Co-construction of sustainable collaborative practices in a smart neighbourhood: a methodological approach for analysing the future sharing of resources

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This paper exposes a prospective methodology for anticipating scenarios and collaborative practices in a Smart and Collaborative Neighbourhood. We aim to identify the conditions necessary for the acceptance of such a socio-technical system, and focus on the co-construction of sustainable collaborative practices by analyzing communicative interactions and collective decision-making processes. Our global approach respects the three foundations of Prospective Ergonomics. We first introduce the study of emerging practices in a collaborative housing project. Then, we discuss a creativity workshop we carried out in order to produce news ideas for scenarios. Finally, we discuss a tool we used to develop and test these scenarios: a collaborative serious game.

Keywords: Sustainable collaborative practices, Smart neighbourhood, Communicative interactions, Serious game

1. Introduction

A new economic paradigm is born: “collaborative commons”. Its emergence was possible thanks to the development of the Internet of things. This concept refers to new ways for people to create peer-to-peer networks and makes all activity potentially collaborative. People share intangible resources such as information, knowledge and leisure activities. They also share spaces, goods and products such as cars, homes, gardens and domestic appliances (Rifkin, 2014). This abundance of disconnected sharing modifies individual and collective activities. As objects and services are in common, the paradigm of their possession is itself replaced by the paradigm of their shared use. In this context, ergonomics aims to identify and analyse these new practices and their modes of organisation, including collective decision-making processes that allow people to co-construct rules of collaborative and sustainable consumption.

Our research aims to specify the design of a socio-technical system for sustainable collective management of resources. This system is the “Smart and Collaborative Neighbourhood”. We consider the “collaborative commons” paradigm from a prospective point of view, given the fact that it is currently only under emergence, focussing on the analysis of the sharing of resources in a hyper-connected neighbourhood. This is different from a smart grid because shared resources are not only energy or water. Our perspective suggests a new vision for future smart cities: 1) It assumes new models of collaboration between human actors and artificial actors, and 2) It assumes that the management of resources is based on intelligent agents.

Our study is included in a multidisciplinary project, involving research in cognitive ergonomics and in autonomic computing. Autonomic computing is a technology that can create new forms of collaboration (Kephart and Chess, 2003). This concept imagines computers capable of self-management in the matter of the human autonomic nervous system. An autonomic system has the ability of self-configuration, self-healing, self-optimization and self-protection. It can control resources like photovoltaic panels, electric cars’ recharging terminals or dishwashers. Depending on the environment that it perceives, it establishes a plan for this resource: turns it off, turns it on, increases its speed, etc. These are reasons why this technology should help us to model a smart neighbourhood containing intelligent agents named autonomic systems.

In this paper, we will present the prospective methodological approach that we are implementing to achieve our objective.

2. Research problematic

Firstly, it is accepted that Cognitive Ergonomics and Human-Machine Interaction research could contribute to the reduction of energy consumption (Bastien, 2012). In our model of the smart neighbourhood we project that actors will have collaborative practices as well as “green” practices. Interactions between people will exist because exchange of information, resources or services will be established. These interactions will be
between two extremes: entirely Humans Interactions, in the case where inhabitants reject autonomic systems; entirely Humans Interactions mediated by autonomic systems in the case where inhabitants let the system decide and let it inform other people about their actions. In addition, a first question emerges: which scenarios, collaborative practices, involving Human Interactions and Human-Autonomic systems Interactions could be anticipated?

Secondly, focusing on an innovation requires the investigation of the acceptability of such technology. The concept of acceptability concerns “whether the system is good enough to satisfy all the needs and requirements of the users” (Nielsen, 1993, p. 24). It is divided into social acceptability and practical acceptability. Practical acceptability combines utility (the system can achieve the purpose for which it is designed?) and usability (is the system adapted to the physical and psychological characteristics of the user?). Social acceptability refers to the social context in which the technology is used. Several social factors, such as social relationships that the individual maintains with its use behaviour, or the social environment in which the user is integrated, may influence the willingness to use an innovation (Terrade, 2009).

Social acceptability can be considered at two levels of analysis. The first level is the a priori acceptability of a technology. It concerns future technologies and innovations and assumes the fact that people are able to imagine new situations of use. The second level takes place when the technology is already introduced and aims to analyse the processes of acceptance of the system. A priori social acceptability seems to be the initial step for studying the adoption of the system. It considers that users will approve or not approve of the innovation, by having clearly identified what this use might change for their personal and/or professional activities (Bobillier-Chaumon, 2009). This is why a second question emerges: what are the conditions — the features of the socio-technical system — that are necessary for the acceptance of the system, namely, the acceptance of co-constructed sustainable collaborative practices, and how are these conditions organised? And because social acceptability concerns future technologies, tools and methods that can help to represent the future must be employed. These methods include creativity, scenario building and simulation (Robert and Brangier, 2009, Brangier and Robert, 2014).

3. Prospective Methodology

Our methodological approach is prospective (Robert and Brangier, 2009), given that smart neighbourhoods with their attendant collaborative practices does not yet exist and that autonomic computing is still at its initial stages of development. We consider the co-construction of sustainable collaborative practices to be similar to a collaborative problem-solving situation. People must find solutions together to consume resources better and to avoid waste, whilst respecting uses and needs of each. They will work together to develop rules of life, exchange rules and resource sharing rules, in a dynamic context (evolution of energy prices, purchases of goods for the community, etc.). Because events related to management of resources concern all users, analogous to a co-design process, we are interested in the integration of views and by the way in which people/designers jointly imagine solutions (Détienne, Baker and Visser, 2009).

We explore this co-construction process through the analysis of communicative interactions and, more specifically, collective decision-making processes involving deliberative and cooperative argumentation. Indeed, argumentative interactions produced in collaborative problem-solving can be constructive, in the sense of leading to co-elaboration of meaning and knowledge, and in the sense of fulfilling a specific role in the collaborative activity (Baker, 1999). Our global approach respects the three foundations of Prospective Ergonomics (Brangier and Robert, 2014). Step by step we: 1) study emerging practices, 2) use creativity to produce news ideas, 3) use tools of Ergonomics to develop scenarios and test them. This last step will involve a collaborative serious game.

3.1 Step 1: a study of emerging practices in a collaborative housing project

In order to identify emerging sustainable collaborative practices, we have conducted a study in a Collective Housing project. Collective (or Collaborative) housing is defined as “housing with common spaces and shared facilities” such as washrooms, food and newspaper subscriptions. The term refers to “housing that is oriented towards collaboration among residents” (Vestbro, 2012, p. 1). This situation is the closest to our target project. It has two main characteristics: communities formed are intentional, based on shared values and their decision-making process is consensual (Renz, 2006).
3.1.1 Presentation of the co-housing field study and data collection

The co-housing that hosted our field study comprises seventeen individual homes and about thirty people. The group is still developing and co-constructing its project (the persons involved did not as yet share housing). In order to aim at being successful, the group has organised itself into committees. Working in a (or several) committee(s) is based on volunteering as well as on the expertise and availability of each participant. Committees are dynamic. They appear when there is a need for them and disappear when topics are closed. As examples, the architectural committee deals with the relationship with the architect and choices of green building; the finance committee looks for investors; the energy committee seeks for what is the best amongst ecological materials, etc.

The group meets one weekend per month, to collectively develop the project. Committees report on their work during these meetings. People debate each idea (some of them requiring additional work, to be discussed in the following meeting) and the entire group makes decisions based on the model of “Sociocracy”. “This term refers to a mode of decision-making and governance that allows an organization to self-organize and to behave like a living organism” (Buck and Edenburg, p. 2). All components of the organization may exercise power with respect to the management of the main organization. Sociocracy respects four rules inspired by systems theories: 1) consent, 2) election of members for a specific function or a mission, 3) organization in circles, each pursuing clearly identified goals and each having their own policies, 4) the double link: a circle is connected to the circle immediately higher thanks to two people who are in the lower and the higher circle (Buck and Edenburg, 2004). For all meetings, the group names a facilitator, a person who distributes speech turns, a person who monitors time, and a reporter (who takes minutes).

During two days, we videotaped one meeting of the group. This was participatory observation because we integrated and lived with the group during the weekend. The first day, the assistant for the management of the project was present. This was a professional person that the group hired a few months earlier. We used two opposite cameras to film the entire circle, and collected more than 25 hours of videos.

3.1.2 Data analysis

We first transcribed exchanges between group members. Then, we analysed the communicative interactions. Our analysis methodology derived from a study of a collaborative design situation in architecture in which three designers were engaged in a discussion (Baker, Détienne, Lund and Séjourné, 2009), given similarities between the two types of task-oriented and creative discussions.

Analysis has allowed us to study both the co-construction of the project (the “technical” aspects) and the co-construction of how people must behave towards each other. For these two aspects, we wanted to relate: 1) an enunciative dimension, that is, the persons or groups of people whose words are reported by speakers; 2) an argumentative dimension, relating to reporting views and expertises of each, to reporting obstacles and constraints resulting in rejection of an option, and to reporting of shared values. In fact, these are reasons for adopting (or not) an option, which lead people to consent or not; and 3) an epistemic dimension, relating to proposed and debated solutions. It indicates what kinds of knowledge are evoked by group members.

Table 1 is an extract from our analysis. The first column is the number of speech turns. The second column indicates speakers. We use a letter to refer to who is speaking. The third column is for speech. The fourth column indicates enunciators, e.g. a person, a committee, a family whose words are reported by the speaker. The fifth column indicates the argumentative dimension. It is divided into two categories: the type of argument (Arg) and the related speech turn (Rel). The sixth column indicates the epistemic dimension. It is divided into two categories: epistemic activities related to the technical aspect of the project (Proj) and epistemic activities related to the social and collective (Coll) aspects of the project.

In the example (table 1), there are three different speakers (G, A and F). They discuss about the right moment to start a debate concerning information provided by the assistant of the project. This occurred on the morning of the first day; the assistant would come during the ensuing afternoon to bring news about construction plans. Because the group had decisions to make, they had to debate after the assistant’s intervention. They could choose to debate at the end of the first days afternoon or the next day, during the second day of the meeting. We note three enunciators (“voices” that are made heard by the people actually participating in the meeting): the entire group (Gr), the subgroup who planned the schedule (Sc) of the meeting and the building committee (ComB). For the argumentative dimension, P refers to the proposition (here the right moment to start a group debate); the question mark refers to a precision’s request; Arg+ and Arg- refers to arguments for or against the proposition; [+] and [-] indicates the acceptance or the rejection of
the proposition. For the epistemic dimension, BC refers to the subcategory “building choices for the project” and OrgM refers to the subcategory “meetings organisation”.

Table 1. Extract from the meeting analysis of the co-housing project

<table>
<thead>
<tr>
<th>N</th>
<th>L</th>
<th>SPEECH</th>
<th>E</th>
<th>Argumentative</th>
<th>Epistemic</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Arg</td>
<td>Rel</td>
</tr>
<tr>
<td>0530</td>
<td>G</td>
<td>After the departure of MA today we will have a collective debate to collect all the questions and the building committee will take these pieces of information to work on it</td>
<td>ComB</td>
<td>P</td>
<td>0</td>
</tr>
<tr>
<td>0531</td>
<td>F</td>
<td>Yes except that... Sunday at 14:15 we also have the return of shared information [with MA it is on Sunday at 2pm]</td>
<td>Gr</td>
<td>?</td>
<td>0530</td>
</tr>
<tr>
<td>0532</td>
<td>A</td>
<td></td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>0533</td>
<td>G</td>
<td>The return of shared information</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>0534</td>
<td>A</td>
<td>Yes but it's the same</td>
<td>0</td>
<td>Arg+</td>
<td>0530</td>
</tr>
<tr>
<td>0535</td>
<td>F</td>
<td>[to let us time for reflexion]</td>
<td>Gr</td>
<td>Arg-</td>
<td>0530</td>
</tr>
<tr>
<td>0536</td>
<td>G</td>
<td>Ah you prefer to make the collective debate about this on Sunday</td>
<td>0</td>
<td>?</td>
<td>0531</td>
</tr>
<tr>
<td>0537</td>
<td>A</td>
<td>Yes we planned it on Sunday</td>
<td>Sc</td>
<td>Arg+</td>
<td>0531</td>
</tr>
<tr>
<td>0538</td>
<td>G</td>
<td>Ok the point is that the building committee carries through group speak that's how we work so I remind you we make the collective debate and the Committee notes it and works on it after</td>
<td>ComB</td>
<td>[+]</td>
<td>0531</td>
</tr>
</tbody>
</table>

3.1.3 Contribution of this study for the continuation of our research

Analysis of both the co-construction of the project and the co-construction of how people must behave towards each other allowed us to design the rest of our study in the form of the organization of a creativity workshop. Because we are interested in how people will collaborate and make decisions together in the Smart and Collaborative Neighbourhood, we focused on the co-construction of the community and for example we highlighted the fact that rules concerning group deliberation are dynamic. We explain this point in the ensuing paragraph.

According to the rules of Sociocracy, the group makes decisions on the basis of consent, this being a somewhat flexible form of consensus. On one hand, consent does not require the participation of all. A person can leave the debate if (s)he is not interested in it, or feels not qualified to participate. On the other hand, any objection must be argued for. The person who rejected a proposition must contribute to finding a solution to his/her objection. This avoids saying “no” just in order to say “no” (Buck and Edenburg, 2004). Inspired by these theoretical rules, a few rules concerning group deliberation are: 1) speak only once during a debate, 2) speech turns follow a circle; people speak one after the other, 3) do not bring up again as debatable a decision that has already been made, etc. Observing a debate of the group, we understood that these rules are hypothetical. In fact, every question requires an adaptation of rules. For example, we noticed the speaker A questioning a decision made when he was not yet included in the project: “I think it’s a pity that the group chose to finally get rid of that thing, to sell it. So I know you have talked, you have already decided, but I thought there was a lot of people absent to make the decision and unfortunately today we are a few to make a decision like that. Maybe… I don’t know… I tell you what I feel, it’s a pity.” This questions whether a decision should remain definitive or not. In this example, other speakers agreed that a decision may be reviewed if the subject evolved since the decision. But this was not the case for this topic. This shows that rules of decision making are dynamic, with the possibility of being continuously reviewed by members. We considered these aspects for our future work. Indeed, during the creative workshop we conducted after the Co-housing study, we asked participants to imagine their rules of consensus.
3.2 Step 2: a one-day creativity workshop for generating scenarios

Prospective ergonomics uses several methods, including creativity methods for defining usage scenarios. In order to go further in identifying scenarios of collaborative practices to be implemented in a smart neighbourhood, we conducted a team creativity workshop. With this one day workshop, we collected 1) data on how each team had co-constructed sustainable collaborative practices and 2) ideas of scenarios to be implemented (possibly) in a serious game, for the continuation of our approach. Four teams participated in our workshop. Each team was composed of four students having distinct profiles: one student in business studies, one student in ecology, one student in design and one student in engineering. In each team, we planned to have at least two “gamers”, who often play video games. Students of today are the future potential inhabitants of smart cities. They are actors of the connected generation and users of the collaborative consumption services.

3.2.1 Presentation of tasks in the morning and data collection

During the morning, each team had to design a model of a smart neighbourhood that integrated group functioning rules based on a consensus process. The model created had to be a neighbourhood in which the participants would agree to live. Group creativity was stimulated by videos of smart cities, co-housing and collaborative consumption. Participants engaged in two tasks in order to create their model.

The first task was an individual brainstorming (writing). Participants had to imagine a Smart and Collaborative Neighbourhood by listing the maximum of ideas into ten categories: objectives of the neighbourhood, means of production/distribution of energy and water, shared resources, non-shareable resources, collaborative places, housing and infrastructures, exchange/monetary system, rules of consensus, the use of digital tools in the collaboration and events/unforeseen.

The second task was collective creation of a document that summarised 10 items on which the group agreed. Participants had to confront their individual ideas with those of other members of their team. Together, they had to write a collective document and they had to agree to develop a common vision of their Smart and Collaborative Neighbourhood. They were filmed during their exchanges of opinion. Figure 1 is an example of a team's production. For theme 2 (means of production/distribution of energy and water) the participants proposed self-sufficiency for electricity, energy redistribution in the district and between districts, as well as collecting rainwater. For theme 8 (rules of consensus), groups proposed the possibility of objecting to proposals, committees for technical decisions and procedures of election of representatives.

![Figure 1](image)

Figure 1. A part of a team production during the morning collective task at the workshop.

3.2.2 Presentation of tasks of the afternoon and data collection

In the afternoon, each team had to imagine functionalities of a collaborative serious game, profiles/characters of the game and scenarios. They had to take inspiration from their model created during the morning. We filmed the entire session. The first task was to individually create one fictional character. We expected characters to have a name, an age, a job, a family situation, hobbies, needs, a more or less
collaborative lifestyle and a consumption profile. The second task was to create small scenarios for the game. To do that, we used a convergence method. For each scenario, we asked participants to choose three to five ideas, each idea taken from different themes among the ten categories. They had to choose characters involved in their scenarios and they had to name and describe them.

3.2.3 Data analysis and expected results

Regarding video data, we transcribed exchanges between team members. Our analysis methodology is still in progress. We are building our analysis method from the “QOC” formalism (Questions, Options and Criteria) developed by McLean, Young, Belloti and Moran (1991). Questions are the ten themes we imposed, Options are ideas proposed by the participants for each theme and Criteria are arguments for assessing and comparing ideas. With these analyses, we aim to reveal, for each theme, the conditions that may have impact on the social acceptability of the socio-technical system. We seek to highlight the most important points to be taken into consideration for the specification of our system. We would then be able to test these crucial points using a simulation of the Smart and Collaborative Neighbourhood. Raw data of the workshop (documents, drawing, collective generating, etc.) will be used to create our simulation. We will use scenarios constructed by participants so as to implement them in a collaborative serious game.

3.3 Step 3: a serious game to test scenarios and analyse collaborative practices

Prospective scenarios will be tested using a collaborative serious game for touch pads. On the one hand, a serious game is a game that has aims other than “fun”. It has a very important teaching component and leads players to perform some more or less enjoyable tasks (Charsky, 2010). On the other hand, a game is named collaborative when all players win or lose together. This component motivates gamers to exchange, to discuss and to develop strategies together in order to compete in the game and to try to win. A collaborative serious game is a good simulation of our socio-technical system to test interactions in a projected “Smart and Collaborative Neighbourhood”. We will also obtain feedback about the acceptability of the system. Players will be five to ten in number, in co-presence so that we can assess the “social” aspect of the system (the construction of community rules). Participants (“players”) will be faced with actions for which they will have to make decisions together. Intelligent agents actions may be added and users reactions may be evaluated.

3.3.1 Overview of the game

Players will have an individual touch pad that displays game variables. They will have real cards that represent authorized actions in the game. There are two categories of cards: “consumption” cards, containing “save resources” cards and “waste resources” cards, and “collaborative” cards including “Help someone” cards and “give a disadvantage to someone” cards. Game variables are the environmental impact of the neighbourhood (common numerical value for all players) and Individual comforts (individual numerical values). Every player will have a consumption profile (excessive, moderate or attentive consumer) and a collaborative profile (very, moderately and not interested by the collaboration). Profiles will be defined using a questionnaire that players answer before playing the serious game.

Depending on their profiles, players need to reach a more or less high level of individual comfort. They will have the same number of cards, but more or less cards of the type “save resources”, “waste resources”, “serve someone” and “disadvantage someone”. For example, a player who has an excessive consumer profile will play with 70% of “waste resources” cards and 30% of “save resources” cards. Its impact on the environment (that is on the neighbourhood) will be important. Further, he/she will have to maintain a high level of individual comfort. “Waste resources” cards make an increase in both the neighbourhood environmental impact and the comfort of the player who uses them. “Save resources” cards do the inverse. “Help someone” cards lead to an increase in the comfort of the player who is helped. According to the actions of the card, they lead to increase or decrease in the neighbourhood environmental impact. “give a disadvantage to someone” cards do the reverse.

3.3.2 First version of the game: without intelligent agents

Turns of play number will be defined at the beginning of the game. On every turn, an event concerning all the players will occur. This may be an increase in the price of electricity, or a proposal to buy car sharing, etc.
Events will affect each player differently (depending on their profiles) and they will affect the common environmental impact variable too. An administrator of the game (the experimenter) could also create events aimed at affecting one or more players. This may be hosting friends (which increase consumption), going on holiday (which decrease the consumption), having a car problem, etc. Players involved will be notified of this personal event. We still have to reflect on the extent to which other players should be or not, and perhaps both conditions could be tested.

Common events and personal events will modify variables and all players will see this on their touchpads. Firstly, these modifications will remain hypothetical, as indications. Then, players will propose cards to counter events. They will have to discuss, debate and make decisions together. This will change hypothetical modifications. Once all agree with which players play which cards, actual modifications appear on touchpads and the next turn of play will begin. Following turns will be exactly the same. There are two objectives at the end of the game: the environmental impact variable has to be less than a limit and individual comfort variables have to be higher than a given limit, being different for each user. Limits are set at the beginning of the game and they depend on gamers’ profiles. Because we are working with computing researchers, we can easily automate metrics (variables) of the game.

3.3.3 Second version of the game: with game assistants to simulate intelligent agents

In a second version of the game, we will add actions of autonomic systems. They will be implemented as individual game assistants. The game will be played in exactly the same way as described above, except that each player will have a game assistant on his touch pad. Autonomic systems (game assistants) will have two modes of interaction. They may be in a “learning” mode, namely in the interaction with the player, questioning him and trying to understand his profile. Or they may be in an “autonomous” mode, neutral, without trying to adjust themselves to the player.

The game assistant, in “learning” or “autonomous” mode, will on certain occasions make decisions for players, by imposing cards on them. During the group discussion, players could support their assistants’ proposals or they could modify, reject them, etc. When the system does not make itself manifest, the player could request it to help him. Likewise, the player could at any time activate or deactivate his assistant.

4. Discussion

Our methodological approach responds to two questions: 1) which scenarios could be anticipated? 2) What are the conditions for the acceptance of the system and how are these conditions organised? Our approach can be discussed on two levels.

Concerning the global approach, its advantage is to be gradual, respecting steps. Each step studies users and uses, examining our approach with a degree of prospective that increases throughout our research, and helps us to anticipate the next step. The co-housing study allowed us to specify workshop tasks, especially the consensus part. The creativity workshop allowed us to get ideas of scenarios for the serious game. Moreover, the analysis of questions that participants asked to others will help us to create controversial game situations. We think it is important to test these debatable possibilities. Iterations of the serious game will allow us to supplement scenarios. Results of the first version of the game (without intelligent agents) will form a basis for the design of game scenarios with autonomic systems. Finally, the sequence of the steps leads us to specify scenarios.

Regarding each step independently, the analysis of communicative interactions allowed us to study both the construction of rules and collective decision-making with respect to this "sustainable and collaborative" lifestyle: how we share together, how we create and implement sustainable and collaborative practices, etc. Analysis of constraints, oppositions and negative perceptions of the system leads us to anticipate correct specifications of our system, necessary for its acceptability.

Each step has limits too. The co-housing study was limited, since the situation is not a “smart neighbourhood”; and the creativity of the inhabitants is not stimulated during their meetings so they do not imagine many scenarios. Furthermore, it is a project that takes a great deal of time to be developed, and which would have required us to adopt a longitudinal approach. Limitations concerning the creativity workshop concern the duration of the tasks, which were sometimes relatively short. Although we obtained four realistic collaborative neighbourhood models, we have to choose just one of them for implementation in the serious game, which requires making our criteria of choice explicit. The collaborative serious game is limited by the fact that it is very difficult to create playable and fun scenarios. Moreover, everything cannot be
computerized, especially human relationships. It is possible that information and data collected in the previous steps will be lost or will be modified and adapted for the design of the game.

Despite certain limitations, we see the need for prospective ergonomics to respect a step-by-step methodology, beginning with the analysis of emerging practices and gradually approaching the future that we seek to clarify.

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References


