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A need, no app: just do it! But do people support dynamic composition of interactive systems for fulfilling emergent needs?

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Abstract. In Human Computer Interaction engineering, both the context of use (<user, platform, environment>) and the user task (<goal, procedure>) are supposed to be set at design time. However, in ubiquitous computing, the context of use is dynamic, making user needs possibly emerge on the fly. As a consequence, there is a need to go beyond pre-computed User Interfaces (UIs) and to be capable of dynamically composing UIs for fulfilling such emergent needs. This paper relates a user study conducted for understanding to which extent dynamic composition of UIs can match user needs. The study consists of 26 qualitative interviews and 3 focus groups. It provides interesting insights for future research.

Key words: Ambient computing, User Interface, dynamic composition, social study, qualitative interview, focus group.

1. Introduction

In ubiquitous computing (Weiser, 1991), citizens are envisioned as being mobile, making their context of use (<user, platform, environment>) variable and possibly unforeseeable, as a result triggering opportunistic needs no application is devoted to. This evolution calls for tools capable of dynamically composing User Interfaces (UIs) for fulfilling such emergent needs. COMPOSE (Gabillon et al., 2011; García Frey et al., 2012) is a personal assistant that invites the user to specify his/her goal at anytime. Once the goal is specified (e.g., See a doctor), COMPOSE generates a UI that

provides the user with the *right* information and services in his/her current context of use. An early prototype has been implemented, making it possible to collect user feedback. This paper relates the user study we conducted for gathering user-centred functional and non functional requirements.

In the first section, we present a running example to serve as a support for illustration. Then we describe the qualitative study we conducted and report the outcomes and conclusions.

2. Running example

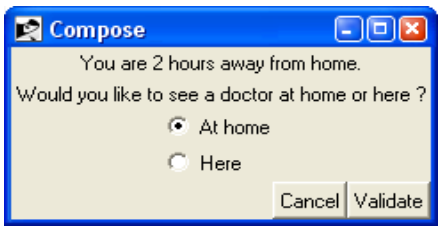
The running example is depicted from both the end-user and the designer perspectives.

2.1 User perspective: what has the end-user to do?

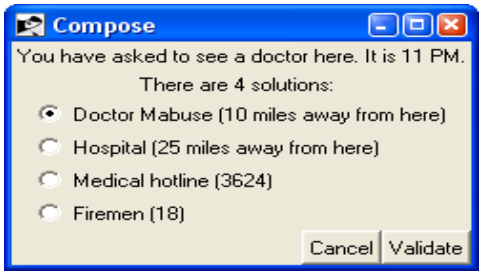
Victor lives in New York. He is on holiday in Philadelphia. Suddenly he does not feel well. He needs medical assistance. However, it is late in the evening and he is not familiar enough with the neighbours to call them for help. Fortunately, he has installed a system named COMPOSE that can be of help to him.

Victor specifies his goal "I would like to see a doctor" in natural language. COMPOSE tells him that he is 2 hours from home by car (Figure 1 a). Either he goes back home or he gets assistance here in Philadelphia. Victor prefers this second option. In turn, COMPOSE computes four solutions (Figure 1 b): the duty doctor (Dr. Mabuse, 10 minutes by car), the nearest hospital (Dapi hospital, 25 minutes by car), a medical hotline and the firemen. Victor prefers to see the duty doctor. COMPOSE composes a UI on the fly making it possible for Victor to call the Dr Mabuse (the number is preset), get guidance to reach the office (see the map) as well as the nearest chemist. Depending on the platform Victor interacts with, the resulting UI is not the same: Figure 1 c is displayed on a large screen versus Figure 2 appears on a smartphone.

(a) Two main options for getting medical assistance



(b) Four possible solutions given the current context of use



(c) The resulting composed UI on a PC

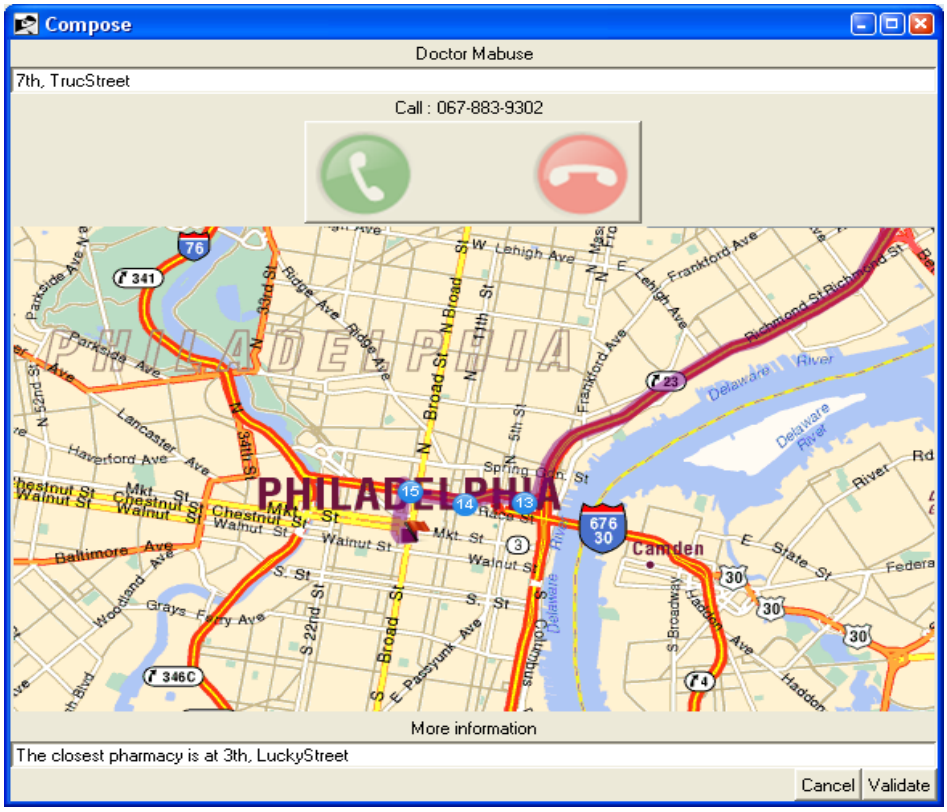


Figure 1. Three UIs dynamically generated by COMPOSE to fulfil Victor's emergent need: "To see a doctor".

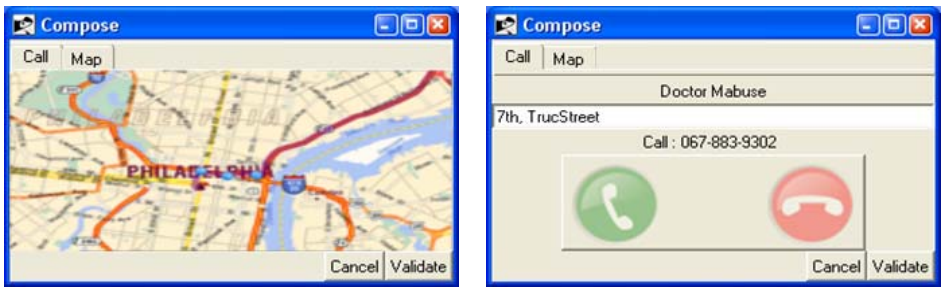


Figure 2. An alternative of Fig1c for smartphones. The sub-tasks are browsable through tabbed panes (Call and Map) instead of being directly observable. In addition, the information related to the nearest chemist is suppressed as not key.

2.2 System perspective: how does COMPOSE work?

From the specification of the user need by the end-user him/her self (e.g., See a doctor), COMPOSE generates a task model that refines the need into sub-needs. The computation process is based on a repository of fragments of task models. It takes the context into account for selecting the pieces to combine. Thus, depending on the current context of use, the task model may vary. Figures 3 and 4 present two variants of the task model for the "See a doctor" case study when running on respectively a desktop wall versus a smartphone.

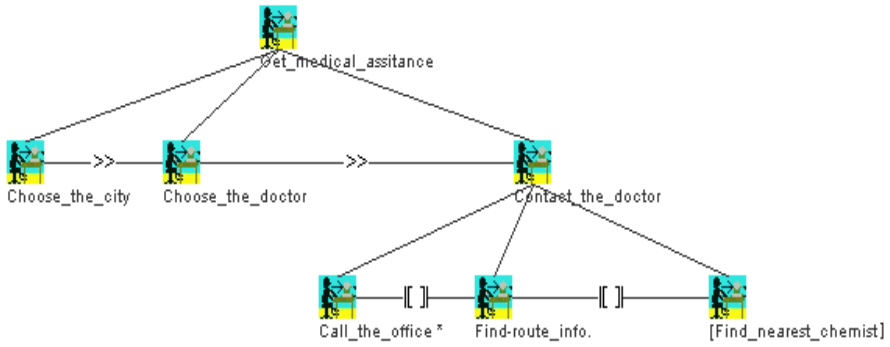


Figure 3. The task model computed for the large screen. The optional task "Find nearest chemist" is supported because the display surface is large enough.

In both cases, the user need is "Get medical assistance". The user has to first "Choose a city", then "Choose the doctor" and finally "Contact the

doctor". To "Go to doctor", the user must "Call the office" and then "Find route information".

On a large screen (Figure 3), he/she can also "Find nearest chemist". This subtask is supported because the size of the display surface makes it possible to display additional information relevant for the task such as the chemist. Both task models are depicted using CTT (Mori et al., 2002).

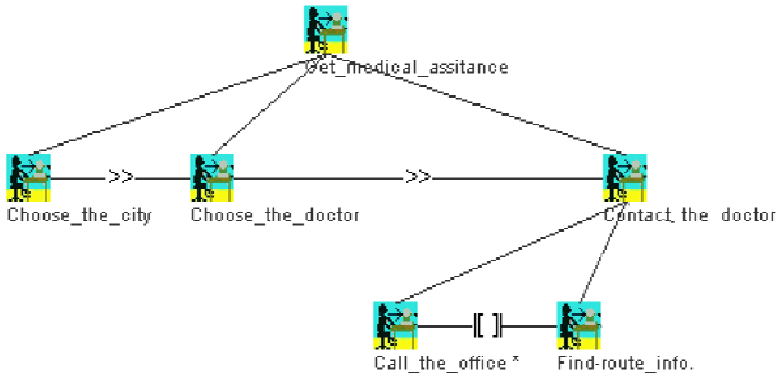


Figure 4. The task model computed for a small screen. The optional task "Find nearest chemist" is not integrated into the task model due to the small space on the screen.

The two next sections describe the user study we conducted to sharpen COMPOSE specifications.

3. Qualitative interviews

Semi structured qualitative interviews (Dey et al., 2006 ; Hindus et al., 2001) were conducted to promote open and free discussions. Qualitative interviews favor the emergence of ideas, opinions, or habits whatever their frequency is. The goal was not to quantify these behaviors or needs but to elicit a large set of ideas. Sociology recommends 20 interviews at least. Practice shows that beyond 20 interviews, new and original ideas are rare.

3.1 Protocol

The interviews involved 26 persons of different profiles:

Age: 9 between 18 and 25 years old, 7 between 26 and 40 years old, 7 between 40 and 60 years old, 3 more than 60 years old.

Sex: 12 women and 14 men.
Professional status: 14 active, 9 inactive and 3 retired.
Professional category: 1 artist, 8 high level of responsibility, 4 medium, 2 employees, 2 workers, 9 students or inactive.
Living areas: 18 urban, 5 suburban and 3 rural.
The interviews lasted 1 hour per person in average (Figure 5).

Measure of knowledge about new technologies What do "new technologies" stand for? We say that "new technologies are everywhere". What do you think about that? Do you use new technologies? If yes, which ones and for which purpose? Measure of perception of new technologies Please mention examples of new technologies? Do you use such objects? Measure of knowledge about online services Do you use online services? What advantages and disadvantages do you identify? Measure of new technologies usefulness Have you ever been in a difficult situation that could have been solved by using new technologies? Which tools? Compose What do you think about COMPOSE? Why? Could you elicit interesting situations COMPOSE could contribute to solve? Tolerance towards errors To which extent would you accept errors? How many questions would you accept to answer to get the right answer?

Figure 5. Main qualitative interview questions.

They started by measuring the knowledge of participants in new technologies, their habits towards computers, Internet and ambient computing. Progressively, discussions were focused towards COMPOSE. The participants were invited to remind difficult situations in which they would have appreciated the help of COMPOSE. A mock-up of the case study "See a doctor" was finally presented to materialize the concept of assistant able to fulfil opportunistic user needs. The participants asserted about the system relevance, the expected functions, desired quality and interaction modalities.

3.2 Results

The study shows that COMPOSE is globally appreciated whatever the user profile is (23 subjects over 26 have a positive opinion towards COMPOSE). The system has been judged as useful by inexperienced participants as well as by computer experts. There is nearly no difference between those profiles. However we noticed that novice users in informatics would appreciate a daily simplification: COMPOSE appears as key in emergency situations as well as in daily interactions with computers.

The case study "See a doctor" is appreciated by most of the users: "*It is the whole bit to find an on call doctor. It's great if it works*". Other case studies have been suggested such as the petrol failure or a problem abroad. Surprisingly COMPOSE is also appreciated in daily situations: administrative assistance, renting paperwork, technical help etc. "*I have problems using my software. I will have a tool to guide me*. […] *The disk is full. COMPOSE will suggest me which files to delete*. […] *A video or sound file is too big. I don't know how to zip it. I don't know how to evaluate the quality. COMPOSE has to tune the parameters, to zip files, etc.*"

The study shows that people prefer text-based UIs (24 subjects over 26). Only some of them are in favor of oral or question mode.

In addition, we learn that subjects would fairly accept interpretation mistakes or answer inabilities. Personal assistants don't have a unanimous answer: it may not match with the question. The request specification could be slow and tedious. "*All the assistants I used were crummy. They didn't work. I didn't understand anything"*. "*The answer never refered to my problem"*. On the other hand, if the answer is correct, people are ready to answer more questions in order to get a better score. *"I will answer 20 questions if I get the right answer*".

An additional outcome of the study is that participants do not trust commercial systems. They wish to know if the services that are used are profit-making or not. The subjects claim for a quality label to certify the services quality: "*a certification for the payment, a seriously and reliable certification of the sites*". "*The information should be reliable*". They would like to screen out the services according to the quality labels.

4. Focus Groups

Focus groups (Bruseberg and McDonagh-Philp, 2002) are a form of qualitative research. People were asked about their perception, opinions, beliefs and attitudes towards COMPOSE. Questions were asked to an interactive group setting which participants were free to talk with other group members. Focus groups aim at making scenarios and user needs emerge.

4.1 Protocol

Three focus groups were organized: one with computers students; two with citizens. The first group was composed of 9 students: 2 women and 7 men; 22 years old in average; 5 among them had experience in web sites development. The second group was composed of 7 people: 4 women and 3 men; 36 years old in average; 2 among them had experience in web sites development. The third group was composed of 8 people: 4 women and 4 men; 43 years old in average; none of them had experience in software development.

Among the three groups, the participants used computers for professional as well as private purposes. Only four limited usage to private situations. All were familiar with email. The first group (the computer students) largely used Internet. The general public mainly used Internet for email, touristic and administrative information. The discussions and forums were familiar to young people (students group) only.

Each focus group lasted 2 hours and 30 minutes. The participants were first asked to describe how they organize a quick removal: nothing is foreseen so far and the removal will take place in two weeks. Then, grouped in pairs, the participants were shown a problem scenario (e.g., “See a doctor”). They had to elicit the necessary information to formulate their request and then think about the expected results. Then they outlined their favorite UI to specify the request and look at the results. Each group presented its scenario and mock-ups to the group. These discussions made emerge unexpected needs.

Finally, four types of interaction modalities were presented to the participants (Figure 6): natural language (a); constrained natural language (b); sketch (c); iGoogle (d). The results are presented below.

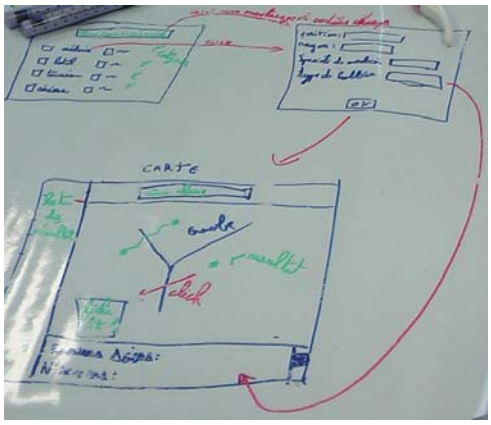
(a) Natural language

(b) Constrained natural language

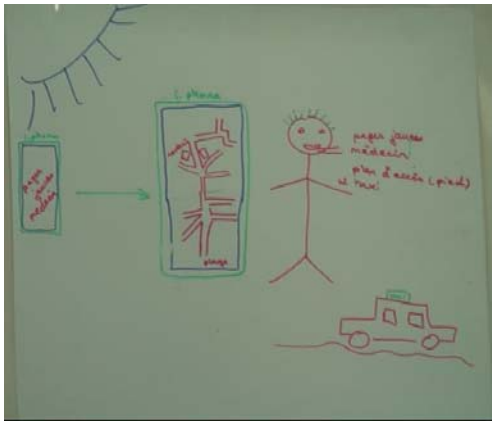
(c) Sketch (SketchiXML; Coyette and Vanderdonckt, 2005)

(d) iGoogle

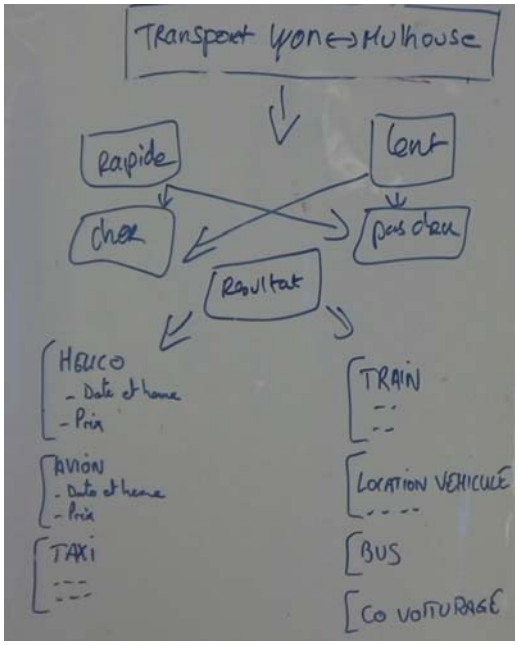
Figure 6. The four UIs shown to the participants to discuss about interaction modalities.



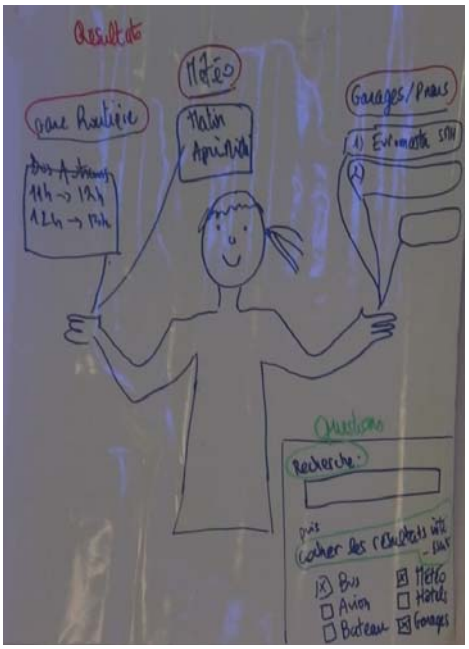
a) UI that looks like the UI of figure 1.



b) UI for a public display.



c) UI that allows selecting more options.



d) An avatar-based UI for interacting with the user.

Figure 7. For example of mock-ups made by subjects during the focus group.

4.2 Results

Figure 7 shows four different mock-ups of UIs made by subjects for the « See a doctor » running example. The first mock-up looks like the UI used for illustrating the case study (Figure 1). The second mock-up reduces the number of proposed services because the system is used on a public display. The third UI supports the selection of optional information such as the cost of the services. The last one uses an avatar speaking to the user.

Table 1. Quality, goal and context of use.

Topics		Number of quotes
Quality	Adequate answer	9
	Simplifying tool	8
	Performance	4
Goal	Focused search	11
	Emergency	5
Context of use	If "easy to use"	3
	If "adequate to the users needs "	4

The favourite interaction devices are the classical devices such as the screen and the keyboard (Figure 8). The sound-based devices were chosen by one of three persons. Exotic modes were mentioned seldom (somewhat by the 20-25 years of age), probably because of lack of habit.

	Nb
Screen	19
Keyboard	14
Audio	8
Mouse	8
Microphone	7
Stylus	4
Tactile	2
Thinking	2
Webcam	2
Motion detection	1
	24

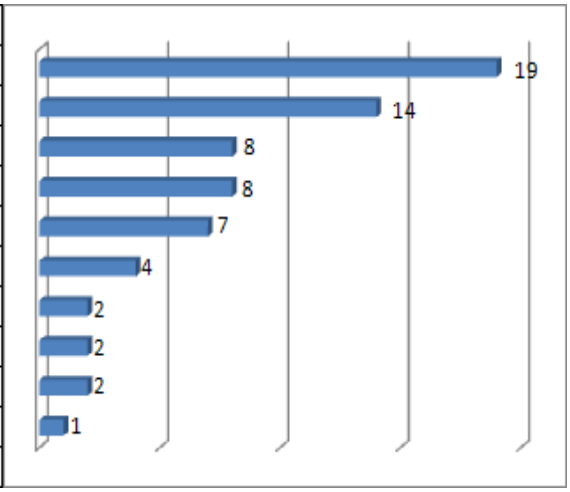


Figure 8. Favourite interaction devices.

The subjects massively preferred the natural language. 23 of 24 ranked it as 5 or more over 10 (Tables 2 and 3).

Table 2. Average, standard deviation, number of marks greater than or equal to five and number of marks less than five (marks on 10).

	Average	Standard deviation	≥ 5	< 5
Natural language	8,2	2,1	23	1
iGoogle	7,2	2,5	20	4
Constrained natural language	5,0	2,7	14	10
Sketch	2,5	2,1	5	19

The manual selection of services like in Google is also appreciated (20/24). Natural language is appreciated by a majority to refine the request and, therefore, specify the answer. The number of additional questions for narrowing a demand doubles between normal and emergency situations (5.2 questions versus 2.5). However, for some people, successive questions convey a lack of quality: "*a well designed system should not ask additional questions. Additional questions give the feeling of a badly designed system*".

Table 3. Marks of four types of interaction preferences.

Marks	Natural language	Constrained natural language	Sketch	iGoogle
0-1	1	4	12	1
2	0	2	4	0
3	0	1	1	2
4	0	3	2	1
5	1	3	2	0
6	1	2	1	4
7	3	5	2	4
8	6	3	0	3
9	4	0	0	3
10	8	1	0	6
Total	24	24	24	24

In addition to interaction preferences, people have expressed functional needs. For example, a composition explanation has been massively requested: people would appreciate to understand how the UI is composed by COMPOSE. They also would like to store the UI in order to reuse it later on.

5. Related work

The study exhibits user requirements for future research in Human-Computer Interaction and other communities.

For example, UI generation (Gajos and Weld, 2004 ; Nichols et al., 2008) has been investigated for long. In the past, the purpose was roughly to generate UIs at design time based on a task model in input. UIs were mostly form-based, made of simple widgets (e.g. radio buttons, labels).

Later on, pushed by ubiquitous computing, UI generation was re-investigated (Myers et al., 2000) driven by three main new challenges: (1) a generation at run time, (2) capable of recruiting tuned components for going beyond "fast-food" UIs, and (3) put under the control of the end-user. The work is still in progress. It is mostly addressed along a forward engineering process based on task descriptions.

At the concrete UI level, ComposiXML (Lepreux and Vanderdonckt, 2007) explores the composition of two concrete UIs. It defines a set of operators such as union and difference to create new UIs from existing descriptions. The composition is performed at design time with homogeneous descriptions only (i.e., concrete UIs).

Mashups (Lin et al., 2009) also perform a composition at the concrete level but data driven instead of task driven. The composition is pre-computed at design time and placed under the control of the end-user to display the relevant data and services on the fly. The context of use is not taken into account.

Other works focus on the context of use and the UI distribution among a set of platforms (Nichols et al., 2006). UI (de/re)composition and tailoring (Grolaux et al., 2005) allow the user to manually control the UI distribution among the available windows and platforms (Stuerzlinger et al., 2006). The user manually extracts parts from the UI or conversely imports other ones into the UI. Sometimes this is done by the system (Paternò et al., 2008).

Composition is not limited to Human-Computer Interaction. Other communities such as Web Services (Peer, 2004; Traverso and Pistore, 2004) explore this topic as well. However, they deal with design time only. Their scope is limited to the functional core: they do not address the UI.

Some other works deal with the connection between the functional core and the UI (Dery-Pinna et al., 2003). Based on the functional core composition, they infer requirements for the UI composition. Again, the work applies at design time only.

5. Conclusion

To sum up, the lessons of the study are that:

1) COMPOSE is globally appreciated by users whatever their profile is. It is mainly seen as a simplifying tool. Most people expect a gain of time and comfort;

2) Surprisingly COMPOSE is also appreciated in daily situations such as administrative assistance, renting paperwork or technical support;

3) The case study "See a doctor" is appreciated by most of the users. However other valuable case studies were suggested such as the petrol failure or a problem abroad;

4) Users claim for a quality label for services. In particular, they wish to know whether the services that are used are profit-making or not;

5) Explanation of how the UI is composed was massively requested;

6) From an interaction point of view, people are ready to answer additional questions so that to get the right answer;

7) Users prefer natural language and classical devices such as screen and keyboard for interacting with COMPOSE.

6. Acknowledgements

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