

CONSTRUCTION APPLICATION OF A GEN-NETWORK : UNIFORM ACCESS TO STANDARDS, PRODUCTS AND COMPANY INFORMATION

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ABSTRACT : Facing an increasing competitive environment where flexibility and adaptability to change are the obliged route to success, building and construction companies have to continuously renew their working habits while keeping business processes under quality, time and cost control. In the Architecture, Engineering and Construction (AEC) domain, the wide diversity in terms of the object built, but also associated to the geographical dispersion of actors and building sites makes such an agility even more crucial. Considering the design and tendering phase of a construction operation, the architects and construction engineers have to efficiently select the manufactured products that will best suit the project while complying to its numerous constraints. Beyond the functionality, performance and cost characteristics, a suitable product has also to conform to the applying regulations and standards, be eventually accompanied with a corresponding technical agreement, offer acceptable delivery solutions on the building site. Moreover, once identified within a manufacturer catalogue, the product has to be integrated into the architect or engineer application desktop, whether it be a CAD, specification writer or quantity take-off application.

Addressing these needs, the Global Engineering Networking (GEN) initiative is promoting the reuse of company internal and external engineering knowledge through the emergence of new kind of global market places where actors publish and retrieve on-line a wide range of engineering information and services. In particular, The Construction Pilot in EP 22 284 GENIAL project demonstrates over the AEC domain, the relevance of new generation of Information Technology infrastructures supporting the erection of Value-Added Service Provider (VASP) sites that materialise the GEN vision, i.e. allowing information and services to smoothly be retrieved where required whilst the succeeding company is concentrating on its core competencies. With such an infrastructure, whether it is through material, performances, manufacturer, regulation or price discrimination, the appropriate component, document or service is rapidly and cost effectively brought on the designer desk for the best value of the overall project. On the other side of the communication pipe, the supplying partner gains the opportunity of reaching an enlarged audience as IT now commonly break any geographical distance.

In practice, three major information publishers and a building contractor in Europe initiate the GEN network in the AEC domain through the erection of VASP sites offering product, company or document related information. User queries are governed by various standard (EPIC, UNICLASS) or corpus specific (BATIBASE, EDIBATEC) classification systems. Relevance of the overall approach is demonstrated through the presentation of a large variety of such queries for the various information corpuses used : Techcom company and product information, BIC company, product and document, REEF regulation documentary corpus or EDIBATEC product information.

KEYWORDS : AEC, GEN, PRODUCT INFORMATION, STANDARDS



1. OBJECTIVES

1.1 The challenge

Global competition poses an ongoing pressure on price, improved quality of products and services [And97]. Companies are forced to increase their overall effectiveness, level of co-operation, flexibility and response time to the customer, while at the same time product complexity is constantly increasing [EC94]. Not only big companies but in particular Small and Medium Enterprises (SME) depend more on their intellectual properties than on their physical assets since SMEs are often specialised on knowledge intensive products. Information and knowledge, as the strategic resources, enable companies to recognise chances early and to increase their competitiveness. The ability to manage various kinds of information from different companies/departments and to convert it into new innovative products and services is a critical success factor. The major challenges for the current practice in engineering can be characterised as follows [Ret94, Vis97]:

- Rapidly increasing volume, complexity and diversity of engineering information due to the adoption of new technologies, materials, and production processes.
- Enter strategic collaboration as a key factor to survive (especially for SMEs): companies must concentrate on their core business and purchase external products and services from partners.

1.2 Limitations of current technologies

The role of information technology is changing from a supporting technology to an essential driver on which the strategy of a company depends. Unfortunately, despite the huge market potential and the explosive growth of Internet commerce, several significant obstacles block the emergence and effective use of engineering information and services towards end-users. Nowadays many companies already offer some engineering information on the Internet. However, the companies present a different detail level of information, i.e. some restrict on the companies name and address, some give a sketch on the product portfolio and others present in details all their products including parameters, technical specifications, etc. All Web sites are structured in a different way and are often not connected. As a result, the engineer as the user of the information is confronted with a quite time-consuming search process. Searching for a window with given dimensions and performances can in principle be done in one of two alternative ways, both having significant deficiencies :

- Visit all web-sites of potential suppliers – consequently knowing all relevant suppliers and their URLs in beforehand. Therefore, the end-user must guide himself through the web-pages of each supplier (which are in generally differently structured) to figure out whether they provide a product with that characteristic.
- Start global searches by Internet search engines – often returning hundreds of non-relevant web-pages where for accident also the search-keyword was mentioned (e.g. searching by EXCITE for an "axle" results in 23 229 hits with – amongst others – web-pages publishing reports on some person's last accidents).

Hence, the Internet in the area of engineering is being threatened by "digital anarchy": closed markets that cannot utilise each other's services, incompatible applications and platforms that cannot inter-operate or build upon each other. In particular this results in inefficient and non-precise access to information such as product/component specifications, data sheets, CAD mode, company profiles, or services such as simulation or calculation programs.

2. THE GENIAL PROJECT

2.1 The GEN vision – The GENIAL mission

The GENTM Global Engineering Networking (GEN) Initiative works toward these challenges [Ret97]. The GEN Initiative is an open co-operation of industry and university partners and has started in 1994. The mission of the GEN Initiative is to foster the development of a global electronic marketplace for engineers – opening up world-wide markets for European users and suppliers of engineering products and services [Rad98]. The mission of the GENIAL project is to realise and exploit an IT infrastructure for those global electronic marketplaces for engineers. Thereby the engineer can precisely search for the information by engineering classifications, parameters and keywords[Rad97, Sei98].

This GEN infrastructure allows :

- (1) suppliers of products, services, documents, etc. to upgrade their Web sites with capabilities to precisely search for the information – a supplier-specific GEN marketplace,
- (2) to build up a marketplace of products, services of multiple suppliers – a supplier-crossing GEN marketplace (e.g. of an association), or
- (3) to connect GEN marketplaces along a supplier chain or even toward a domain-specific global engineering network.

The most important aspect of GENIAL, the interoperation of GEN marketplaces (3), is supported both at a supplier or between the suppliers. Thereby even bigger companies can maintain the huge amount of engineering information at different sites, e.g. in different autonomous country departments. Please note that of course suppliers can first build up their supplier-specific GEN marketplace and decide at a later point of time to connect to other supplier/department GEN marketplaces. Even a connection step-by-step to further GEN marketplaces is possible.

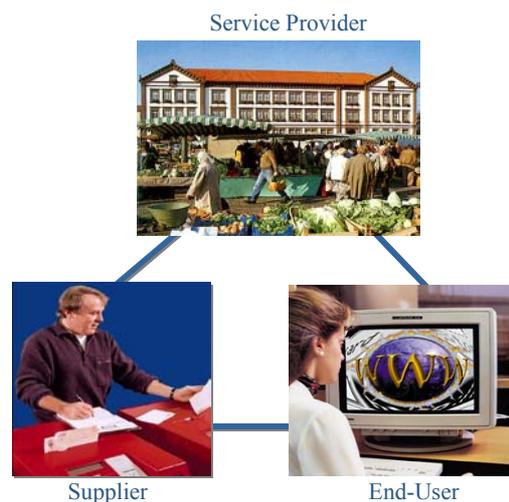


Figure 1: User Groups supported by GEN

As shown in Figure 1, Global Engineering Networks support three groups of users :

- End-user: The users of Global Engineering Networks are provided with an easy and precise way to search for different kind of engineering information and services from different suppliers and countries.
- Supplier: The owner of content can easily bring in their products, documents, services, etc. into a GEN marketplace and establish relationships across the information that can be used by the engineers to navigate, e.g. from a standard to all products which are compliant to that standard.
- Service Provider: A GEN Service Provider offers a marketplace of engineering information such as products, documents, services, persons and companies. A supplier can also represent a service provider, i.e. build a GEN marketplace for his own information (upgrading the company Web site to a GEN site), or send it to a Service Provider of his choice.

2.2 The GENIAL consortium

The consortium of the GENIAL project reflected the demands of a complex project that involved partners from various engineering sectors as well as IT technology providers. The project is performed by leading members of the GEN Initiative and reflects a representative cross-section of the participants in GEN: users and suppliers of engineering knowledge, technology providers and value added service providers. Customers have driven the project by specifying the requirements and testing the methods and tools in real end-user scenarios of three pilot areas: construction, machinery and microelectronics.

The following industrial and academia organisations are project partners of GENIAL :

Construction Engineering (specifying requirements and realising pilot marketplaces)

- BBRI - Belgian Building Research Institute (B)
- BIC - Building Information Centre (IRL)
- CSTB - Centre Scientifique et Technique du Batiment (F)
- Taylor Woodrow (UK)
- BRE (UK)
- Loughbrough University (UK)

Mechanical Engineering (specifying requirements and realising pilot marketplaces)

- CADBAS (D)
- Hellenic Aerospace Industries (GR)
- WTCM – RD section of the Belgian Association of the Metalworking Industry (B)

Electronics Engineering (specifying requirements and realising pilot marketplaces)

- MET -Federation of Finnish Metal Engineering and Electrotechnical Industries (FIN)
- SGS Thomson (F)
- Siemens (D)

Information Technology (realising the IT solution for GEN marketplaces)

- Siemens / C-LAB (D)
- Paderborn University / Heinz Nixdorf Institut (D)
- FHG-IAO (D)
- TU Braunschweig / Institute for Institute for Engineering Design, IKMF (D)
- Karlsruhe University / Institute of Applied Computer Science in Mechanical Engineering, RPK (D)

- TU Darmstadt / Department of Computer Integrated Design, DiK (D)

3. SOFTWARE RESULTS

The framework presented here allows to build up individual GEN marketplaces and link them together. From a user's perspective, a global engineering network is set up. The first product realising this framework for interoperable GEN marketplaces is ANTEROS from SIEMENS.

3.1 Architecture

The main idea from a technical perspective in GENIAL has been to establish an electronic marketplace for engineering products and services. For this, an information infrastructure has been built up that is responsible for managing these kinds of information. Users would access them by means of standard interfaces (web browsers). Suppliers are provided with import- and export filters to populate the marketplaces. Service Providers finally can couple different marketplaces to make up a global engineering network in a certain domain.

The logical architecture (illustrated in figure 2) shows the scalability of GEN: from a marketplace of a single supplier, over a marketplace which is distributed over multiple departments toward a domain-specific marketplace of multiple suppliers. The GENIAL architecture is platform independent to avoid expensive investments in new hardware. One of the unique selling points is its generic nature: it can be applied for different domains: electronics, machinery, construction and also non-engineering. The underlying information model guarantees future extensions within or for further domain areas.

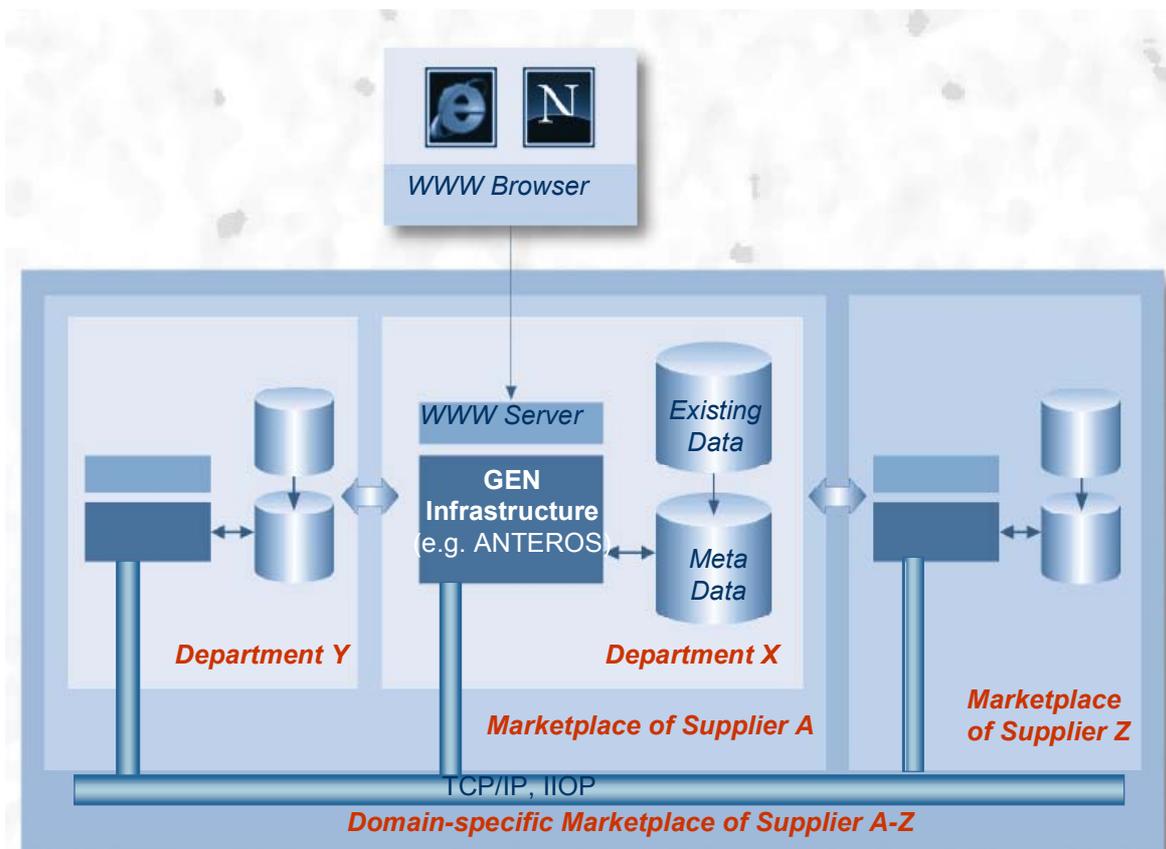


Figure 2. Figure caption

3.2 The search process

The search process starts at the portal of a GEN marketplace of any Service Provider. This portal can have a login facility where the marketplace owner can ask for a login/password (but may also offer a guest login) or where the user can start registration on a separate page. After logging into the marketplace, the user can formulate a search request. We distinguish between simple search (keyword based) and advanced search (category selection and restriction of parameters). In case there is more than one information item fitting to the search request, the user gets back a result overview which allows to make a selection for object details. If there is just a single result, the details of the resulting object will be directly passed back.

Search by Keyword

Keywords represent significant terms for an information item on a GEN marketplace (hereafter called object). Keywords can be associated to single objects or object groups (categories – see below). Objects can be associated with one or multiple keywords (synonyms), which are mainly language-specific. For example, a window "Velux 12H34" can be associated to the English keywords "window" and "roof window" and the German keywords "Fenster" and "Dachluke". An end-user just has to type in a keyword or a substring of it (e.g. "win") and will get back all objects which are associated to this keyword. Internet Search engines usually extract keywords from static HTML documents. In GEN, this extraction can be done from various data sources. Also, in the GEN domain, bigger GEN customers such as associations also want to announce keyword-sets agreed among their customers and place it on the marketplace.

Search by Classification

Objects can be grouped in categories that build up classification hierarchies with one category representing a specialisation of another. There are already standardised classification systems in engineering sectors such as IEC 61360 for electrical and electronic components (see Figure 3).

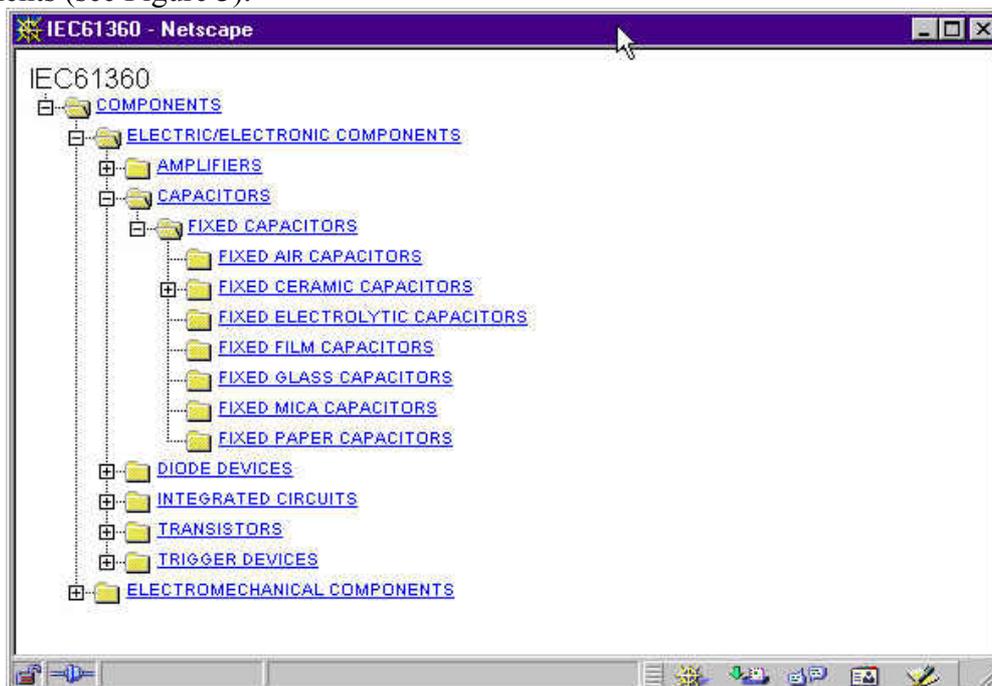


Figure 3: Classifications in GEN

This classification tree starts with the name of the classification “IEC61360” followed by global categories such as "Electric/Electronic Components” and "Electromechanical Parts". "Electrical Electric/Electronic Component" is specialised to the category "Amplifier", "Capacitor", etc. Users can browse through a classification similar to a "Windows Explorer" and select a category or search by keyword for it. As many GEN Marketplaces offer information from multiple suppliers, they will mainly use standard or supplier-independent classifications. However, if a supplier adds further specialisation (e.g. film capacitors as a specialisation for capacitors) he can define so-called object collections. Object collections are a good choice, if a supplier has many products for a single category. The benefit for the user is the reduction of overhead – only a list of object collections and their characteristics is passed back as search result. Detailed object information can be requested in a second step. ANTEROS supports multiple sets of classification systems that can be customised by the Service Provider. That means multiple classifications can be presented to the user, e.g. different views like a "material” view and a "functional view". Therefore, also an object can be associated to one or multiple categories from different classifications. The user will find the product in both views – the material and the functional one.

Search by Parameters

The Service Provider can associate parameters to the categories. Some standard classifications consider this aspect already. For example, the IEC 61360 standard defines "Capacity", "Di-electrical Element", etc. as parameters for the category “Capacitor”. Furthermore, the GENIAL configuration also associates parameters to some object classes, e.g. the parameters "name" "ZIP", "City", "Country" etc. “or a "Company" object.



Figure 4: Parametric Search in a GEN Marketplace

If the user has selected an object class or category with some parameters attached, he can restrict the values of those parameters. As an example, when searching for a "Company" object, he could restrict the Country to "Germany" and the ZIP code to begin with "33". For such restrictions, the user interface offers operators such as "begins with", "ends with", "equals" and "contains" for string values and "<", "=", ">" for integer values.

3.3 User Authentication and Profiles

A Service Provider may provide a login and register facility for the end-user engineers. The registration allows the user to specify detailed information about his person, such as his name, the company's name and address. Having received an acknowledged login and password from the Service Provider, the end-user can login into the portal of that GEN Marketplace and search for any (if accessible) information in his -- and all connected -- marketplace in a uniform and transparent way. Moreover, the user can define preferences such as a preferred language of the user interface and received data. Also, the user may indicate whether he prefers data in other languages in case the data is not available in his favourite language. A favourite classification can be chosen which is set as default entry point in a search, etc.

3.4 Integration of End-User Applications with the Search

In order to further ease the work of engineers and to smoothly integrate the capabilities of the GEN marketplaces into his existing environment, the engineer's applications can be coupled with the GEN search. In GENIAL, we performed this task already for the two CAD systems: the 2D system AutoCAD and the 3D system CATIA. By that integration, the user can directly call the GEN Marketplace search from his application, and search for a specific product on the marketplace. If the chosen product is also offered on the GEN marketplace with a CAD model, he can directly load this CAD model into his running CAD system and continue his design with that chosen part.

3.5 Filling GEN Marketplaces with engineering information

The interchange format for the extraction process is the eXtensible Markup Language (XML) [W3C98]. XML is considered to complement HTML as lingua franca in the business-to-business domain. XML allows to define individual structures and serves best to exchange structured bits of information in a platform independent way. GENIAL has defined a specific "Document Type Definition"(DTD)". This DTD holds tags and rules how a valid document should be built up. The first phase of the extraction process generates valid XML files using the GENIAL tags and their semantics. The second phase checks the validity (this phase is implemented in the import component).

3.6 Customisation of the User-Interface

The GEN infrastructure product ANTEROS comes with a ready-to-use search interface – it allows users to login, to specify a search and to retrieve search results right from the beginning. User interfaces are predefined in different languages like German, English, French, Dutch, Finish. However, the Service Provider can customise it in a similar way to defining HTML pages. For this purpose so called HTML templates are used in the GENIAL system. The Service Provider can either modify the existing HTML templates of his installation (which is recommended for first tests to better understand the technology) or

define completely new ones. By using Style Sheets he can ease his work in the customisation and a customisation wizard allows customisation by a graphical tool.

3.7 Implications on Standards

Within the GEN community, it became evident that a European or even international standardisation is the corner stone for Global Engineering Networking. Standards are essential if suppliers and users of information want to agree on a nomenclature for open information exchange within application domains. Standards are substantially needed if applications are to work together in different system environments and achieve global engineering networking through interoperability. To support the transfer of GENIAL-technology towards standardisation and the take-up by third parties, a number of partners have initiated the GENIS, Standardisation Support for Global Engineering Networking, project. GENIS should help to guide companies and standardisation organisations through the standardisation maze and contribute to the standards in three levels (see Figure 5): domain specific nomenclatures, a semantic model to describe the nomenclature as meta data and the operational level to access the engineering information using the meta data. Therefore, GENIS brings the results from the current GEN research projects towards standardisation organisations (CEN). It aims to increase awareness both at producers and end-users of standards and contributes by technical submissions and test-beds to the realisation and validation of the foundation of a future GEN.

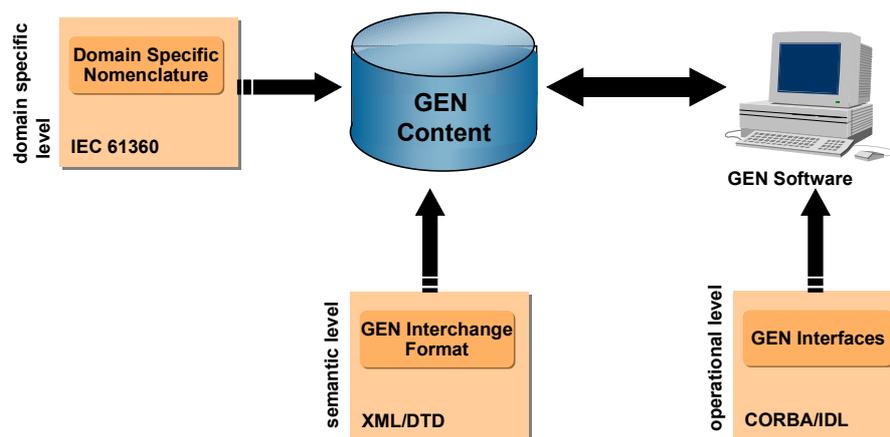


Figure 5 : Standardisation Aspects for GEN

4. APPLICATION TO THE CONSTRUCTION SECTOR

4.1 Architecture, Engineering and Construction Context

In the Architecture, Engineering and Construction (AEC) domain, the wide diversity in terms of the object built, but also associated to the geographical dispersion of actors and building sites is crucial. Considering the design and tendering phase of a construction operation, the architects and construction engineers have to efficiently select the manufactured products that will best suit the project while complying to its numerous constraints. Beyond the functionality, performance and cost characteristics, a suitable product has also to conform to the applying regulations and standards, to be possibly certified by a technical agreement, to offer acceptable delivery solutions on the building site. Moreover, once identified within a manufacturer catalogue, the product has to be integrated into the architect or engineer application desktop, whether it is a CAD, specification writer or quantity take-off application.

However, although a multiplication of information sources that possibly contribute to the product selection are emerging, the identification of satisfying products remains for various reasons a critical task in the design process. The medium conveying the information is certainly the first problem. Many manufacturers still rely on paper catalogues published annually and widely delivered to their customers. Beyond the inherent edition cost, paper catalogues suffer from their low frequency updating rate, their weak search capabilities, the absence of digital representation to directly capture the product view in a CAD desktop, the limitations in terms of distributing a physical book. CD-ROM or even WEB sites are appearing nowadays that tend to overcome these drawbacks. On the manufacturer side, such light-weight digital media widens the customer audience. On the user side, search engines and reusable digital formats are appearing. However, major limitations still remain associated with the heterogeneity of these information sources in terms of search front-end and result presentation, their non-integration of the various information types (companies, products, documents, services), the non-adoption of common domain specific classification systems and taxonomies, the lack of complementary services as Electronic Commerce or on-line marketing that will enable their wider acceptance.

4.2 Putting GEN in practice within AEC

New Information and Communication Technologies (NICT) are more and more recognised as a very promising way to meet today challenges. Building upon such technologies, the Global Engineering Networking (GEN) initiative is promoting the reuse of company internal and external engineering knowledge through the emergence of new kind of global market places where actors publish and retrieve on-line a wide range of engineering information and services.

In practice, as a very tangible result of the GENIAL project, the erection of Value-Added Service Provider (VASP) sites already materialise the GEN vision, i.e. allowing information and services to smoothly be retrieved where required whilst the succeeding company is concentrating on its core competencies. Moreover, suppliers gain the opportunity of reaching an enlarged audience as IT now commonly break any geographical distance. The overall picture that illustrates the Construction Pilot at play is depicted here under.

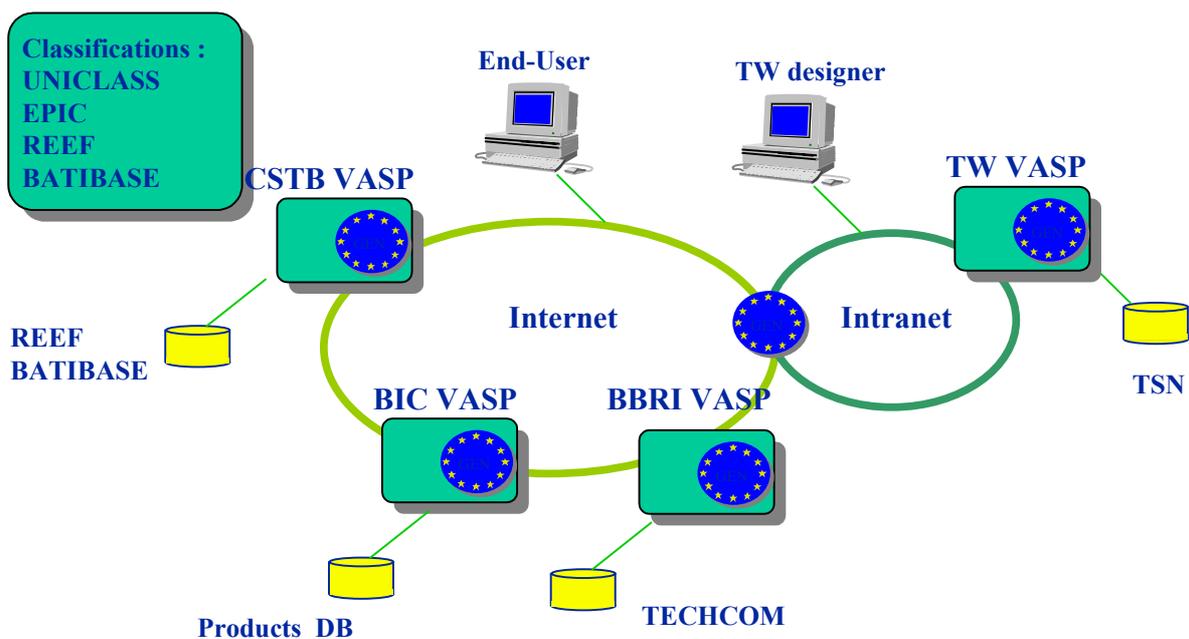


Figure 6 : Construction Pilot: overall view

As evidenced throughout the picture, note the difference between Taylor Woodrow (TW) VASP (Value Added Service Provider) only accessible from TW users on TW Intranet network and other GEN VASP (BIC, BBRI, CSTB) accessible by any GEN user.

4.3 Content Preparation and Indexing

A crucial step towards the erection of such VASP is the preparation and indexing of content. In the AEC domain, information providers currently use diverse classification systems (UNICLASS, EPIC, EDIBATEC, REEF, etc) that govern efficient retrieval of information in this specific domain. These classification systems and associated keyword sets have been experimented in GENIAL. The list is not limited and can be extended to other systems if necessary as the generic approach towards ontology representation will allow it. Next step toward a better integration of the information sources is associated with a federated approach to these various classification systems. This is today performed by mapping these systems one another. Multi-language aspects regarding the classifications themselves or the associated keywords and synonyms have also been considered to allow a uniform way of querying any VASP sites through out the construction pilot in GENIAL. Such a mapping approach will allow a English user to query a French VASP using his favourite classification for instance, instead of being constrained to use another classification.

4.4 The Construction Pilot at play

As already mentioned, typical current business practices are hampered by limited access to heterogeneous and disjointed types of information. Whether it be through paper catalogues, CD-ROM, web sites, necessary and up-to-date information is currently not easy to find, if not impossible. GENIAL overcomes the problem by offering an homogeneous access to complementary types of information related to reach other : documents, products, companies or services. More precisely, let's see which type of questions GENIAL is able to answer in the practical case of an architect identifying suitable windows for the facade of the building whether the project is taking place in London, Brussels, Dublin or Paris:

- Which building regulations and standards apply to windows in France ?
- Beyond regulations and standards, are there best practise documents dealing with windows in France ?
- PVC windows seem a possible solution for the architect. Which companies manufacture such windows in Ireland ?
- Moreover, are there technical agreement associated with these windows ? If not, are there windows complying with a technical agreement ?
- Moving to Brussels, the level of in terms of product information gets higher. The architect knows about a company named like komm and guess this company could provide suitable products. Let's find back the company details and see which products this company distributes ? are there other distributors, ie competitors, for these products ?
- Staying in Brussels, the architect wonders whether luxaflex windows could suit its needs.
- Coming back in France, question now is to find a suitable air extractor for our offices. Of course, manufacturing company details would be mostly welcome.

4.5 The Business perspective

Beyond technical outcomes, the business perspective has to be carefully evaluated to assess the success of GEN in the AEC sector. Various business roles have already been evidenced at a generic level throughout GENIAL : VASP, Supplier (Manufacturer, Publisher, Consultant, etc.), End-User, Technology Provider.

Requirements and obligations but also potential financial flows among these partners need now to be carefully described. Such a business model will then be completed with detailed quantitative description. Beyond revenue streams expected from manufacturers (e.g. for assistance in preparing and publishing information), a special attention shall be paid to complementary revenue sources such as online advertising and marketing. More precisely, a large scale deployment of the GEN market place requires sufficient business potential for new VASP to step in. Advanced IT offer new supports to vehicle the information. They also provide new means to analyse on-line the market through automated user profiling by marketing agents. Adding upon their information provider role, VASP will then also be capable of transferring promotional messages from the suppliers to their user, or to convey market analysis results to the suppliers. Electronic Commerce shall also be considered, as the ultimate step of the selection of construction products and procurement process. Indeed, supplier products and related information, services or documents appear as natural candidates for electronic trading on the Internet. Such an extended business model and their related technological support will ensure the viability of the GEN market place.

5. CONCLUSION

The market of global engineering has been substantially growing over the past several years. The Internet is evolving from a passive publishing medium to an environment hosting a set of platforms for applications. Although the Internet has provided least-common-denominator standards, enterprises trying to use the technologies for more demanding applications must cope with extensions and proprietary implementations that deliver real value but at the cost of portability with some interoperability trade-offs. GENIAL provides a substantial solution to this problem. The paper demonstrates the significant advantages of GENIAL based solutions and their applications in the construction :

Time Benefit

- Precise and efficient searches according to engineering classifications, keywords, and parameters.
- Combined access to information and services from different sectors and countries.

Quality Benefit

- Up-to-date information as data can remain in legacy data sources.
- Structured engineering information, re-usable in applications, e.g. CAD systems.
- Scalable from Intranet solution with internal information to Extranet and Internet solutions.
- 24 hours service to customers.

Cost Benefit

- Low costs for suppliers to distribute their information and services toward many (potential) customers. The systems can easily capture any taxonomy within arbitrary engineering domains. Also, the underlying information model guarantees future extensions within or for further domain areas.
- Fast decision flows by global access to engineering information as well support for multi-linguality.

Successor projects on national, European and international level are and will be launched to solve open issues, to complement the environment and to establish further marketplaces.

REFERENCES

- [And97] Andersson K.E.: "Electronic Procurement and Commerce", Proc. Of the G7 Conference on Global Marketplaces for SMEs", Bonn, March 1997
- [Ban94] Bangemann, M. et al.: "Europe and the Global Information Society - Recommendations to the European Council". Brussels, 26 May 1994
- [EC94] Commission of the European Communities: Europe`s way to the Information Society: an Action Plan. COM(94) 347 final, Brussels, 19 July 1994
- [Gar99] Gartner Group: "Portals 2003: The Proof is in the Context", Strategic Planning, SPA-08-6292, August 2nd, 1999
- [Meta99a] META Group: "Workgoup Computing Strategies, Internet Portals, Part2", April 2nd, 1999
- [Meta99b] META Group: "Electronic Business Strategies", SPA-06-821, June 17th, 1999
- [OMG99] Object Management Group: "CORBA 2.3 / IIOP Specification", <http://www.omg.org/library/c2indx.html>
- [Poc98] Pocsai, Debras, Gui, Hagemann, Seifert, Stumpf: "The Common Semantic Model in GENIAL: A Critical Gateway towards an Intelligent Access to Component Libraries and Engineering Knowledge"; Proceedings "Product Data Technology Days 1998", 24th-26th March 1998, London/U.K.
- [Rad97] Radeke, E.: "GENIAL – Turning Engineering Knowledge Into an Accessible Corporate Asset", Proc. Of the 2nd Symposium on Global Engineering Networking (GEN'97), Antwerp, Apr. 1997
- [Rad98] Radeke, Carpentier, Buckley, Debras, Leonard, Salminen, Schürmann, Seifert, Kesteloot : "GEN – Global Engineering Networking ", Proc. Conf. Integration in Manufacturing (IiM'98), Göteborg, 1998
- [Ret94] Rethfeld U.: "Manufacturing and the Information Highway", 10th Annual ESPRIT-CIME Conference, 5-7th October 1994, Copenhagen.
- [Ret97] Rethfeld, U: "Gobal Engineering Network: Vision, Status and Demo", Proc. Of the 2nd Symposium on Global Engineering Networking (GEN'97), Antwerp, Apr. 1997
- [Sei98] Seifert, L. et al.: "Common Semantic Model in GENIAL: from conceptualisation towards engineering networks", Proc. Of the Conf. On Integration in Manufacturing (IiM'98), Göteborg, Oct. 1998
- [Vis97] Visuri P.: "Building an Electronic Marketplace for Industrial Commerce", Proc. Of the 2nd Symposium on Global Engineering Networking (GEN'97), Antwerp, Apr. 1997
- [W3C98] Extensible Markup Language (XML); W3C Recommendation 10-February-1998; Doc. No.: REC-xml-19980210.
- [Yoc98] Yockelson, Lehmann, Kopriwa, dePlanque, Martin: "Portalmomics: The New Business of Web Interaction", 7th Trend Teleconference, 1998