BUSINESS PRACTICES ANALYSIS FOR THE ADAPTATION OF IT SERVICES TO AEC PROJECTS. CASE STUDY OF DESIGN ASSESSMENT RELATED PRACTICES.

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ABSTRACT

Many professionals of the construction sector feel a need for improvement of the Information Technology (IT) that supports their work. Our main hypothesis is that this improvement is strictly dependent of a good knowledge of business activities. This study addresses this issue, introducing a method to adapt IT supported services to business practices. This method is based on a structured approach aiming at (1) identifying Collective Practices, (2) focusing on actors' Individual Practices and Operations, (3) distinguishing different technology-related Usages and finally (4) selecting or designing adapted IT services relying on precedent analysis. An example based on sustainable project practices will illustrate the approach.

Keywords: ICT adaptation, Computer-Supported Collaborative Work (CSCW), Collective Practices, Sustainable Building design, Human-Computer Interactions (HCI) design.

1. INTRODUCTION

One can define AEC (Architecture, Engineering and Construction) projects as Highly Collaborative Contexts of work. In order to respond to the customer's requirements (i.e. architectural program), teams of heterogeneous actors (architects, engineers, contractors, material providers, etc.) have to cooperate temporarily. According to their role assumed in a project, each teams use and manipulate different types of information with their own internal processes, methods and IT infrastructures. This context changes from a project to another: each project generates its own "cooperation context".

In the specific context of Sustainable design and construction projects, the requirements in terms of objectives and quality involve a particular rigor in design and construction methods, project management, and information exchange. The cooperation context in such projects is specific. The first part of our study consists in identifying business "best practices" characterizing the cooperation context.

The aim of our research is the development of an integrated method for the adaptation of IT services to support such practices. This adaptation consists in selecting pertinent services but also in innovating by the development of new ones. Our research in IT services development is mainly inspired by the usage-centered design approach from HCI design research.

The next chapter of this study highlights different issues from the scientific fields that we explore (collaboration, sustainable construction, IT services development). Section 3 describes our main issue and objectives. Sections 4 and 5 develop the different steps of our research with both conceptual descriptions and applied examples. The final chapter will conclude this study and present possible outcomes.

2. LITTERATURE REVIEW

As numerous IT solutions exist to support professionals' practices, a remaining issue is the identification of such practices to develop adapted and useful services. Some AEC organizations have the possibility to involve themselves in IT services design processes within R&D projects. But most of practitioners need efficient and adapted solutions to support their daily work without personal engagement in the design process. The challenge is then to interpret the collaborative activities through generic modeling techniques but with the possibility to focus on more specific analysis when needed. The following state of the art considers 1) Collective practices identification methods in different domains, 2) more specific sustainable construction practices identification methods and finally 3) software development and adaptation approach.

2.1 Process Modeling and Collective Practices analysis

If construction practices can be defined as "processes that are systematic to execute, and measurable in order to determine achievement" (Matar et al. 2008), collaboration processes related to project management in the whole life-cycle of a construction project remain variable. Except in cases of reproducible projects designs, or stable teams, the collective practices related to management of information, resources, or people are highly dependent to project context.

Efficient representation methods are used to model processes and provide solutions for business practices identification (e.g. BPMN and IDEF0). Hence, we explore other fields of research providing more flexible methods. This first part of the state of the art focuses on methods to identify coordination principles and "best practices", considering different domain of application.

(Sandkuhl 2010) introduced the concept of "information supply pattern" to in order to understand how to identify "best practices". This work is derived from industrial requirements and is illustrated by an application to the automotive industries.

(Malone & Crowston 1994) lead an interdisciplinary study of coordination. They conceptualize the coordination and define it as "managing dependency between activities". They characterize the different dependencies to identify "the coordination processes than can be used to manage them".

(Schmidt & Simone 1996) introduce the concept of coordination mechanisms as "protocol that […] stipulates and mediates the coordination of distributed activities so as to reduce the complexity of coordinating distributed activities of cooperative work settings". This concept can help 1) to understand "how procedures, forms, and other artifacts can be considered mechanisms supporting coordination", and 2) "to support design of computer-based coordination mechanisms" (Carstensen 1996).

(Tellioglu 2006) develops the concept of Coordination Design (CoorD) to look for "coordination patterns in work practices". His aim is to "attach IT systems in use" to domain-specific coordination mechanisms. Five steps compose this "methodology-based approach": contextual inquiry, task analysis, domain modeling, rule creation, deployment of coordination rules.

(Schmidt & Wagner 2004) argue that cooperative work in an AEC project can't be defined as an overall process. "The actors not only interact by changing the state of some part the world", but "in a highly distributed manner" through many coordinative practices and artifacts.

2.2 Sustainable construction practices analysis

Sustainable building construction projects are specific contexts and, according to (Matar et al. 2008), there is a need to define "sustainable construction practices that can be practically engineered in construction projects". This part of the state of the art introduces studies focusing on sustainable construction practices. The objective is often their analysis to understand and improve them.

(Arditi et al. 2002) and (Pulaski et al. 2006) identify "constructability methods that increase inputs from construction professionals during design and construction" through the concept of Constructability Practices. They define which issues arise, when in the project they arise, how they are resolved and including which members.

(Vanegas 2003) proposes a roadmap for implementation of the sustainability in the built environment at three levels: the strategic, the tactical and the operational level.

(Cole 2000) highlights the benefits obtained (e.g. environmental and economic) by the adoption of "good construction practices". His study focuses on the assessment of such construction practices.

(Matar et al. 2008) introduces the Operational Context Space (OCS). This original approach aims at facilitating the association of responsibility by assigning each sustainability requirement to specific actors and during specific project phases.

2.3 Software and HCI adaptations

The most frequently identified issue for construction industry is "related to collaboration and particularly Web-based collaboration and project management systems followed by integration of software tools across the project lifecycle" ((Froese et al. 2007) cited in (Shen et al. 2010)). As the final objective of our research is the adaptation of IT services, we finally consider the field of software engineering and HCI design.

In the domains of knowledge management, social computing and virtual communities, (Soulier & Lewkowicz 2006) propose a descriptive modeling for the simulation and assistance to business collaborative practices. By integrating physical, social and cognitive aspects they define seven models based on real-time information gathering (agent, activity, object, context, time, knowledge and communication).

In the software engineering domain, (Constantine 2006) introduced the usage-centered design based on three principal abstract models which guide the process of an adapted design of user interface (role, task and content models) and two surrounded models (domain and operational models).

(Riedemann & Freitag 2009), usability engineers, developed some techniques and tools for modeling usages. They express through use scenarios in tabular notation, the conversational style of user action and system reaction. “Use scenarios are an effective technique for modeling usage based on the concept of tasks”.

Over scientific literature and conceptual approaches we also consider practical case studies of ICT use within a professional context.

2.4 Statement

The different parts of the state of the art highlight the following issues:

- There is a need of methods to evaluate “best practices” in collective activities like automotive industries, architecture projects…
- The sustainability quality of a building deeply relies on the implementation of sustainability in business practices, from decisions making to construction operations.
- Analyzing and characterizing business practices are useful to enhance IT services development in order to assist such practices.

3. MAIN ISSUE AND DEVELOPED APPROACH

Considering the issues presented in the state of the art analysis, the following study presents an original approach to identify business practices in AEC projects and IT services to support them. The aim of this structured approach is the composition of an integrated method to propose adapted IT services for actors of the construction sector. It consists in two major challenges (see also figure 1):

- Understanding and characterizing collective and individual practices in AEC projects to identify corresponding needs (section 4). The objective is here to define atomic business operations that will be performed through IT. This model-driven approach consists in describing collaboration processes with recurrent and reusable concepts.
- Understanding and characterizing appropriate usages depending on adopted technologies to propose adapted IT services (section 5). The objective is here to take in account the context of execution of the business operations. Recurrent concepts are also used to describe usages and are linked to services properties in order to adapt them in an efficient way.

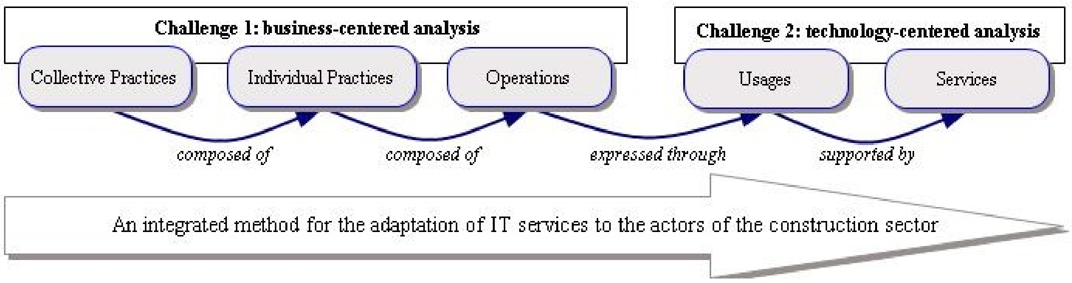

Figure 1. Schematic representation of the study

Model-Driven Engineering methods (Favre 2004) will help us to conceptualize our analysis. Each concept will be illustrated by a scenario example in the field of sustainable design.

4. CONCEPTUALIZING BUSINESS PRACTICES

Considering collective motives in AEC projects, the first sub-section develops the concept of Collective Practices. A second sub-section introduces the concept of Individual Practice, defined by business individual goals and performed by each actor according to their role. At the last step of the decomposition, come the business operations, introduced in the third part of this section. For each part, an example will illustrate the approach.

4.1 Identifying Collective Practices to understand business motives

A practice can be defined literally as "the exercise of a job" or "a way to work, a habitual behavior with finality". According to (Kubicki 2006), the collaboration is the result of formal activities within a hierarchical structure whereas during cooperation, relations are more informal and less structured. Because this characterization can vary from a situation to another, we don't take position and define practices as Collective, grouping both Collaborative Practices and Cooperative Practices under a single one. Then, considering a collective work context (here, AEC projects) we define Collective Practices as activities in which (at least two) actors are involved, working together with a common objective (or finality), according to project-specific business activities and with project-specific artifacts to manipulate. We distinguish the actors through their organizational role in the project. The activity is defined by the tasks, the phases and type of project to which the CP is linked. The artifacts are all documents, objects, messages… that support the collaboration (Borstrom et al. 1995). The meta-model represented in figure 2, illustrates this description.

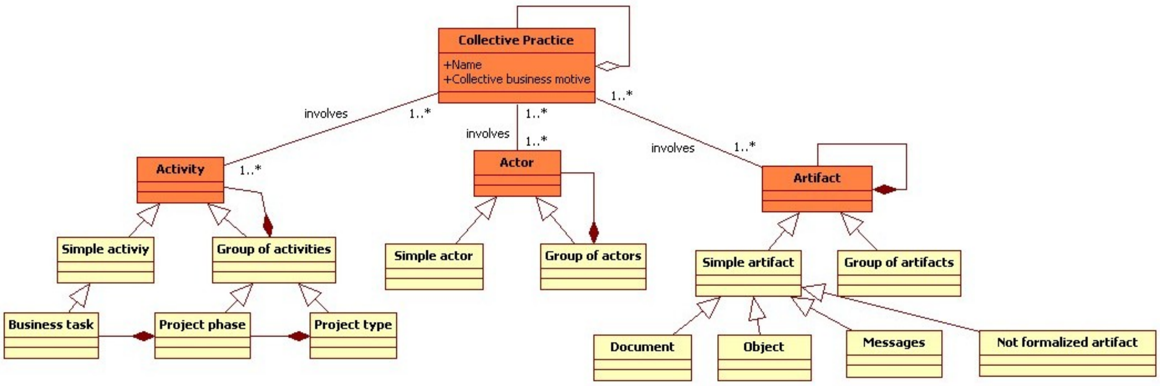

Figure 2. Collective Practices Meta-Model (CPMM)

The study of sustainable approaches and standards like HQE, BREEAM, MINERGIE and DGNB (http://assohqe.org/hqe/; http://www.breeam.org/; http://www.minergie.com/home_en.html; http://www.dgnb.de/_en/) provides a global overview of a project process, a precise description of the roles played by the actors (or the role they should play) and a precise description of the objectives to reach as well as their needs.

From this analysis, we identify five general objectives to be reached by the actors of an AEC project, and especially with a sustainable design approach. They generally collaborate to:

1. Ensure the quality of the building: it includes both conceptual and technical choices. This objective can refer to focused requirements like limited impact on environment with reduction of energy wasting, use of green materials…
2. Ensure the user's comfort: this objective also concerns conceptual and technical choices but focuses on thermal, acoustical or visual aspects. It also includes quality in terms of security or accessibility.
3. Ensure the economical efficiency: within their choices, actors must control the budget but also ensure the flexibility and adaptability of the building.

4. Ensure the quality of the site: according to localization and linked risks, environment quality, connections to transports, services, infrastructures…
5. Ensure the socio-cultural quality of the project: this objective concerns the impact of the project on population, administrations…

Through a brainstorming with professionals, we have been able to identify what they usually perform to achieve these objectives. A set of eleven families of CPs (also called generic CPs) has emerged: (CP1) Site choice and assessment, (CP2) Designer determination, (CP3) Objectives determination, (CP4) Budget determination, (CP5) Design and reporting, (CP6) Contractors determination, (CP7) Design assessment and reporting, (CP8) Meetings organization and reporting, (CP9) Execution preparation and management, (CP10) Execution assessment and reporting, (CP11) Users' awareness. Each one can be specified depending on the requirements to achieve (e.g. (CP6.1) Consultation folder elaboration and (CP6.2) Contractors recruiting, or (CP7.1) Analysis of requirements respects and (CP7.2) Thermal simulation). Then, one can also observe variants from a project to another.
As introduced in the chapter 3 of this study, the aim of the identification of such CPs is to gather information about the way to collaborate in specific contexts. The following examples of CPs are certainly simplistic but realistic as they were observed in real projects. Different phases of project's lifecycle are considered.

Examples: We briefly introduce here three of the CPs that can be observed in an AEC project: 1) During the determination of the site, owners have to gather different analysis like the nature of the ground, the inundation risks, noises possibility but also networks access… To obtain this information, they have to collaborate with many competent organizations (land surveyor, administrations…). 2) To execute sustainable building construction, contractors must be particularly competent and their determination is important. Then, the "elaboration of the consultation folder" and the "contractors recruiting" are two important CPs involving owners and designers at the end of the design phase. When necessary, owners' assistants are also involved. 3) During the design phase, owners may require specific assessments of the project. The "thermal simulation" is one the many CPs identified as "design assessment and reporting" practices. Sometimes, designers perform their own analysis but to obtain a certification, owners may need assessments from experts. Table 1 illustrates a possible description of this CP in a more formalized way.

<table>
<tr><td>CP 7.2</td><td colspan="2">Thermal assessment and reporting</td><td>Variant 2</td></tr>
<tr><td colspan="4">Description</td></tr>
<tr><td colspan="4">The owner assistant obtains and sends design documents from designers to expert for assessment. Then he consults the report and finally asks the owner to validate it. If the report contains modification requirements, the designer must be informed to take them in account.</td></tr>
<tr><td colspan="2">Actors</td><td>Artefacts</td><td>Activities</td></tr>
<tr><td colspan="2">Owner, Owner assistant, Designer, Expert</td><td>Design documents, assessment report, request and notification messages</td><td>Public building project, conception phase, coordination and evaluation tasks</td></tr>
</table>

Table 1. Possible description of the CP "thermal assessment and reporting"

At the end of this step, one can understand Collective Practices as well-defined situations but can't know what each actor has to perform exactly. This is the object of the next sub-section.

4.2 Identifying Individual Practices to understand business individual goals

The challenge of this part of the approach is to distinguish business needs from an actor to another. It consists in decomposing a Collective Practice (CP) into Individual Practices (IP) characterized by business individual goals. Each actor is "responsible" of his own IP, depending of his role in the project. When performing it, one actor uses and/or produces specific artifacts. Because it is necessary to trace these artifacts (to know the work executed), they have some properties: a name (which can be normalized), the author(s), the date(s) of creation and/or modification, the version… The meta-model in figure 3 illustrates this decomposition and characterization. The characterizations of the concepts already defined in the CPMM do not appear in the IPMM (e.g. simple actors/group of actors; simple artifacts/groups of artifacts…). However, they exist through the dependency between CPs and IPs.

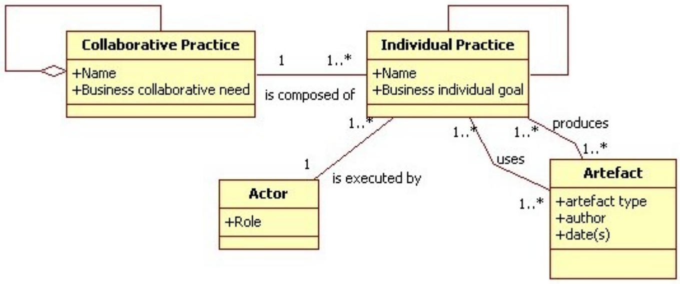

Figure 3. Individual Practice Meta-Model (IPMM)

At this step, we can define CPs as processes of IPs succeeding each other. This is illustrated in the following example, considering the CP “thermal assessment and reporting” introduced in 4.1.

Example: The CP “thermal assessment and reporting” is composed of the following Individual Practices:

- IP1: The designer produces the appropriate documents for assessment
- IP2: The owner assistant submits these documents to the Experts agency for assessment
- IP3: The expert agency performs the assessment
- IP4: The owner assistant analyses the report and submits it to the owner for the last validation or to the designer for modifications if needed.
- IP5: The owner has to validate the assessment report when approved by his assistant

The diagram (figure 4) illustrates the execution of these IP by each actor. Each artifact produced by one IP is used by the following (e.g. plans produced by IP1 and used for IP2 and IP3).

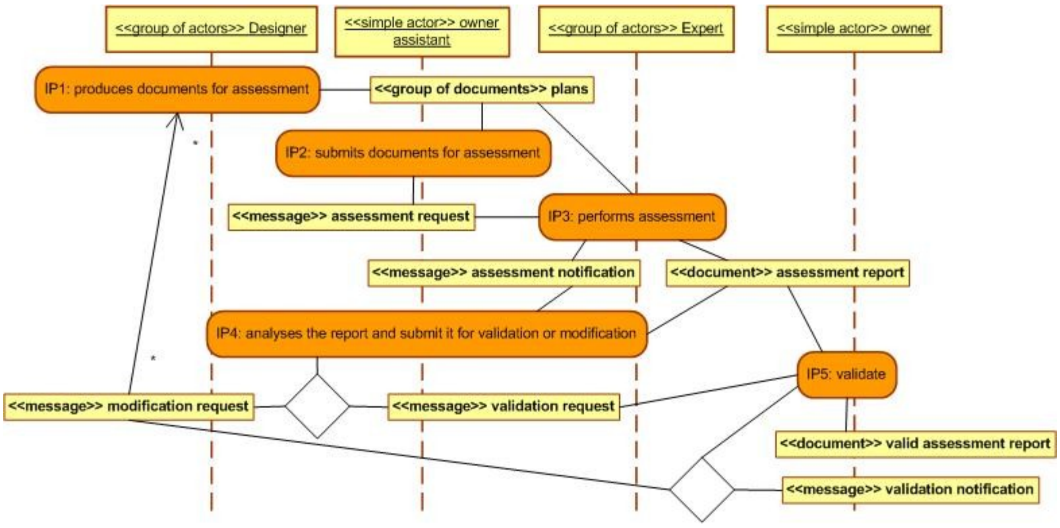

Figure 4. Graphical representation of the CP "Thermal assessment and reporting"

When they perform their IPs, actors execute some atomic tasks that become automatic and implicit. The next sub-section will introduce this concept that we call operations.

4.3 Identifying operations to understand technical individual needs

As we identified CPs as processes of IPs, IPs can also be decomposed in atomic operations. In other words, IPs can be defined as sub-processes of operations that will be expressed through Information Technologies in Construction (ITC). In order to classify these operations, we use the four “information process activities” defined by (Björk 1999):

- Person-to-person communication: *contact, advertise, ask for something*
- Edition of information: *create, modify, upgrade, delete*
- Information search and retrieval: *get, consult, identify, verify*

- Making information available: *share, comment*

The Operation Meta-Model (OMM) proposed in figure 5 is an evolution of the IPMM.

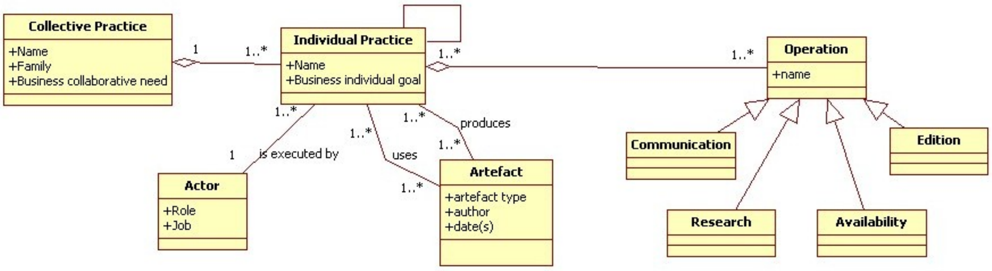

Figure 5. Operation Meta-Model (OMM)

Example: The owner assistant identified in 4.2 as "submitting documents for assessment" (IP2) performs several operations to achieve this IP:

- He *gets* appropriate documents from the designer
- He *shares* these documents with the expert
- He *asks* the experts for an assessment

His operations are different when he "analyses the report and submits it to the owner for the last validation or to the designer for modifications if needed" (IP4):

- He *gets* the assessment report
- He *consults* the assessment report
- He *identifies* if there are modifications to bring to the design
- He *comments* the report (optional)
- He *shares* the report to both designer and owner
- He *asks* the designer for modifications or the owner for validation

A graphical illustration of the operations performed (cf. diagram of IPs, figure 4) could be representative. The most relevant issue consists in a tool-supported generation of such diagrams, based on the recurrent concepts identified. This outcome will be discussed in conclusion of this study.

The next section of this study will focus on the "way to perform" such business operations through the concept of usage.

5. ADAPTING IT SERVICES TO BUSINESS NEEDS

The second challenge of our approach is the definition of adapted IT services considering the business analysis performed above. This part is still in an early stage.

5.1 Identifying usages "expressing" business operation

Our method of services adaptation doesn't focus on the users themselves but on their business operations and how to accomplish them. That's why we situate our study closer to a usage-centered approach than to a user-centered one (Constantine & Windl 2003). Then, it is a model-driven approach, limiting inputs from users themselves. The following description of a usage includes the reinterpretation of Constantine's concepts.

A usage can be defined in a general way by "the use of something to fulfill personal needs". It has an instrumental value and proposes solutions for how to perform things. While the concept of "use" refers to a process, a method (e.g. following a user's guide), the usage refers to the appropriation of something by a person, depending on his context(s). One can say that a usage "expresses" one or more operations (i.e. operations are expressed through usages).

Until now, we have considered actors as project participants with their own organization role. When, these actors become IT users, they have to be identified (e.g.. they have a user ID) and they have more or less limited access rights to project information. Then, their usage depends on their physical environment (localization, noise, luminosity, people around…) and the device that they use (device type, mobility, input technology, output technology, connectivity…).

According to (Constantine 2006), usages may also have some characteristics to consider, like the frequency, the regularity, the duration, the volume of information…

The last concept, well-defined in CSCW research (Johansen 1988; Baecker 1993), characterizes the dispersion between several usages, i.e. the time dispersion (synchronous vs. asynchronous usages) and the geographic dispersion (distributed vs. non-distributed actors).

The Usage Meta-Model (UMM) proposed in figure 6 illustrates these concepts.

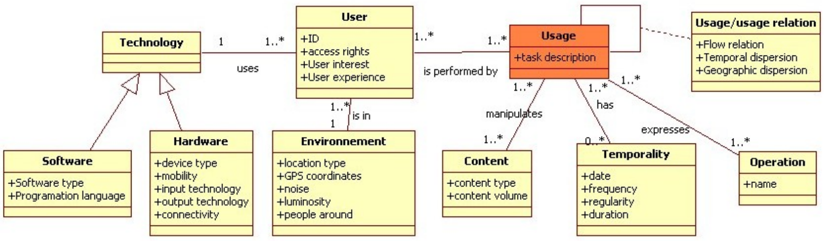

Figure 6. The Usage Meta-Model (UMM)

The following example refers to a hypothetic scenario based on our own knowledge of the field; more enquiries could help us to define more realistic ones.

Example: For all the operations identified in 4.3, we assume that the characteristics of the usages performed are constant: frequent usages (because many assessments have to be performed in a sustainable building project), but short usages with little information to deal with (some design documents and reports). However, the environment and the device used can vary. For example, the owner assistant may want to get and consult the assessment report then identify problems while he is away from office (e.g. in train, in waiting room, etc…). He may own a tablet: a mobile device with a touch screen, with an internet connection (depending on the situation). To share and moreover to comment document, he may prefer to be at office, where he uses a personal computer with bigger screen, keyboard, mouse… and where the environment is more favorable. Regarding the usages of his collaborator (e.g. the expert who will send the report, the owner who will get the report to validate…), they are executed asynchronously and in a different place.

As operations and related usages are identified, one can propose adapted services to support them.

5.2 Identifying services adapted to operations and usages

One can give several definitions to services, depending on the domain of application. According to (Kohlborn et al. 2009), we have defined business services (through the concept of IP and the corresponding operations), i.e. "a specific set of actions that are performed by an organization". The objective is now to propose software services which "support the execution of business services" and "describe part of an application system which can be consumed separately by several entities".

A software service is defined as functionality (atomic service) or a set of functionalities (composite services) provided by a service provider and executed through technologies (software and hardware). They are used by a service consumer who brings data in input and wait for information in output. Some constraints involved by usages will limit the functional aspects. Then, several non functional aspects like the quality or the price must also be taken in account.

Two objectives characterize this adaptation of services: the first is an identification one and the second an innovation one. Indeed, many services already exist and can be proposed to support business operations and usages. However, some services must be modified, enhanced or invented.

In all cases, each property of an adapted service should be relied on operations and usages identification. The following example aims at illustrating this adaptation based on the operations and usages defined in sub-sections 4.3 and 5.2.

Example: In most cases, actors and organizations have their own tools to manage information. Most observed ones are file servers. Documents are produced and read by CAD tools and text editors. Communication between organizations is mostly supported by e-mails. From our case study analysis, we know that the owner assistant needs to get information from designers, experts and owner, i.e. from other organizations that his one. He also needs to share documents with them or make some request and comments. In addition, he would like to get and consult documents like assessment report when he is away from office, using his tablet. Several solutions can be proposed to support his work: (1) a common set of services composed of text editors, file server and mails or (2) an innovative one based on a Document Management System (DMS) proposing several functionalities in place of the first set. Then, depending on the choice, the service sets could have the following properties (table 2):

Owner assitant business analysis					Services Set 1: Text editor + Files server + e-mails			Set 2: Text editor + Document Management System		
Collective practice	Individual Practice	Operations	Usage 1: "at office"	Usage 2: "mobile"	Functionnalities	Inputs	Outputs	Functionnalities	Input	Output
Thermal assesment and reporting	Submitting documents for assessment	*gets* appropriate documents from the designer	**yes**	no	receive mail, download from mail, depose on	mail ID, location on server, name of document	document retrieved	see document on DMS	DMS ID, document properties	document available
		shares these documents with the expert	**yes**	no	link document to e-mail and send e-mail	mail ID, document, expert e-mail adress	mail sent	give access to document	DMS ID, expert profile	document accessible
		asks the experts for an assessment	**yes**	no	send e-mail	mail ID, expert e-mail adress	mail sent	add request to document	DMS ID, request	request on document
	Analysing the report and submitting it to the owner for validation or to the designer for modification	*gets* the assessment report	**yes**	no	receive mail, download from mail, depose on	mail ID, location on server, name of document	document retrieved	see document on DMS	DMS ID, document properties	document available
		consults the assessment report	**yes**	**yes**	open and read document	location on server, name of document	document to read	open and read document	DMS ID, document properties	document to read
		identifies if there are modifications to bring to the	**yes**	**yes**	highlight elements	text parts	higlighted text parts	highlight elements	text parts	higlighted text parts
		comments the report (optional)	**yes**	no	edit new document	text edition	comments document	add reaction to document	DMS ID, comment	reaction on document
		shares the report to both designer and owner	**yes**	no	link document to e-mail and send e-mail	mail ID, document, owner/designer e-mail	mail sent	give access to document	DMS ID, owner/designer	document accessible
		asks the designer for modifications or the owner	**yes**	no	send e-mail	mail ID, owner/designer e-mail adress	mail sent	add request to document	DMS ID, request	request on document

Table 2. Definition of services sets supporting owner assistant's business operations and usages

Through the example illustrated in Table 2, one can see that:

- We can propose alternative solutions in terms of services definition, fitting with specific actors' needs. Here we proposed two sets of services supporting all the operations of an owner assistant (involved in a specific Collective Practice). One set is based on traditional tools whereas the second consider the use of a more innovative one.
- For any of the solution under consideration, we can specify it according to the different usages. This specification consists in choosing only useful functionalities and developing them. Here a technical solution should be developed for the owner assistant to open and read assessment reports while he is "mobile". Other mobile functionalities aren't necessary in this particular case.

Prospects of this method will be discussed in the next section.

6. CONCLUSION AND PROSPECTS

According to different issues highlighted by literature analysis, this study introduces the need for adapting IT services to professionals of the construction sector. We introduce a method based on a structured approach. This method is firstly composed of business-centered part, with the characterization and identification of Collective Practices, Individual Practices and Operations. Regular discussions with professionals allow us to analyze specific situations and partially validate our approach, but we still need a method to formalize this knowledge. As graphical representations are useful to illustrate practices, we are working on a tool to support their identification through diagrams editions, and assist our validation enquiries. This editor is developed with the Eclipse environment and particularly the GMF framework (Graphical Modeling Framework). Indeed, the GMF Tooling project provides a model-driven approach to generate graphical editors in Eclipse. Then second part of the approach, i.e. the technology-centered part, introduces with the specification of Usages expressing business operations and adapted Services to support them. The entire method is based on recurrent concepts. However, we are not actually sure that this amount of concepts is exhaustive. We have still to identify which ones are the more relevant to improve the characterization of practices and usages. Testing the method on various examples by proposing different services (through basic prototypes), we will be able to evaluate its relevance and originality. But considering the last step of the method, we still need to develop a more structured way to compare services and identify the most adapted ones.

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