Integrating a Web-based System with Business Processes in Closed Loop Supply Chains

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Abstract

Closed Loop Supply Chains include operations for physical collection of end-of-use products, selection based on their configuration and/or condition and decision making for reuse, remanufacturing or recycling. Uncertainty factors regarding the time, place of origin, and status of returns introduce many difficulties in planning these operations. With the aim to minimize such problems, this paper presents an architecture for virtual reverse logistics networks and an implementation for end-of-use PCs. The virtual reverse logistics network for PCs relies on E-commerce and WWW technologies for remote monitoring and benchmarking, instead of physical transportation and inspection. A configuration monitoring and benchmarking agent screens the computer that is about to enter the end-of-use stream and registers the data in the system's databases. The virtual reverse logistics network regards all incoming PCs as submitted offers. Also, users or agents may explicitly register requests for PCs or modules. Offers are matched to requests with a decision support system to provide recommendations for reuse, remanufacturing or recycling of end-of-use PCs. An electronic marketplace matches requests and offers. The proposed architecture diminishes the uncertainty factors and provides us with an understanding on what is missing and it is likely to have a positive impact to the development of virtual reverse logistics networks for computers and other equipment with embedded logic.

1 INTRODUCTION

Reverse logistics, that is all operations related to the reuse of discarded used products, commercial returns, excess inventory of products and materials have attracted attention in recent years for the following reasons reasons.

- **Positive environmental impact:** In EU, the concept of sustainable development is spreading rapidly in countries with traditionally high environmental sensitivity, like Germany and the Netherlands. As a result, legislation acts, also called "producer responsibility laws", require manufactures to develop a policy for the collection and reuse of products at the end of their life cycle. These laws aim to shift waste management costs to producers, reduce volume of generated waste and increase use of recycled materials.
- **Competitiveness Advancement:** Efficient handling of returns leads to reduced costs, increased profits and improved customer service. As noted in a [Rogers 1998], returns related costs for U.S. companies in 1997 are estimated to $35 billion (0.5% of the U. S. GDP). With e-commerce expansion, this figure becomes more prominent, because e-tailers have higher return rates than their brick-and-mortar counterparts. According to [MMH 2000], estimated returns for products sold through U.S. e-tailers are on average 30% of all purchases and they amount to $11 billion out of which $1.8 billion to 2.5 billion will represent losses. For e-tailers learning to manage the return flows is of vital importance. In supply chains, efficient and effective handling of returns clearly represent a competitive advantage for those who face competitive parity.
- **Regaining value:** Beyond increase in competitiveness, efficient reverse logistics contributes to regaining value from reusing products or parts or recycling materials. As noted in [Lund1998] there are over 70,000 re-manufacturing firms in U.S.A. typically for jet and car engines, auto parts and copiers that amount to total sales of 53 billion (USD).

For the systematic handling of returns, reverse logistics networks need to be designed and developed. However, planning and control of reverse logistics operations are very difficult due to the high uncertainty regarding the time, place of origin, and quality status of returns. As outlined in [Kokkinaki 2001], information and communication technologies (ICT) can be used to minimize uncertainty and volume of incoming returns. In this paper, we show that ICT can be used to substitute some of the operations involved in reverse logistics with information processing and lower uncertainty, costs and required time. Furthermore, we develop an architecture for virtual reverse logistics networks and describe an electronic marketplace coupled with virtual reverse logistics networks to facilitate redirection of returns in the market. We include an implementation of a virtual logistics network for PCs and we examine how that can be extended to support other returns. At large, virtual reverse logistics networks offer the following benefits compared to conventional reverse logistics networks.

In virtual reverse logistics networks, information flows actually precede returns flows and they can be used to diminish uncertainty on configuration, condition and place of origin and enable better planning and control for the remaining operations in a reverse logistics network. Furthermore, virtual reverse logistics interfaces can be used to offer incentives to set optimal policies for time and methods of collection for returns.

Virtual reverse logistics networks enable higher visibility on products data, even before products enter the returns flows. For certain classes of products, these data can be used to accelerate their reentrance in a reverse logistics network. For example, consumer electronics can not afford to get stacked idly because they get depreciated literally by the day; a virtual reverse logistics network for consumer electronics can be used to swiftly redirect excess inventory or commercial returns into the marketplace.

Information flows in virtual reverse enable multi-echelons of reverse logistics networks and take advantage of economies of scale for transportation. Regional recovery subsidiaries can be organized to collect and disassemble products with known reusable components. After disassembly the regional subsidiaries can forward only the reusable components to a centralized facility for remanufacture, while allocating less-demanding recycling locally.

The proposed architecture demonstrates the feasibility of virtual reverse logistics networks and provides us with an understanding for further research and development, which is likely to have a positive impact for future virtual reverse logistics networks. This paper is structured as follows: in Section 2 we describe the information flows related to reverse logistics. In section3, we describe the architecture of the virtual reverse logistics network, followed by the system’s implementation for end-of-use PCs. Open issues and conclusive remarks are summarized in section 4. A list of the principal abbreviations and acronyms used in this paper may be found in Table 1.1.

Acronym	Definition
COTS	Commercial Off-The-Shelf (Product)
HTML	Hyper Text Markup Language
JSP	Java Server Page
MVC	Model View Controller
OO	Object Oriented
RL4PC	Reverse Logistics for PC

Table 1-1 Terminology

2 INFORMATION FLOWS IN REVERSE LOGISTICS NETWOKS

Some authors [Rogers 1998] view reverse logistics in isolation, whereas others [Fleischmann1997, Guide2000] tend to view reverse logistics as the complement to forward logistics within a closed loop supply chain approach. We follow the holistic approach.

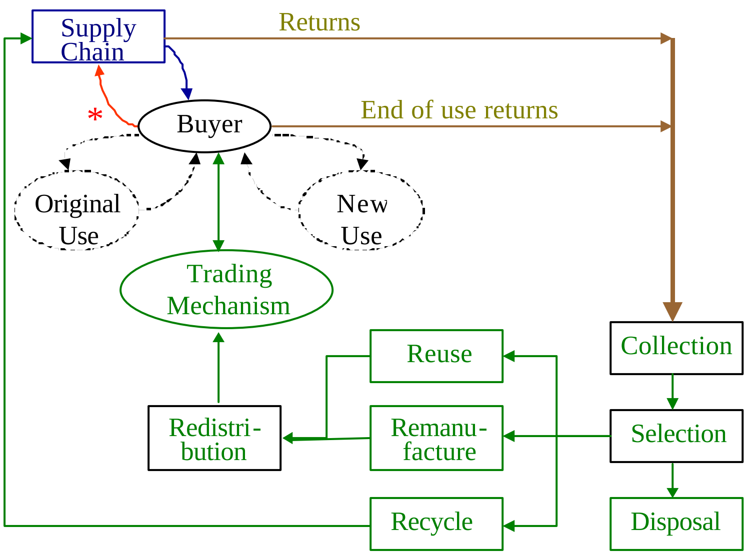


Figure 1 Reverse Logistics Network

As shown in Figure 1, re-occurring activities in a reverse logistics network, include collection, inspection/separation, reuse, re-manufacturing, recycling, re-distribution and disposal. Logistics processes are depicted as rectangulars and product-flows as solid arrows. Ovals denote states of ownership or use and dashed arrows represent transitions from one state to the next. In general, one may notice that reverse logistics networks focus on handling "returns", that is, products or packaging that result from various stages of the supply chain from the first level (commercial returns) to the last (end-of-use products).

To illustrate this point, let us bring an example from the computer industry. At first, products are purchased for the value delivered by their original functionality; i.e. a company buys a web server for its e-commerce project. After the computer is delivered and installed, its packaging is retrieved by the supplier for recycling and this is denoted by the star flow in Figure 1. After being used for a while, the product is no longer useful to the original user. In our example, the industry standards have evolved or the company’s transactions have increased and that particular server can no longer support them. Frequently, the product is traded in a marked down price once or several times. In Figure 1, this is denoted by the loop between “original use” and “trading mechanism”. It is worth to point out that through the repetitive changes of ownership, the product is still used in its original functionality. In our example, the computer might be bought from another company or for personal use. Eventually, however, products reach the end-of-use stage. The main idea for reverse logistics is to promote and support alternative uses for such products.

For PCs, in particular, end-of-use flows will amount to 500 million units by 2007 in U.S.A. and are ranked as the fastest-growing category of solid waste by the Environmental Protection Agency. Beyond their ever-increasing volume, end-of-use PCs present direct environmental threats, if simply disposed in a landfill; that is, PCs contain lead, cadmium, mercury and other heavy metals. In this example, we can follow the reverse logistics principles, when the computer is dismantled in modules that:

i) can be directly reused as spares: CD ROMs, hard disks, the keyboard etc.

ii) can be remanufactured into new products: old chips get used in electronic toys, and

iii) the rest is recycled. It is worth noting that a computer's processor has gold tips, the motherboard is made of copper, fiber glass, and silver and gold connectors, the frame is made of steel and the outer casing is made of plastic.

Anyway, with new or old functionality the product (or parts of it) enters the market again where it may also go through several trading cycles. This concept is denoted by the closed loop between “new use” and “trading mechanism” in Figure 1. Certainly, at some future point in time, the products originated from the initial purchase will reach again the end-of-use return in the reverse logistics network. To complete this point, we present the recycling scheme for ICT in the Netherlands. Since January 1st 2001, V-ICT receives contributions from manufacturers and importers of ICT. They pay per recycled product plus 1 NLG for products without active manufacturers. Consumers and companies return their old equipment to retailers or municipalities without paying disposal fees. V-ICT, in turn, pays companies like MIREC and Computer Recycling Service to recycle the ICT equipment.

In a conventional reverse logistics network, information flows coincide with product flows, but they have a phase delay compared to physical flows; that is, information are generated by a physical process performed on some physical flows. In this paper, we show that ICT can be used to get information on the upcoming return before the physical flow reaches the process.

3 A Virtual Reverse Logistics Architecture and its application for end-of-use PCs

In this chapter, we describe the architecture of a virtual reverse logistics network and the functional decomposition of the implementation for handling returns of PCs first into a set of top-level subsystems whivh are further decomposed into processes and functions by mean of object-diagrams.

3.1 A Virtual Reverse Logistics Architecture

As shown in Figure 2, the collection and inspection processes have been substituted by data collection an decision making systems, which use WWW technologies to extract from potential returns data on their configuration and condition and evaluate if upcoming returns should be directed for reuse, re-manufacturing, recycling or disposal. Logistics processes are depicted as rectangulars and product-flows as solid arrows. Subsystems are denoted as rounded rectangulars and information flows as dotted arrows.

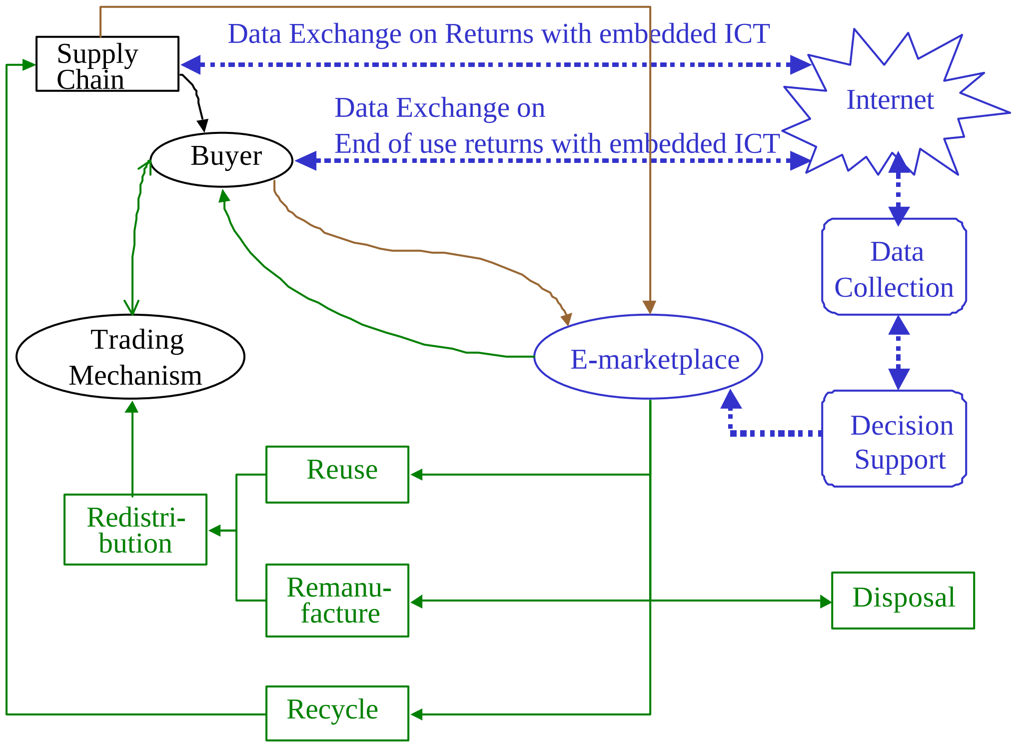


Figure 2 An architecture for virtual reverse logistics networks

The next subsection discusses the functional decomposition for the implementation of a virtual reverse logistics network for PCs, called RL4PCs.

3.2 RL4PC System Overview

The RL4PC system will be based upon the 3-tier software architecture. The following diagram shows a simplified form of this architecture:

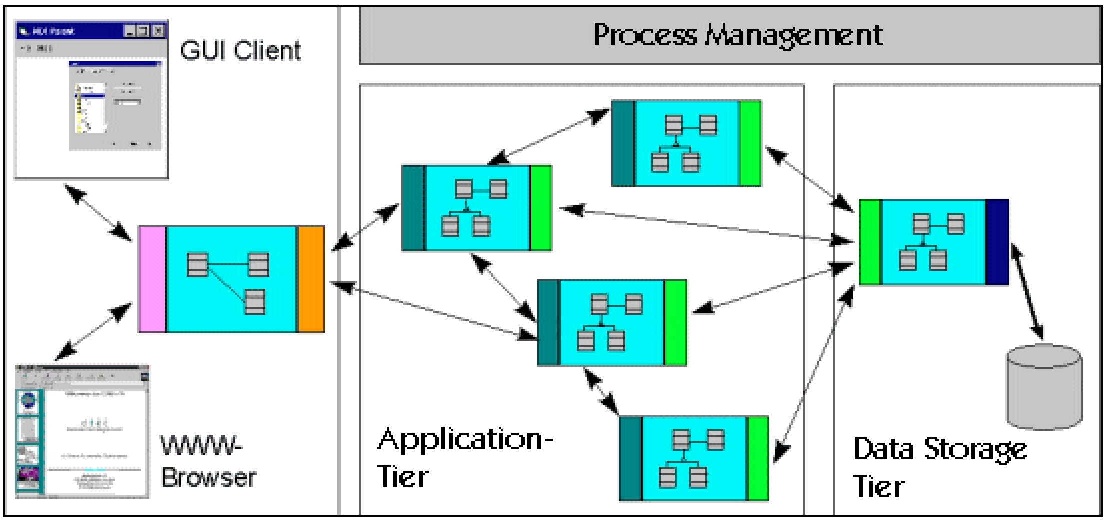


Figure 3-3 Typical 3-tier Architecture

The proposed system is designed based on the Model View Controller design pattern. The **Model-View-Controller** (**MVC**) design pattern was first developed using the Smalltalk programming environment for the creation of user interfaces. It is a popular OO pattern and is often referred to in the literature.

The goal of the MVC design pattern is to separate the application object (model) from the way it is represented to the user (view) from the way in which the user controls it (controller).

The **Model** object knows about all the data that need to be displayed. It also knows about all the operations that can be applied to transform that object. The **View** object refers to the model. It uses the query methods of the model to obtain data from the model and then displays the information. The **Controller** object knows about the physical means by which users manipulate data within the model. Figure 3-4 shows a network diagram between the components of the MVC.

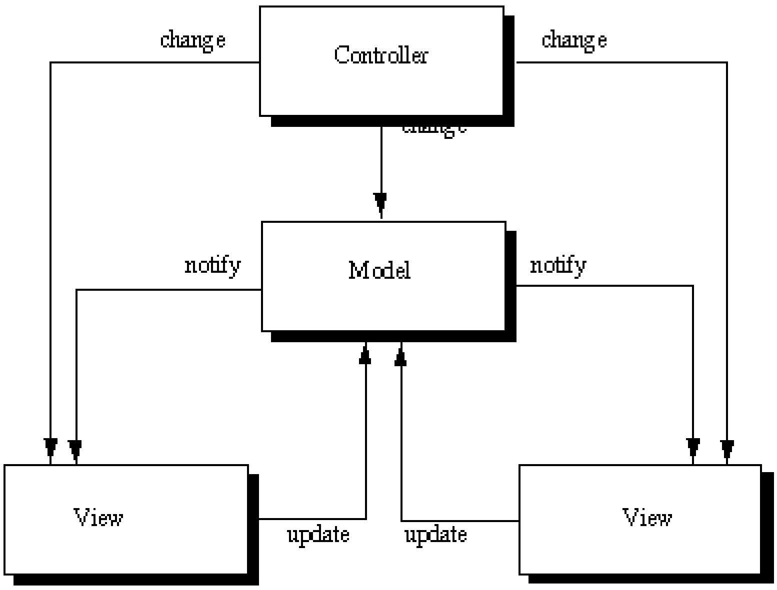


Figure 3-4 Relationship between model, view and controller objects

In the proposed system, the client tier (View) will be based upon a standard Web Browser, the data storage tier (Model)- also called "the repository" - will be implemented as a RDBMS, and the application tier (Controller) will be implemented by means of Java Servlets and Java Server Pages supported by an Application Server.

The following component diagram represents a first architectural view of the entire system. The components with the stereotype application are generic applications while the components with the stereotype RL4PC are subsystem related components. The components without a stereotype are RL4PC COTS.

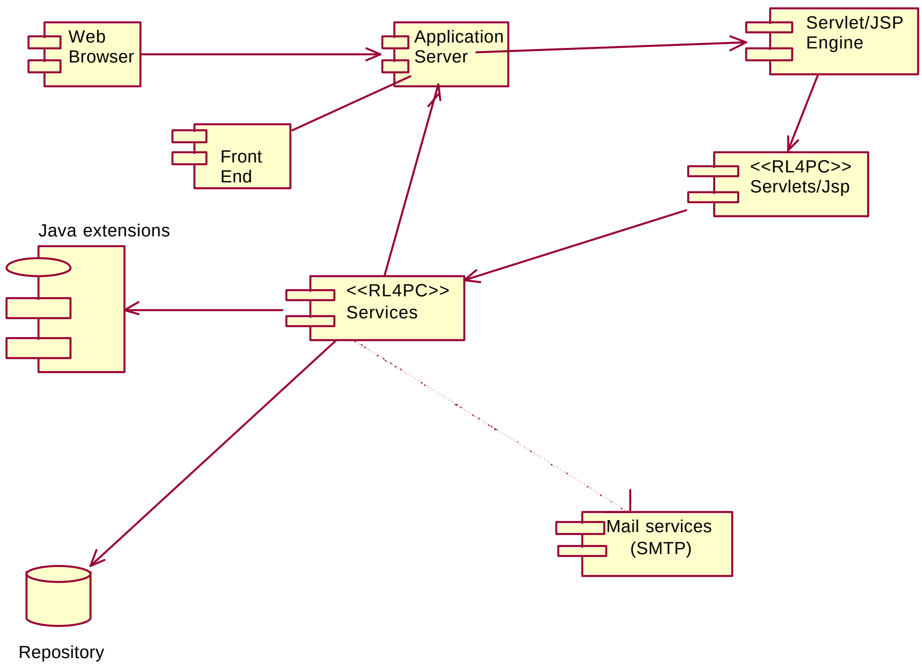


Figure 3-5 Component Diagram - Architecture overview

Table 3-1 summarizes the RL4PC components depicted above.

Component	**Description**
Servlets / JSP	Servlets or Java Server pages running on the Servelt/JSP engine of Apache Tomcat.
FrontEnd	Static HTML, DHTML, JavaScript served by the Tomcat Server. Execute on the web browser.
Services	Java classes providing various services. Run on the Java virtual machine of the Application server.

Table 3-1 Components Overview

The mapping between the above-mentioned architectural components and theRL4PC COTS is presented in Table 3-2.

COTS	**Architectural Component**
Apache Tomcat 3.2 Application Server	HTTP Server, Servlet/JSP Engine
Micrososft Access DataBase	Repository
Java 2 EE	Specific Java Extensions: Java Mail, Servlet API, Java Server Pages (JSP), Java Activation Framework and Java DataBase Connectivity (JDBC) 2, from the Java 2 Enterprise Edition (EE)

Table 3-2 COTS vs Architectural Components

As stated previously, the system is decomposed into four subsystems; and the detailed technical architecture will be described in four related sections, after introducing a set of building blocks shared by all subsystems.

3.3 Building blocks

The following components – shared by the four subsystems – form the basis (or building blocks) of the CS/MIS system.

- **Repository**: holds all application data. The persistent storage of the repository is guaranteed by the use of a relational database system. All textual data will be stored in Unicode format.
- **Application Server**: accepts/process all HTTP requests.
- **Security**: controls system access in conjunction with the Java Cookie technology.
- **Mailer:** sends a notification to the appropriate recipients of the system, every time a new request or offer has been successfully submitted.
- **Presenter:** presents the appropriate JSP or html according to the user status (registered or not registered) and according to the user request.

The Security, Repository and Presenter component are part of the *Services* component.

The following diagram illustrates the dependencies between these components.

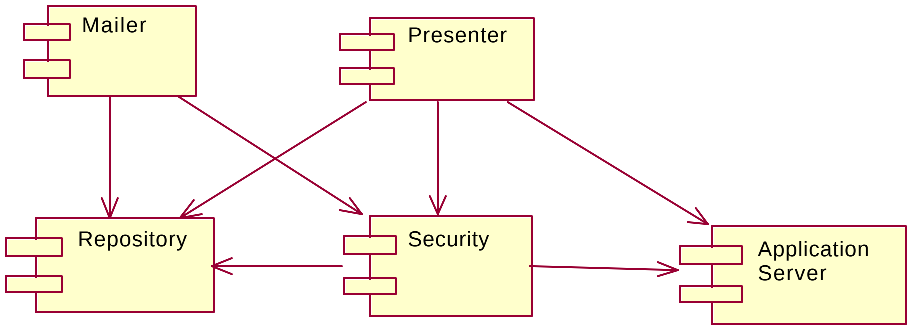


Figure 3-6 RL4PC Building Blocks

Table 3-3 shows the relation between the architectural components and the Java Servlets/JSPs implementing the component functionality.

Architectural Component	**Java Servlets / JSPs**
Mailer	SendMail.java, MailObject.java,
Presenter	OfferServlet.java, RequestServlet.java, ReuseServlet.java
Repository	Form.java, RequestForm.java, Reuse.jsp, Request.jsp, Offer.jsp
Security	Login.java, Logout.java

Table 3-3 Architectural Components vs. Java Servlets / JSPs

3.4 System Decomposition

From a business perspective, the RL4PC consists of the following six subsystems:

- Handling Registration
- Handling reuse, disassembly or recycle user requests
- Handling requests for the available offers
- Handling offers

- Receiving/sending e-mail reports
- Hardware Detection

From a technical point-of-view, a seventh and eighth subsystem, addressing the system security (authorization) may be added (Login and Logout Subsystems)

3.4.1 Registration Subsystem

This subsystem enables the users to register to the system. For the registration the user's e-mail address and password are required. These are firstly checked for validation and then checked for authentication. The validation check is performed on the client's browser and any user error messages are displayed instantly.

The authentication is performed by examining the provided user details against the existing users stored in the database in order to avoid two users from having the same registration information. The authentication is performed by querying the database for a match only on the user's e-mail address. The user defined password is required for login purposes (see section 3.4.2). Since the e-mail addresses are unique this subsystem provides a security mechanism as well because both validation checks have to succeed in order to store the user details into the system.

Furthermore, in order to be able to track user's requests this subsystem creates application cookies based on the user's registration information and stores them in the user's browser for later use. Therefore once the user registers into the system a cookie with the e-mail and password is created and stored in the user's browser. This allows the user to navigate through the system without any additional login.

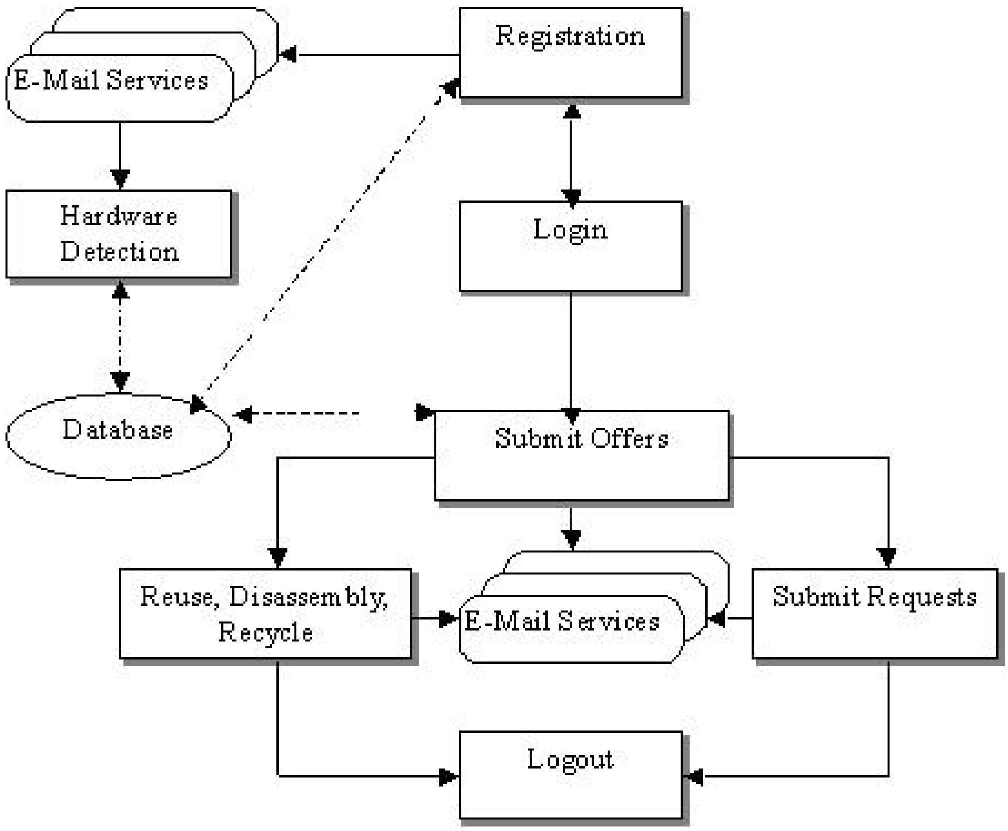


Figure 3-7 RL4PC Subsystems Architecture

The following figure shows the various processes, which form the Registration subsystem:

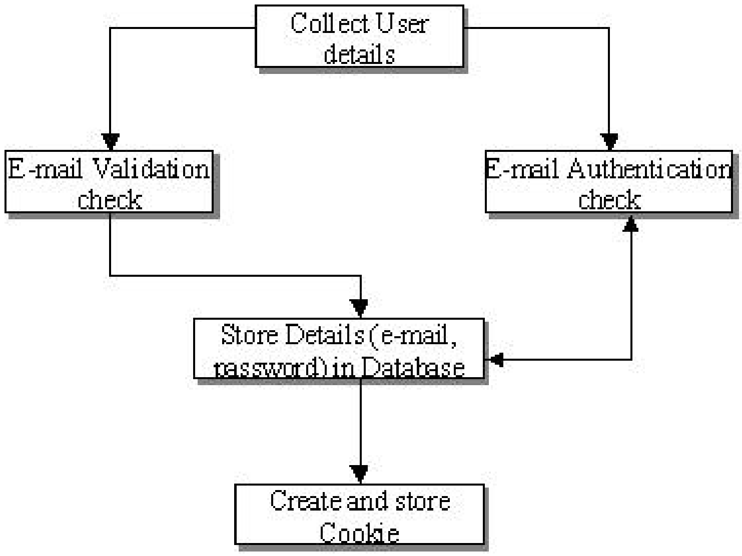


Figure 3-8 Registration Subsystem

3.4.2 Login Subsystem

This subsystem enables the registered users to login to the system. For the login the user's e-mail address and password are required. As in the Registration subsystem (see section 3.4.1), user details are checked for validation. Since the Registration subsystem provides an authentication mechanism, in the Login subsystem authorization is required. The validation check is performed on the client's browser and any user error messages are displayed instantly.

The authorization is performed after examining the provided user details against the existing users stored in the database. The authorization requires both values of user details (e-mail address and password) to match one database entry. This means that the authentication provided in the Registration subsystem has to be successful in order to find one existing entry in the database and so pass the authorization phase (Login) successfully.

Furthermore in order to be able to track user's requests this subsystem creates application cookies stores them in the user's browser. These are created after a successful login and the contents of the cookies are based on the login information. This feature allows multiple users from the same computer to access the web-site without interfering with each other.

The following figure shows the various processes, which form the Login subsystem:

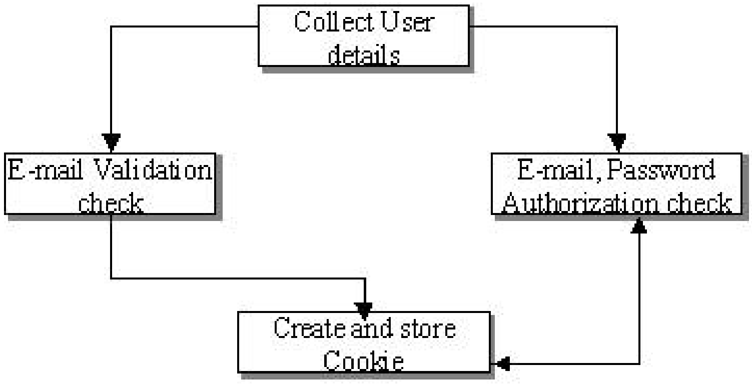


Figure 3-9 Login Subsystem

3.4.3 Logout Subsystem

This subsystem enables the logged in users to exit the system. Once the logout option is pressed, the system searches the client's for stored application cookies matching the provided login information. Once this cookie is found the system removes it from the client's browser. In case that no cookie was found, this means that the user has either not registered or has not logged in to system. Then a user message is displayed stating the cause of the Logout failure.

In case the user exits the system without pressing Logout he/she will remain logged in to system. So, in the next visit to the site he/she will already be logged in.

At this point it has to be mentioned that it is suggested to users for better operation to logout before exiting the system.

The following figure shows the various processes which form the Logout subsystem:

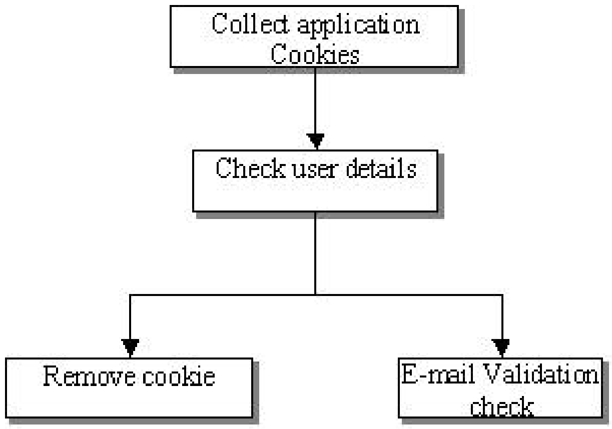


Figure 3-10 Logout Subsystem

3.4.4 "Submit an Offer" Subsystem

This subsystem is responsible for handling user offers for specific Computer Components. The user is able to select from a wide range of computer components according to the specification of the components he/she wishes to offer. The system dynamically after each selection proposes a price for the selected component. For the completion of the offer the user has to press the submit button.

In order to access this subsystem the user has to register first. If the user has already registered he has to login to the system by providing the registration information (e-mail address, password). Once the "Submit an Offer" option is selected this subsystem searches for RL4PC cookies from the client browser which where created either during registration or during login.

If the search is successful it connects to the database, retrieves all the available computer components and creates dynamically the drop down lists. Once the user has pressed the submit button to complete the request, the Offers form is checked if all the required lists have been selected. In case the check is successful an entry to the database is made using the details from the user registration and a user message is displayed indicating the success of the request.

The following figure displays the various processes, which form the Offers subsystem:

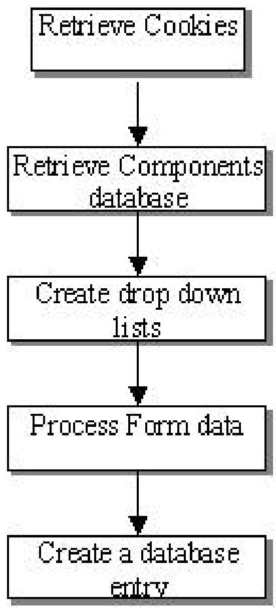


Figure 3-11 "Submit an Offer" Subsystem

3.4.5 "Make a Request" Subsystem

The user of the system is able to submit a request for some particular computer components. The "Make a Request" subsystem is similar- from the design point of view- and is dependent –

business wise- to the "Submit an Offer" subsystem. The user is able to select from a wide range of computer components and submit his/her request.

This subsystem first retrieves all the cookies from the client's browser and checks from the cookie information if the user is registered (so, he/she is using the system for the first time) or if he has logged in to system. After the check is successful the drop down list boxes containing the available components, are created. The available components are based on the user offers that have been made so far. Therefore the requests subsystem displays as many computer components as they have been offered at the time of the request.

After the dynamically creation of the components drop down list boxes and once the user has chosen to submit his/her request the form data are checked for validity and any error messages are displayed to the user instantly. On successful submission of the request, a message is displayed to the user indicating the success or failure of his/her request.

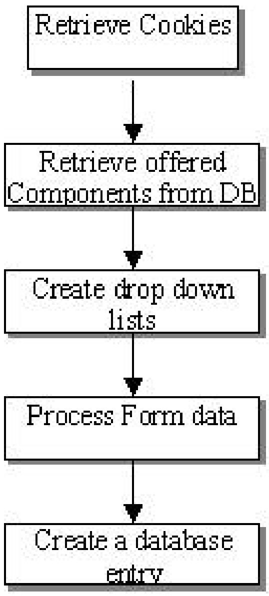


Figure 3-12 "Make a Request" Subsystem

3.4.6 “Reuse, Disassembly, Recycle” Subsystem

This subsystem is based on the offers that have been successfully processed so far. For this reason only registered users are allowed to use this facility. Therefore on selection of this option the system checks if the user is registered. This check is performed by retrieving the cookies stored on the client’s browser and checking them against the users stored in the database. If the check is successful the user is presented with all the offers that have been made from him/her so far.

Each offer is a hyperlink that displays more information about the selected offer. The following figure shows the processes involved with this subsystem:

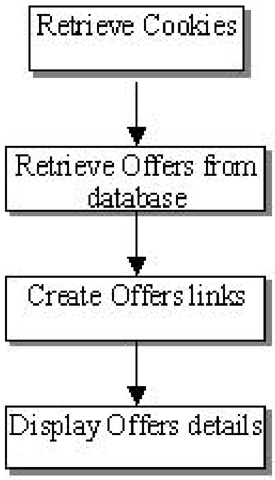


Figure 3-13 "Reuse, Disassembly, Recycle" Subsystem

3.4.7 Mailing Subsystem

This subsystem is responsible for the sending e-mail reports. These reports are automatically generated according to the user's actions.

More specifically once the user has submitted an offer, a report is generated and send to the user by e-mail. The report's contents are a description of the selected components along with a price list of the selected components. The purpose of this report is to re-assure the user that his/ her offer has been successfully received by the system and to provide a more detailed view of his/her offer.

The following figures show an Offer Report, which is generated by the system and send to the user:

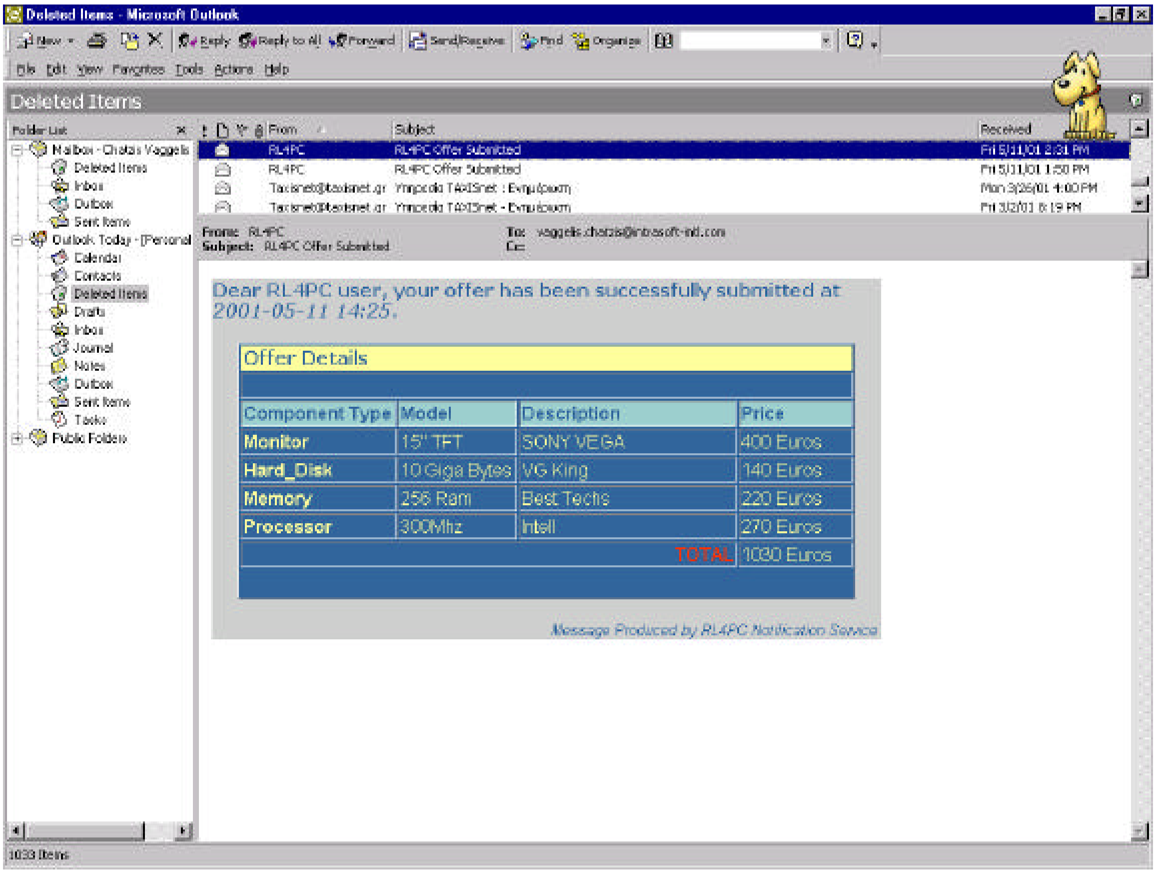
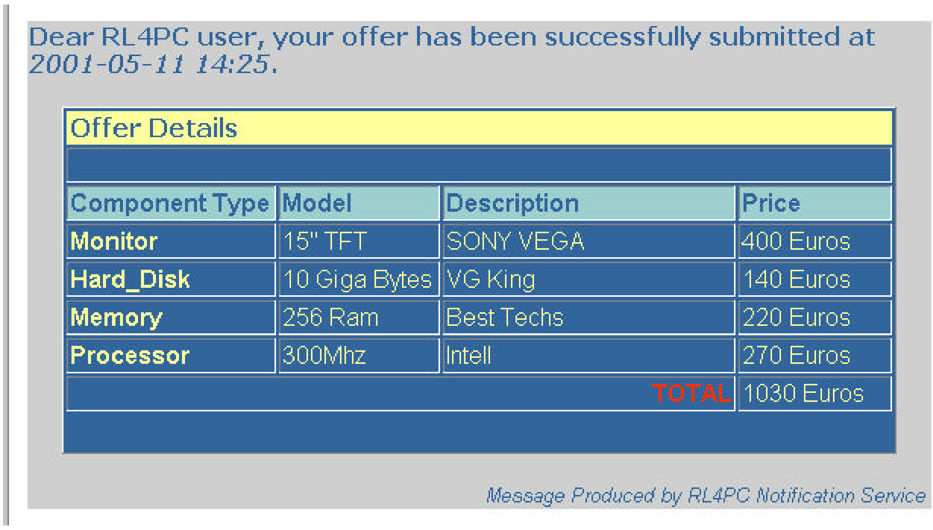


Figure 3-14 RL4PC e-mail Offer Report


Dear RL4PC user, your offer has been successfully submitted at *2001-05-11 14:25.*

Offer Details			
Component Type	Model	Description	Price
Monitor	15" TFT	SONY VEGA	400 Euros
Hard_Disk	10 Giga Bytes	VG King	140 Euros
Memory	256 Ram	Best Techs	220 Euros
Processor	300Mhz	Intell	270 Euros
		TOTAL	1030 Euros

Message Produced by RL4PC Notification Service

Figure 3-15 RL4PC e-mail Offer Report (maximized)

Apart from offer reports, the system generates request reports, as well. Therefore for each user request the system creates Request reports and sends them by e-mail to all the stored users which have offered at least one of the selected components. The number of the generated Request reports depends on the number of the offered components stored in database.

For example:

User A has made an offer for Components 1,2,3 and User B for components 2,3,4. Another user, User C makes a request for components 2,4.

In this case the system generates 3 reports one containing the details of the component 2 and send to the Users A and B and another containing the details of the component 4 and send to User B.

The display of the Request report has a similar appearance to the Offer report (Figure 3-15). The purpose of the Request report is to notify the user who has offered that particular component that a request has been submitted for his/her offer. The request report gives a description of the requested components, the requested price and details of the requested user. The following figures show a generated Request Report for a monitor. This e-mail request report is sent to the user who has offered that monitor:

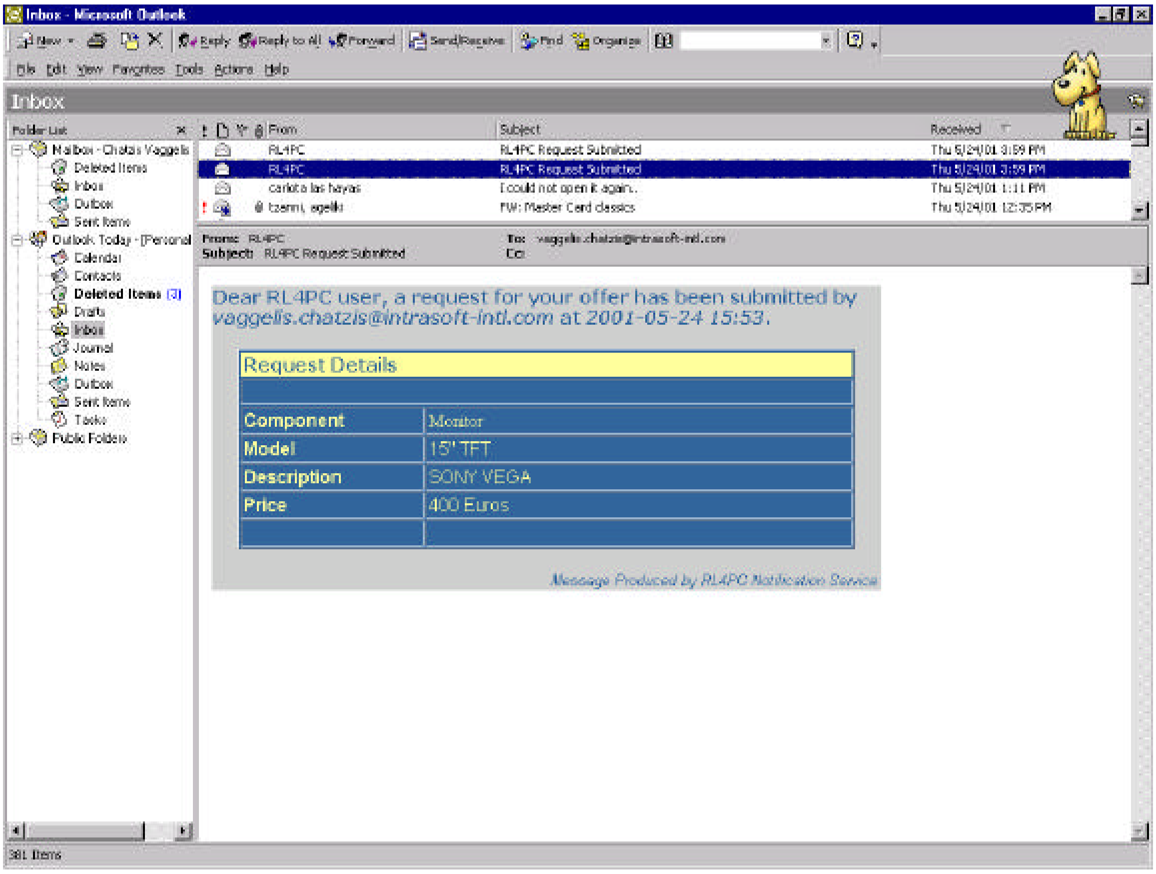


Figure 3-16 RL4PC e-mail Request Report

Figure 3-17 RL4PC e-mail Request Report (maximized)

The Mailing Subsystem is also used to monitor the RL4PC mailbox for specific messages in order to receive hardware specification reports from users which wish to offer their computer or selected parts from it (see, section 3.4.8).

3.4.8 Hardware Detection Subsystem

This subsystem allows the registered (or logged in) users to auto-detect the hardware specification of their computer (from where they are accessing this site). Once the "Hardware Detect" option is selected the user is prompted with assisting information regarding this feature.

More specifically the user has to connect to an external site from where he/she can download the *"SiSoft Sandra"* free tool. This tool once it is installed it can auto detect the user's hardware specification. Therefore the user must configure the tool properly so that the tool generated hardware detection report is send by e-mail to the RL4PC's e-mail address.

In order the system to accept the user's hardware reports it monitors its own mailbox for messages addressed to RL4PC with a relevant subject. Once a message of that kind is received the contents are parsed line by line and the description of the hardware components is expected. The specified hardware components are inserted to the database using the e-mail address of the message sender (the registered or logged in user). Therefore the user has completed an offer submission and the database has been updated.

The following figure shows the processes involved with this subsystem:

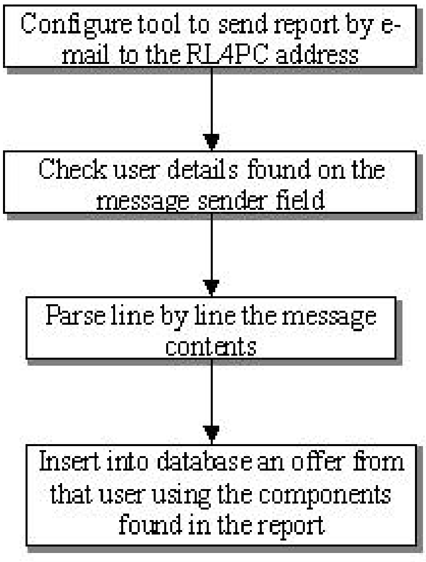


Figure 3-18 Hardware Detection Subsystem

To have a clearer view of the Hardware Detection report generated by the *"SiSoftSandra"* tool we refer to Figure 3-19, which illustrates a system report generated by the tool and sent by e-mail to the configuration e-mail address. It is clear from the sample that the user can configure the tool to generate and send a report that contans only those components that he/she wishes to offer

```
***** SiSoft Sandra Standard Version 2001.3.7.50 *****
------------------------------------------------------------------------------------------------
Unregistered Shareware Evaluation Copy. FREE for personal use.
See Ordering Document for information on the Professional version.
------------------------------------------------------------------------------------------------
Evaluation Licence to FEW at EUR
Report done by kokkinaki
System-Run ID: 1235-796
Report done on ???t?, 15 ?  a??? 2001 at 3:34:18 μμ
------------------------------------------------------------------------------------------------

<<< System Summary >>>
------------------------------------------------------------------------------------------------

< Computer System >
Name:                         KOKKINAKI
User Name:                      kokkinaki
Logon Domain:                     FEW/EUR
```

< Processor(s) >
Processor(s): Intel Pentium III @ 552MHz
Performance Rating: PR662 (estimated)
L2 On-board Cache: 512kB ECC synchronous write-back

< Mainboard and BIOS >
Bus(es): ISA AGP PCI USB SMBus/i2c
Multi-Processor Support: No
System BIOS: Phoenix Technologies Ltd. HZ.01.05US
System Chipset: Intel Corporation 82443BX/ZX 440BX/ZX CPU to PCI Bridge (AGP Implemented)
Installed Memory: 64MB (200% true allocated load)

< Video System >
Monitor/Panel: CPD-120AS
Adapter: Matrox MGA-G200 AGP - English

< Drives and Storage Devices >
GENERIC IDE DISK TYPE01: Disk Drive
GENERIC NEC FLOPPY DISK: Disk Drive
MITSUMI CD-ROM FX4820T!B: CD-ROM/DVD

< Peripherals >
Serial/Parallel Port(s): 2 COM / 1 LPT
USB Controller/Hub: Intel 82371AB/EB PCI to USB Universal Host Controller
USB Controller/Hub: USB Root Hub
Keyboard: Standard 101/102-Key or Microsoft Natural Keyboard
Mouse: PS/2 Compatible Mouse Port

< MultiMedia Device(s) >
Device: Crystal SoundFusion(tm) PCI Audio Accelerator
Device: Crystal SoundFusion(tm) Game Device
Device: Crystal SoundFusion(tm) Joystick

< Printers and Faxes >
Model: HP 2500C Series Printer
Model: HP LaserJet 6P

< Operating System(s) >
Windows System: Microsoft Windows 98 Ver 4.10.2222 A
DOS Sub-System: Microsoft MS-DOS Ver 7.10 A

< Network Adapter(s) >
Networking Installed: Yes
Adapter: 3Com Fast EtherLink XL 10/100Mb TX Ethernet NIC (3C905B-TX)

***** End of Report - Report created successfully *****

Figure 3-19 "*SiSoftSandra*" hardware specification report

3.5 System Configuration

The system can be configured by editing the *mail.properties* file. This file contains information regarding the Mailing Subsystem such as :

- The RL4PC hostname
- The RL4PC sender name
- The RL4PC mailbox name
- The RL4PC monitoring frequency
- The RL4PC username and password for the mailbox
- The message header and subject of the received hardware reports

These properties can be defined according to the required system operation. For example if for some reason the Mailing Subsystem is required to be de-activated the hostname must take the value "No". Other properties regarding the Mailing Subsystem or other subsystem can be configured if such an arrangement is required.

4. CONCLUSIONS

For virtual reverse logistics to extend to include other products, we view that future products will be designed to include self monitoring and telecommunication capabilities. In fact we can see the first step in this process with datalogger in Bosch equipment, imbedded numbs in the thread of a tire that show when it is time to change it and vehicles with on-board computers that remind the owner of an impenitent maintenance service. We also view the emergence of inexpensive wireless communications technologies. We believe that are many interesting research and application issues in the intersection of ICT platforms for reverse logistics purposes.

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