any number of players within or outside the boundaries of the firm. Their duration is also part of the picture: an activity lasting fifteen minutes is different from one lasting a year.

Articulating the problem space first allows then time to think about the “what” and “why” before the “how” has a place at the table, and hence to understand and conceptualize the desired future user experience and the way it will be supported. In such a process, an information architecture is laid out that structures the information flows of the system or ecosystem and the possible behavioral patterns of the actors first, and then individual touchpoints are designed or redesigned to contribute and support the experience through careful interaction design.

A rather well-known formalization to characterize the different ways human-computer interactions can be modeled is presented by Rogers, Sharp and Preece in their book (2011). It relies on the conceptualization of any exchange in accordance with one of four types, instructing, conversing, manipulation, and exploring, and as it precedes implementation, it allows to weigh the potential trade-offs of different approaches, from gestures to voice control to traditional WIMP (Windows, Icons, Menus, Pointers), longitudinally, with little to no consideration for the underlying technology in the early stages.

Instructing is any type of interactions where actors issue instructions to a system. This includes typing in commands, selecting options from menus in a windows environment or on a multi-touch screen, speaking commands aloud, pressing buttons, or using combinations of keys.

Conversing is any type of interaction where users have a dialog with a system. Conversations happen via any interface, for example users might type a question, to which the system replies via visual, aural, or ambient output, including speech.

Manipulating refers to interactions where actors interact with objects in a virtual or physical space by manipulating them, by opening, holding, closing, or placing. It relies on their familiarity with similar (or the same) objects. Gesture interfaces are now mature enough to be usually considered as belonging to manipulation.

Exploring happens when users interact by moving through a virtual environment or physical space, such as a 3D world in a videogame or a sensor-augmented environment in physical space (Rogers et al, 2011).

As relevant as this model still is, the one problem it clearly illustrates is that it does not take into account both the systemic nature of cross-channel user experiences nor the typical touchpoint nomadism they support. A different approach is needed for these.

In a workshop held at the CHI 2013 conference in Paris, Jetter, Benyon and others (2013) approached the design of interactions in physical environments considering how technology can now be used "to blend the power of digital computing with natural work practices and collaboration styles". In their view, this would allow to "combine the virtues of physical and digital artifacts so that desired properties of each are preserved and computing is integrated in a considered manner" (Jetter et al, 2013).

Their starting point is that traditional WIMP or post-WIMP approaches are inappropriate for systems with which we interact in a variety of ways, some of them entirely through our behavior. Think for example of a mobile phone set up to switch to voice control mode when connected to a specific car's Bluetooth system.

At the workshop, Jetter and colleagues suggested using Reality-based Interaction (RBI) as a starting point (Jacob et al, 2008). RBI interfacing builds on "users' pre-existing knowledge of the everyday, non- digital world and use good tradeoffs between the power of the digital world and our familiarity with the real world" (Jetter et al, 2013). For example, an RBI interface may make normal surfaces clickable to achieve goals, mapping a usual hyperlinking function we recognize as familiar through our use of the Web to a physical location, thus creating a blended space of action. Or they might allow to interact with information objects via a physical proxy, such as moving mail from an inbox to an "urgent" folder by repositioning tokens on a desk. This approach would allow to take away some of the cognitive load associated with using technology, "so that we are freed to use computers without thinking and to focus beyond them on new goals" (Jetter et al, 2013).

In the context of workplace or office usage, this means turning technology transparent, so that cross-channel activities carried out day in and day out disappear into behavior that is mutated from, or built upon, well-known affordances from everyday life.

2.5.5 Office space as blended space

RBI alone might not be sufficient, though. Jetter and colleagues highlight how such an approach requires the conceptualization of the space being designed as a blended space. In semiotics, blending is a creative process that we employ to bring together concepts from different spaces so that we can create a new one that has its own emergent properties.

Figure 8. Microsoft, Project HoloLens.

As such, a blended space is a space where "physical space is deliberately integrated in a close-knit way with (a) digital space" (Benyon, 2014). Physical and digital here are completely coupled, and people can feel they are present in a blended space and can act directly on its structure and content. RBI helps by allowing people to repurpose their mental models as-is, but this mapping process should not be misinterpreted to be a simple transposition. In a recent video Microsoft published for their Project HoloLens (2015) we see a number of people interacting with holographic projections in physical space thanks to a special visor. We watch a young woman replacing plumbing thanks to animated digital RBI instructions that are timed to her actions and superimposed on the parts she has to fix, telling her to tighten, loose, or move, and then we see someone grabbing a holographic spraycan to paint a holographic spaceship.

While the idea of mimicking the act of spraying itself can be said to be in line with the general RBI framework, the actual holographic spraycan in Fig. 8 is an unnecessary skeumorphism (Payne, 2013) that introduces a barrier between the action being performed and the goal, and that reintroduces that focus on the act of computing itself that we should steer away from in a well-designed blended space (Jetter et al, 2013).

Furthermore, from an actor's perspective this blended space of action coincides with the space of the ecosystem being instantiated, and its structural consistency depends not on only on the punctual interactions we have with a switch or a wall or an application, but on the mapping out of a personal and meaningful pervasive information architecture that allows such an ecosystem to exist in the first place.

2.5.6 Current trends in office space

In his book "Digital Places" (2000), Thomas A. Horan introduces the idea that interweaving of digital technology and physical spaces is creating new structures for us to inhabit, that he calls "digital places" and that we identify in this study as the blended spaces of cross-channel ecosystems. According to Horan these are not "stable end-states, but dynamic settings that evolve over time" emerging along a continuum of technological integration. At one end of the continuum, we have "unplugged" places that "manifest little or no digital technology in their appearance and construction". Towards the middle we can find a number of different "adaptive" designs, those that visibly introduce digital into physical space. At the other end of the continuum lie "transformative" places: "room, buildings and communities composed of truly interfaced physical and electronic spaces".

Unplugged places are still the majority: cafes, buildings, public spaces, they have been built with activities in mind that require no digital layering. Still, many places have been undergoing subtle alterations to make them incorporate some level of technology: a classroom or office is renovated to accommodate personal computers, for example. When this happens, a process is set in motion that alters the complex choreographies that connect human space and human activities. Maybe because of the way computers are lined up, the teacher will change the way she interacts with children. Children themselves start to peek at what others are doing.

Slowly but steadily, "the introduction of digital technology into the physical environment (…) calls for a more fundamental rethinking of the activities" conducted in those specific settings. In the end, places become transformative, organized around the demands and changed affordances of a new type of blended space where information systems are comprehensively integrated from the beginning into the process that generates the workflows, layout and structure of the place itself.

In the Seattle-based "Office of the Future" project (Horan, 2010), office space has been completely reconstructed to offer "innovative 'commons' areas for informal collaboration, as well as flexible space for 'heads down' work, all united by an integrated suite of (…) communications, computational, and display technologies".

From the perspective of this pre-study, the workspace of the office of the future configures a transformative space in terms of integration and a blended space in terms of architecture and interactions, a space where technology is calm, invisible technology that supports the instantiation of personal but shareable work-related cross-channel ecosystems that do not stop at the physical boundaries of the "office" and the slow dissolution of interfaces into behavior.

This transformative space will process information differently, use it differently for different uses than we have today, and promote different mental models, affordances, and activities.

Computing will move, as the institute for the future put it in their 2009 white paper "Blended reality", "from just-in-time to proactive contextual computing", with distributed processes moving

> *from time-consuming foreground computing to ambient, proactive, contextual computing. This means that our smart, wearable systems will negotiate with embedded sensor networks and pervasive information to process patterns of our activities, patterns of places where we work, and perform tasks on our behalf.*

Because of the sheer amount of data available for this proactive computing, we will leave behind "sparsely sourced analysis" and embrace "deeply informed decisions":

> *our most important decision-making and planning practices will change substantially. Using more powerful combined-knowledge processing applications for data mining, semantic analysis, numeric analysis, pattern processing, visualization, and simulation, we are moving from making decisions based on shallow analysis and thin resource processing to deeply informed decisions and plans (IftF, 2009).*

In turn, these changes in the way we process and use information will also drive changes in the way we organize work, with formal structures losing ground in favor of "emergent and cooperative organizational structures":

> *new cooperation technologies, including social software and peer-to-peer architecture, will enable us to move from working in small co-located and formally aligned clusters of enterprise workgroups to larger, loosely coupled, ad hoc networks of mobile colleagues. In this new structure, we will work virtually in distributed teams cooperating on specific tasks and projects together in real time. Upon task completion, these teams will dissolve and reform in new arrangements based on the next task (IftF, 2009).*

Finally, and most importantly, the basic premise of cross-channel ecosystems, their spanning different services while not being tied to any specific single physical location, will turn our "desk-bound" activities to "ubiquitous", allowing us to display and use information to accomplish whatever tasks we have at hand regardless of where we are located:

> *we are growing closer to a world where interaction with displays will be seamless and ubiquitous. As we move through our workspaces, our mobile personal information artifacts will be capable of seamlessly projecting a personal, common digital workspace on nearby ambient displays, on desktops, in meeting rooms and public spaces, on wearable displays, and on dash-board screens (IftF, 2009).*

This will be accomplished through both repurposed and new and different technology, and the official absorption of personal devices into the workplace. Offices used to give us computers, and they were usually high-end devices, much better than anything we could buy for our own private delight. Today, we have better computing devices at home. As a consequence, much that was personal has become hybrid in nature, and is used for both leisure and professional use.
Devices are brought into the workplace from home in what has been called the Bring Your Own Device (BYOD) phenomenon. Smartphones, tablets, laptops, they have all become BYOD tools that belong to both the workspace and hour homes. Currently, the majority of the professional workforce uses 2 or 3 personal devices for both work and leisure in their daily lives. More than half of this workforce considers they are accessible for work 24 hours a day, 7 days a week, and three in 10 are

accessible by both email and phone, with asynchronous communication increasingly supplanting direct and synchronous. In the year 2020, connected personal devices will be an even more important part of how we perform daily work duties (Meister, 2014).

Together with personal devices, wearable devices will be a relevant, even more symbiotic element. Augmented reality glasses such as Google Glass or Microsoft HoloLens are already widely known, and raising issues in concerns to the way they could potentially alter human activity just because of their presence. If or how these devices will be used in the workplace, either playing a supportive role for specific functions or becoming a full-fledged alternative computing center to smartphones, will be one of the areas that need investigation.

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2.6 Transparent intelligence

2.6.1 Introduction

Transparent intelligence is a quite wide concept which virtually includes all thinkable functions on transparent surfaces ranging from colored glass used as protection from the sun to invisible interactive interfaces. As for usage in the office of the future functions like various sun blocking techniques and energy saving windows are peripheral, although the coatings used in such applications are related to more high-tech ones. In modern architecture glass and other transparent material are used extensively, and the possibilities of using such surfaces for additional functions are endless. This document reviews interior design and information sharing aspects relevant to office environments.

2.6.2 Architecture and indoor environment

Possibilities for adjustable transparency can be achieved by privacy laminates. They consist of a polymer film containing particles that scatter the light, but can be re-oriented to let directed light through by switching on a power supply. Privacy by a laminate makes the glass translucent rather than opaque. This means that outdoor light for instance, may pass through the glass to illuminate the room even though one can not see what is behind the glass. (1)

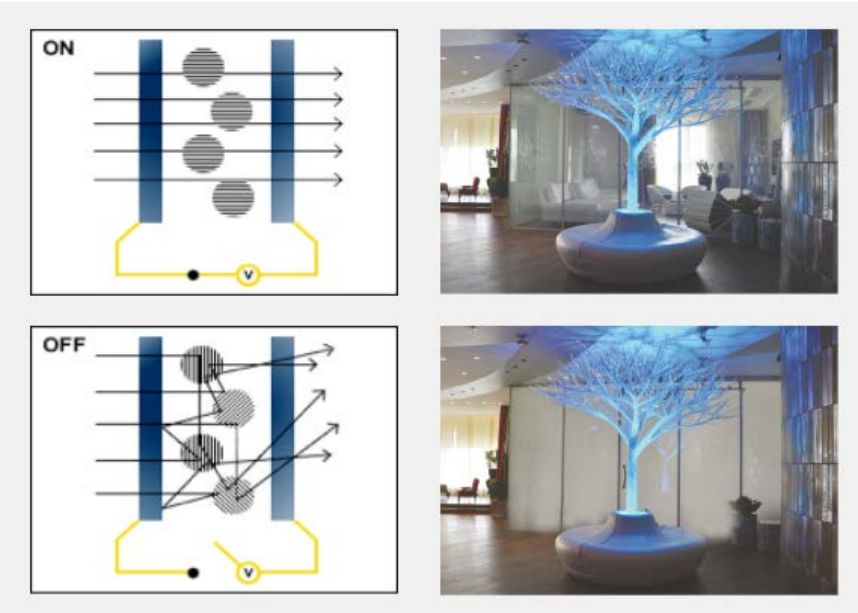

Figure 1. The function of privacy smart glass (1).

Transparent surfaces can be utilized as illuminators if LED (Light Emitting Diode) units are incorporated between glasses. Either as small luminous spots, that are not transparent but separated

to keep the overall transparency of the surface, or as transparent OLEDs (Organic Light Emitting Diode) which enables for transparent illuminating surfaces. Combined with solar cells, which can also be made transparent, the diodes used can be self-supporting for some time. An example of this is the GreenPix building in Beijing, where solar cells laminated between glasses during daytime store enough energy to make the façade a gigantic color display by night. (2) (3) (4)

Figure 2. The GreenPix building in Beijing. Energy is stored during the day and used to illuminate the façade at night (4).

Electrochrome glasses are glasses that can change color "by the flick of a switch", i.e. with an electrical current. The coloration is achieved by oxidation/reduction of either a laminated layer or a sputtered coating that can change between a transparent and a colored state, typically blue. They are typically used in façades and cars, but could be fitted in interior applications like partition walls as well. (5) (6)

The acoustic environment in an office becomes increasingly important when more and more transparent solutions are used. To be able to reduce sound although an office seem more open is vital both for confidentiality reasons but also for the working environment and personal integrity. There are special sound reducing laminates for glass and also transparent solutions that resembles perforated sound absorbers that is normally found in ceilings and walls. (7)

Figure 3. Transparent sound absorbing screen (7).

In some cases animated transparency is of interest, to give an illusion of windows for example, to raise the level of comfort in conference rooms. Techniques with displays and cameras that project a real time image of the outside is used in aircraft and automotive applications, but could be introduced in office environments as well. (8) (9)

2.6.3 Sharing information

Transparent displays allow for windows or other transparent surfaces to act as communication channels and are available through a few different techniques. The display itself is made transparent by choosing transparent materials for substrates and electrodes in the LCD (Liquid Crystal Display) and OLED (Organic Light Emitting Diode) based cases. LCD devices need backlighting and are therefore somewhat limited in see-through displays. Used as windows, LCD displays require quite strong light on the outside (or backside) to function. OLEDs emit their own light and can thus be used in dark environments. If applied on flexible substrates, OLEDs can be bent. (10) For electroluminescent displays a transparent thin film applied directly to a transparent substrate is used. (11)

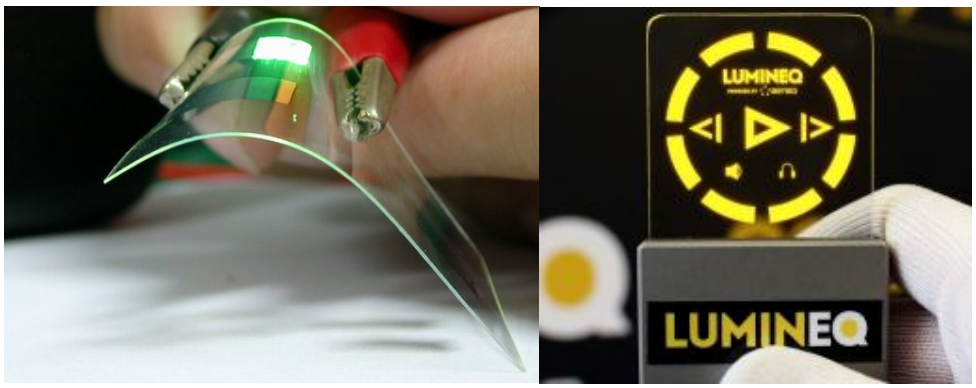

Figure 4. Left: Flexible OLED (10). Right: Transparent Lumineq® electroluminescent display by Beneq (11).

Touch devices are now in every person's hand and it has become natural to share information through touch-enabled hardware. The touch function may be handled in quite a few ways, including resistive or capacitive recognition or detection of disturbances in light in or on a transparent material. There are large multi touch panels, which allows for simultaneous co-working with high precision. In addition to the touch function, gesture recognition may be integrated in the displays. (12) In education environments smartboards, which allows for sharing of notes and lecture material, has been used for some ten years as a support for teachers and students. (13)

Figure 5. Smartboard used for educational purposes (13).

Not just advanced smart electronic devices like phones and tablets are connected to the internet anymore. More and more devices are connected to internet without direct human monitoring. The Internet of Things allows for sharing of extreme amounts of information between machines and devices, which could be used for anything from environmental monitoring to smart shopping systems that provide customers with special offers depending on their shopping habits. Different types of sensors and/or memory units are used to gather data, and to be able to connect almost anything these must be small and cheap. An example is printed electronics on polymer substrates that can be used as disposables for monitoring goods during freight or storage. (14)

Devices that enables for augmented reality, where the user is provided with more information than what can normally be seen are finding their way to the market. These can be found both as wearables and in automotive applications. Typically transparent displays are used together with invisible user interfaces to achieve an additional information layer on reality. (15)

2.6.4 Future outlook

A requirement for an effective sharing of information is connectivity. Energy saving windows has been a problem especially for mobile units (phones and tablets), but the same window that causes this problem may be used for the solution if a transparent antenna is integrated in it. Transparent WiFi-enhancing antenna windows have been developed and work on mobile phone coverage antennas is ongoing. (16)

New transparent materials that can act as luminescent solar concentrators are being developed. Together with solar cells they can enable for some charging of mobile devices etc. (17)
As for the future it can be expected that the use of existing surfaces is broadened by integrating different functions to windows, tables, cars and so on. To get a seamless connectivity is crucial for the level of automation and information sharing that the future may hold. Scenarios like in the Youtube video “A day made of glass” by Corning (18), which describes a super connected, intuitive and interactive glass related environment, or the movie Total Recall, where the main character has to ‘Find a glass’ (any glass surface) to receive information are not that far away.

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3 Case study

In order to progress towards the office of the future it is essential to know from which position one starts. Hence, it is necessary to create a baseline of how current offices function on an architectural level (I.e. the layout of an office), what type of IT-systems are used, how the information flows look like, how collaboration take place, etc. One important activity in the pre-study has therefore been to collect some of these pieces of information through the participants of this project, namely Länsstyrelsen in Kalmar and Pdb in Jönköping. The following subsections describe how the information was collected through the use of semi-structured interviews followed by the results or findings that came out of these interviews. The interviews have been divided in two parts, one focusing on the technological aspects of an office and the other on the design aspects. The interviewees have been office workers at Länsstyrelsen in Kalmar and Pdb in Jönköping.

3.1 Technical aspects

3.1.1 Länsstyrelsen in Kalmar and Pdb

We carried out a study on the use of ICT in local companies. The purpose of the study is to gain in-depth information and understanding of the use of ICT in the workplaces. The objective includes,

- identifying the uses of ICT in workplaces
- understanding how ICT meets users' needs in workplaces
- understanding the effects of usage of ICT in workplaces
- identifying key issues in the usage of ICT in workplaces

Study Methodology

We conducted interviews for the study purpose. Interview is a qualitative research method. It suits for this study because it is the most appropriate method to explore an area where issues are not yet well understood or properly identified, particularly at 'real-life' context. We employed "semi-structured" interviews in this study. It involves a number of open-ended questions defining the area topics under investigation. The open-ended questions prepared for this study can be found in Appendix A and B. Other questions will emerge during the dialogue between interviewer and interviewee, in order to gain insights into peoples' opinions, feelings and experiences of the usage of ICT in their workplaces.

Samples in qualitative research are usually purposive. Participants are selected because they are likely to generate useful data for the project. In this study, seven interviewees are from our project partners, *Pdb* and *Länsstyrelsen in Kalmar*. They were suggested by the stakeholders. They represent a cross section of workers in the companies, such as level of job and sector of employment. Participants include administrative worker, knowledge workers in different sectors, managers and a CEO, who work in an office some or all of the time. The information about the participants is given in Figure 1.

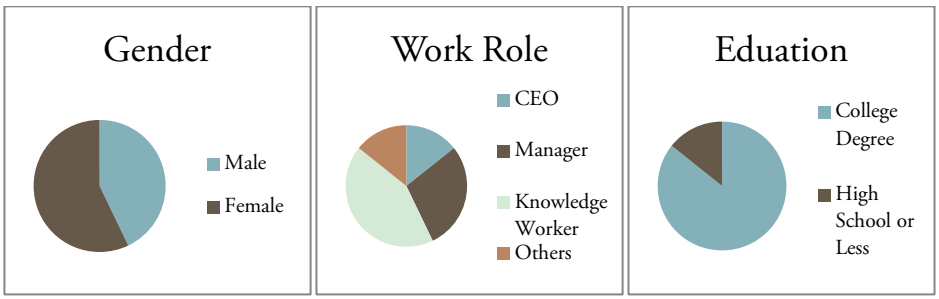

Figure 1. The information of the interview participants.

Interview Data Analysis

Interview generates words (locate in tape recordings, transcriptions of the tape recordings, and interview notes), rather than numbers, for analysis. The first step is to make these data as abstract as possible. The common method is to look across all the data to identify the common issues that recur, and identify the main themes that summarize all the collected data. We defined the four themes after looking in detail at the data,

- Business (work) processes: a collection of related, structured activities or tasks that produce a specific service or product to serve a particular goal.
- Roles (responsibilities): the problems and the details of what happens when they perform their tasks or activities.
- Data sources: the data (in any format) is required to perform tasks or activities.
- Technology: the ICT is used to perform tasks or activities.

In order to better understand the themes and the correlations between them, Business Process Model Notation (BPMN) is used. BPMN enables that business processes are represented in a graphical model, so that they are readily understandable by different users. To ease the analysis of interview data, a BPMN model is built for each business process. Working roles of people in a business process, required data sources and the use of ICT in the business process all are represented in its model. Figure 2 and 3 shows two such BPMN models.

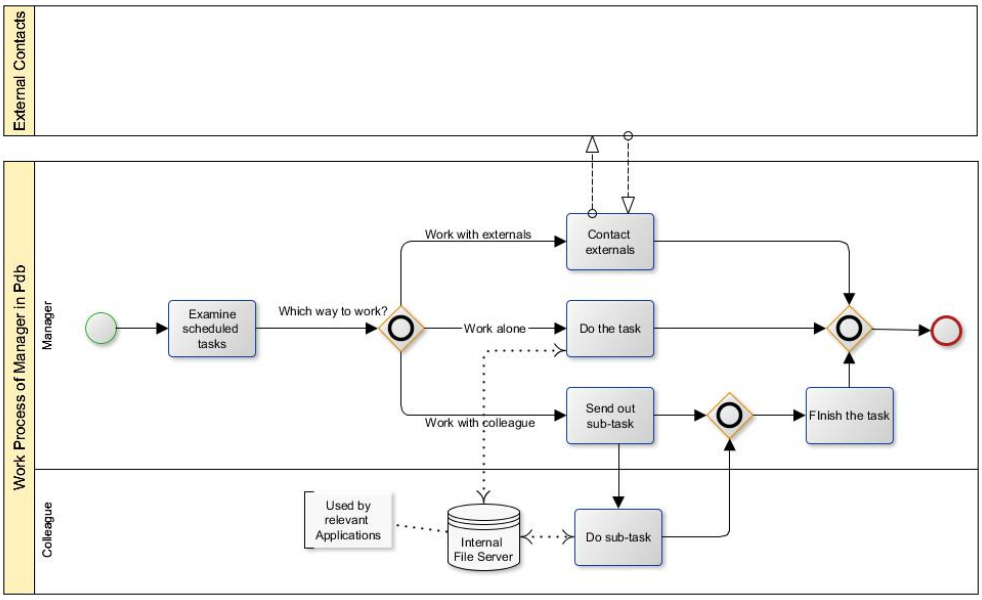

Figure 2. BPMN model of work process of manager in Pdb.

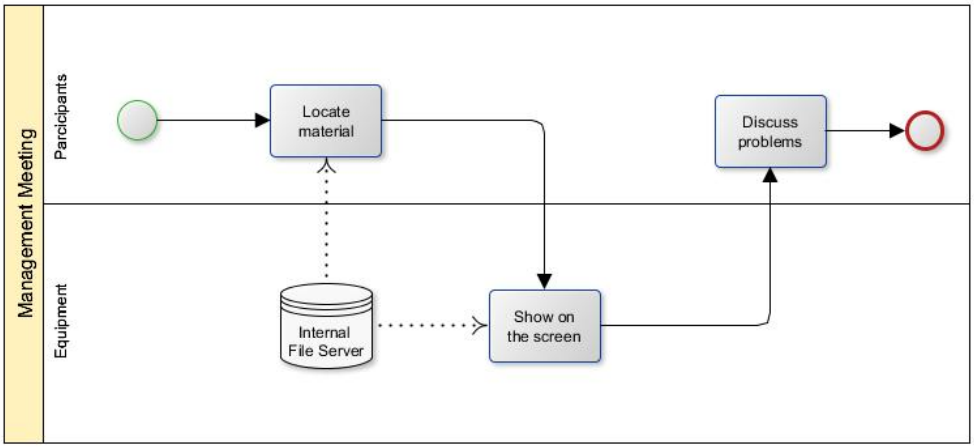

Figure 3. BPMN model of work process of management meeting in Pdb.

Key Findings

In this section we conclude the key findings from the study.

1. Papers are still very often used in the workplaces

Although it has been predicted the arrival of the paperless office for more than two decades, a lot of paper are still produced in our daily work. Here are some of the reasons why paper is still very often used:

- It is a tradition to keep paper records.
- Signed paperwork is a necessity.

- People like to bring papers to discussions and meetings.
- People like the way paper feels.

It doesn't have to be this way. It is possible to get rid of paper entirely. Digital documents are simpler, easier to store and send, more searchable and more versatile than paper.

2. People work in teams

All the interview participants work in teams some or all of the time, in different shapes and forms. Team work requires the ability to interact with each other to achieve objectives through a shared understanding of resources, such as members' knowledge, skills, and experiences, and explicit goals and objectives. The support for teamwork we found in the study is all right but traditional. Emails, phones, and face-to-face meeting, among others, are the main ways in which people communicate with each other, and share information and knowledge.

3. Project managers do not have desired support from ICT

The support for project management is also very traditional. Excel and emails are the main tools used for project management. The advanced project management applications, like Microsoft project, are not the choices, since they are found too advanced or complex to be used for the management of small-medium projects. The effort needed to plan and manage project using such applications is often overload, compared to the project workload.

4. No special support for work-on-the-move or other kinds of mobility

No special support for work-on-the-move is found in the study. Even tablet and smartphones are not used. Although Work-on-the-move is requited by few participants in this study, workers are always expecting their workplace to offer high level of freedom both physically and technically. It is believed that in near future more than 30% workers will become "mobile" workers due to the rapidly development ICT technologies and digital natives entering workplaces.

The Opportunities

The findings listed above are not completely new. Concepts like mobility, collaboration and flexibility that were on the cutting, radical edge now have moved to the center. What is important today is how they are being shaped and implemented in companies, particularly SMEs. In this section, we suggest the opportunities for future work of ICT in the continuation of the project.

1. A Paperless Office

To be paperless means essentially that the traditional paper-based practices-such as writing, note taking, reading, editing, communicating, and even drawing-are instead performed electronically with ICT devices and software. The use of ICT should naturally lead to becoming paperless.

2. Office for Efficient Teamwork

We need better workplace to support better teamwork. People don't just work together in meeting and conference rooms. Collaboration can happen all the time at personal desks and in hallways, or virtually via internet or smart phones, and it's often spontaneous and informal, rather than planned in advance. Effective collaboration involves knowledge exchange, brainstorming, the inclusion of diverse perspectives, and scenario building. Office of the Future must provide tools that allow people to record ideas and create a visual, side-by-side review of alternative solutions. Such tools are key enablers helping groups reach a shared understanding faster and more effectively.

3. Seamless Support for Project Management

There are many software applications that can help with project management tasks on the market. However, it is a difficult question: what's available out there and what tools might support your particular project-management needs? Project managers are using software mainly to support six different types of project-management functions: planning projects, managing tasks, sharing and collaborating on documents, sharing calendars and contact lists, managing issues and tracking time. However, no single project management "super tool" meets all sophisticated project management needs listed above. Is it unlikely that one package will include all the functionality project managers cared about? Or any other solutions?

4. Integration of "mobile" workers and the "stationary" office

ICT increases people's freedom to decide when, where, and how they wish to work, communicate and collaborate. New generation - digital natives are entering the workplace. They are different to previous generations in how they approach work, communicate, and integrate technology into their daily lives. Companies need to build working environment that attracts digital natives. At the same time, most of workers are still "old" generations. The challenge is what is a balanced working environment attracting digital natives, but not exclude other generations, and how it is implemented.

Appendix A: Interview Guide – Technical aspects (IT-responsible)

1. Introduction
   - Persons participating in the interview (both interviewers and interviewee)
   - Introduction of the purpose of the interview and the overall procedure

2. We will cover several aspects in the general interview
   - To know the background of the interview partner
     a) Can you tell me a little about you?
     b) Can you tell me about your education?
   - To know the job of the interview partner
     a) What are your roles at work?
     b) Can you describe what those involve?
   - To know a typical day of the interview partner at work
     a) Where do you work typically?
     b) What are the typical activities?
     c) Work alone or in group, or both?
     d) What tools you use mostly to do your job?
     e) Who are the people you interact with mostly? Why? How do you interact with them?
   - To know the expectation of the interview partner for an office of future
     a) What is that you like the most about your daily routine? And what is that you dislike the most?
     b) Anything that you would change? Why? How would you like to change them?

3. Conclude the interview

Appendix B: Interview Guide – Technical aspects (whiter collar)

1. Introduction
   - Persons participating in the interview (both interviewers and interviewee)
   - Introduction of the purpose of the interview and the overall procedure

2. We will cover several aspects in the interview for the IT-management
   - Intranet: documents/data, user policy, access restriction
   - Internet: the things published to “the world”
   - ES/EA: the systems are used
   - Equipment: The hardware equipment are used
   - Services that support collaborative work

3. Conclude the interview

3.2 Design aspects

3.2.1 Länsstyrelsen i Kalmar

Länsstyrelsen, County Administrative Board, Kalmar, Sweden

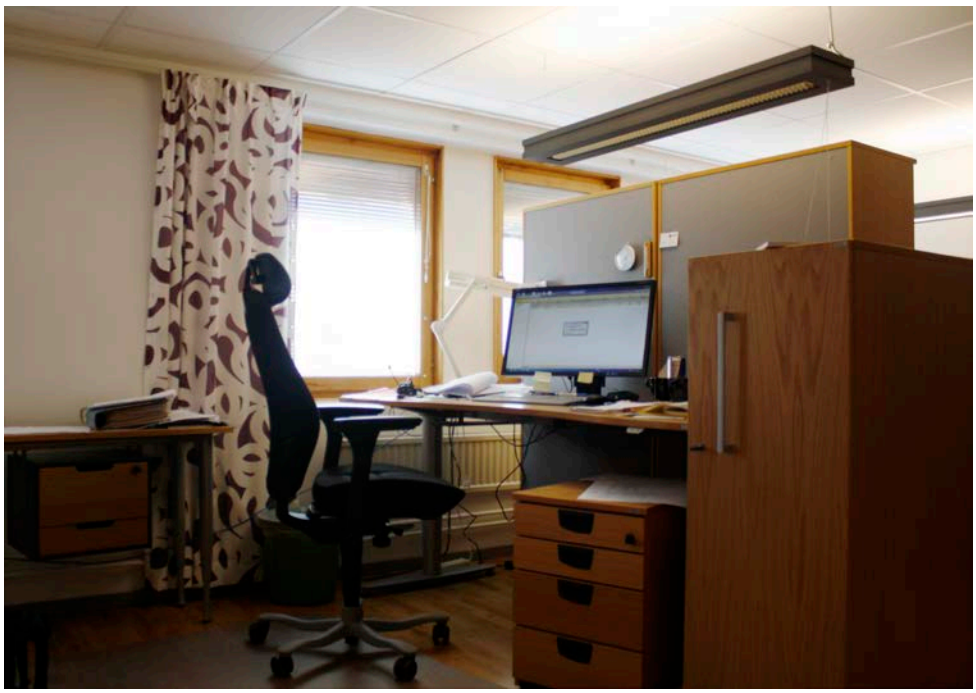

Figure 1. Head of Internal Services, Länsstyrelsen Kalmar, personal office space.

Head of department, Internal Services

The Head of Internal Services list of devices includes desktop computer, laptop computer, tablet (iPad for meetings, email, and scheduling), smartphone (quick communication), printers, and a scanner (for digitizing documents).

The interview was mostly conducted in English, sitting at a table in view of the Head's own workplace, and lasted roughly 45 minutes. It dealt with how he sees both his own personal routines and, because of his managing position, the general workings of the office itself. He described the department's duties as being *about giving service indoor, in the house, making sure that our colleagues indoor can have the information they need and know what they are going to do with the information after they're finished. Make sure that the flow of information indoors work, that's one part. So I have distribution here, is where all the information comes in and we send, we start to put the information into our IT systems and make sure that the information goes out to the, to the handläggare, administrators, out in the house, so they, so they can do their work.*

Distribution indoor is then followed by a collection phase:
And afterwards, if they have it in paper, all the information comes back here and we put them in the archives.
It is worthy of note that the current Head was trained as an archivist and has previous experience working in other government agencies, and he clearly illustrated throughout the course of the interview that his background shapes the way he sees what his (and consequently, his staff's) work actually is:
keeping track of information and making it available, not only to, to the (staff) but also to the public, we have a, in England we have something called free (access to) information and here, Sweden, Offentlighetsprincipen. So, so, this, the, this is where I'm coming from.

In terms of his personal routines, the Head of Internal Services maintained most of his work is organizational in nature and conducted digitally with a certain clear-cut separation between devices and activities that distinguishes between what is private and what is office property:

Q: Do you use a mobile phone when you work?

A: Yes. I use my mobile phone. And the, I have an iPad.

Q: Is that mostly for mail or ..?

A: My mobile phone and my iPad is most, the mobile phone is for calling too, my iPad is to make sure I turn up on time. I have a calendar and I check my emails.

Q: Are those your, yours, personal items or are they office items?

A: The iPads are office items. So, so it's connected to my work email and to my work schedule.

Notable point is that laptop and desktop computers, while still certainly used to an extent for mail as a mail program was installed, were not considered when freely describing his set-up. When it comes to mail exchanges, phone and tablet are the dominant devices. The reasons for it being difficult to make tablets a larger part of the workflow seems to descend from both IT constraints (*"it is the architecture"*) and security concerns:
So the only thing I really can use (my Ipad for) is my (calendar) and my email, which means I don't really have use for an iPad, I can do notes and stuff like that, but that's it. And which means there is very few (of us who) actually have use of them and there is only the management that uses iPads because of that.

Q: Why is that? Is that because of architecture?

A: It's IT architecture, yeah.

Q: Are there security concerns as well or?

A: There's (a) lot of (these). New hardware into a government, you have to have this different kind of aspects covered. One is security and also information security, yeah.(...) How do we make secure? Because we have to transfer information. And we also have information which is highly (sensitive), which we, we can't put into, into IT solutions. We do have work connected to the military, so we have military security here also. And then, that kind of information, we have to treat (it) separate(ly).

According to the results of the interview, the single most important and strategic aspect of the job is the constant refinement (or maintenance) of good day-to-day practices aimed at obtaining an optimal workflow throughout the office, especially information-wise, in order to decrease the inevitable frustration all employees experience as a consequence of working in the fuzzy area between being analog and being digital.
And being an archivist, working with information, organizing information and keeping it in a way which is easy accessible, (...) is what I do. And try to work with processes and then trying to visualize them, to make them (visible).

Working across these boundaries which very often have opposite or conflicting goals (eliminate all paper, store a copy of the complete paper trail) creates a consistent but often bothersome workload for the staff. For example, every physical document the office receives is also exported to digital and stored in their software repositories.

Q: So you, you basically scan and organize, or?

A: If we get it in on paper, we do digitalize the information and make sure it comes in to our IT systems and then distribute it indoors, digitally. Too much anger, frustration.

Q: Why is that?

A: You will see. I will show you our IT systems and, as a designer, you will cry.

While the software applications they use for these tasks are up-to-date, according to the Head they still suffer from being designed and implemented without actual users and usage in mind as a consequence of the procurement process currently in place:
When we buy stuff, it costs a lot of money (…) We have to document it, document our needs and make them public to providers and providers have to say 'This will cost this much money'. And it's a very public process which is very highly regulated. (All the way) up from EU. Which means that one of the most important parameters is money. (…) And the problem is always putting in the soft values; like design, in this kind of contest, because it is a contest, how do you rate design, which will hold up in court.

At the same time, it is not possible, because of external constraints (such as for example how citizens initiate a dialog with the office) or because of legal requirements (such as for example the hurdle

presented by documents demonstrating will through signatures), to simply completely abandon the acquisition, managing and storing of physical documents.
Other major problems that emerged in the course of the interview were the reliability of their infrastructure, the consequent down-times, and the way centralization in the organization has broken the connection between normal staff and the IT staff.
That is the, the biggest problem is (the) reliability (of our IT systems).We have sometimes very long response times. (…) We have sometimes lot of down time, because we can't access (the) IT systems, we can't work. That is really one of our biggest concerns.

These down-times are a consequence of a centralized structure that has moved both the hardware, in this case the servers where data is stored and processed and the personnel into one single common location for all of Sweden. Technical resources and know-how have been both co-located elsewhere and that can become a bottleneck:

Q: (Does that mean) you just need to wait (when that happens)?

A: We need to wait. (...) We are over 21 Länsstyrelser and we put all our IT resources together into one department, one unit. And we've also centralised all our keepings of information, so all our servers are on the other side, in Vänersborg. So (...) we lost all our IT personnel, we lost all our resources to fixing problems. So it's a process of lot of administrative problems solving the smallest problem. (…) we don't have the resources anymore; we don't know how we solve problems in IT (locally).

On-site IT staff exists, but is not part of the local organization:

We actually we have three people who work at the IT (services) here. But they are not my people. We cannot talk, we're not even allowed to talk to them (outside the official channels).

Another part of the work the office carries out involves being outside in the field, and this is another area that is being considered for improvements, especially in terms of time spent on the process and efficiency. Tablets (iPads) are considered as well:
We're talking about putting a (...) router in one of our cars, with extra antennas, so when they go out they can take the laptop with them and they can access all our information digitally and have a 12V writer (printer), for writing or documents. So that they can go out, meet the farmer, have the meeting, document their decisions at (the) site, give also the decisions. And we think that is a way of speeding things up. (...) And those workers, (…) I believe, if they had an iPad, that would, I think that would be enough (to carry out their duties).

Little connections were made throughout the course of interview in terms of considering how the relationship between technology, office space, behavior and work procedures is a complex series of feedback mechanisms. One major exception being when we discussed the upcoming move to a new open-plan space and what that means in terms of mobile technology:

We have a lot of discussions (with our IT management) about what kind of IT stuff are we going to have. Today almost all of our employees have stationary hardware. Which means you can't take your computer and move because it's big and lumpy. And when we move, (shows a blueprint of the new open-plan office) you can see we have a larger work environment, where you sit, where they sit together. Which means that you can't be chained to your desk. You're supposed to take your computer and go somewhere else and work. And if you need to meet a group of people to solve a problem, you (have to take your computer with you).

According to the Head, the open-plan will necessarily change the way staff works, so that implies changes to the technology they need to use. This precedence of the physical environment over the digital environment creates interesting feedback loops though: the new plan will require the implementation of a Wi-Fi network, something the office does not currently have, and this will also modify the demarcation line between public and private usage of devices and allow a far larger degree of flexibility than simply hard-wiring physical workstations.

So we're upgrading to mobile computers next year, to make it possible. We don't have Wi-Fi here in the house, which means that those of us who have mobile computers really can't work efficient(ly) when we take (them) out of docking. I can work with my mobile computer indoors, but I have to turn my mobile phone into a router. And, and I have to connect it via VPN, as a secure internet to, to access my programs.

Conversations are also along way with IT to achieve more granularities in terms of the technological resources considered for staff, since *there are lots of us (in the office) who don't need a PC because we don't work that way. We don't need the process capacity, because most of us work with documents, as in writing documents.*

Solutions involving tablets are being considered. The Head mentions how these also challenge the conceptualization of work hours and of the office space as a single, monolithic place, and shows a fairly positive attitude towards what the results of such changes are:

can we have workers who have iPads or another type of pad, which (...) they have with them all the times and I don't really care where they sit and work. And when they come to their normal workspace, they just plug it in and they have a keyboard and larger screens. But, but if they work at home, if they work at the bus, I don't really care.

Regardless of their software applications being a chore to use and often requiring too many steps to accomplish routine activities, the attitude towards incorporating more technology into the workplace throughout the interview was definitely positive, with the idea that a different infrastructure and more and more diverse devices, including personal portables and ad-hoc solutions (such as those for staff in the field), can help make the office a more functional and flexible place. Länsstyrelsen's long-term policies of going fully digital is seen as a positive resolution:

We're moving towards more digitalized workplace and that I wouldn't change. Because as an archivist I know how much time it takes working with paper documents. That takes a lot of people and we don't have the resources anymore, we have to let the machine keep track of something.

Administrators

The list of devices includes a handheld GPS device (used on the field), smartphone, desktop computer with two screens.

The interview was conducted in Swedish, with a few questions in English which were answered in Swedish, in the administrator's office. Administrators at Länsstyrelsen often work their cases on site, outside of the office, for two-three days a week: they are tasked with verifying that applications from farmers in respect to fields and pastures, for which they receive EU money, are legitimate and truthful. This is not a Länsstyrelsen-initiated process: administrators act after an application to the Ministry of Agriculture (Jordbruksverket) has been filed, so their job involves constant communication and sharing of information with outside systems and entities.

Asked to quantify which interlocutors she has to deal the most with, the administrator we interviewed ranked other Länsstyrelsen first, and farmers second, citing phone and mail as her primary communication channels.

She has been provided with a smartphone and a handheld GPS device (Figure 2), both supplied by Länsstyrelsen, and she also uses a traditional paper map that provides an additional source of information to supplement the hefty and heavy, small-screen GPS device which can become uncomfortable or difficult to read in specific environmental situations.

Man använder mobil och man använder en sån där handdator (GPS) där man har karta och så i och sen så använder man papperskartor .. också för den där är så liten skärm (…) man ser inte så jättebra på den.

On-site use of the smartphone is mostly connected to taking pictures that are then geo-tagged. The paper maps come in handy again:

Men det är ju så, vi använder ju mobilen för att ta kort, dokumentera det på (inaudible) den där finns en GPS i så då ser man var man är på i betesmarken exempelvis. Men sen så måste man ändå ha kartor i pappersformat eftersom det är så dålig bild på GPS:en.

The flow of work changes constantly through a yearly cycle, with a peak following applications in late April and another one in October:

Alltså det är nog mer på våren i april när ansökningarna kommer in, då är det väldigt mycket, sen är det lite lugnare över sommaren och sen nu har det börjat dra igång igen för nu är det utbetalningar på hösten, så då är det också mycket. Sen så är vintern lite lugnare, då kan man städa undan sånt som man inte har hunnit med. däremot om man tänker controller som jag jobbar med, då är ju den säsongen bara till oktober, så då är det intensivt hela tiden och då följer man samma ärende från början till slut, liksom börjar med ett förarbetet, är ute i fält och sen efterarbete, sen skickas resultatet ut och sen börjar (igen).

She makes a point that the smartphone is the offices and for outside work, not used for any other activity indoors:

Q: Ja är det så om du börjar klockan nio på morronen och sen när du slutar liksom, vad är det du kollar först din mejl eller .. har du först ett möte?

A: vi har inte jättemycket möten så att oftast kommer jag hit runt halv åtta och så kollar jag min mejl, som du säger (...).

Q: Är det via din dator eller din mobil?

A: Ja datorn, jag har ingen (mobil).

The main reason behind this non-reliance on mail and phone is given as a direct consequence of her job taking her away from the office regularly. When she is on site, mail could potentially sit waiting for days, so processes have evolved around this to avoid forming a bottleneck. As she put it, *så får inte jag så mycket mejl som är så här akuta, är jag ute två dar och jag har missat två mejl så gör inte det så mycket oftas.*

Chat is on the other hand used extensively when in the office to quickly solve small issues. It is not considered a communication tool, but rather a problem-solving tool.

Vi skickar ju ganska mycket frågor till varandra också på länk och chatt. (…) Det är nog oftare chatsystemet om man har en snabb, vill slänga ur sig en snabb fråga och ett snabbt svar.

She also added that reading mail often feels like a task that takes away too much of her time.

As her workflow does not involve much mail and few meetings, most of her interactions are either person-to-person, both on site or in-office, or mediated through the software she uses to move the application verification process along. She qualifies said software as difficult to use, requiring too many steps to carry out day-to-day operations and with the interface being more of a hindrance than help, even though she has become proficient through continuous usage and some explicit knowledge made available in guidelines:

Det är väldigt många steg och vi jobbar i väldigt många olika program men vi har ju en rutin beskrivning som jag, alltså man får titta på fortfarande.

Men det är ganska gammalmodiga program som vi jobbar i.

(Gränssnittet) är väldigt urålderligt, i alla fall i det jag registrerar det i, det är ett gammalt system men nästa år kommer det några nya system för då blir det ju ett nytt landstingsprogram (inaudible).

She described her main work process in detail as such: back from an on-site visit, it takes roughly 3 hours to register the data from a case. First she needs to transfer images and data she has in her phone to the computer. Then she creates folders and sorts these out. Then she switches to one of their applications which allow the editing of maps and areas. Then she moves to email management and creates documents for the applicant. Finally, she accesses a 3D system where she can compile and register all of the information concerning the case. It's a long process made more complicated by the fact that moving back and forth between sections is not easy. When a case is registered, she sends printouts on to a colleague who takes it up from there.

Overall, the paramount concern she has is autonomy and competence around the processes she manages and consequently interactions with co-workers. She thinks processes could certainly be improved upon as they seem mostly to depend on personal attitudes or personal organization:
Men annars är det nog mer att alltså vad som skulle kunna bli bättre här, det är att vi det är ganska många positioner som vi har, arbetsuppgifter där exempelvis bara jag kan en sak, så om jag är borta eller sjuk då är det ingen som vet hur man gör det och då stannar allting upp liksom. Så att det skulle vi ... behöva för att hålla bredda sin kompetens lite.

Alltså nu är inte jag den mest nyckelpersonen här (inaudible) där dom är sjuka, ja då får man låta ett ärende ligga för man vet inte hur man ska gå vidare och det känns ju väldigt onödigt, resursslöseri.

Figure 2. GPS device.

As such, communication is of the utmost importance. At the organization level, that means improved relationships between the Ministry and Länsstyrelsen. But at day-to-day level, this mostly mean respecting the different workflows and understanding how they move differently. She underlines her work requires her having a private space where she can take private calls, and the possibility to easily access meetings rooms if conversations are necessary.

An interesting observation was made during the interview in connection to the work environment and the lifestyle of a sizable part of the staff at Länsstyrelsen: according to this administrator, *det är ganska många av oss som jobbar här på lantbruksenheten som bor ja två tre mil ute på landet och vissa har egna gårdar också, så det är så.*

Even though she started her reply with a negative when asked if according to her this has an impact on the work environment in any way, or more directly changes the way she sees her work or feels more or less comfortable in the work environment, she clearly sees a connection:

Nej men det tillför positiva saker, tänker jag, som att det är lite mer verklighetsanknytning, man sitter inte bara och gör ett jobb utifrån regelverket, man har mer bakgrundskunskap och vet med kring det hur det faktiskt är, så det tycker jag är positivt att man har många som har lantbruk (inaudible).

Legal counselor

The interview was conducted in the interviewee's office, in Swedish with a few questions in English, and lasted roughly 26 minutes. At the time of the interview, the legal counselor had been working at the Länsstyrelsen for about 7 months after longer periods at Kronofogdemyndigheten and Polismyndigheten in Kalmar.

The list of digital devices she uses includes a desktop computer with two screens, a private smartphone, and a work smartphone.

Her day-to-day job involves appeals, permits, and generic legal counseling for the organization. Mail on her office computer plays a forefront part in her routine: every day *jag börjar med att gå igenom mailen (på datorn). (…) och sen öppnar jag upp vårat ärendesystem i Platina*.

Mail is also a large part of her communication routines:

Ja, alltså, ja, mailen använder vi ju mycket, där jobbar vi ju.

Cases are shared at weekly meetings by her boss with a team of six, but they all mostly work individually. Platina is the main interface she has to her cases, and she uses that together with access to three distinct juridical databases. She has devised a simple but effective personal procedure to move on with both new cases and the ones she inherited with the job:

Där ligger ju alla mina ärenden. Och sen börjar jag jobba, alltid uppifrån och ner (inaudible), mycket gamla ärenden som jag fick ta över när jag började här, så att det är bara att välja ett ur högen, vad man känner för. Och sen se vad som ska göras, läser mycket- alltså mycket är ju att läsa sig in på lagar förarbeten, läsa in sig på praxis, vad passar i just i mitt ärende, för att komma till en slutsats, sen är det ju mycket att kommunicera ut till olika parter, kommun, enskilda personer, mycket kommunicering, som vi har också i ärendena.

Even though she concedes that some of her criticism could be a direct consequence of having used the application for a short period, she thinks Platina would definitely need benefit from some changes: it lacks a few functions (especially connected to searching documents), and it is difficult to navigate.

Då hade jag velat ha en sök- alltså att man skriver ut, där man kan skriva ut alla handlingar, nu får ju vi sitta och klicka upp varje ärendekort och skriva ut manuellt för att skicka. Där hade vi velat ha "skriv ut allt i ärendet", rutt, så kommer det på skrivaren. Det är ju en sån sak. Mer tekniskt så, jag skulle även tycka att det var bra att ha en fri- alltså ett fält i Platina där man kunde skriva egna noteringar som ligger i ärendet, om ni förstår, så hade man kunnat skriva: "Obs! Ring…". Nu kan man lägga påminnelser, det har inte riktigt funkat för mig, vilket- jag har fått ett eget system vid sidan av. Så det hade varit bra, att ha en fritextruta där man kunde skriva, ja, sånt där som… mm.

Some oddly working functions have been moved out of Platina and implemented by means of Excel sheets that are now shared and have become part of a parallel flow that sidelines the official procedure in Platina:

Sen har jag ju egna Excel-dokument där man lägger upp mer sånt som- alltså eftersom allting ligger i datan och man ska söka och så, man kan ju vilja- förr kunde man sätta in i en pärm så här, åh, det här rättsfallet är bra att ha, eller den här är bra att ha. Nu gör jag så att jag lägger det i Excel-filer istället, så där jobbar man ju lite i.

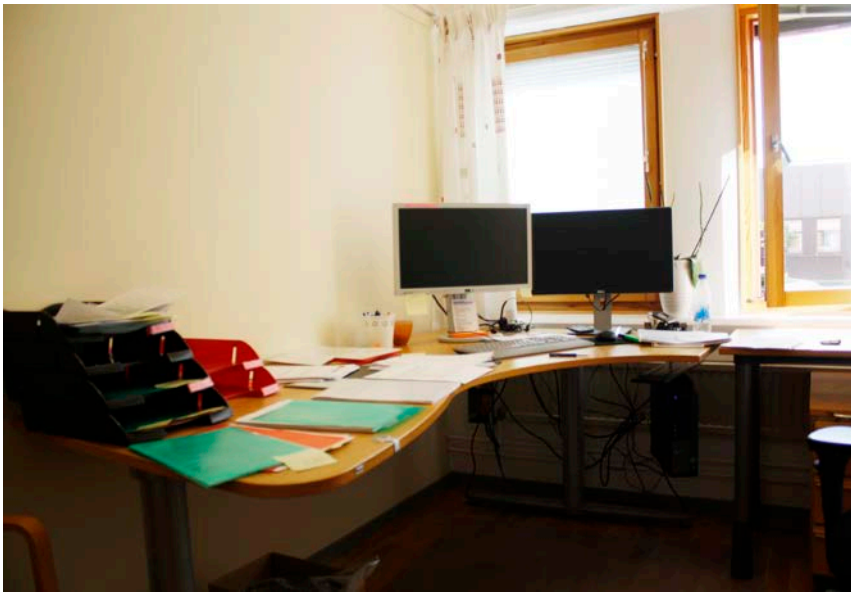

Figure 3. Legal counselor's desk.

Most of her work makes use of digital, and she only resorts to paper when working with older files. She considered the possibility of carrying out some of her work on a laptop computer or a tablet interesting, but was not enticed by the idea these would allow more flexibility in the way they arrange meetings or the possibility to work from home.

Jag jobbar gärna på jobbet, jag sitter gärna på- ja. Alltså jag sitter gärna, jag tycker inte om att ta med mig jobbet hem, mer för att det är ett stressigt jobb och det blir ju liksom, då tar man med sig arbetsbördan hem. Men det- i vissa fall skulle det ju kunna underlätta att kunna ha med sig om det är nåt- alltså rejält man måste läsa in sig på och man har kort tid. Så man slipper sitta kvällar här då, men… Men jag, jag tycker om att jobba på jobbet. Om man kan säga så.

Figure 1. The CEO's desk.

3.2.2 Pdb

CEO

The interview with Pdb's CEO was conducted in English with occasional switches to Swedish in one of Pdb's meeting rooms at their main office in Jönköping. It lasted roughly 28 minutes.
The list of devices used by the CEO includes a desktop computer, a laptop computer, a tablet (iPad), and a smartphone (iPhone).
Throughout the interview, the CEO stressed how communication among the different units and between staff members is the most important issue he and the company face daily and one that is not easily solved by technology alone, but rather is an issue deeply steeped in behavior:
I think (it is important) to communicate correct(ly), (...) in the right context and with the right facts also. I think that is a challenge. And definitely an opportunity to work more well. And, and so far (…) I haven't, I haven't really decided whether this is a matter of devices or screens or is it a matter of how the modern people behave. Is it a behavior thing or is it the device thing. I haven't really decided yet.
(Interviewer: It's a good thing that you haven't yet decided)
No, probably it's a good thing because I can see that if we capture this, this question (can) be a, a window thing. (…) If we talk about communication and how, how we want to influence people in the workplace with information, then this is really interesting.
It is from this point of view that he also submits that technology should "influence" or "inspire" staff interactions.

I want to see technology as, as a, mm, influence or maybe, mm, call it an "inspirator" (that supports) interactions between people, the relationship or interacting or communicating between people. We can do a lot of that if we could, could break this spoken/written word barrier, in a good way. And in that, maybe there we could have the technology could, maybe, help us in that way.

Reliance on technology alone is then sometimes counterproductive, as the main issue is one of behavior and policies: in information terms what should be communicated, and how much is to be communicated. This approach gets mentioned more than once in the course of the conversation. It is clear that while mail is such a natural part of work routines at Pdb that is practically taken for granted, it is not considered a useful metric to quantify one's work in itself:

Ja visst, jag kan säga så här att, nej jag gör ingen sån där morgon rutin att jag, då kollar jag mejlen, för den har jag koll på redan innan den, den har man löpande kontroll på. Sen kan det va så att nej ja, ja sen är jag inte den som sitter och skriver mejl på nätterna, för det tycker jag är totalt fel. Men det kan jag återkomma till den frågan. Så det kan va att man skickar, skickar några mejl som man tycker ja det här ska jag delge så, baserat på saker som har hänt.

As a poster case of confusing "communication" with "mail exchange" he mentions conversations that went on for days, with the issue being discussed changing in scope and meaning, misunderstanding cropping up, and people getting more and more uncomfortable. He describes this as a totally unproductive way to work that is predicated on the differences between communicating face to face as opposed to communicating in writing:

I think that, really important thing here in, in, in communicating is that there is too much difference between the written word and the spoken word.(...) You have a conversation (via mail). (…) There is some problem you have between people that are not in agreement, you see this. By that time it could have been ongoing for some days and maybe you have 10, 15 mails in that conversation, and you can see if you study it (that they don't understand each other). How the issue changes and how it's diversified in scope and meaning and so, and that is a totally unproductive way to work. So, so mostly I send a mail (that says) stop sending mail! Meet (face to face).

One's emotional state or one's capability to read and attribute emotions play a big role in this shift from understanding to misunderstanding:

I actually if I am writing a mail where I maybe want to point out some things,you see, it's probably very important that I put that kind of smile(y) here, because otherwise people will put in some other (emotion) in that sentence. The risk that this will be misunderstood is very high. Especially if we, if I go into some kind of argument where I want to make it less dramatic or just say "please talk" (laugh).

The CEO describes the company as a competence organization, where relationships play an important role and which is run in a rather traditional way:

We (are) actually running this company really traditional, well we have a board, we have management groups, we have teams, we have an organization and so on. And that is a structure that are really, really, really old in some case. Maybe we are, what you call it, (a) flat organization and we are okay. We are close to each other but still we are really traditional.

His work routines, which mostly addresses high-level processes in the company, as managing staff and projects is usually the care of team leaders, are laid out on a monthly basis:

I don't have a routines for a day. If I have routines that is for the month. (...) I follow the major management processes of the company and that is more or less monthly or maybe quarterly but the most of it are monthly.

As such, a meeting face to face is a key moment for both daily operations and specific project work. When it was asked if he sees his work as tied to the physical space of the office, he made a point that it is not so but that could be seen as something that changes the system of symbolic structures of the company.

Q: Are you tied to the office? As the place where you work? Do you need to be here? Do you feel like you want to be here? Or can some of your work be done in some other ways?

A: I would like to answer like this. If I say, at first, that I don't think my job needs to be done in my room, (that is true and) it is actually "en begränsning", a limit. Because that room has a lot of symbolic (value), all sorts (of it), so that you know.

Q: So you are making a conscious decision not do that sometimes?

A: I think it is much better to see people in other contexts, some other room, I think that is important.

Besides that, he acknowledges his room has a functional destination that serves the purposes of the workflow and hierarchies within the company, and that while he concedes that there could be technologically-apt ways to reproduce or substitute direct interactions, these should account for some form of face-to-face management:

Then, is this location important for me to do my job? Yes it is if I meet my staff here, if I meet my employees here. So I think the important room is where I meet people and, and mm, actually I think it is very important to have, to have… the face to face meeting. That could be on electronic form or something like, but the face to face management I think is important.

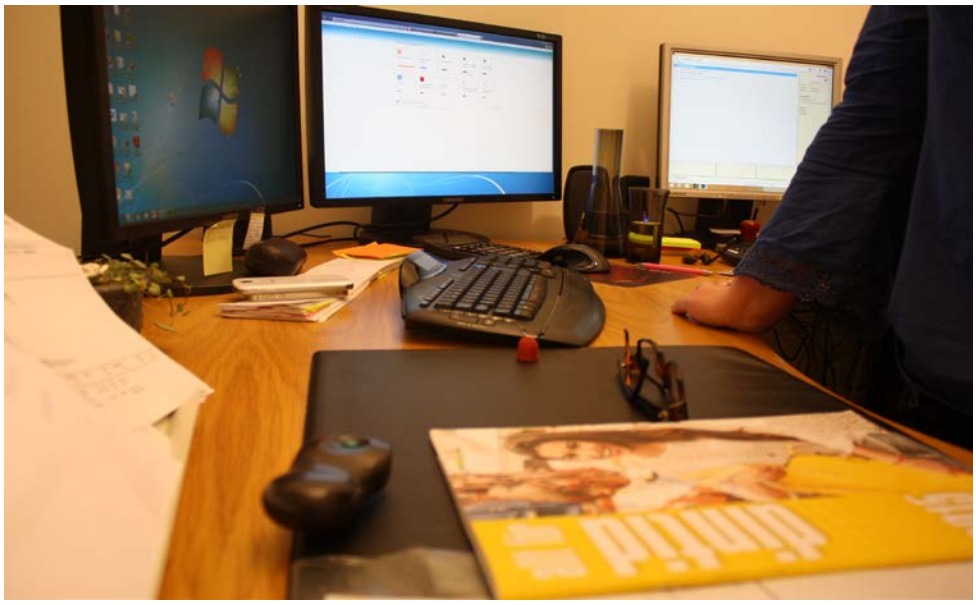

Figure 2. Receptionist's desk.

Accountant

The interview was conducted in one of Pdb's meeting rooms and lasted approximately 14 minutes. It was conducted in English. The accountant's main role is that of taking care of the wages, the salaries, the invoices, and the bookings, monthly bookings and yearly bookings. At the time of the interview, she has been working at Pdb for eleven years.

The list of devices she uses daily includes a desktop computer with three flat screens, laptop, and a smartphone.

When asked about what a normal, routine day is like, she points out that *there is no such thing at all! I do a lot of things at the same time, always.*

When asked if that is just how work happens or if there is some planning going on, she establishes that she *can definitely plan what I want to do or have to do but usually do a little bit there and a little bit there. When I do the wages, I do the wages. I register and do that. Mainly (for) 1 or 2 days. And, and when I do the bookings for the each month I mainly do that, but sometimes you know, (the) telephone is ringing and people come and ask things.*

The most important issue for her work is hence constant successful communication: she stresses how she has to plan that will take care of her assignments if she gets sick, and how the flow of questions that gets to her every day is an important factor that has to be taken into account. Interruptions come from both outside and inside the company:

the phone calls I get is from customers and regarding to invoices mainly. Even maybe they are going to be a bit late payment or we are late with payment for our vendors. (From staff) I get questions about their holidays, how any days have they left on holiday. How is it working if you have- if you are staying home with kids and other stuff, that kind of questions?

She largely self-organizes her work and reports to the CEO once a week, and while she's helped occasionally by another staffer, she takes care of most of her assignments even when on holiday, if she wants to, working remotely:

Nobody does my work when I'm on holiday. Although I, I don't really mind I can, I have a place at the west coast where I stay most of the time. I can work from there if want to.

She uses one software application for invoicing, including accounting of hours within the company, a number of custom Excel spreadsheets, and mail, which constitutes a large part of her communication work, but she underlines how paper is still a large part of every workflow, either in the form of printouts of internal files or in the form of documents coming in from third parties.

She maintains that she would need better software to do the invoices.

4 Consortium

During the pre-study of the *Smart Housing Småland* project *Office of the Future* the consortium has concisted of the following participants: *Länsstyrelsen* (Kalmar), *Pdb* (Jönköping), *Glafo* (Växjö) and *HJ/JTH-JIBS* (Jönköping). A continuation of the project is planned for the autumn of 2015. The purpose is to submit an application to the Vinnovas program *Utmaningsdriven innovation* (UDI) in August 2015. Possible new participants are: *Atea*, *Tengbom*, *Flexator* and *Forserums Safety Glass*.

5 Vision

This section synthetically identifies exploratory threads and possible future areas of research for the office of the future as they emerged from the pre-study.

The *office of the future* is a transformative space. Calm, invisible technology is completely integrated into the workflow and supports the instantiation of personal but shareable work-related cross-channel ecosystems.

The *office of the future* does not stop at its physical boundaries, its walls and doors. Cross-channel ecosystems connect different services into meshes cut loose from any specific single physical location, turning “desk-bound” activities into “ubiquitous” and “pervasive” ones. As long as we can display, use, create and modify work-related information, the space we are in is part of the workplace.

The *office of the future* is a blended space, a new and different type of place that combines and remixes in emergent choreographies the affordances of both the physical workplace and the digital layers. It is a pervasive, far-reaching architecture.

The *office of the future* is many different offices, each of them the partially overlapping individual outlook of staff members over the ecosystems as they attend to their duties in the digital and physical space of the workplace.

The *office of the future* is a different kind of office: it is a collaborative, pervasive blended space supported by technology.

The *office of the future* processes information differently, uses it differently, stores it differently, and promotes different mental models and activities. Its technological layers support the slow dissolution of interfaces into agency and behavior.

The *office of the future* is open 24/7 365 days a year.

The *office of the future* is where Generation Z-ers, the “digital natives”, work.

The *office of the future* is a proactive and contextual computing environment that supports informed decision-making. Personal devices and wearables collaborate with location-provided systems, sensors and actuators to unobtrusively perform tasks on staff’s behalf.

The *office of the future* is a loosely joined structure. The constant flow of information changes the way we work, with formal, static structures losing ground in favor of emergent, flatter, cooperative ones based on larger ad hoc networks of mobile peers.

6 Continuation

During the autumn of 2014 a pre-study has been conducted under the name Office of the Future. The starting point has been to answer the call from Smart Housing Småland, to create an international innovation environment that, with the user in focus, creates smart living and a sustainable environment based on glass and wood, by focusing on the part in modern society that is focused on the office, its physical construction, employees, working processes and tools. The pre-study included, among other things, an analysis of today's offices and the daily activities that take place there. The results from this pre-study have been presented in this report and they will form the basis for the continuation of the research towards the Office of the Future. Some of the things that have been analyzed during the pre-study have been: 1) how does different actors work in an office today, 2) which tools, methods and processes are they relying upon, 3) which IT-tools and sources of information are available to the employees today, 4) how can new tools based on among other things transparent intelligence (i.e. touch sensible glass surfaces in desks and walls) be incorporated into the office to improve, deepen and facilitate the daily collaboration, and 5) how could work be made more efficient in the office using all new types of tools available, such as mobile platforms, touch sensible glass surfaces, semantic technologies, etc. The answers to question 1-3 have mainly come from interviews with personnel at Länsstyrelsen in Kalmar and Pdb while the answers to question 4-5 have come from analyzes of ongoing international research projects. The answers to the five questions also helped us formalizing our thoughts for future research activities (Fig. 1). The diagram offers a synthetic architectural model to approach the design of the workplace of the future. The technological layer holds the base infrastructural foundations, for example, access to mobile broadband. The spatial layer accounts for the physical environment and the spaces and objects in the physical environment that participate to, shape or modify the concept of workplace and how people work. The applicative layer is the tools layer. Application software, office gear, personal devices, they all belong to this layer. The organizational layer is the people's layer. It considers how individuals and groups organize and interact the workflows by means of the underlying layers. Orthogonally to the layers are found the future research activities (ontology, business process modelling (BPM), information architecture (IA), user experience (UX), and enterprise architecture (EA).

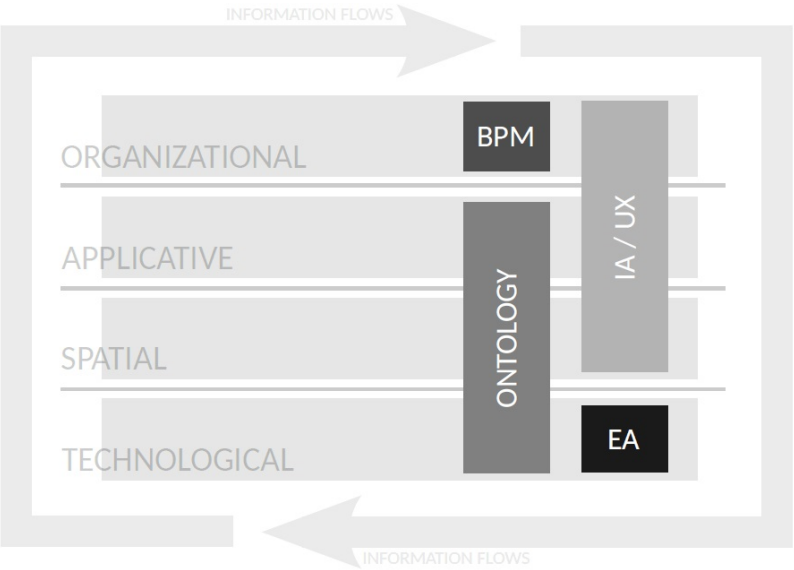

Figure 1. A synthetic architectural model of the workplace of the future.

The continued, extended project also fits well into Vinnova's program *Utmaningsdriven innovation – Informationssamhället 3.0 – Konstellationsbyggande och idéutveckling*. An application will be sent to Vinnova by the end of August, 2015. One of the most important aspects to consider when writing a research proposal is the identification of the main research questions to be answered by the project. As a consequence, the current research group is planning a workshop to take place at JTH on May 5th, 2015. Among the invited persons are professors from universities abroad that do research in the field of user experiences, as well as representatives from Swedish industry. A closer connection to the research area, Built environment at JTH, is planned. Hence, some researchers from the area will be invited to the workshop. The workshop is conceived as a hands-on meeting bringing together different experts and professionals, from architecture to economics, from service design to human-computer interactions, from product design to information systems, in order to advance a multi-disciplinary understanding of the office of the future as a cross-channel ecosystem in digital / physical space. Focus is not on technology per se, but on how we will work differently and how technology can support this. The primary goal of the workshop is to work on and refine some of the ideas and issues we highlighted in the pre-study to better flesh out our case in upcoming KK and Vinnova applications. Secondary goals include developing better connections with some of the participants' offices or institutions, both in the light of the need to enlarge the team of partners for said applications and for more general collaboration, and the possibility, depending on the final outcomes, to disseminate the results of the workshop itself in the form of a conference paper or other academic output.

6.1 Challenges and goals

The goal with the research is to develop a general platform for the *Office of the Future* taking into account new developments such as transparent material, new IT-technologies and improved

interfaces to increase the user experience. Furthermore, a demonstrator in the form of a bounded prototype exploring some of the ideas, based on the developed general platform and different types of tools (e.g. desks with touch sensible surfaces) will be developed towards the end of 2016 or the beginning of 2017 and it will function as a prototype for the continued research work. The demonstrator will consist of an IT solution (software, a user interface for an increased user experience and a model describing the office activities and information flows) as well as a proposal for an altered office layout based on the usage of transparent touch sensible surfaces in desks or walls. A number of publications are to be published in areas such as semantic technologies, user experiences and cross-channel information architectures, related to the *Office of the Future*. A long-term goal is to create a dynamic and creative research environment, within the new KK-environment at JTH, consisting of private enterprises, public organizations, research institutes and universities.

6.2 The potential of the idea with a focus on a sustainable growth

One of the points in the Vinnova program *Utmaningsdriven innovation – Informationssamhället 3.0* is focused on the potential of a project, especially when it comes to sustainable growth. The project *Office of the Future* has the ambition to change, facilitate and improve the daily tasks for the office workers, whether they are performed within the office (the *physical office*), or at home or during the transportation between home and the office (*digital office*). One of the driving forces behind this proposal is the arrival of new, often wireless, technologies such as tablets, Apple Watch, Google glasses or touch sensible glass surfaces in desks and walls. The solutions will lead to changes in the behavior of the personnel and the way they perform their daily office activities, something that will benefit *green growth* due to a reduction in transportation between home and the office and a reduction in the use of paper due to optimized working processes and the usage of new technological solutions. This, in turn, will lead to *economical savings*, while at the same time creating a change in the *social behavior* among the employees due to a modified way of realizing their daily tasks and the collaboration between the coworkers. The physical office environment is also contemplated in the project, in accordance with the goal of *Smart Housing Småland* to create smart solutions with the user in the center, based on sustainable solutions using glass and wood. The glass aspect is contemplated through the use of touch sensible glass surfaces, so called transparent intelligence, and is handled primarily by *Glafo* and *Forserums Safety Glass* in collaboration with the other project participants. The wood aspect is contemplated when creating attractive office solutions based on glass and wood. This is primarily handled by *Tengbom* and *Flexator*, also in collaboration with the other participants. To sum up, the intangible goals in the project *Office of the Future* is to create the conditions for an increased innovation within the wood and glass sector in the region through the collaboration between private enterprises, public organizations, research institutes and universities.

6.3 Approach

The competences and experiences of the different participants complement each other in a natural manner and their different contributions within the research project are outlined in the following section (the abbreviations IS, UX and EC are described in the figure). *Länsstyrelsen in Kalmar* provides experiences related to activities in an office environment from a public organization's point of

view. As a consequence, they will verify and validate the obtained results (IS, UX, EC). *Atea*, which is a consultant enterprise within the IT-sector, provides its knowledge and experiences in the area as their clients often require answers to problems related to office solutions with existing IT-systems. *Atea* has a strong focus on helping their clients identifying solutions to current problems within virtualization, cloud solutions, etc. (IS). Hence, *Atea* will participate during the development, implementation and testing of the demonstrator. *Forserum Safety Glass* is concentrating its efforts on finding solutions based on glass. Together with the glass research institute, *Glafo,* they will present solutions based on the concept transparent intelligence, solutions that will offer new and more effective ways of realizing day-to-day office activities, for example by using touch sensible glass panels (EC). These glass panels will be integrated in *Flexator's* module based office buildings (EC). *Tengbom* is an architectural firm with experience in presenting office plans. This experience will be most valuable when realizing suitable office solutions, whether related to the physical layout (UX, EC) or the collaboration among office employees (IS). Finally, the participants from the *University in Jönköping*, are responsible for the development of models describing the information flows between the different actors and the IT-systems in a *virtual* or *physical office* (*JTH*, IS). Furthermore, appropriate solutions will be developed to enhance the office workers user experiences, their collaboration with the IT-systems and the office environment itself but also concerning their normal, day-to-day relations with other coworkers (*JTH-JIBS*, UX).

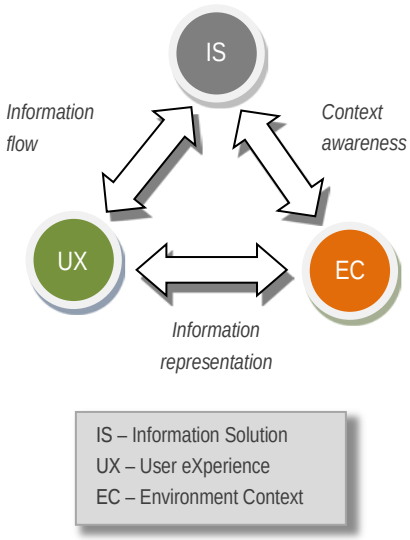

Figure 2. The relations between the different activities, actors and competences in the project

7 Conclusions

The project *Office of the Future* was initiated in 2014 as a pre-study financed by *Smart Housing Småland*. The project ran between September 2014 and January 2015 with the goal of taking the first steps towards a vision of creating an office ambient where it feels natural for people to engage in coordination, collaboration and knowledge sharing. In order to reach the goal of the project (a project that is planned to continue for several years), interviews were conducted with personnel from the two external participants, Länsstyrelsen in Kalmar and Pdb in Jönköping. The aim of these interviews and the following analyses was to create a knowledge platform related to the activities that are currently performed in today's offices. Another approach to enter the research field was to perform a number of state-of-the-art studies on relevant topics. The results from the interview analyses and the state-of-the-art studies indicate that the research group is on the right track. The knowledge and experiences from the pre-study will constitute the input to the upcoming workshop in May 2015 at JTH as well as to the submission of a new research proposal to Vinnova in August 2015.