

Intelligent and Secure 3D-Configuration of Products in Electronic Shop Systems

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Abstract

During the last years, marketing of products via the Internet became increasingly important for both customers and manufacturers. Today, electronic shop systems enable people to select products from catalogues, gather further information, finally order, and pay the articles via a WWW browser. However, most products sold this way are fixed and cannot be customised to satisfy the buyer's requirements.

The objectives of the European project INTELLECT are to enable the suitable representation of such products - including all practicable variants - in electronic commerce systems to achieve the most realistic possible visualisation. New concepts of configuration using 3D user interfaces will enable potential customers to design a product customised to their individual needs and wishes.

This paper will present the first results of the project, which has started in the beginning of 2000. User requirements' analysis has already been carried out by interviewing the end-users in the consortium. Based on these results, the system concept has been also finished and here described. The paper will close with a description of the envisaged results and a description of the upcoming tasks.

1. Introduction

This paper aims to contribute to a new type of trade in the business sector of trading and shopping in Europe. Based on the research project INTELLECT it describes an electronic shop system offering an online configuration module for products which will be represented by 3D / virtual reality techniques as well as advanced user assistance and advice to improve the business opportunities for European service providers and consultants as well as for manufacturers, wholesalers, sellers, and consumers.

INTELLECT objectives are to enable the suitable representation of products including all practicable variants in electronic commerce systems to achieve the most realistic possible visualisation. Industrial target groups are bicycle and scooter manufacturers, suppliers, and wholesalers, distributors of computer equipment and networking products and in addition average customers. The conception of the system will be as generalised as possible to facilitate the transfer to other industrial sectors.

The use of the INTELLECT system will support the close co-operation of companies and customers in the European production, supply and trade chain in order to strengthen the enterprises involved in the European market against the worldwide acting competitors.

As a result of the project's activities, by the end of the project, the e-commerce system prototype developed will be ready for commercialisation and the end users involved in tests and demonstrations will be able to use the system for their core business, then extended to the Internet.

The overall INTELLECT result will be an electronic commerce system for products, which can be configured on-line in virtual reality. Company's back-offices, security and privacy demands, a configuration module including management of variant dependencies, and an interactive multimedia assistance module will be integrated. Milestones are the establishment of a user group, the specification and implementation of the system, the conclusion of the pilots, and two international workshops for dissemination.

2. State of the art regarding the modules of INTELLECT

2.1 Configuration

Configuration is the process of composing complex products out of components. A configurator is an expert system that supports this process and thereby uses predefined goals as well as expert knowledge. Design goals can be i.e. constraints, functional requirements, predetermined components or various quality criteria [1]. Such systems do not follow a single predefined method, but rather a strategy based on a series of small steps, each step representing a certain aspect or assumption leading to the configuration of the product.

Configuration is therefore considered as the solution to a single exercise and not the solution to a whole problem or problem class that has to be first methodically analysed [3].

This implies the following:

- The set of all possible solutions is finite.
- The solution sought after is not innovative, but rather a subset of the available parts.
- The configuration problem is known and well defined.

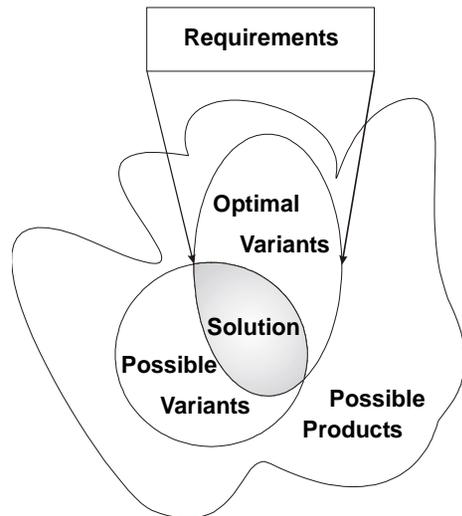


Figure 1: Variant configuration

Configuration functionality is nowadays normally a part of large software packages meant to support the production process. Such software known as ERP (Enterprise Resource Planning), PDM (Product Data Modelling) or DPM (Decentralised Production Management) normally contains extensive knowledge based configurators that are integrated in the design and production process. Popular eShops or other similar Internet or Web related technologies do not possess any comparable functionality.

2.2 Virtual Reality

Virtual Reality (VR) is rapidly leaving the realm of experimental science and is becoming an increasingly popular concept. Even though the level of resources currently needed for a sufficient immersion level is still forbidding for the average consumer, the popularity of said technology is growing. It is conceivable that, in the near future everybody will have at home a private VR system, which will allow him to completely immerse himself in a virtual universe [3].

Immersion in a custom VR universe typically involves 3D model technology created with the help of 3D modelling tools. Such tools often depend on graphical material based on an existing setting. VR is achieved using a dynamic and interactive simulation of a limited space based on 3D graphical representation. The realism of this simulation depends heavily on the quality and responsiveness of the graphical material and technology involved.

Other existing techniques like a stereoscopic vision system can increase the quality of the immersion. Even better results can be achieved using motion capture, force feedback and tactile sensation technologies.

Full sensory VR immersion based on the aforementioned techniques cannot be achieved in the scope of an eShop because it would require resources not available to the average consumer. Internet VR on the other hand is based on interactive 3D worlds that can be viewed and navigated through a normal browser. Such technology can make navigating a site more entertaining for the consumer and help showcase the products offered more attractively and ultimately more effectively.

2.3 Online User Assistance

The goal of the Online User Assistance to be offered through INTELLECT is improving the online shopping experience by emulating aspects of a real shop pertaining to situations where the customer is in need of consulting and product information in general. Community services (like conferencing systems, news systems, etc.) that help create and support the customer community by offering the functionality needed for communication on product issues also helps achieve this goal.

The second goal addressed by the Online User Assistance is after-sales support. The customer must be able to get effective and immediate help on any problems he might encounter with a product he purchased. A study by Forrester Research [4] indicates that 66% of all on-line shoppers during last year's holiday shopping season abandoned their shopping carts before checkout.

Reasons for this could be:

- Customer is not comfortable dealing with an eShop lacking human interaction.
- Customer cannot find the product he is looking for.
- Customer has problems in configuring the product.
- Product quality is not demonstrated in a plausible way.
- Customer just wanted to look at the price of the specific configuration.

These issues clearly demonstrate the need for further development in the area of pre-sales and after-sales service. Both functions belong to the area of Help Desk/CRM (Customer Relationship Management) tools, one of the fastest growing markets last year.

2.4 Electronic Shop Systems

Most of the currently available eShop solutions are only of limited flexibility and therefore of little use when facing special requirements such as variant configuration or 3D visualisation of the product at hand. The fact that such products also lack adaptability only makes the problem more acute.

The eShops evaluated [3] share a number of common properties. The aesthetics of the sites always depend on and reflects the product sold i.e. not every configurable product can profit from a 3D presentation. On the other hand, sites selling products for which 3D and VR would be helpful or attractive seldom make use of such techniques. Most of the shops also lack user-friendly helpdesk systems. Catalogues sometimes lack elementary features like search functions. Interaction with the site is very limited. Consumer profiling and community building are only rarely supported. Product information is scarce and hard to find. The use of standards is normally restricted to techniques for traditional payment and secure communication; Internet payment systems are non-existent.

To put it briefly, most eShops lack basic functions like search engines, personal favourite lists, bookmarks or different payment methods. User-friendly features like online assistance, multimedia representation and 3D configuration are rare or non-existent.

For the issue of community building a classical newsgroup solution with a web-front-end (instead of a newsreader-client) seems to provide enough functionality. This allows a hierarchical arrangement of contributions; additional search/filter functionality would ease the action to find articles on a specific issue. The market for newsgroup software is rather mature and there is not much innovation there, so we did not examine these products at this state of the project.

2.5 Security

The modern world of information and communication needs increasingly the help of information technology to manage the growing amount of electronic data. Numerous work processes, in both the public as well as the industrial sector, are electronically controlled. As a result, many organisations depend on perfectly operating IT and communication systems. Information is digitally stored, electronically processed and transferred through private and public networks, such as the Internet. The Internet is a low-price possibility to connect business partners, suppliers and customers worldwide. However, availability of the connection is not enough, the user needs the certainty that his data transmission is secure. Especially for pecuniary transactions, which will take place increasingly often via the Internet, IT security must become an integral part and develop from security systems to secure systems. Therefore, the awareness for security must grow. The following list of security aspects can help to identify the threats to messages transferred via the Internet or stored on servers connected to the Internet:

- Confidentiality
- Data Integrity
- Availability
- Authentication
- Access Control
- Non Reputation

Most common methods employed to ensure secure transactions are based on various encryption techniques. Such technology should be an integral part of any e-commerce environment.

2.6 Order Processing

The term „order processing“ is used to indicate a superset of all the processes, which take place in an eShop after the customer has expressed his decision to buy the goods he has selected until then, order processing functions in this respect as a front-end to the BackOffice system. BackOffice Information handled by the order processing can also be essential for many pre-sales services i.e. availability data. Order processing consists of the following components:

- Well defined information flow in the merchant's back office
- Communication over different media such as:
 - Different parties (consumer, merchant, business partners, suppliers, etc.)
 - Different BackOffice systems, which have to be integrated (legacy systems, accounting software, fax, mail system, etc.)

There are two approaches to eShop order processing; on the lower end, most eShop solutions already include a simple order processing, on the other end, such tools enter the area of third party workflow tools.

Workflow is the superset of all tasks, procedural steps, organisations, required input and output, and tools needed for each step in a business process. Business benefits of the INTELLECT order processing are:

- Higher reliability through automation
- Reduced personnel costs
- Quicker execution of order processing
- Automatic order state tracking for customers and merchants

There currently exist many different order-processing products based on a variety of technologies. New B2B communication and integration of BackOffice systems are heavily based on XML. The Workflow Management Coalition (WfMC) has defined standards for workflow tools to ensure interoperability between different products.

2.7 Payment

Automatic payment processing is an important step in the order processing process. By now, only two kinds of payment methods have gained a wider acceptance:

- **Credit card transactions:** the user has to type in his credit-card number into a form, which is sent to the merchant via SSL; the merchant then submits the payment to the credit card organisation.
- **Cash on delivery:** customer pays directly to the deliverer, who advances the amount to the merchant.

There are many new competing standards in payment processing, i.e. wallet based payments, eCash, SET, Mondex etc., but it is not sure, which one will be of importance in the next years. Available products include a variety of payment methods and are rather easy to integrate into an eShop.

2.8 IP-based communication

Internet Telephony software allows a multimedia PC to transmit and receive voice (audio), video and text "phone calls" over the Internet. The only costs associated with the service are the regular ISP fee. IP telephony can be employed in two modes PC to PC; and PC to Telephone.

The first method forces the users to essentially schedule calls with others, or to use directory servers listing potential partner. On the other hand, PC to Phone Voice-over-IP (VoIP) the Internet Telephony call is carried over the Internet to a gateway. At the gateway, the call is converted between the Internet and the standard PSTN network. Hardware solutions can enhance the quality of basic Internet telephony via DSP-based voice compression and echo cancellation (e.g. Quicknet Technologies' Internet PhoneJACK).

A video conferencing system consists of the following components:

- Computer
- Web cam/Full-duplex soundcard
- Headset or speakers/microphone set
- Codec for audio/video compression

The following list was extracted by examining the features of available products:

- Live-transmission of video- and audio information
- Whiteboard
- Text chat
- Voice chat
- File transfer
- Application sharing
- Internet directory used to locate individuals

Leading products are based on H.323. H.323 is an ITU standard (International Telecommunication Union) that describes how a flexible, real-time, interactive set of multimedia communications can be exchanged on packet-based networks like TCP/IP. There are standards for voice, fax and video; it is also important for multimedia streaming. H.323 is a call-control protocol. The protocol stack is running on both machines (end-entities) and it negotiates call set-up, teardown, voice codec used and the relative priorities of voice and data traffic between nodes during the conversation. H.323 also defines other entities for other communication infrastructures, but we will concentrate here on point-to-point communications. H.323 can use G.729a codec or the G.723.1 codec (voice compression algorithms).

T.120 is another standard from ITU for data collaboration over the Internet. It handles Multipoint Data Delivery, Interoperability, Reliable Data Delivery, Multicast Enabled Delivery, Network Transparency and Scalability. It can be used for working collaboratively on a document (e.g. application sharing or whiteboard).

Internet Telephony also depends on QoS (Quality of Service) of the TCP/IP connection for a minimum of latency and bandwidth between the two end-users. The IETF specification for QoS (or better Class of Service) is also known as Integrated Services (IntServ) and Differentiated Services (DiffServ). These standards aim to improve the quality of the heterogeneous networks that comprise the Internet in the near future.

3 User Requirements

3.1 B2B partnerships

SMEs targeted by INTELLECT typically rely on an extensive network of partners such as retailers or distributors in order for them to bring their product to the end-user. These partners offer a diverse amount of services to the consumer including pre- and after-sales support, warranty services, delivery, etc. Competing against such partners is clearly against the best interest of most SMEs as they are generally not in a position to offer comparable services on a broad basis, because of the considerable investments involved with the construction and maintenance of such a large-scale support infrastructure. eCommerce presents a separate sales venue aimed at consumers that are not being attended to by any local business partner. These could be customers living in regions or countries where no such stores currently exist (i.e. new markets or isolated areas) or customers in need of very specific products, configurations or services that cannot be delivered by the local dealers.

INTELLECT as a world wide accessible information centre could enable the producer and its business partners to more effectively sell the product in question by providing consumer support in the form of state of the art 3D configuration, interactive multimedia helpdesk, community building services, multimedia product information etc.

3.2 Product types

The products offered by the INTELLECT end-users have different characteristics thus requiring different sales strategies. Most of the products are highly configurable, some of them even require the consumer to possess special skills in order to integrate them in existing configurations. This characteristic has a number of consequences depending on the development cycle for new products, the nature of the components or products and the marketing strategies

of the specific firm. Nevertheless, all of the end-users could greatly profit in different ways from a configuration process simplified through intelligent software and visual representation of the data. Functionality of this nature would even enable less experienced consumers to produce their own configurations or individualised variations based on existing models.

High-end bikes are individual configurations and cost well over 4000 € This limits the customer group to very involved hobbyists or professionals. Push-type scooters on the other hand attend to no practical need, they are a highly life-style oriented product. Their configuration is simpler but the overall presentation sets rather high aesthetic standards. Personal computers as a product do not really require any visualisation even though they might profit from an attractive presentation. However, configuration as such offers the customer the possibility to create a product on his own without running into trouble because of an inconsistent specification.

3.3 Added Value

The 3D configuration support integrated in INTELLECT aims to deliver benefit through innovation. This feature is meant to both assist salespersons in a retail store in producing and ordering correct individual configurations according to the customer's wishes, but also to allow for private customers to experiment in a user friendly fashion with new variants on their own. This feature reduces the requirements on the salespeople on one hand, and at the same time involves the consumer personally giving him the feeling that he is ordering something individual and special.

Configuration should always be based on an existing model in order to make it easier for the consumer. The basis for the 3D representation should be a 3D wire frame model that represents an idealised form of the product. The software should be able to freely rotate and move this model in 3D space. The user should then have the possibility to add or change various components to this wire frame thereby "filling" it piece by piece. The categorisation of components in groups (i.e. Compulsory, Useful but optional, Luxury) according to their importance would also support less experienced buyers. Component models should be low detail 3D models of the actual components or of other components with a similar function. It is not required that every make of every component have its own detailed 3D model. This process should ultimately lead to the creation of an individual configuration.

The system should offer a great variety of configuration criteria ranging from "hard" factors like price, size, weight, performance criteria, etc. to "soft" factors like a certain image, popularity, etc. Configuration based on non-technical criteria would be a service to consumers interested in an individually

configured product, but lacking the technical knowledge to assemble the configuration on their own. The system should i.e. be capable of configuring computer systems that are explicitly using the most “trendy” components or are primarily suitable i.e. for playing games or running scientific simulations, etc. Other criteria i.e. as the system with the fastest CPU under a certain budget or the best possible system built around a specific graphics card would also be interesting.

The eShop could also offer a great deal of information as added value in order to offer better pre- and after-sales support as well as promote the image and lifestyle the company wants to associate with their product. Such information would be technical data (data sheets, case studies, reviews, etc.), usage tips and tricks (new applications, performance tuning, etc.), supporting software (drivers, demos, screensavers, etc.), multimedia features (animations, music, art, etc.) and much more depending on the actual product.

Customer loyalty and brand name recognition will also be supported by INTELLECT through the implementation of community services based on standard CSCW (Computer Supported Co-operated Work) tools. These services would aim to create and support an on-line community based on a clear preference for the company’s products that communicates through conferencing systems (video and text), voting ballots (customer surveys), on-line events (interviews with product gurus), etc. Such communities form the basis for many modern services offered by customers to other customers.

Other features the companies would like to offer through INTELLECT are a configuration Hit-List containing the most popular model variants. Statistical analysis of the orders to harvest the innovative ideas and potential coming from the customers would produce products that are more desirable and anticipate future trends. Statistics on which models (even new customer made individual configurations) sell best could be used as a basis for the development of products better suited to the customer bases thus increasing demand.

4. INTELLECT system concept

The system to be developed is composed of several modules, which are shown in the following figure. The main Intranet modules consist of the common product database for all modules, the Configurator as a front end to the database, the eShop as the main interface visible to the customer and the order-processing module as a front end to the BackOffice system. The database contains all product and order related information partitioned into separate areas one for each module. It will be populated and updated using information already available in the supplier systems. This information will be updated on-line using standards for the exchange of product data (e.g. STEP). In addition, a

second database filled with multimedia data (volumes models, sounds, videos, textures, etc.) exists and is used for product demonstrations within the product catalogue.

Further – next to the electronic shop module – the VR module is intended as the main module for interactive configuration with the customer. This module offers:

- Individual configuration of the viewed objects,
- Textual and audio visual explanations,
- Tips for the customer concerning his selections, things that fit well together in terms of technical properties, style and design,
- Strengths and weaknesses of the product

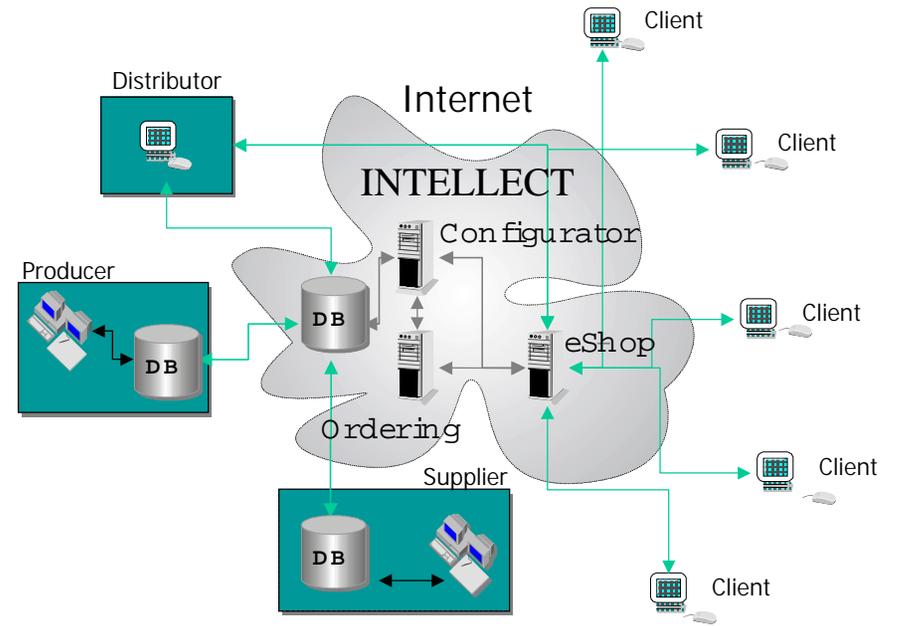


Figure 4: System architecture of INTELLECT

All presentation on the screen of the customer's computer will be realised with newest multimedia technologies. Virtual reality (VRML) will be used to demonstrate e. g. the fit of the accessories selected to the virtual image of the main product.

In case of unanswered questions, the customer has the possibility to call the company's hot line or call centre via the Help module. Technologies to be used are Internet telephony with screen sharing and / or video conferencing. The electronic shop module takes the order of the customer over a secure connection via the Internet. At this time, a human employee could carry out a spot check of the order to attest the customer the correctness of the order. An acknowledgement with complete details of the order will be returned automatically to the customer.

5. Module Specification

This chapter describes the general functionality of the INTELLECT application and all its modules. This functionality is based on the results of the user requirements from questionnaires and interviews with the end-user partners, and the end-user groups.

The functionality of each module and their interfaces is explained in detail in internal INTELLECT documents [6]. The specifications are described using UML diagrams (class and use-case diagrams). This document describes the graphic user interfaces, illustrating the module's main functionalities.

5.1 Modules and interfaces

The INTELLECT consortium aims to provide an enhanced shop system including all practicable electronic commerce features, and offering a suitable and realistic representation of the products. The INTELLECT application will contain five modules:

- The eShop will supply the general infrastructure of an e-commerce system (basket, catalogue, secure communications, localisation, multimedia presentations, etc.).
- The Virtual Reality module will provide a 3D visualisation of the product, and enable the customer to configure its own product by choosing each of its components.
- The Configurator will support the generation of product variants and tailor-made products as well as offer infrastructure for the administration of products and components.
- The help desk will provide on-line help to the customer using features like chat, voice over IP and video conferencing.

- The order-processing module will manage the orders, and offer an interface between the INTELLECT application, and the back office systems.

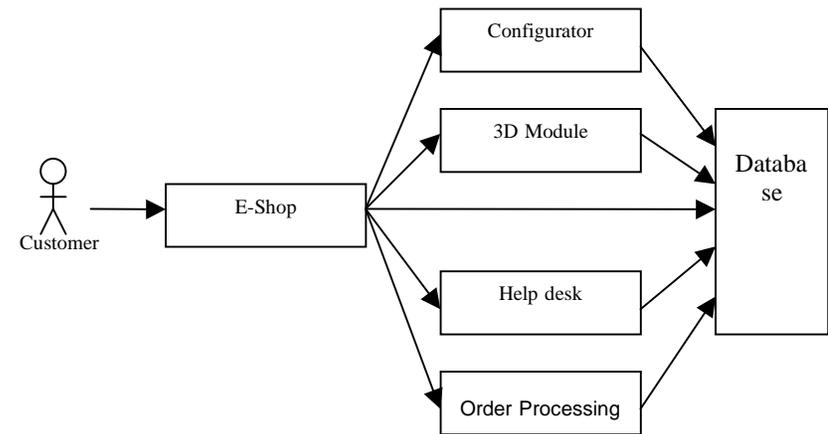


Figure 5: Modules of INTELLECT

5.2 eShop module

The Shop module is responsible for the main user interface of the eShop offering basic functionality like navigation, a product catalogue, a shopping-basket as well as an ordering/payment interface based on functions supplied by the ordering module. Configuration and 3D representation of a specific product is accomplished with the help of the VR module, which can be started by the user on demand. The Help module can be called in the same way in a situation where the customer is in need of consulting or support.

The INTELLECT eShop aims to prevent the customer from leaving the shop without buying anything. User requirements analysis and market survey suggest that the following properties represent essential steps towards that goal:

- Navigation has to as simple as possible.
- The search function should help the customer to find what he wants.
- As few clicks as possible to order (each click can be the click away from the shop).
- Personalisation/Localisation as well as individual products.

- Brand name recognition and customer loyalty through community services.
- Demonstrate competence through qualitative technical data and support.

The shop module is responsible for starting the Configurator during start-up and creating the product catalogue from the database. It is also responsible for the initialisation of the other modules.

5.3 eShop functionality

The shop module offers basic functionality to the customer like navigation, product catalogue, shopping basket, login as well as some advanced features like community services.

Customers can register by supplying their personal data, payment means and physical measurements if applicable to the product. Registration is necessary only if the customer wants to place an order or for the configuration of personalisation features. Registration is also necessary for the authentication of business partners.

Registered users can be addressed personally, can get a personalised web site with their special interests available on the front page, can get special prices, can have access to different stock, discount and other bonuses. Personalisation offers the possibility for a better customer relationship.

The system has to find out the responsible/nearest distributor or retailer. This can be done over the address from the customer's profile. This function is especially necessary if parts of the eShop are distributed like several help desk in different countries. Then the customer has to be connected to the right help desk.

The catalogue contains a hierarchical structure of different categories. Each category contains an arranged listing of products with short information and if available a picture. There will also be the possibility to get information that is more detailed as well as multimedia material and customer comments or reviews. Products can be included in different categories. The customer can at this point also use the search function by using different indices or the full text mode for all available attributes of the products and their components like size, prize etc. The system supports multimedia presentations (videos, sound, pictures, animation etc.) for components, categories of components and products.

The customer sees a list of products when he navigates through the different categories of the catalogue and can get detailed information including

the list of component the product consists of for each product and even change them in the VR module. Configuration is not restricted to complex products though, even single components have attributes like colour, size etc. which can also be changed or automatically configured to fit the physical size of the customer.

The shopping-basket serves as a container for all the items the customer wishes to purchase. The basket can be examined at any time and the customer can remove items, take items from the last stored basket and put them into the current, change the quantity of any item or finalise the order as well as access and possibly manipulate past orders. Ordering without the shopping basket will also be possible by simply selecting the desired product.

Different discount systems can be realised, e.g. in percent as well as in absolute form for certain products or special customer and business partner. The customer can also get a quantity discount, which also can be calculated in a percent and/or absolute mode.

Navigation elements will be available to the customer at all times. Such elements will be i.e. a toolbar containing functions like of news, search, services, contact information, help, home and shopping basket. A separate toolbar possible located to the side will include elements that allow navigation through the product catalogue, access to personalised version of the shop via login as well as links to other parts of the shop that may be relevant. Navigation via direct links to all possible parts of the shop should always be possible so that the customer can navigate as quickly and intuitively as possible. The customer should also be able to call up his shopping basket at any time.

3D representation and configuration of a product will be available with the help of the Configurator and VR modules. Pre-sales service and support will be available via the help-desk module.

All customer transactions are secured by current security mechanisms for example SSL (*Secure Socket Layer*). The shop will supply plenty of information concerning the use and effectiveness of such security mechanisms, as well as information concerning the handling of the personal data entered by the customer. No cookies should be used if the customer does not want this.

The administration front-end system gives the manager the opportunity to manipulate product data, special offers and configuration patterns as well as BackOffice relevant data like availability, prices, inventory etc. The eShop should will also be adaptable regarding the style and design i.e. logo, colour, font and the catalogue structure. This feature will make the implementation of many different sub-eShops with different look and feels based on one BackOffice and one catalogue.

The following diagrams illustrate the general functions and the ordering process:

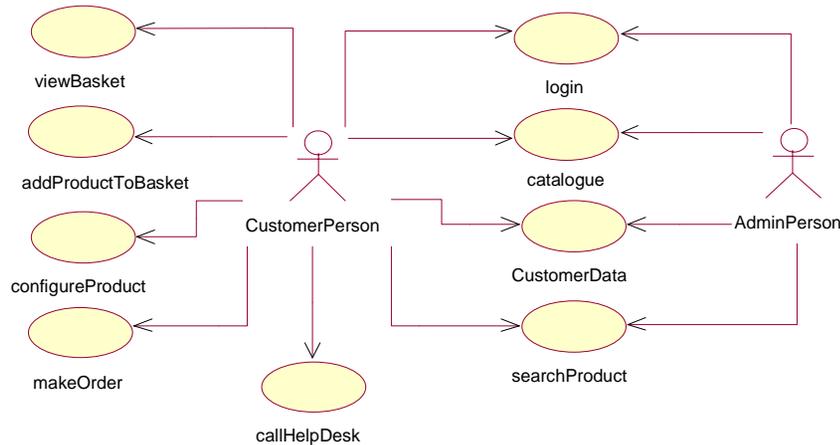


Figure 7: General functionality of the Shop

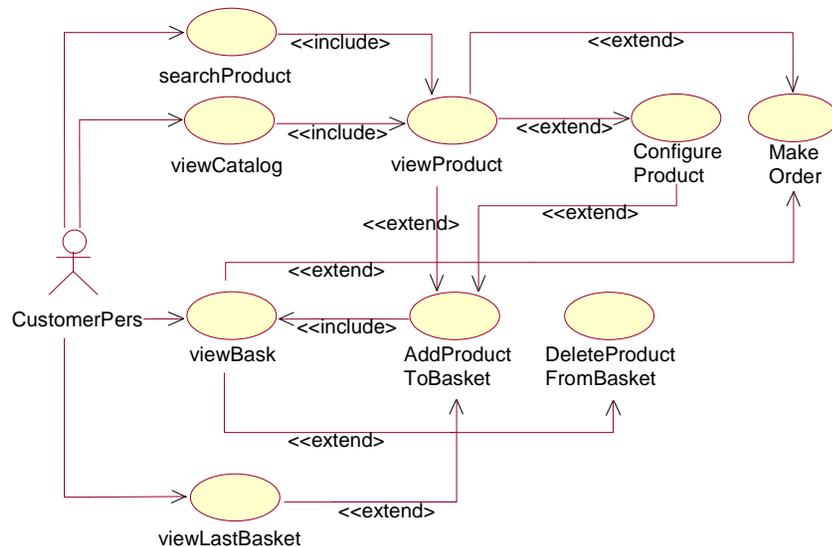


Figure 8: Ordering process

5.4 Virtual Reality module

The VR module functions effectively as an interface to the Configurator. It aims to present the product in a way that is as realistic as possible. The user can interact with the product: turn, zoom, select and configure a component; the Configurator supplies the possible configurations. The 3D view of the products will be obtained by assembling 3D models of its components stored in VRML files. However, even if no 3D model is available for some of the components, configuration should be possible.

The Virtual Reality module will be divided in two parts:

- The manager application will be intended for the shop operator, which will be in charge of the management of the 3D data, and the assembling rules definition.
- The user application is intended for customer use, and will mainly offer a 3D view of the product (if available), which the customer will be able to view in several positions, and to configure according to his wishes.

According to the end-user requirements, the VR module will be able to display 3D animations and Avatar simulations.

The use of Java3D - the 3D API for Java – allows the rendering of a 3D world in a Java application or a Java applet. Java3D provides a collection of high-level constructs for creating, manipulating and rendering 3D geometric objects in a virtual universe. The Java3D world corresponds to a scene graph, which is an arrangement of 3D objects in a tree structure that completely specifies the contents of the virtual universe, and the way it is rendered. VRML files can be loaded and added to a Java3D universe thanks to the VRML97 library, defined by the VRML-Java3D working group.

The 3D representation will offer the customer a user-friendly and attractive image of the product. For most of the components, the level of detail is not very important, excepted for few components where appearance may be more important than technical features.

These features would require some important input from the end-users (3D product representation, and 3D animation), which can be easily obtained with the help of photo-modelling tools.

5.5 Functionality of the VR module

The functions of the VR module are:

- Product 3D visualisation
- Navigation (zoom, rotate, predefined point of view)
- Change component (add, delete only if allowed by the configuration module)
- Add/delete avatar
- Play simulation (with or without avatar)
- Display non 3D information (general description of components)
- Call basket functions
- Save/delete configuration

A product is composed of several components; each has a 3D model described in a VRML file. To view the product, we have to assemble correctly the components.

To define the assembling rule between two components of a product, an “Anchor” is needed for each component. This anchor is composed of an origin and an orientation relative to the origin of the scene. When the two components are assembled, their two anchors correspond exactly. The two anchors for an assemblage have the same name.



Figure 9: Anchors for the assemblage between a frame and a wheel

The shop operator has to define the two anchors for each assemblage in the manager application, and then the assemblage can be calculated by composing the transformations corresponding to the anchors.

As shown on the following Use Case, the manager (the shop operator) will have the possibility to load a single component, and manage its anchors. When the manager loads a component, the application shows its 3D model and its existing anchors in the Java3D view (*ViewAnchor*). The anchors are also displayed in a list. The manager can select an existing anchor in the list, or in the visualisation area (*SelectAnchor*), but only if he is in the interaction mode (see Navigation); the selected anchor appears in a different colour than the others; it can be edited in a separate window (*EditAnchor*). While an anchor is edited, its values can be modified in the edition window or by “drag and drop” in the visualisation area (*MoveAnchor*), but in order to avoid confusions, the manager is not allowed to select another anchor until the edition window has been closed. The manager also has the possibility to create a new anchor (*AddNewAnchor*), which is instantiated with default values. He can also suppress an existing anchor (*SuppressAnchor*).

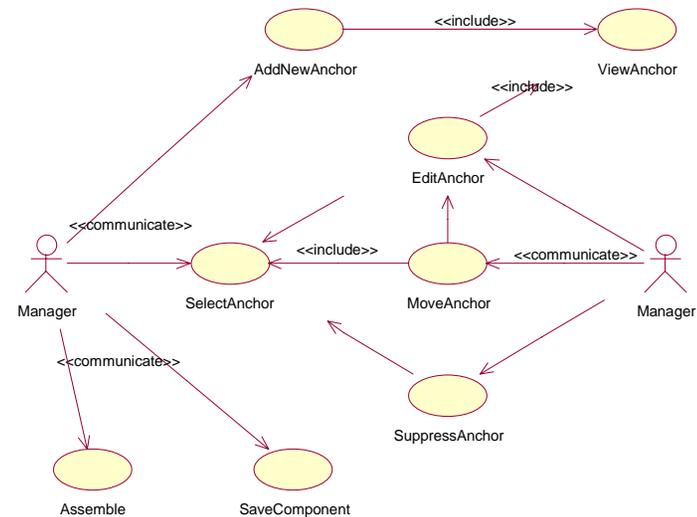


Figure 10: Use Case

To choose the name of an anchor, the manager will have to select the second component of the assemblage from the existing components and then choose one of its anchors, if it has already been created, or define a new name if the anchor does not exist yet on the other component.

The manager will have to save the component (*SaveComponent*) if he wants its modifications to be taken in account. He if does not, and tries to exit the application, a dialog frame will ask him for confirmation, and give him the choice to save or not.

The manager will have the possibility to view the results of the assemblage (whether the component has been saved or not) thanks to the *Assemble* functionality. He will have to choose from a list of available components, including the one, which is edited, the components he wants to assemble. The application will load every component, read the anchors list and calculate the corresponding assemblage. Once all the anchors needed for a product have been placed, the manager will ask the configuration module if its product is correct (to be sure he hasn't forget a component or an anchor), if yes, he has the possibility to save this product as a pre-defined product.

In the two applications, we have to show the 3D representation for one or several component(s). In the manager application, the manager must have the possibility to choose a component in the list, and the application will load its VRML file in a Java3D graph. The application also has to read its Anchors list, and construct the corresponding objects. One single component can be loaded once a time.

In the user application, as same as in the assemble functionality of the manager application; the application must load a list of components. In the assemble functionality, the manager can choose the components he wants to view together, whereas in the user application, the list is given by the configuration module by the method `GetComponentList`, and corresponds to the selected product whom the key is given by the eShop. The application will load each component, create the corresponding java3d sub-graph, find the correlation between anchors, and calculate the transformations to apply to each object.

The navigation possibilities are the same in the customer and manager applications. Navigation includes everything that allows the user to see the object (product or component) from a different point of view. Some usual navigation possibilities in Virtual Reality applications are more or less user-friendly, depending on the viewed scene. Navigation using the keyboard for example (\leftarrow , \uparrow , \rightarrow , \downarrow) are mostly used in games or worlds the user can walk into; but in our application this navigation type become very unfriendly; turning around an object is very difficult, and it is better way for the user to manipulate (translate or rotate) directly the object, and make it move (*MoveObject*).

Three modes are available for the user: Translate, Rotate and Interact. The translate mode allows the user to use the mouse to translate the object in the current visualisation plan, the rotation mode allows the user to rotate the

object with the mouse, and the interaction mode disables navigation with the mouse (but not the other navigation means), so that the user can use the mouse to interact with the scene (select an anchor or a component, or move an anchor).

To make it easier for the user who may not be used to use the mouse for moving objects, the application calculates a list of predefined ones (Face, Back, Right, Left, Up, Down), using rotations from the initial viewpoint. Another viewpoint allows the user to see all the objects of the scene.

The user also has the possibility to zoom in or out with the *Zoom* functionality. He can give directly the zoom value, increment or decrement the existing one, or reset the zoom.

All these navigation possibilities allows the user to view the object in several points of view even if he isn't very used to navigation, and to move objects with the mouse, which may seem difficult for a novice, but which bring the sensation of manipulating the object.

In the user application, the customer must have the possibility to configure the product. He can select the component he wants to modify in the components list (*ListComponentSelection*) or in the viewing area (*3DComponentSelection*), if he is in the interaction mode, and if the 3D model is available.

When the user asks for changing the selected component (*SelectComponent*), the application proposes all the possible configurations obtained from the `getPossibleComponents` method of the configuration module (*ViewPossibilities*). For each possible component in the list, the user can see the properties of the component, and a 3D representation (*ViewDescription*). When the user selects one of the components (*ChoosePossibility*), the application updates the visualisation (*Update*), and must inform the configuration module about the new configuration with the method `updateComponentList`. For the first configuration of a predefined product, the application must ask the configuration module for a new product key with the method `getNewProductKey`, and must inform the eShop with the method `updateCurrentProductKey`.

5.6 Avatar

The presentation of many products can benefit from a human avatar in the scene, in order to give the user a get a better idea of the product's size or other properties in relation to a human the same physical size as the user. If this is relevant for the viewed product, the shop manager will have the possibility to add some VRML avatars in the database.

In this case, the user will have the possibility to add an avatar to the scene (*AddAvatar*); he will be able to choose its avatar from a list of predefined

ones, and will have the possibility to configure it (*ConfigureAvatar*) by giving for example its size, hair colour, etc. The application will load the corresponding VRML file, set its attributes, and show it in the scene next to the product (*ShowAvatar*). The user will be able to manipulate the avatar thanks to the functionality *MoveAvatar*.

One of the user requirements is to show animations with the product or its components in order to give the customer a better idea of the capabilities of the product, or to explain how it works. The VR module will provide the customer the possibility to view predefined 3D animations, which are in VRML files, or to ask for a multimedia demonstration (video animation), which will be displayed within the eShop. When an animation is available, the VR module will propose the functionality *PlaySimulation* to the customer; for a multimedia demonstration, the application will ask the eShop to lay this animation with the *playMultimedia* method, and for a 3D animation, it will load the corresponding VRML file, and play the animation inside the viewing area (*LoadVrmlSimulation*).

The VR module will display textual information describing the component in the configuration window, so that the customer will have the capability to choose each component comprising a product, with all required information.

The customer will be able to order the product from the VR module. The eShop will provide the required methods to update the basket from the VR module.

The customer will be given the possibility to save or delete its configuration. The product will automatically be saved, but if the customer does not want to keep its configuration, the VR module will ask the Configuration module to delete it, using the *deleteItem* method.

5.7 Graphic Interfaces

The pictures in this chapter show the prototypes of the main windows for the customer and administrator graphic user interfaces of the VR module.

The customer will see in the first window the pre-defined product he has chosen in the eShop, and will be able to manipulate it and view it in different points of view. The customer will also be able to select a component in the visualisation area or in the list, and check the possible alternatives thereby opening the configuration window.



Figure 11 : User Application Main Window

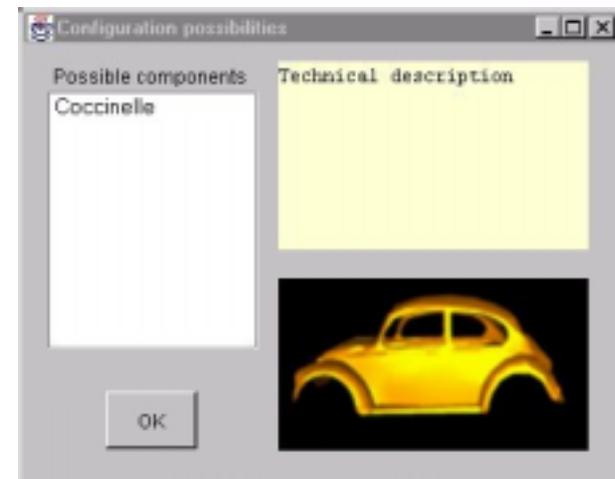


Figure 12 : User Configuration Window

The configuration window will display the list of possible components that can replace the selected one. Selecting a component in this list will show a 3D view of the component (if available) and its technical description.

The manager will see the component and its anchors in the main window. He will have the possibility to move the component, and to add new anchors or modify the existing ones.

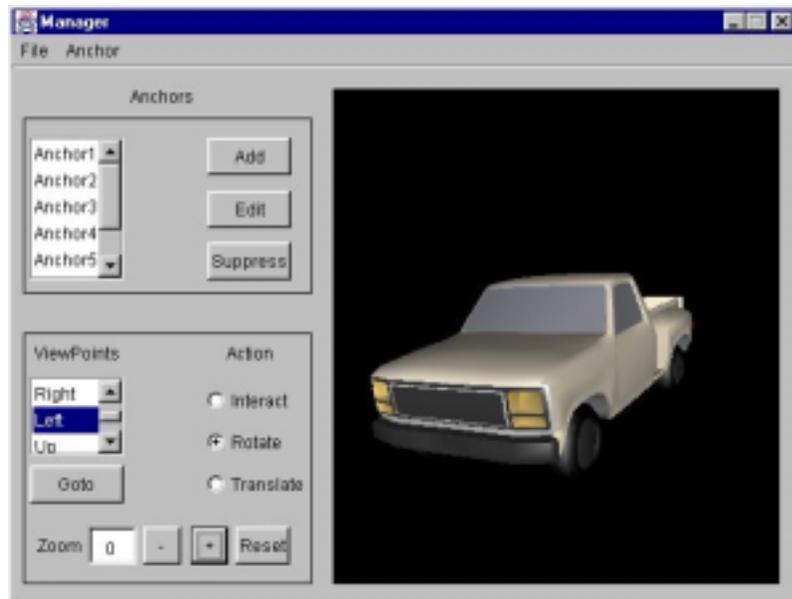


Figure 13: Manager Main Window

Another mode will allow the manager to display the results of the assemblage. In this mode, the manager will chose from the available components list, those he wants to put together, and he will see in 3D the result of the assemblage based on the anchors he has defined.

For many people, a 3D interactive virtual universe is very attractive and entertaining; but manipulation and interaction with a 3D virtual world may not be so easy for non-technical people. Main design goal of the VR module GUI of both the manager application and the user application has been user-friendliness. The user is free to navigate and interact with the 3D world both in the 3D rendering area and from the controls offered in the window.

5.8 Security module

Encryption technology is used to encode messages with the help of a key so that only the rightful recipient is in a position to descramble the data and read the message. The aim of encryption is to make an attack on information as difficult as possible. Encrypted information can ideally only be decrypted, with the knowledge of the decryption key. The effectiveness of an encryption method depends on factors like the type of encryption (asymmetric/symmetric), encryption algorithm and the key length but also the technical knowledge, resources, effort and time an attacker is willing to invest in this effort.

Authentication is the process of verifying identity so that one user can be sure that the other user is who it claims to be. One way of authentication is the digital signature that uses the public key encryption technology. A digital signature is a cryptographic means that a particular message did indeed originate from the signer and was not alerted or exchanged during transmission.

The digital signature is created using a hash function to the message creating a message digest. This hash is usually shorter than the message and can be easily encrypted with the signer's private key. After receiving the message the same hash function has to be applied to this message, the received encrypted digest has to be encrypted with the public key and the two digest have to be compared. If the two are the same, the signature was successfully authenticated.

Secret key encryption, also known as symmetric encryption, uses the same key for encryption and decryption. Secret key encryption algorithms are DES (Data Encryption Standard), Triple-DES, Blowfish, IDEA (International Data Encryption Algorithm), RC4 (Rivest Cipher Nr.4), etc. Problems with the secret key cryptosystem are:

- Key transmission (key exchange): It has to be ensured that the private key will be transferred to its destination in a secure way.
- Limited number of users: Everyone who is in possession of the private key can decipher the data. The less people are in possession of the key the safer is the data.
- No signature possible: Two people (at least) are using the same key, so it has to be ensured that both people are legitimate users.

The benefits of secret-key encryption technology are its fast encryption (compared to public-key encryption). Especially in open systems with a large number of users, secret-key cryptosystems has difficulty providing secure key management. Key management is the generation, transmission and storage of keys. All keys in a secret-key cryptosystem must remain secret. The main problem that has to be solved is the key exchange. In order to solve the key management problem the public key encryption can be used.

To overcome the problem of key exchange, Whitfield Diffie and Martin Hellman created the concept of public-key cryptography in 1976. The Diffie-Hellman algorithm can only be used for key exchange. 1977 Rivest, Shamir and Adleman invented a public key algorithm (RSA) for key exchange and data encryption, today's de facto standard among public key algorithms.

Public key encryption is a technique that uses a pair of asymmetric keys for encryption and decryption. Each pair of keys consists of a public and a private key. The public key is made public by distributing it widely, the private key is never distributed, and it is always kept secret. Data that is encrypted with the public key can be decrypted only with the private key. Conversely, data encrypted with the private key can be decrypted with the public key. This asymmetry is the property that makes the public key encryption so useful.

- Advantages:
 - Provides data encryption **and** digital signature (RSA)
 - Increased security: Private keys never need to be transmitted to anyone.
- Disadvantages:
 - Slow: Caused by the complex mathematical concept the asymmetric encryption is slower than the symmetric encryption.
 - Does the public key of a potential recipient really belong to this recipient?
 - Need of a certification authority

A digital certificate guarantees that a public key belongs to a certain person or organisation. The standard for digital certificates is defined by the ITU standard X.509 and will be used by all browsers, Internet servers and security protocols (e.g. SSL).

This certificate will be issued by a trusted organisation called Certification Authority (CA), also known as a Trust Centre. A certificate issued with the user's public key will be encrypted with the CA's private key. To verify that the public key belongs to the sender the receiver decrypts the certificate with the CA's public key.

A certificate contains the following information:

- Subject (who has to be certified): name and public key
- Issuer (CA): name and signature
- Period of validity: not before date, not after date
- Administrative information: serial number and version

Secure Sockets Layer (SSL) is a crypto protocol created by Netscape for managing the security of message transmissions in a network. Netscape's idea is that the programming for keeping the messages confidential ought to be

contained in a layer between an application (such as the Web browser or HTTP) and the Internet's TCP layer.

SSL allows a SSL-enabled server to authenticate itself to an SSL-enabled client (e.g. sending a credit card number over the network), allows the client to authenticate itself to the server (e.g. a bank is sending confidential information to a customer) and allows both machines to establish an encrypted connection.

SSL is an integral part of each Netscape and Microsoft browser. If a Web site is on a SSL capable server, SSL can be enabled and specific Web pages can be identified as requiring SSL access.

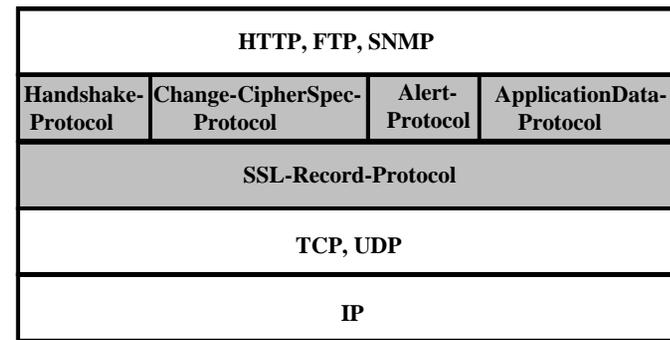


Figure 14: SSL Protocol Stack

The cryptographic parameters of the session state are produced by the SSL Handshake Protocol, which operates on top of the SSL Record Layer. When a SSL client and server first start communicating, they agree on a protocol version, select cryptographic algorithms, optionally authenticate each other, and use public-key encryption techniques to generate a session key.

After negotiating the security attributes of the session the Change-CipherSpec protocol informs the Record layer about the cipher (cryptographic algorithm) settings.

The whole SSL secured communication will be encapsulated by the Record Protocol, which defines the format, used to transmit data and fragments, compresses and encrypts data (or attaches digest signatures) as specified by the current active session state (see figure 15).

The Application Data Protocol transfers data from the application layer to the Record Protocol. If problems during the data exchange occur, the Alert Protocol is sending error and warning messages. [12, 13]

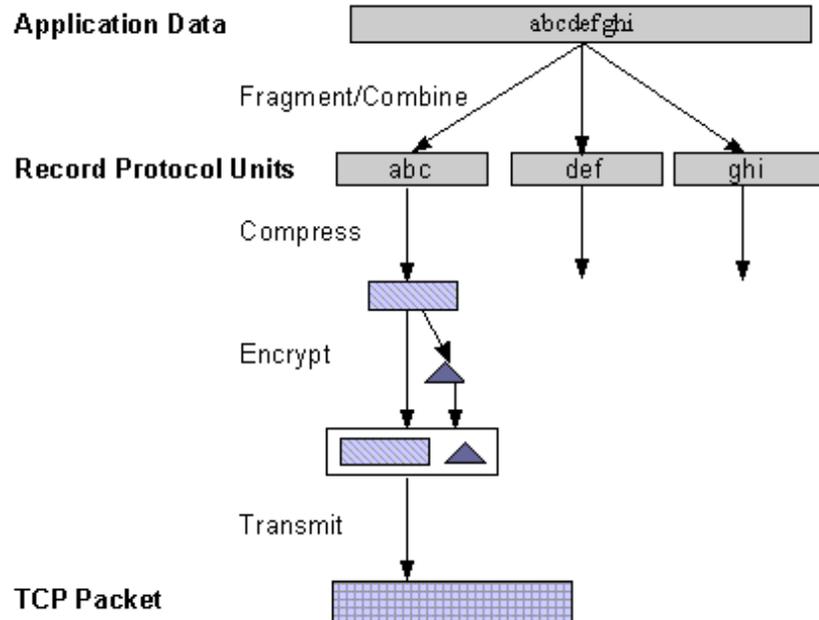


Figure 15: SSL Record Protocol

Caused by this encapsulation, web servers, which are communicating with HTTP via SSL, receive messages at a port different from the standard. HTTP communication without SSL will be received normally at port 80. The HTTP communication via SSL takes place at port 443 (SMTP at Port 464, NNTP at port 563).

SSL supported a variety of cryptographic algorithms:

1. During the handshaking process, the RSA key exchange algorithm (certificates are used) or the Deffie-Hellman key exchange algorithm (without certificate) is used.
2. After the key exchange, a number of ciphers are used including RC2, RC4, IDEA, DES or Triple-DES.
3. The MD5 (128 bit) and SHA-1 (160 bit) message-digest algorithm is also used. The public-key certificates follow the X.509 syntax.

A common use of SSL is to secure HTTP communication between a browser and a web server. Using HTTP over SSL is named HTTPS and will be indicated with the URL scheme *https* and a different server port (443).

For financial transaction via the Internet SSL (HTTPS) will be used. This technology is a standard security protocol, already tested and commonly used in the Internet. SSL can be implemented in every http-based application. With the encoding, it is only important that one uses long key lengths. Thus SSL should use RSA with a 1024-Bit-key for key exchange and Triple DES or IDEA with 128-Bit-key at least. [5]

The secret-key encryption is fast, but needs a secure way for transmitting the key. The public-key encryption is slow but offers a secure way for the key exchange. To overcome the limitations the secret-key and a public-key encryption will be combined.

There are two basic approaches:

- At the beginning of the communication, the secret key will be encrypted by the public key. Now, the encrypted secret key can be transferred in a secure way. At the other side, the public key can decrypt the secret key. Finally, a secure data exchange can be realised by using the secret key.
- The secret key will be transferred with the data altogether. This is called a digital envelope. The information, which will be transferred, contains the encrypted secret key followed by the data, encrypted with the secret key (digital envelope). [13]

5.9 Approach to Configuration

There are many methods developed to implement knowledge based configuration. Most of them share certain common basic mechanisms like classification resp. taxonomy and constraints. Classification in AI research generally means the selection of one or more elements out a pool of available parts [9]. Configuration methods (i.e. structure based methods) generally make use of taxonomic and heuristic classification. Taxonomic classification is based on existing specialisation hierarchies. Heuristic classification on the other hand depends on transformations that map one set on another (i.e. functions on structures) and is therefore more appropriate for rather vague criteria. Dependencies between components that can not be modelled using traditional classification methods are normally enforced through constraints. Whereas classification can ensure that components are combined in a certain way constraints can be used i.e. to make sure that certain attributes only get values from a predefined range. Constraint networks emerge in complex systems that impose many constraints per component or attribute [10].

- **Structure based configuration**

Configuration data like the number and type of components involved in the product, or the attributes of the components involved are static in a

given configuration scenario. Structure based (sometimes also referred to as domain based) configuration systems are a popular method relying on a structured representation of the configuration data in order to assemble a correct configuration. Such a graph is composed of many smaller AND and OR graphs that represent aggregation/composition and specialisation/taxonomy relationships between different components [11]. Configuration is then simply a matter of instantiating appropriate objects and fitting their attributes with the correct values. [10]

- **Rules based configuration**

Rules based configuration also requires an extensive knowledge base that contains a set of rules covering every component usable in a product [10]. These rules are composed of conditions and actions that strictly define when a component is entitled to act and what action it should undertake. Not only the creation but also the maintenance of such a database is very costly and time consuming as it requires the constant updating every time new components are to be added to the product line.

The Configurator will implement a combination of rules based and structure based configuration. The user requirements analysis has made the existence of two distinct categories of constraints evident. Physical or hard constraints represent conditions that have to be met in order to produce a complete configuration that can be assembled and is fully functional. Logical or soft factors on the other hand represent secondary criteria that are used to create a new variant with specific properties i.e. the fastest possible workstation for 3D applications. Structure based techniques like a specially designed class hierarchy and Database schema will be implemented in the Configurator in order to accommodate hard constraints. Soft constraints on the other hand require great flexibility and will thus be implemented with the help of the Rules based configuration approach.

5.10 The Configurator

The Configuration module aims to offer state of the art configuration technology in a lightweight form that can handle any sort of configurable product and be incorporated in an online environment like an eShop. The INTELLECT Configurator also allows for simple, interactive, user friendly configuration and tailoring of existing products via an interactive multimedia (VR) interface.

The following functions will be implemented:

- Configuration facilities for use within INTELLECT by the VR and eShop modules. Allow the interactive creation of product variants based on:
 - Preconfigured variants offered as part of the eShop catalogue
 - Free components exchange (within configuration limits)
 - Logical as well as physical criteria
- Product handling module
This will be a module implementing basic product/component/component category infrastructure needed by all the INTELLECT modules.
- Wizards
Wizards supporting non-technical customers based on logical/soft criteria.
- Facilities for product customisation
Customisation of a certain variant according to the customers physical measurements
- Storage of variants for later use (i.e. evaluation purposes)
- Tool based administration of all the aspects/functions of the shop

6. Conclusion

Capturing the user requirements, INTELLECT collected valuable information on both the merchants and the customers buying and selling configurable products. Interviews and questionnaires proved an increasing need for customer support in the area of product configuration and support. Even products that do not seem suited to 3D visualisation, like personal computers, will definitely profit from this innovative approach. User requirements analysis also showed that customers need individual support and personal contact raising the need to offer a comprehensive help desk system.

Furthermore, the VR Configurator and the integration of a security module are all important innovation factor that will help this system to gain greater acceptance. Due to the lack of widespread security mechanisms many people in Europe today do not trust eCommerce applications enough to use them on a day to day basis. A security module in an eCommerce solution is therefore indispensable in order to win the trust of potential customers. VR and the manned Help-desk system will also help create an attractive user-friendly interface.

Currently, the INTELLECT system architecture is being defined. The next step will be the implementation of a first prototype that will then be evaluated by project end-users as well as by potential customers. The findings of this process will lead to the final prototype that will be installed at the end-users' sites. Testing the system in real-life situations (first as a simulation but later for

authentic business cases) will lead to the final INTELLECT system that will be marketed after the end of the project. The current status, future events, and activities of the INTELLECT consortium can be found under <http://www.ist-intellect.com>.

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8. Glossary

API	Application Programming Interface
B2b	Business to business
CA	Certification Authority
CoS	Class of Service
CSCW	Computer Supported Co-operated Work
DES	Data Encryption Standard
DiffServ	Differentiated Services
DPM	Decentralised Production Management
ERP	Enterprise Resource Planning
FTP	File Transfer Protocol
G.723.1	Recommendation G.723.1 (03/96) - Dual rate speech coder for multimedia communications transmitting at 5.3 and 6.3 kbit/s
G.729a	Recommendation G.729 - Coding of speech at 8 kbit/s using Conjugate-Structure Algebraic-Code-Excited-Linear-Prediction (CS-ACELP)
H.323	Recommendation H.323 - Packet-based multimedia communications systems
HTTPS	Hypertext Transport Protocol Security
IDEA	International Data Encryption Algorithm
INTELLECT	Intelligent Online Configuration of Products by Customers of Electronic Shop Systems
IntServ	Integrated Services
IP	Internet Protocol
IST	Information Society Technologies

IT	Information Technology
ITU	International Telecommunication Union
MD5	Message Digest Version 5
NNTP	Network News Transfer Protocol
PC	Personal Computer
PDM	Product Data Modelling
QoS	Quality of Service
RC4	Rivest Cipher Nr.4
RSA	Rivest, Shamir and Adleman (public key algorithm)
SET	Secure Electronic Transaction
SME	Small and Medium Enterprise
SMTP	Simple Mail Transport Protocol
SNMP	Simple Network Management Protocol
SSL	Secure Socket Layer
STEP	Standard for Exchange of Product Model Data
SW	Software
T.120	Recommendation T.120 (07/96) – Data protocols for multimedia conferencing
TCP	Transmission Control Protocol
UDP	User Datagram Protocol
UML	Unified Modeling Language
URL	Unified Resource Locator
VoIP	Voice-over-IP
VR	Virtual Reality
VRML	Virtual Reality Markup Language
WfMC	Workflow Management Coalition
WWW	World Wide Web
XML	eXtensible Markup Language

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