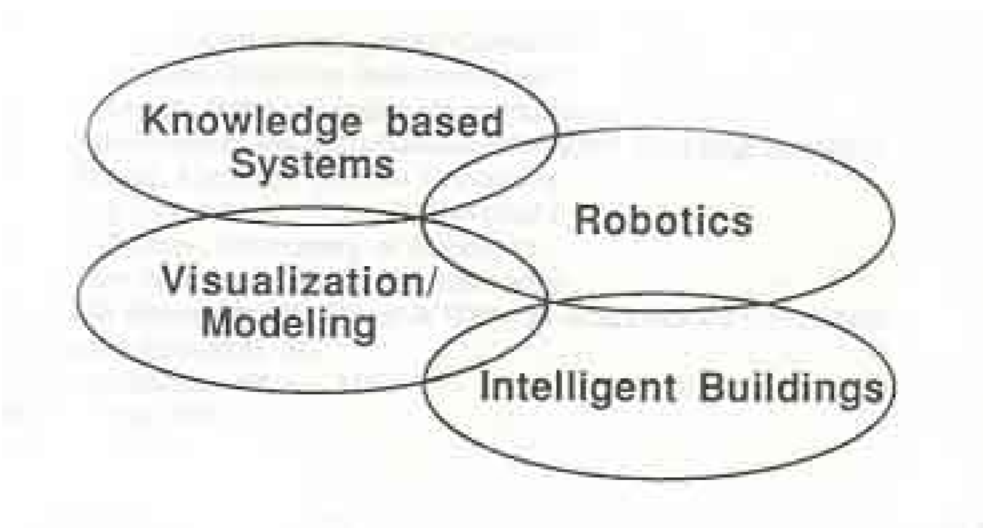
NBS·DATA

INFORMATION TECHNOLOGY IN THE BUILDING PROCESS
DEVELOPMENT TRENDS IN THE USA 1988

NBS
NORDISKA BYGGFORSKNINGSORGANENS SAMARBETSGRUPP

NBS-DATA USA-tour 1988



Information Technology in the Building Porcess
Development Trends in the USA 1988

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Published by:

Swedish Council for Building Research
Stockholm
Sweden

Department Of Structural Engineering
Lund Institute of Technology
Lund University
Sweden

Thanks from the organizer!

I would from my heart like to thank all my friends and colleagues in the USA who made this tour possible and who contributed to make it a great experience, that we now share with other people in the Nordic countries. THANK YOU!

A Special to thanks for making excellent local arrangements to:

Dr. Kent Reed, Computer Integrated Construction, NBS
Dr. John Eberhard, Building Research Board, NRC
Mr. David Harris, National Institute of Building Sciences
Mr. Richard Geissler, Ms. Jan Goebel.Intelligent Building Institute
Dr. Dan Rehak, Carnegie Mellon University
Prof. Donald Greenberg, Cornell University
Dr. James Turner, University of Michigan
Prof. William Mitchell, Harvard University
Dr. Kenneth Reinschmidt, Stone & Webster Engineering Corporation
Prof. Charles Helliwell, MIT
Prof. Tomas Lozano-Perez, MIT
Mr. Earl Mark, MIT
Prof. Patrick Purcell, MIT

I would also like to thank the Nordic group for the privilege to share almost two weeks of dense program and travelling under very enjoyable circumstances. And furthermore for the notes you delivered which finally became the present report.

Lund in May 1989

Per Christiansson

NBS-DATA - arbejdsgruppen under Nordiska Byggforskningsorganens Samarbetsgrupp - initierde og gennemførte i april 1988 en studierejse til USA. Rejsen varede tolv dage og dækkede det norøstlige USA. Her har en række forsknings- og udviklingsmiljøer fokuseret på anvendelsen af højteknologi i byggebranschen. De opnåede resultater tegner i dag frontlinierne indenfor denne domæne.

Det var rejsens formål at formidle et overblik over den højteknologiske udvikling i USA - rettet mod emneområder, som i en overskuelig fremtid forventes at påvirke udviklingen i de nordiske lande: Robotisering, videnbaserede systemer. modellerings- og visualiseringsteknikker samt nye medier for informationslagring. Formålet var endvidere at skabe kontakter til forskere og fagfolk i USA, blandt andet som referencer og støtte i forhold til kommende nordiske forsknings- og udviklingsprojekter indenfor højteknologiområderne.

Denne rapport dokumenterer rejsens faglige udbytte i form af referater beskrivelser og bilag fra besøg på universiteter, forskningsinstitutter og i byggevirksomheder. NBS-DATA takker alle, som har gjort det muligt at realisere rejsen, og som siden har formidlet deres indtryk i nærværande rapport til gavn for byggefagfolk i de nordiske lande. En særlig tak rettes till vor amerikanske venner og kollegaer, som med enorm entusiasme har stillet ressourcer til vor rådighed. Deres viden er med til at bane vejen for en frugtbar indføring af højteknologier i de nordiske byggebrancher.

December 1988

Fritz Sigrist

Formand for NBS-DATA

"INFORMATION TECHNOLOGY IN THE BUILDING PROCESS. DEVELOPMENT TRENDS IN THE USA 1988. NBS-DATA.

Persons visited

National Bureau of Standards
- Dr. Richard Wright, NBS
- Dr. Richard Smith, Center for Fire Research, NBS
- Dr. Kent Reed, Computer Integrated Construction, NBS
- Mr. Mark Palmer, Computer Integrated Construction, NBS
- Mr. William Danner, Computer Integrated Construction, NBS
- Mr. James Albus, NBS Automated Manufacturing Research Facilities

National Research Council
- Dr. John Eberhard, Building Research Board, BRB
- Mr. Henry Borger, Federal Construction Council, FCC

National Institute of Building Sciences.
- Mr. David Harris, Ms. Terry Griffith, Mr. Tom Tiedeman

Intelligent Building Institute
- Mr. Richard Geissler, Ms. Jan Goebel, Kathleen Merlo.

Carnegie Mellon University
- Prof. Red Whittaker, Field Robotics Center,
- Mr. Carlos Zozoya-Gorostiza, PLANEX Demo, Civil Engineering Computer Lab
- Dr. Walid Keirouz, Civil EngineeringComputer Lab,
- Dr. Irving Oppenheim, Civil Engineering
- Ms. Carol Scheftic, Center for Design of Educational Computing 37
- Dr. Chris Hendrickson, EDRC Conference Room 38
- Dr. Gerhart Schmitt, EDRC Conference Room
- Dr. Rob Woodbury, EDRC Conference Room
- Dr. Mary Lou Maher,EDRC Conference Room

Cornell University
- Program of Computer Graphics
- Prof. Donald Greenberg

University of Michigan.
- Architecture and Planning Laboratory
- Dr. James Turner

Harvard University
- Graduate School of Design
- Prof. William Mitchell

Stone & Webster Engineering Corporation
- Dr. Kenneth Reinschmidt

MIT. Department of Civil Engineering
- Prof. Charles Helliwell
- Dr. Fred Moavenzadeh
- Dr. John Williams
- Prof. Duvvuru Sriram
- Ms. Laura Demsetz

MIT. Artificial Intelligence Lab
- Prof. Tomas Lozano-Perez

MIT. Department of Architecture
- Mr. Earl Mark, Electronic Design Studio
- Prof. Frank Miller, Electronic Design Studio

MIT. Media Lab
- Prof. Patrick Purcell

Computervision, Bedford
- Mr. Pertti Vulli
- Dr. Thomas Peters,
- Mr Earl Mark

CONTENT

INTRODUCTION

The Working group for Information Technology under the Nordic Building Research Cooperation Group, NBS-Data, this spring (1988) arranged a tour in the north-east part of the USA to universities, institutes and companies which are at the leading edge (research/development and use) within one or many of the following areas:

- KBS, knowledge based systems/expert systems/ object oriented systems
- Robotics
- Visualization and modeling
- Intelligent buildings

This report contains summary reports from the visits made. The different sections are written by the tour participants and put together by Per Christiansson. The different chapters were delivered on floppy disks for IBM/PC and Apple/MAC and transferred to and collected on a MACII. The word processor WriteNow was used on MACII.

Pär Silén	chapters	1
Einar Skjörten	chapters	2
Christer Finne	chapters	3, 4
Sven Bertelsen	chapters	5, Summary
Hilka Lehtonen	chapters	6
Peter Hauch	chapters	1, 7, 15
Kristian Agger	chapters	8
Väino Tarandi	chapters	9, 14
Pekka Leppänen	chapters	10
Hans-Petter Sundh	chapters	11
Per Christiansson	chapters	Summary, 12, 13, 15, Appendix 1, 2. Editor

Appendix 1 and 2 contains the tour program and participants.

SUMMARY

(notes by Per Christiansson)

The Working group for Information Technology under the Nordic Building Research Cooperation Group, NBS-Data, this spring (1988) arranged a tour in the north-east part of the USA to universities, institutes and companies which are at the leading edge (research/development and use) within one or many of the following areas:
(a) **KBS**, knowledge based systems/expert systems/ object oriented systems, (b) **Robotics** , (c) **Visualization and modeling**, (d) **Intelligent buildings**. The tour was arranged under the heading "Information Technology in the Building Process. Development Trends in the USA 1988. NBS-Data"**.**

12 persons from Denmark, Finland, Norway and Sweden participated in the tour. The group was composed of persons who have a broad knowledge within the field and also are active in positions entailing strong possibilities to influence and contribute to future works within the area.

The aim with the tour was to take part of the State of the Art developments and trends delivered by highly distinguished individuals and research/development groups in the USA and to communicate experiences.

Visits were made at
National Bureau of Standards (**NBS**) in Washington - (Computer Integrated Construction, Center for Fire Research, Automated Manufacturing Research Facilities),
National Research Council (**NRC**) in Washington - (Building Research Board BRB, Federal Construction Council FCC),
National Institute of Building Sciences (**NIBS**) in Washington,
Intelligent Buildings Institute (**IBI**) in Washington,
Carnegie Mellon University (**CMU**) in Pittsburgh - (Field Robotics Center, Civil Engineering Computer Lab, Center for Design of Educational Computing, Engineering Design Research Center EDRC),
Cornell University (**Cornell**) in Ithaca - (Program of Computer Graphics),
University of Michigan (**UM**) in Ann Arbor - (Architecture and Planning Laboratory), Harvard University (**Harvard**) in Cambridge - (Graduate School of Design)
Stone & Webster Engineering Corporation (**S&W**) in Boston ,
Massachusetts Institute of Technology (**MIT**) in Cambridge - (Department of Civil Engineering, Artificial Intelligence Lab, Department of Architecture, Media Lab),
Computervision Corporation (**CV**) in Bedford .

The tour took place between April 17 -April 27 1988.

The report contains summary reports from the visits made. The visits at the Carnegie Mellon University, Massachusetts Institute of Technology, the National Bureau of Standards (NIST now) and Stone & Webster Engineering Corporation are further commented on below.

The main impression of the tour is that a great deal of very interesting work is going on in the U.S.A. Existing contacts between individuals were deepened and new contacts formed during the tour. The tour has and will no doubt contribute to the future research and development activities in the Nordic countries.

The studied areas overlap of course to some extent. It is noticeable that the development of the computer tools within the building process is in a mature and more realistic stage now than a few years ago. New connections are established within the R&D community and with the building practice. The actual **transfer** of **knowledge** and the means to do it is often emphasized.

The **conceptual** modeling of different parts of the process becomes very important including **representation** of knowledge, representation couplings, product and process modeling, and vertical and horizontal **integration** in the building process.

The result of the conceptual modeling work leads to the difficult task of actually integrating different computer **systems** and **programs** on different levels (both in practice and on R&D sites) - **data exchange**, **model connection**, **terminology**, integration of **knowledgebased systems** and of **new media**, connections to **robotics** units and manufacturing processes.

New **advanced information technology** makes it possible to formulate and try out very refined **man/machine** interface and new **distribution**/storage media - very realistic **synthetic images**, use of **compact** disk and **videodisk** in **hypermedia** applications.

New information technology improves the performance and maintenance of buildings, **electronically enhanced buildings** as well makes possible development of sophisticated **sensor** systems (stationary and mobile).

Often research and development efforts are **demonstrated** in the laboratories to test and get response on new ideas and to establish a beneficial flow of ideas between the laboratories and practice.

More often projects are carried out in **collaboration** within different units at the universities. Computer science, AI, media, psychological etc. units are directly **interacting/collaborating** with architectural and civil engineering units.

The **computer** resources and **infrastructures** at the **universities** visited are often very powerful and under continuous development and extension. CAD, computer graphics, as well as geometric and information modelling and advanced visualization are at most universities highly integrated in the traditional **building subjects**.

A favorable computerization of the building process with quality gain both in the final product and in the process to get there is to some extent a ´political´ problem. It was mentioned that "it seems that the biggest winner in an integrated construction environment, where data can be exchanged without limits will be the **building owners** or the **occupants**" and that it is a "very important issue for the success in the future is that the /project/ **managers** start to use the systems".

The national **committees** which are formed consisting of different actors in the building process are very important fora in the process of formulating, capture and communicate ideas to improve the introduction of computer resources in the building process.

Summary notes by **Sven Bertelsen**

"These notes contain my impressions from the NBS-DATA tour 88 and especially those from the Carnegie Mellon University, Massachusetts Institute of Technology, the National Bureau of Standards (NIST now) and Stone & Webster Engineering Corporation.

Even though the tour program was very concentrated a raw of relevant knowledge centers could not be visited. This may indicate that my summary impressions may be too general.

It was a general impression that in all the places work is going on to integrate the computer systems. Nobody though presented the for me evident idea to regard all the systems as one system, i.e. CAD-systems, visualizing systems, systems for exchange of graphical information, systems to control robots and systems for design - and everything based on an integrated data structure build with regard to objectoriented programming.

It was also distinctive that we did not find any in practice used expert system developed with respect to building sector needs, and only at one place (NBS) a development project within the field was presented. Though expert system thinking was to a high degree present in the process of integrating design systems. Moreover AI ideas was of course highly integrated in the development of robots. Finally we experienced that an incredible amount of equipment was available and much attention was focused on utilizing computer aids in the building process.

DATA STRUCTURES.

It was a general impression that the objected oriented approach is gaining ground and that there also is a trend towards 3-D solid representations.

At several places intense work was accomplished on how to build databases in parallel to an ongoing design process. The traditional database concepts demand, as is well known, that the data structure is determined before data is put in place. But as data structures are dependent on the final building the database may only be structured in pace with the ongoing design.This fact leads, according to experience, to problems with placing data when these arise during the design process.

As it seems the object oriented approach contains solutions to some of these problems. Among other places at Carnegie Mellon work is carried through with computer assisted design process through prototyping. In short, tools are envisaged which support a successive modeling process. The units are objects that do not have to be fully defined to start with. These objects may at a later stage be broken down to more specific components, completely in harmony with the usual architectural and engineering work.

At the same time systems are developed that can support the designer during consistence analysis or to serve as bridges to more traditional programs which are used for example for statistical analysis or calculation of foundations.

Especially at Carnegie Mellon intense work is carried through concerning representation of design information and exchange of this information between different design systems, among other things by use of ´blackboard´.

Extensive work is also going at Carnegie Mellon in the area of robotics. It was here emphasized that objectoriented representations make it possible for the robots to ´interpret and understand´ the design information and to use it in the construction process. Robots on the other hand do not understand drawings, yet.

DATA EXCHANGE

From the meetings with among others NBS it was clear that the development of IGES continues, but that they were aware that the todays design of IGES leads to a dead end. As more CAD-systems work with 3-D solid models there will be a need for another form of data exchange than the IGES graphical exchange support. As a consequence the PDES (Product Data Exchange Standard) is developed. In PDES exchanged data is regarded as information about objects (products). This data have then to be remodeled by receiving Cad-system in its internal format. A parallel development is STEP (Standard for the Exchange of Product data) which is an ISO project.

There is still a long road to go for these data exchange standards but the need for this type of information transfer was clearly announced from a lot of the more practically oriented institutions and enterprises.

Among other things it was also pointed out that there is a growing need for a vertical data exchange, that is data exchange between different bodies working on the same project. Furthermore it was pointed out that there is a need to transfer and make useful the information which arise during the design and construction phases to the later operation and maintenance phases - i.e. a horizontal data stream.

More practical considerations were taken at the Stone & Webster Engineering Corporation. Here a system concept is developed together with IBM where the CAD-part (CATIA) is closely connected to the IBM database DB2. The horizontal data flow is clearly incorporated into the concept and Stone & Webster actually offer their customers to operate data-management on the facilities in other words to collect data during the design and construction phases and make them available for the owner in the following phases.

TOOLS

The different visits left the impression that there is work going on concerning many sorts of tools which all may use the same data representation.

In the first place there are the traditional CAD-tools which to a high degree are based on 3-D solid modeling. We were also shown very advanced systems for visualization, including color management, lighting and shading.

An exiting development which was worked on in many CAD-systems was the ability to animate for example the deformations and movements of buildings exposed to earthquake loads, animation of assembly work, animation of complicated crane movements at construction site, or animation of robot movements in narrow spaces. The technique was at many places emphasized as vary valuable for example during planning of complex plants or during resource planning.

Perhaps because we mainly visited university and research environments the predominant computers were SUN workstations with Unix and MacII´s.

Software development tools were as we could expect, being in USA, LISP-based furthermore at many places applications were developed in Small Talk."

NATIONAL BUREAU OF STANDARDS. WASHINGTON.

Monday April 18.

Dr. Kent Reed, Dr. Richard Wright,
Dr. Richard Smith, Mr. Mark Palmer,mr. William Danner, mr. Al Jones,
Mr. James Albus

Notes by Pär Silén.

NATIONAL BUREAU OF STANDARDS (NBS)

The NBS is chartered by the Congress. Standards are seen as a means to promote commerce. Standards for e.g. measures, weights, test methods, engineering standards are developed at and issued by NBS.

NBS has about 2500 employees, working in two centers, one is located in Gaithersburg near Washington DC, the other is in Boulder, Colorado. The scandinavian group visited the Center for Building Technology in Gaithersburg.

The Center for Building Technology (CBT) is divided into three divisions:
1) Structures division
2) Building materials division
3) Building environment division.

The staff totals about 130, more than 80 of these are professionals. The staff is supplemented by over 70 associates from the US industry, guest researchers from foreign laboratories, visiting faculty members from universities and students.

The mission of the Center for Building Technology is to increase the usefulness, safety and economy of buildings through advancement of building technology and its application to the improvement of building practices.

TYPE OF WORK

The types of work presented to the visitors were: Research and development projects related to expert systems, data transfer, conceptual modeling and robotics. Most of the projects are ongoing or recently finished.

COMPUTER INTEGRATED CONSTRUCTION ACTIVITY AT NBS

The goal of the group for Computer Integrated Construction (CIC) is to remove the technical barriers to automation and integration of construction processes. The near term objectives of the group is to:
- Understand expert system technologies
- Develop methodology for objective, rigorous and correct representation of standards
- Establish information interface technologies
- Develop a consistent framework for modeling construction information.

CIC has interactions with other centers at NBS and with the Carnegie Mellon University, the University of Illinois and with the North Carolina State University. CIC also participates in the works of CIB/W78: Commission on Integrated CAD, the IGES/PDES Organization and the NRC/Building Research Board: Integrated Project Data Base Committee.

The current scope of CIC activities were presented as follows:

1) Knowledge based expert systems - new vehicles for technology transfer. (Three expert systems have been developed).

2) Representation and use of standards. The work has focused on Standards Analysis Synthesis and Expression (SASE), Standards Interface to Computer Aided Design Systems (SICAD) and Natural Language Processing of Building Standards.
3) Data exchange protocols. The work has focused around the Initial Graphics Exchange Specification (IGES), Product Data Exchange Specification (PDES) and the Standard for the Exchange of Product Data (STEP).

EXPERT SYSTEM FOR ASSESSMENT OF FIRE SAFETY IN BUILDINGS FOR THE AIR FORCE

The ongoing project was presented by dr. Richard Smith. The aim of the project is to develop an Expert System that helps a lay person to assess whether a building design complies with the Air Forces' building regulations. The system that is being developed will initially cover the fire safety aspects of warehouses, later it might be enlarged to cover also computer facilities and hospitals. The work is scheduled to be finished in the summer of 1989. The system development is done on a Symbolics machine with the ART software shell and Lisp.

The system will contain a default universe, that makes it possible to get answers in the initial phase of a design project, even though the data in that phase usually is very fuzzy. The user will have the possibility of changing this default universe during the design process until the whole is described in sufficient detail in the system. No connections to ordinary CAD systems are scheduled yet, because there are no CAD drawings in the initial phase, the interfacing is complicated and because the amount of information needed for fire protection is much less than the amount needed for building the structure.

Some of the building codes will be replaced by proper engineering analysis. This analysis will mostly be implemented in Lisp, not by the use of rules.

COMPUTER INTEGRATED CONSTRUCTION CONCEPTUAL MODELING ACTIVITIES

The project was presented by William F. Danner. He stated that the development of a conceptual model for building-project information requires a precise description of the meaning of the information to be maintained. He presented an analysis of the conceptual structures that are available to specify that meaning, using a proposed "global model" as an example. The model is currently under development by the Architecture, Engineering, and Construction (AEC) Committee of the IGES/PDES Organization.

The conclusion of the presentation was that a core semantic vocabulary is needed. This core vocabulary derives from how meaning is expressed without regard for specific domains of information. Preliminary elements of such a core vocabulary are defined. Further, a means by which that core is extended to add necessary domain-specific semantics was presented. In the analysis work have been identified those aspects of developing a global model for building-project information that should proceed in the context of a broad interdisciplinary effort to represent information and those that require extensive technical input from the building industry.

AUTOMATED FACTORY RESEARCH FACILITY

The status of the automated factory research was presented by Al Jones. The Automated Factory Research Facility (AMRF) is primarily budgeted by the Navy. The budget is roughly $ 50 M. The goal of the work in AMRF is to demonstrate, that it is possible to build up a manufacturing facility piecemeal and make it work. The intended use is to produce quality spare parts quickly for the Navy.

In March 1987 AMRF had produced a working facility. The facility has 6 different workstations for different tasks, flexibility is achieved through device independent control code. The products are fabricated on the basis of pure data.

AMRF is now concentrating on:

1) Manufacturing data preparation, i. e. how to generate process plans, NC-codes, inspection programs etc. from the product data.

2) Going back to the start:
- the concept of the control system (sensing systems)
- the question of making a part
- increasing the accuracy of measuring machines (On-line instead of afterwards checking)

3) Heavy emphasis on transferring the results to the industry. Establish manufacturing centers throughout the country. Placed "between" the universities & research establishments and the end users.

ACTIVITIES IN THE FIELD OF ROBOTICS

NBS' activities in the field of Robotics was presented by James L. Albus. He stated that the emphasis of robotics development have been on industrial manufacturing robots. Recently the NBS' activities have been shifted to other fields, such as robot cranes and moving vehicles. The robot crane project was presented in more detail. (Nicholas Dagalakis is responsible for the practical development of the crane.)

The ultimate aim of the project is to develop a crane for shipyards, which would make it possible to accurately place a big load under an overhang that is 24 feet wide. This task will probably be accomplished by a stabilized platform and a manipulator arm with a counterweight. The stabilized platform is hanging in three pairs of wires, arranged in a manner that makes it possible to freely adjust the position of the platform while still maintaining its' stability. The oscillations of the platform is a problem which currently is studied with big scale models.

Mr. Albus also mentioned another robotics project, which is under way in the University of Maryland. The aim of this project is to develop a stone cutting robot, that would take its' input from design drawings. NBS consults on this project.

RESULTS

The results of the projects presented to the group are described above under the different headings.

COMMENTS

The visit showed clearly one of the current problems with expert systems - nobody uses them in practice. Also the crucial importance of a well structured conceptual product model could be noted. Almost all of the presented projects would in one way or another benefit of such a model.

NATIONAL BUREAU OF STANDARDS.WASHINGTON.

Monday April 18.

CENTER FOR BUILDING TECHNOLOGY, CBT
COMPUTER INTEGRATED CONSTRUCTION GROUP, CIC

Dr. Kent Reed

Notes by Peter Hauch

IGES, PDES activities at NBS

NBS has played a central role in developing ways and methods for the exchange of graphics between different CAD systems. The CBT has housed a secretariat for the IGES organization since the beginning of 1978. Kent Reed and Mark Palmer are both very active in the IGES organization, especially in AEC committee.

History of IGES

IGES version 1.0 was carried out as the result of a small working group within 1979-1980, and became an ANSI-standard in 1981.

IGES version 2.0 was carried out in 1983 with wide participation in the development from the industry, which meant that user demands played a more important role in the development works.
IGES version 2.0 is widely implemented in the most common US-CAD systems, but only partially implemented.

IGES version 3.0 was developed during 1986 and became ANSI-standard in 1987/1988.

IGES version 3.0 introduced some entities which are of particular interest for the AEC industry, i.e. subsets, macros and references to databases.

The documentation in version 3.0 is much better and easier to understand by CAD-vendors than the earlier versions, though the IGES version 3.0 still only have partial implementations appearing, but version 3.0 seems to be the version must widely implemented.

IGES version 4.0 was developed during 1987 to 1988. Version 4.0 have improvements on drawing models, solid models and curved surfaces, all which have less interest for the AEC industry. Version 4.0 is approved by the IGES organization and is still in the publication process.

IGES version 5.0. Though the industry is relaying heavily on the development within PDES/STEP, there still seems to be wishes to carry the development of IGES specification even further than version 4.0. Therefore it has been decided that there will be a version 5.0 of the IGES specification, but it is not yet specified which improvements it will include, and when it will be available.

The content and capability of the current IGES versions:

IGES defines a neutral format for the exchange of CAD drawing datasets. It is the only approved ANSI-standard for data exchange, and the original scope was to provide the industry with geometric, graphical and annotation entities needed to draw a picture or a blueprint engineering drawing.

It was for filing and retrieving means defined, that the specification should include the definition of received datasets to be possible to be read and interpreted by human beings, and not only by application programs.

There is no governing information model behind the IGES specification. The specification is actually not much more that a non-structured list (and specification) of graphical and geometrical and annotation entities, based on existing CAD systems-functions, which makes it possible (or partly possible) to match different entity pairs in different CAD systems.

At the present state IGES has the following capability

You can transmit the following information:

- engineering drawings
- 3 dimensional drawing models
- 2D and 3D wireframes
- ruled surfaces
- constructive solid geometries
- finite element models and analysis results
- network subfigures (connectivity)
- flow associativity (for plant design)
- macro language for user-defined entities
- external file references
- attribute tables (relational data)

The most widely implemented functions are the first mentioned i.e. engineering drawings, 3 dimensional models and wireframes, while all the structural entities (the last mentioned) seem much more difficult to implement, and are not implemented yet.

There seem to be two tendencies in the development line on IGES.

One is to expand the number of entities in order to match the development of CAD functions in the different CAD systems, and to refine the specification of the different entities in order to be able to reach a higher level of accuracy in exchange between different CAD systems.

The other line is to include still more structural entities in order to be able to transfer between different CAD systems not only separate drawings but whole drawing models.

Current status of use of IGES

Many users are quite satisfied and use IGES in daily production.

It was mentioned that Boeing, General Motors, Lockheed, Pratt & Whitney, Scandia/Bendix, Bechtel Corporation, and Stone & Webster use IGES very extensively. Some of them exchange up to several hundreds of drawings a day using IGES.

It is characteristic, that the most intensive IGES users are large corporations, homogeneous with long-lived construction teams, and with huge in-house EDP expertise.

Other users are more frustrated. They claim that the exchange results seem unpredictable and that the exchange process often seems to run out of control. These experiences are mostly claimed by small heterogeneous corporations with short-lived construction and design teams, and corporations which exchange data with many different and new partners every time -such as the AEC industry!

These frustrations have resulted in a very intense work within the IGES organization and the AEC committee concerning the development of special IGES subsets to be used for the exchange of special types of construction data, and for the specification of the use of the different entities, so called "application protocols".

(See notes from Mark Palmers presentation)

PDES/STEP/ISO:

Much emphasis within the IGES organization has in the last years been put into the development of PDES, Product Data Exchange Specification.

PDES is still only a development project and not yet a product or an exact specification to implement in different CAD systems. PDES is based on a rigorous top-down information modelling methodology.

PDES and STEP will probably grow together and be the same standard provided the definition of functional requirements can be reconciled.

PDES concepts and functionality.

PDES/STEP will permit the exchange of complete product models, which can be interpreted directly by CAD/CAM/CAI application programs.

The model consists of three information levels:

- Application information
- Logical entities
- Physical file formats and data entities

PDES is set directly to address some of the deficiencies in IGES.

The physical file format is designed to prevent large file sizes, and long processing times.

The overall structure puts emphases on information and information structure of whole building models, not only on raw entity data concerning drawing models.

Schedule for the PDES work

PDES started out within the IGES organization during 1986, where the initiation effort completed test of modelling methodologies, the grammar, and language binding.

- In 1988 a testing draft with limited application information content was released.
- In 1988/1989 there is planned to be a joint PDES/STEP version 1.0.
- And through 1990-1991 the first validated translators are expected to be available

CIC involvement in IGES/PDES/STEP

The CIC group organizes and has co-chaired the IGES AEC committee. The CIC group has organized and chaired the application validation methodology committee. The CIC group has initiated the IGES AEC translator forum. The CIC group has initiated the IGES AEC application protocols development project, which also handles subset specification. The CIC group is also conducting comparative studies of the modelling methodology used in the AEC committee and of the resulting models.

The CIC group work in very close co-operation with people from Carnegie Mellon University, University of Illinois, and University of Michigan on the questions of modelling methodologies, and is - together with some of the people from the universities - active both in PDES and in the STEP/ISO works.

Kent Reed mentioned, that the hardest problem to overcome in the question of data exchange, is not a technical problem, but rather a political problem. It seems that the biggest winner in an integrated construction environment, where data can be exchanged without limits will be the building owners or the occupants.

Yet the building owners or the occupants do not see it this way, and do not believe, that they will benefit, and therefore are very slow or not willing at all to contribute with funds for solving the -their own - problem.

This seems a problem since solving the data exchange problem is quite expensive due to extensive use of highly skilled resources and the need of working on an international basis. Both which is very expensive.

Evaluation

The CIC group seems to work on the same overall goal as we all do in the Nordic countries.

The general idea is to make it possible in the future to work with different (functional defined) applications around one single building data of information model, which can be developed from all partners, and from which everyone can retrieve the information they need for their specific purposes.

The interest in the data exchange question seems to have split in two main areas:

The first is concentrating on making the entity - or drawing oriented - data exchange format, IGES work in practical production with less problems than now, through specification of subsets and application protocols. This effort needs support from as many CAD environments as possible -also The Nordic countries- and the INSTA B project is seen as an important contributor to this line of development.

The second line is concentrating on conceptual modelling, and modelling methodologies, and contribute to the development of PDES/STEP/ISO.

It seems to be important that work is carried out in both areas, since this makes it possible that either can contribute with information input to the other.

NATIONAL BUREAU OF STANDARDS. WASHINGTON.

Monday April 18.

CENTER FOR BUILDING TECHNOLOGY, CBT
COMPUTER INTEGRATED CONSTRUCTION GROUP, CIC

Mr. Mark Palmer

Notes by Peter Hauch

Developing Methods for Ensuring the Successful Use of IGES by the AEC Industry

Mark Palmer went briefly through the problems with CAD data exchange in general, and using IGES.

Problems occur on different levels.

Level 1:

When exchanging data between two different CAD systems, there will often be a mismatch of entities in the different systems, i.e. one system will give you possibilities to generate and transfer information about geometry, dimensions, notes, tolerances and finishes, while the other system i.e. will only provide functions as geometry and dimensions. This means, that all the information concerning notes, tolerances and finishes will be lost while transferring data from one system to another.

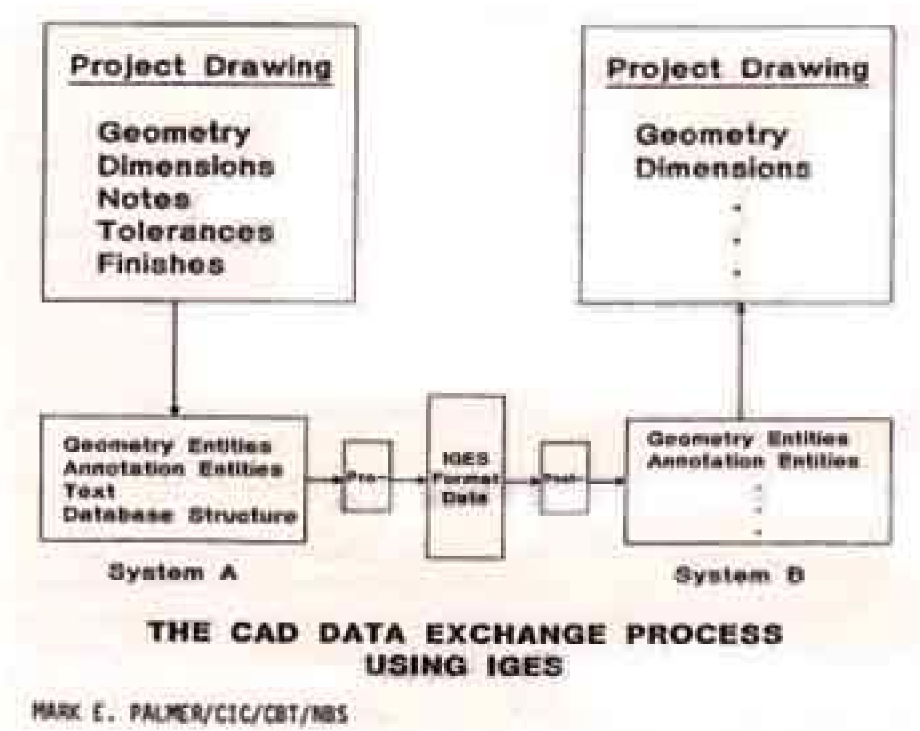

Figure 1 shows the data exchange process using IGES.

This problem has nothing to do with how and by which format you in fact exchange data, it has to do with the existence of different functions in the different CAD systems.

Level 2:

Even if you have CAD systems which contain the same functionalities, i.e. geometry, you will often have problems transferring data from one system to the other.

Different geometrical entities will be handled in different ways by the two systems. This will cause problems or mismatch to occur when transferring data from one system to another.

(i.e. the CAD system DOGS does not know of or contain functions as circles. Every circle is considered a unique instance of an ellipsis and is represented as a lot of short, connected lines. If you transfer information from a CAD system containing the circle-function to this system not containing a circle function, you will not be able to revert the process and end up with a circle in the original system. You will end up with a bunch of lines, if something special is not arranged.)

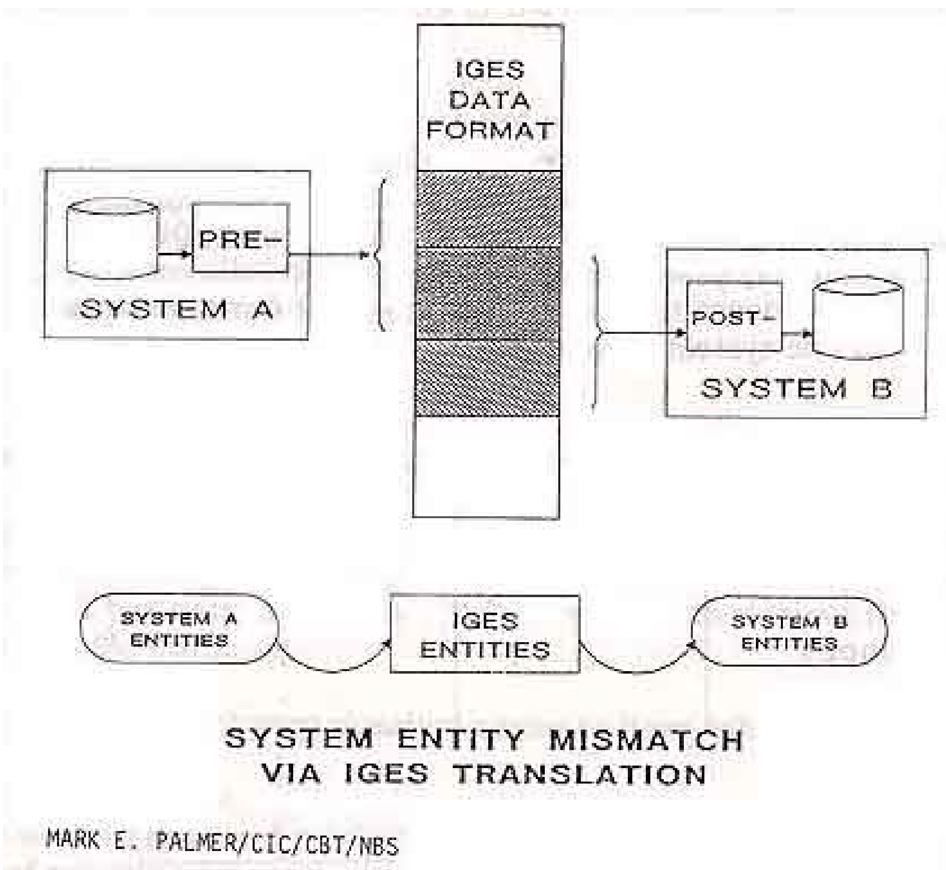

Figure 2 shows system entity mismatch via IGES translation.

Level 3:

Project information - even in project drawing form - in all CAD systems contain some database structure information.

This structure is specific to every CAD system and is defined partly by the CAD database structure itself, partly by the way you use the different CAD functions within the CAD system.

When you transfer information from one CAD system to another CAD system the database structure information will always cause a lot of problems. Especially if the neutral exchange format does not contain any general database structure, or is designed to transfer such information.

Since IGES does not do that, it is very difficult to exchange structured information (CAD database information containing both alphanumeric and graphic information and links between them) using IGES.

In order to overcome some of these problems, the IGES AEC organization has started a project within the AVM committee, in order to draw up a specific subset of IGES entities to be used within the AEC industry, and to develop and provide IGES subset specifications and IGES application protocols.

An IGES subset specification is a limited selection of entities to bee used for a specific application area.

An IGES application protocol consists of a conceptual information model for the application area which it is supporting, and contains:

- documentation
- application protocols format specification
- protocol usage guide
- a set of application protocol format test cases.

The work is carried out in coordination among some of the big manufacturing firms in the US, the IGES organization, the Naval Corps of Engineers and the Army Corps of Engineers.

IGES Application Protocols

The idea behind IGES subsets and application protocols is to provide a method and means to achieve consistent and reliable exchange of product data within a specified application area.

The ambition is to make it possible to transfer all information from one CAD system to another, within a specified application area.

The IGES AVM organization has given a paper: "Guidelines for the specification and validation of IGES application protocols", which describes the concept of IGES application protocols, the required technical content of an application protocol, and the validation methodology for candidate IGES application protocols.

In this paper the key components of an IGES application protocol are mentioned:

The application protocol consists of the following information:

- A conceptual information model for the application area
- An application protocol format specification
- A protocol user-guide
- A set of application protocol format test cases

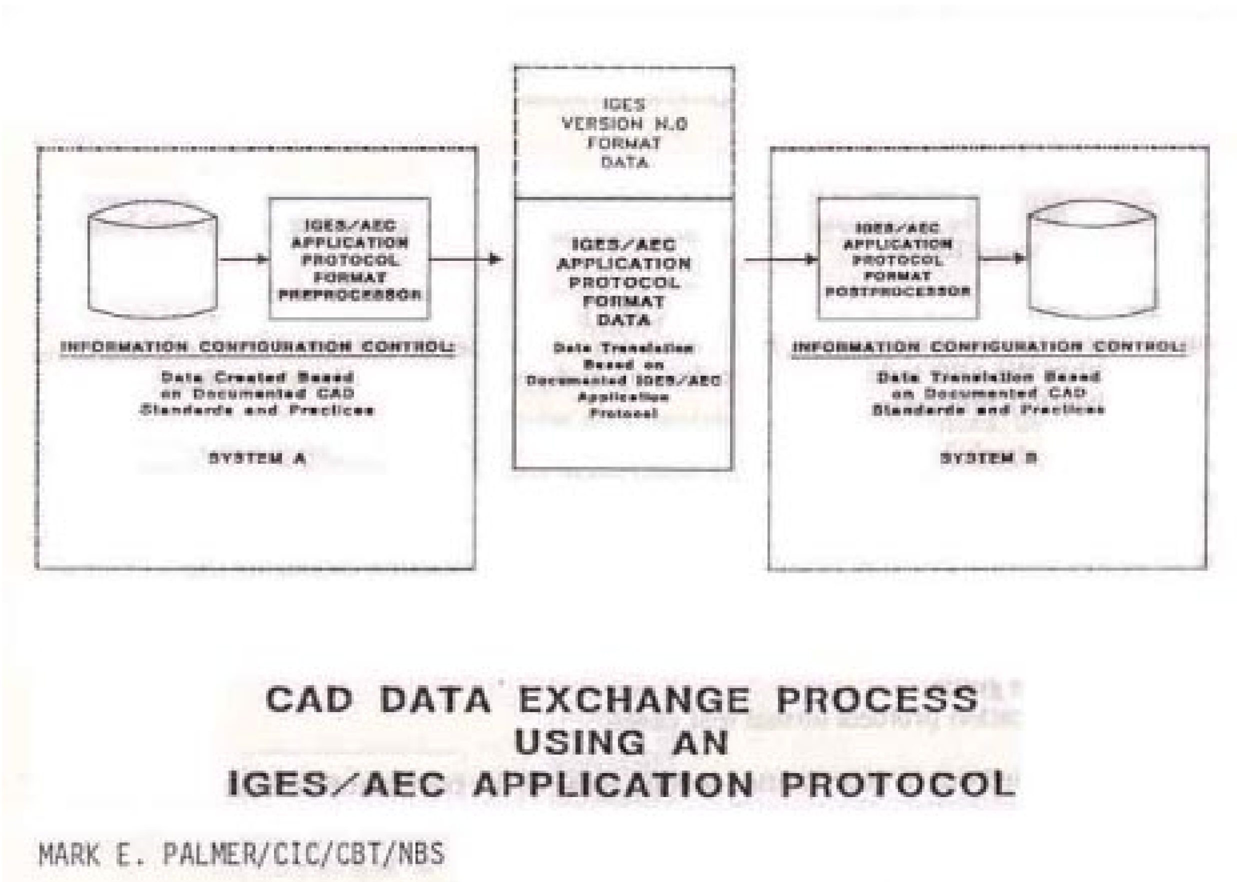

Figure 3 shows the data exchange process using an IGES/AEC Application Protocol.

Testing

Mark Palmer mentioned another very important issue, testing.

The AVN committee is working on testing and validation methodology, and have come up with the idea of establishing an IGES AEC translator forum as a forum for general exchange of experiences when testing across multiple translators, documenting problems in the specification and in the current translator manuals, and the development of subset and IGES AEC application protocols.

Currently the organization is working on the development of new IGES test-files in order to be able to test the translators written for the IGES 4.0 specification.

Evaluation

It is the impression, that the IGES AVM committee is doing a really good job making IGES work in daily production.
The work on subsets and application protocols will make it possible (if subsets and protocols are implemented by the CAD vendors) to maintain a very high level of data exchange between CAD systems using IGES, and it will have very big impact on the way people should use their CAD systems, if they want to obtain this 100% functionality in the data transfer process.

It is also our impression, that the work with application protocols will contribute in a very effective way to the PDES/STEP works, since the AVM committee has decided to use the same conceptual and functional modelling techniques as those used in the PDES works.

Results

Guidelines for the specification and validation of IGES application protocols.

IGES documentation status: None.
IGES/AVM committee
Draft version 0,05, March 15 1988

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THE NATIONAL RESEARCH COUNCIL. WASHINGTON.

Tuesday April 19.

BUILDING RESEARCH BOARD

Dr. John Eberhard, Director Building Research Board
Mr. Henry Borger, Federal Construction Council

Notes by Einar Skjörten

The National Research Council is an operating arm of the National Academy of Sciences, a Congressionally chartered non profit cooperation. The National Academy of Sciences was established in 1863.
The National Academy of Sciences is a 'club' of 1200 scientists with the purpose to give advice to the government on science and technology.
The National Research Council has about 500 committees. The customers are federal agencies: army, navy, post office, veterans etc.

The Federal Construction Council (FCC) is a continuing activity of the Building Research Board of the National Research Council. The Federal Construction Council was created in 1953 and has now 14 members.

The primary purpose of the FCC is to promote continuing cooperation among the sponsoring federal agencies and between the agencies and other elements of the building community in order to advance building science and technology, particularly with regard to design, construction and operation of federal agencies.
Over the years, committees under the auspices of FCC have prepared a wide variety of reports. Most of these include recommendations to the sponsoring agencies. Reports prepared by committees composed entirely of federal government staff usually do not include recommendation.

HIGHLIGHTS OF TOPICS FROM THE FCC WORK:

(1) Microcomputers

...help make more programs for microcomputers.

Report:
Improving the evaluation and use of computer software for buildings.
Committee for the Evaluation of Software 1987

(2) Information in the building process

In 1983 the question was asked:
In what way will computers influence federal agencies?

One main answer is that owners have the most to gain from use of computers, but it will be necessary to have a computer network where the owner can extract what is useful for him into a database.

Today a lot of information is being lost. The bid process is like throwing the drawings over a high wall and get the bid thrown back over the same wall. How to catch drawings in a way that is relevant for the computer?

In 1986 a demo was put together, using a relational database, for catching information but not drawings.

Report:
Report from the 1986 workshop on integrated data base development for the building industry (1987). NRC Committee on Integrated Data Base Development.

(3) Building design and engineering

An evaluation based on truss design for federal buildings

Report:
Report from the 1985 workshop on advanced technology for building design and engineering (1986). NRC Committee for Advanced Technology for Building Design and engineering.

(4.) Building diagnostics

Diagnostics is not measurement, it is "prognosis of the future condition of a building by a knowledgeable person, without intervention"

Report:
Building diagnostics: A conceptual framework (1985). NRC Committee on Building Diagnostics

What are the needs for instrumentation in a building?

Report:
The workshop on building diagnostics (1983). NRC Committee on Building Diagnostics

(5) Intelligent buildings

Federal agencies operate in a very different environment from private. Why did federal agencies get so many bad systems? (Pushed specs too far)

The term "intelligent buildings" is corrupted. Rather use "electronically enhanced buildings". Electronically enhanced in the sense that it can respond to change of conditions related to heating, ventilation, safety etc.

So far the term is stuck to office buildings. It is necessary always to begin with the inside working environment and work out, which is opposite to the ordinary architectural approach.

(6) Miscellaneous statements

Miami Airport is now installing the largest IBM mainframe, part of which will be used for an integrated database for building design and maintenance.

"Robots have a number of strong points, but so far they can not run around a building site." / "There is too little interest in construction-related research." / "Productivity is very difficult to evaluate."

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NATIONAL INSTITUTE OF BUILDING SCIENCES WASHINGTON.

Tuesday April 19.

Mr. David Harris
Ms Terry Griffith, Mr. Tom Tiedeman

Notes by Christer Finne

Subject

NIBS Construction Criteria Base (CCB). The CCB is a data base system which contains federal agency guide specifications, standards and manuals which govern the design and construction of federal facilities. The data is stored on a Compact Disk-Read Only Memory (CD-ROM).

Background

The project started two an a half years ago and was completed during 1987. Its sponsored by the Naval Facilities Engineering Command (NAVFAC) and the Army Corps of Engineers.

When the army or the navy buy a building from a contractor they do it according to their own criteria describing different components and including 50.000 pages of criteria which are their own or adopted from the private sector. The criteria are updated regularly, some parts monthly, some yearly. Conventional distribution media like papers and micro form have lead to problems like old copies and missing pages.

The Construction Criteria Base, (CCB)

The CCB is a data base system which contains federal agency guide specifications, standards and manuals which govern the design and construction of federal facilities. The data is stored on a Compact Disk-Read Only Memory (CD-ROM) and accessed through a menu driven program containing slots like:

- Search data bases
- Move files to disk
- Translate & Copy
- Run SPECTSINTACT
- Installation check
- CCB introduction
- Word processor

Some slots like Word processor are user definable.

The CCB contains the construction guide specifications of NAVFAC, the Army Corps of Engineers and NASA, about 21000 pages. A project specification builder and a cost engineering system are also included.Future revisions are planned to contain similar documents produced by other federal agencies.

Hardware

The user needs an IBM compatible personal computer, a CD-ROM reader, SuperKey and a word processing program to operate the CCB. (95% of CCB users are in the IBM world). The CCB provides an interface to ten different word processing systems. NIBS provide SuperKey and CD-ROM readers as long as common data shops don't provide them.

Advantages

The use of NIBS' CCB makes it possible to make project specifications faster and improve their quality. Search operations can be made using more advanced index systems than is possible in manual work.

Future development

The CCB contains only alfanumeric data. Including graphic information would be an important issue, but the tools don't exist.

It would be possible to develop a dictionary with the main words correct but with bad grammar and a bad syntax in order to make the data base international within two years.

There are no good programs for reading documents on the screen. A program which makes the screen as user friendly as a book is needed.

There is a need for an interface between the CCB and CAD systems.

Subscription

Subscription is is available for 1000$ a year. Revisions are produced quarterly. The amount of subscribers is 160. There is about one request a day, and the monthly growth is 20.

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INTELLIGENT BUILDINGS INSTITUTE. WASHINGTON.

Tuesday April 19.

Mr. Richard Geissler
Ms Kathleen A. Merlo
Ms Jan Goebel

Notes by Christer Finne

Background

A few years ago the term intelligent building was invented. It usually meant a building with advanced electronic equipment, integrated computer aided control systems and often shared tenant services.

After that the term has been used for everything from really intelligent buildings to simple office buildings with a local area network and lost much of its flavor. The original idea of intelligent buildings was an idea of engineers and not the response to a market need. Intelligent buildings have not gone in the way then forecasted. They do exist today, but they have developed in a different direction.

Intelligent Buildings Institute, (IBI)

The Intelligent Building Institute is a non-profit organization serving all sectors of the intelligent buildings community. Activities include:

- promoting the concept of intelligent buildings
- developing guidelines and standards
- government relations

Intelligent Building Definition

The early term intelligent building focused on technical equipment. IBI takes a different approach. An intelligent building should be looked at as a tool, not as a shelter or a place to keep warm in. IBI puts owner and occupant needs in the center surrounded by four basic elements, building structure, building systems, building services and building management. In their publication "Intelligent Building Definition" IBI gives a new definition of the term intelligent building. "An intelligent building is one which provides a productive and cost-effective environment through optimization of its four basic elements and the interrelationships between them. Intelligent buildings help building owners, property managers and occupants realize their goals in the areas of cost, comfort, convenience, safety, long term flexibility and marketability."

IBI emphasizes that long term costs and flexibility are more important than first costs. They show figures which claim that each year 40% of the building users make changes. This leads to the need for on line report generating and monitoring facilities. Consequently one of the next issues is open protocols or standard protocols HVAC, security and electric controls.

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CARNEGIE MELLON UNIVERSITY. PITTSBURGH.

Wednesday April 20.
Prof. Daniel Rehak

FIELD ROBOTICS CENTER

William (Red) Whittaker, Senior Research Scientist, Director

Notes by Sven Bertelsen

The Carnegie Mellon work within robotics is mainly concentrated on applications of great value in the U.S. The work includes matters such as robots for handling waste, for work in nuclear plants and for work in space.

The work on robots in the construction industry was started in 1982. In order to increase the small value the institute changed its scope to Field Robots, which includes the construction industry as well as surface mining, excavation, underground pipe detection, etc. This makes it easier for the center to obtain sufficient funds.

The center consider the robot's size and mobility as important features.

All robots are mobile, very forceful and capable of multiple tooling. They use wave sensors and are based on advanced computing.

The center has set the goal to complete an new system every six months. Each system is built to demonstrate the feasibility of at least one new idea.

The Japanese development of robots for the construction industry is mainly aimed at jobs requiring multiple movements, work in the hazardous areas, work with waste materials and work that produces such waste.

Red Whittaker presented video and slides, showing a number of the projects undertaken at Carnegie Mellon.

The Three Mile Island robot is a device built after the accident on the nuclear plant.

The project was carried out in 1984 in order to investigate what tasks it would be possible to undertake in case of a similar accident. Matters like demolition, material handling etc. was dealt with. The device is a 6 feet high mobile robot that can drive, walk and pull up with 35 degrees of freedom and 200 functions.
It's reach is approximately 8 to 9 meters. It is possible to tele-operate the device monitored by television or pre programmed. Some of the programmed tools-movements are with built-in rules.

Another project is a robot able to map buried pipes. As the machine moves over the surface, pipes etc. in the ground are detected, and a contour map is established.

Originally, the machine was developed to sense reinforcing in concrete, but the first responses came from the public administration which had a need for a machine like that to sense piping in the ground.
Now the techniques are also used to sense other buried objects e.g. drums with chemical waste etc.

For the time being the sensing is based on magnetic sensing, but underground radar, sonar, etc. is also considered. The center tested at number of commercial sensors before deciding to build their own.

The computer in the robot performs an image processing on the sensed picture, transforming it to a vector image. This is then by means of an expert system transformed to the final 2D-picture. The expert system knows what to look for e.g. the expected picture of a pipe Tee. Its knowledge base is continuously updated adding pictures from investigations undertaken. The development group is now working on methods to expand to 3D-terrain model and to measure the depth of the buried objects in the soil.

In 1984 a project concerning navigation inside coal mines was started up. This sort of navigation is considered an easy task because the movements are slow and the robot is alone. The navigation was undertaken by acoustic means (sonar).

The center has constructed the Locomotion Emulator as a test bed for mobile robots´ movements. This vehicle can perform any motion a wheeled machine can do. The vehicle is controlled by a computer program that emulates the necessary characteristics of different types of steering, and transmits the necessary control signals to the vehicle.

Jim Lad went through the principles behind the locomotion emulator.

It is possible to program the emulator to emulate any point on the actual vehicle as a control point. The emulation is undertaken in a multi task, multi processor environment and is based on a response to human commands and to input from the the environment through e.g. vision.

The high level computing generates input to the control computing, which transfers the movements of a control point on the emulated vehicle to the movements of the control point of the locomotion emulator. Finally, the actual commands for the locomotion vehicle´s movements are generated (for instance steer, drive or turret).

The subject of computer vision was discussed. Red Whittaker expressed that laser scanning was considered an accurate technique which is fast repeatable, a characteristic which is necessary for navigational purposes. Direct range measurement makes it possible to build correct geometric maps with any desired accuracy, but real vision is still far away. The problems to be dealt with includes e.g. pattern recognition.

The center will work with three-dimensional mapping in the coming year, combined with techniques for sampling and characterizing a site. This technique could be used when working in hazardous work areas, in space or on the ocean sea bed. (The Viking satellite on Mars - which was constructed ten to twenty years ago - could show only what it could see from the position where it was landed, and it could sample only what it could reach). Another project is a walking machine to operate on almost zero power (200W) and totally autonomous. The machine is planned to be 10 feet in diameter and to be able to work in very rough terrain.

Jeff Zingh then went through the project Navigating Outside in the World. The project is making use of the Navlab, an automatic one ton truck. The navigation is based on a combination between GPS satellite navigation and inertial positioning.

The satellite system, which gives a position with rather great but constant inaccuracy, is used for establishing fix points, whereas the inertial navigation system, which gives a very high accuracy at the beginning but growing exponentially, is used to calculate the position between the fix points. The navigation is based on 20 updates per second with a maximum
tolerance of approx. 1 meter.

The work undertaken in this project falls within three areas:

- Path generation: where shall the vehicle move related to the navigational signals.
- Path tracking: recording the path and re-planning when a new fix point is established,
- Collision detection, which includes research areas such as
  - sensors,
  - assumptions based on dimensions, movement in the world, detectable obstacles and noise within specific ranges,
  - evaluation of growing obstacles and clearance checking,
  - fast data processing, where it is estimated that in the real world approx. 8 million instructions per sec. must be handled.

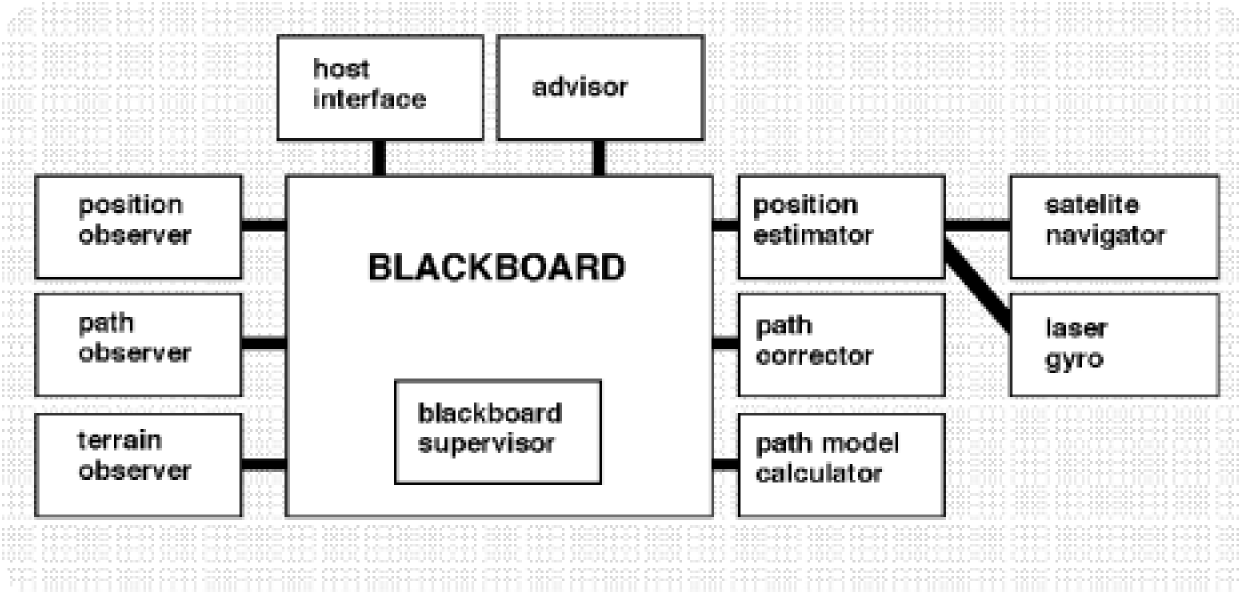

Fig 1 Self-navigating robot, overall system architecture.

The present status is that all ideas are simulated successfully and are now being implemented in the real time environment. It is hard to do the testing in a real environment wherefore all algorithms are tested by emulation. It is expected that the vehicle will actual run this time next year.

Evaluation

The research undertaken at the institute was quite fascinating, and some of the results impressive. However, the practical implementation within the construction industry is quite a number of years away, with the exception of very specialized work areas. Some of the work e.g. pipe detection might be of interest for the public utilities.

The approach made by the center seems far too expensive for the Nordic countries, and it looks like the approach made by the MIT Department of Civil Engineering is far more realistic.

CIVIL ENGINEERING COMPUTER LABORATORY

PLANEX - AN EXPERT SYSTEM FOR CONSTRUCTION PLANNING

Carlos Zozoya-Gorostiza, Post Graduate Student.

The idea behind Planex is to develop an expert system to assist in the entire construction planning process, where normally only scheduling is computerized.

PLANEX works on detailed specifications from which it recognizes elements, makes networks, selects technology and performs cost estimating and scheduling. Output is cost estimates as well as activity and resource plans. The system is developed in Lisp and the expert shell Knowledge Craft. It is running on TI computer "Explorer".

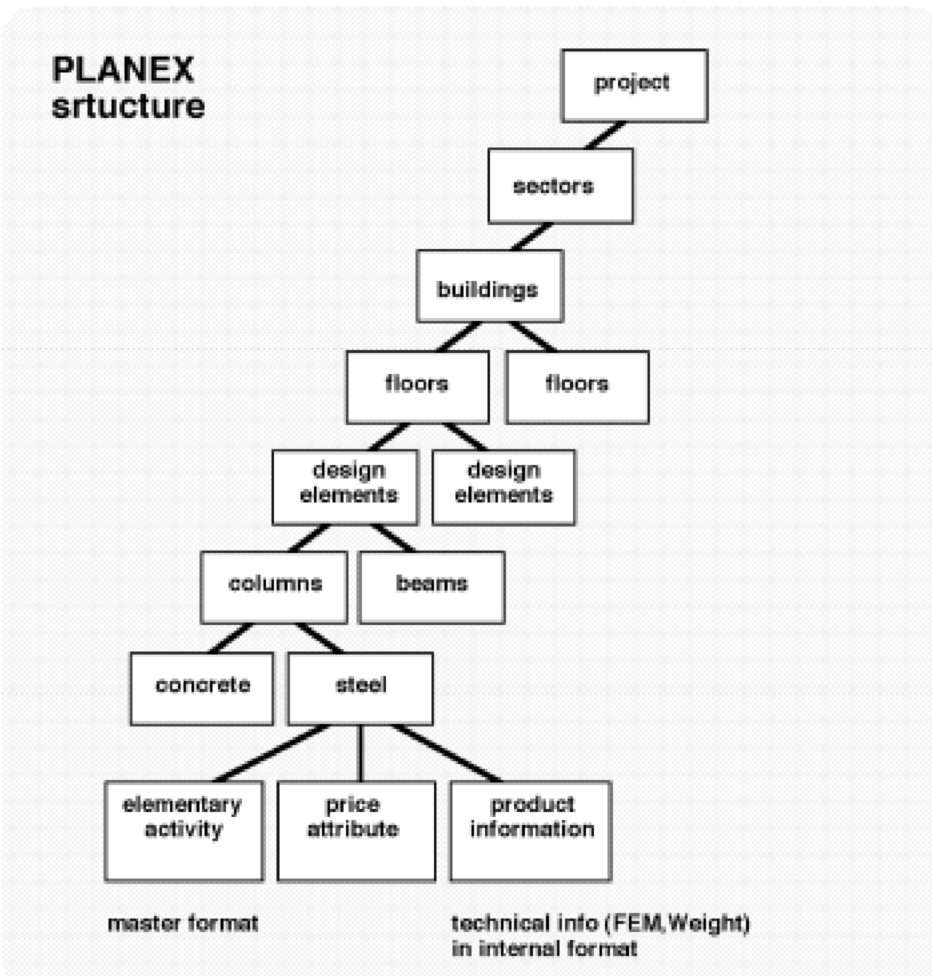

Fig. 2 Illustrates the object- and datastructure of PLANEX

The system works on a tree-structured model of the building. The components can for instance be: building; floor; design elements such as beams and columns etc.

Within the system the knowledge is represented in rule tables.

The present version of the system has been tested and is running. However, this version can only handle fairly simple building structures and the problem concerning multiple construction activities performed simultaneous has not yet been attacked.

A fascinating feature of the system is its animation of the construction process making use of an 3D wire frame model.

MODELLING OF CONSTRUCTED FACILITIES

Walid Keirouz, Research Assistant.

The idea behind the modelling is that robots operating in a constructed facility must maintain and operate on a computer based representation, a domain model, of the facility.

The model is based on an object oriented approach and is programmed in Small Talk. The hierarchical model comprises descriptive as well as functional information.

3 basic object classes have been used: primitive objects (boxes, tubes, cylinders etc.), domain objects (pipe, valve, room etc.) and connection objects (relations).

Furthermore, functional systems are defined, for instance the electrical system, the piping etc. The model makes it possible to extract classes of elements, such as the entire electrical system, a specific component (a pump with all the objects connected directly to it, the pipes, the electrical supply etc.), or all valves.

OBJECT ORIENTED ENVIRONMENT FOR ROBOT TASK PLANNING

Irwing Oppenheim, Associate Professor.

The idea behind the project is to develop models of the environment for the use of the robot.

The models are developed in Small Talk running on Sun/Unix work stations.

Two different Small Talk environments are being established:

Force cognitive excavation

A real time implementation related to the robot manipulator in order to make the robot able to undertake simple tasks such as moving blocks or doing excavation. The aim of the project is to demonstrate that it can be done, but the system will be too slow for real life use. Physical experiments are made with a laboratory robot doing tasks such as excavation. In general, excavation is limited by the geometry i.e. the combination of load and reach, the soil conditions etc. When a human is doing the excavation, these factors are evaluated by the feeling. In the laboratory they are trying to emulate the same.

Domain derived task planning

An environment to develop an object oriented task plan. The idea behind this project is that when you want to dig a trench you need a task plan. In the system an object oriented representation of the volume and of the bucket is made. The aim of the project is to give answer to questions such as which actions in which sequence should be made by the robot. The strength considerations dealt with in project 1 is not part of the work in this project.

CENTER FOR DESIGN OF EDUCATIONAL COMPUTING (CDEC).

Carol Scheftic.

The background for establishing the center is an agreement made in 1982 between Carnegie Mellon and IBM on developing a network throughout the university (the Andrew network). The network includes a great number of work stations, file servers etc. The network also provides network services such as mail. The operating environment for the network is Unix and X-Windows and the Macintosh Window Manager.

CDEC was established to look into the educational aspects of the network environment. The center operates as a support center to the faculties throughout campus and assists the tutors in building model systems for educational purposes. CDEC also acts as educational center for ICEC. (InterUniversity Consortium for Educational Computing)

CDEC has developed the CT-language (Carnegie Mellon Tutor) based on the program Micro Tutor. The CT-language makes it very easy for the teacher to develop small applications and in particular make use of interactive graphics for educational purposes. CT is a language on its own but can be combined with other languages for instance Lisp, C, or Pascal.

The system was originally developed to operate on the IBM work stations, but is now also available on Mac and IBM PC. The system has been distributed to approx. 50 universities, but only to universities as yet, and only in the work station version. Within a year it will sell for approx. $ 100.

The language is now independent of the Andrew network, but the same source code is being used on the IBM PC'S the Mac's and the work stations.

ENGINEERING DESIGN RESEARCH CENTER

The EDRC center is established to develop an integrated design methodology, which includes integrated building design. The center draws on staff from a number of faculties throughout the university and thus establishes a cooperation between engineers, architects and computer experts.

PROJECT MANAGEMENT FOR CONSTRUCTION

Chris Hendrickson, Professor, Dept. of Civil Engineering.

Chris Hendrickson presented his work on a fundamental concept for owners, engineers, architects and builders, to be presented in a textbook this fall. The book deals with all the traditional items within construction management, as well as such items as finance, use of knowledge based expert systems, construction automation and robotics.

Chris Hendrickson is a member of the Construction Industry Institute based in Austin, Texas. The director of the institute is professor Richard Tucker, University of Texas at Austin, and the institute is sponsored by industry professionals and contractors, but not suppliers and manufacturers. The institute sponsors studies and establishes task forces on topics such as constructability, productability, and barcoding in the building industry.

The integration of data within the building industry was discussed. Up till now most data structures are designed to deal with accounting and not with construction elements. This is part of the reason why data are not exchanged between the parties in the project i.e. the planners, the designers, the contractors and the owners. Some companies have, however, taken up the task of establishing an integrated building data base for the building owners, for instance Stone & Webster.

The lack of a standard format will, however, be the greatest obstacle to these efforts. Particularly, within facilities management certain problems will arise because the existing formats for graphic information do not go down to the necessary level.

Some utilities are today establishing 3D models of their facilities for the use in planning of maintenance, rehabilitation, etc. The existence of these models will be an incentive to use them in the design phases as well.

It was mentioned that studies in the steel industry had shown that CAD should be taken into use before robots.

Integrated SW Environment for Building, Design and Construction

Chris Hendrickson then presented the EDRC approach to the integration of software for the building design and construction.

The Integrated Building Design Environment (IBDE) integrates a number of different programs already in use or being developed. The programs integrated are

- ARCHPLAN, an architectural planning expert system which assists in the development of a conceptual design of a building,
- CORE,
- HI-RISE, a knowledge based expert system that performs a preliminary structural design of high rise buildings,
- SPEX, which performs a preliminary design of the structural components for the structural system selected by HI-RISE,
- FOOTER, an expert system that performs a preliminary design of the foundation of a building,
- PLANEX, a knowledge based expert system intended to assist the construction planner.

The programs communicates via a 'Black Board' and the integration is controlled by a Controller program which communicates with the Data Manager which again takes care of the Project Data Store, see also figure 3.

Integrated Building Design Environment, EBDE

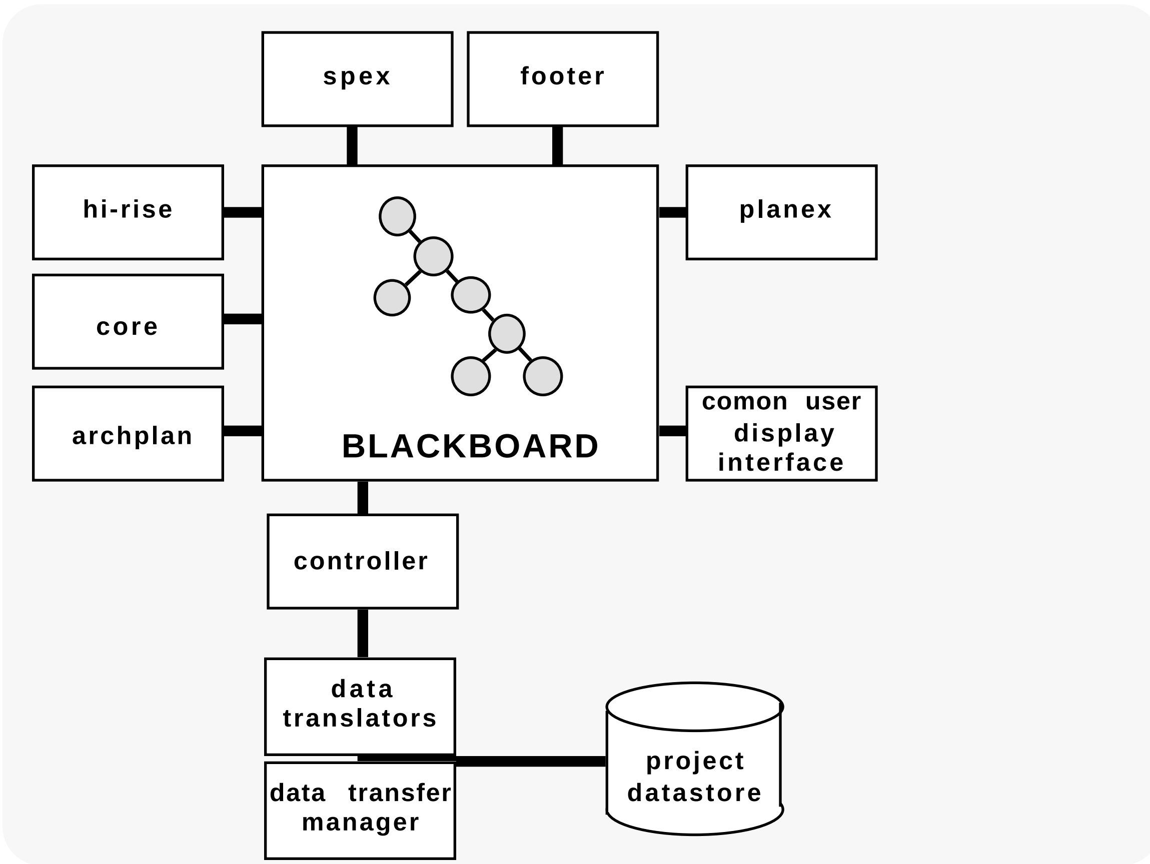

Fig 3 Architecture of the IBDE.
Frit efter Mary Lou Maher, Carnegie Mellon University.

ⓒ peter hauch
BPS-centret

Fig. 3 The Integrated Building Design Environment.

The system integration is now so far that a forward pass can be done i.e. from the building program towards the solution. However, it is still a prototype version, and it will take quite an effort to make it into an operational system. A rough estimate was 2 to 3 man years, which seems to be a great deal on the lower side.

ARCHPLAN

Gerhart Schmitt, Asst. Professor, Dept. of Architecture.

ARCHPLAN is one of the programs in the above described integrated software environment. It produces the output needed as input for all the other systems.

ARCHPLAN is based on a prototype representation of the building which makes it possible to make loose conceptual definitions, which later can be refined. The system is programmed in Lisp and is based on an object orientated approach. The system size is 15-20.000 lines of code.

Input to the program is information concerning the site, the client's program, budget and geometric constraints. The output provides 3 dimensional functional, circulation, and structural information. The system is not a stand alone system but is to be considered as an assistant to the designer.

The program has 4 basic modules

- site, cost and massing
- function
- circulation
- structure

Input to the site, cost and massing module is what you can measure, count or look up, for instance facts from building codes etc. The program considers site characteristics to be facts and therefore fixed, whereas building requirements are more flexible. The site, cost and massing module develops a massing model that fits a given budget and a range of other parameters given as input.

The function module assists in the vertical and horizontal distribution of building functions within the basic massing volume. Functions can be office, retail, atrium, mechanical and parking space.

The circulation module addresses the problem of moving occupants and equipment from floor to floor and within floors and guaranteeing safe evacuation in case of emergency.

Finally, the structure module gives the designer an overview of possible structure types appropriate for the building in question. The application has a built-in fractal generator which can generate non-regular shapes & forms of the proposed building.

The act of structural design is solved by the program HI-RISE.

The data transferred to the other programs via the black board are not structured hierarchically, but just delivered in the form of frames, where the involved parties in the project have agreed upon the use of the slots.

It has been discussed to plug in other programs, for instance programs developed by professor Gero from University of Sydney in Australia.

GEOMETRIC REASONING

Robert F. Woodbury, Asst. Professor, dept of Architecture.

The building representation in the Integrated Building Design Environment (IBDE) handles only strictly rectangular objects. The representation is based on a grid, where an array data structure contains the information concerning each of the grids.

However, architectural planning in the real world does not work with a system that only handles rectangular objects, but with one that is dealing with shapes of different kinds.

The geometric modelling is a spin-off of the computer modelling made 10 to 15 years ago. The geometric model is based on well defined mathematics.

The concept behind the geometric modeling is to build a set of graphs that connect the building elements. Each graph will represent a class of solutions. To do the design one has to solve a map problem. The representation will not in any way restrict putting elements in a space.

The work comprises 2D as well as 3D models. The only significant difference between 2D and 3D is that there might be more than one path between elements.

By means of geometric modelling it is possible to analyse for instance the geometric stability of a construction and thus make input to the calculation of a feasible construction sequence.

PROTOTYPES OF THE BUILDING DESIGN

Mary Lou Maher, Asst. Professor.

Mary Lou Maher has since 1980 been studying AI for structural design. She designed the HI-RISE program for structural engineering based on the ideas behind the MYCIN expert system. At the present she is working on the development of the Integrated Building Design Environment.

Prototypes in the building design are necessary because of the nature of the design process. Consequently you must be able to manage them. The design process comprises a number of different levels of abstractions, starting with the functional requirements and ending up with the detail design.

Some people try to define the entire design process and put it into fixed steps with well defined landmarks. The approach made at the center is to establish tools for prototyping with the process undefined or ill defined. The idea of the prototype was originated from language understanding, but the center went further and made it an active system strategy.

The idea is to make it easy to describe alternatives in order to avoid that the designer does not get further than the first feasible design. The aim is not to put up databases of solutions - as design offices tend to - but to put up general information concerning when and why a solution will work. MLM is working on prototypes following 2 different lines, including a contribution to the modelling of the creative design process.

The 2 lines followed are:

1. Manual/human driven design, where the designer follows a "trial and error" - like process, and the system evaluates the proposals and check the solutions.

2. Application driven design, where the application acts on the basis of design rules. Provided sufficient rules (if it is possible at all to model the creative design process) the system could automatically generate a detailed design on the basis of few parameters.

MLM believed in line 1 as the overall concept, but with elements of line 2 built in.

A hybrid conceptual model of this kind would have many levels of abstraction reflecting the different levels of requirements, reaching from functional requirements, aesthetic requirements, technical solutions, and to detailed design specifications.

MLM underlined that the question of modelling and emulating the creative design process was not as much a technical question, but a question of understanding the depths in the design process itself with all its psychological, epistomological, moral and aesthetic implications.

The aim of the work is to develop some ideas that in 5 to 6 years will be integrated in for instance CAD systems. The idea will support design by computers better than today and help understand how people design.

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CORNELL UNIVERSITY. ITHACA

Thursday April 21.

PROGRAM OF COMPUTER GRAPHICS

Prof. Donald Greenberg

Notes by Hilkka Lehtonen

Cornell University has, among other things, become well-known in the field of computer graphics. Professor Donald Greenberg (by his education an architect), Mr Sanjiv and Mr Boone presented the work recently carried out as well as development outlooks of the field. The Program of Computer Graphics is under the leadership of professor Greenberg.

Engineering, art and science as well as architecture and planning are the three main fields being connected with computer graphics at the Cornell University. Eight faculties are representing those fields. The computer centre was founded at the university in 1974, where research concerning computer graphics was springing up. The research demands comprehensive knowledge of the field, thus only some students of architecture are able to specialize in it. Raster graphics has been an object of a special interest.

Realistic, or rather photo-realistic presentation has been a main object in architectural applications. The ray tracing technique dates from the year 1979. Ray tracing models reflective properties of light and distortions caused by light passing through an object. It can model only intra-environment reflections in the specular direction. Ray-tracing procedures are view-dependent and the entire process must be repeated separately for every different view. As a high quality version the technique is time-consuming, even with large computers (1Mips). A radiosity-technique is on its way and has its origin in thermodynamics. It models a phenomenon in which diffuse reflections from each object in a scene contribute to lightning of all other objects. The radiosity method determines a global illumination of an environment independent of the viewer position. The radiosity model could be used in a stereo work station. The aim of the development work are faster hidden surface algorithms in order to get zooms, pan and turn around by 3 D-programs almost in a real time as well as a new boundary representation from a database.

For a planner the working speed is very important. In the architect studio of the university there are one drafting and two modelling programs. The card-board-program simulates card board model building. Julie O'Brien has written the software. According to Greenberg the following aspects could be combined in sketching programs:

- standard solid modelling
- card board
- curved surfaces
- clay

At the Cornell University also a new working database (Face edged data structure) has been developed. Its use has proved to be difficult for architects, students do not have any corresponding problem.

On the application field of structural engineering, structural mechanics and geomechanics different inter-active-adaptive, nonlinear and dynamic analysis have been developed (for example for three - dimensional steel frames or for displacement analysis of framed structures). Earthquakes can also be simulated three dimensionally animation like fashion. In interactive-adaptive method analysis parameters and algorithms are selected and changed by a user during the analysis. In the future parallel processing will be used.

Computer graphics demands work stations of a high standard. Analysis software of the structure planning have been developed in the first place with 32-bit mini computers being linked with editing terminal, a dynamic vector refresh display, digitizing tablet and an alpha-numerical video terminal. HP-processors have been linked to the net.

Artificial intelligence was commented by Greenberg as follows: thus far it has promised more than it has been able to give. In checking of planning matters it is O.K., but the artificial intelligence will not be allowed to make any decisions. It belongs to the planner.

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UNIVERSITY OF MICHIGAN. ANN ARBOR

Friday April 22.

ARCHITECTURE AND PLANNING LABORATORY, APL
ARCHITECTURAL RESEARCH CENTRE, ARE

Dr. James Turner

Notes by Peter Hauch

Subject

Research and education at University of Michigan, UM,
UM School of Architecture and Planning, SAP
Architecture and Planning Laboratory, APL
Architectural Research Centre, ARE

Facts, history and strategy

James Turner gave a brief overview of the history of the EDP-activities at SAP.

Harold Borkin started out with computer graphics in 1976 based on a Tektronix workstation. At that time it was the general idea, that "CAD would happen" within the next 5 year period among architects, and it was the general idea behind the activity to support that development.

There were 3 areas in which to start:

1 Computer graphics
2 Computer aided design (i.e. space planning)
3 Application areas (light, acoustics, finite element, structures, energy)

At SAP and ARE it was decided to choose item 1 and 3 as the development areas specific for the school.

During the first 5 years the main emphasis was put on data structures, transformations, hidden line removal and a question of developing a sketching CAD programme.

The main idea was, that the drawings were not to be the subject, but the underlaying general information model of a building.

On this basis work was carried out to establish a general database structure for architecture, but the department found it very hard to handle alone. First now with modern ways of information modelling, they feel, that they really have success with the structuring of an architectural database.

During the years ARE has developed a framework for an architectural relational database, and a CAD system with strong emphasis on the relation between graphic and alphanumeric information. The database-model has several applications around it, and there still are. developments going on in new application areas. The name of the database/CAD system is "ARCH.MODEL".
Some of the previous work and the coming developments are going to examine ways and possibilities of including artificial intelligence and expert systems in applications around ARCH.MODEL.

ARCH.MODEL is a geometric model (geometric information database structure) and some of the basic ideas are contained in some of the existing CAD systems.

A lot of the research funding for this database model has come from big firms and CAD vendors and the Army Corps of Engineers. Today research funds have dried up, and the department is now concentrating on implementing all the work carried out in the architectural education.

Education

At the ASP great emphasis is made (and will be made) to incorporate the use of CAD and EDP as general in the education. For that matter investments in CAD workstations will be made through the next year.

At present they have 10 Apollo workstations and they plan to buy approximately 50 more new workstations, before the starting of the new semester. In the CAD shop and the department they now have 16 Apollo workstations, 22 MacIntosh workstations and 6 IBM PC´s.

The 50 new workstations will be partly Apollo, partly Mac II´s.

The school will gather the computers in a computer room (CAD shop) and will not spread out the school´s own workstations in the classes. This is partly of security reason, partly based on the idea of establishing a CAD environment.

JT put big emphasis on the education of programming skills for the students, and will give lectures in computer graphics as well as in geometric modelling and information modelling. At present they have two courses in CAD fundamentals, CAD fundamentals I and II.

At present the school has approximately 3000 graduate students, which will all have a CAD education to some degree.

At present they have about 40 doctoral students a year, some of them will study artificial intelligence, expert systems, solid modelling and a few information modelling, while most will be occupied within different application areas.

Since 1974 most of the time has been spent on the development of geometric modelers and solid modelers. But since 1976 to 1977 the interest in these areas have flattened out and application areas has been the areas of most interest. Now there is again an interest in geometric modelling and solid modelling because of the difficulties porting the modelers from mainframes and mini´s to smaller machines. ARE has been active in this development, and have provided some of the software houses developing CAD systems for the Mac II with CAD modules.

The department has sold some of the developed CAD-programmers. Some Fortran 77 CAD modules are sold to CAD vendors, and these modules are now incorporated in marketed CAD systems. Some of the royalties from these works are now financing the research at the center.

Besides the CAD fundamentals courses they offer the following courses:

- General 2D computer graphics
- General 3D computer graphics
- The use of color and development of painting-programs
- Handling of geographical information
- The use of drafting systems (user courses)

Programming courses are mostly visited by foreign students, while the user courses are mostly used by US students.

About AutoCAD

JT is against education in the use of AutoCAD, because AutoCAD is too low end, too simple, too primitive and unstructured, and too general as a drafting tool.

JT would rather have people use the database oriented ARCH.MODEL programme, instead of different AutoCAD modules, which can never anyway reach the same high level of representing structure and conceptual architectural ideas.

On the other hand JT was very aware that people often forget that CAD is only a tool.

JT stressed very hardly that much effort must be put on pushing the computer business down to what it actual is - a tool.

Conceptual modelling

The work on conceptual modelling is within the ARC, and is carried out by doctoral students and JT.

JT is active within the PDES and STEP works, on the AEC part, and thinks that he will work with this area the rest of his life. JT finds it "very fascinating the way you bring order in your data".

The main question is, what is an architectural database really:
"What kind of data do you have in various phases of the project? How do you define them, deal with them and transfer them to the next phase?"
"Object oriented programming could help you bring order in handling these data structures."

At UM only very few people are working on conceptual modelling, so JT is working together with John Eberhard and his group. JT is a very active participant in the STEP/ISO group and works very closely together with -and against- Wim Gielingh, IBBC/TNO.

It is JT´s impression on the modelling question, the US is not the world leader now a days, and JT is very much inspired by the participation in the international activities.

One of the problems is that the CAD environment in the US is very closed, especially when it comes to the car manufactures, where the big CAD resources and experiences are found.
It seems a problem for the modelling discussion that a lot of US firms seem to prefer to solve their problems within closed doors.

JT gave a view of conceptual modelling on the basis of a paper given to the STEP/ISO technical committee 184, see /J Turner March 1988/.
The purpose of the paper titled - AEC building systems model - is to present an initial AEC building model in parallel with the product modelling efforts of other PDES and STEP application committees.

JT mentioned, that the question of how to represent time and history is very important in the discussion going on right now. The question of different phases in the design process from sketching to maintenance is very important when it comes to conceptual AEC modelling. It is necessary very thoroughly to examine how data does change through the process, and it is JT´s point of view, that there is room for the use of AI and expert systems within this area.

While the first databases were geometric oriented and fixed in time they could very poorly handle alphanumeric attributes and relations between objects and the change of objects through time. They were so to speak oriented against the production of exact drawings and specifications, rather than general building information models.

It is JT´s opinion, that a CAD database structured on the idea of conceptual modelling must be object oriented, and that object oriented programming is the way to go - but it is not clear how exactly one should do - yet.

On the question of data exchange JT stressed that IGES was, and will still for a long time be relevant - since most CAD systems are still oriented against geometric entities, and that most people do actually use their CAD system (however advanced they may be) as 2D drafting systems. The idea of modelling is still not supported by the proper tools, and is therefore not yet accepted as the main perspective in the users of CAD.

The main idea behind JT´s conceptual modelling framework is, that a building is to be understood as a system consisting of subsystems consisting of components - a hierarchical model. This system approach is opposite to another approach which could be called the "parts-entity-approach".

It is JT´s idea that it is not actually possible to numerate all components of a whole building, and to trace their change in time, within one, single, general database structure.

With JT´s hierarchical approach every component is seen as part of a subsystem or a system, and JT finds it much more easy to break down the building in systems and subsystems, until it is then possible to support every component of a system. This makes it possible to support a whole building with the necessary information, within one, single, general structure .

Definition of a system

A system is designed with the purpose of being able to generate a certain set of desired system outputs for a particular range of system inputs.

A system output has one or more system output qualities which can vary over time.

Systems exist to satisfy needs. The needs can be either human or natural.

For a building or man-made subsystem, desired outputs are human needs. I.e. an enclosure system satisfies the human need of security, privacy and protection against the elements. A circulation system satisfies the needs of movement of components within the spatial system.

Any system is designed to perform a specific system function which must be described.

JT gave a brief introduction to the modelling technics used within the framework of PDES. The PDES people are using NIAM (Niesens Information Analysis Method) and the there described notation techniques for modelling.

Other people (Europeans) in the STEP works are using the IDEF 1X specification, which gives a lot of problems in the discussions. JT would very much like people to use the same methods and annotations.

JT has chosen the NIAM method mainly because it was widely in use in the PDES group, but also because it provides the best graphic results. JT´s approach is to try to describe a robust system, building a frame for systems which can be used for all areas covered, to be used as a framework for others.

It should be possible on the basis of JT´s point of view to have many people developing different models for different areas, and combining them in the end to one big total model of a whole building.

The main conclusion of this work is that every component falls in one or more systems, if their properties can be described properly.

Objects and properties

Properties are characteristics of objects.

It is assumed that most CAD systems of the future will be based on "objects" or "frames " and not drawings or geometry entities.

With this approach one can use spatial and non-spatial properties on the same level, and not be handicapped by having to attach properties on geometries or drawings.

Properties can be 2D and 3D geometry, such as solid models for finite element analysis, drawings and text for drafting, text for non-machine readable applications, and structured data in the form of tables, tuples, and attribute value pairs.

JT very much stressed the point, that in the future, CAD systems should be based on the idea of an information model, and that the model itself is the central issue, and is very much against the idea of the drawings playing a central role in the systems. The drawings are after all only one of many output possibilities from the information model.

Database structure

JT has been working on developing a new general database structure for the CAD system at ARE - "ARCH.MODEL"- based on the ideas developed during the works with conceptual modelling.

The general database structure will have the following contents:

- Attributes - colour - lineweight - text
- Attribute values
- Tuples
- Attribute list (columns and rows)
- Table (relations) (a table is a collection of tuples)
- Directed network
- Enclosed area (JT found it very important that the general database structure made it easy to spot enclosed areas)

The next phase of the development project will be to include the approximately 50 examples of models that have been developed, and see if the general database structure is sufficient for those needs. These 50 examples include site, HVAC, interior design, lighting.

This experiment will show how real data will fit in the overall general database structure.

The work on restructuring the general database in use at the department, will bee carried out in cooperation with a lot of other people, and will in some ways dominate the work going on the department for quite a long time.

JT stressed, that the breaking down of the overall model in systems and subsystems is a way of making it practical to handle the very complex problems, by breaking them down into part problems.

JT also made the point, that he is not trying to make an architectural programming language, but to develop a database structure, making it possible to store and retrieve all the information about a building which is needed for the different design applications.

JT also mentioned that design is a funny thing: Functionally it is in fact quite simple, but aesthetically it is very difficult to define and to handle, and it is very difficult if not impossible to formulate design rules, which can handle the aesthetic aspects, in general.

JT noted, that one experience in trying to implement the conceptual model in a database structure was, that the distance between conceptual modelling and actual implementation in real life is very very big.

JT versus Wim Gielingh models

JT pointed out the differences in the concept of his model compared with the concept of Wim Gielingh´s general reference model, the STEP/GARM-model

It was JT´s opinion, that it was fair to say, that Wim Gielingh´s model was to be considered as a model for decision-making, a model for design in general and for the design process, and that Wim Gielingh´s model was mainly oriented towards the design issue.

On the other hand JT´s concept was more based on the actual existence of functions and objects in a fixed structure, and in that aspect more closely or directly oriented to database structures.

DEMONSTRATION AT THE COMPUTER ROOM

Doctor of architecture (coming) Ted Hall.

Ted Hall gave a demonstration of the capabilities of the CAD programme "G-EDIT", which is a not-finished updated version of the old ARCH-Modeler. G-EDIT is developed from the geometric part of the ARCH-Modeler, (2 1/2 D), with a polyhedron boundary representation, which can be represented in isometric view.

The programme is object oriented.

The programme had a very smooth interactive graphics approach including windows and menus, and looked very much like the GB-based system "GABLE".

Ted Hall demonstrated the use of the system, the drawing of walls of different kinds, placements of windows and doors, how alphanumeric information such as project dependent tuples were stored, and how information about displacement of a door in a wall is stored as an instance-information together with other information within the door object.

Ted Hall also mentioned an application built on the same database structure, which had built in expert knowledge on fire resistance of materials, and a model describing the development of a fire outburst in a building.
The application could retrieve database information on a building, read and analyse it, and give information on fire resistance, smoke problems during a fire.

The application could simulate a fire in a building and give advice on where the weak points were to be found, how smoke would develop, and how to rescue personnel in the building. The application had also been run emulating famous fires.

Ted Hall mentioned one basic question concerning the design of CAD systems.

There is a contradictory tendency, that users would like systems to be more and more easy to use, but the easier the system is to use, the more assumptions there must be about the design within the system, therefore more restrictions in the use of the CAD system.

The idea with the overall structure of the "G-EDIT" programme was to make it possible to start out with a very simple menu, easily building a raw model of the building, and then later being able to successively develop the model by manipulating the database through different applications.

GENERAL DISCUSSIONS:

JT was asked about his view of the possibilities of including expert systems in CAD applications.
JT was not exactly sure on what was going to happen, but expressed the general feeling, that AI and expert systems were over estimated, and that they will not play a big and independent role in the development of CAD systems in the future.

On the other hand, a lot of CAD applications already include knowledge -and in that aspect are to be considered as expert systems themselves- and this development will of course continue.

JT had the opinion, that more and more of the development efforts around CAD-systems would be on building in expert knowledge in the systems.

These expert systems in relation to CAD would mainly be checking programs, i.e. tools for the designer making it possible for him to have the system giving him answer to questions like how do I do this? How am I performing? Are my decisions consistent or conflicting?

Evaluation

There was a strong feeling among the participants, that it is of extreme importance, that the Nordic AEC-community, expands its activity within conceptual modelling, that we coordinate the efforts being made with one another, and with the ISO/STEP/AEC-group.

In this field seems to lie the key to learn to use the existing CAD-systems more productive, to make CAD-systems more productive, to learn to understand the basics of object oriented database structures and programming, and to include expert knowledge in the systems, -the key to understanding the fundamentals of integrated building modelling.

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HARVARD UNIVERSITY. CAMBRIDGE

Monday April 25.

GRADUATE SCHOOL OF DESIGN

Prof. William Mitchell

Notes by Kristian Agger

Architectural education

Bill Mitchell came from UCLA to Harvard two years ago.
The institute has 300 students in architecture and 100 in landscape.
Research in CAD started in the 60'ies with cartographic, landscape and geographical information systems.

Two years ago it was decided that CAD in the coming period should be an essential part the education. Until then it had only been a research field for a few teachers and students.

1. The first problem is **hardware**.
It is a very difficult problem that has not been fully solved, but the plan is to start up with 100 students workstations next year, and in three years time, it is expected, that each student is going to have a workstation.

Network is necessary. Harvard University has not like MIT and Carnegie Mellon University a large overall network. There will be a heterogeneous network at the school based on Ethernet which will make the four most important operating systems UNIX , MS-DOS (still), MAC II and VMS talk together through the TOPS network software from Berkeley.

Enough **workstations** is an enormous problem. Workstations must out in the studios. PC's is considered too small. MAC II will be the low-end workstation. SUN is interesting, with less restricted UNIX, lower prices and MAC like windowing. Also high-end PS/2 is considered. The students will be able to rent a workstation, which they can bring with them when they leave the school. This is the best way of financing hardware, and secure that students have CAD-tools available after graduating. It's important that all students are given this opportunity regardless of their financial situation.

Also enough **input/output hardware** is a problem. Network will facilitate the sharing. **Laser printers** will replace matrix printers. They are silent and can be placed in the studios. It is easy to control their use through 50$ cards. It is necessary with large scale **electrostatic plotters**. They are fast and reliable. To facilitate paint systems, **scanners** must be available , output from colour screens is done with **cameras and thermal colour printers.**

Hardware will demand many **economic and technical resources**. It will be necessary with continuous investments in **new equipment** and in **maintenance**. And it demands a new qualified staff to keep it up. Which is necessary. Daily work demands high and good performance. Management will take several full time staffs, and the school does not know where to find them, although the network system will be a help in this situation.

2. **Application software** is used in the education on three levels.
At the fundamental level **Computational Literacy** is established. Algorithms and data structures are thought as a basis for programming. The aims are to be able to communicate with software developers, and it is considered very important that these fundamentals are given in an architectural context. Programming is trained on architectural problems.
The second level deals with **Representational Fluency**. Students must learn to use different modelling tools in practice like the way they learn to draw. That is:

a. Bitmapped representation, paint, scanning and raster output.
b. 2D Line systems.
c. 3D Wire Frame.
d. 3D Surface modelling .
e. 3D Solid modelling.
f. Architectural modelling, a modelling system with architectural semantics and intelligence.

It is preferable to use many different systems, and also commercial systems. The education should deal with principles. And the students must have a critical attitude towards the tools. Modelling existing buildings is a good training. The school uses Computervision systems on SUN workstations. It's expensive, but covers b) to e) . It's a practical choice and other systems could have done the same.

The third level is **Practical Students Work**. The use of the tools in practice is a one year discipline. And the next year the students can specialize, for example at the CAD department, where the architectural education is carried on with extensive use of CAD. This is what is needed to educate an architect as a CAD user today. Specialized CAD studies will disappear in the future, when everybody will be working with CAD.

Research

Integration will improve the advantage of CAD. Vertical integration is the integration of subsystems for the different disciplines and participants in the design process. Whereas horizontal integration is integration between the different phases in the design process. There is big differences from one activity to another, and this leads to different demands on the project database.

Another important area is **Architectural Knowledge**. There are three directions. **First**, the pragmatic. 2D systems have shown not to be as productive as expected. One of the reasons is that they work with lines , not with building elements, e.g. walls. The **pragmatic solution** expands the tools with an **architectural vocabulary** and with **architectural operations**, to improve productivity. **Second** direction is the academic research on using **Artificial Intelligence Theory**. This raise the problem of **knowledge representation**. The **third** direction is to develop **grammar rules** for **solution generation**.

The situation is not clear. The pragmatic approach is limited but useful. The experiments with AI have been naive but are important in the long term. There has been a shortsighted over estimate and a long sighted under estimate of **AI**. Many of the AI-firms that started two years ago are closed now. At **Harvard** work has been concentrated on the use of grammar. A system called **TOPDOWN** has been developed, as a **shell** to generate shapes (2D) trough **grammar formulated parametric construction**. The idea is to move from abstract to detail.

TOPDOWN run on MAC, Unix and PS/2 and is fast. Work on **knowledge representation** has recently started (Earl Mark). Representation of architectural knowledge falls in **three areas. First formalism.** The representation of shape grammar is not yet solved. And the architects can not wait for the AI researchers to do it. **Second**, how do we map **existing architectural knowledge** on this formalism. E.g. the knowledge of Paladio or of experienced architects. This can be investigated by making non trivial experiments with knowledge databases. **Third**, the need for an **architectural theory**. A theoretical foundation is lacking.

All this work has to be done in the universities. Development is a problem of the industry.

Discussion: What about the connection between architects and engineers in the design team?
Years ago a central non-redundant project database was considered. A database from which all drawings and reports could be derived and from which all subsystems could get there data. To do that a big database system was needed. The idea was naive. The different design phases need different representation. The work on Harvard now is to work with multiple, loosely coupled representations. It is useful to be able to move from sketching to detailing, there has to be a paint layer, a drafting layer etc. in the system. An example is plan sketch to solid modelling. The idea of vertical integration is OK but has to be done with multiple representation forms. The

representation in the beginning of the design has to be incomplete, inconsistent and unstructured. In the late phases it is opposite. The representation has to be complete, consistent and highly structured.

Here the modern database systems can help. In the beginning the problem is that we don't know what to put into the database. The idea of FRAME based representation from AI could be an effective solution here. To use database systems in the beginning is like dancing with an elephant.

Results

TOPDOWN was demonstrated on MAC II in two areas, design of classical columns and design of trees. The students are working with shells for many different design problems. The system is public available and will be integrated to the Computervision system. The current version is 2D but a future SUN version will be 3D. The implementation is in PASCAL with graphical routines, next version will be in LISP with FRAME implementation.

A 3D visualization system developed at Harvard was shown on SUN. The system is based on ray tracing technique. Radiation technique is regarded as to slow.

From the earlier work a Graphical Information System with a highly topological mapping representation was shown.

SCHEMA a simple modeler, sold commercially is not developed further.

Evaluation

Harvard is one of the architectural schools in the world that is closest to full integration of CAD in the studies. The plan is to have networked workstations on every students desk in three years time.

The education is in three levels:
1. Computational Literacy
2. Presentational Fluency
3. Practical Work

Hardware: DEC , MAC II, SUN and PS/2, is networked with Ethernet and TOPS. Besides software developed at Harvard, Computervision is used.

Research areas is Architectural Knowledge Representation, Visualization, Geographical Information Systems and Modelling.

In the first area a system called TOPDOWN has been implemented, In TOPDOWN, shells for parametric grammar shape generation can be formulated in a MAC environment. Visualization is based on ray tracing technique. The Geometrical Information System is based on mapping. A simple modeler SCHEMA is not developed further.

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STONE & WEBSTER ENGINEERING CORPORATION. CAMBRIDGE

Monday April 25.

Dr. Kenneth Reinschmidt

Notes by Väino Tarandi

Subject

Computer graphics (3D design)

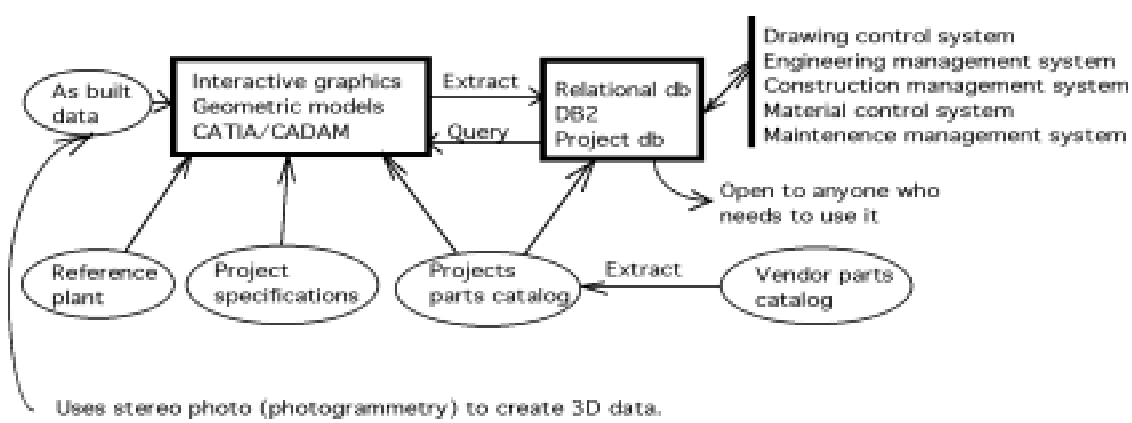
S&W is a Design Construction company working all over the world. Their projects are for example civil construction, power plants and airports. They have used computers since 1968, and they have used IBM mainframes since then.

1968 Technical calculations

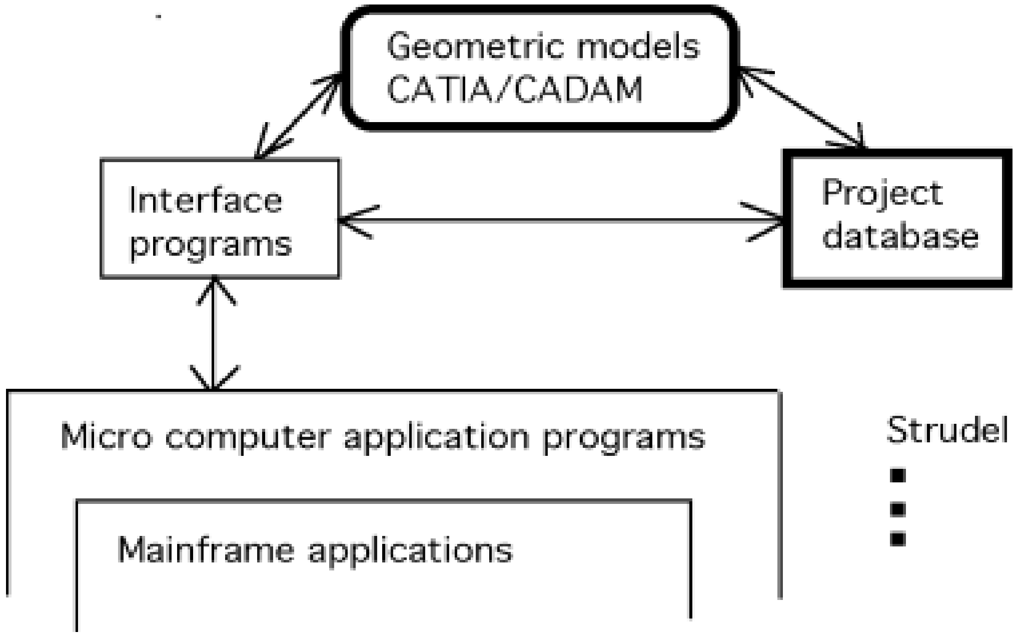
1975 Interactive CAD
CALMA, Intergraph and Autotrol

1981 Not satisfied.
CAD was used only as drawing generator. They understood that there was no money in just using the CAD-system in that way. At this point they contacted IBM. They found CADAM not good enough. The discussions went on for 4 years. Their aim was:
* Integrated database.
* Conceptual model.
* The whole process from design to facility management.

1985 Joint study started together with IBM.
They wanted to provide a data base of the project. The CAD-drawing should be connected to the data base and parts catalogs and other important information for the process. Today the model of the relations looks like this:



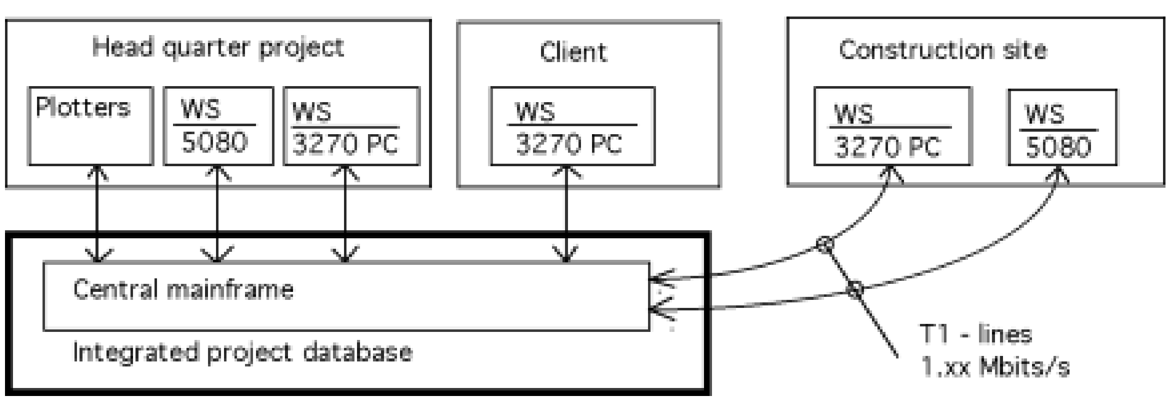
Parts inventory/handling in data base systems saves more than automation! In this first figure above we can see how all parts of the project are controlled from the graphics in the CAD-system.



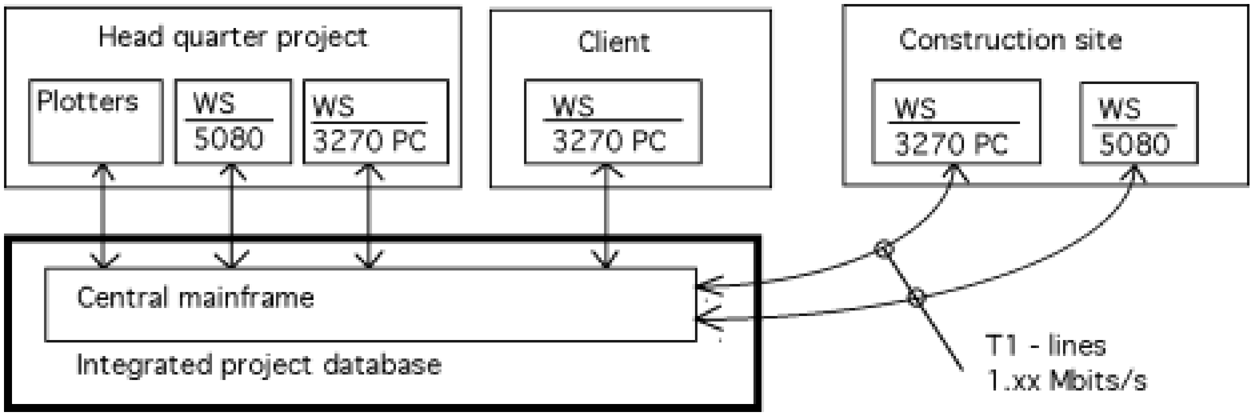
This figure shows how application programs can interact with the CAD-drawings and the project data base.

The important idea is to have only one data base for the whole company! All participants should be able to extract relevant data from the data base. Here are some examples:

COMPONENT MODEL	DATA EXTRACTED FROM GEOMETRY	OTHER DATA
* Solid (3D)	* Component ID	* Specification No
* Geometric model	* Part No	* Purchase order No
	* Location	* Field required date
	* Orientation	* Delivery date
	* Length	* Installation date
	* Connectivity	* Operation data
	* Flow	* Maintenance data
	* Model name	* Work package



This figure shows communication during the construction phase.



This figure shows communication during the operation and maintenance phase.

S&W do the models of the project in 3D using solids, assembled solids, joined assembled solids and shaded images. Service areas are also modelled to prevent other building parts to conflict. From this 3D model drawings are created. Changes are made in the 3D model and after that the drawings are taken out once again.

They started 1987 with quantity take off, planning and quantity following up from 3D. This is now used in one project in Florida (Disney world).

Here follows some examples of how they use the CAD-system:

* Cuts through the 3D model and compressing the result to create a 2D section.
* The ideal is never to keep drawings! Throw away and plot a new one.
* In models and drawings there is nothing more than the details that S&W need for their work.
* PNI diagrams are used separately. They plan to connect it to the CAD system. Important to keep connectivities.
* Bill of material and cut lengths for all pipes are created automatically.
* CATIA marks every "interference" in the model. They can be seen in any view. Approximately 5.000$ are saved for each traced "interference".
* Can check if and how 3D models of components can be transported through another 3D model.
* Simulates changes (moves) in 3D with the "robot" function in CATIA. A crane for example, can move up, down and rotate step by step.
* Can break down the model into its parts and extract information about:
  - m^3 concrete
  - m^2 formworks
  - kg steel bars (based on experience data)
  - man-hours per m^2. From this it's possible to get a time schedule if you input available man-hours!
* Managers can ask the data base how much work is to be done the coming week.
* Completed work is pointed out and quantities are connected with man-hours (from time cards).
* They work with calculated, actual and scheduled resources.
* Information about maintenance history is stored for every component.
* Can follow how the project advances in the 3D model.

S&W have all disciplines in house. This makes it possible to have one data base for the whole project. Workstations are placed at clients and consultants sites. If the client wants the model, S&W are ready to sell it. They store data and convert it when a new computer, data base or software is planned to be used in an old project. When they continue on old projects, someone has to measure coordinates in order to get "as built" data.

S&W have 3 shift on the mainframe. Workstations are now relatively cheap so they are used only 8 hours per day. They have about 250 workstations on 2500 engineers and designers. 300-400 PC:s are in use with databases of their own, and that gives problems. The users like PC:s but for the managers this mean no control, no coordination and no quality control. Very little architectural work is done by S&W. "Don't know if architects like the system!" They have many systems only because of clients having them. Other systems they have are Autocad for "schematic diagrams" and Intergraph for mapping and facility management. IGES is used between their systems. They are also using expert systems in their work.

For the future they plan to connect activities to the time schedule in the data base. That will give automatic project advancement. A very important issue for the success in the future is that the managers start to use the system. If they begin to work with it all other participants follow after. The managers must be convinced about the advantages, then they will use the system!

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EXTRA™ Service. Engineering Design. Construction. Mechanical Equipment and Systems Diagnosis. Plant Operations. Scheduling.

MIT. CAMBRIDGE

Monday April 25.

DEPARTMENT OF CIVIL ENGINEERING

Mr. Charles Helliwell

Notes by Pekka Leppänen

Hosted by Prof. Charles H. Helliwell, Deputy Director, Center for Construction Research and Education, MIT, we attended four presentations on the activities of the Center:

Recent problems in construction in US

Dr. Fred MOAVENZADEH, Director of the Center

In recent years, the US construction industry has declined from 12 % to 8 % of the GNP. There are many reasons:

- construction is very fragmented, there are some 480.000 contractors in USA, only few are big
- volume is flat
- productivity is low and dropping rapidly (10-15 % faster than inflation)
- foreign competition is high R & D is rather negligible, both in public and in private research at the bottom.

There are presently identified infrastructure needs roughly 3000 Bil. USD and for transportation needs roughly 1800 Bil. USD in US construction.

What is needed is dramatic change involving radical realignment of how the things are done. R & D is needed to get more output per 1 USD. An object is to provide a research environment conducting improvement in technology that provide long term benefits on three primary fields of construction:

- automation and robotics
- computers
- materials and process.

One can estimate, that construction industry will follow the auto industry in changes. As a result of simplification and automation in construction in the 80ies and 90ies it is to expect same dropping of costs as made by mechanization of construction in 2000ies.

How we represent objects inside a computer.

Dr. John Williams

When representing a solid for structural analyses in computer a FEM-model is usually created. But there are a lot of information needed to specify every element (x,y,z-coordinates of every node) of a FEM-model. So, MIT is developing an other model based on "super quadratics" like function $x^i + y^i - R^i = 0$. These functions have very nice properties for various types of finite elements (cubic, cylindrical, rounded cubic etc.) and only very few para¡meters are needed to specify an element.

Mostly the bodies to be researched are continuous. For granular bodies new problems arise for example these of contacts and relative locations of bodies. Dr. Williams works to find new ways to represent bodies described hereupon. He presented pictures of some examples of representative objects:

- flow of a granular material from a hopper
- penetration of a wedge-shaped solid into granular material

- a bullet hitting a wall
- ice on water breaking against a wall.

Information flow in construction.

Dr. Duvvuru Sriram, Assistant Professor of Civil Engineering

Dr. Sriram works for Intelligent Engineering Systems Laboratory of MIT on tasks for civil engineering problems which include:

- communication, coordination and control of cooperative design
- design innovations
- construction planning
- computer-aided construction
- sensor interpretation
- maintenance of constructed facilities
- construction robots

As an example of the problems in information flow in construction Dr. Sriram explained the reasons of the collapse of pedestrian bridges in a hotel in USA some years ago resulting about 150 deaths and 200 injuries. This incident has been researched and efforts to facilitate effective coordination and communication in design and construction has been made. A conceptual view of a Computer Integrated Design and Construction System has been developed for these needs.

Designing robots.

Ms. Laura Demsetz

The development of robots for construction is an effort to turn the US construction industry to the growth. The automation of construction industry is needed to improve productivity by:

- reducing labor costs (% cost due labor)
- increasing speed (on or near critical path)
- improving quality (frequency of rework and repair)
  and
- increasing safety (frequency of injuries).

The robots developed should combine:
- human sense
- human intelligence and
- human adaptability

to a machines speed, strength and reliability.
Ms. Demsetz presented a family of three robots which will operate in a sequential, mobile line to move through the building space and assemble an inner wall. Also he told about cable suspended platform for robots or workers. The lateral stiffness of the platform is good enough when using heavy platform and crosswise hanging cables. The increase of productivity depends also on the ergonomics in various work-phases. As an example in this field Ms. Demsetz presented a stud-welder, which one can use without hunching his back.

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MIT. CAMBRIDGE

Tuesday April 26.

ARTIFICIAL INTELLIGENCE LAB

Professor Tomas Lozano Perez

Notes by Hans-Petter Sundh

The structure of MIT is a matrix where departments is one of the axes and laboratories the other. At the Artificial Intelligence Laboratory students from the following departments dominate:

* Electronics
* Cognitive Sciences
* Mechanical Engineering

But there are also some from Sloane School of Management and other departments.

The laboratory has an annual budget of 8 million dollars and around 150 people work there:

* 15 faculty
* 100 students
* 10 post doctorate
* 25 staff

Sponsors are mostly government, but there are also a number of industrial sponsors at a lower level of engagement. The activities of the lab are as follows:

* Natural language
* Learning
* Mobile robots
* Stereo vision
* Motion
* Colour
* Recognition
* Manipulator control
* Expert model base system
* Problem solving

In addition high level development of computer software, e.g. parallel processing, the connection machine and knowledge based programming.

The lab tend to go for many small projects rather than a few large ones. Part of the research takes place in the individual offices (Learning, natural languages, problem solving, expert model base systems), part in the labs proper.

The role of the Artificial Intelligence Lab. has been changing, there is now greater interaction with the rest of MIT, e.g. in robotics, control theory etc. There is a growth of interest in psychological teaching, e.g. in connection with computer vision.

The work on robotics is centered on mobile robots in unstructured environments. The lab do not tend to work on specific applications, but on a more basic level. Ideas are tested, but on the laboratory level. Development of applications usually will require larger groups of people.

Application also change too often, as compared to development periods. It is preferable to present ideas to others, leaving development to them. Unfortunately what often happens is that ideas are snatched up by the Japanese, who develop and manufacture applications which are then sold back to the US.

The lab does not work on neural networks (do not believe in them) in its language research. The interest is in computational theories of language. Neural networks are only studied to observe their limitations. They have a role to play, but a limited one.

A fair bit of work is done within mathematics, particularly related to robotics and vision. Experimental checking of theory is of particular interest.

The lab has been doing work on mechanical and electronic design, but not architectural.

The lab is not doing any robotics work directed towards the building industry. Professor Slocum at the Centre for Construction Research and Education is the one who is doing that at MIT. Professor Lozano-Perez has his main interest in the programming of robots from models.

Programming a robot to learn is very difficult today. If it is to be of any use, the robot must ultimately represent what it learns. If we are able to represent the parametric process this requires, and know the parameters, we are getting somewhere. It is not possible to create the learning system today, but to make the robot learn some things, e.g. the connection between calibration and the actuator. But we really do not know the sequence in which learning processes takes place.

Work on vision is focussing less on individual elements of vision, more on integration. Work is carried out in layers, assigning values to parameters in arrays, trying to find optimal probability for the total. The key problem in vision is the segmentation of the elements. Motion can be of help, together with stereo.

Demonstrations:

* Autonomous toy car
* Mobile robot
* Connection machine
* Puma
* Two-laser navigation system

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DEPARTMENT OF ARCHITECTURE. MIT. BOSTON.

Tuesday April 26.

ELECTRONIC DESIGN STUDIO

Mr. Earl Mark
Assistant Prof. Frank Miller

Notes by Per Christiansson

Two visits at the Department of Architecture where made during the afternoon.

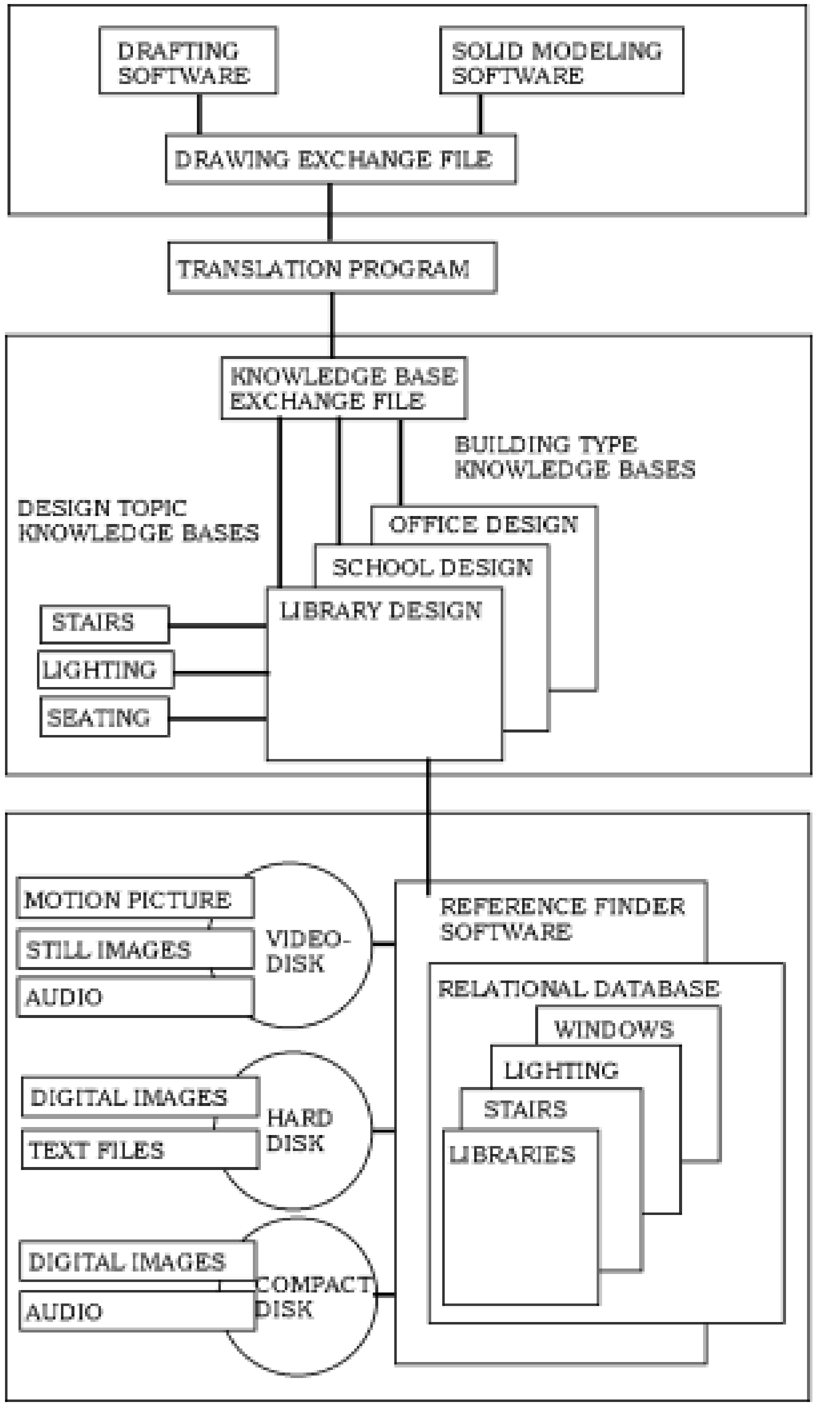
Mr. **Earl Mark** who is a doctorate student at Harvard University and also engaged in research and education at MIT talked about issues in knowledge representation in connection with computer aided design. EA states that "there seems to be a "tyranny" of predefined purpose in some highly automated CAD products. A paradox of design automation is that adding higher level functionality to a CAD product bounds its use within a specific design modeling domain and restricts its use from other more general domains. On the other hand, more general CAD products are flexible at a primitive level, but can not be used to provide "high level" functionality".

EA discussed how different assumptions about knowledge representation will influence the representation of a intersection between two joining walls. EA means that both the theory or view of how architectural elements are interrelated is hidden in the system as well as the encoding language (Fortran, C etc.). One important question is: where is the topology intelligence stored about for example how to join two walls and represent the result .

One way to overcome existing problems lays in the possibility to use a frame representation. EA points out that frames are interesting because they offer a somewhat flexible form of knowledge representation that is capable of expansion in a number of semantically and syntactically interesting ways.

Both **Earl Mark** and assistant professor **Frank Miller** has been involved in a project where different software packages (Cad- and rulebased expert systems) and videodisc media has been integrated. The work was partly reported after our visit in the paper
"Knowledge Based Design Systems" by Earl mark and Frank Miller (1 July 1988). The abstract of that paper is cited below

"Computers aid the preliminary design process in the areas of modeling, interacting with reference and archive material, codifying design knowledge, and in presenting the process. As a tool to generate and edit geometric form, different design needs are served by database and algorithm options based on either lines, surfaces, solids, or fractals. Secondly, interactive techniques continue to develop for assembling and interacting with large libraries of text, image, audio and motion picture references. As a means to represent and codify design knowledge, computers are an important platform for testing cognitive models of the design process. Finally, new display and presentation capabilities are available for managing the various processes which manipulate geometry, information and knowledge. A prototype system integrating the capabilities of available application software is described, and several case studies are outlined. This work has been conducted at the Computer Resource Lab in the School of Architecture and Planning."
The system was demonstrated and an overview is found in the figure below



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MIT MEDIA LAB.

Tuesday April 26.

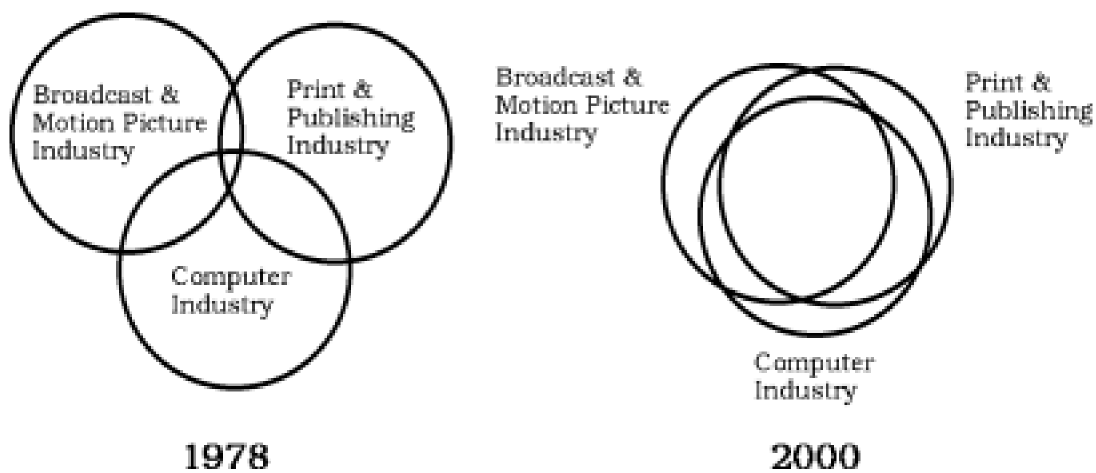
Prof. Patrick Purcell

Notes by Per Christiansson

Professor Patrick Purcell who since several years are active at the MIT Media Lab, within the area of computer graphics, gave a condensed history of the wide spectrum of projects that have been started up at the Media Lab. The director of the lab professor Nicholas Negroponte founded and directed a research project on computer aided design called the Architecture Machine Group. One result from this project is the computer controlled video disk of Aspen, Colorado in 1978.

Since 1985 the Media Lab is housed in its own building at MIT, the Weisner Building. PP emphasizes that the lab is not a computer science lab but a media lab. People working at the lab may be knowledgeable within graphics, arts and science (as artificial intelligence, computer science etc.), that is ´both´ brain halves is highly present at the lab. The work do not focus on large databases, compilers etc but on media.

PP showed the figure below which Nicholas Negroponte drew in 1978. The figure shows how the three areas of Broadcast & Motion Picture Industry, Print & Publishing Industry and Computer Industry will slowly merge. The purpose of the lab is to invent the future of newspapers, cinema, television and music through fundamental changes by use of new technology.



´Demo or Die´. The work at the lab is very much concentrated around demonstration rather than writing papers about ideas. The projects are demonstrated for sponsors and visiting researchers to show working prototypes and to get feed back to the projects.

The media gets its main funding from industry. Many projects are carried out in collaboration with other unites at MIT. PP commented on some of the projects and areas of activities (see also the reference list below)

* 1976 interactive text, video, automobile maintenance
* Movies of the future. Paperback movies on CD.
* Interactive computing and video graphics

* School of the future (LEGO/ Logo)
* Eye tracking, painting etc. Multi module channel of communication
* Personalized newspaper
* the Athena project at MIT
* Visible language workshop.
* Animation and computer graphics. Real time animation
* The Vivarium. Animals in complex computerized ecosystems
* Use of the Connection machine for computer graphics etc.
* Synthetic holograms

etc.

During the walk around at the lab, professor Purcell had the opportunity to show the very creative and innovative environments that exists at the lab as for example the terminal garden in which work is going around 24 hours a day at different workstations and powerful computers.

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COMPUTERVISION. BEDFORD

Wednesday April 27.

Mr. Perrti Vulli
Dr. Thomas Peters

Notes by Väino Tarandi

Subjects

AI, KBS. Software development for end users

P VULLI
Prime and CV have a turn over of 1.5 billion$ and 12.000 employees. The technical application part, including CAD/CAM is 800 million$ and administrative applications is 700 million$. 10 % of the turnover is used for research and development. 1000 persons are developing software. CADDS has used about 7500 man-years for its development.
The goal is to be leading company for wide solutions in the CAD/CAM field and related areas. This demands large companies. P/CV is ranked no 2 among CIM companies according to official reports, but as no 1 according to their own calculations. In the future there will be only a few big companies, and P/CV intend to be there.

P/CV has two product lines today for CAD:

* CADDS for application systems.
* MEDUSA for mechanical, architectural and structural design.

P/CV will keep their two product lines. They will recommend CADDS for some applications and MEDUSA for other, but some "grey" zones are unavoidable. For these applications there will be workstations from low end (10'$ per user seat) to high end (<150'$ per user seat). CADDS will run on SUN. MEDUSA will run on PRIME, SUN and VAX.

CV's mission will be to supply solutions that allow their customers to:

* Bring products to market faster
  For example in the car industry it's possible to cut the time from 6 years to 2. In most cases you can't cut time by using more persons.)
* Improve product quality.
  Design errors are expensive. With CAD you have the possibility to test many solutions.
* Reduce product programme cost.
* Utilize more fully their designers technical talent.
  More complex products and fewer skilled persons makes it necessary to use expert systems to bring over knowledge from experts to less qualified persons. The next generation of systems will permit the operators to "teach" the computer how he or she is thinking.

The two MEDUSA versions will merge together in one years time. That won't effect the users as the two versions still are so similar. This also means that the resources available for development are doubled.

TOM PETERS

Rule based "expert systems" will be the fastest way to give the users (customers) good solutions. Important parts are:

* Rules : IF, THEN format
* Features : Holes, slots, bosses, ...
* Capturing knowledge : From the expert
  - Expertise is stored in rules
  - Common language of features

  : In the software
  - Objects for features
  - Rules that operate on feature objects.

In ordinary software the programmer has to consider how rules are influencing each other. This is not needed in expert systems. Features makes it possible to use commands as "hole" instead of the corresponding geometrical command. (Insert hole instead of boolean operations).
You have to find the expert first, then the right objects, and after that you let the rules operate on the objects.

Why rules?

* Easy to express expertise.
* Easy to modify and change in the rule base.
  No need to check influences on other rules.
* Extensible.
  The developers have engineering tools in the software and can use common syntax.
* End user friendly.
  They can use the structural editor.

Software

They have chosen KEE from Intellicorp. One reason for this is the stability in that software.
The other alternatives they had were:

* Knowledge Craft (Different for forward and backward chaining).
* Art (").
* S1 (Technically limited, but small in memory).

The reasons for CV to choose KEE were:

* Same syntax for rules independent of forward or backward chaining.
* Object oriented software.
* Frames (Very important).
* Rules
* Common lisp (will be standard. Portable).
* Expert system platform

CV has one interface between their CAD-system CADDS and the Expert system KEE. This works both to and from the database. The steps are as follows:

* Reads the CADDS database. (Takes snapshots)
* Takes each item and turns them to objects in KEE.
* Calculates and operates on the objects.
* Sends the result back to CADDS for graphical presentation.

Three possible projects were considered for their expert system application.
They were:

* Automatic dimensioning (drawing generator).
* Intelligent assembly
* Design rule checking

The first project is "Automatic drawing generation". This system creates dimension drawings which takes 8-10 minutes for a small drawing and 2 hours for an advanced. It was one of the prototypes in TAC (technical advisory council) challenge and was therefore already thought of.
Many problems are to be solved. For example you must decide what shall be dimensioned and where shall the result be placed?

The project is now a staffed project.

Some of the reasons for choosing this project as the first were:
* Elimination of much tedious dimensioning.
* Drives standard CADDS dimensioning package (in batch).
* Built on commercial shell.
* Base rules supplied by CV (using CADDS commands).
* Extensible for local expertise.

CV is also doing some AI-research. The following were mentioned:
* CV sheet metal manufacturing
    In-house prototype
    Accompanying research paper for SME
    Use of features (interaction with KEE using features)
* Domain of sheet metal and suite of products.
* End user editing of rule base (3-5 years from now)
* Customer research

PDES
CV takes part in the PDES group today. They had a period a couple of years ago when they didn't take part. PDES is a global product. CV finds that to "broad". They want that the committee shall choose fewer areas. CV wants to emphasis "features".
They find feature creation and recognition a very important issue.
They have good relations with The National Bureau of Standards in their discussions around PDES.

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TOUR PROGRAM

Per Christiansson 1988-04-08

"INFORMATION TECHNOLOGY IN THE BUILDING PROCESS. DEVELOPMENT TRENDS IN THE USA 1988. NBS-DATA.

The Working group for Information Technology under the Nordic Building Research Cooperation Group, NBS-Data, will this spring arrange a tour in the north-east part of the USA to universities, institutes and companies which are at the leading edge (research/development and use) within one or many of the following areas:

- KBS, knowledge based systems/expert systems/ object oriented systems (K)
- Robotics (R)
    - Visualization and modeling (V)
- Intelligent buildings (B)

The invitation is sent to persons who have a broad knowledge within the field and are active in positions entailing strong possibilities to influence and contribute to future works within the area. Our aim is to restrict the number of participants to approximately three from each of Denmark, Finland, Norway and Sweden.

The aim with the tour is to take part of the State of the Art developments and trends delivered by highly distinguished individuals and research/development groups in the USA and to communicate experiences.

The program for the 12 day trip is as follows:

Date		Place of visit/host	Subject areas
Sunday	*Car rental:*	3, 4 door E-size (Avis), until wednesday 20, (3 days)	
April 17	*Reception:*	Ramada Renaissance, Washington (1800PM-2000PM))	
Washington	*Hotel:*	Ramada Renaissance, Washington	
Monday	**National Bureau of Standards**		KRV
April 18	0900AM	Dr. Richard Wright, NBS	
Washington	0930AM,	Dr. Richard Smith, Center for Fire Research, NBS	
	1030AM	Dr. Kent Reed, Computer Integrated Construction, NBS	
	1130AM	Lunch	
	1230AM	Cont. Computer Integrated Construction	
	1330PM	NBS Automated Manufacturing Research Facilities	
	1430PM	Free time	
Tuesday	**National Research Council**.,...		KRVB
April 19	0900AM	Dr. John Eberhard, Building Research Board, NRC	
Washington		(Mr. Henry Borger Federal Construction Council?)	
	1100AM	Mr. David Harris, National Institute of Building Sciences	
	1230AM	Lunch	
	1400PM	Mr. Richard Geissler, Ms. Jan Goebel. Intelligent Building Institute	
Wednesday	*Flight:*	AL591, dep 0800 (Wash/IAD), arr 0850 (Pit)	
April 20	*Hotel:*	Sheraton Station Square (412) 261 2000	
Pittsburgh	*Transport:*	Cab direct to CMU (0930AM)	
	Carnegie Mellon University		KRVB
		Prof. Daniel Rehak	
08:50AM		Arrive Greater Pittsburgh International Airport	
08:50AM - 09:30AM		Baggage Claim	

09:30AM -	10:15AM	Bus to Carnegie Mellon
10:15AM		Arrive Engineering Design Research Lab, Coffee, Leave Bags at EDRC
10:30AM -	11:55AM	Field Robotics Center, Prof. Red Whittaker
12:00 M	- 12:30PM	Center for Design of Educational Computing, Dr. Robert Cavalier
12:45PM -	13:30 PM	Lunch, Skibo
13:45PM -	14:15 PM	PLANEX Demo, Civil Engineering Computer Lab, Dr. Carlos Zozoya-Gorostiza
14:15PM -	14:35 PM	Domain Modeling System Demo, Civil Engineering Computer Lab, Dr. Walid Keirouz
14:35PM -	14:50 PM	Dr. Irving Oppenheim, Civil Engineering
15:00PM -	15:30 PM	Prof. Steve Fenves, EDRC Conference Room
15:30PM -	16:00 PM	Dr. Chris Hendrickson, EDRC Conference Room
16:00PM -	16:30 PM	Dr. Gerhart Schmitt, EDRC Conference Room
16:30PM -	17:00 PM	Dr. Rob Woodbury, EDRC Conference Room
17:00PM -	17:30 PM	Dr. Mary Lou Maher,EDRC Conference Room
17:45PM -	18:00 PM	Bus to Sheraton Station Square
18:00PM -	20:15 PM	Free
20:15PM		Meet in Lobby for Dinner
20:30PM		Dinner, Grand Concourse, Station Square

Thursday	*Flight:*	AL663, dep 0935 (Pit), arr 1115 (Itacha)
April 21	*Hotel:*	Holiday Inn, Itacha
Ithaca	**Cornell University**	
V	1300PM	Prof. Donald Greenberg Program of Computer Graphics

Friday	*Flight:*	AL461, dep 0800 (Ita), arr 0852 (Pit) AL351, dep 1040 (Pit), arr 1134 (Dtw)
April 22		
Ann Arbor	*Hotel:*	Sheraton University Inn, Ann Arbor
	Transport:	Pick up by campus limousines. Stop at hotel.
	1245AM	Lunch at campus
	University of Michigan.	
KV	1400PM	Dr. James Turner Architecture and Planning Laboratory

Saturday	*Flight:*	AL275 dep 1015 (Ita), arr 1133(Pit) AL322, dep 1415 (Pit), arr 1610 (Bos)
April 23		
Boston	*Car rental:*	3, 4 door E-size (Avis), until Wednesday 27, (3-7 days)
	Hotel:	Back-Bay Hilton (south of Harvard Bridge)
		Free time
Sunday		Free time
April 24		
Boston		

Monday	**Harvard University**	
V		
April 25 (am)	0900AM	Prof. William Mitchell
Boston		Graduate School of Design
	1200AM	Lunch
Monday	**Stone & Webster Engineering Corporation**	
KV		
April 25 (fm)	1400PM	Dr. Kenneth Reinschmidt
Boston	1630PM	
Tuesday	**MIT**	
April 26	**Department of Civil Engineering**	
KR		
Boston	0900AM	Prof. Charles Helliwell
		Prof. D. Sriram
		Prof. Alex Slocum
	MIT Artificial Intelligence Lab	
KRV		
	1100AM	Prof. Tomas Lozano-Perez
	1200AM	Lunch
	Department of Architecture	
KV		
	1300PM	Mr. Earl Mark
		Prof. Frank Miller
		Electronic Design Studio
	MIT Media Lab	
KV		
	1530PM	Prof. Patrick Purcell
	1630PM	Free time
Wednesday	**Computervision, Bedford**	
KV		
April 27	0900AM	Mr. Earl Mark
Boston	1100AM	Free time

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Per Christiansson 1988-04-08

Number of participants 12.

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