Requirements for developing an information system for architecture

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INTRODUCTION

This paper discusses possibilities of developing new tools for architectural design. It argues that architects should meet the challenge of information technology and computer-based design techniques.

One such attempt has been the first phase of the development of an architectural design information system (ADIS), also an architectural design decision support system (1). The system should benefit from the developments of the artificial intelligence to enable the architect to have access to information required to carry out design work. In other words: the system functions as a huge on-line electronic library of architecture, containing up-to-date architectural design information, literature, documents, etc. At the same time, the system offers necessary design aids such as computer programs for design process, drawing programs, evaluation programs, cost calculation programs, etc. The system also provides data communication between the architect and members of the design coalition team (2). This is found to be of vital importance in the architectural design process, because it can enable the architect to fit in changes, brought about in the project by different parties. Furthermore, they will be able, to oversee promptly the consequences of changes or decisions in a comprehensive manner.

The system will offer advantages over the more commonly applied microcomputer based CAAD and IGDM (integrated graphics database management) systems, or even larger systems available to an architect. Computer programs as well as hardware change rapidly and become obsolete. Therefore, unrelenting investment pressure to up-date both software and hardware exists. The financial burden of this is heavy, in particular for smaller architectural practices (for instance an architect working for himself or herself and usually with few or no permanent staff). ADIS, as an on-line architectural design aid, is constantly up-dated by its own organisation. This task will be co-ordinated by the ADIS data-base administrator (DBA). The processing possibilities of the system are faster, therefore more complex processing tasks can be handled. Complicated large graphic data files, can be easily retrieved and manipulated by ADIS, a large system. In addition, the cost of an on-line system will be much less than any other system.

The system is based on one model of the architectural design process, but will eventually contain a variety of design models, as it develops. The development of the system will be an evolutionary process, making use of its users' feed-back system. ADIS is seen as a step towards full automation of architectural design practices. Apart from being an architectural design support system, ADIS will assist the architect in his/her administrative and organisational activities.
ARCHITECTURAL DESIGN AND CAAD

The result of a survey carried out by the authors (3) shows an increasing tendency amongst Dutch architects to make use of the latest developments in office automation, data-bases and computer-sided architectural design. A number of remarks can be made with regard to the manner in which these developments are taking place:

Firstly, these developments tend to gravitate towards the internal functioning of the company concerned. Data communication between the various participants within the building process or the construction team (e.g. builder and supplier) is practically or virtually non-existent. Contradictory to this trend, ADIS is particularly concerned with this data communication. The confidence of those interviewed in the present state-of-the-art technology is only very limited; it is widely thought that the quality of the available software is not yet satisfactory. In particular, the lack of adequate methods to check the completeness and the consistency of the information is experienced as a negative point. Such check programs must be developed and included within the ADIS program assortment.

The attitude of the building industry towards taking the initiative to develop software is rather indolent, contrasting sharply with other sectors of industry. In order to break through this barrier, ADIS will have to conform to very high quality standards.

Finally, the established fact of most of the companies surveyed being unable to define their own priorities and bottlenecks with regard to automation developments would seem to indicate only a very limited level of knowledge of the information sciences and their application possibilities.

The above results are further compared with earlier surveys in the Netherlands and similar studies in the UK, France and the USA. The similarity of these results is significant (4), illustrating the inevitability of a change of environment in the traditional ways of practicing architecture.

These environments will eventually benefit from automation of not only the design activity but also in all aspects of organisation of a professional architectural firm such as administration, planning, co-ordination, marketing and research. At present users of CAAD techniques are mostly limited to drawing and evaluation aspects. However, ideally at the same time a system should be able to support the user's design decisions. In effect, ADIS contains an architectural design expert system acting as his/her advisor in most activities to be performed and mainly in the design activities. Consequently, such a system must be more complex in order to be able to perform such complex tasks. It is obvious that such complicated tasks, also meant for a multi-user environment, cannot be handled by limited systems such as microcomputer-based stations or even larger systems.

In order to design such a huge system capable of being a complete intelligent architectural design assistant, it is more feasible to define all activities of architectural, practices and the requirements for each activity. While it is true that introducing automation into the practice of architecture will change the working conditions of architects, on the other hand the automation process should also be based on the way in which architectural design is carried out in the real world. The changes of the environment will result from a combination of the two. This may require certain changes but it does not imply introducing a completely new system or method of work and/or design.

INFORMATION REQUIRED FOR ARCHITECTURAL DESIGN

One of the requirements of the architectural design activity is information about the project which the architect has to design. He/she must collect all this information, for instance a knowledge of similar projects, technical
data, norms, standards, costs, site descriptions, etc., from various sources. Collection of these data consumes a great deal of time. He/she further has to transform and structure the data for use at the design stage. Most architects have at least a collection of the most essential books and documents in their office for immediate reference. They have to purchase a great deal of books and documents. Alternatively they have to consult different specialised libraries and documentation centres for every small item of information. This, in most cases, will not be possible for architects working in remote areas or when they are a small firm. Sometimes these data are not needed for other projects in the nearby future. Economically, this is an infeasible investment, particularly for small firms. Furthermore, most information after some time will be obsolete. This implies that, for a similar project, the architect has to acquire the latest edition of the same document. To reduce this cost, it would be a good idea to share the required documents. Considering the location of various architectural practices and the fact that architects will prefer, in most cases, not to have regular visitors from competing offices, suggest that data sharing must be in some other form. In a traditional meaning of sharing data, there will also be the problem of demand for the same document at the same time. How can such problems be solved?

ARCHITECTURAL DATABANK

The answer to the problem of data sharing for architects is already provided by the information and computer technologies. In most fields of science, industry and business, data sharing is possible in the form of on-line data-banks. ADIS is such a data-bank containing types of data required by architects. These data types can be graphical data in the form of drawings, graphs, maps, plans and charts; numerical data like tables, figures, numerical norms and standards; pictorial data like photographs of existing or historical buildings; or they are textual data such as descriptive norms and standards related to design of various projects, building regulations, etc. These data can be stored in a central information centre. But, the use of this data-bank alone will not be sufficient for an architect to perform his/her design work. In addition, he/she will require various computer programs and design decision-making aids for different tasks during different phases of an architectural design process. Main sections of ADIS available to architects, therefore, should be:

(a) an architectural data-bank,
(b) an architectural design program bank,
(c) a design decision support system,
(e) an architectural design expert system,
(f) a communication system for the design coalition team and users’ project-related data-bases.

The latter section will be data files of individual users, i.e. they will be retrieved information from the architects practice, unaccessible to other users. Nevertheless, if information about a particular project or method is interesting for general use, an architect may make part of his/her files available to the system for others. In fact, it will not be necessary to collect and store all the necessary data in ADIS. A great deal of required information can be obtained from other data-bases. All data-bases, related to different members of the design coalition team, will form a network for the field of building design (Figure 1).
Figure 1 A general view of ADIS and its contents.
DATA COMMUNICATION OF THE DESIGN COALITION TEAM

Access to these specialised data-bases will be organised by APIS. But other ways to collect information will be available as well. For example, all the information related to building materials, their specifications and cost can be obtained from the data-bank of the building industry which can be linked with ADIS be a satellite data-bank of the design coalition team network. In this case, individual manufacturers of building materials will make part of their own files accessible to the system while having control over up-dating of specifications and costs.

Via APIS, the architect can scan these files and select the required data for his/her work. Amongst other advantages, this will be a very convenient way for more accurate cost calculations. Also, direct access to manufacturer’s files will enable architects to make enquiries with regards to possible changes of specifications by directly bringing his/her required changes on product specifications. Such changes will not affect the original files of the system. They will be part of data communication between the architect and the manufacturer concerned. Decision on implementation of changes will depend on the manufacturer entirely who may adopt it for the project or make it, alternatively, part of the current product specifications.

Data communication is not limited to data enquiries. ADIS will enable the architect to make his/her project-related data-base available to a selected number of other experts, such as structural, civil, mechanical and electrical engineers; and any other experts whose expertise may be required for the design of the project. Using the system, these advisors will be able to make use of the original designs made by the architect. The difficult task of the architect is co-ordination of all these different activities, very often requiring changes of the original design. This could prevent construction problems, which may occur due to mismatched working drawings of different experts. ADIS will provide adequate assistance for this type of co-ordination activities, indubitably increasing efficiency of the practice (Figure 2).

COMPUTER AIDED ARCHITECTURAL DESIGN ACTIVITIES

The surveys carried out by the authors pointed at two significant issues with regard to expectations of architects who, in some way or another, tried to use CAAD techniques. The first issue refers to the data of various CAAD programs, particularly for the most commonly used systems. They found that CAAD programs are, in most cases, drafting programs, not offering the flexibility required for carrying out a complete design process. Recent developments in CAAD program packages have provided some compatible programs, enabling architects to perform different tasks using the same data, but still the scope of such programs is limited to small tasks and simple manipulations within small projects.

The main goal of ADIS is to provide design programs for architects. The second significant issue is that most available CAAD programs are general purpose design aids. Many such programs are available (5). While each of these programs contains many useful functions, applicable in architectural drafting, no available CAAD program offers all the required aspects and an unlimited capacity for complicated projects and various design tasks during all phases of the architectural design process.

For the architectural design activity, the architect should be able to use the same system for all phases of the design process. He/she must have a clear picture of every phase of the design activity and be able to examine all possible design alternatives. At the same time, consequences of various aspects of every design alternative should be easily available to him/her. Furthermore, the system must be capable of assisting the architect in making accurate decisions with regards to these alternatives.
Figure 2. The network of databases of the Design Coalition Team.

Figure 3. Phases of architectural design activity.
THE CONCEPT OF ADIS

ADIS offers a model for the phases of an architectural design process. This model is used for all phases and the system supports the model in terms of data and processes. The latter are programs required to retrieve, transform, manipulate or calculate the data generated during the various phases of the design activity. Input and output of different phases of the architectural design activity exist in various types and structures. They can be textual, graphic, parts of drawings, simulations, models, or data. The output of a phase depends on the input data of the phase. Therefore, in this phase approach, output data of each phase will become the input data for the next phase.

Phases are discrete, well-defined and clear stages of the design process. They are a timeline with milestones to fit the protocol. They are definitive review points for decision making and inclusion of other influences. Milestones express explicitly what results, approvals and updating should be expected, at a specific point of time, from the architectural design process. Milestones are frequently based on estimates of the design activity at a given phase, duration of the phase and access to resources. Phases also encourage a realistic focus on the design process and arriving at the key decision points (6).

In order to analyze the process, the following steps have to be completed:

(a) the process should be broken down into unique feasible activities (phases and steps);
(b) all activities should be listed in detail;
(c) all constraints have to be identified;
(d) network of activities and their relationships should be outlined; and
(e) utility data for each activity should be prepared (7).

The model of architectural design adopted for ADIS is based on many available studies of phases of architectural design activity in practice. It is based on a combination and yet modified versions of phases of the architectural design activity, as used by RIBA (8), BSA (9), AlA (10) and many others. The choice of these models was made on the grounds that they are based on the practice of architecture rather than theoretical assumptions. The authors make a distinction between the use of computers for making drawings and the use of automated systems for the architectural design activity. The latter is an area wherein automated systems should not become an obstacle in the way of the architect's creativity and intuition (Figure 3).

Phases as defined by ADIS (11) begin from the inception of the project, preparation of the outline of work to sketch design and detail design and further to a phase of maintenance and management of realised projects (12). The model offered by ADIS allows the architect to formulate his/her own definition of phases according to specific requirements of the project or the architect's method of work and design. The model will adapt to this new definition. Therefore, we need a model capable of encompassing this flexibility without bringing about fundamental changes in the system or new training for the architect in using the model. With regard to this characteristic of the architectural design activity, the structure of ADIS will also require a dynamic model to encompass the changing status of procedures in conjunction with the data environment which will change accordingly.

Models are simulations of the real world. They can be static models, simulating the real world at a given point in time. An architectural plan is an example of this. Models can also be dynamic, simulating the real world seen over a period of time and allowing a study of the consequences of actions. In other words, the dynamic models give us the capability to describe changes, and unlike static models, are not rigid and can offer a great deal of flexibility. Therefore, they offer a possibility to oversee the consequences of different directions or courses of actions (Figure 4).
Figure 4  A representation of static and dynamic models.

Figure 5  Three different views of the design activity.
THE LOGICAL SEQUENCE OF THE ARCHITECTURAL DESIGN ACTIVITY

The dynamic model of a phase in the architectural design activity (applicable to all phases) has to follow a logical sequence. Each phase will, by having a similar structure, be open for consideration of all required design factors for each phase. This will be a convenient approach for the development of the system and the subsequent automation of the whole or part of the design process. To comprehend this, a clear understanding of the definition of each phase as described by the Strathclyde model of the design process (13), Lawson's view on a phase (14) and, finally, a phase as defined by Archer (15) must be acquired (Figure 5). ADIS adopts Archer's alternative as the basis for description of each phase. In this respect, each phase consists of the following five consecutive steps:

(a) the problem definition or problem state, which refers to the listing of all design requirements, rank ordering of problems, interrelation of these problems and global intended outcome or solution of the phase and finally formulation of courses of action. This step is, in Archer's view, "gathering whatever information is available and confronting it with the intended outcome. This information must be converted to a form that can be used to define the required characteristics of intended solutions" (16);

(b) the analysis, which refers to the listing of all design requirements and the reduction of these to a complete set of logically correlated performance specifications. Analysis is defined by Hillier as "a rationalised design process by breaking down a design problem into its elements and adding an information context to each element" (17);

(c) the synthesis, which refers to finding suitable solutions for each individual performance specification and a complete design from these with as little compromises as possible. Synthesis, in Hillier's view, is "inducing a solution from the information provided at the analysis step by a set of logical or procedural roles, i.e. design "(16) process);

(d) the appraisal, which refers to evaluating the accuracy with which alternative designs fulfill performance requirements (19); and

(e) the decision or solution state, which refers to the logical selection of an optimum solution in the context of the list of requirements and the intended solution. "The optimum solution should be demonstrably incompatible with some of the sub-problems" (20).

THE ADIS-MODEL OF THE ARCHITECTURAL DESIGN ACTIVITY

The model developed for ADIS is the basis for structuring the data-bank which will contain all required information for architectural design, the program bank containing CAAD program packages, cost calculation programs, evaluation programs, energy calculation programs, etc. and decision making models for both the design activity by the architect and the participation of the design coalition team.

To construct the model, steps of the phase, as defined in the previous section, have to be further structured in a manner suitable for our purpose. The model then combines these arguments with the GOM-model of the design activity (21). The model considers design as a problem-solving activity where each state can be obtained by the application of an operation to the previous state. We can refer to each problem-solving process as a chain or network of states (which are data) and operations (which are processes) in such a way that loose-ends are also attached. The task of problem solving corresponds to finding the right sequence of operations (or action path) that transforms the problem description state into the solution state (22).

The architectural design activity is a hierarchical process, controlling the
Figure 6  The GOM-model of the design activity.

Figure 7  Main categories of processes in ADIS-model.
order in which a sequence of operations is to be performed (plans). In a way, this complexity has to be disaggregated into chains of simpler conditions of input/output, related to the logical action path of the design activity. The complexity of relationships and their subsequent disaggregation can provide the basis for concurrently executed problem-solving activities (23). Simultaneous or concurrent design activity requires an organisational structure of the design activity, demanding a system of rules and/or patterns/measures to allow a thorough analysis of the problem state and its subsequent synthesis to attain the decision state. The ADIS-model adopts an structuralist approach as its basis to replace atomistic attitudes or holistic explanations (24).

The structuralism, according to Piaget, is "positing systems of interactions or transformations as the primary reality and hence sub-ordinating elements from the outset to the relations surrounding them, reciprocally, conceiving the whole as the product of the composition of these formative interactions" (25).

Relating these arguments to the architectural design process we can take the view that the structuralist view of the design process can provide a chart of the design activity wherein all elements and their relationships can be explained in unity. Structures are adequate modes of analysis that can be developed further in the actual design process or synthesis step. They also provide relevant attributes to discuss the possible effects that is likely to be produced by the design activity. The determining factor in this model is change which will take place at a rate that is appropriate to the process and is related to the time intervals of the architectural design process, defined as phases (26).

The GUM-model provides the theoretical basis of the model of ADIS for architectural design activity. This model is described in terms of fields of knowledge and how knowledge can be organised; and values as related to the various functions in the architectural design activity. Implementation of these arguments in ADIS as a practical model requires the support of information and computer technologies (Figure 6).

The model of ADIS is defined in terms of data and processes. In this model, the design starts with a choice for the architect with regard to defining the phase according to his/her requirements, or alternatively, he/she can follow the standard phase requirements for the phase as already implemented in the system. The system will assist the architects if he/she chooses to follow a different action path. Input of every phase will be the solution of the previous phase. These data, confronted with the intended solution of the same phase, define the problem. In the analysis, synthesis and evaluation steps of the phase, we have to break the problem down into smaller feasible fields. In this respect, the first step will be to break the design problem down into different design aspects or attributes. The architect will either define the design aspects or attributes according to the project requirements and his/her creativity and experience, or follows the standard attributes as will be suggested by the system, also based on the project to be designed. The architectural expert system of ADIS will be the architect's assistant in this matter. Further, we have to analyse each design aspect at different levels. Levels are measures of analysis ranging from specific to general. During the analysis step, ADIS will provide any further information required to carry out the design activity. This will be the only data-entry point in the model (access point to the data bank). Therefore, if in other steps the system indicates insufficient data, the feedback mechanism of the system will advise the architect to return to an appropriate step in the process. This return will be always at the analysis step of an appropriate phase. This relates to the regulation of data flow by the system and structuring of a phase as adopted by ADIS.
The architect will start the design activity at the synthesis step where all accumulated data have to be integrated in the order of first levels of each aspect (co-ordination processes) and then aspects (integration processes). The processes related to phases are development processes (Figure 7). Depending on the variety of alternative information and/or decisions of the architect for co-ordination and integration of data, alternative designs will be generated. These alternative designs at appraisal or evaluation step have to be compared with the intended solution. On this basis and/or the architect’s creativity and intuition, the architect, with the assistance of the system, will select a set of acceptable solutions. At the decision step, the architect will choose his/her optimum design solution. At the early stages of the design activity, the architect may choose more than one of the accepted solutions but ultimately only one solution has to be selected for the realisation of the building. We believe that ADIS-model is applicable to all fields of design such as product design, urban design, etc. Nevertheless, data requirements and types of processes as well as number and definition of phases, levels and aspects will be different for each field of design (27).

Participation of members of the design coalition team can only happen at decision points of the model depending on their position in the team. The system allows concurrent design processes by different members of the team, particularly with respect to the architect’s advisors. Feedback mechanism of the system does not follow a hierarchical pattern. This will enable the architect to return to any part of the model (any step or any phase) and at any time. He/she can freely explore the entire process and bring about any desired changes or review previous actions. In addition, the architect is provided by the system with a sketch-pad directory for inserting new design ideas during one step for a previous or future step. All changes made by the architect in previous steps will be incorporated by a default system contained in ADIS. Therefore, the architect does not need to repeat the whole process for any new change which he/she makes. The system keeps a record of all changes for the architect’s review before the decision step for optimum solution or the final design solution (Figure 8).

GEOMETRIC INPUT/OUTPUT DATA

Input and output data of different phases of the architectural design project are in various forms and structures. They can be textual, graphic or numeric data. The type of data related to each phase depends on the requirements of each phase. Data with regard to graphic I/O (geometry) are produced during the following phases:

1. Structure plan phase

The architect begins this phase by producing spatial relationship matrices, functions relationship diagrams and bubble diagrams which are the output data of this phase. His task during this phase is to transform input data to output data using ADIS-model. ADIS-model is in this respect his tool for transformation of data. The system enables the architect to consider his design abilities, intuition and creativity by allowing changes to I/O data before, during and after the phase.

The architect processes input data using analytic processes which are provided by the system. It is an agreed convention of ADIS-model that the difference between input data and output data explains the problem. Input data of this phase is the detailed brief of the project and outline of work and output data will be bubble diagrams and spatial relationship matrices. These are in architectural design terms, useful
Figure 8 The ADIS-model of the logical sequence of one phase of architectural design activity.
preliminary design materials enabling the architect to proceed with preparing sketch designs. In order to define the problem, the architect must have a view of output data, or rather the characteristics of output data.

Input data of the analysis stage is textual, graphic and numeric data provided by the previous phases of APIS-model. At this stage the architect has to process these data in order to proceed with the architectural design activity. APIS-model suggests that the problem should be broken down into sub-problems, i.e. the problem is decomposed into aspects, in effect various design aspects or attributes. Number of aspects and their definitions are chosen by the architect. ADIS-model suggests three main aspects which can be further broken down if necessary. The standard aspects of ADIS-model are utility, durability and manufacturability. The accent of this phase is more on the aspect of utility. In order to complete this stage, the architect has to analyse each aspect further in terms of levels. He has to select levels relevant to this phase, being space unit, single building, group of buildings and neighbourhood levels. The purpose of this stage will be to completely define what spatial functions or sub-functions exist. They should be recognised and classified. Relationship of all functions must be clear and their characteristics or specifications known.

The decomposed problem into spatial functions have to be integrated, giving them a meaningful structure. This will be in the form of matrices of functions relationships which describe all possibilities of spatial arrangements of spaces or functions. It will also provide the architect with all possible diagrams each offering a possible spatial arrangement of spaces or functions. The output data of this stage are different alternatives of possible solutions and have to be tested or evaluated against certain criteria set by the system or the architect. The order of the synthesis stage is the opposite order of the analysis stage. In other words, at this stage, first integration process occurs for levels of each aspect. Then the process will continue to integrate aspects.

Alternative design solution generated at the end of this phase, have to be evaluated and weighed according to the criteria set by the designer. He/she can also select his/her criteria from the set of criteria offered by the system. These criteria determine validity of the solutions which is mainly correspondence of the solution to the intended outcome of this phase. Also, the designer may find some or all generated solutions unacceptable even though they may conform to the set criteria on the basis of his experience, intuition or creativity. On the other hand, the architect may select some of unacceptable solutions by the system for the same reason. The system will evaluate each solution separately and make its suggestion on acceptability of the solution. The designer will confirm or reject suggestion of the system. Evaluation of alternatives are independent of each other. At the end of this phase, the system will provide an overview of the output data, classifying them into three categories of acceptable solutions, solutions which the architect is in doubt on their validity or acceptability, and rejected solutions. It is also possible for the system to arrange the solutions according to their weight of acceptability for an overview of solutions. This will be done by the system in a matrix of evaluated solutions which contains a scale showing range of acceptability of solutions. If no acceptable solution is found, the system will suggest the architect to return to an appropriate place of ADIS-model to make proper changes in input data, enabling him to generate different set of solutions. In this case the system's Feedback Mechanism, will follow the previously carried out processes with consideration of the changed input data and the architect does not need to go through with all the work carried out already. Nevertheless, the system will pause at the end of every stage for confirmation of the
output data by the architect. This is seen as an advantage of the system, saving the architect's time for repeating the same process in the event of some necessary changes in any previous stage of architectural design process. The architect has to make a decision on one or more of the acceptable solutions which were evaluated during the last stage of this phase. The system will support the architect’s decisions by providing him/her with the decision-making requirements, decision-making models and additional data if necessary. The input data are in effect the matrix of evaluated solution. The designer will create decision criteria for this stage, or alternatively can take the suggestions offered by the system. Though eventually the architect must produce only one final design solution at the Detailed Design Phase, he may choose to select more than one acceptable solution at this phase. This will enable him/her to produce more design alternatives, providing him/her with a possibility for offering a choice of the design solution to the user and/or client. Participation of members of the design coalition team at this phase will be possible. The system will offer appropriate collective decision-making models, which will assist the architect with this task.

2. Sketch design phase

At this phase the architect will generate sketch designs of the project to be designed. Input data of this phase are accepted alternative bubble diagrams and spatial relationship matrices which were output data of previous phase. The design process for each alternative solution will be carried out independently. Each of these separate processes will generate a set of alternative solutions, that is different sketch designs. In effect the architect does not need to repeat the process of transformation of each bubble diagram. The system will allow him/her to carry out the process with regard to the first chosen bubble diagram, and will repeat the process with the next alternative bubble diagram from acceptable solutions of the previous phase. Similar to the previous phase, at this phase he/she will be able to stop the process or making any required changes as the process proceeds from one stage to the next. The advantage of ADIS-model is that once an architect uses it as his/her design process model, he/she will realise that all phases of ADIS-model have same principles and follow exactly the same procedures. The only difference in different phases will be the input data. The further the design process goes, the more difficult will become the Feedback Mechanism. This complexity will be due to increase of feedback points in the system and will be managed by the system. In principle, the Feedback Mechanism does not follow any hierarchical procedure. Feedback points are known to the system and literally the architect can move between these points at any time during the design process whether returning to that point is recommended by the system or not. All data produced during previous phases of ADIS-model are in a well structured form available by the system to the designer in appropriate data types. The architect begins this phase using these data to produce sketch designs of the project including sketch drawings of different plans, elevations and cross sections of the design as well as schematic isometric, axonometric and perspective drawings of the design, the output data of this phase. His/her task during this phase is to transform input data to output data using ADIS-model. ADIS-model is in this respect his/her tool for transformation of data. The system enables the architect to consider his/her design abilities, intuition and creativity by allowing changes to I/O data before, during and after the phase.

In this phase the goal of the architect is to transform the bubble diagrams and spatial relationship matrices (input data) to sketch
designs (output data). The result of this phase, that is output data of this phase, are drawings as well as tables related to the cost, energy and other calculations. Data at this phase will also include data with regard to the requirements of other members of the design coalition team. At this phase participation of members of the design coalition team is possible. During stages of this phase of ADIS-model, the architect will carry out the design independent of members of the design coalition team. At this phase of the design process, the architect has to consider effective participation of engineers who will eventually take care of all technical designs of the project. They include structural, civil, mechanical and electrical engineers as well as quantity surveyors, experts and building advisors. Nevertheless, the architect may consider other members of the design coalition team to exert influence on the design process. It should be mentioned that at this phase any major changes made to the brief of the project by the client after this phase is completed, will result repeating the whole process from the very beginning. Minor changes can be taken into account and provisions are provided by the system in the Feedback Mechanism which will allow such considerations.

3. Detailed design phase:

At this phase the architect will prepare detailed designs of the project to be designed (i.e. working drawings, specifications, contract of tender, etc.). Input data of this phase are accepted sketch design drawings which were output data of the previous phase. The design process for each alternative solution will be carried out independently if different sketch designs are selected. This means that several buildings of the same brief have to be built, as every detailed design should be realised as one building. For example this can happen when designing a housing project. Each of these separate processes will generate a set of alternative solutions, that is different ways of detailing a building, but the architect and his expert team have to decide only one of the acceptable solutions if the project requires construction of only one building.

The architect begins this phase using data generated at the previous phase to produce detailed designs of the project including working drawings of different plans, elevations and cross sections of the design as well as detailed isometric, axonometric and perspective drawings of the design. At this phase he should provide all necessary technical data needed for realisation of the building. These working details will be either designed by the architect or in part or whole will be selected from the libraries of ADIS. The latter data can be modified by the architect later in the process to fit special requirements of the project. This will include precise dimensions of the details corresponding with actual sizes of the building to be realised.

At the synthesis stage of this phase of ADIS-model, the sketch drawings and specific data provided for this phase have to be integrated, giving them a meaningful structure. This will be in the form of detailed drawings (geometry data) which describe exact spatial arrangements of spaces or functions and their exact dimensions and volumes. Output data of this stage will be working drawings of the project together with the relevant reports, bill of materials, specifications and contract of tender for the contractor in addition to a construction time-table. In order to enable the architect to proceed with the design process, the system will assist the architect to make a decision with regard to the optimal solution. It should be mentioned that the system will provide the other experts involved in the design process with the same data as produced by the architect. This will make communication of experts
easier and the architect will be able to see consequences of experts advice very quickly and can promptly respond to their advice. In addition, the system will allow the architect to see the total effect of advice of all experts involved on his/her design. At this phase, all experts involved in the design of the project, have to produce their exact working drawings using the same data as produced by the architect and almost simultaneously. It will be possible for the system to create a teleconference between all experts involved and the architect. The effect of this being a possibility for every expert to see consequences of all different decisions and final decisions can be reached collectively. The use of the same data by different parties enables participation of experts from early stages of design and simultaneous design will become significant and possible. At the end of this phase, the architect will have a complete set of detailed drawings of the project as well as all necessary calculations for active involvement of the contractor and accurate decision of the user/client, saving time for site preparations (Figure 9).

ADVANTAGES OF THE SYSTEM

a. Ability of the system in offering required data and or information on the particular project.
b. Ability of the system to offer procedures to the architect to carry out the architectural design process, or creating his own choice of architectural design methodology.
c. Ability of the system to allow generation of a greater number of alternative solutions than traditional methods of architectural design process. The latter would be more time consuming and in practical terms is usually not feasible, especially for professional designers, due to both time and economic factors.
d. Ability of the system to show the consequences of each alternative solution with regards to his/her set of criteria.
e. Ability of the system in offering the Feedback Mechanism as a timesaving factor. In effect, the Feedback Mechanism is designed in such a way that can implement any required data at any stage of any previous phase of the architectural design process by returning to the exact place in ADIS-model where it was necessary to seek a change in the input data.

DESIGN OF THE SYSTEM

Each module of the network of the Design Coalition Team databases will be designed separately in co-ordination with design of the rest. This will be carried out with possibility for complete data compatibility and data communication of all related databases. In this research we concentrate on designing ADIS as an integrated part of the whole system. The network of the DCT databases (Figure 2) is the highest level of the system providing complete, efficient and consistent understanding and communication of information between satellite databases and their branches. This research concentrates on designing the system for ADIS, in itself a network of databases and databanks. The databases, databanks and program-banks are either directly part of ADIS (developed, implemented, maintained and organised by ADIS) or are provided by other organisations (information institutes, vendors, etc.). In the latter case ADIS have to maintain data compatibility. The agreement on compatibility and standardisation of data will be reached between ADIS organisation and other parties before they join the system.
Figure 9 Phases of architectural design activity generating graphic I/O.
We argue that subscription to APIS will be beneficiary to both users of the system (by having access to up-to-date high performance programs and the required information) and vendors (by being able to develop program packages with less limitations and a guaranteed copy protection rights). Phases of designing the system and sub-system are logical design (present state of this research), physical design, implementation, use and maintenance (Figure 10). Main issues to be taken into account with respect to designing the system are:

a. understanding and communicating the content of subjects;
b. defining requirements of the system;
c. understanding and defining the structure and content of the system;
d. understanding and designing an appropriate filing system;
e. providing unambiguous, non-redundant, consistent and understandable information; and
f. defining requirements of ADIS-model in terms of performances, types of data, types of processes, decision points, etc.

CONCLUSIONS

The authors argue the necessity of a change in the professional execution of work of the architectural practices. This proposed change is in the context of introduction of information and computer technologies in the carrying out of activities of the architectural practices. The results of the case-studies show an increasing interest amongst the professional architects in the implementation of these technologies in order to improve their professional performance. They also point at the importance and necessity of such developments. The concept of ADIS has been introduced to fulfil these needs. We have argued that the amount of information required for the architectural design process is accumulating rapidly. APIS will provide an opportunity for the architects to have access to these data during the design activity. Furthermore, ADIS contains means of manipulating and retrieving the data which the architect will collect from APIS for his/her particular design project. These are referred to as tools. Tools can be in the form of models, methods and techniques. They can be also partially or totally automated. In this case we refer to them as programs such as the CAAD program packages, etc. These programs are means for realisation of the design activity. They vary from design programs to evaluation programs. These tools are necessary means in the conduct of the practice of architecture and will inevitably increase the architect’s professional expertise by providing extra opportunities for his/her intuition and creativity.

We have also argued that another important aspect of APIS is supporting the architect in the design decision-making processes. This has been referred to as the design decision support system which benefits from an architectural design expert system. We have pointed out that this capacity of APIS will facilitate participation of members of the design coalition team. Members of the design coalition team are defined as those who are involved in, affected by or able to exert direct or indirect influence on the process of designing the built environment (26). Participation has been introduced as a necessity in the changing image of the architectural profession.

All services of APIS are provided by a number of databases containing all requisite data and tools. They have been referred to as the project-related databases and the general databases. The latter, as a matter of convenience, has been referred to as the databank (containing all the architectural data) and the program bank (containing all the design tools including CAAD program packages). Also, in this paper we have made a general reference to the requirements of the development of APIS. We have argued that, in order to define the data
Figure 10 Logical design of the system (a).
types and processes, we have to define the logical sequence of the architectural design process. This model, based on the GOM-model of the design activity, will guide us in determining the data flow and the processes. The logical sequence of the architectural design process (ADIS-model), is defined by three dimensions of phases, aspects and levels. Applied to architecture, they represent respectively the development, integration and co-ordination dimensions of the architectural design activity.

ADIS provides a network of distributed data bases which will serve the information requirements of members of the design coalition team, providing adequate communication channels between them in terms of data and processes.

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