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Eve Ross

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# *A COLLABORATIVE ENVIRONMENT FOR ACTORS FOR SUSTAINABLE DEVELOPMENT*

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**Ève ROSS**

Maître de conférences en sciences de l'Information et de la Communication  
Centre de recherche sur les médiations (EA 3476)  
Université Paul Verlaine – Ile du Saulcy – BP 80794 - 57012 Metz cedex  
[eve.ross@univ-metz.fr](mailto:eve.ross@univ-metz.fr)  
(+33) 6.61.31.43.43

## **Summary:**

This article concerns an investigation into a new methodology and computational tools facilitating a collaborative environment in the field of architecture and urban design. Desk research by way of literature search has been applied on projects in three countries. The results of the empirical studies have shown three problems in the collaborative environment: semantics, synchronisation and communication. Besides these handicaps, there are professional handicaps. The article sketches a scenario for a virtual environment for collaborative learning with network technology and simulation games. This will lead to a filter mediated interaction model. The scenario is illustrated with three screenshots of the interface. Practical, professional tools, based on the methodology and the mock-up, will be developed in an international effort.

## **Keywords:**

Territorial intelligence, 3D virtual collaborative environment, sustainable development, architecture and urban design, implementing filters.

# A collaborative environment for actors for sustainable development

Ève ROSS

Centre de recherche sur les médiations (EA 3476)

Université Paul Verlaine – Metz

Université de Technologie de Compiègne

eve.ross@univ-metz.fr

## SUMMARY

This article concerns an investigation into a new methodology and computational tools facilitating a collaborative environment in the field of architecture and urban design. Desk research by way of literature search has been applied on projects in three countries. The results of the empirical studies have shown three problems in the collaborative environment: semantics, synchronisation and communication. Besides these handicaps, there are professional handicaps. The article sketches a scenario for a virtual environment for collaborative learning with network technology and simulation games. This will lead to a filter mediated interaction model. The scenario is illustrated with three screenshots of the interface. Practical, professional tools, based on the methodology and the mock-up, will be developed in an international effort.

## OBJECTIVE OF THE INVESTIGATION

With Prof. Kalay, M. Yongwook Jeong, Center for New Media, University of Berkeley and Prof. Carrara, University of la Sapienza, Rom, we develop a new methodology and computational tools for understanding and facilitating multi-disciplinary, cross-cultural collaboration in architectural and urban design. It has both theoretical and practical values, because collaboration is an important aspect of modern architecture and construction activities that operate in a globalized environment by taking into account the sustainable definition<sup>1</sup>. Collaboration among project developers, local authorities, architects, engineers, contractors, building inspectors, clients, future users, and others, increases the pool of knowledge and skills available to undertake activities that exceed the capacities of any single person or organization on its own, thus making possible the design and construction of complex buildings. Yet, fostering collaboration in fields where the educational and disciplinary backgrounds of the participants are heterogeneous, as is the case in the construction industry, is difficult. While each participant contributes his/her own expertise, they also bring their own—often different—understandings, viewpoints, and preferences.

## RESEARCH METHODOLOGY

We perform a literature study into territorial projects financed by the local authorities or by a project developer (client) in three countries. We took a constructivist approach (Avison & Myers, 2001, Le Moigne 1995, Crozier & Freiberg, 1977). The model for the empirical studies is based on four central aspects of the architectural design process: the generation of design solutions, the communication, the evaluation of design solutions and decision-making (Kalay 2004). This model emphasises that a good decision-making is important on several levels in the architectural design process (Morin 1990, Callon 1996, Kalay 2004, Lundequist 1992, Schön, 1991). These give a certain dynamic to the process to avoid the sequential understanding of the process from the 1960s (Lundequist, 1992).

The generation of design solutions is the most important criteria for the decision-making in the architectural an urban design process. A decision can directly impact on both the architectural design process and the product, in the form of a new requirement. The assigner, the citizenship, or the local authorities can accept or reject the proposed solution. Decisions are taken at different levels and by different actors. The assigner or the local authorities will make a decision about the price and the building's definition. The architect will make his decisions about which design solutions are worth being put on the paper. A good decision relies on the architect's ability to generate design solutions in first place (Lawson, 2006).

The communication and interaction between the building process actors, each representing different interests and experiences as basis for evaluation of the proposed design solution, can essentially impact the decisions made and the further development of the architectural design solution. Furthermore, decisions are made based on the

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<sup>1</sup> These actors are responsible for the definition of the life cycle of the building regarding its sustainability , its adaptability, its transformations through the time, of the space management. They take into account the following criteria: population's movement, material movement, pollution's factors, maintenance, modernise, and recycling of the building.

decision-makers' or other participants' evaluations of for instance the design solution's quality or its consequences for the design as a whole.

The model is also based on three levels. We applied operations and actions on the architectural design process. We distinguish the individual solving a process, for example the assigner or the representative of the local authority finding a solution regarding the management of the space or the designer's conversation with the design solution (Schön 1991). Another level deals with the interaction between the assigner, the representative for local authorities and the architect or between the architect and the engineers, or the local authorities with the architect and the citizen. The last level comprises the whole processes. The use of levels allow us to structure and organize the different approach by taking into account the different research fields like, individual theories, group theories, organisational theories and societal theories.

The methodology and a mock-up have been tested by students in four countries, working together on a hypothetical design project.

## RESULTS OF THE EMPIRICAL STUDIES

The client organisation and the building authorities are defining the overall constraints, requirements and aims. It impact on both the design process and the design product.

The computer-generated drawings made by the architect are used as the basis for communication, evaluation and decision-making.

The problems in collaborative design and in urban design are: technical, social and professional. To collaborate, the participants need a shared access to the project information. There are three main problems:

1. **Semantics**: information developed by one professional may not be comprehensible to others, due to the particular language and conventions each profession uses to code and represent its work.
2. **Synchronization**: information is developed incrementally and a-synchronously: the information one professional needs to get from another professional may not yet be available. To avoid delays, the first professional may have to make decisions on the basis of assumptions, which may or may not be true. Moreover, there is not a clear sequence of decision-making: the work of each professional may constrain the work of others.
3. **Communication**: there needs to be a way to share information in a timely and accessible manner. The World-Wide-Web may be the solution to this problem.

The interoperability is not a problem anymore since the IFC and BIM are a standard (Ross 2007).

Besides technical problems, social and professional impediments were signalled. Architects, engineers, construction managers, facilities managers, building owners, and end-users all have different world views. In general, the project developer and local authorities have a budget for the construction of the building. They do *not* want to *increase the building costs*. They are taking care about the design solutions and check if these could *satisfy the future users*. The building authorities' architects often emphasize the *quality* of artefacts over their function, purpose, and the processes of making them. Engineers tend to emphasize the *function* or *purpose* of the artefact, placing less emphasis on the process of making, and still less on its formal qualities. Construction managers are interested mostly in the process of *making*, whereas facilities managers are interested in the process of *maintaining*. Owners and end-users are usually not interested in their environment, as long as it does not impinge on their activities and interferes with the achievement of their personal or institutional goals (i.e., how well the place supports the education of students, the fabrication of goods, or making people well). Hence, to collaborate we need to develop a shared-understanding of the qualities of the product and the goals it strives to achieve.

The professional impediment depends on the further education and standards used.

## VIRTUAL ENVIRONMENT FOR COLLABORATIVE LEARNING

The CAD systems used within the design process, support drafting and modelling rather than special design attributes and analytical capabilities. CAD systems allow architects and designers to produce a huge amount of drawings and realistic representations of design solution. Other computer programmes offer better support, like SketchUp. The virtual reality offer way to innovate form generation. Other IT systems propose a design agent, an intelligent agent.

The network technology allows easy and fast access to information. It contributes more to accelerate the design process than the CAD tools. The problem remains still the effect of information

Traditional models of the design process use a single knowledge base or data base. It is precisely the uniqueness, the pre-established cataloguing of the building organism, its components and the process that reveals that these models are visibly unsuitable for urban, architectural and building design. It is actually characterised by a

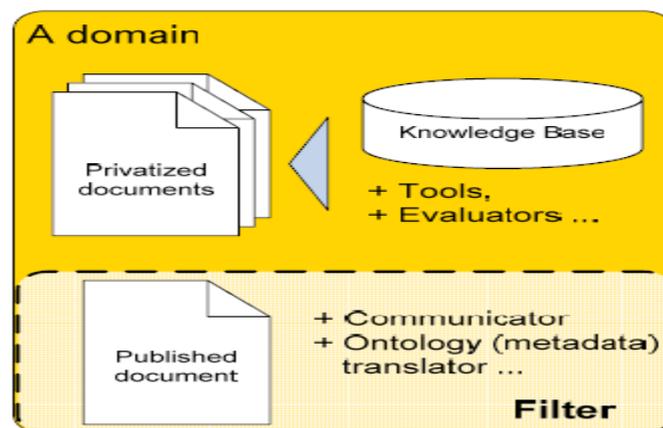
localised multidisciplinary process. The gaps in the software system supporting building design reside in the rigidity of the data bases, which do not allow inconsistency, in the difficult of having incoherent knowledge bases of the various operators, in the incongruity of multi-semantic objects, in the synchronicity of the process itself in which the IT objects referring to a process of urban, architectural and building design are simultaneously modified by several operators.

We define the workplace as follow. Each team has its private workplace with its specific information (e.g. architectural team, economical and financial, electrical engineering, etc.). They share a shared design workspace common to all of them where the various choices are combined into a synthesis.

Another relevant factor within ICT is interoperability, like the standard ‘Industry Foundation Classes’ (IFC). It allows the development of the 3D product model or building information modelling (BIM). Such models are based on the definition of objects (products) containing so-called intelligent information. This approach is inadequate in the fields of urban, architecture and construction, because the same data can be interpreted differently by the participants, based on their own roles, knowledge, and cultural understandings.

Our approach will focus on sharing *meaning*, not only *data*. It is based on the hypothesis that meaning is produced by placing the data within the appropriate cultural and professional frame of reference. Since the professionals who participate in the design of a building do not share the same educational, professional and cultural backgrounds (unlike in other engineering fields, e.g., automotive, aerospace, and electronics), the frames of reference they use to construct meaning are different, resulting in different outcomes, which often lead to misunderstandings, conflicts, and ultimately construction delays and cost overruns. Our approach will try to overcome this problem by introducing the notion of discipline- and culture-specific ‘filters,’ which will help the participants re-construct the original meaning of the other participants in the collaborative effort, thereby fostering a closer alignment of intents and results. The role of the filters will be to connect the shared data with the participant’s own disciplinary- and culturally-specific frame of reference, thereby helping the participant construct disciplinary- and culturally appropriate meaning from the shared data.

The filters are envisioned as customizable computational tools that ‘expand’ the shared data by adding to it discipline- and culture-specific information, derived from specific knowledge bases. They will work bi-directionally: extracting specific meaning from the shared data, and re-formulating disciplinary- and culturally-specific information into shareable information which other filters can interpret according to their own disciplinary and cultural knowledge bases. This will likely involve dictionaries of meaning—translators of common concepts between different frames of reference. The common data will use XML tags, so the filters can identify and connect the appropriate objects to the disciplinary-specific knowledge bases. We explore the feasibility of the hypothesis.



**Overview of the filter**

We employed case studies drawn from architectural and urban design, which will elucidate both the process of collaboration and the disciplinary frames of reference used by the participants. We will then construct a mock-up, in the form of a serious game, a simplified, role-playing collaboration simulation ‘game,’ which will emulate the typical interactions between the different participants in the building industry. It will use agent-based computational tools to simulate some of the key principles derived from the case studies and the proposed methodology.

The use of game-like simulations to understand complex phenomena is a well-known strategy in fields where knowledge is acquired through experimentation, and strategy is developed through experience. In addition to simplifying complex phenomena and putting the players in an un-encumbered learning mood, games also provide a universal means of communication, transcending cultural, social, and gender difference. By using abstractions and well-defined rules, the game will focus on the core issues of the simulated phenomena of design collaboration. To test the simulation game, and by extension the methodology, it has been ‘played’ by architecture and engineering students in the U.S.A., Italy, and France.

### FILTER MEDIATED INTERACTION MODEL

The basic strategy adopted in the research is analogous to the operation of an architect with the interaction of a builder and client. Firstly, the client creates his or her requirements within a certain boundary such as budget. The requirements may have the specification of rooms (size, number, material and so on) and adjacency between certain rooms, which can play as constraints. The architect starts designing a building based on the requirements and constraints. However, the client’s goals and constraints could be in conflict with themselves (because he doesn’t have enough knowledge), making it impossible for the architect to fulfil them. In this case, the architect should negotiate with the client to reduce the difficulty and make it more manageable. It is also possible that even if the architect’s design meets the internal constraints (space adjacency), it exceeds the client’s budget due to excessive designs.

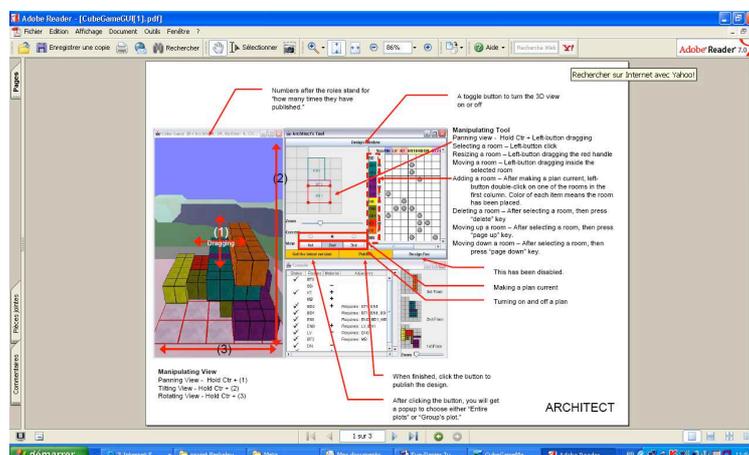
A possible action expected by the client or the local authorities is to communicate with the architect to revise the design to fit the financial/physical requirements. Since the builder’s primary objective is to gain as much profit as possible, it is an inherent source of conflicts between the builder and the client. When that’s the case, the client and builder can react to each other in different ways. The client might ask the builder to lower the builder’s profit margin and the builder could suggest the client to change initial requirements such as materials. All three stakeholders have to collaborate with each other to solve the conflicts, changing the design, the requirements or the profit margin.

Although what we have stated is very simple interactions among three players, we can easily increase the complexity of the interactions by expanding the unit of analysis to group interactions.

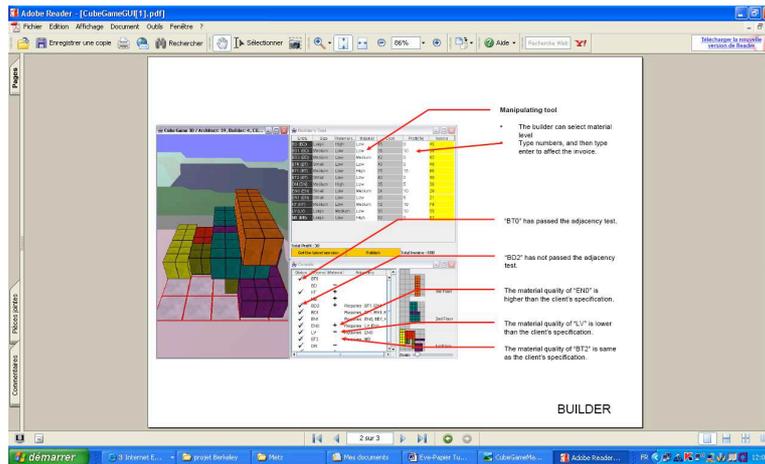
What if there are a group of people in different domains instead of just individuals? What if there are groups in a single domain that have to collaborate with other domains? Let us try restating the analogy with more formal terms. When the stakeholders make decisions and negotiate with each other, they use their own representations and knowledge. Based on their methods and resources, they must satisfy two sets of goals: shared (or common) project goals, and the experts’ individual goals, which derive from their role, personality, culture, education, interests, etc. One participant’s primary source of contemplation should be others’ most recent works. In this vein, we assume that there are two conceptual workspaces, public and private. The shared representation is not a pile of data but a set of metadata to define domain vocabularies. Each domain has its own encoding/decoding way following the rule of vocabularies. In the public space, only the latest version of the participants’ works should be placed while they can make as many revisions as possible in their own private space. An explicit way to make their works is “publish.”

### SCENARIO

The goal is to build a building. Each actor has his own knowledge and point of view on the project. Each filters the information of the other, interprets it and proposes it in the form conformed to the point of view of the actor. The filtering allows representing one object by combining the domains of each actor.



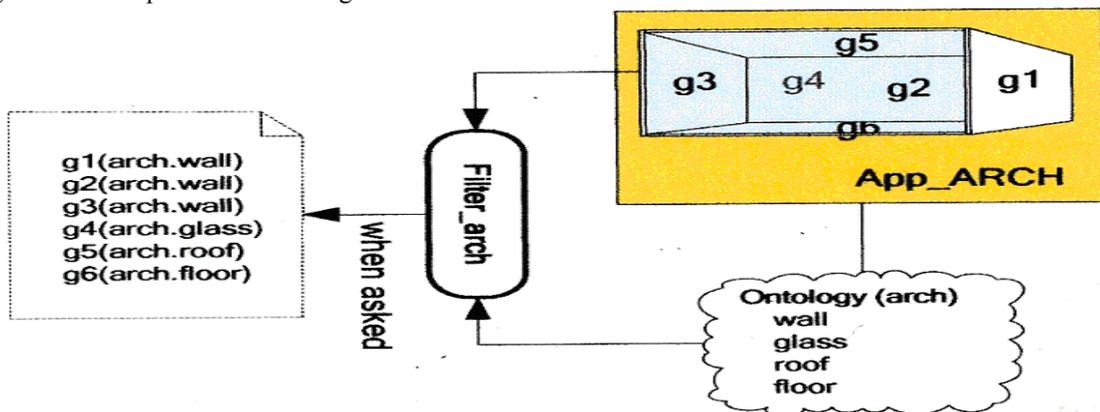
Interface as seen by the architect



Interface as seen by the builder

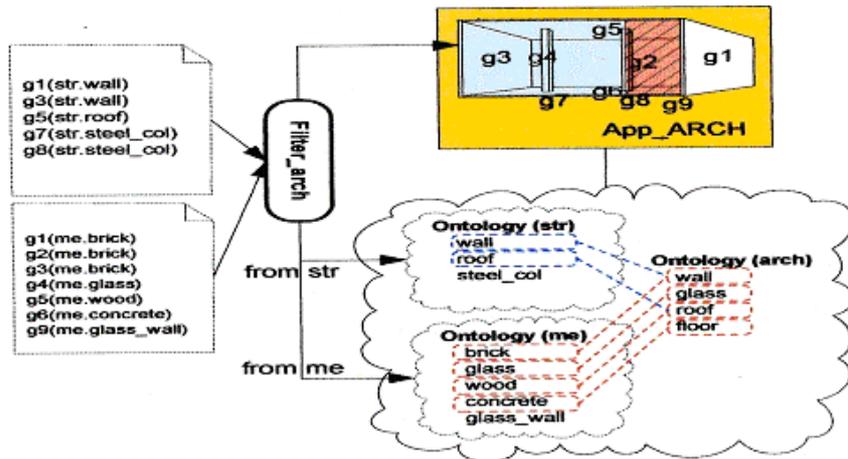
The client (local authorities, project builder) asks to build a house with a certain budget and a number of floors, flats, and rooms per flat, conform to the environmental laws, and the request from the future users. The architect plans the house with the application “App-Arch” (e.g. AutoCAD). He designs the building with geometrical data. During the design process, he uses his ontology like (“wall”, “windows”, “roof”, ‘floor’, etc.) and assigns them to its conception. The filter of the architect sends the first version of the conception. The published data contain geometrical aspects and XML tags bound to these data.

1



Filter of the architect

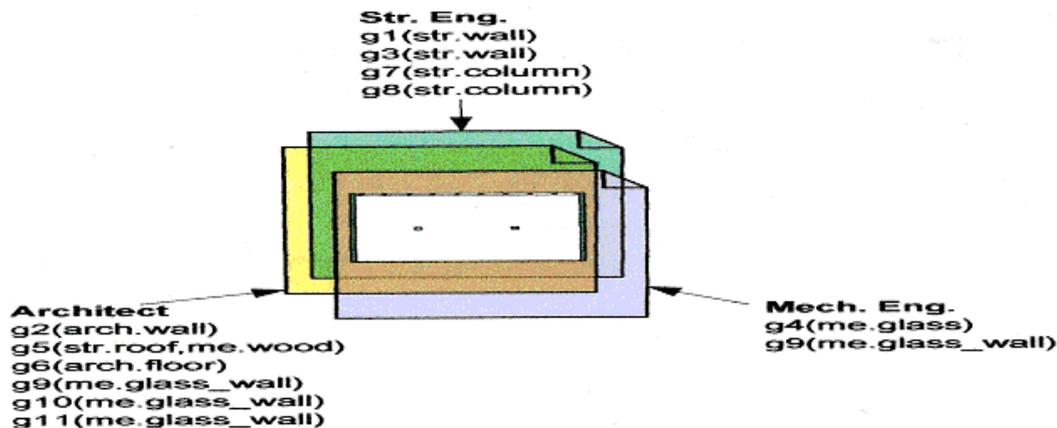
The construction engineer controls the feasibility from his point of view. First, the filter of the engineer takes the last version of the document written by the architect. It put a link between the representations of the wall represented by the architect with its properties that it possesses about the load bearing. These properties are given to the wall of the architect. Then the filter put the drawing of the (plafond) in its representation. The roof can be modelised as a structure composed by girders and pillars made of steel. The construction engineer attributes the property of load-bearing to the wall « g1 » and « g3 », in order that the wall can carry the roof (g5). After a couple of tries with “App\_STR” in his workspace, he decides to put 2 steel pillars and call them “steel-col”. The filter of the engineer edits the geometrical data and stores the semantic information that that the engineer has added (see fig. below)



**Architect looks for changes made by the engineers**

The mechanical engineer analyses the design with the help of “App\_ME”. He sees that the energy level is too low for the big glass façade. He thinks that it is better to have only 1/3 of the façade made of glass and should be “wall of glass”, object (g9). This object has its own ontology. He writes a text concerning the changes that should be made. Then the filter of the architect looks for the data that have been published by the construction engineer and the mechanical engineer. The architect is able to see the changes and also to read interpret them. He knows how asked for a change and sees the point of view of both engineers. He accepts the 2 steel pillars, but he does not want to renounce to his glass window. He puts 3 small walls between the glass window ‘g9’, ‘g10’, ‘g11’. Since the architect knows about the ontologies of the both engineers, he can communicate with them by using their terminology.

Every time the project can be visualised in its globality (see fig below).

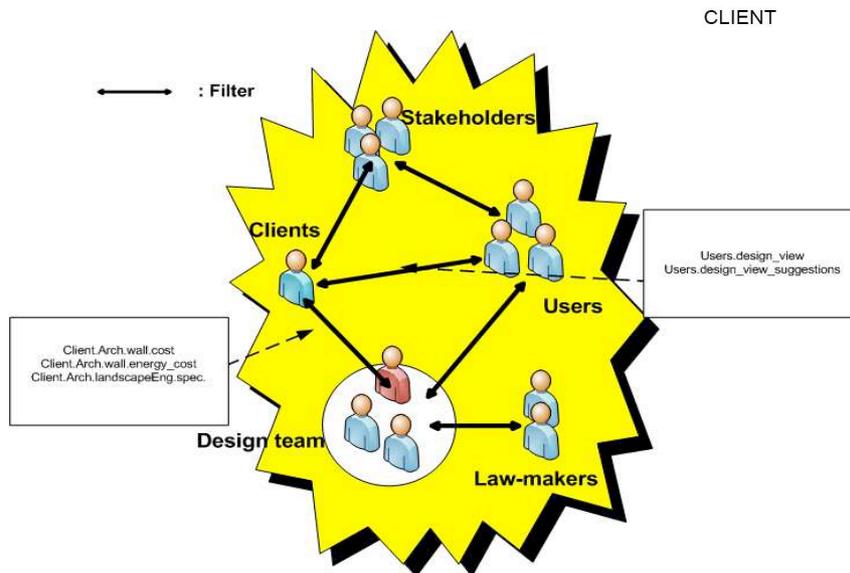
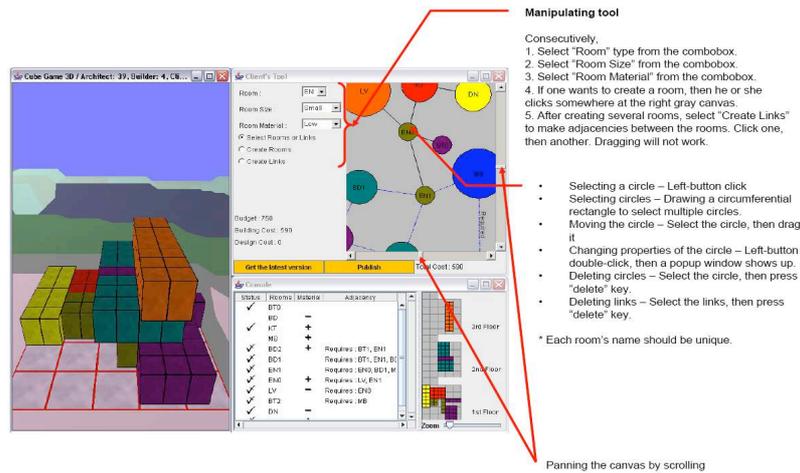


**Global view of the project with filters**

The design can be then be shown to the clients and at the users.

The filter of the client retrieves information from the design team like costs, number of rooms.

Concerning the users, they only see the result of the design process (virtual 3D-picture). They also can add some comments to the project.



Communication flow between the design and the clients

## FURTHER RESEARCH AND CONCLUSION

We will use tithes basic research to start an international effort to develop practical, professional tools based on the methodology and the mock-up.

We will complete the model with other empirical researches and define deeper the profile of each actors. At a later stage, several models would help to define a tool for supporting the collaborative and urban design.

Implementation of the methodology in the form of a serious game in the form of an educational simulation game will help to communicate the principles of collaboration to students, who will become knowledgeable about the issues, rewards, and difficulties involved.

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