

# MULTI-TIER BASED VISUAL COLLABORATION

## *A Model using Semantic Networks and Web3D*

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**Abstract:** Geographically distributed development has consistently had to deal with the challenge of intense awareness extensively more than locally concentrated development. Awareness marks the state of being informed incorporated with an understanding of project-related activities, states or relationships of each individual employee within a given group or as a whole. In multifarious offices, where social interaction is necessary in order to distribute and locate information together with experts (as well as their availability etc.), awareness becomes a concurrent process which amplifies the exigency of easy routes for staff to be able to access this information, deferred or decentralized, in a formalized and problem-oriented way. The appropriate visualization and navigation of this information is a requirement for ensuring that staff and project managers can orientate themselves most efficiently. This paper develops a model for visualizing the collaboration in development projects using semantic networks and Web3D.

## 1 INTRODUCTION

In accordance with the description of collaboration, metadata systems are suited for application to virtually any contingent object (Schmaltz, 2005). A metadata system uses, stores and generates data on arbitrary objects. The importance of these objects should be automatically recorded, thus making particular linguistic differences such as ambiguities easy to overcome in the future. The objects are based on a formalization concept, such as those used for taxonomies and thesauri, which provide the foundation for semantic networks. A semantic network is a representational form of knowledge which illustrates excerpts of reality as a graph containing a node-set and a set of edges. The first set describes the objects from reality while the latter describes the relations of these objects to each other.

There is a majority consensus on the use of semantic networks in order to portray collaborative objects as well as their relations to each other. See the Aether model (Sandor et al., 1997), the event oriented model (Fuchs et al., 1995) and the Model of Modulated Awareness, shortly termed as MoMA (Simone and Bandini, 2002). Semantic networks are well-structured, flexible and intuitive. They allow transparency in important relationships and allow for a context-menu of concept chains. In the search for

objects, access paths are predefined through the specified set of edges.

A concrete implementation of semantic networks is Topic Maps (TM), its conceptual and technical aspects are held by the Topic Maps standard family (for an overview see Maicher, 2007).

A Topic Map consists of *Topics*, *Associations* and *Occurrences* (the so-called TAO principle). *Topics* are formed from things in reality that transcend the *Associations*. *Occurrences* are references to further information on *Topics* in external documents. The informational content is not included in the Topic Map itself.

The definition for Web3D is extensive. In a wider sense, Web3D is a generic term for all techniques identifying the three-dimensional visualization of the content on the Internet. It involves the use of three-dimensional computer graphics in web applications, usually through a browser plug-in for the use of 3D models. In the strictest sense, this means the standard *X3D (Extensible 3D)* that is developed and maintained by the Web3D Consortium. This standard can be used for the web-based depiction of three-dimensional objects and scenes described in XML and because of its backward compatibility, importing existing VRML models.

Two aspects of this technique, with consideration to their integration using the model that has been introduced in this paper, are:

- The intuitive navigation and visualization of large quantities of information with the help of semantic networks, and
- The interaction of project members in different location or times in the four-dimensional time-space-system as world metaphors, close to reality based on cartographic geo-visualization.

## 2 MULTI-TIER ARCHITECTURE

The core requirement of a model for the visualization of collaboration lies in its illustrative aptitude for depicting the essential characteristics of a coalition, including the amount of people involved, the activities they do and the objects they use, as well as their relations to each other.

The model presented here distinguishes between three levels of representation, which all serve as a kind of detail:

- World view (macro view): Core members of the global development network and channels between them;
- Location view (meso view): Local offices/business units, located partners and relevant site-related infrastructure
- View of the business unit (micro view): workplace, roles, responsibilities and artifacts

Staff and project activities are specifically presented to each case at each corresponding level. The threefold division presented above is pragmatic – in very large organizations even intermediate stages could be conceived. Entities in the micro view (roles) are atomic. The elements of each level are displayed using a semantic network. This may, in turn, be described by some element of a semantic network in a subordinate detail. Their technical implementation may, for example, be described in the ways mentioned above (Sultanow, 2005, 2006).

The user can apply the information needed to filter out criteria at each level. Relevant criteria include projects and their components, enterprise, skills, industries and artifacts. The filtration itself is based on a search using semantic query languages for Topic Maps like Tolog or TMQL (Topic Map Query Language).

### 2.1 Macro View

The perspective from the first levels looks at the locations of the core members, including their connections, as shown in figure 1. This can be, for example, a software development office in Munich and a testing division overseas with a (possibly automated) transfer of test artifacts and result protocols. It takes into account the principle and the available channels between these locations. These connection types can vary, from lines of communication to those used for people, data or handling of materials. Each connection contains sensitive information such as formats to be used for data exchange, timetables, transportation policies, organization-specific requirements, limitations or forms.

An established connection between two entities is a channel in accordance with this model. Here, however, this can differ from the concrete form. The internal representation as well as the visualization looks at the mail server, data pathways and user devices as one entity, similar to travel routes consisting of flight connections, taxi connections and intersections (e.g. an international airport). The existence of a channel, not merely its appearance, is thus the main focus.

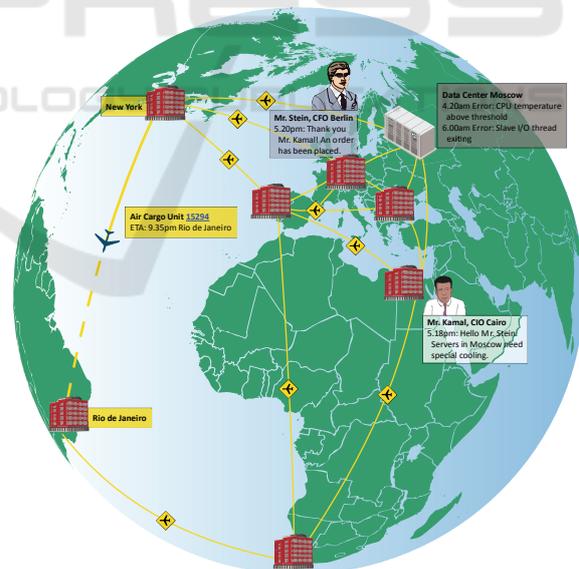


Figure 1: The world-view of global collaboration.

### 2.2 Meso View

The second presented layer provides a detailed view of individual sites. It lists those sites and channels that are only noteworthy for the establishment of network development at any one particular regional

site. These could include advertising agencies, hardware suppliers, travel agencies or office suppliers, who are only interested in this particular regional site to implement and maintain its value-added work. Their existence is not of any interest for network members in other locations as they would already have their own regional supply network at the other locations. No doubt, this also includes the most expeditive regional delivery services such as those implemented for pizza delivery – which keeps up the performance and morale of employees working extra shifts.

Analogous to the macro view, this view also shows the established link between regional locations. The focus on visualization is once more primarily on the mere existence of these connections rather than their actual design. On the other hand, there are institutions which act as an interface in order to facilitate connecting with other sites and to function as regionally significant sites. Thus, an airport is not part of a regional connection but is an end junction of a separate component of regional infrastructure. There may be a user who retains the power to cross-site links.

The example scenario displayed in figure 2 shows an urban area, in the business' warehouse, web design and marketing operation. This is displayed together with flight, bus and taxi connections. Individual documents, such as project reports, flight schedules or delivery confirmations are linked together and are formed in the Topic Map. Other visualized elements in the second representational level are links to courier services and telephone accessibility.



Figure 2: Departments and local infrastructure (rendered with LandXplorer CityGML Viewer).

### 2.3 Micro View

The third and final level is semantically linked to the places of employment, positions, roles and project artifacts. This level details the view of individual business units. It further displays the principle as well as all of the available channels. Jobs are

associated with artifacts (documents), whereby job descriptions or access rights act as additional information which can be complemented in the form of *occurrences*.

The micro view also extends to the people; but as a rule they are assigned to their according jobs, positions and roles. Links may be between jobs, positions and given roles. Such connections represent the exchange of documents which belong to their related objects. Direct links between separate actors represent the exchange of tacit knowledge. Personal knowledge may not be treated as an attachment to a job, position or role.

Actors are yet another feature by which they can exercise any detail. Human actors (artificial actors are also possible in principle) also have the ability to use the channels which are visually available in the macro, meso and micro views. When they are in the relevant period of use in any one given channel, then they will be visualized. Additional information about the current activity will be then be treated as an occurrence and displayed accordingly.

Activities are always addressed by at least one actor and are treated as Topics. The visualization not only show those as directly neighboring objects of the involved actors, but also at the depicted connection lines which offer the channel for this activity. These relationships between activities and actors as well as those with each other are displayed spatially. Topics, and in particular, activities, may vary according to their temporal occurrence and can be faded in and out. This provides an opportunity to visualize temporal relationships.

Figure 3 shows the structure of a business unit in a dynamic view. It serves to show how two actors interact with each other. This could be, for example, a phone call or a sent fax.

Various activities of actors have already been featured in figure 1. The communication aspect was related to the first level (macro view) of project members blended in at globally distributed sites to synchronously communicate with each other, such as instant messaging or VoIP (Voice over IP)-conferences.

## 3 TECHNICAL REALIZATION

The model shown here is realized as a presentable prototype (see figure 4) which introduces separate Web Services and provides specific visual information to a client including geo positions of settlements, branches, business units, conferences, alerts from IT systems and event notifications. The

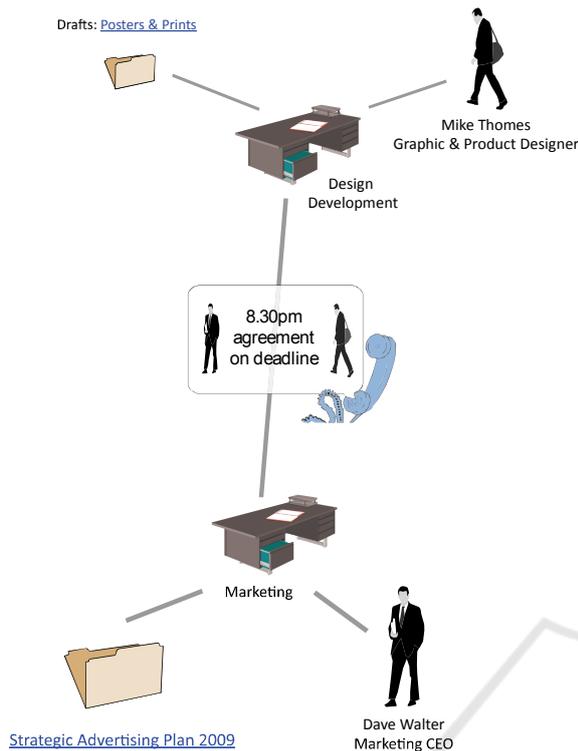


Figure 3: Employees, Artifacts and Activities.

client application displays this information appropriately in the spatial reference system.

In the macro view, the application uses API functions, which displays labeled objects at specified geo positions on a rotating earth – distinguished by a globe covered with a world map. Two organizations; namely, the OGC (*Open Geospatial Consortium*) and the ISO defined the standard GML (*Geography Markup Language*) as an interchangeable GIS (*Geographic Information System*)-format on the Internet.

In the meso view the topographical information model *CityGML* (*City Geography Markup Language*) is used. It was developed by the Special Interest Group (SIG) and has been adopted by OGC as an international standard. CityGML is a GML application schema for describing three-dimensional city and landscape models.

In the micro view, network-like graphs such as those in the “They Rule Project” (theyrule.net) which display the relations between some of the most influential economic U.S. leaders will be shown. Various network graph visualizations of complex relationships are given by a comprehensive compilation of more than 630 projects (visualcomplexity.com).

As shown in figure 5 the systems architecture is layered: External applications generate data due to business and development processes or by participation in development training (where the skills-database is ever growing). Third party services and mobile devices generate data such as the updating of vehicle/flight times and training sessions, seminars, etc. To ensure that the information is linked in a semantic network and can be visualized, they are intertwined within the topic map layer. The linking is done manually and automatically, for example, if an employee links requirement documents or test case documents through web-uploads. Finally, the graphic representation of the information or the web-based search is carried out in the client/GUI layer, filtering and accessing information and the relevant documents. The GUI client application is written in Java and uses the *NASA World Wind* API, an interface providing GIS capabilities.

The technical basis of each of the three levels of representation is built upon two frameworks. The first is a web-enabled visualization system – a Java Applet or Webstart application using *NASA World Wind* API.

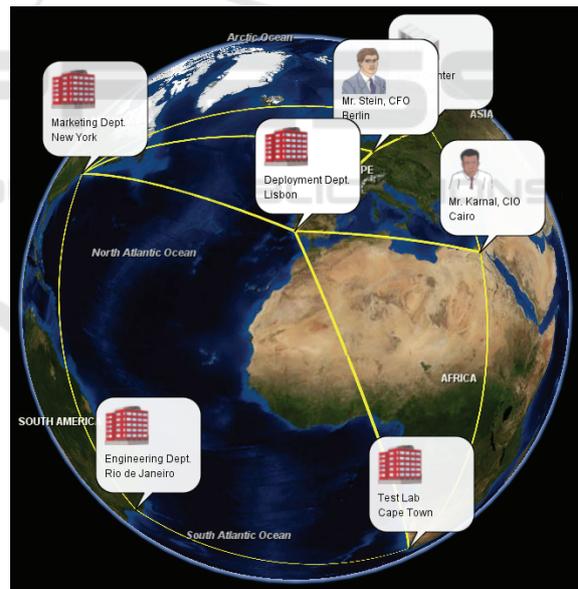


Figure 4: Screenshot of implemented Prototype.

The second is a TM-Framework – this concerns an ISO-13250 reference implementation (TM4J, Ontopia Knowledge Suite, etc.), which allows the creation, editing and processing (for the graphical representation) of Topic Maps.

All delivered content is requested and displayed over filters and is managed in different systems and formats. Geographical information is referred to in

spatial data which is stored in diverse formats such as GML and can be obtained in World Wide Web exempt from charges (Margaria and Sultanow, 2008). Timetables are retrieved in XML format. Event messages are delivered by monitoring and warning systems, such as those exposed by the Nagios software in the technical administration environment. Project management related data, which is linked in the Topic Map, contains status reports and other project documents delivered by a CMS (Content Management System) or a project management platform.

The use of project and bug tracking systems offers awareness information about developments, activities and task dependencies. The Topic Map also contains all staff contact information and data pertinent to their skills, IM profiles (Skype or ICQ usernames). All of this information ultimately serves as an integration basis for various interactive and synchronous communication applications.

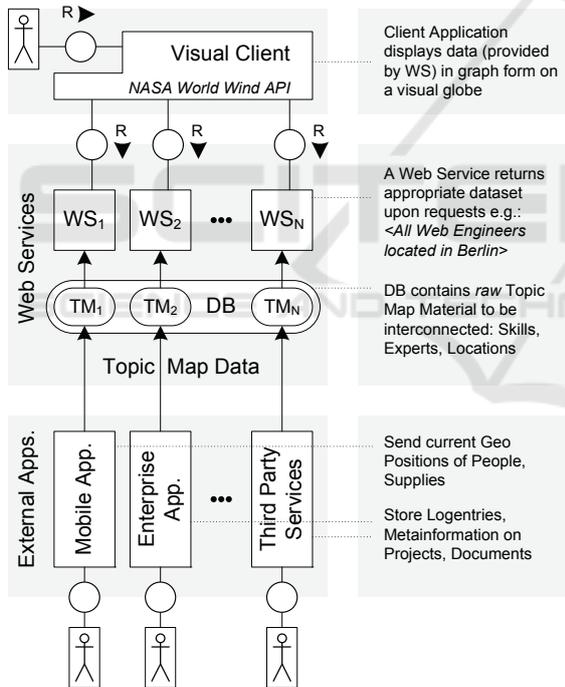


Figure 5: Mobile and Enterprise Applications produce data which will be linked into a semantic web.

#### 4 LIMITATIONS

The success of this collaborative model and the subsequent building tools produced depends not only on the quality and quantity of data, which is the basis for the visualization of the collaboration form,

but simultaneously on several other conditions. Data production can be technically complicated and can either take up copious amounts of time or virtually no time at all. Both discipline and personnel are, however, required for productivity. The key to finding the right balance between benefit and burden must be identified by each user.

One major problem is how to coordinate the paradigmatic necessity of transparency in order to support work coordination juxtaposed against the privacy rights of the workers observed (Dourish and Bellotti, 1992). When personal data is at hand, data protection rules must sufficiently be taken into account. This challenge, however, has to be made with almost all measures related to knowledge management. Nonetheless, without the consent and voluntary participation of the users such a tool cannot be fully utilized because the employees are not only users but are also participants who should ideally be voluntarily entering into the non-formal, non-automated activities. Indubitably, then, on the employee-level a stable balance is to be made between individual benefits and burdens.

#### 5 EVALUATION IN COMPANY PRACTICE

Within scientific literature, different sources are often cited regarding models with respect to the identification and classification of their benefits to business software. Some such benefit models were developed by (Shang and Seddon, 2002, Gable et al., 2003, Schubert and William, 2009). The Schubert and William model subdivides the benefit into levels similar to that of Shang and Seddon. As a result, five levels are distinguished (table 1), in which tangible benefits can be clearly obtained through the use of the business software. Measurable criteria can be determined for every beneficial element, such as the availability of information on the level of management. In this manner different benefit-describing triplets (level, element, criterion) can be formed. The specification capacity and intuitive structure of the model led to the decision to use it as a basis for the evaluation.

For the evaluation, staff in eight small to medium-sized businesses (table 2) in the areas of development, leadership and organization were introduced into a prototypical system and interviewed. Subsequently, a discussion took place regarding the benefits to the specific business needs. To this extent, the general reaction of the participants was positive in the way, that they took on the 3D-

Table 1: Levels of benefit from using business software (Schubert and William, 2009).

| Level                  | Beneficial-elements  |
|------------------------|--|
| Business Design        | Structure and Processes: Control structures, Business Processes and Workflow |
| Management             | Resources: Finance, Staff, Information, Products and Strategy                |
| Department             | Functions: PR/Marketing, procurement, Production and Sale                    |
| Supply Chain           | Participants: Suppliers, Partners and Customers                              |
| Information Technology | Technological elements: Applications, Databases and Operating Systems        |

Visualisation and GUI, acknowledging it and using it intuitively. Following the guidelines of this graphic representation and navigation, there were at least two occurrences where participants raised concerns about data protection.

Chiefly, the knowledge around the current location of persons, documents and products was perceived as useful because one could be directly lead to immediate or presumed accessibility.

On the management level of the model of Schubert and William, benefits were identified in all companies, which exist in the increase of the volume, availability and depth-of-detail depth of information, and therefore in the creation of an increased awareness for information that is likely to be sought out. In addition, three companies named a financial benefit on the same level – the cost-cutting through dissolution of media gaps.

A pharmaceutical distributor identified the quality-security and forgery-security of products, in this case: medicine, as a further benefit. By invoking the visualization of medicine flow irregularities could be detected, such as the purchase of large quantities that do not re-appear on the market. Such "black holes" within this industry can lead to illegal export, forgery and manipulation of the products. To the question with regard to the advantage of the three-dimensional real time presentation, staff stated that they could quickly grasp visual information and would prefer this to previous information representation methods on the basis of number tables, for example. Four Companies identified a benefit on level of the information technologies which exists therein, that the meaningfulness of stored data (in databases) would increase by its semantic networking as well as the usability of this more meaningful data in existing business applications. A company in the e-commerce-area named the use of the real-time delivery data for SCM and CRM applications as an example, out of which a benefit arises on the level of

the departments, because of the awareness increase for procurement and sale.

Another example presents a company operating in worldwide import/exporting construction material which not only wants to make visible storage depots and routes for supply transportation on a visual globe but also the cargo itself at its current location. This company also communicated the desire to display important routes as well as weather and traffic conditions, which can be retrieved by several external services from third party sources.

Still another example is a company in the internet business which manages and operates server farms. They expressed the aspiration to display its datacenters, which are covered all over the world, together with current power consumption and electricity rate as dependent on each location.

Table 2: Business profiles of interviewed companies.

| Area of operation                             | Activities   |
|---|--|
| E-Commerce                                    | Portal development: Provision of product, offer and consumer information   |
| Search Engine Optimization (SEO)              | Online Marketing, competition analysis, structural optimization of web pages for search engines                  |
| Pharmaceutical distribution                   | Forgery security, web-based real time QS, Track-&-Trace and condition control of medicine                        |
| Online Community                              | Portal for organizing and administrating interests-group-specific events   |
| Design Led Innovation (DLI)                   | Elevation of market and user demands, solution conception, user feedback driven software development             |
| Intercultural exchange                        | Assisting international communication, construction of culture spreading cooperations, organizing culture events |
| Global import/export of construction material | Storage, international sales, marketing and import/export of construction materials                              |
| Customer Acquisition in WWW                   | Online marketing of security technologies and systems for renewable energies                                     |

These are all examples for the preliminary requisites for evaluating the model in companies. This evaluation is currently in progress and will ultimately result in specific requirement specifications for individual business needs.

## 6 FURTHER APPLICATIONS AND OUTLOOK

It is not the primary intention of this approach to visualize process models. Nevertheless, it provides an extension to process tools. On one hand, the immediate environment in which the business processes run is shown; on the other hand, such activities which appear unsystematic or have no direct value-added character are presented and can also be taken into consideration. Information on such informal activities (i.e. conversations in the corridor, spontaneous discussions, long-term training in a subject) cannot be extracted from databases. There are modeling and survey methods such as KMDL (Knowledge Modeling and Description Language) to formally capture informal trains of thought, typical for any personal form of knowledge (Gronau et al., 2005, Fröming and Fürstenau, 2007).

A visualization of one's own collaboration is only one purpose for the presented model. It can also apply to the activities of competitors that are developing similar products, where often the same regional partners are involved. The crucial keyword here is product piracy and its defense (Bahrs and Vladova, 2009). Important decisions will provide the average amount of one's own Topic Map, and those representing the competitors. Who, from where and to which network has had contact with whom, when, how and why? This tool can be used as a monitoring device to control one's own network so that the contacts and knowledge flow to competitors and their partners can be purposely channeled out.

Search engines are used to quickly locate required objects and always exist in data from a collected part and from a query part. The introduced method for the visualization of collaborative networks as well as the navigation through the functions of these is covered by a search engine. However, it is a semantic search, which allows the user an entry point in the Topic Map, graphically processed and examined about the advisability, semantically relevant neighboring objects context-specific search. The visual background of using Web3D technologies provides an extensive GUI (Graphical User Interface) for semantic search, and additionally prepares the search results without omitting the visual context.

An implementation of the approach presented in this work is done here at the University of Potsdam. Addressed here are the various sub-disciplines of applied and practical computer sciences, such as semantic technologies, process management,

geographic information systems, experience from the software engineering, knowledge management and web technologies.

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