Master Architect: an object based Architectural Design and Production system

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Abstract:

Master Architect is an object based CAD system which tightly integrates architectural modelling and drafting activities. The design elements within Master Architect have built-in architectural intelligence. The system includes a number of architectural oriented editing commands. The design elements are 'objects' which dynamically respond to these commands. This enables the architectural user to construct and dynamically edit a complex and realistic building model.

Introduction

Architectural practitioners are always under considerable commercial pressure to generate production information in an efficient and timely manner.Early commercial CAD system addressed this type of issue by providing facilities to construct and edit graphical information. Typical of the facilities were static graphical components or sub-figures, which could be placed or 'instanced' in some building assembly space. Some systems provided 3D as well as 2D assembly spaces. Other systems provided parametric components, but a general feature of systems of this type was that the editing and manipulation facilities were limited to move, copy and delete.

Although some dedicated users struggled hard to make this type of system productive, there was always an underlying feeling that this approach was fundamentally limited because it presented the user with a computer graphics system and not with an appropriate model of the 'creative' design process.

The philosophy at Intergraph has been to develop specific application packages which reflect the 'user models' of the different construction industry professions. Master Architect is a further realisation of this approach.

The intention in developing Master Architect was to address the creative architectural design process. Buildings are complex systems of interconnected design elements. Architectural concepts also involve spatial and logical relationships within and between elements. Master Architect enables the user to model these relationships, and to locally or globally modify the building by controlling these relationships.

Fundamental to the implementation of these design concepts in Master Architect is the 'Object Oriented' software engineering method. This enables the software authors to construct a software system which can support the required complexity of these design relationships. The user can then construct a logical and graphical representation of the building within this software system. Effectively, the user is operating on computational objects which are a metaphor of real building elements.

Multiple representations

One of the essential characteristics of architecture which separates it from other design disciplines is the mix of graphical representations used both in the generative design process and to communicate the outcome of this process in the form of production information.

Master Architect provides both:

- plan representation
- model representation

Plan representation obeys the architectural conventions such as:

- wall intersection clean-up
- door arc swing representation

Model representation is 3D and can be viewed in wireframe or as a shaded image.

The benefits of the object system are evident in the implementation of multiple representation within Master Architect. Design elements, as objects,know how to display themselves in a model window or a plan window. Both types of windows can be displayed simultaneously. The user can edit in either type of window, depending on the particular representation which is convenient for that type of edit operation.

'Primitive graphics'

Master architect provides 'primitive' wireframe and surface graphics, which the users can freely place in his design. This graphics is particularly useful for setting up control geometry for the form of a building, but it would be inconvenient, though not impossible, to construct the whole building from such primitive graphics.

Generic editing facilities

Primitive graphics can be manipulated with generic editing facilities, such as: copy, move, rotate, scale, mirror, delete.

Geometry types mapped into Application types

To provide a higher level 'user model', Master Architect gives the user access to a set of geometry types, which are in turn used to implement a set of application types. The following table describes the mapping between geometry and application types.

Geometry types	Application types
linear element	columns and beams
planar elements	walls and slabs
volume elements	rooms
openings	windows and doors
discrete elements	fixtures

A Master Architect design element is a particular combination of application type and geometry type. The system is flexible and extensible. Future design elements are planned and, for example, may implement application types as different geometry types.

Application specific editing facilities

In addition to being able to manipulate Master Architect design elements with generic editing facilities, the system also includes facilities tailored to the editing of specific design elements. For example:

- walls can be extended, optionally to intersections
- openings can be manipulated within the constraints of walls and slabs
- door swings can flipped.

It is the presence of these application specific editing facilities which gives significant power to the architectural user. He can manipulate architecture with architectural commands, not just general graphics commands.

Editing control

The application editing commands above operate on individual or pairs of design elements. However, both buildings and architectural concept are complex systems. An effective CAD system must enable the user to represent complex relationships between elements. These relationships may be inherent in the finished building or may purely be used to manipulate the design concept. Master Architect provides two relational systems, which the users may optionally use. These are:

- reference planes
- networks of linked elements

Reference Planes

These are available in three different forms:

- vertical planes (represented by grid lines)
- horizontal or sloped reference planes
- active limit planes

The user can have many different reference planes and at any stage select a pair of reference planes to be the currently active limit planes.

Different design elements may be freely placed in the design, or be constrained to be placed on grid lines and/or between the currently active limit planes.

Reference planes can be used just in the initial placement of design elements, and optionally can be used to control the subsequent editing of the design. In the latter case, the design elements are 'connected' to the reference planes. These connected design elements can be globally edited by moving the reference planes.

The user can review which elements are connected to reference planes and can connect or disconnect elements to reference planes.

Networks of linked elements

Design elements, which are geometrically connected, may optionally also be logically linked as a network. If one of the design elements within such a network is moved or modified, then the geometry of the other elements in the network is modified to retain the logical connections.

These networks may represent relationships between design elements which exist in the finished building (for example, the structural systems), or relationships which are transitory and may only exist during part of the design process (for example, a network of walls used to experiment with a particular room layout).

The elements which form a network may be reviewed, and elements added and removed from a network, or moved to another network.

Summary of editing facilities in Master Architect

We have seen that there are the following editing facilities:

- generic editing
- application specific editing
- global editing via reference planes
- editing, preserving network relationships

The use of the sophisticated editing facilities is optional and depends on the requirements of the users. There are so many important design decisions which are involved in editing that it is impossible to anticipate all requirements. The intention in Master Architect is not to hard code specific design judgements into complex editing commands, but rather to provide the user with a comprehensive tool kit of simple, yet powerful, commands. These are totally compatible and can be combined by the user to achieve a wide variety of building geometry.

Parameter control

To complement the extensive geometric editing capability, Master Architect also provides higher level facilities to control the parameters used in the definition and placement of design elements. These facilities have important implications when an architectural practice wishes to set practice or project standards for different types of design elements.

For each type of design element, there is an associated set of placement parameters. Different sets of placement parameters can be defined either prior to a design session or during a design session and used to control the placement of that type of design element. Each specific set of parameters can be given a 'design code' name which can be subsequently used as the key to recall that set of parameters.

For example, a standard external door may have a different set of parameters to a standard internal door, which may need to be controlled via specific design codes.

Similarly, the user can define a schema for non-graphic attributes. Sets of attributes can be defined and given an 'application code' name. The name can be used to tag design elements with a set of non-graphic attributes.

The use of design codes and application codes is completely optional and depend on how 'managed' or 'creative' the users want to be.

Non-graphic reports

Non-graphic reports can be run on:

- individual design elements
- assemblies of design elements
  (for examples: a wall and all the openings, windows and doors within it)
- fenced areas of the design

These reports include the design and application codes and 'quantity take off' information.

Visualisation

An important aspect of Master Architect is the facility to generate a variety of different types of graphical output. Master Architect has a direct link to the ModelView visualisation package. The user can use the wireframe or QuickShade facilities in ModelView to set up perspectives for ray tracing. Completed ray traced images can be reviewed and post processed with additional material and colour tables.

Connectivity with IGDS

Translation routines are provided to convert the Master Architect database structure into the following Intergraph formats:

- Vax Architectural Production Documentation Package (APDP)
- Vax Architectural Modeller (AMOD)
- Clipper Project Architect (P-Arch)
- Clipper Project Modeller (PMOD)

These translation processes provide connectivity with other Intergraph AEC products.

Production Drawing output

Master Architect has its own drawing assembly process, which enables different views of a model to assembled, annotated and plotted as a single drawing.

Associativity with the original model is maintained so that modifications to the model are always reflected in the drawing.

A User Extensible system

The authors of Master Architect have produced a 'user model' for an advanced building editor, which addresses many of the issues ignored by previous 'production' CAD systems. However, it is quite unrealistic to assume that we can anticipate many of the detailed requirements of specific types of users.

It is better to provide general capabilities first and then the tools which allow the system to be tailored and extended by the users. A good example of this are the doors and windows. The system is delivered with a set of standard parametric door and window types and with the facilities for the users to generate their own additional parametric types.

The real advantage of the underlying software architecture is that these user written parametric doors and windows are integrated into the main software product. The resulting doors and windows created participate in the same assembly relations as do the Intergraph supplied design elements. In addition, user defined doors and windows can be manipulated by the same application specific editing facilities that applies to the supplied design elements.

The tools available to enable the user to extend the system include:

- Parametric Programming Language (PPL)
- I/Interface (interactive user interface design system)

PPL

This is a 'C' like language, which can be used, by the user to:

- create higher-level commands from calls to existing Master Architect commands
- create new types of parametric design elements

I/Interface

This can be used to design or modify; icons, menus, forms, messages, etc. The user can tailor the user interface to his own local requirements and develop new forms to drive the user written parametric design elements.

Conclusion

To move forward from the previous generation of Architectural CAD means that systems have to break away from static hierarchical data structures and generic graphics editing. But to achieve this break requires that a CAD system must be able to represent complex building systems and to provide dynamic editing facilities. This is what Master Architect has achieved, but this could not have been possible without the type of advanced hardware and software technology available from Intergraph.

The technology is not an end in itself. Our aim is to make it a joy to create real architecture.