

Participative Technologies: an Internet-based Environment to Access a Plural Design Experience

Knowledge Modeling to Support User's Requirements Formalization

Armando Trento¹, Gianluigi Loffreda², Gökçe Kınayoğlu³

^{1,2}Sapienza – University of Rome, Dept. of Architecture and Urban Planning for Engineering, Italy

³University of California at Berkeley, Dept. of Architecture, USA

^{1,2}<http://www.dau.uniroma1.it>

¹armando.trento@uniroma1.it, ²gianluigi.loffreda@uniroma1.it

³gokce@berkeley.edu

Abstract: *“Re-shaping artificially the Earth on human needs” implies a very complex industrial system that is performed through a very complex process. It consists of a collective, finalized and plural-constrained process, scheduled by phases, made up by several actors, characterized by the co-presence of numerous and very different (non-) specialist skills. In this paper we define the enhancement path of a web-based collaborative environment – discussed in a previous work – laying upon actual design entities representation an innovative logical level for knowledge formalization. It is presented an example of end-users requirement formalization, aimed at supporting the designers in the process by means of rule-based project suggestions.*

Keywords: *Collaborative environments; participative design; knowledge modeling.*

Introduction - participative design and ICT

Environmental, urban and building design, construction and management, as a whole involve the largest number of employees, imply the most diversified set of professional profiles, waste more than half of total energy consumption, produce a major environmental impact, have a very large economical effect on other industrial sectors. As a consequence, “re-shaping artificially the Earth on human needs” implies a very complex industrial system that is performed through a very complex process. It consists

of a collective, finalized and plural-constrained process, scheduled by phases, made up by several actors, characterized by the co-presence of numerous and very different (non-) specialist skills.

The support of new technological environment/tools could facilitate the actors along the entire common design experience:

- Different types of media affect the level of engagement of the participants.
- Different types of collaborative media enable the participants to address different aspects of design problems.
- Participative virtual environments increase the

frequency of situational awareness as designers and actors.

- New collaborative environments help actors checking inconsistencies and speed up new design solutions production.

Collaboration among the designers has to be enriched by integrating the participation of the future user in the design process (actors = designers + users). This is acknowledged by such ICT developments as user involvement (Kokosalakis, 1998), community information (Ennis and Lindsay, 2001), and user preference measurements (Orzechowski et al., 2000).

However, it is important to note that the extensive body of knowledge generated in participatory design, is not often referred in current CAAD research (Pranovich et al., 2002).

State of the art

A technology-driven alternative to design methodology has emerged through the advent of new, digital media. Individual researchers, specialist designers, professional societies and construction professional actors have embraced the modeling and visualization abilities aided by computers to create entities' structures and interactive virtual models. These efforts have typically focused on the building models without taking into right account the complexity and the cross-disciplinarity of AEC domain.

However, the new technology has the potential to move the state of the art of participative design approach beyond static three-dimensional space representation, by including the social, cultural, and human aspects of the societies that will inhabit them in interactive form. In so doing, the technology can help the actors in perceiving different perspectives with a measure of presence in the site, allowing them to participate in design, to interact with representations of the context, and to get feedbacks from other designers and all the other actors involved. It has the potential to transform the experience from passive viewing and sequential designing to active participation and real collaborative design.

Virtual user simulation is employed as an evaluation tool to assess the performance of buildings and environments that have not been built. In that case, the buildings and environments can still be modified if the evaluation shows they are deficient in a way.

Design participation for non-specialist, non-trained participants (users, clients, community etc.) is especially difficult because:

- Disciplinary specificity of representational frameworks;
- Impenetrability of disciplinary jargon, language of design.

According to Sanoff (1999) the mere "sense of participation" is often enough to generate design satisfaction. Yet in the industry, participatory design is often replaced by pseudo-participation. Users may be incorporated in the process but their ideas, requests, expectations are not properly, efficiently, and adequately represented within the design procedure. Therefore users' perspective often gets misunderstood or plainly ignored. This is mainly due to the lack of a communicative framework that effectively represents the "Tacit Knowledge Model" of the end-user. Therefore, we need a semantically well-defined knowledge representation framework and a new model of intuitive participation media through which the participants can exchange design information and tacit knowledge with design professionals.

This predictive approach is based on modeling both the environment and the humans who will use it, and simulating their interrelation "in action" much like electrical and mechanical engineers can "run" their designs to see how they perform under certain conditions.

A collaborative working environment: Arch 132

In continuity with the collaborative exercises that have been experienced at UC Berkeley, in this paper we describe the enhancement path of a technological tutoring support system developed for Arch132,

a collaborative design studio led by Prof. Y.E. Kalay. In order to facilitate the students while they exercise in a common design experience, Trento and Jeong (2008) defined a web-based working environment and they developed a 'filter-mechanism' that improves some design operations (Figure 1). It enables the students to a 'real time interactive communication' allowing them a critical exploration of the relationships between different individual contributions and assisting them in the process of constructing a shared, agreed and participated project.

The participants export their design purpose – which can be expressed in many forms (e.g. hypertexts, images, 3D models) – linking it to the geo-referenced Earth position, where everyone can see it. Every time they want to visualize their own project (e.g. a house) together with their colleagues' updated ones in the shared site (the neighbourhood), they have to activate the 'filter mechanism'. It recognizes them, checks for the login on the course web page, manages the upload of their model on the centralized server, merges it on a common file and, finally, it enables to access the shared model updated view just by clicking a button.

Every time the participants want to experience the human scale visualization of the updated site, they have to export the model of their house from the design modeling application into a game-like environment and upload it on the server. At this point each participant can see other fellow students' avatar walking through the environment, and communicate with them by chat and e-mail.

This can be done multiple times, so they can figure out what the other actors are building, they can get feedback on their own solution, and re-shape it according (or opposing) to others comments. Each participant's last-updated work is always visible to others, eliminating the problem of making design decisions based on obsolete information and easily accessing to the updated scenario of negotiation.

Limitations

Creative Collaboration starts when participants share some of the objects of the design: if they want to modify the configuration of some properties they necessarily have to confront their colleagues' choices and motivations. 'Arch132' simulation process operates some simplifications: for instance, since the shared site is already defined in its general organization and doesn't allow overlapping of properties and responsibilities then the actions of the individuals are largely independent of each other. 'Arch 132' has no formalization of design entities (objects-concepts) and rules: no overlapping constraints, no way to suggest some requirements from the end user. The actors can easily experience Association and Teamwork as forms of collaboration, but hardly participate in the higher level of Creative Collaboration. (Kalay, 2005).

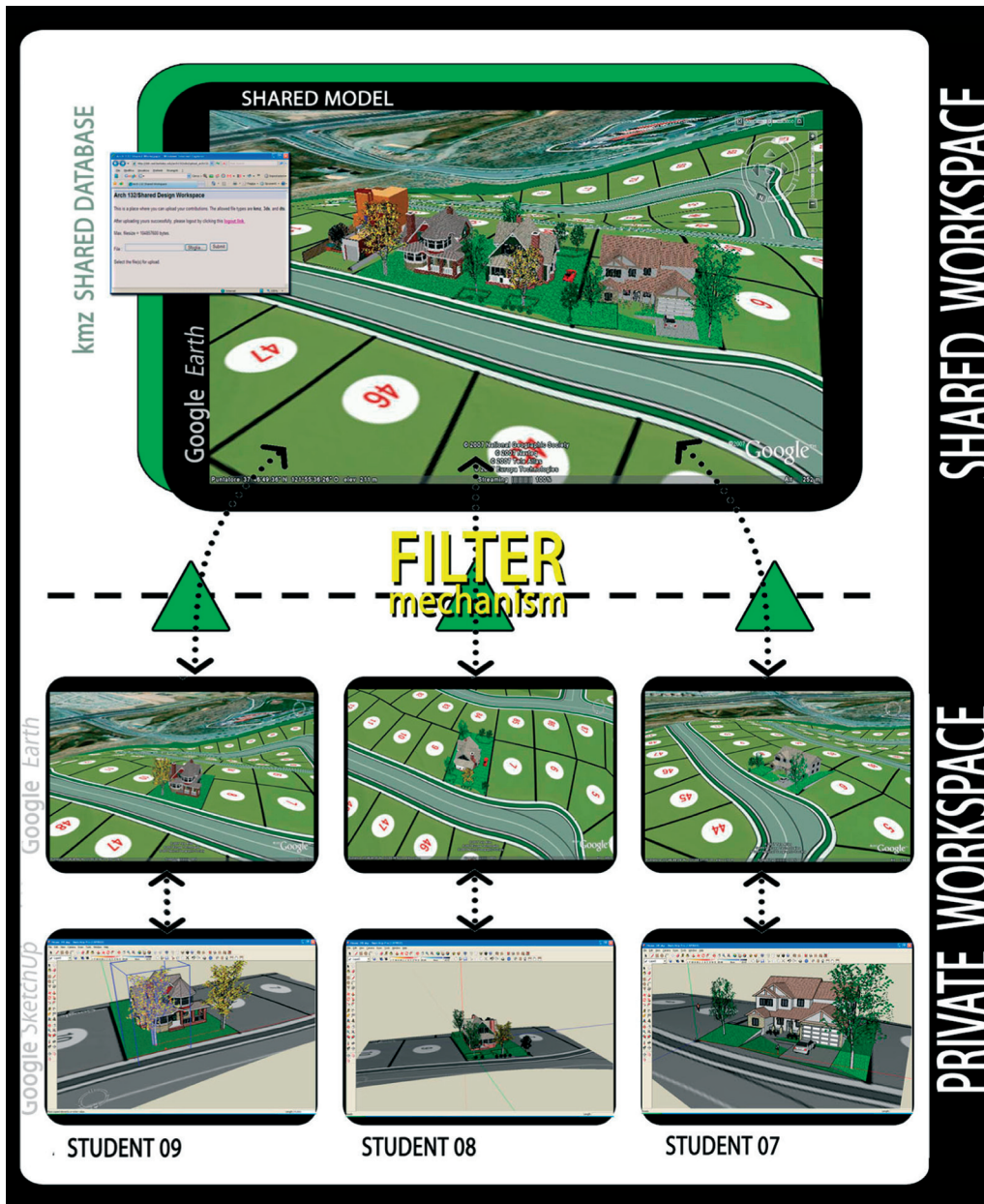
As a matter of fact, the correct formalization of the information exchanged is still actually an open problem: currently, the excess of low level information exchanged, which is both the cause and the effect of the potential of the new ICT, implies the simplification ('semantic impoverishment') of the information exchanged, thus leading to incomprehension among the actors and to a step backwards as regards effective communication among them.

The entities involved are generally represented by often dimensionless, symbolic graphic signs and jargon filled technical reports. No entity has any intrinsic meaning, but merely the one it has in the cultural, scientific and professional contexts it is situated in. Therefore, the only way to give it a 'meaning' and to constrain its behavior is by an accompanying informative-explicative attachment.

Each of the abovementioned entities corresponds to a specific logical concept, which itself contains very little - often non-existent - meaning, even though it may possess an excellent figurativeness.

It is thus an exclusive task of the actors to 'translate' meanings, perceive differences among different versions, carry out comparisons among different solutions, and point out conflicts and contradictions.

Figure 1
Collaborative Working
Environment



All this hinders an easy and efficient collaboration among them.

A participative approach to building design includes clients and final users during the design process. Usually these actors can't contribute efficiently mainly because they can't represent their objectives and specification/requirements by using standard object representation.

In order to support actors in sharing not only geometric data, but concepts and knowledge attached to each entity involved in the design process, a new model for knowledge representation and management is crucial in building design process.

A new knowledge modeling layer

The present work defines the enhancement path of the discussed collaborative environment, making use of an innovative level for knowledge representation and management that is the subject of an in progress research by the authors (Carrara et al., 2009; Jeong and Trento, 2008; Loffreda, 2008).

Technical knowledge concepts can be formalized on the proposed level by means of the technology of ontologies, for defining entities and by means

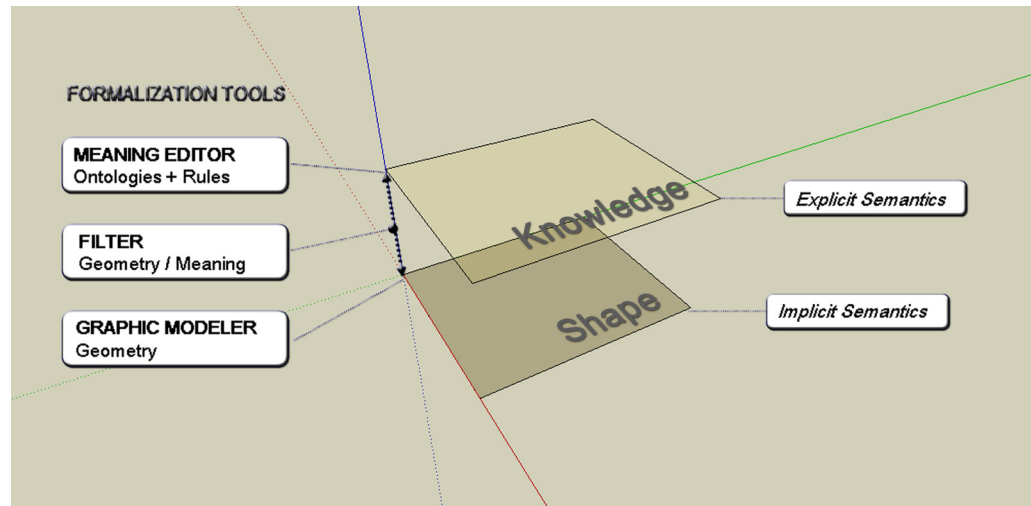
of explicit semantics for defining their meanings. In this theoretical model, the connection between implicit and explicit semantics representation of design entities is ensured by a 'filter-mechanism'. Design entities can be structured according to different actors' perspective in terms of meanings, properties and rules, by this way being allowed to point out requirements and intents (Figure 2).

A 'Knowledge Structure' (KS) is composed of a set of Entities each of which is related to an Ontology (its definition) and has a Semantics (its meaning). Each entity can have a set of Properties (geometric, physical, values) and Attributes (function, methods or computing programs), a set of Belonging Relationships with other entities (part-of / whole-of), a set of Inheritance Relationships (class-of / is-a), a 'situation' (or 'Condicio'), (Carrara and Fioravanti, 2004) dependent on a set of 'Rules'.

'Rules' can be classified in:

- Reasoning Rules and Algorithms: formal codes for analysis, checking, evaluation and control of concepts associated to specific entities with inferential procedures of 'If-Then' type.
- Codes, Laws and in force Rules: context dependant rules referred to the in force law that will

Figure 2
Entity Representation: a new
Knowledge Modeling Layer



become constraints for the entities which they are related to;

- Consistency Rules: algorithms to check the consistency of values, parameters, attributes, instances, relationships and properties referring to the specific meanings associated to each entity in the specific context on which it is used;
- Traditional Rules: non-formalized rules, practices and concepts that represent part of the reasoning process of each actor on his own specific disciplinary domain during the design process.

By means of Inference Engines able to match rules among the ontologies - all of which formalized into a syntactically coherent IT structure - a deductive layer allows the designers to use in a coherent manner different levels of abstraction, or to exploit a conceptual interoperability (Calvanese D. et al, 2008).

The dynamic and semantically-specific

representation detecting incoherent/favourable situations by means of a constraint rule mechanism can allow them to be highlighted and managed in real time (Figure 3). At the same time it allows actors to make alternatives, more consciously reflecting on the consequences of their intents.

In this way the impact of a networked ontology-based system can make actors more aware of overall design problems, helping them in operating more participative and shared choices.

An example of end-users requirement formalization

A case study to simulate a participative approach to building design could be related to requirements formalization based on interviews to single house end-users.

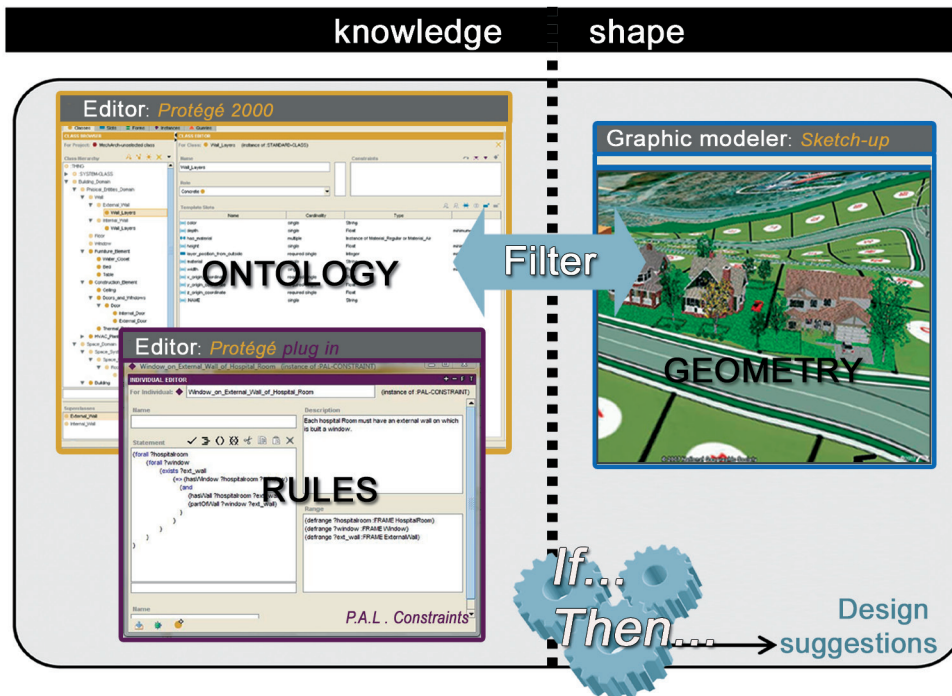
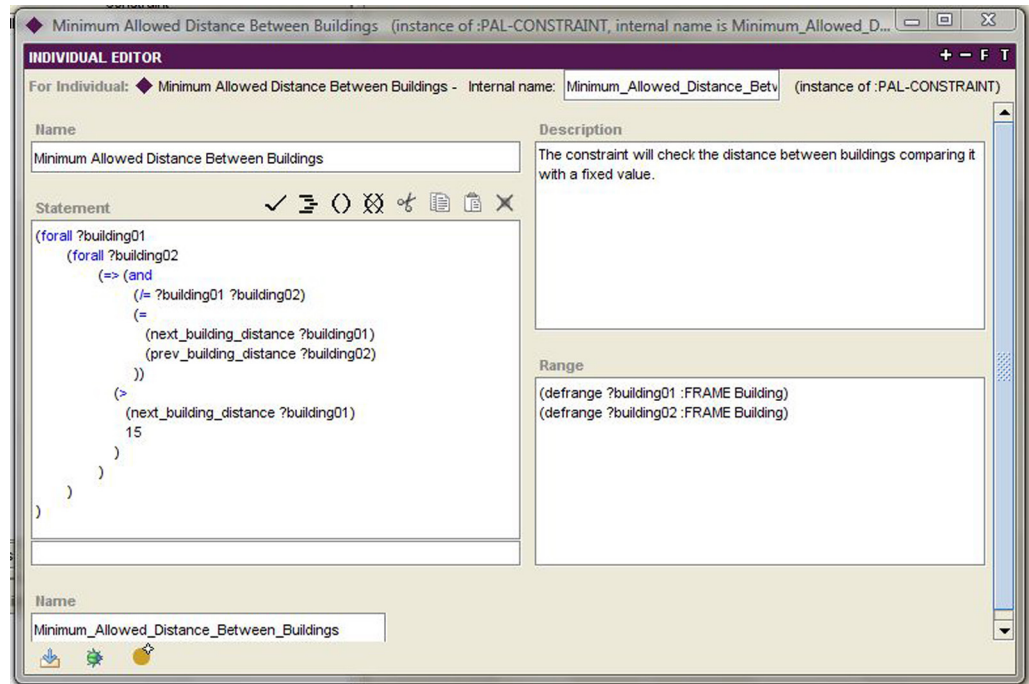


Figure 3
Inference framework

Figure 4
Design rule formalization on
Protégé Axiom Language



Among the interviewed actors 'desiderata' list, we recognize the need of not having any kind of visual privacy intrusion. In terms of design requirements, it could be translated in a minimum distance allowed value.

Using an existing ontology and rules editor (Protégé 2000 + PAL Constraints), authors implemented a design rule which states that each single family house (denominated 'building') must not be closer than 15 meters to another building (Figure 4).

This simple example shows how users' needs can (easily) be introduced in the participative environment as reciprocal design constraints and 'rules' into the process.

By means of the purposed Knowledge Modeling level, this rule can be linked to the building entities involved in the design process and formalized in order to support the designers with some inferred suggestions.

The overall objective of this work is to define a knowledge-based participative model and to develop suitable methods, technologies and tools for a virtual environment that can support the collaborative participated design process.

The Goals and Constraints editing, through the described mechanism, allow the coherence of the design to be verified vis-à-vis the objective sets.

The research in progress is revealing the potential of the approach adopted for the preliminary design phase representing a first-step validation of the illustrated software system implementation.

Conclusions

This paper defines a scenario for enhancing the participation of design product end-users since the early moments of the decision making process.

The implementation of these kind of rules into

the building entities model involved in the design process is not so easy and accessible to all the users: just few actors (end-users, designers and clients) can implement their own meanings, attributes and rules by themselves. The most of the participants, to exchange design information and tacit knowledge with design professionals, need an agent (human or software) which acts as a mediator able to well understand their “desiderata” and translate it in formal project constraints.

To develop participative technologies, therefore, intuitive interfaces are needed: this can be possible by means of a semantically well-defined knowledge formalization framework, which allows filtering agents to connect and integrate different levels of representation.

Acknowledgements

The theoretical model for knowledge representation and management is object of studies - for a long time - of the research group coordinated by Prof. Gianfranco Carrara at Department of Architecture and Urban Design, “Sapienza” University of Rome.

References

- Calvanese D., De Giacomo G., and Lenzerini M.: 2008, Conjunctive query containment and answering under description logic constraints. *ACM Transactions on Computational Logic*, 9(3) pp. 22.1–22.31.
- Carrara, G. and Fioravanti, A.: 2002, ‘Shared Space’ and ‘Private Space’ Dialectics in Collaborative Design, Collaborative Decision-Support Systems, Focus Symposium and InterSymp-2002 Conference Proceedings.
- Carrara, G., Fioravanti, A., Nanni U.: 2009, An Innovative Knowledge Structure for Supporting Collaboration in Building Design, in Dado E., Beheshti R., Zreik K. (eds), *Innovation for Building and Construction*, Europa, Paris, pp. 331-350.
- Ennis, G., Lindsay M.: 2001, VR Glasgow.co.uk – Implementation of Internet multiuser functionality to Glasgow’s virtual city, in Stellingwerff, M. and J. Verbeke (eds.) *Accolade – Architecture. Collaboration. Design*, Delft University Press, Delft, pp 135-142.
- Jeong Y., Trento A.: 2008, Interleaving Semantics: a Filter Mediated Communication Model to Support Collaboration in Multi-Disciplinary Design, *eCAADe Conference Proceedings*, Antwerp, 18-20 Sept. 2008.
- Kalay, Y.: 2004, *Architectures New Media*, MIT Press, Cambridge, MA.
- Kokosalakis, J.: 1998 Remote file sharing for community-led local agenda 21 sustainability with Internet, intranets and video conferencing, *Computerised Craftsmanship - eCAADe Conference Proceedings*, Paris, 24-26 September, 1998, pp. 116-122.
- Loffreda G.: 2008, Knowledge Bases - Strutture il sapere. Ontology based design for collaborative environments, in AR.TEC. – CODAT: Research in disciplinary area of Technical Architecture “Research in Ph.D. – Fields, methods and perspectives”, Edizioni TCP (eds).
- Orzechowski, M., H.J.P. Timmermans and B. de Vries: 2000, Measuring user satisfaction for design variations through virtual reality, *Design and Decision Support Systems in Architecture – Proceedings of the 5th International Conference*, Ampt van Nijkerk, 22-25 August, 2000, pp. 278-288.
- Pranovich, S., Achten, H.H. and Wijk, J.J. van: 2002, Towards an Architectural Design System Based on Generic Representations, in Gero, J.S. (ed.), *Artificial Intelligence in Design’02*. Kluwer Academic Publishers, Dordrecht, pp. 153-164.
- Sanoff, H.: 1999, *Community participation methods in design and planning*, John Wiley and Sons, New York.
- Trento, A., Jeong, Y. 2008, A facilitated learning environment to support the simulation of the collaborative design process in architecture. *EAAE/ARCC Conference 25 – 28 June 2008. Changes of Paradigms in the Basic Understanding of Architectural Research*.