A state-of-the-art platform for engineering collaboration

Virtual Engineering Office

Gerhard Mauthe, Kurt Kaltenegger, Harsh Karandikar, Oliver Claus, Marek Florkowski, Marek Fulczyk, Tomasz Nowak, Michał Banaś

A sales force in Latin America, the design department in Europe, and production in Asia? Arrangements of this kind are the new business reality for today's global manufacturing companies. But how are such global operations to be effectively coordinated?

ABB's answer was to develop and implement a new platform for high-performance, real-time collaboration. Globally distributed engineering teams can now work together, regardless of time, location or the CAD system they use, making ABB easier to do business with, for customers as well as suppliers.

It sounds like a paradox, but there is only one real trend evident in today's global market, and that is continuous – and rapid – change. The market environment is uncertain; competitors are changing; new, disruptive technologies are emerging; and topping all this, customers are becoming more demanding.

To be successful in such a dynamic market, globally operating companies must be able to supply goods designed to meet individual customer requirements. The focus is shifting from 'mass production' to 'mass customization'. This new orientation is forcing companies to reorganize the way they do business. New 'virtual organizations' are being formed to handle specific orders – organizations that are established, managed and terminated according to market demand.

These 'virtual factories' can be described as a multi-layer network of links between suppliers, sub-contractors, customers and different departments of the same organization. A customer who is involved in order processing at a very early stage is able to significantly influence product design, and is assured of getting exactly what he wants. While most experts agree that companies will have to become 'virtual' in order to

ensure future business success, the reorganization inevitably presents new challenges to the participating teams, especially with regard to the way they collaborate and communicate with each other.

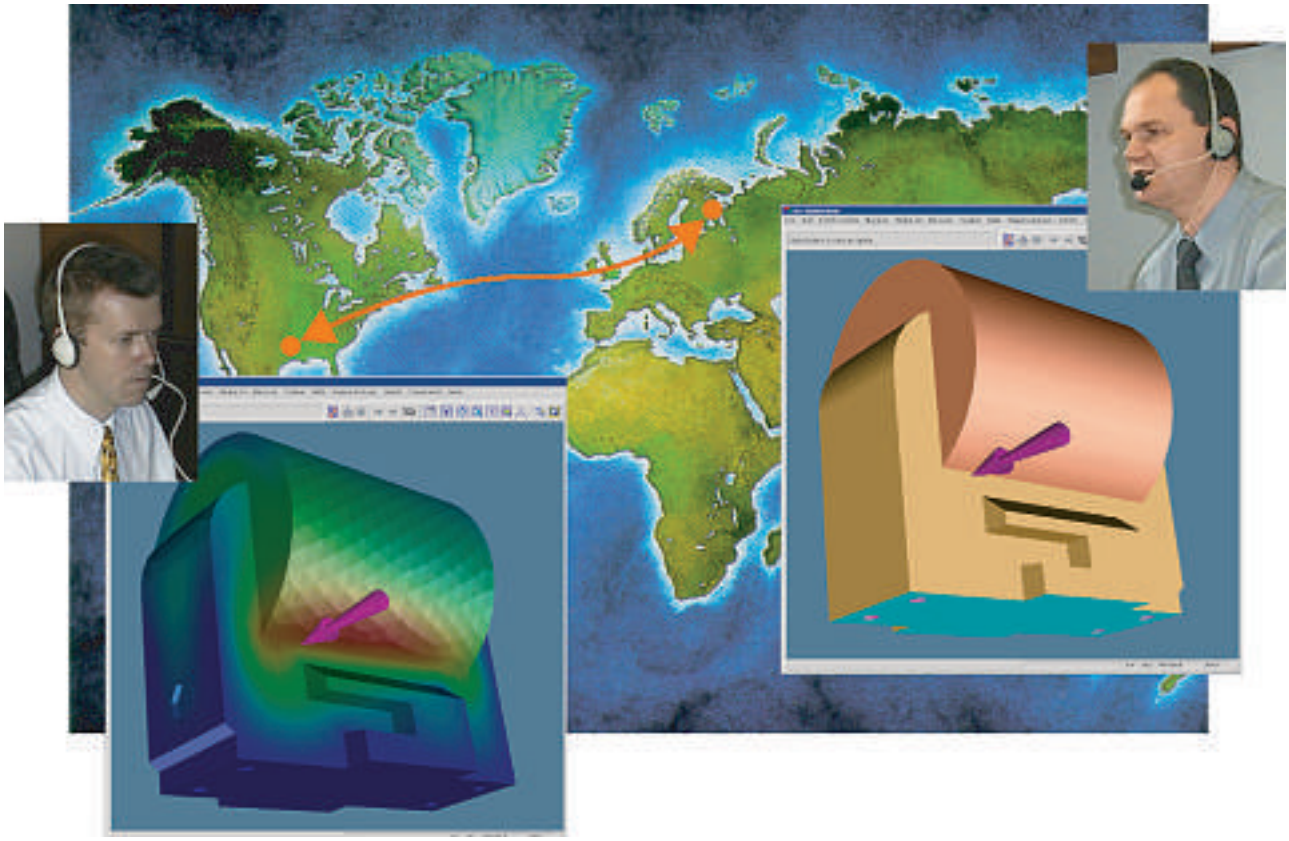
The new paradigm: collaborative engineering

ABB developed the Virtual Engineering Office (VEO) to address new issues that have been raised by the above trend. A core element of the concept is that all the business partners (producers, subsuppliers and customers) are involved in the ABB product development process at the earliest opportunity. Product information, new proposals, and changes to orders, are shared across the virtual organization, greatly improving coordination while reducing development time and costs.

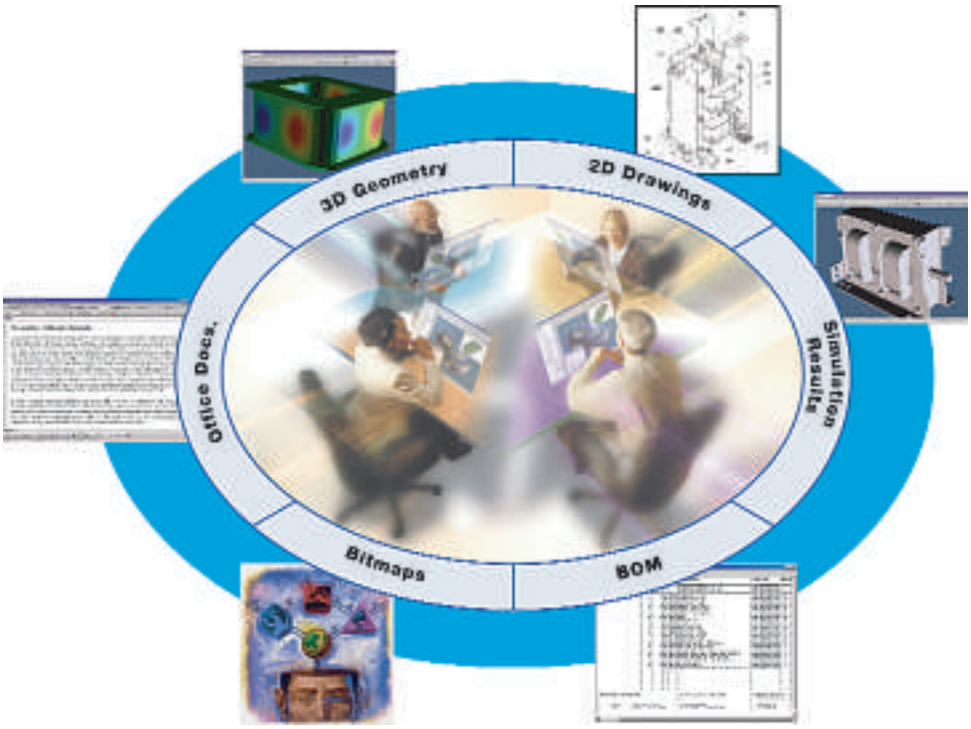
At least, that is how it is supposed to work. In the real world several factors combine to make collaborative engineering much more difficult to manage. One of them is the enormous amount of data that passes to an fro between the project partners. Another is that engineering data come in many different formats, which causes interoperability problems. Moreover, global teams working across time and space have to overcome certain geographical and cultural barriers. And finally, for security reasons, most companies have 'firewalls' in place to protect themselves against 'undesired' interaction.

The VEO project was launched to manage all of these difficulties and make ABB a company that is easy to work in and with. Its goal was to define and implement a computer-based environment supporting collaborative processes for widely dispersed engineering groups 1. The main emphasis was put on hetero-

1 The idea behind collaborative engineering – heterogeneous information sharing, data visualization and secure communication across firewalls



2 A variety of data can be shared in the VEO environment.



geneous information sharing, data visualization, and secure communication across firewalls.

Working in a VEO is almost the same as working in a real office. Projects pass through the usual phases and team members play their usual roles and participate in familiar review meetings. The only difference is that project members do not have to travel to meetings and sit across from each other – instead, they are located all over the world. This allows more frequent, shorter sessions, which speeds up and improves the quality of product solutions. As in real life, the main elements of a virtual project are project meetings, referred to in ABB's VEO as collaborative sessions. Each session is dedicated to a particular engineering (manufacturing, electrical or mechanical) problem. All the people involved, for example designers, simulation engineers or external partners, can log into a virtual session on their local workstations to make their knowledge available to the whole team. Once inside the virtual session, experts from different disciplines can collaborate, identify potential problems, brainstorm ideas, and come up with good workable solutions. During this kind of collaboration, session members can view and modify relevant parts, and notify others of changes in order to discuss options and decide on the best one. Communication among product development partners is enhanced by an application that allows them to co-inspect a multitude of 2D and 3D files, such as CAD drawings and models, bitmaps, spreadsheets, and text documents 2. All the discussed items and decisions reached during a session can be stored as well as traced.

The technical solution

To unify all the operations in the product development chain, a VEO needs an architecture that will allow co-viewing and real-time modification of the vital product data. Further, there has to be support for additional features for searching and accessing data which also take into account role-based security. ABB has therefore developed a framework that is able to provide, to the distributed engineering team, product data created in any system – regardless of the data storage location, format or authoring tools.

The developed solution is based on a client–server architecture. The collaborative server consists of a CAD-neutral tool for data visualization and a web-based data management system for engineering information control. The visualization module is based on CoCreate's OneSpace [1] – a commercial 3D modeling kernel that supports viewing and modification of large, high-performance models. Use of unique technology has made it possible to drastically reduce the amount of data transferred during a collaborative session.

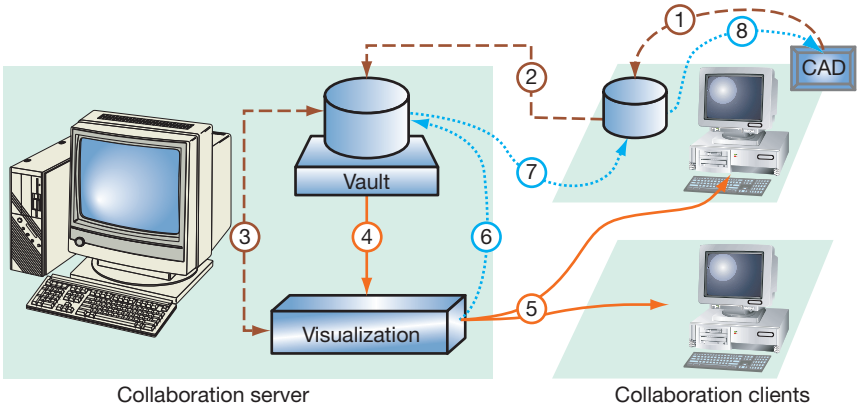
Once a model has been loaded, the server starts a data broadcast to all the connected clients. The geometric model resides only in the modeling kernel of the server; its graphic representation, together with essential structural information, is transmitted over the network. No intermediate files or data formats are involved.

3 Automated file translation in the VEO environment

Data flow during project preparation phase

Data flow during collaborative session

Data flow after session



During the streaming process, the receiving clients can render the 3D model part-by-part as it is sent over the network. All relevant attributes for high-quality shaded rendering are transmitted together with the facetted model.

When the initial loading phase is over, each client is equipped with all the data needed to render the model locally, independently of other clients and of the server. Since all clients have the information in their local scene graphs there is no need to send bitmaps or pixels. Synchronization is accomplished by exchanging a small amount of data describing the viewing parameters, which include the position of the virtual camera, the viewing direction, and the zoom factor. This approach ensures that any delays in graphical visualization between widely distributed clients are minimal. A display update involving incremental data flow between an engineer in the USA and one in Norway, for example, was found to take less than a second!

The collaborative server works with standard documents (MS Office files, 2D drawings, and bitmaps) in the same way. Moreover, users can take advantage of markup and notification capabilities. Notes, arrows, geometric shapes and relevant links can be added to the data, as required. These items are transformed into a *collaboration report*, which is sent to team members after a session.

In order to manage project information our solution further includes a web-based repository, known as the vault. All the engineering data are stored here in a multi-level hierarchy of *folders* and *classes*, secure access to shared information being controlled by a verification scheme. The two main components of this mechanism are 'groups' and 'rights'. A user belongs to one or several groups, each of which has specific rights assigned to it. Rights entitle a person or group to perform certain tasks within given projects. To make administration easier, users are assigned certain privileges, or 'roles'. Users can, for example, be a 'viewer' in one project and a 'manager' in another. The chosen architecture ensures that several projects can be run in parallel using the same resources – human as well as hardware.

However, even a state-of-the-art web-based repository accessible to the whole company cannot guarantee the seamless exchange of information among widely dispersed teams. It was therefore decided to standardize CAD and CAE file formats and automate the shared data exchange [2]. With the help of advanced features offered by STEP and VRML formats [3], and by integrating the visualization system

Optimized engineering data flow

In the first phase, called Project Preparation, users store their CAD models in STEP format (1 in *Figure 3*). Next, these models are transferred to the vault either from a user's file system or from his local PDM (2). The last activity in this phase is a Batch Process run: the visualization module converts CAD models from the STEP format into its internal graphical representation – a PKG format – and stores them back in the database (3). The collaboration session involves an Automated Loading Process – one of the users initiates loading of a PKG file into the visualization module (4), after which the graphical representation is sent to all session members (5). When shared models are discussed or modified only a small network bandwidth is used to update the visual representation. After the session the modified models are stored in the vault (6) and can be transferred to the local file repository (7) as well as next to the user's native CAD application (8). Further development is executed locally – until the next virtual meeting.

The VEO experience

To get a feeling for the VEO environment, let's attend a virtual meeting. But first meet Jack, a manufacturing specialist responsible for making sure that ordered products can be produced and that process costs are minimized. He has been collaborating with Oliver, an ABB designer, on a part that is causing both of them some trouble.

Concerned that work on a key project could be delayed, Jack checks his electronic mailbox and finds an urgent request from the ABB factory for feedback on a proposed design change. The e-mail contains an invitation to a virtual meeting and details of today's connection (the server address and session password). The virtual meeting is due to start in a few minutes…

Jack double-clicks the VEO icon on his PC, selects the server hosting the session, and logs in. The system automatically establishes connection through the ABB firewall and asks the newcomer for the conference ID. After entering the conference number Jack watches parts of the 3D model being rendered on his computer as the data streams from the server. By rotating the view and zooming in and out, he familiarizes himself with the assembly as he last saw it. While waiting for the meeting to start, he inspects the associated notes and – within minutes – is well prepared for the discussion.

In the members' subsection of the graphic workspace, Jack can see that he is the second person to join the session. Oliver is already in, and has obviously loaded the CAD model into the VEO server. The designer now takes the driver's seat and work begins. Listening to Oliver's explanation of the intended change, accompanied by synchronous movements in the viewport and using the pointing tools and markup features, Jack reflects that there is really very little difference between this session and a real meeting. In some respects, the virtual 3D meeting is even better. Jack can take full advantage of the accurate measurements that are so important to his work. And he can use his expertise to suggest alternatives, which the designer can try out on-line, for improving manufacturability. That is just the case today; Oliver wants to create an 8-mm radius between two surfaces in order to reduce mechanical stresses. Since he hasn't an 8-mm turning tool in his workshop, Jack suggests using a 10-mm radius or, alternatively, creating a tapered face between the surfaces. Oliver wants to evaluate both proposals, but to check potential collisions additional assembly parts must be loaded. This can be done simply by dragging and dropping needed files from the local file system or the vault application into the workspace window. Oliver is allowed to do this, but an access control system is in operation to guarantee the necessary security and data integrity.

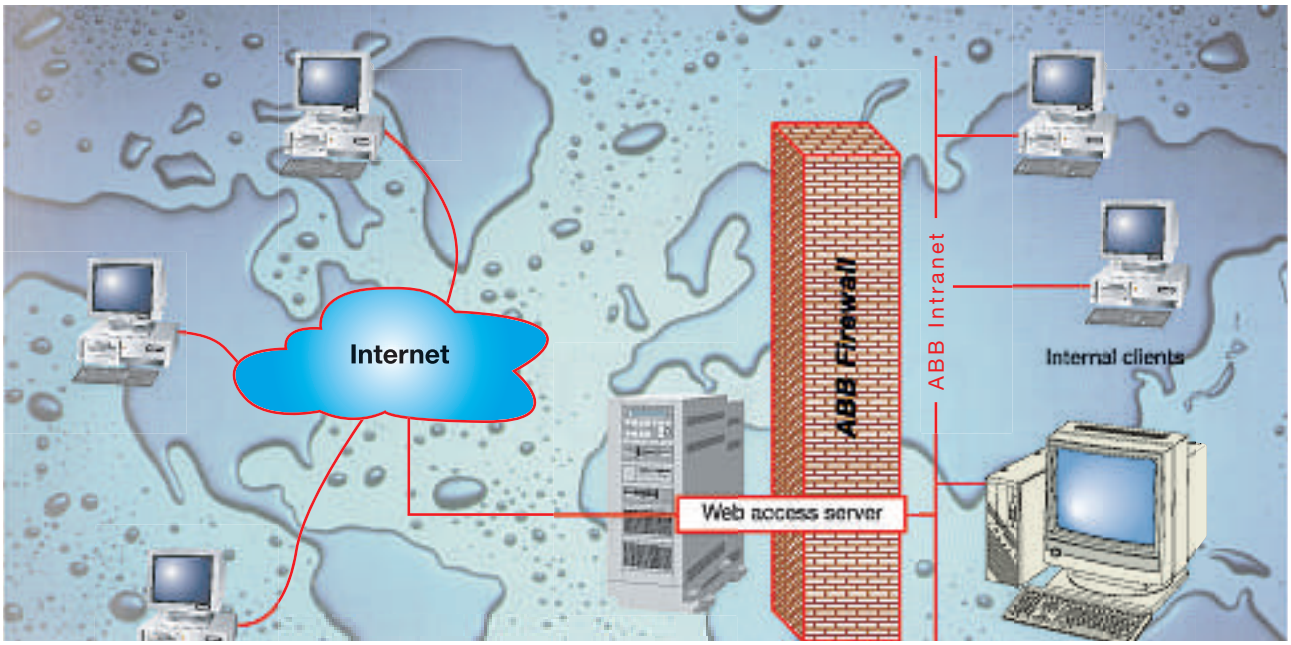
Jack and Oliver are pleased with the session. In less then half an hour, their team has accomplished what would in the past have taken a day or two of iterations. Even better, the participants have also started to think about a promising idea for an innovative modification. They will run another virtual session tomorrow, with additional experts on board, in order to explore this idea further...

The ability to share expertise remotely while working with a 3D model that can be viewed and modified by everybody seems almost too good to be true. No longer do 2D drawings have to be faxed to an fro for discussions between ABB and its business partners. This is now, definitely, a thing of the past.

and vault, it was possible to coordinate product development activities and ensure optimized data flow 3. Thanks to this approach, use of this collaboration environment has been significantly simplified and, even more importantly, the network bandwidth requirements could be drastically reduced.

Even so, being able to manage the projects, users and data is worth little until the security issue has been successfully tackled. In the interests of security, companies use firewalls to shield themselves from the outside world. The VEO co-workers, who may be located in many different companies, have to be able to communicate in spite of this technical precaution. To allow external partners to join collaborative sessions a web access server – special proxy software – has been installed on the ABB firewall 4. This server can be accessed by Internet users and connected to the collaborative server, enabling external

4 The VEO environment can be accessed from outside of ABB.



partners to be involved in the development process. Safe communication and data sharing among all the team members – ie, across firewalls – is thus ensured.

Adding value through boundaryless collaboration

Market-driven companies must work closely with suppliers and customers to precisely define their goods and services. Collaborative processes and product information exchange are therefore a critical necessity, and designers and manufacturers are quickly realizing the potential of sharing ideas, plans and commonly found workarounds. Early integration of expert knowledge can considerably reduce development time, while spontaneous, ad-hoc collaboration between team members drives innovative solutions that not only improve product design but also minimize the number of design changes. The saving in traveling cost and time is another factor that cannot be ignored. Of course, it is neither possible nor desirable to fully eliminate face-to-face contact with our business partners. But this should not stop us from wanting to manage business relations in a better way, one that, like VEO collaboration, is attractive and efficient. The benefits of VEO are just one click away.

Authors

Gerhard Mauthe
Dr. Kurt Kaltenegger
ABB Power Technology Products Management Ltd
CH-8050 Zurich, Switzerland
gerhard.mauthe@ch.abb.com

Dr. Harsh Karandikar
Corporate Research Center
DE-68526 Ladenburg, Germany
harsh.karandikar@de.abb.com

Dr. Oliver Claus
ABB Calor Emag Mittelspannung GmbH
DE-40472 Ratingen, Germany
oliver.claus@de.abb.com

Dr. Marek Florkowski
Tomasz Nowak
Dr. Marek Fulczyk
Michał Banaś
ABB Sp. Zo.o
Corporate Research Center
PL-31-038 Krakow, Poland
marek.florkowski@pl.abb.com

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