INTERNET-BASED COMMUNICATION INFRASTRUCTURE FOR AN ECO-ACCOUNTING SYSTEM USING WEB-BASED SERVICES AND RFID TECHNOLOGY

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ABSTRACT

The Internet-based information communication infrastructure for an ecological accounting system, so called myEcoCost, is reported in this paper, which is applied to deliver the ecological impact assessment results of products through the product' life cycle from one operation model within supply chain to another, predominantly from supplier to customer. The infrastructure consists of upperware, middleware, and resource layers. As a significant feature of the infrastructure, load balancing is developed to handle the information data within the myEcoCost system using the Web-Service application programming interface (API) to distribute the load of tasks across different computers. The case study has been conducted to transmit the product's ecoCost information from a supplier to a consumer over the Internet, which successfully validated the system developed.

Keywords—Communication infrastructure, ecoCost, environmental impact of products, Internet, load balancing, RFID, Web Services, Web-based interface.

INTRODUCTION

Supported by the Environment programme of the European Commission's Seventh Framework, an ecological accounting system is developed by myEcoCosy project [4]. The ecological accounting system measures products' ecological cost, or so called 'ecoCost' in short, throughout the product supply chain as shown in Figure 1 [1].

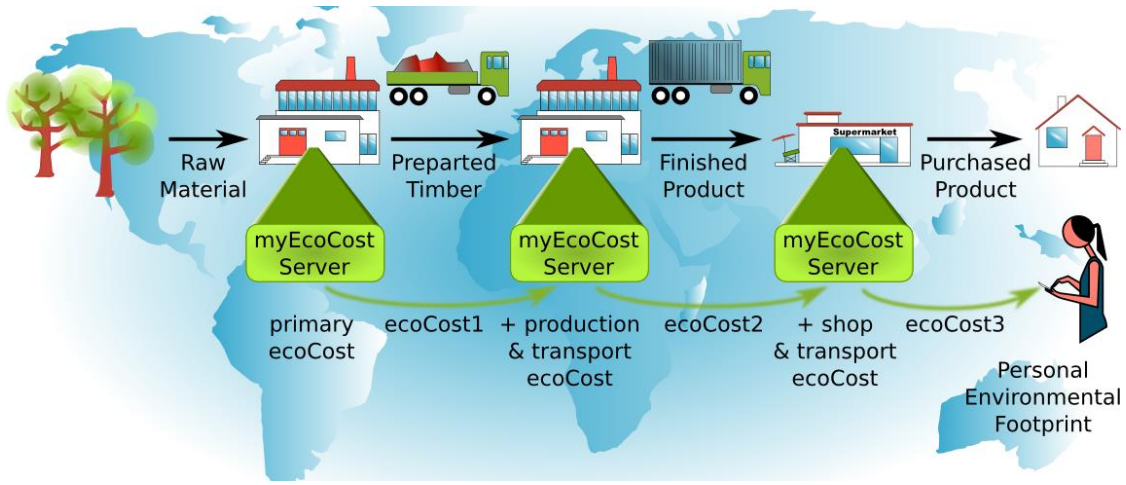

Figure 1 myEcoCost information flow

The myEcoCost project develops a methodology that defines a global collaborative network of resource accounting nodes. It provides a means of accounting for the usage of natural resources for products, services and technologies, to inform all economic actors on environmentally relevant information with dynamically calculated, near real time figures. Using an Internet-based Service Oriented Architecture (SOA), relevant and timely data is

passed from supplier to customer recursively through the whole value chain to produce ecoCosts for each product or service [1] [4].

The project aims at developing key Information and Communication Technology (ICT) and software to demonstrate the resource accounting framework and infrastructure in a proof-of-concept prototype, involving users, environmental data processors and policy makers [4].

To fulfil the aim of the project, an Internet-based information communication infrastructure for myEcoCost environment is developed. It works as a top-level platform to coordinate the inter-operation among the operation models, including sustainable production and supply chain, environmental space, generic accounting systems, process supporting tools, distributed laboratory, and end user systems.

SYSTEM OVERVIEW

The information communication infrastructure is applied to coordinate and manage all the systems, platforms and interfaces within the myEcoCost environment. The infrastructure consists of upperware, middleware and resource layer.

As the top layer of the information communication infrastructure, as shown in the Figure 2, the upperware is developed to manage the middleware, which consists of intermediate systems and platforms (Web-based services, RFID-based mobile access network platform, load balancing system, and resource management system). Using a Web-based interfaces over the Internet, the upperware interacts with the operation models within the myEcoCost environment, namely suppliers and consumers using PC and mobile devices [1].

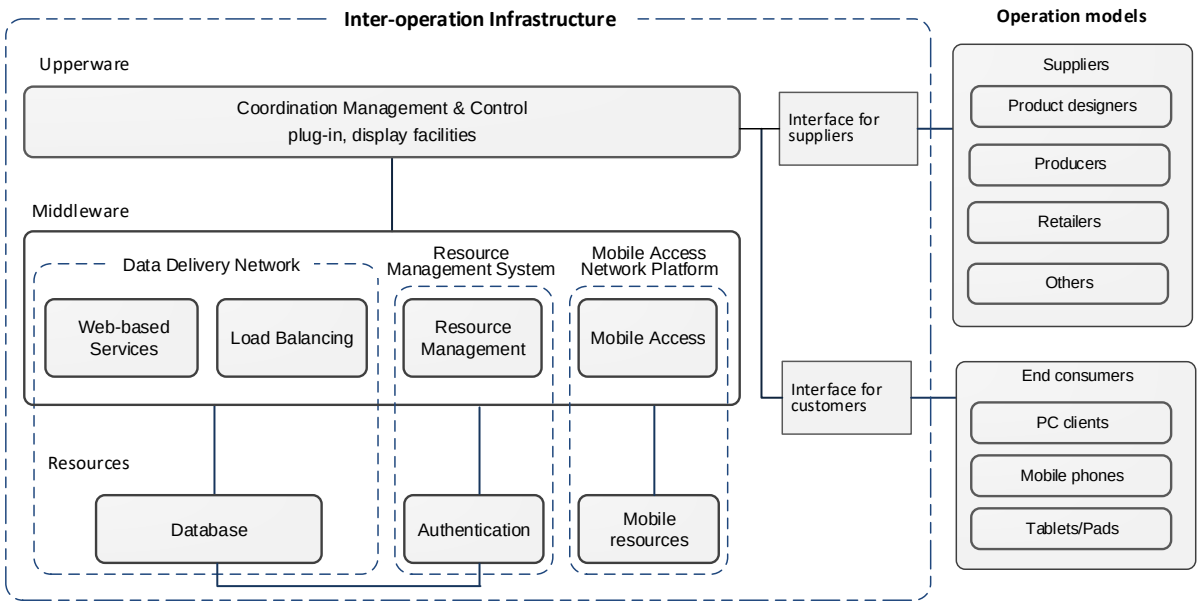

Figure 2 Overview of Information Communication Infrastructure

The major functions of the upperware includes controlling and coordinating mechanisms, plug-in and play facilities, to interact with the Middleware and integrate with resources (database, mobile facility and relevant resources).

The middleware's elements is connected to the upperware with the interface for the integration with middleware. To ensure that those interfaces are compatible with the upperware, the graphic user interfaces (GUIs) for the middleware are developed, which allows the manager to configure the systems and platform to manipulate the inter-operation among the systems. The necessary interfaces and GUIs are adapted to the different systems

and platforms, and able to track and control the working status of those systems and platform through the wireless remote connectivity.

The middleware with the above systems and platform provides the following functions: Web-based interfaces and services for the interaction with operation models, the distribution of loads throughout the infrastructure, the optimisation of the flow of ecoCost information, management of the interfaces and related resources, and the mobile authorisation for the access to consumers. The resource layer interacts with the middleware and connects to the upperware via the interfaces.

TECHNOLOGIES APPLIED IN THE COMMUNICATION INFRASTRUCTURE

The major technologies used in the information communication infrastructure include Web-based services, RFID-based mobile access, load balancing, and resource management, which are detailed in the following sub-sections.

1.1 Web-based Services

Web-based services within the information communication infrastructure are used to produce and transfer the environmental impact value of products, which is called 'ecoCost' of products, from one operation model to another, for example, from a supplier's business server to a consumer's client computer. The major services implemented in the infrastructure contains invoice service, life-cycle inventory (LCI) service, consumer and business registration service, consumer account/HMI service, and software download service.

As a core service of myEcoCost system, the invoice service delivers ecoCost data from one business server to another one, and then to consumers. The data delivered by the invoice service include eco-invoice, eco-quote and eco-cost.

The invoice service allows for business servers to send and receive ecoCost data through the information communication infrastructure. For example, the business server initialises the contact with the infrastructure and submit a 'Send' request via calling the interface exposed by the Web server. Then the Web server passes the request on to the application server. The request includes ecoCost data to be transmitted to the next business in supply chain, and the ID of a session with which a business user is able to interact with the infrastructure. The application server performs the request via placing the ecoCost data in the correct location in the invoice database. After the operation successes, Web server sends back the result 'Success' to confirm with the business server regarding the completion of the operation.

1.2 Radio Frequency Identification (RFID)

Within each myEcoCost product, particularly electronic product, there is a RFID-based tag attached. The tag is written by the product's serial number. With identifying the serial number, the ecoCost information of product is able to be accessed from the myEcoCost system and then received by a consumer.

Also, the RFID technology is used to validate the consumer's identity when they try to access the product's ecoCost information from the myEcoCost system. Compared to traditional identification mechanism such as username/password, RFID simplifies the authentication process and facilitates the operation of consumers who is not required to enter the confidential [5] [6]. A RFID reader is used to capture the ecoCost information and relevant software is developed.

1.3 Load Balancing

Load balancing is developed to handle the information within the myEcoCost environment, which is streamed through the Web server and application server developed in the communication infrastructure. The load balancing system is able to automatically distribute the load of tasks across the different computers, to process and optimise the flow of myEcoCost information.

A typical load balancing system consists of a load balancer and load workers [1]. The load balancer is used to manage the distribution of load. With monitoring the physical computing resource of load workers, the load

balancer is able to distribute the load to the load worker which has the lowest usage. The above-mentioned physical computing resource includes CPU usage, memory usage, and load progressing in load workers [1].

Within the load balancing system developed, there are a Web server, two application servers and a database server, which are deployed on the public/internal network available. The Web server works as a "load balancer" to distribute the load, which is related to a task/request from supplier or consumer, to the application server having the lowest usage; and the application server acts as a "load worker" to take over the load. In this case, the Web server itself does not execute a special task, while application servers are to perform the specific tasks assigned, so that the load is distributed across the different application servers. With interacting with the database server, the application server executes the querying, such as getting ecoCost information, and then returns the result to the Web server.

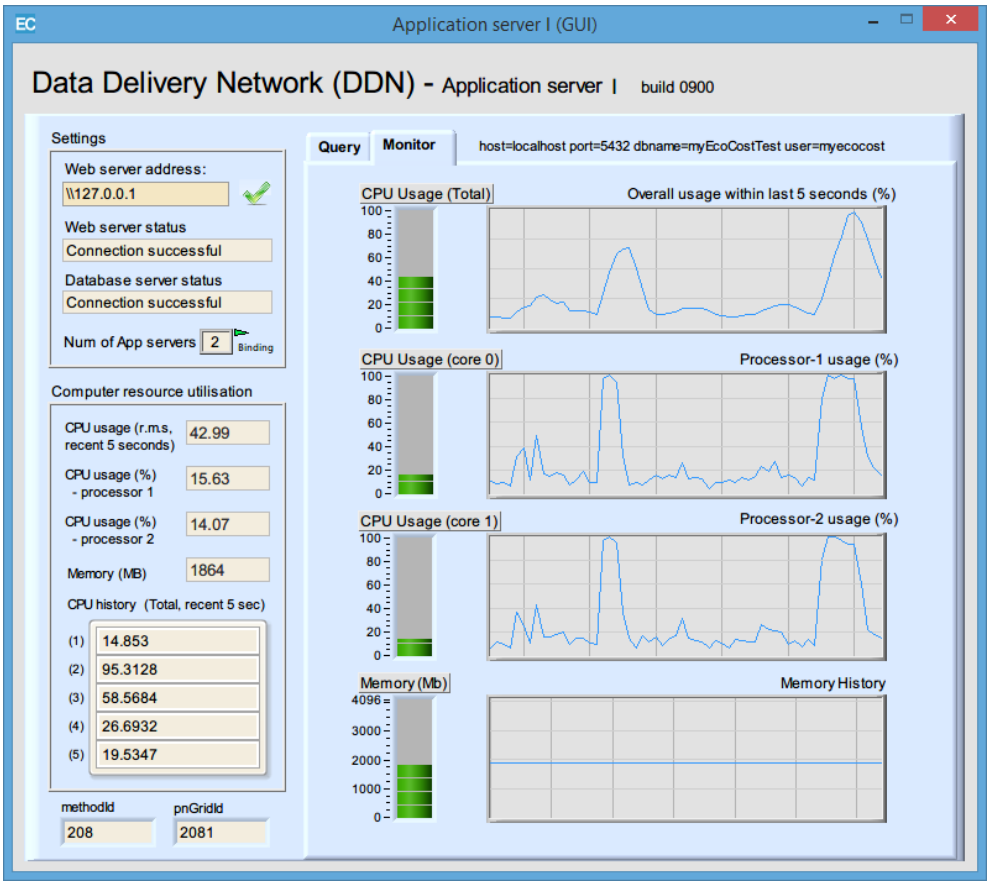

Figure 3 Monitoring of physical resource of the application server computer, including the usage of CPU and memory and load progressing in the computer

Figure 3 presents the usage of an application server via capturing the physical resource information of the computer. The application server's usage is determined by a group of parameters relevant to the physical resource and operation status of the computer, including CPU (processing power), memory and load progressing. The lowest usage indicates that the computer is running the fewer tasks and has the higher idle rate than other computers operating in the same distributed management model. Each server works at a stand-alone computer in the location somewhere on the internal network.

1.4 Database

Based on the life-cycle impact assessment (LCIA), the products' ecoCost information is analysed, such as the ecological impact indicators throughout the products' life-cycle. The ecoCost information is placed in the database with the PostgreSQL database management system.

The database is installed on the database server, which closely works with the application servers for product querying purpose. Also, the Web server and application servers have their own databases, which are used to store temporary exchanging data in the computer locally.

CASE STUDY

The information communication infrastructure has been successfully developed to transmit the ecoCost information of products from a supplier to a customer over the Internet. Within this case study, a wireless networking environment (WLAN) formed by a Web server, two application servers and a database server, is set up to transmit the ecoCost information of products to a customer. With the wireless network established, the ecoCost information within the infrastructure is handled via distributing the requests/tasks to the different application servers.

A consumer ID card is made for the consumer to log in the myEcoCost system. There is a RFID-based tag embedded in the card, which includes the user's details (see Figure 4). Also, a computer mouse is used as a new product to be sold to the consumer for demonstrating the process. The Web server, as the core of the WLAN, is to validate the detail of consumer via the Internet and then send the ecoCost information of the product to the customer.

Figure 4 myEcoCost consumer ID card with RFID-based authentication

With a RFID-based reader, the consumer ID card is scanned, and a 13-digit serial number is acquired. To verify the consumer's identity, the serial number is sent to the Web server by invoking a Web-based service over the Internet. Based on the actual use of the application servers, the Web server allocates the request of validating the serial number to an application server with the lower usage. The necessary interaction with the database is conducted between the application server and the database server. After successful verification, the consumer is authorised to log in to further the interaction with the Web server. The consumer is enabled to obtain the product's ecoCost information reflecting the ecological impact of product.

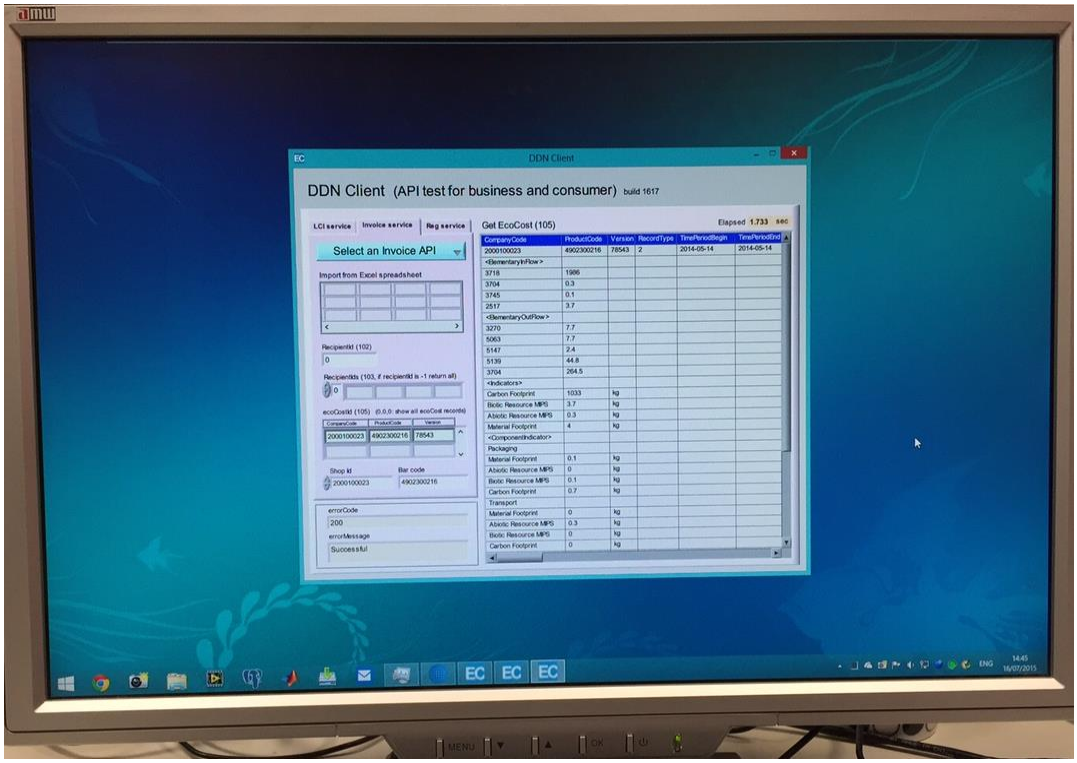

Figure 5 Product ecoCost information showing on the consumer's client computer

Then the computer mouse embedded with a RFID tag is read by the reader. The serial number of mouse is acquired from the tag, and sent it to the Web server to obtain the product information. The Web server works on the querying request and transmits the result back to the consumer client. Figure 5 presents the ecoCost information of the product, which was received from the Web server and shown on the consumer's client computer subsequently. The ecoCost information received includes the product's environmental impact indicators, such as carbon footprint (CF) and material footprint (MF), and the details of process flow and elementary flow relevant to product manufacture.

CONCLUDING REMARKS

The Internet-based information communication infrastructure for the myEcoCost ecological account system has been successfully developed. The information communication infrastructure is applied to produce ecoCost information of products throughout the life-cycle, and transmit the summary ecoCost from suppliers to consumers, which is a novel application in this area. With the environmental impact value of product, so-called ecoCost information, the consumer is enabled to make a comparison between different products, and choose and purchase a sustainable product.

The infrastructure consists of the following three layers: upperware, middleware, and resources. The upperware layer controls the middleware (Web services, load balancing, resource management, and RFID-based mobile access network) and associated resources, and interacts with the operation models operating in the myEcoCost environment, which is shown in the overall structure of the information communication infrastructure (see Figure 2). The case study illustrated the method developed via delivering the ecoCost information of a product from a supplier to a consumer through the Internet, which has successfully validated the system developed.

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REFERENCES

[1] D. Su & W. Peng (2014), "Internet-based Inter-operation Infrastructure for Data Management within an Ecological Accounting System", *Proceedings of the International Conference on Computer Science and Software Engineering (CSSE2014)*, 18-19 October 2014, Hangzhou, China, Pp. 759-772.

[2] W. Peng & D. Su (2013), "Development of an Online Recycling Monitoring System for Customer Electronic Products Using the Advanced Internet, NFC and RFID Technologies", *Key Engineering Materials*, Vol. 486, 2013, Pp. 81-86.

[3] D. Su & W. Peng (2012), "Application of PDA and wireless technology in a server-client structure for remote machine condition monitoring", *Key Engineering Materials*, Vol. 450, Pp.449-452

[4] myEcoCost, European Commission FP7 myEcoCost project entitled "A Consumer Oriented Prototype - Forming the Nucleus of a Novel Ecological Accounting System" (Grant No. 308530), project duration: October 2012 - October 2015.

[5] D. Zhang (2012), "Radio Frequency Identification (RFID) Technology", *Telecommunications Technology*, Vol 2, Pp. 86-88

[6] M. Isard, M. Budiu, Y. Yu, A. Birrell & D. Fetterly, Dryad (2007), "Distributed data-parallel programs from sequential building blocks", In EuroSys, Pp. 59–72