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DESIGN AND IMPLEMENTATION OF A RICH INTERNET APPLICATION FOR PLANNING AND VISUALIZATION OF SUPPLY-CHAIN-PROCESSES

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Abstract

The globalization of markets characterized by increasing networking of economy, result in a strong competition of worldwide producing companies. These companies face challenges evented by individual products and short production times. This requires planning fundamentally refocuses on production and logistics which are highly complex supply chain processes. To handle the amount of information, companies currently use various slides and spreadsheets and documents or personally meetings in project rooms. The distributed and heterogeneous representation of the complex interactions reduce transparency and hamper the understanding of processes. A technology which offers an interesting approach to solve these Problems is the new technology of the Rich Internet Applications (RIA). RIAs are a new kind of web-based applications, equivalent to traditional desktop programs in their performance, capabilities and display options. In this paper this technology is used to design and implement a RIA for the planning and visualization of modern supply chain processes.

Keywords: Logistics, Supply Chain Management, Build-To-Order, Rich Internet Application

1 Introduction

With the globalization of markets, characterized by an increasing integration thanks to the rapid developments of the information and communication technologies, the competitive pressure of companies manufacturing worldwide increases steadily. Simultaneously, companies do face increased demands of the customers on individualized products, short production times and also a high product quality. For this reason, there was a change of the markets in the past few years, in which the companies were oriented towards alternative product systems. In the past it was usual to produce in stock (Build-To-Stock, BTS), but today there is a trend towards a costumer-order production (Build-To-Order, compare figure 1) observed. The first time this kind of production was given proof of, was in the computer industry by firms such as DELL. The customer designs his computer system individually according to his wishes and then it will be produced after the order confirmation. The suppliers of the individual components obtain the specific order according to the requirements when the demanded parts have to be delivered during the production process. In this way it is possible to keep inventory costs low and to be more flexible (Hebert, 2004)(Lauza and Blecker, 2005). Even other companies, as for instance those of the car industry, have recognized these advantages and pursue the goal of manufacturing vehicles best suited to market demand and individual customer requirements. In order that this should be successful and respected in particular the delivery periods, accomplishing the adherence to delivery dates and any incidental order changes can be made possible, it is required to fundamentally realign the planning, production and logistics (Hebert, 2004)(Lauza and Blecker, 2005)(Parry and Graves, 2008). The result are complex supply-chain-processes, which consists of many individual sub-processes in which much information of the globally distributed locations centrally converges. On the one hand it is about global information to distribution relationships and the production network, comprising core production and suppliers, and on the other hand it is about inside information concerning the locations it selves, such as logic of process, inventory and time scheduling.

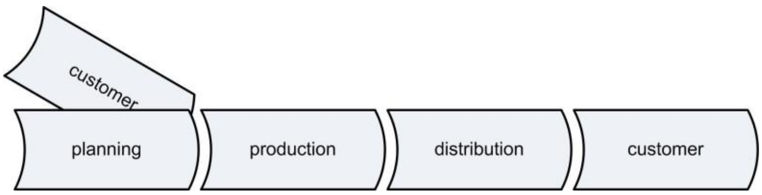

Figure 1. customer-order production

Dealing with this, takes place in companies currently by diverse slides, charts, documents or during meetings in project rooms. The procedures and the type of preparation may differ as a result of historically evolved structures of individual sites and department. The distributed and non-uniform imaging of the complex relationships reduces the transparency and also hampers the understanding of the processes. Additionally, the manual examination of multiple scenarios such as planning and target states according to changing market situations is difficult and certain flexibility is therefore not given. This problem is now counteracted with a specialized software solution for the standardised planning and visualization of supply-chain-processes. An interesting approach is given by the technology of Rich Internet Applications (RIAs). RIAs are a new kind of web-based applications, equivalent to traditional desktop programs in their performance, capabilities and display options. These can be accessed via the Internet from a web server and be run within the browser. As a result there are several advantages provided. The first is that the internet is becoming an implementation platform which can be used independent of the location by an universal access through the web browser. Apart from that the effort to install is low and the distribution of software-updates also no longer required thanks to the availability of new versions by only upgrading the web server (Allaire, 2002)(Jazayeri, 2007). In this study the above-described technology is used to design and to implement a RIA for the planning and visualization of supply-chain-processes. In order that the RIA should come up to the requirements of the firm and it should be used in this environment, there also have to be designed and built the right infrastructure, consisting of web server and database.

2 Rich Internet Applications

The term “Rich Internet Application” (RIA) was introduced in 2002 by Jeremy Allaire, an employee of Macromedia and it describes a combination of features of traditional desktop and web applications. ”*...models that combine the media-rich power of the traditional desktop with the deployment and content-rich nature of web applications”* (Allaire, 2002). In December 2005, Macromedia was acquired by Adobe Systems and was integrated as developer of the FLEX/AIR-framework for creating RIAs. Since then also other companies such as Microsoft and Sun Microsystems try to position themselves on the new created market with products named Silverlight (Anglin, 2007) and JavaFX (Weaver, 2007). RIAs are web based systems, which represent a transition between desktop and web interfaces and therefore show strengths of both areas. ”*Rich Internet Applications capitalize on the strength of both web and desktop applications*” (Noda and Helwig, 2005). As it can be seen in table 1, is this possible to achieve without taking over the disadvantages of both other areas. In particular, it is to be preferred to outsource the entire business logic to the client, in order to allocate the available resources of the client and thus to exploit the full potential of RIA. *”Client side business logic is more adequate to take full advantage of the client capabilities available when using RIA technologies, while server side business logic is typically used in traditional Web applications when client capabilities are quite limited”* (Preciado and Linaje, 2007). RIAs can be in the same sense as ordinary web applications executed in an internet browser. Consequently, the required installation is opposed to the pure desktop application easy, but equal opportunities are given to interact.

These can be ensured by methods for operating of graphical user interfaces such as drag & drop or by including controls (rich controls). A RIA is loaded by the client with a part of the data and then a communication with the server takes place only when further data is required or changed data is saved (Bozzon et al., 2006). In this manner, the periodic reloading of complete pages as for instance on conventional web applications is not given anymore and the requests to the server are minimized.

Feature	Desktop	RIA	Web
universal client (browser)	NO	YES	YES
client installation	Complex	Simple	Simple
interaction capabilities	Rich	Rich	Limited
server-side business logic	YES	YES	YES
client-side business logic	YES	YES	Limited
full page refresh required	NO	NO	YES
frequent server round-trips	NO	NO	YES
server-to-client communication	YES	YES	NO
disconnected functioning	YES	YES	NO

Table 1. Comparison of desktop, web application and RIA (Bozzon et al., 2006).

3 Problem area: Supply Chain Management

The work in this application being developed is mainly provided for the area of planning within the supply chain management (SCM). All required data must be made available at the workplace by using the application, along with calculations, visualizations and features. On this account, the current situation (see Figure 2) has to be fully described in an Information System.

3.1 Definition of the problem area

The figure 2 outlines the general situation according to the production and distribution of the SCM. This results in a global perspective on the core production, consisting of the factories, as well as the other location types, such as suppliers, ports, traders and stocks. The emphasis is put on the information about the purchasing range of factories of the Just-In-Sequence (JIS) accessed supplier parts and distribution relationships (factory-market relationship). For the latter, the centre of attention is the volume, the duration of supply contracts and the types of transports used. A considerable number of locations worldwide of various types and its interrelationships are considered. Apart from the global information are even the internal factors and parameters of the factories and suppliers of importance. In the factories are particularly the specific details concerning the dispatching of orders, time scheduling and working time models to be taken into consideration (see figure 2). The locations themselves are dependent from each other. Therefore, for example, the supplier's choice of a working time model affects the time budgets of the supplied plant. Furthermore, the factors within the distribution have to be considered, such as the timetables of the commissioned forwarders.

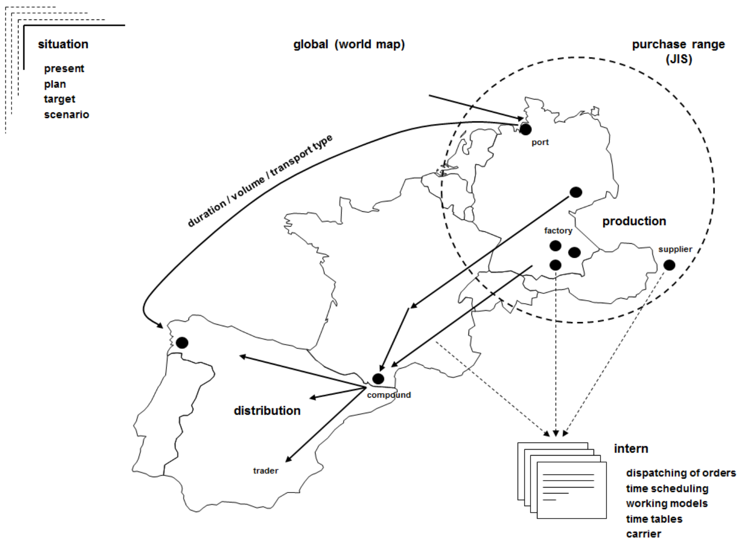

Figure 2. Draft, general facts, SCM

3.1.1 Present, plan, target and scenario

The consideration of core production and distribution relationships is taking place in dependence of the state present, plan, target and scenario. These define quantities of valid situations in time and indicate what information will be considered. The states are each limited by start date and end date. The present state is used for the evaluation of historical data and can also be used for the consideration of processing time of past productions. Perceptions resulting of this will be used in order to make adaptations in the production and to ascertain a plan state. By contrast, the state scenario describes all validity space in time, in which information are considered on test purpose. This allows to examine different scenarios and to use their results for the other states like present, plan and target. The result obtained of this approach is the outline of the core production and distribution relationships to a considerable number of various validity periods.

3.1.2 Scheduling

Figure 3 shows a concept to represent the dispatching of orders in a factory. As it can be seen in the figure, the scheduling takes place for two weeks. A dispatching of orders refers to specific scheduling days and identifies the times of several workdays of the week for the production. The day packages (see figure. 3, circles), which obtain several orders, are fixed to a special time (for example, twelve o'clock noon) on a certain day of the week. By this, they receive themselves a certain state such as all obtained orders (beginning of the production process with simultaneous retrieval of suppliers' parts). This stipulates that no changes are allowed on the individual orders any more. A day package is also the sum of all orders, which have been set to this state together, also called "order freeze".

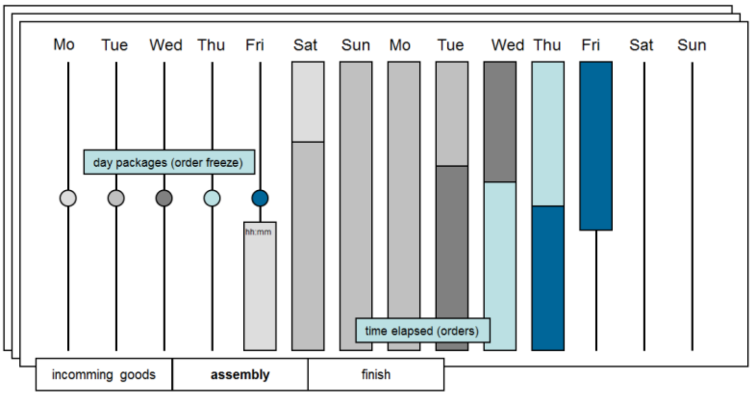

Figure 3. *Concept, dispatching of orders*

The amount of a day package's orders is limited by the achievable performance of a day of the concerned factory. By defining the point in time of the order freeze, it is possible to calculate per day package the times according to the individual orders. As these enter in sequential order in the assembly, the processing times of the first until the last order the essential elements of consideration (see figure. 4, bars). Accordingly, the point in time of the first order of a day package can never be before the one of the last order of a previous day package. The lead time per order results of the lead time of the factory's assembly. The consideration of the times within the scheduling takes place out of three perspectives: The last possible delivery date for incoming goods, assembly and finish (see figure 4). Based on a planned deadline of the car completion (target finish) on a scheduling point in time (order freeze), the entry point into the assembly and also the last possible delivery date for incoming goods, according to the several orders, can be determined by backward scheduling (see figure 4). The time periods of a scheduling consequently depend on the chosen working time model within the assembly and the time scheduling of the processes according to the present factory.

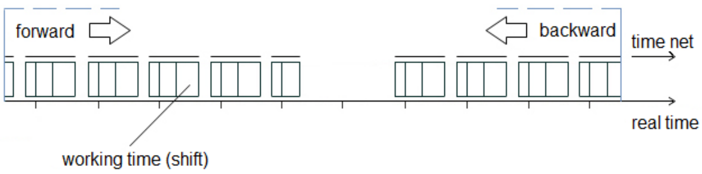

Figure 4. *forward and backward scheduling*

3.1.3 Time scheduling

The time scheduling of a factory, also taking into account the lead times of individual sub-processes during the car manufacturing, (see figure 5) determines the timing of orders based on the order freeze of a scheduling day. Here are two essential objectives: on the one hand, the minimization of the average cycle time of orders, but on the other hand, the maximization of the available lead time for purchasing. The latter has the aim of increasing the purchasing coverage of the just-in-sequence suppliers' as much as possible (see fig.2, JIS).

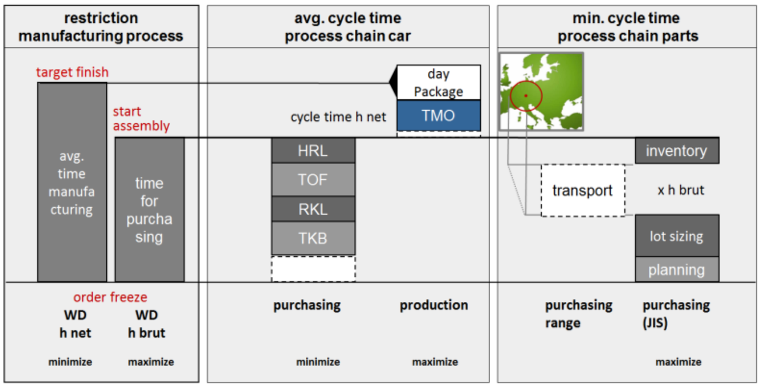

Figure 5. Concept, time scheduling

The processes' lead times have to be determined within the car manufacturing and parts of the process chain for calculating the times of the scheduling. The basis of the processes of procurement and production of car manufacturing are different parameters. With these parameters it is possible to calculate the respective cycle time as net hours in individual. The car manufacturing consists of car body manufacture (TKB), the storage of the (RKL), surface (TOF), high rack warehouse (HRL) and assembly (TMO) (see fig. 5). Notwithstanding, the lead times in net hours for the planning and production of lot size are dependent on the time budget of the relevant supplier within the process chain parts. For the stock (skeleton stock), is the lead time in net hours stated by the related plant. Using this information, the time budgets can be defined for each of the scheduling days, starting from the respective freezing date. The given objectives of the time budget influence the time progress of the first and also last orders for the last possible delivery date for incoming goods, assembly and complementation of the chosen scheduling day (see figure 5). Therefore, it influences the entire scheduling (sequential order of the orders). The arising points in time for the complementation, entrance in assembly such as beginning and end points in time of the part processes are determined by the forward and backward scheduling (see figure 4) of the net lead times. In consequence, the entire times are dependent on the elected work time model. In this case it is about a work time model of the assembly on which determinations are performed. The average lead time for the complementation of a vehicle in work days is given as objective (and therefore the flexibility of changes of orders before manufacturing end).

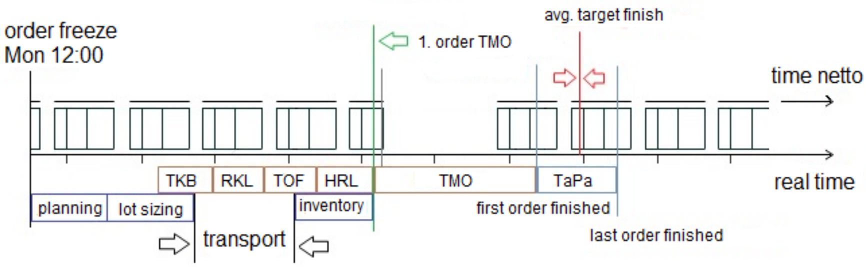

Figure 6. Time budget of a scheduling day, forward and backward termination

The average point in time of the complementation of an order (see figure 5, target finish) is determined by a forward determination based on the point in time of the order freeze. To this end, the predetermined working time along the working time model of the assembly is ran through in a sequential order of the layers and that is how the point in time of the complementation is determined (see figure 6). The lead time in net hour for complementation of the first until the last order (see figure 6 TaPa) is dependent on the amount of orders of a day package of the considered scheduling day such as the installed cycle time of assembly (the time, in which each time an order is accomplished).

Hence, determining the points in time of assembly of the first to the last order is possible by a forward and backward termination. The point in time for the finalization of the first order deducting the lead time for assembly determines the point in time, on which the first painted bodywork has to retract in order to attain the target (see figure 6, begin of assembly). Consequently, the available lead time for procurement results. The start and end points of the further processes can be determined in the same way.

3.1.4 Relations of distribution

Factory-market-relationships within a distribution are shown by relations of distribution which can as the case may be span several countries or continents (see figure 2). These range from the factory to several stages, such as stock or harbours, to even the distribution to the merchants of a respective market. Each relation is a directed connection between two sites, which indicate a transfer of finished cars from the start to the destination location. The transport of vehicles can be carried by various modes of transport such as truck, rail or ship. In this connection, the underlying tables, the responsible forwarding agency, the capacities of units, the total lead time for transport and potential waiting times (e.g. loading at a port) are of relevant importance.

3.2 Model of the problem area

In this section, the facts described above are clarified by a specific graphical model (see figure 7). In literature, there it is possible to find multitudinous procedures for showing the structural relationships of a problem area in a model. One of the best known methods is given by the Entity-Relationship-Model (ERM, Chen 1975), which has been developed further in the subsequent years by various other concepts, such as specialization and aggregation. Meanwhile, there exist different variants that differ from each other by their mightiness and illustration facilities. Since the basics of ERM in this paper are not the subject of closer examination, but exclusively used as a method, at this point it is to refer to additional literature (Kemper and Eickler, 2006)(Heuer and Saake, 2000).

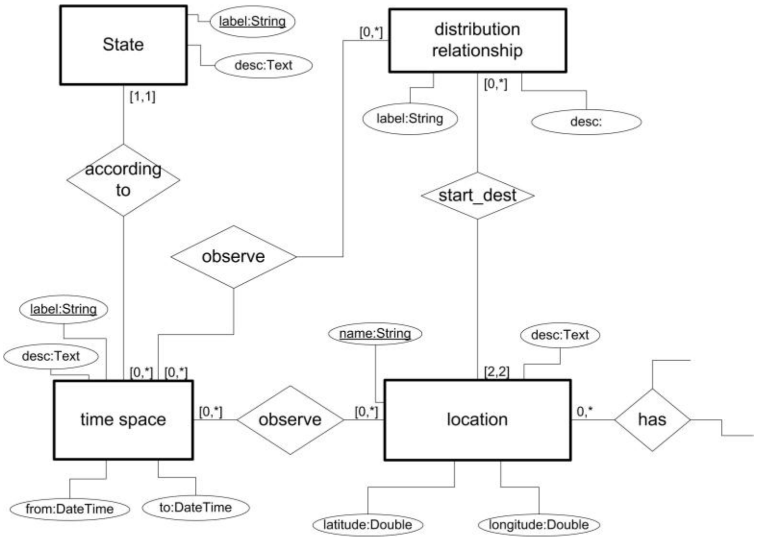

Figure 7. Part of ERM, model of problem area

The ERM created in this process, serves as bases of accommodation between software developers and operators. Moreover, the ERM forms the basis for the later derived database schema as well as for the structural design of the implemented application. The advantage in comparison other solutions is the possibility to develop a concrete model for each company.

4 System environment

The application is realized with the help of Adobe Flex 3.3 SDK. In order to implement a RIA in practice by this technology, result other sub-tasks, which have to be solved in this paper. Furthermore, an infrastructure being essential for the operation of RIA has to be planned and implemented. On this account, the system environment of the RIA is being considered in the following and a specific realization is being introduced. The system environment (see figure 9) consists of two parties, the office PCs and one server computer. The office PCs and the server computer are connected to the internet and can communicate via this or possibly exclusively via the company-internal intranet. The transfer of data is all encrypted. On each of the office PCs is a web browser with a special plug-in for implementation of RIA. Firstly, the latest Adobe Flash Player has to be installed as plug-in of the web browser, because the application is implemented with Adobe Flex. On the server computer, there is a web server installed which provides the application, being embedded in an HTML page, for transfer. In this case it is called Apache HTTP Server. Furthermore, a database management system (DBMS) for managing a database (DB) is to be set up on the server computer. This system stores all persistent data regarding the model being considered. In this regard, the MySQL server, a relational database management system, is used. Thus, the RIA being performed in the browser can communicate with the database management system at run time via internet, a middleware on the server computer is necessary. This middleware provides different functions for implementation of database requests and also serves as an interface between RIA and database. At this point the basic middleware is set up to PHP.

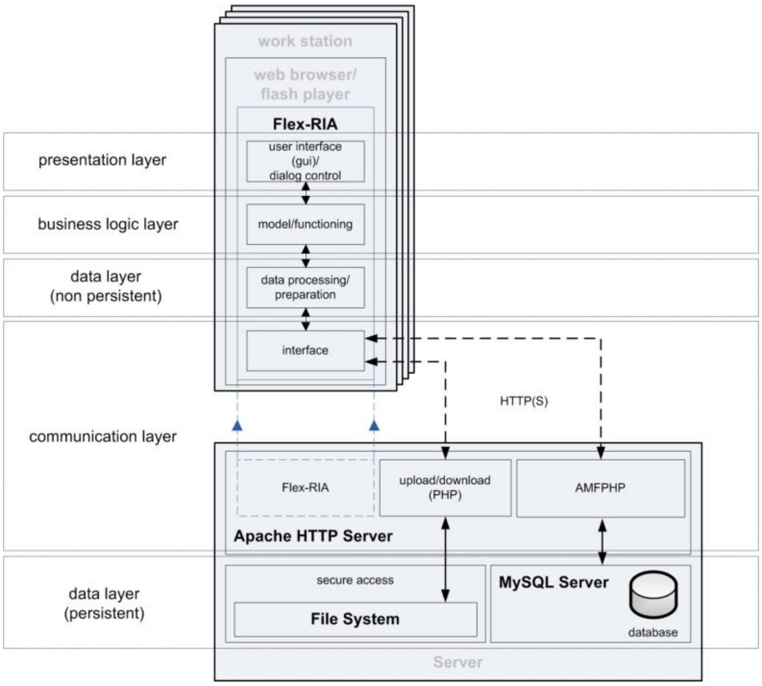

Figure 9. Architecture, Flex RIA and system environment

5 Architecture

Figure 9 shows the architecture of the information system consisting of the Flex RIA, which is executed in the web browser’s flash player on the office PC and also on the server computer running the web server and also providing RIA. The given architecture is a two-tier one with two physical units, the office PC and the server computer, on which five layers are allocated with different responsibilities. Three of the five layers are located solely on the client. There are many possibilities of designing architecture for a flex application with having if necessary more than on server participating or for example having parts of application logic also on the server. For the implementation of Flex RIA in order to visualize supply chain processes, the architecture is reduced to a minimum. It is structured generic and can be consulted for a variety of different scenarios. The necessary form is only reached by the development of flex application and the specifying of a specific model with a corresponding database scheme in the database.

5.1 Presentation, application and local data storage

The presentation layer (see figure 9) contains complete modules, which are responsible to interaction with the user and to the outline of contents. The full interfaces (GUI) of the flex application with its dialogue control such as additional specialized visualizations are found in this layer. The logic layer (see figure 9) consists firstly of a concrete implementation of the model, in which the pure structure of the facts is further enhanced by functions, and on the other of supporting modules for execution for business. With the help of the data layer to the non-persistent data storage (see figure 9), all data is managed and processed, which are used for run time of the flex application. Here, a selective loading and storage of data with the database of the MySQL server takes place. A part of the data is being loaded during the initialization of the flex application into the data layer and being held there the whole period of execution. Additional data will only be reloaded when they are needed in the application as well.

5.2 Communication and data transfer

In order to communicate between the flex application and the web server, in particular the MySQL-server, it requires special modules on the side of the flex application and the web server. These are assigned to the communication layer (see figure 9). On the Apache HTTP server are AMFPHP located, for the communication of data between the flex application and the MySQL server, and other PHP scripts for the upload and download of files. Consequently, it is also possible to procure database requests of the flex application and to conceive their results. For this purpose, an appropriate interface is to be implemented in the Flex RIA. In order to transfer complete files, a separate communication channel by upload and download PHP scripts is possible.

5.3 Persistent data storage

The last layer is the data storage for the persistent storage of data (see figure 9). In this case the MySQL server as a database management system manages a database with a specific database scheme and takes orders and also answers these. Moreover, there exists a restricted access area of the file system in this layer. This is provided solely for data storage. The exact path to each file is saved in the database as information for the flex application for parameterization of upload and download scripts.

6 Database design

In the following section the database scheme of MySQL database, which defines the implementation for persistent storage of data of the flex application, is presented and its derivation described. In this context, it is briefly explained how a concrete database scheme is deduced from the model of problem area by applying different rules. With the help of these, the database is implemented and it is possible for the flex application to save persistently and to upload if required supply chain data. In deriving the database scheme, the ERM, which describes the situation conceptually, has been transformed by applying special rules. A detailed design of the individual rules and their application is to be found in the literature (Kemper and Eickler, 2006)(Heuer and Saake, 2000). In order to be able to react to additional requirements during the whole implementation phase, if needed the ER model has been extended. Also a transformation process was carried out by manually applying of the rules for the various sections and thus the database scheme was adjusted. The rules of thumb do not exactly fix the resulting scheme, but give the developer more creative leeway (Heuer and Saake, 2000).

7 Application

In this section, the implemented Flex RIA for planning and visualization of supply-chain-processes is introduced. Just the relevant areas of RIA according to the external and internal view are being briefly described and explained. Figures 10 show the flex RIA which is performed in the web browser. The user has induced the web browser by stating the corresponding internet address to load the RIA from the web server and to execute this in the Flash player. The application itself is presented to the user in form of a login window through which a signing in into the system via username and password is possible.

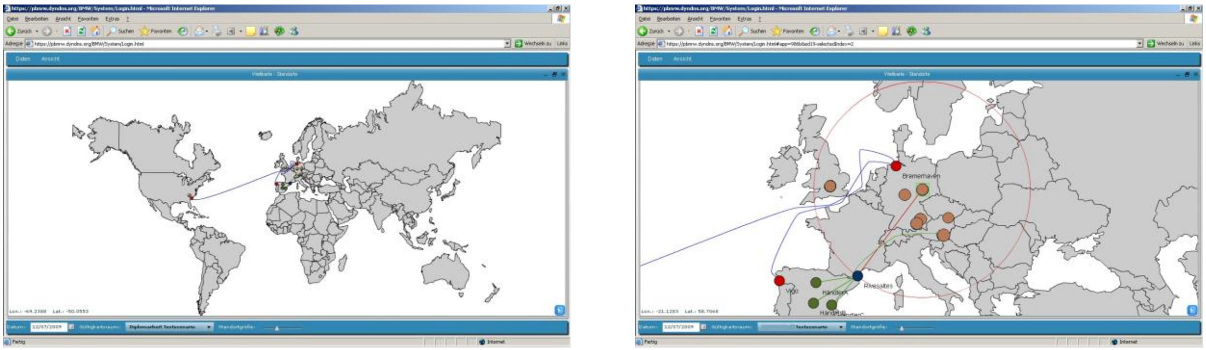

Figure10. Interactive world map and zoom-in function and JIS-radius

7.1 External view

After the user has logged in and the required data of the MySQL database has been received, the locations and the distribution relationships are displayed in the world map in global view (see figure 10). Now the user can navigate in the world map and look closely to the areas. Figure 10 (right) shows an extract with locations of different kind, the distribution relationships and the JIS-radius of a factory. Input masks have been relinquished and the entering of the required files, on layer of database, during the implementation of the Flex RIA has been translated into an appropriate window (see figure 11). Figure 11 (right) shows the opened internal view of a selected location. Since it is in this case a factory, the view of the location contains in addition to the general location information, the areas of dispatching orders and time scheduling, each of which can be selected. Moreover, it is possible to enlarge the internal view on the total window area. Figure 12 shows the area dispatching of orders within a factory.

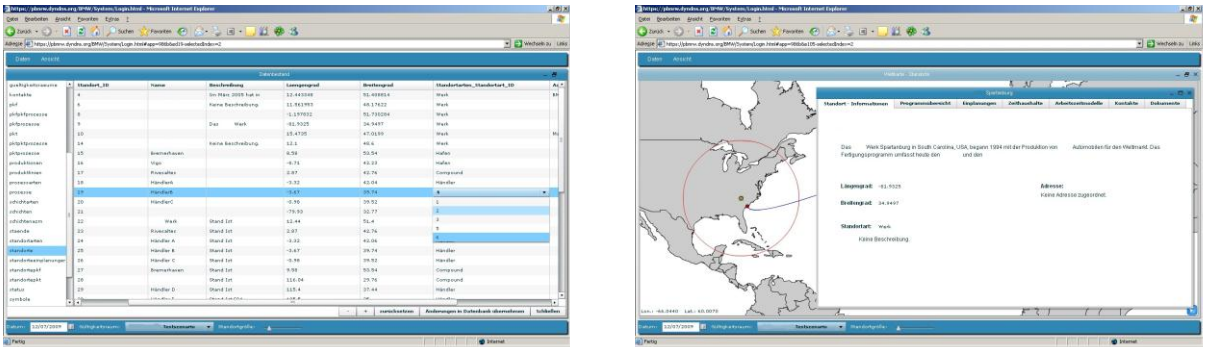

Figure11. Editing database and entering a location

You can see the marks of the scheduling days at the time of freeze orders and each corresponding time histories of the first and until the last order with the entry point into the assembly. The individual scheduling days are differenced by color and additionally the running time histories are represented dependent on the deposit working time model. The running times are interrupted by the time in which no work is done. By moving the mouse pointer over the selection of a scheduling day, detailed information will be displayed. This is on the on hand, details on the time of order freeze, entry in the assembly, complementation and the last possible delivery date for incoming goods for the first and last order and on the other hand, details on the number of orders such as the corresponding lead times (see fig. 14). Figure 14 (right) is to be taken of the area time scheduling of internal view of a factory. In this are sub-areas to restrictions, to production and to procurement with their sub-processes displayed by the special visualization. On the left side of the graphic are the days of the week and the working time model being chosen in the assembly. This model is removed as a sequence of layers over time and is implemented in the forward and backward scheduling to determine the start and end times of the processes.

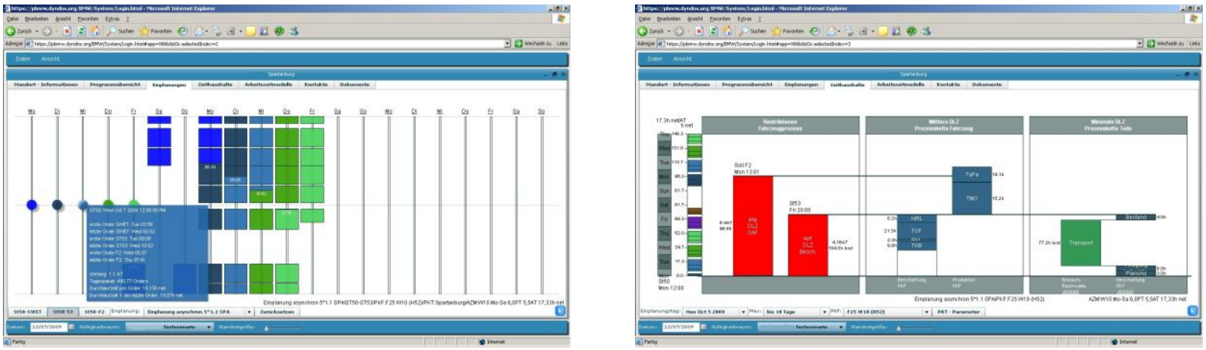

Figure14. Internal view factory, dispatching of order and time scheduling

The two horizontal lines that extend over the entire length of the sections give the details for the points in time of the entry in the assembly and of the target for finishing. The user can in an easy way parameterize the demands by simultaneous clicking and dragging of these lines. The start and end times of processes adjust thereupon immediately. This also has a direct impact on the available time for transport of the procurement and thus indirectly on the purchasing range of the factory. With a narrowed window in the internal view (see figure 11, right), it is possible to observe the expansion and contraction of the JIS-radius in the background on the world map during this interaction. Furthermore, the opening of another window with detailed information and for configuration of the given process is persuaded by clicking on a specific part of the process. Changing these parameters, especially the working time model being used in the assembly, also has a direct impact on the presented time scheduling. The start and end times of the processes automatically adapt after applying the new values. In addition to that, it is also possible in the lower part of the area to change the scheduling day and to determine for this one the time scheduling.

8 Conclusion

With the help of the flex framework and the system environment set up as a basis, a RIA could be implemented for planning and visualization of supply-chain-processes. The performed implementation has shown that the innovative and web based technology of the RIAs offers a suitable approach for the realization of an information system for the here presented scenario. The global and local information according to distribution and production network can be easily accessed pooled from any work place and also displayed consistently across sites. Besides, a simple such as targeted examination of several scenarios, present, planning and target states was made possible by the opportunity of validity rooms. By the used technology it was possible to make each current stage of development of the application during the total implementation phases and also without additional effort accessible. Therefore, first successes could be achieved. After consulting users, the RIA is a good basis for communication in which the representation contributes an increase of the understanding of process by the specialized visualizations and in particular the direct feedback of effects of the interaction. A key point is still at the elaboration and the use of roles or rights concepts with respect to the individual users of the system. Only persons who are authorized to also, it should be allowed to see, modify or even delete certain data. This can be achieved by specific reading and writing rights. Moreover, there is a future value that data and fitted parameters can be stored and accessed dependent on individuals. Consequently, there exist many individual views, which show for each user a customized information content. In conclusion, it can be said that by the procedure in the present work and the gained knowledge from the implemented application, an important basis for further developments in this area have been created. The web based technology of RIAs will gain more importance in the future and as the example of this work shows, this can also be used for the implementation of large applications without further ado. In a future realization of such a system, it is possible to establish on the outline and the knowledge of the implementation of this paper.

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