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CAD A New Generation of ECAD/ECAE Systems

Dr Dirk Schaefer of Georgia Tech (USA) presents an overview of recent advances in ECAD systems development.

The domain of electrical computer-aided design and engineering (ECAD/ECAE) is currently undergoing major and rapid change. The globalisation of markets has significantly enforced companies to increase their productivity in order to sustain their competitiveness.

Computer-aided design (CAD) tools developed in the early 1990s no longer meet future requirements. Moreover, due to their monolithic software architectures they can not be sufficiently extended or adapted. Consequently, a new generation of ECAD/ECAE systems, often referred to as 'electrical engineering solutions (EES)', have recently been under development. New modular system architectures, contemporary software engineering tools and object-oriented approaches have been deployed, to develop a novel generation of advanced engineering software systems.

Over the past five years, several workshops and conferences have been held, bringing together research into the development of third generation ECAD/ECAE systems[2]. An overview of recent advances in this field are presented in this article.

Key system requirements

A decade ago, key technical requirements to be met by these systems were identified to be:

- Concurrent engineering. Unified software architectures based on the CAD reference model.
- Variant design technology.
- Adaptive and more intelligent user interfaces.
- Modularisation and standardisation in design.
- Enterprise-wide systems integration.
- International standardised data exchange.

Although a decade may appear to be a long time, it took just about this period of time to realise the so-called third generation of ECAD systems, which today represent the state-of-the-art. However, the development of these systems has never been straightforward for various reasons as discussed later. Furthermore, they have still not fully reached their anticipated functionalities and potentials.

Even their industrial deployment and replacement of previous systems has happened with a much greater deal of delay than expected.

First and second generation systems

The main purpose of the ECAD systems developed around 1980 was simply to replace the traditional drawing board. Key advantages were an improved overall quality of drawings, more efficient ways to modify them, the opportunity to reuse existing designs for new projects by means of copy and paste, as well as space saving digital

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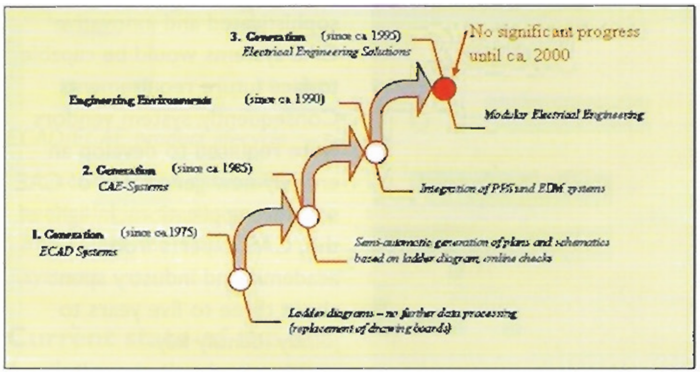
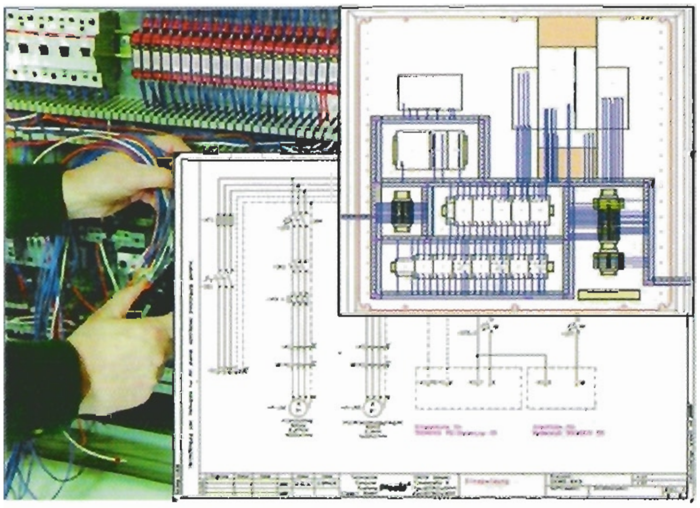




Above: Figure 2: Three generations of electrical engineering CAD systems
Right: Figure 1: Contemporary ECAD/ECAE environment

archival storage of designs. However, the early ECAD systems did not support any processes performed after the generation of the actual drawings. Consequently, the envisaged increase in productivity was never realised.

The development of second generation ECAD systems commenced in 1985. By that time, a major technological innovation was to semi-automatically generate various project documents, such as terminal plans, wiring diagrams, and part lists, on the basis of a drawn ladder diagram. This was a major breakthrough and henceforth ECAD systems with this functionality were referred to as computer-aided engineering (CAE) systems.

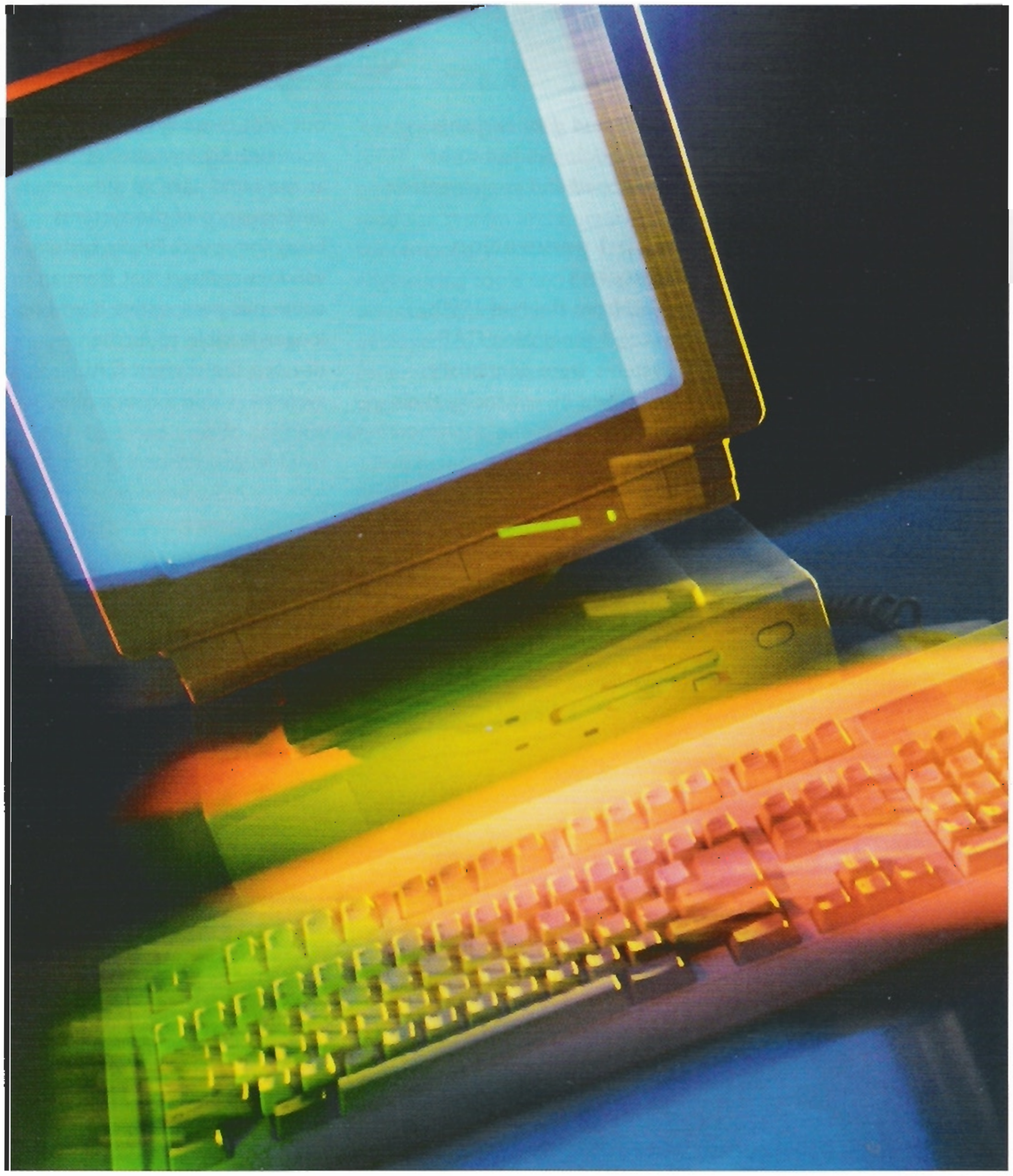
From the mid 1990s, systems integration became a key issue in CAE system development. In order to make the overall process from design to manufacture more efficient, CAE systems had to be linked to other engineering systems, such as finite element method (FEM) packages, engineering data management (EDM) and product data management (PDM) systems, as well as product lifecycle management (PLM) and enterprise resource planning (ERP) systems. In light of this, new data interfaces and associated data exchange methodologies had to be developed and implemented.

Third generation systems

Also from the mid 1990s, second generation CAE systems were continually improved by enhancing their functionalities and implementing more sophisticated design and product modelling features.

However, project lead times and productivity appeared to remain nearly unchanged. This was mainly due to the fact that the complexity of engineering design projects to be carried out with these systems continuously increased at least at the same pace as the performance of the systems being improved. Finally, system vendors realised that from an economic perspective it was no longer feasible to further develop the current CAE systems within a reasonable amount of time and cost. The main issue with regard to this was the software development methods practiced in the 1970s and 1980s, ie the time in which the core parts of the CAE systems were implemented.

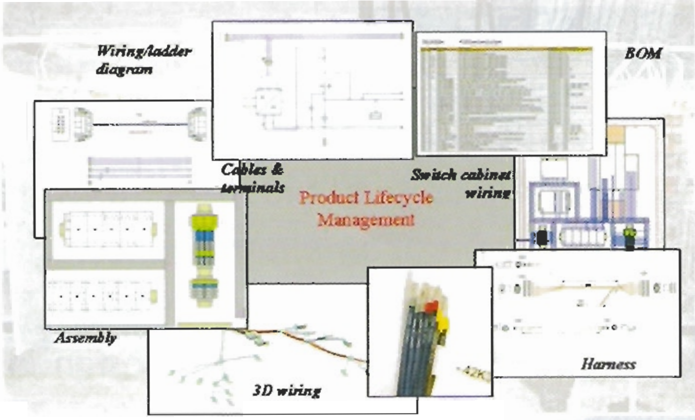
Due to a lack of professional software engineering



techniques, such as modularisation, expendability, adaptability, robustness, and monolithic software architectures those systems became more and more difficult to maintain and extend.

Eventually, it became apparent that only a new generation of highly sophisticated and innovative CAE systems would be capable to face future requirements. Consequently, system vendors were required to develop an entirely new generation of CAE software applications. In light of this, CAE experts from academia and industry spent about three to five years to jointly identify key requirements to be met by a new generation of CAE systems[4,6]. These key requirements included:

- Adaptive and more intelligent user interfaces.
- Intelligent, interactive design support.
- Improved online mechanisms for analysing design information and data.
- Support of modular electrical engineering design.
- Support of concurrent engineering.
- Support of efficient mechanisms for reusing existing designs and the generation of design variants.
- Automated switch cabinet layout and cable routing.
- Support of subsequent processes, such as design-to-manufacture integration.
- New ways to automatically generate complete project documentations for manufacture and assembly purposes.
- Improved mechanisms for standardised national and international data exchange.
- Realisation of the CAD reference model in order to develop unified, modular system architectures.
- Use of latest software engineering methodologies, Computer-Aided Software Engineering (CASE) tools, and



ECAD/ECAE product lifecycle

object-oriented database technologies to design and implement the new CAE systems.

Current state-of-the-art

A milestone in developing the third generation of CAE system was the successful porting of UNIX™-based systems to more contemporary PC-based Windows™ and Linux™ platforms. In the first instance, the new systems appeared to be clones of their predecessors, however implemented using latest object-oriented technologies and modular software architectures. Most CAE system vendors developed proprietary object-oriented data models, which formed the basis for modular electrical engineering design. This means, in order to start working on a design project, it was no longer essential to begin with drawing the ladder diagrams. Due to the newly developed data models and associated object-oriented database systems it became possible to process several parts of a CAE project concurrently. Furthermore, relevant project information could be entered into the system at almost any sensible stage of the design process rather than in a particular order. This was a major step towards supporting concurrent engineering.

With regard to the realisation of the CAD reference model mentioned earlier, no system vendor is known to have implemented this approach towards unified software architectures within a commercial CAE environment[1]. This may be due mainly to competitive reasons rather than practicability as the CAD reference model was successfully implemented in a number of piloting projects[1].

Meanwhile, the majority of CAE vendors have made their products scalable. This means they offer a variety of software modules for various purposes that can be customised and combined to form customer specific engineering packages. Furthermore, most systems allow users to adapt the language of menus and system commands, as well as that of printing options, to meet their own or their customer's specific requirements.

Another key requirement to be met by third generation CAE systems is the support of variant design and an efficient reusability of existing design projects. Currently, the majority of CAE users prefer variant design approaches that allow for automated generation of complete project documentations, based on configuration using modular standardised components[3]. With regard to this, some system vendors have developed low-budget add-ons based on Microsoft™-Excel or Access™ that can be linked to their customer's product data management system.

To date, all these solutions are of a proprietary nature. A novel generic approach to support variant design technology, based on modular product structures using standardised components, has recently been proposed[7]. That approach allows for an automated generation of complete technical documentations of an installation on the basis of a placed order specification.

Significant progress has been made with regard to design-to-manufacture integration. Some of the high-end CAE systems established in the market provide modules to automatically support switch cabinet engineering. This involves algorithms for optimised cable routing, as well as tools for producing labelled cables of the right type, diameter and length. Also, modules to support cable harnessing are available.

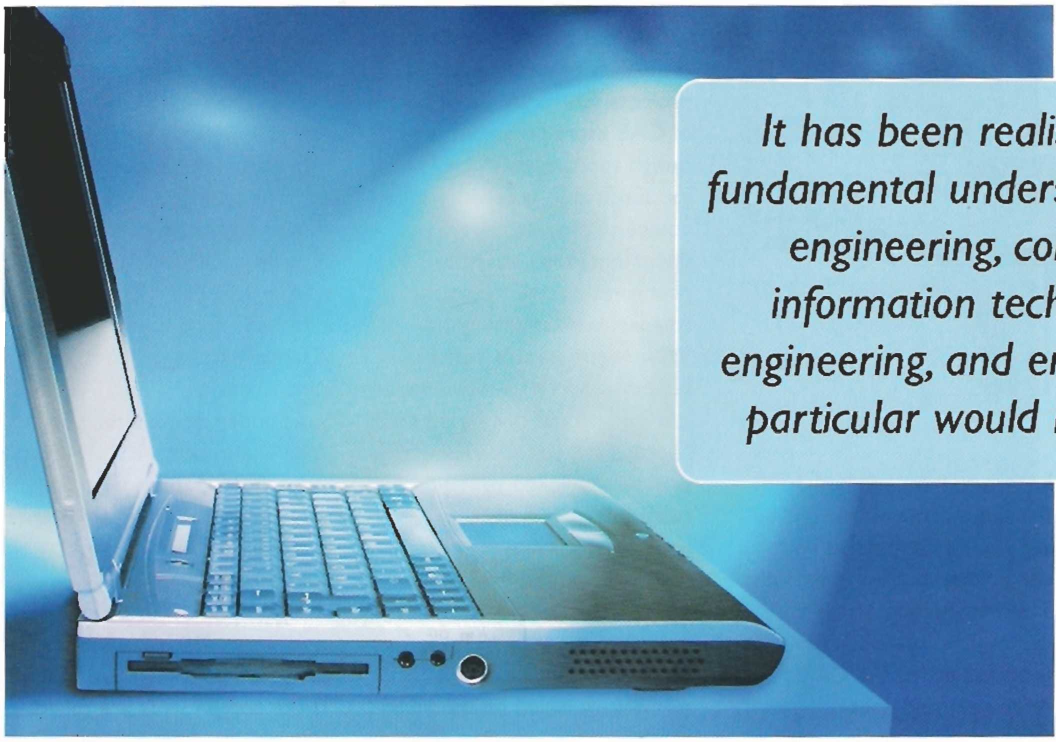
In terms of standardised international data exchange, some progress has been made regarding the international standard ISO 10303, which is informally known as STEP (STandard for the Exchange of Product model data)[5]. STEP has been under development since 1984 and in use since 1994. Its scope is much broader than that of other existing CAD data exchange standards. STEP consists of a number of components, which define data models on which translators for CAD data exchange are based. These components are called application protocols (APs). The AP most relevant to ECAD/ECAE system developers is 'AP 212: Electrotechnical Design and Installation'. It was published in 2001, and some major CAE vendors have recently made corresponding translators available.

Conclusion

Considering the requirements to be met by third generation CAE systems and the current state of realisation, reveals that significant progress has been made. However, not all the requirements and associated

Requirement to third generation ECAD/ECAE systems	fully met	partly met	not met
System development by means of Software-Engineering, CASE-tools, object-oriented databases and other advanced technologies	•		
Adaptive and intelligent graphical user interfaces		•	
Multimedia support		•	
Implementation of CAD reference model			•
Object-oriented data models (proprietary ones only)	•		
Support of modular electrical engineering		•	
Support of Concurrent Engineering		•	
Intelligent design support/assistance			•
Tools for design analysis and simulation			
Support of variant design (or automatic variant generation)		•	
Automated Layout of switch cabinet and cable routing		•	
Integration of design with manufacture		•	
Standardised data exchange (STEP)		•	

Third generation ECAD/ECAE systems – requirements vs. state of realisation



It has been realised that ideally a fundamental understanding of software engineering, computer science, information technology, electrical engineering, and engineering design in particular would be most beneficial

synergy effects have been met so far. One of the reasons for this is that system vendors have to keep maintaining their previous systems for several years until they have finally been completely replaced by the new ones. Consequently, the amount of resources available to further develop third generation systems is limited.

Another reason for lagging behind is a shortage of staff having the appropriate skills to develop highly sophisticated engineering software. It has been realised that ideally a fundamental understanding of software engineering, computer science, information technology, electrical engineering, and engineering design in particular would be most beneficial. However, only relatively few staff are multidisciplinary skilled.

In summary, a satisfactory conclusion can be drawn. The key players among the CAE system vendors have been able to develop third generation systems, which bear a tremendous potential for synergy effects with regard to international distributed engineering.

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GRUMPY OLD MEMBERS

Bathroom shower hose

I am going to have to replace another bathroom shower hose! They only seem to last about two years before the outer helical reinforcing strip bends or breaks near one end, and the inner hose starts to twist and block the water flow. From that point on it cannot be repaired, you have to replace it, if you can find one which matches style of the original.

It shouldn't be difficult. A short coil of wire, wound in with the reinforcing strip at each end, would ease the transition between the stiff end connection and the main flexible section. Alternatively the inner hose could be reinforced with a tapered end, say 10 cm long, which would have the same effect. They have to put ends on the hose anyway.

Why don't they do something about it? They probably think they will make more money from selling you a new one every two years. Think again; the first manufacturer who produces a longer lasting one could sell millions to every hotel chain in the world and then corner the domestic bathroom market. With that sort of volume, a hose that lasted 10 years wouldn't be a problem.

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