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Data Integration between Farm Management System and Web Based GIS

A case study of Droevendaal Farm, Wageningen University and Research Centre

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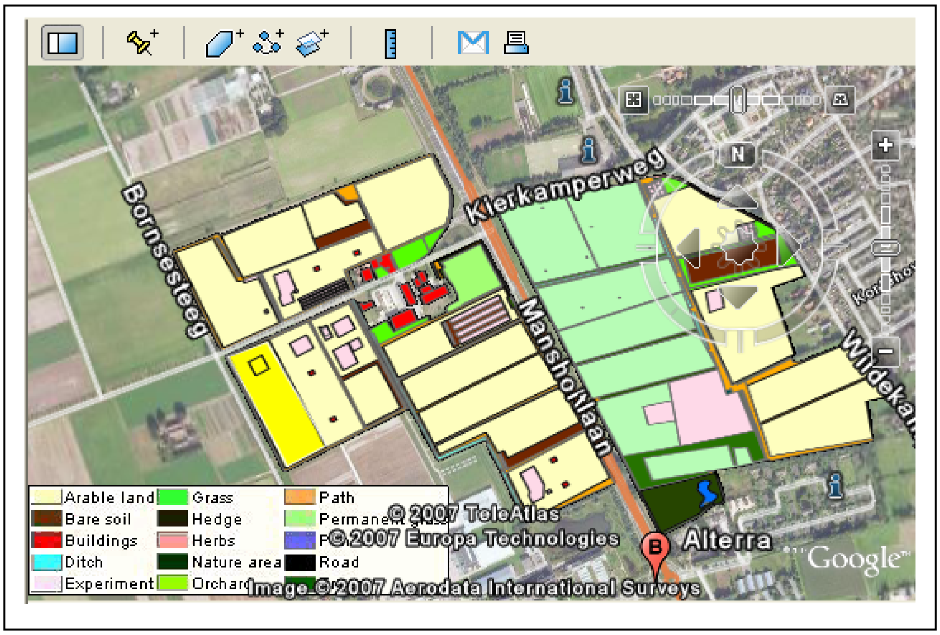

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Data Integration between Farm Management System and Web Based GIS

A case study of Droevendaal Farm, Wageningen University and Research Centre

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Foreword

This thesis report is part of the MSc. Geo-Information Science.

First of all, I would like to thank Dr. Ir. Sytze de Bruin, my supervisor, for giving me the initial idea of the thesis as well as a lot of support and advice throughout the period of my work, Ing. Aldo Bergsma for several technical support and advice, Mr. Wouter van der Veeken of ISAGRI for providing us a temporary licence for the Isateelt software and for his help with exporting the EDI Teelt message, and Mr. Joop van Westeneng of Plantkundig Proefcentrum Wageningen (PPW) for providing us a copy of the FMS database.

It was not my bad time that I had to spend 6 months on this thesis. Most of the things are new and challenge for me. The EDI-Teelt message is in Dutch. And now, “Ik spreek een beetje Nederlands”. I have learned many things from this thesis. And I realized that writing this thesis report was not easy for me at all. But it is worth learning, isn’t it?

May the “Integration” be everywhere on Earth.

Supawoot Tripasai
Wageningen, February 2007

Abstract

This report studies and implements data integration between a Farm Management System (FMS) and a web based GIS, based on the case of Droevendaal Farm, Wageningen University and Research Centre, the Netherlands. In addition, the feasibility of using Google Earth as an alternative viewer for the web based GIS is evaluated. An EDI Teelt message is an XML message which is generated by the FMS. EDI Teelt is a standard format being used in the Netherlands to communicate between farmers and buyers. Implementation of EDI Teelt for data exchange complies with XML/EDI framework. The data integration is implemented based on the framework. XSLT is used for data transformation from EDI Teelt message into another XML message structure compatible with the web based GIS. The implementation is done by using a web page interface to get the input EDI Teelt document, upload it to the web based GIS' server, transform it by XSLT into the desirable format, and import the transformed document to the database. However, the real implementation for the Droevendaal farm is not possible because the EDI Teelt message generated by the FMS is problematic. Some data in the FMS, which are supposed to be included, are not included in the EDI Teelt message. It will be solved in FMS software update. In addition, some data in the web based GIS are not in EDI Teelt message such as pasture. Study of using Google Earth as an alternative viewer for the case of Droevendaal farm shows a negative result. Google Earth is not appropriate for this particular application because of the ineffectiveness of two important functionalities namely communication with the database and the interaction with the map, which is ability to query the map. In addition, data accuracy of the imagery provided by Google Earth depends on the location. And it is poor in Droevendaal farm area. However, let alone these two functionalities as well as the data accuracy, Google Earth mostly shows equivalent and better effectiveness to the existing system which was implemented by using ArcIMS. Therefore, applications that do not rely on communication with the database and the interaction with the map, and data accuracy is not important can be well implemented using Google Earth as a viewer.

Contents

1. General Introduction

1.1 Context and Background

Farm management systems are deployed by many farms worldwide. The Netherlands is a small country, comprising about 41,528 km^2, where agricultural sector is very important. It is one of the three largest exporters of agricultural products in the world with approximately 19,240 km^2 cultivated areas where 8,209 km^2 are arable crops (Agricultural Economics Research Institute (LEI), 2005). In a recent survey under arable farmers and cattle farmers, 45% of the farmers used a farm management system (FMS), but only 19% used a FMS with a geographical component (de Bruin, 2006, personal communication). With web based Geographic Information System (GIS) technology, it is possible to publish the map on the Internet with some GIS capabilities which will improve visualization as well as accessibility of the data.

In general, a web based GIS provides GIS services on the Internet, which can be accessed via web browsers. Visualization and accessibility of the spatial information, including farm information, could be improved by deployment of the web based GIS. It is a technology that is currently in trend. As the use of the Internet became more widespread, there came a remarkable growth in web based GIS (Chang and Park, 2006). Many of them are tailored to specific tasks (Carver et al., 2000).

Along with the growth in web based GIS, needs of data integration have arisen in many fields including farm management. For example, there is a project of agriculture and environment in the Balkans and Turkey which integrated systems are needed for monitoring Agri-Environmental Measures (AEMs) and Good Agricultural and Environmental Condition (GAECs) in order to balance the stakeholders (farmer, agriculture, environment and administration and control). In this case, agri-environmental and farm management systems must be able to integrate and data exchange is crucial because it enables controls and checks data exchange between farmers and administrations and it helps farmers to set up efficient management systems (Walloon Agricultural Research Centre, 2006).

Another important factor that has driven the data integration in food safety management is the data traceability of food products. In this context, traceability could be defined as the ability to follow a product batch and the ingredients of the product batch forward through the production process via the distribution chain to the immediate customer and backwards to the supplier of the ingredient services and packaging, and processes (Ayalew et al., 2006). Traceability of food products on one hand, and cross compliance control on the other hand impose more and more information exchanges between farmers and related parties (Waksman and Masselin-Silvin, 2005). Traceability was established as a principle for food safety policy of European Union (EU) food law in order to facilitate tracing problems in case of outbreak as well as to provide incentives for producers to improve safety (Buzby, 2003).

Technically, Electronic data interchange (EDI) is a reliable means for the exchange of traceability data (Ayalew et al., 2006). Therefore, EDI has potential for such data integration. However, most of the farm management systems, as well as most proprietary systems, are developed with their own principles and they may run into problems when such integration between heterogeneous application software, including the web based GIS, is needed. Therefore, challenges arise in implementation of data integrated systems. These might be overcome by using standard messaging language like Extensible Markup Language (XML).

Extensible Markup Language (XML) is a language initiated by World Wide Web Consortium (W3C). It is derived from Standard Generalized Markup Language (SGML) and designed especially for web documents. XML is considered as a self-describing language which allows users to encode data with meaningful structure and semantic and ability to create customized tags. It is ideal for data exchange among heterogeneous applications and increasingly plays an important role in data exchange on the Internet and also other environments. In 1997, XML/EDI was proposed by XML/EDI group to accelerate the adoption of EDI (Webber, 1998). It is a framework integrating XML and Electronic Data Interchange (EDI) to provide business, irrespective of size, and is a cheaper system to carry out electronic transaction with any trading partner worldwide (Ayalew et al., 2006). An empirical study showed that XML/EDI framework was good for exchanging documents between servers because all receiving XML documents agree on a set of standards (Lu et al., 2001). Moreover, there was a belief that due to low setup and operating costs, XML/EDI would become increasingly attractive to small and medium-sized enterprises (SME) and would be the key technology for exchanging business data in the future (Buxmann et al., 2005). As a result, this research study in part of data exchange is based on XML and XML/EDI.

Case of Droevendaal farm, Wageningen University and Research Centre

The Wageningen Plant Sciences Experimental Centre (Plantkundig Proefcentrum Wageningen, PPW: http://www.ppw.wur.nl/UK/) is a modern, multifaceted service organisation within the Wageningen UR Plant Sciences Group. The Experimental Centre offers services in setting up and conducting plant and crop experimental research and education to researchers and educators throughout Wageningen UR, and to external clients. PPW manages 232 ha of experimental fields in and around Wageningen under organic management. The experimental fields are used for field production of vegetables, arable farming, and grassland. Most of the fields can be irrigated. Among these, a farm of PPW is organic farming and the FMS used in the farm is ISAGRI, which is produced by a French company. ISAGRI has more than 25,000 customers for agricultural business all over Europe (http://www.isagri.com/).

The Uniform Resource Locator (URL) http://imsgrs.wur.nl/droevendaal/ links to a web based GIS application. Both the web application and most of the data shown (particularly geometry) are the result of earlier student work within the context of AMC2 course 2005, Wageningen University and Research Centre. Originally, it was developed by using the data from the FMS mentioned above. The web based GIS allows potential clients of the organic farm to check previous crops, fertilizer applications, etc. at agricultural field level online. It was implemented by using ESRI's ArcIMS as the map server. The existing database of the web based GIS employs Microsoft Access as the Database Management System (DBMS).

The updating of the web application currently involves several operations and much interaction. Therefore, this thesis research aims to study and implement data integration between the farm management system and the web based GIS based on this case. An automated procedure for updating the web content using data directly exported from the ISAGRI's FMS is implemented.

ISAGRI's FMS has an ability to export data into an XML based message called EDI Teelt message. This thesis research also studies the EDI Teelt and the XML/EDI in order to understand the standard as well as the feasibility of using EDI Teelt as the message to communicate with the web based GIS based on XML/EDI framework.

There are several possibilities for implementing a web based GIS, which are different in functions, efficiency, and technical and financial requirement. Therefore, not only the data integration part is conducted in this thesis research, but also study of an alternative of the web based GIS which receives the EDI messages. The study focuses on improvement of the database structure as well as the use of an alternative viewer.

The viewer chosen to study in this thesis research is Google Earth. For general usage, Google Earth is suitable for the activities such as planning a trip, getting driving directions, finding a house or apartment, finding a local business, and exploring the world. Launched in June 2005, Google Earth is very popular software which has attracted millions of casual users because of its ability to explore the earth, zoom from the space and right down to the street level. Its popularity with a growing number of scientists lie in the almost-equal ease with which it lets them lay data with a spatial component on top of a background imagery – a trick they can repeat with multiple data sets (Butler, 2006).

Goole earth was chosen to study in this thesis research mainly because of its availability of free version (available online at http://earth.google.com/), its popularity, its provided basic GIS functions, and its ease of representing and distributing the application as a Google Earth KML file (Hornbuckle and Christen, 2006). Moreover, there has been many potential of using Google Earth in scientific fields. Fore example, Lisle (2006) stated that it could be a new resource for geological study such as landforms, horizontal beds, faults, fractures and shear zones, folds, salt domes and salt glaciers, large-scale tectonic features, volcanoes and sheet intrusions, and meteorite craters. Study from Butler (2006) showed the feasibility of using Google Earth to track animal movements and behaviour from afar over several years. Smith and Lakshmanan (2006) showed that Google Earth is a useful tool for the integration of weather data with GIS information becase it allows easy real-time sharing of data. It can be seen from the product of National Severe Storms Laboratory (NSSL) at http://wdssii.nssl.noaa.gov/. More examples of Google Earth application can be found from Google Earth website at http://earth.google.com/. Other attractive attributes of Google Earth over other products have been stated as follows; the attractiveness, ease of use, visualization ability (Butler, 2006), and user access when offline. Negating the need for a constant internet connection offers an advantage over using a Google Maps web based API (Gibson and Erle, 2006).

1.2 Problem Definition

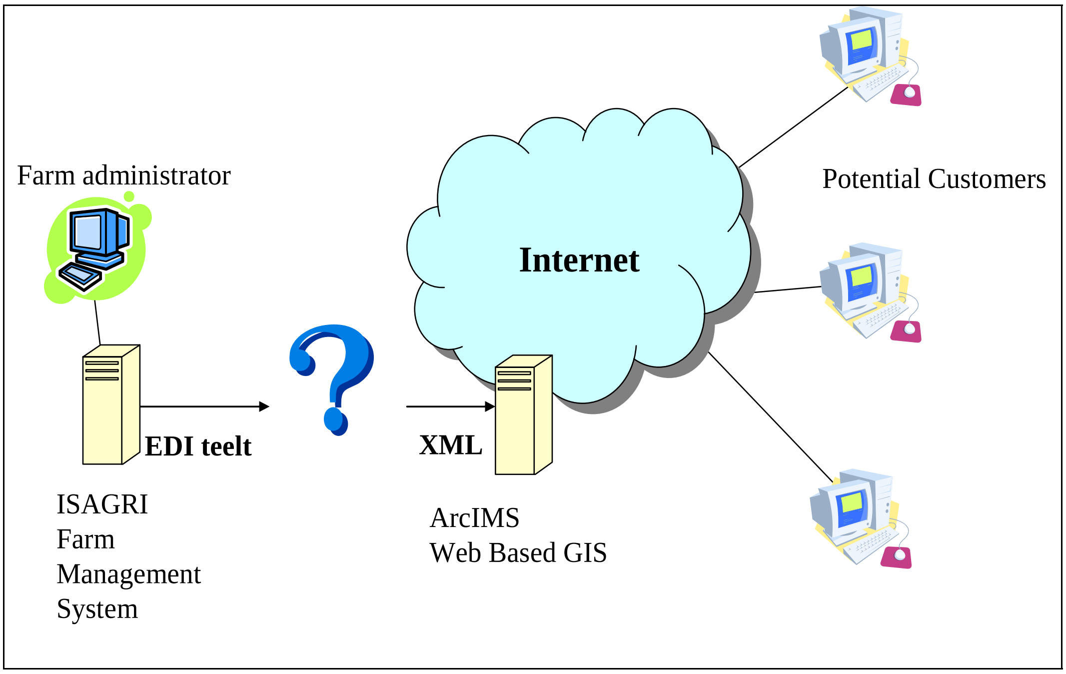

Figure 1. The system architecture indicating the problem of Droevendaal farm

The architecture of the existing system of the case of Droevendaal farm is shown in Figure 1. The FMS used in the farm is ISAGRI. The web based GIS (http://imsgrs.wur.nl/droevendaal/), which is implemented using ESRI's ArcIMS as the map server, uses the data from the FMS to allow potential clients of the farm to check previous crops, fertilizer applications, etc. online. The existing database of the web based GIS employs Microsoft Access as the Database Management System (DBMS).

Currently, updating of the web application involves several operations and much interaction because there is no integration or automated procedure for data exchange between the FMS and the web based GIS. Similar to when the web based GIS was developed, to update data to the web based GIS, the data has to be collected and entered manually to the database. They are virtually 2 separated systems.

Although ISAGRI farm management system has a function to export data from its database in XML format based on EDI Teelt, which is a Dutch EDI standard for crop cultivation, it is not known natively to the receiving side, the web based GIS. Therefore, a mechanism should be implemented to enable automated procedure for data exchange between the FMS and the web based GIS.

To achieve the data integration, XML/EDI, which expected to be the key technology for exchanging business data in the future, is to be studied in order to understand the standard as well as the feasibility of applying it as a framework for the data integration. In addition, EDI Teelt is to be studied in order to understand the standard as well as the feasibility of using EDI Teelt as the message complying with the XML/EDI framework for data integration with the web based GIS.

Because the receiving side of the data is the web based GIS, the database of the web base GIS is to be study. Improvement for the database may be needed in order to make the data integration feasible and effective.

As for the study of Google Earth, although the evidences of utilizing Google Earth in many applications in many fields, there has been no obvious evidence of applying it to such a case as Droevendaal farm where the users query the information from a database with a capability of communication with the map. For example, Hornbuckle and Christen (2006) studied the use of Google Earth to disseminate irrigated soils information which showed a possibility to show vertical profile descriptions of soils, typical properties associated with those soil types and visual image. However, all the soil data was static and had to be prepared manually, and the map could not have interaction with users. Thus the study of Google Earth as well as the existing system has to be done in order to compare both viewers and to evaluate the feasibility of using Google Earth as an alternative viewer. The criteria for such evaluation have to be defined and the evaluation has to be done based on the criteria for each of the functionality necessary for the Droevendaal farm.

1.3 Research Objectives and Research Questions

Aims of this thesis research are to study and implement the data integration between a farm management system and a web based GIS based on a case study of Droevendaal farm (http://imsgrs.wur.nl/droevendaal/). In order to achieve the aims, the following research objectives and questions are defined:

Research Objectives

1. To study and describe EDI Teelt messaging structure and procedure.
2. To design and implement an automated procedure for data exchange between the farm management system and the web based GIS based on the case of Droevendaal farm
3. To compare and analyze EDI Teelt and standard XML/EDI.
4. To study an alternative for the receiving application, i.e. the web based GIS.

Research Questions

1. What are the structure, content and procedure of EDI Teelt messaging?
2. What is the feasibility to use XML/EDI as a framework for data integration using EDI Teelt messaging for web based GIS for Droevendaal farm?
3. What are the structure and content of the input data of the web based GIS?
4. What are the tools/mechanisms for data exchange between the farm management system and the web based GIS?
5. Which are the potential improvements of the current web based GIS receiving the EDI message?
   5.1. Which are the potential improvements of the database structure of the web based GIS?

   5.2. What is the feasibility of using Google Earth as an alternative viewer?
6. What are the useful criteria for measuring the feasibility referred to in question 5.2?

1.4 Thesis structure

This research is divided into 3 major parts as the following:

Chapter 2, XML/EDI and EDI/Teelt: To answer the research questions 1 and 2, in this chapter, both EDI Teelt and XML/EDI standard are explored. In addition, the feasibility of applying the XML/EDI framework to the data integration based on EDI Teelt is studied.

Chapter 3, Data integration: This chapter consists of 2 main parts. The first part, which aims to answer the research questions 3 and 5.1, studies the input data as well as the improvement of the existing database. Whereas, the second part, which aims to answer the research question 4, deals with the data exchange between the FMS and the web based GIS.

Chapter 4, Use of Google Earth in the web based GIS: To answer research questions 5.2 and 6, this chapter evaluates the feasibility of using Google Earth as an alternative viewer for the web based GIS. Firstly, the existing system which makes use of ArcIMS as a map server is reviewed and then followed by a review of Google Earth. Next, the evaluation criteria are defined. After that, the existing system and the Google Earth are assessed based on those criteria. Finally, the conclusions are drawn from comparison of the evaluation results of both of them.

2. XML/EDI and EDI Teelt

2.1 Introduction

There are some EDI standards in Europe that aim for enabling data exchange between farmers and their partners such as Data Plot Sheet (DAPLOS) and Agro XML. DAPLOS (http://www.unece.org/trade/untdid/d05b/trmd/daplos_c.htm) is a standard message for describing information related to a specific cultural plot, in order to facilitate data exchange between various information system (Waksman and Masselin-Silvin, 2005). It also provides technical description and information of the crop production in order to give information about traceability to the farmer's partners. DAPLOS is created by Agro EDI Europe (AEE), which is member and EDI development group of EDIFRANC, based on UN/EDIFACT language. AgroXML is a language that enables the description of agricultural data and allows information exchanges without redundancy between the different actors: land owners, farmers, advisory services, food industry, etc (Waksman and Masselin-Silvin, 2005). It is a German standard, based on XML language.

Technically, EDI is a reliable means for the exchange of traceability data (Ayalew et al., 2006). And both of them are capable for product traceability i.e. ability to trace back to find out where the products were produced. In the Netherlands, similar ideas are applied for the Dutch EDI standard called “EDI Teelt”. EDI Teelt is a standard EDI format being used in the Netherlands to communicate between farmers and their partners such as buyers. It is XML based. In case of Droevendaal farm, the data from FMS can be exported as an EDI Teelt document. Therefore, it is one of the main studies of this thesis research.

This chapter deals with research questions 1 and 2. It studies not only the EDI Teelt message, but also the procedure or mechanism to use it for data integration. Reviews from the literature and web survey show the potential of using XML/EDI to accomplish the data integration. XML/EDI is a framework that integrates XML and EDI. It is chosen to study in this thesis research because of its ability in exchanging business data between servers in electronic format with the advantages from XML capabilities.

The understanding of XML/EDI and EDI Teelt is necessary. As a result, this chapter reviews XML/EDI and EDI Teelt as well as study the feasibility to use the XML/EDI as a framework for the data integration employing EDI Teelt messages for the Droevendaal farm. The sources of study are the literature as well as some practical documents including EDI Teelt document exported from the FMS and its EDI Teelt Schema and standard EDI Teelt and other clients using EDI Teelt messages in farm business in the Netherland.

2.2 Methods

2.2.1 Literature Study of XML/EDI

XML/EDI

Electronic Data Interchange (EDI) is an electronic exchange of business transactions, such as purchase orders and invoices for goods or services among business parties. EDI virtually eliminates paperwork and has advantages from its automated process with a minimum of human intervention. For example, an empirical study by Leonard and David (2006) showed that the EDI supply chain was more effective than the manual supply chain in terms of: shorter order cycles, greater availability, lower (purchase) price, and lower (transaction) cost. Examples of two important traditional EDI data formats are X12 (http://www.x12.org/) and Electronic Data Interchange For Administration, Commerce, and Transport (EDIFACT: http://www.unece.org/trade/untdid/). X12 is the standard of American National Standards Institute (ANSI). Whereas EDIFACT is the international EDI standard developed under the United Nations (UN).

Apart from traditional EDI data formats, in 1997 XML/EDI, framework integrating XML and EDI, was proposed by XML/EDI group to accelerate the adoption of EDI (Webber, 1998). XML/EDI is basically based on the integration of EDI and XML. An empirical study showed that XML/EDI framework was good for exchanging documents between servers because all receiving XML documents agree on a set of standards (Lu et al., 2001). It was believed that XML/EDI would be the key technology for exchanging business data in the future (Buxmann et al., 2005).

The XML/EDI framework consists of 5 components namely; XML, EDI, templates, agents and a global repository, as detailed below:

- XML and EDI provide the basis of the framework i.e. electronic exchange of business data representing in XML format.
- Templates are rules referenced by the XML messages to define how to manipulate the data. Templates are generally defined by using Extensible Stylesheet Language Transformations (XSLT) (Walsh, 1999).
- Agents are programs that parse the XML messages according to the rules defined in the templates. For instance, if the rule applied to an XML document is to transform XML element <A> into <B>, the agent will look for the element <A> throughout the document and, if found, transform it into <B>.
- A global repository is a shared Internet dictionary. It collects reusable objects such as XML schemas, templates and agents to be looked up, downloaded or referenced. The idea behind the global repositories is that developers can create a custom tag if one does not exist in the global repositories (Lu et al., 2001). If the need for a tag is strong, the commonly used tag will finally be created (Lu et al., 2001).

To illustrate the component and their functions, an example of a typical XML/EDI transaction from Lu et al. (2001) is shown in Figure 2.

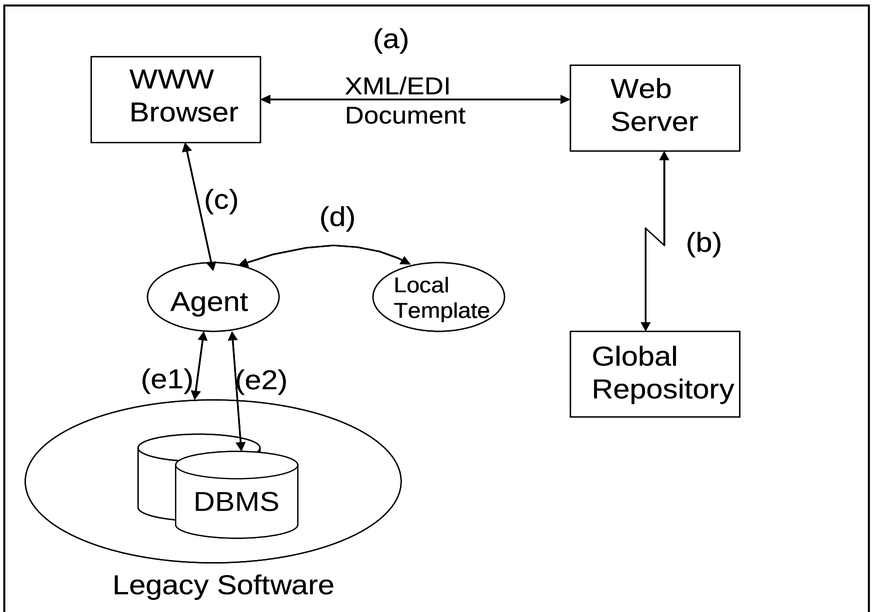

Figure 2. A typical XML/EDI transaction (Lu et al., 2001)

In the scenario, a party would like to get business data from a web server. The data is in XML format. The party has legacy software, which is existing software such as Enterprise Resource Planning (ERP) software that is being used by the party and that the party does not want to modify or replace. And they would like to import that data to be used in the legacy software. The aim is to import the XML data to be used in the legacy software.

The procedure is as follows; (a) A party downloads an XML/EDI document in XML format from a web server. The XML/EDI document contains not only the EDI data but also the associated XML schema and template. The XML schemas and templates either (a) travel along with the XML/EDI document or (b) they are referred to their location in either local or global repository. (c) The agent reads the XML schema and (d) reads the template, checks their validity and transforms the document, according to the rules in the template, into the desirable format. The agent can either (e1) communicate with a legacy system to save the XML data for further processing or (e2) communicate directly to the Database Management System (DBMS).

There are several reasons that XML/EDI is anticipated to be the technology of the future, some of them are listed below (Peat and Webber, 1997):

- It is built on open standards
- It provides self-describing transactions (XML)
- It interfaces very well with legacy systems
- The framework uses an evolving best of breed philosophy - i.e. dynamic shared dictionaries
- It allows object-based documents - data & rules reside together
- It enables more flexible business models (Rules/Agents)
- It is cheaper and easier to implement
- It accesses to a greater number of trading partners (see previous bullet)

- It accesses to "interactive" transactions enabled by the web rather than being limited to "system" or "batch" transactions.

2.2.2 Setting and using of duplicate system and data

Droevendaal farm uses ISAGRI software for FMS. It has an ability to generate EDI Teelt messages. Currently, ISAGRI's FMS supports EDI Teelt standard. For the ISAGRI's FMS, the EDI Teelt message generation is per year and per crop cultivation. A contract code needs to be put in, and only the data of parcel with contract code attached to can be exported to the EDI Teelt message. Besides, data to be entered into FMS is provided in a code list.

The duplicate system and data of FMS were set and used as the following; The ISAGRI's FMS software (ISAGRI 5.60.000) was installed into a Personal Computer (PC). And then the data currently used in the Droevendaal farm was copied to the PC. The duplicate FMS was used. Therefore, fictive contract codes and entries from a code list were entered into the FMS. Next, an EDI Teelt document was generated by the FMS to be used further in this thesis research.

2.2.3 Practical Survey of EDI Teelt

EDI Teelt document exported from ISAGRI's FMS and its EDI Teelt Schema

A EDI Teelt document exported from the ISAGRI's FMS as mentioned earlier and the corresponding EDI Teelt schema are shown in Appendix A (on CD) and B respectively. The EDI Teelt schema defines the structure, content and semantics of the EDI Teelt documents. Thus, the structure and meaning of an EDI Teelt message is understandable by studying its schema. An EDI Teelt document is an instance of the EDI Teelt schema.

Standard EDI Teelt and other clients using EDI Teelt messages in the Netherlands

The Appendix C (on CD) shows the requirement for each of the elements in the standard EDI Teelt message as well as the requirement from other clients that are commonly used EDI Teelt to communicate between farmers and buyers in the Netherlands. A study of the table gained an understanding of the characteristic different type of contracts that are currently known.

EDI Teelt document exported from Opticrop's FMS

An EDI Teelt document exported from the Opticrop's FMS, as shown in Appendix D (on CD), was given and used as an additional document to study in this thesis research. Similar to ISAGRI, Opticrop is a software company that provides FMS. More information about Opticrop can be found at http://www.opticrop.nl/ (in Dutch). The document contains some data that were missing from the EDI Teelt document exported from ISAGRI's FMS i.e. soil research data.

2.3 Results

Table 1. XML Structure of EDI Teelt

Element	Description
<Transaction>	Root of the transaction message-Start tag
<HeaderBericht>	Header information-Start tag
..child elements..	Elements for header information such as version, cultivation year, password
<Bedrijf>	Company-Start tag
..child elements..	Elements for company information such as company name and address
<Perceel>	Parcel-Start tag
..child elements..	Elements for parcel information such as parcel code, name, and area
<Grondonderzoek>	Soil data-Start tag
..child elements..	Soil research information such as research number and date
<Analysetechniek>	Analysis technique-Start tag
..child elements..	Analysis technique information such as analysis code and parameter
</Analysetechniek>	Analysis technique-End tag
</Grondonderzoek>	Soil data-End tag
<Teelt>	Crop cultivation-Start tag
..child elements..	Elements for crop cultivation information such as crop type, ground type, and plant date
<Bemesting>	Fertilization-Start tag
..child elements..	Fertilization information such as fertilization type and date
</Bemesting>	Fertilization-End tag
</Teelt>	Crop cultivation-End tag
</Perceel>	Parcel-End tag
</Bedrijf>	Company-End tag
</HeaderBericht>	Header information-End tag
</Transaction>	Root of the transaction message-End tag

Table 1 shows the main structure of an EDI Teelt message. An EDI Teelt message is a well-formed XML document. It means the EDI Teelt conforms to the XML syntax rules. More specifically, the EDI Teelt document must contain at least one element with any other elements properly nested under it and must contain a unique opening and closing tag as its root. The message contains crop cultivation as well as necessary data to communicate with a counterpart including owner information, parcel information, soil information, soil analysis information, crop information and fertilization information. All the elements are named in Dutch language. More detail and full elements of the EDI Teelt can be seen from EDI Teelt schema (Appendix B). The schema also shows that several elements are not required i.e. they may have from 0 to 99 occurrences.

Study of the standard EDI Teelt and other clients, which refer to contracts, using EDI Teelt messages used in farm management in the Netherlands shows that some of elements are in common for all them whereas some are different. And for each client, some elements are required, some elements are optional, and some elements do not exist. These diverse EDI Teelt contracts present in the farm business in the Netherlands. However, as mentioned above, the schema allows several elements to be optional. Therefore, these contracts conform to the standard EDI Teelt schema.

Implementation of EDI Teelt for data exchange can conform to the XML/EDI framework because EDI Teelt document is a native XML document and it is designed for EDI communication. The URL http://www.edi-teelt.nl/, existing in the EDI Teelt schema, refers to a server that can act as a global repository to collect the necessary common objects including the XML schemas, templates, and agents. However, the URL http://www.edi-teelt.nl/ apparently did not exist at the time this thesis research was conducted. And it is supposed to exist in the future.

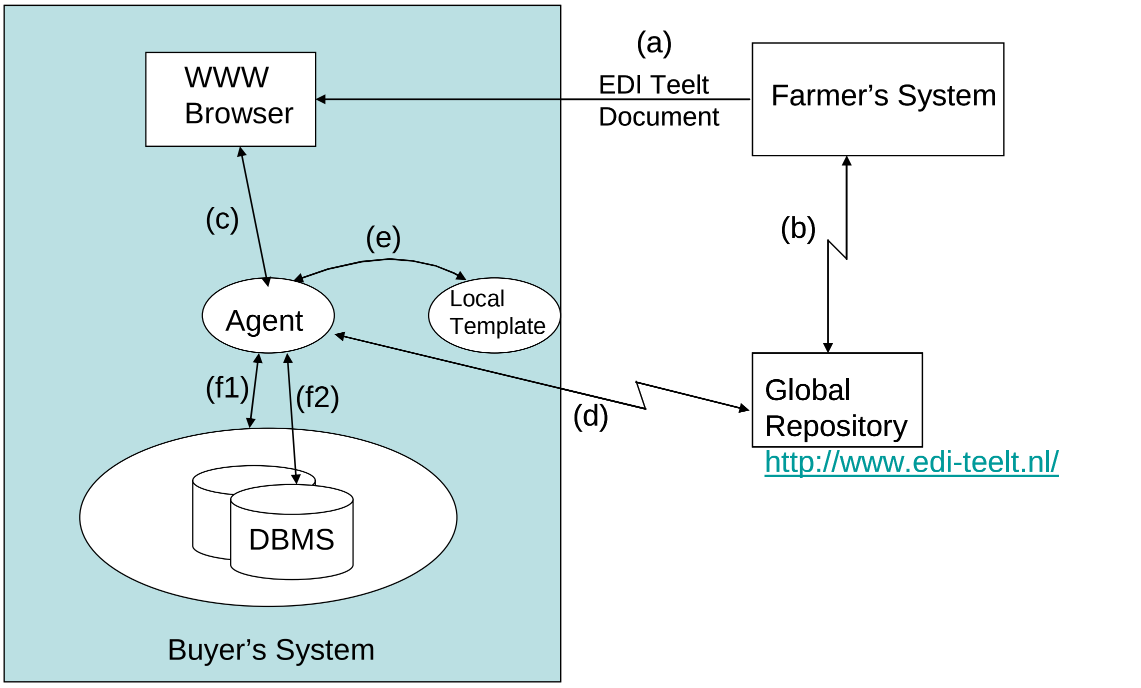

Figure 3. Diagram of hypothetical EDI Teelt transaction based on XML/EDI framework

Figure 3 is a diagram of hypothetical EDI Teelt transaction based on XML/EDI framework. The data flow is as follows; (a) A document contains crop cultivation information from a farmer's system is transferred to a buyer's system in EDI Teelt format via the Internet by a method such as downloading by the buyer or uploading by the farmer. (b) The document refers to its XML schema in the global repository at http://www.edi-teelt.nl. The buyer receives the document referring the XML schema from the global repository which is then (c) passed to the agent to be parsed. (d) The document is checked for the validity, based on the referred XML schema, (e) and manipulated by the agent based on the rules in a local template already defined for EDI Teelt documents. It is possible that some agent and template that is widely used is promoted to the global repository to be reused by any party implementing a similar system. Centralized by the global repository, it is easy to maintain and reduce any duplicate attempt for implementing such a system. And after all the output containing the desirable data in desirable format is produced and can be either (f1) communicate with a buyer's system to save the XML data for further processing or (f2) communicate directly to the Database Management System (DBMS).

However, the EDI Teelt message exported from ISAGRI's FMS is problematic because of the following reasons:

- The XML schema for EDI Teelt is not currently in use, i.e. the document does not refer to the XML schema.
- There are some mismatch between the XML schema and the corresponding EDI Teelt message. In the EDI Teelt message, all the XML elements which contain one or more child elements have their name different from those defined in the XML schema. The prefix "Aded" is added in front of all the elements' name. For example, the XML schema consists of an element <HeaderBericht> which appears as <AdedHeaderBericht> in the corresponding EDI Teelt message. Moreover, for each time EDI Teelt message is exported from ISAGRI's FMS, a contract code value is added to the message between the tag element <TltContractcode> and </TltContractcode> as can be seen from Appendix A (on CD). This element also does not exist in the XML schema. This is probably because of the different versions between the XML document and the XML schema.
- Some data is not exported to the EDI Teelt message. For example, the EDI Teelt structure consists of element <AdedGrondonderzoek>, which is soil research, and its child element <AdedAnalysetechniek>, which is soil analysis technique, to place soil sample data but the data can not be exported to the child element.

2.4 Discussion

Some data in FMS can not exported into the EDI Teelt message because of a bug in the software. However, this problem will be tackled by the software company. The correction from ISAGRI will be included in the next version.

Let alone the particular software problem in exporting the EDI Teelt document as mentioned above, EDI Teelt is capable for conveying the information related to crop cultivation that is needed for the farm's clients. However, it does not convey geometric information such as position and shape of a particular parcel. This will be problematic when an update of geometry is needed. For example, when a field is divided or changed. It is discussed more in Chapter 3.

XML/EDI can be used as a framework for implementing data integration using EDI Teelt messaging. However, the global repository, which is one of five components in XML/EDI, currently does not exist. The EDI Teelt schema (Appendix B) refers to the URL http://www.edi-teelt.nl/ which should potentially act as the global repository when it is set up in the future. The absence of the global repository causes loss of some benefit that should normally obtain from it namely sharing of the reusable objects, and maintaining those objects centrally. Those reusable objects include XML schemas, templates, and agents. Nevertheless, the implementation is still possible. And in this case, the scenario referred in Figure 3 can be different. Instead of referring to the XML schema in the global repository, the XML schema can be transferred along with the XML document to the receiver. Even without referring to the XML schema, the implementation is still possible. This is the case that happened in the implementation in Chapter 3. In such a case, although the EDI Teelt schema is not referred to, there has to be a mechanism to ensure that the EDI Teelt message is in proper structure and semantic. In case of Droevendaal, this is done automatically by the ISAGRI's FMS, for the sender. And for the receiver, the EDI Teelt schama is acquired separately, and used for designing a template that transform the EDI Teelt document.

In conclusion, the structure, content and procedure of EDI messaging are explored and XML/EDI shows feasibility to be used as a framework for data integration using EDI Teelt messaging. The research questions 1 and 2 are successfully answered.

3. Data integration

3.1 Introduction

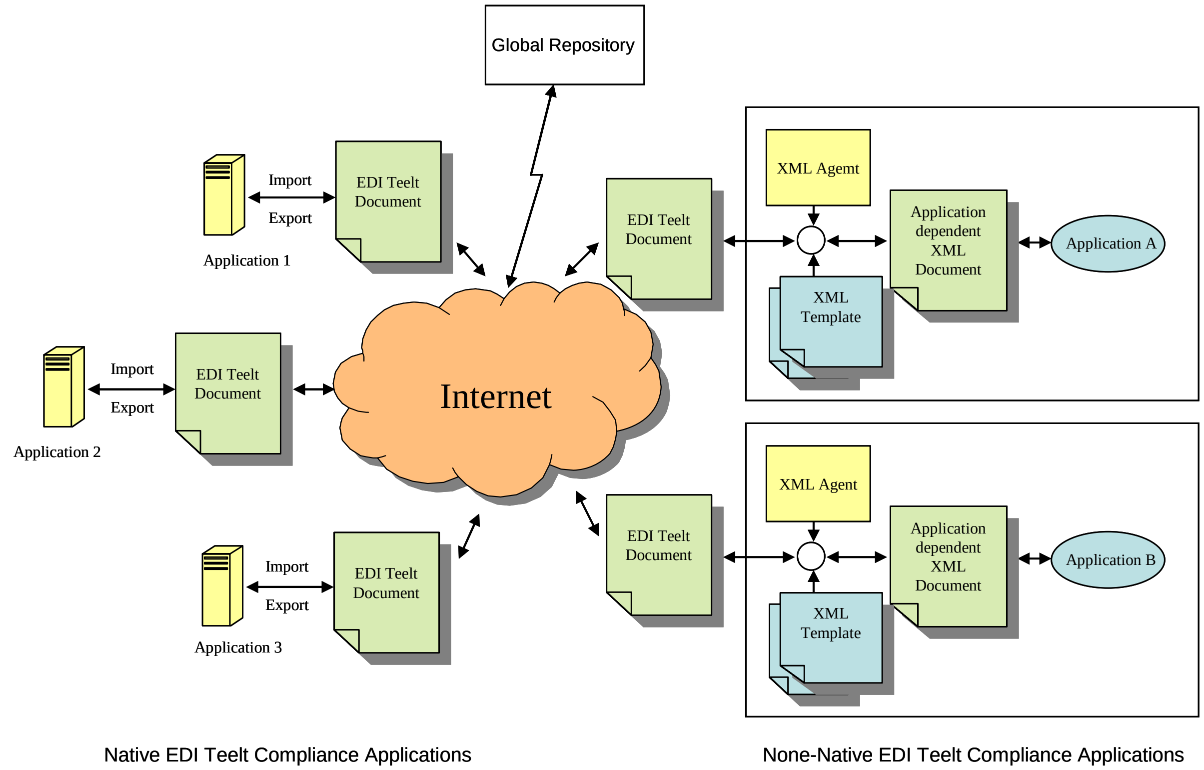

Figure 4. EDI Teelt communication model

This chapter deals with research questions 3, 4, and 5.1 as well as the implementation of data integration between the FMS and the web based GIS. Similar to Figure 3, Figure 4 illustrates an EDI Teelt communication model conforming to the XML/EDI framework. However, the Figure 4 shows broader context where many parties communicate by EDI Teelt documents. Those parties whose applications are native EDI Teelt compliance can directly import or export the EDI Teelt document. On the contrary, those parties whose applications are not natively EDI Teelt compliance can rely on the ability of agent and template, to transform the EDI Teelt documents into desirable XML formats they need, and vice versa.

In the case of Droevendaal farm, the former parties' application include the ISAGRI's FMS whereas the latter parties' application include the web basd GIS. The EDI Teels schema can either travel along with the EDI Teelt document or can be downloaded and referenced locally, or be referenced remotely to the document in the global repository. The latter option is preferable because of ease of updating and maintaining. Because to make any change on a schema in the global repository will automatically affect the referencing documents in term of data validation. The study in this chapter is based on this model.

Data integration between the FMS and the web based GIS is done by studying and implementing of 2 main parts namely existing database and the data exchange process. The EDI Teelt document is generated by the FMS and need to be imported to the existing database of the web based GIS. Therefore, to understand and to see the possibility of the database to receive the data, the study of the existing database has to be done. And after that, by finding appropriate tools/mechanisms, the data exchange process can be done.

Existing database

The database structure and relationships are shown in Figure 5.

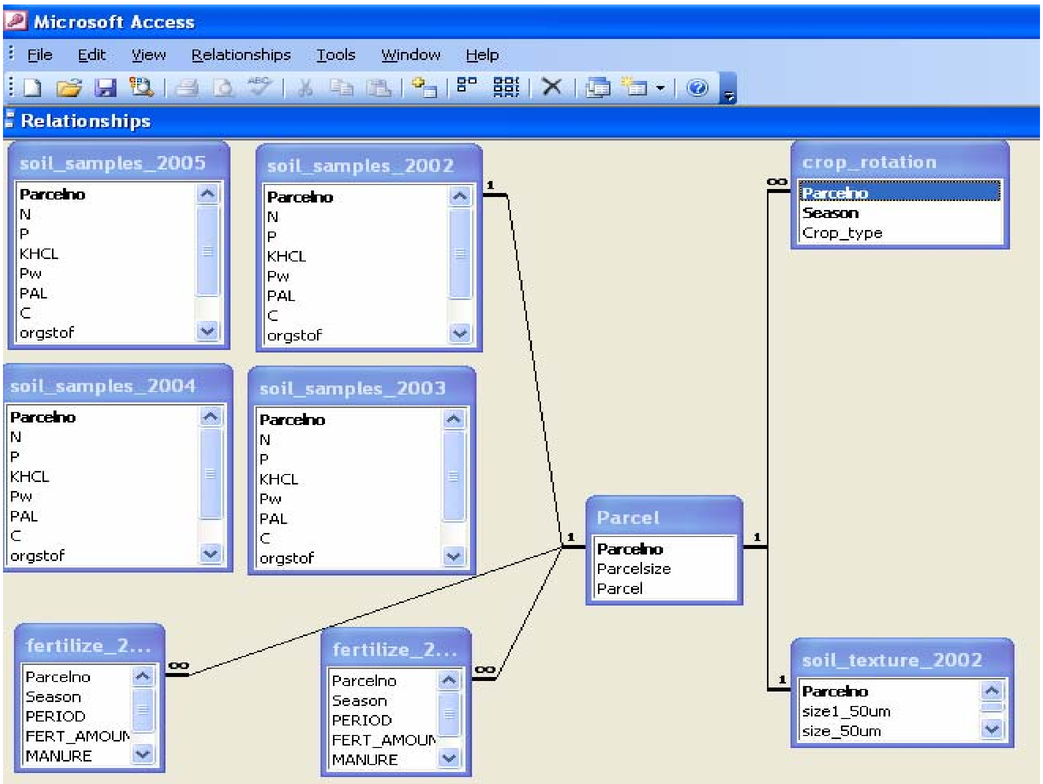

Figure 5. Existing database structure and relationships of the web based GIS

Data exchange

Data exchange between the Droevendaal FMS and the web based GIS can be achieved by XML messaging. The FMS acts as the sender that sends the data to the receiver, the web based GIS.

The receiving side does not natively support the EDI Teelt messaging. The structure and semantic of the database is different from those of EDI Teelt. For example, table soil_sample_2002 in the database consists of many fields such as N, P, and KHCL to collect soil properties data whereas the EDI Teelt message consists of one element, i.e.

<AdedGrondonderzoek> to collect the equivalent data. Moreover, there is no embedded utility to transform the EDI Teelt standard before importing into the database. That is why the implementation of the transformation is needed.

The key mechanism that was studied and applied to achieve the data transformation was Extensible Stylesheet Language Transformations (XSLT). XSLT is an XML based language which mean it complies with the XML rules. XSLT specification is a recommendation developed by the W3C. XSLT version 1.0 was recommended in November 1999. And it was approved as a W3C recommendation on 2 May 2001.

In this thesis research, XSLT was chosen to use because of its advantages and evidence of successful cases. It is more human readable and flexible if modification is needed. Lehto and Sarjakoski (2005) described the success of applying XSLT in the process of real-time generalization of XML-encoded spatial data for Web and mobile devices. In addition, Jovanovic and Gasevic (2005) worked on automation of knowledge sharing between different systems. They said XML was, by that time, widely accepted as knowledge representation syntax and they believe that a more suitable solution for their work would be to use XSLT (Jovanovic and Gasevic, 2005).

XML transformation can also be done by coding in traditional programming language such as Document Object Model (DOM: http://www.w3.org/DOM/) or Simple API for XML (SAX: http://www.saxproject.org/) based writing in Java. DOM is the W3C standard for representing structured documents in a platform- and language- neutral manner. SAX is an event-driven, serial-access mechanism for accessing XML documents. However, to code in traditional programming language, the program is only readable by virtual machines and humans that can read Java-language and it would require a significant amount of modification to track the independent evolution of both the source and target schemas (Box et al., 2001).

Generally, the transformation of XML documents consists of two steps i.e. schema matching and XSLT script generation (Lee and Lee, 2006). In this thesis research, these two steps are discussed in sections 3.2.4 and 3.2.5, respectively.

3.2 Methods

The methods to make the database effective and efficient for data integration as well as to make the data exchange are described as follows:

3.2.1 Setting and using of duplicate systems and data

In this thesis research, the duplicate systems and data of both the FMS and the web based GIS were set and used as described bellow:

Sender: FMS

The setting and using of FMS was described in Chapter 2 (section 2.2.2).

Receiver: Web based GIS

The web based GIS was set up by using the same software as the existing system (http://imsgrs.wur.nl/droevendaal/). The software used in web based GIS is described in detail in Chapter 4. The map and data were copied from the CD generated by the producers of the web site, from the AMC II course, 2005, Wageningen University and Research Centre. The content and structure of XML message that web based GIS can receive can be obtained by using the MS Access export utility. It can export the database content as well as its schema in XML format.

3.2.2 Database analysis

Database analysis is the method to analyze the existing database based on the database relational database concepts. Since MS Access is a Relational Database Management System (RDBMS), design and analysis of the database should be based on the relational database concepts. As a result, the analysis based on the concepts is a good method to solve the problem of the existing database. The following parts relate to the problem's solution and were mainly adapted from Elmasri and Navathe (1994), and Powell (2006):

Relational model

The relational model represents the database as a collection of relations, commonly tables, with interrelations. A relational model consists of three core components: a collection of objects or relations, commonly known as table, operators that act on the objects or relations, and data integrity methods. A RDBMS is a system that applies the relational model. The relational database design aims to store data without unnecessary redundancy and to retrieve data efficiently, accurately and logically consistent.

Entity Relation (ER) Model Concepts

An ER model is a conceptual data model that describes data as entities, relationships, and attributes. It maps well to the relational model and can easily be transformed into relational tables. An entity is the basic object represented in the ER model which is a real "thing" in the real world with an independent existence. An entity can be either a physical object or a conceptual object. Entity is commonly known as table in practical database design. An entity has properties called attributes. The attributes describe its entity's characteristic. For example, Figure 5 can be seen as an ER, and a parcel entity can be described by parcel id, parcel area, and land use type of the parcel.

Relationships

A relationship is an association between two or more tables. From Figure 5, the relationship is represented by the lines joining two tables. Each relationship will have a primary table and a related table. Relationships are expressed in the data values of the primary and foreign keys. The relationship between two tables can be in the following forms;

- One-to-one

Both tables can have only one record on either side of the relationship. Each primary key value relates to only one (or zero) record in the related table. Most one-to-one relationships are forced by business rules and don't flow naturally from the data. In the absence of such a rule, both tables can be combined into one table without breaking any normalization rules. Normalization can be described as being one of introduction of granularity, removal of duplication, or minimizing of redundancy, or simply the introduction of tables, all of which place data into a better organized state.

- One-to-many

The primary key table contains only one record that relates to zero, one, or many records in the related table. For example, a parcel can have many crops. But an instance of crop can be in only one parcel.

- Many-to-many

Each record in both tables can relate to any number of records (zero, one, or many records) in the other table. For example, a parcel can grow many species of a crop and a species can be existent in many parcels. Many-to-many relationships require a third table, known as an associate or linking table, because relational systems can not directly accommodate the relationship.

Key Attributes

A key or uniqueness is an important constraint on the entities of an entities type. Usually, an entity type has an attribute whose values are distinct for each individual entity. That attribute is called a key attribute. It can be use to identify each entity uniquely. Key attributes also improve system performance because they are indexed.

Primary key

A primary key is an attribute or a set of attributes used to uniquely identify a record in a table. Unique identification for each record is required because there is no other way to find a record without the possibility of finding more than one record, if the unique identifier is not used (Powell, 2006)

Foreign key

A foreign key is the copy of a primary key created into child tables to form the opposite side of the link in an inter-table relationship which establishes a relational database relation. It defines the reference for each record in the child table, referencing back to the primary key in the parent table.

Data Integrity

Data integrity is a condition which data in the database is accurate and consistent. There are two basic rules to ensure data integrity; entity integrity and referential integrity which are explained below:

Entity integrity

The entity integrity rule states that the value of the primary key can not be a null value (a null value is one that has no value and is not the same as a blank) because a primary key is used to identify a unique row in a relational table. Its value must always be specified. The integrity rule requires that insert, update, and delete operations maintain the uniqueness and existence of all primary keys.

Referential integrity

The referential integrity rule states that if a table has a foreign key, then every value of the foreign key must either be null or match the values in the relational table in which that foreign key is a primary key.

3.2.3 Database modification

Database modification was applied to modify the existing database to be in the preferable state based on the analysis and objectives of data integration. Due to changes in the database, web pages that contain ASP scripts interacting with the database were modified corresponding to the changes.

The aim of the modification is to achieve data integration, but not to improve elegance of the database. The modification is based on the following ideas;

1. The modification is done only to the parts that really need improvement to warrant proper functionality of the database itself and the data integration thereafter. But is it does not aim to optimize the database.
2. The modification should not affect the output data representation on the web site.

3. The modification should take into account the possibility of data integration (if relevant). It must not make the integration problematic or more difficult.
4. The modified database should be easy to maintain.

3.2.4 XML schemas matching

XML Schemas provide means for defining the structure, content, and semantics of XML documents (http://www.w3.org/XML/Schema). In detail, an XML schema can define elements, their relations (parent and child), their order, and their attributes. More over, it can define data types of those elements and attributes as well as default value and number of child elements that can occur. In other words, an XML schema is designed to set a common rule to referencing XML documents to follow.

To achieve the data integration, the XML schemas of both the sender (EDI Teelt document generated by FMS) and the receiver (the database of the web based GIS) were studied to understand the structure, content, and semantics of them.

The XML schema of the EDI Teelt was given as shown in the Appendix B. Whereas the XML schema of the web based GIS was retrieved from the export utility in MS access as shown in Appendix E (on CD). The export utility can export the existing data into XML document including XML schema.

The structure and semantic of them are different. Therefore, the schemas matching was needed. It was purposely done by matching the elements, attributes, and contents with the same meaning between both schemas into a matching table.

3.2.5 Extensible Stylesheet Language Transformations (XSLT)

XSLT is an XML-based language used for transforming XML documents into different formats such as HTML, flat files, Wireless Markup Language (WML) and other forms of XML. Regarding the XML/EDI, XSLT is the template component of the framework. An excerpt of XSL script is shown as an example below.

```
<xsl:template match="PrcCodePerceel">
        <Parcelno>
                <xsl:apply-templates/>
        </Parcelno>
</xsl:template>
```

The code above transforms “<PrcCodePerceel> Value </PrcCodePerceel>”, which is in EDI Teelt message, into “<Parcelno> Value </Parcelno>”, which is preferable format for the web based GIS. Similar expressions were written to match the other data in the database. More information about XSLT could be found from W3C website at http://www.w3.org/TR/xslt.

An XSLT script was written by the author to use to transform EDI Teelt document into the form complying with the web based GIS data structure.

3.2.6 XML transformation implementation

The implementation was based on the XML/EDI framework. The XML and EDI components were implemented by EDI Teelt messaging. The EDI Teelt document was generated by the FMS. A web page containing an ASP script (Appendix F, on CD) was created to be the user interface to transfer the EDI Teelt document from the FMS to the web based GIS. The script also commanded the agent to parse the template to transform the EDI Teelt document. The agent was MSXML which is an XML parser from Microsoft and it is a component of Windows XP. The template is the XSLT script as mention earlier. It provided the rules to the agent to transform the EDI Teelt document into the web based GIS compatible form. The document was then automatically imported into the web based GIS database. The DBMS, which was MS Access, performed the integrity check based on the primary key and foreign key constraints before importing the data, if no constraints violation.

The transformation was tested on the duplicate system. It was done by using the EDI Teelt document (Appendix G, on CD) as the input. It was uploaded, transformed, and imported into the database. And then, the second test was done by trying to upload the same EDI Teelt document again to check integrity, i.e. the database constraint should not allow a second update of the same data.

3.3 Results

The data structure and content of the input data for the web based GIS are as the following:

- Parcel (parcel number, parcel size and land use type)
- Crop (crop type)
- Fertilization (period, fertilization amount, manure and date)
- Soil sample’s properties (N,P, KHCL, Pw, PAL, C, orgstof, and pHKCL)
- Soil texture (particle size distribution)

Full information can be found in its XML schema (Appendix E, on CD).

The findings showed that the database structure, as shown in Figure 5, was prone to problems of data integrity, redundancy and performance. In some table such as fertilize_2003, there was no primary key. Therefore duplicate records or blank records could occur. Some blank records did exist. Also for data updating, mistaken update can cause duplicate data. It could violate the data integrity of the database. Moreover, lacking of a key could cause a decrease in the system performance. In addition, in some tables with one-to-many relation such as soil_samples_2003 and Parcel, there was no reference between the tables. Therefore, referential integrity of the database could be violated when there was a parcelno value in table soil_samples_2003 but not in table Parcel. Moreover, the presence of tables with same structure i.e. soil_samples_2002, soil_samples_2003, soil_samples_2004, and soil_samples_2005 caused redundancies and made the database difficult to maintain and to query. For instance, every new year a new table as well as a new ASP web page would have to be created and some existing web pages would have to be modified. Besides, this would cause a modification in data integration part afterwards.

The details and reasons of the modifications are shown in Table 2.

Table 2. Detail of database modification

Table	Modification	Reason
fertilize_2003, fertilize_2004	Some records in the table were deleted. A composite primary key [Parcelno, Season, PERIOD] was added. The tables were merged into a single table "fertilize".	These unwanted records are not useful and violate the primary key constraint. PERIOD is included in the primary key to support the possible sub-parcel (more than one crop in the same parcel and the same year). The new table structure is more efficient, not redundant, and easier to maintain.
soil_samples_2002, soil_samples_2003, soil_samples_2004, soil_samples_2005	These tables were merged into a single table "soil samples" A new field "season" was added into the new table. The primary key was changed from [Parcelno] to [Parcelno, season]	The new table structure is more efficient, not redundant, and easier to maintain. The corresponding season values can be added into the new table enabling the tables' merging. This is to support the new table structure and one-to-many relationship with table "Parcel".
soil_texture_2002	The table was renamed to "soil_texture".	This is to be more rational because the soil texture table should not only be

Table	Modification	Reason
		designed for the year 2002.
	The field "date" was added.	This is because the nature of soil texture that will not change on yearly basis and the sample is not taken frequently.
	The primary key was changed from [Parcelno] to [Parcelno, date].	This is to support the new table structure and one-to-many relation with table "Parcel".
crop_rotation	The primary key was changed from [Parcelno, Season] to [Parcelno, Season, Crop_type].	This is to support sub parcel (the presence of more than one crop per parcel per year).

After modification, the database was in good state for the data exchange. Some web pages that contain ASP scripts interacting with the database were modified corresponding to the changes (on CD). The database structure and relationships after modification are shown in Figure 6.

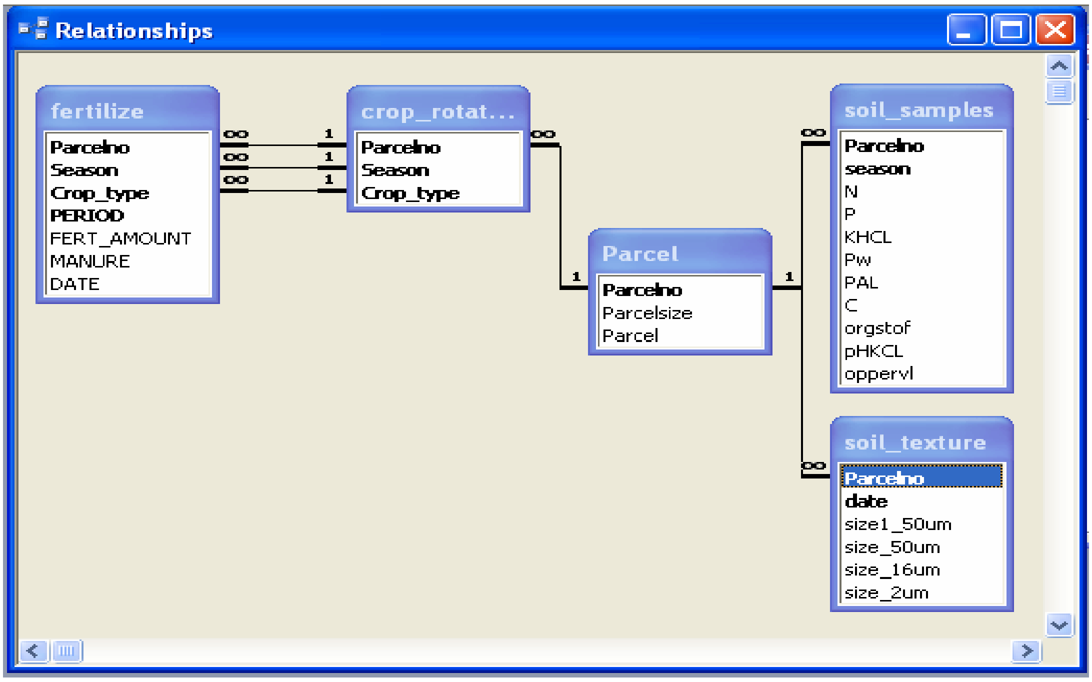

Figure 6. Database structure and relationships after modification

However a study of the schemas and the EDI Teelt message of Droevendaal farm revealed some incompatibility between the EDI Teelt message generated by Droevendaal's FMS and the web based GIS. The problems are shown in the Table 3.

Table 3. Problems concerning EDI Teelt message generated by Droevendaal's FMS regarding data integration with the web based GIS and their solutions

Problem	Description	Solution
Some data in FMS is not exported into the EDI Teelt message	According to the EDI Teelt schemas, the EDI message's structure supports this data but the data can not really be exported. For example, the EDI Teelt structure consists of element <AdedGrondonderzoek>, which is soil research, and its child element <AdedAnalysetechniek>, which is soil analysis technique, to place soil sample data but the data can not be exported to the child element. This is due to a bug of the software.	The problem was solved by manual adding of the data into the generated EDI Teelt message to be able to continue the implementation. The proper message containing this data could be seen from the EDI Teel message exported from Opticrop (Appendix D, on CD) and it was used an an example for the manual adding. In practice, this problem will be tackled by the software company. The correction from ISAGRI will be included in the next version.
Some data used in the web based GIS does not exist as an XML element in the EDI Teelt schema.	Because of the EDI Teelt does not explicitly contain some data used in the web based GIS namely period of fertilization and land use type of each parcel.	The PERIOD value (summer, spring, autumn or winter) can be retrieved from Date (YYYY-MM-DD). For the land use type, normally an EDI Teelt message contains data of cultivation which implies the arable land use type. Thus, the implementation simply forces the land use type to arable land. This is applicable for the data updating purpose of the Droevendaal farm but not for the database creating by the EDI Teelt message.
Only data of arable crops can be exported.	The contract code as mentioned in Chapter 2 is only applicable for arable crops but not for the other type of crop as pasture. Thus, only the arable crop cultivation data can be exported to EDI Teelt message.	So far, Droevendaal farm need to update only data of arable crops. Therefore, it does not affect the implementation. However, if there is need in exchange information of other type of crops, this problem should be solved by ISAGRI.

The EDI Teelt message after changing, according to the solution mentioned in Table 3, is shown in Appendix G (on CD) and it is used further from this point onwards. After that, the matching table is written as seen in Appendix H (on CD) and the XSLT is written as shown in Appendix I (on CD). The implementation of data transformation is shown in Figure 7.

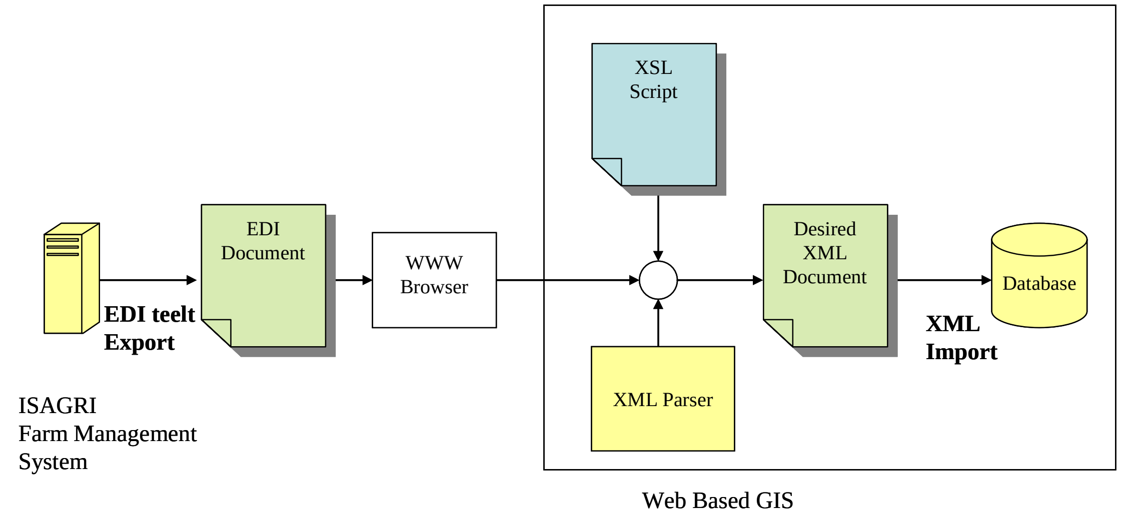

Figure 7. Implementation of data transformation

The scenario of the data integration is as the following;

1) The farmer export EDI Teelt document from the ISAGRI's FMS.

2) The EDI Teelt document is transferred to the web based GIS server via the web interface shown in Figure 8. The farmer visits the website, find the EDI Teelt document, and click the Upload button.

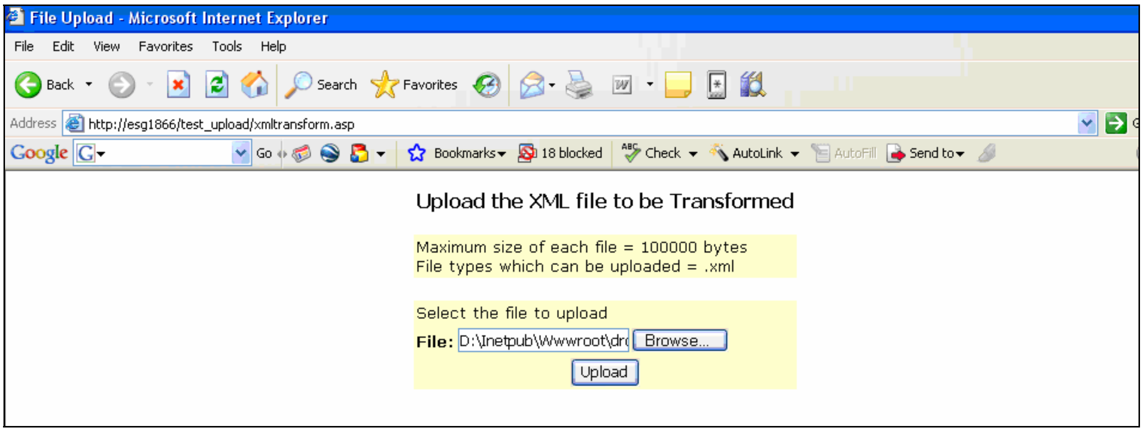

Figure 8. The web interface to transfer the EDI Teelt document

3) The uploaded document is then parsed by the XML parser (MSXML) according to the rules specified in the XML script (Appendix I, on CD).

4) The document is finally transformed into the desired format that is compatible to the web based GIS database.

5) The document is sent to the database for importing.

6) The DBMS checks for the primary key and foreign key constraints. And in case of no violations, the data is imported into the database.

Note that: steps 3-6 are handled automatically by the ASP script (Appendix F). There is no user intervention.

By following the mentioned scenario, the transformation test was done. Data was uploaded, transformed, and imported into the database successfully. The second test, which was done by uploading the same document, showed that it was not possible to import the duplicate records. No data was added to the database.

3.4 Discussion

In this chapter, the structure and content of the input data of the web based GIS was explored. Data transformation was done by using XSLT as the mechanism for data exchange. The database of web based GIS was improved by some modification based on the database analysis. The research questions 3, 4, and 5.1 are answered successfully.

The database structure, relationships and data were modified to conform to the relational database concept because it was not in good organized state. In practice, to modify the database that is currently in use can affect the ongoing system. In other cases where the databases are already designed properly, i.e. in good organized state, they may not need any modification of the database. In addition, it is not always the case that the receiving side employs a relational database. It can be any other data management systems. Therefore, dealing with data management system can vary from case to case depending on the features of each data management system.

After some modifications in the database and the EDI Teelt document, although the transformation works properly, an issue that should be addressed is the semantic difference between the two schemas. For example, before the database modification, EDI Teelt schema shows the possibility of having more than one crop within the same parcel in the same year (see Figure 5) whereas the web based GIS schema does not allow that (see Table 2). This circumstance could be caused by the sub parcel (the presence of more than one crop in the same parcel in the same year) or the real change of parcel's geometry. To illustrate this, the scenario where the geometry of 2 parcels change by time series is shown in Figure 9. So far, the information of change in geometry could not be conveyed by the EDI Teelt message.

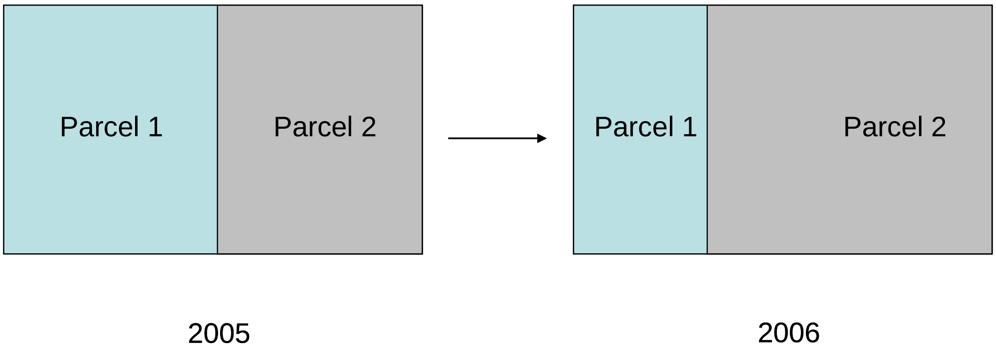

Figure 9. A scenario of change in geometry of 2 parcels

In case of Droevendaal farm, the former problem occurs, and the solution is mentioned in the previous section by changing the primary key to allow having more than one crop within the same parcel. Likewise, in other similar cases of data exchange process, it is recommended to modify the database constraint to allow the collecting of the same data as those in the sending side's schema.

However, the latter problem dealing with the geometry is yet to be addressed. Currently, there are some projects that deal with the geometry problem in farm management system including Interkom and Geoboer.

Interkom was a project dealing with agricultural land use regulation which requires the farmers to identify and draw his crop parcels on a map and fill in a related form with parcel specific information. In 2002 LASER, the implementing body of the Dutch Ministry of Agriculture, Nature Conservation and Fisheries released an interactive website where farmers can find information for the different EU-regulations. The web site included a geographical web application to support the GIS oriented declaration of land use. Farmers can select existing parcels or draw new (sub-) parcels and apply on line for several GIS oriented regulations. More information about Interkom can be found at http://www.wisl.nl/projecten/gisenwerkp_uk.html.

Likewise, the idea of Geoboer is to allow farmers update geometry locally, using their own Farm Management System. Next, he generates a standard XML based message with geometric and thematic data which is sent to an online service of the Ministry and used for an application for subsidy or obligatory declarations. More information about Geoboer could be found at http://www.rgi.nl/index.php?sid=24&folder=66 (in Dutch).

The same idea might be applied for the EDI Teelt. A future version of EDI Teelt should allow geometric data to be included in the message. This is part of Geoboer project.

As mentioned earlier, dealing with data management system can vary from case to case depending on the features of each data management system. However, the method of data exchange proposed in this research is still useful in other cases. Because of the platform independent feature of the XML, as long as the sender and receiver application support

XML, i.e. they can export and import XML messages, the data exchange is possible regardless of the application platform.

Although the data transformation is practically effective, it may not be the technically ideal solution. The standard such as EDI Teelt aims for communication among its domain, i.e. parties involving in the farm's products, with the same data structure and semantic. Therefore, if there is a standard that dominates its domain, i.e. every participant follow the same standard, the communication will be more convenient and seamless as they will speak the same language. The Figure 4 in chapter 3 depicts the situation where EDI Teelt dominates the farm application domain. It is even more ideal if all the farm management applications are native EDI Teelt compliance because there is no transformation needed any more. However, that issue of dominating the standard is not a simple one that can easily be overcome shortly. Moreover, it may not financially beneficial for a minor partner who has to always follows the standard dominated from a major party. Therefore, the data transformation can be an optimal solution for the time being.

4. Use of Google Earth in the Web based GIS

4.1 Introduction

Droevendaal farm’s web based GIS is a web site that provides crop cultivation information and farm’s map interactively to the potential customers. The potential customers can visit the web site and query the information online by using a web browser without any additional requirement. The system was developed by using ESRI’s ArcIMS as a map server with a HTML viewer option chosen. However, there are several map viewers currently in use worldwide. Among them, the popular Google Earth was chosen to study as an alternative viewer for the the Droevendaal farm’s web based GIS in this thesis research.

This chapter deals with research question 5.2 and 6. It studies the feasibility of using Google Earth as an alternative viewer for the the Droevendaal farm’s web based GIS. Firstly, an exploration of the existing system is made. Then the Google Earth functionalities are studied. To evaluate them, criteria are defined. And a comparison and an assessment are based on the criteria.

4.1.1 The Existing System

The existing web based GIS was developed by using ESRI’s ArcIMS, Internet Information Services (IIS) and Microsoft Access as shown in Figure 10. Microsoft Access, a DBMS from Microsoft, is used to manage the thematic data. IIS is a web server that manages the web site. ArcIMS composes, manages, and publishes the maps with interactive capability such as giving corresponding information of a parcel that is graphically clicked by a user. It also provides some functions such as map navigation, zooming, and selecting tools. The information related to ArcIMS, Connector, and Viewer which is described further in this section is mainly based on the information from ArcIMS 9.1 help system (available when ArcIMS 9.1 is installed).

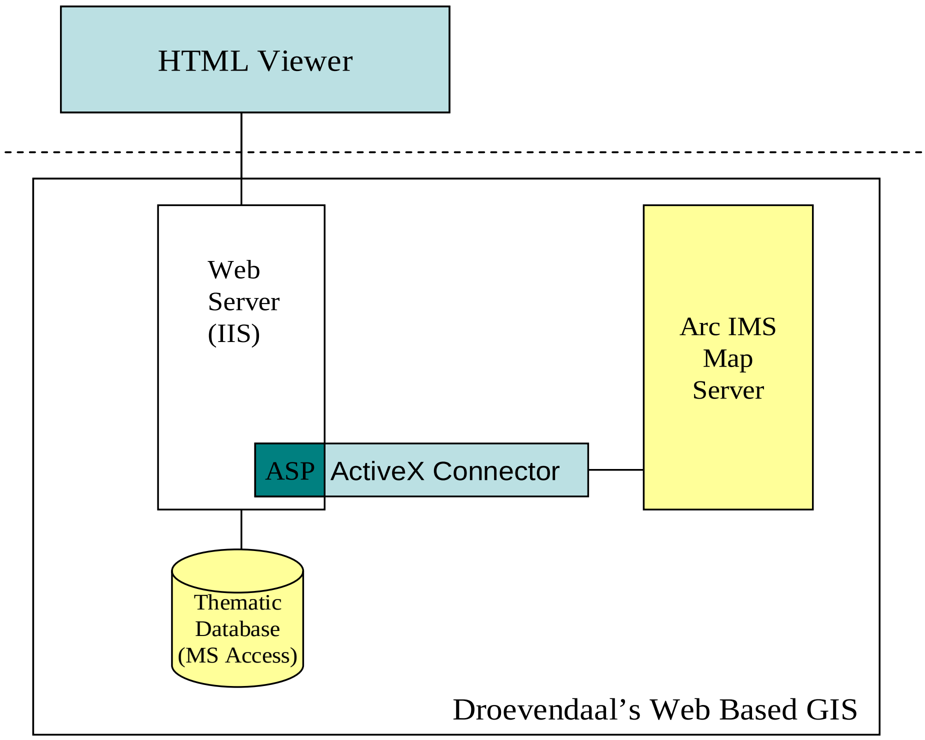

Figure 10. Web based GIS implemented in Droevendaal fram

The ActiveX connector is one out of three connectors available in ArcIMS. It provides ability to add maps, with some mapping functionalities, to existing applications using Active Server Page (ASP). ASP is Microsoft's server-side script engine for dynamically-generated web pages. It is an add-on to IIS. ASP pages can contain either server side or client side scripts which perform functions such as database access and interactive functions.

ArcIMS provides 4 customizable clients namely HTML, Java, ActiveX, and ColdFusion. The HTML Viewer, which is used in Droevendaal farm's case, performs less processing on the client machine than the Java Viewer. This is often referred to as a lighter or thinner client. ActiveX and ColdFusion are the thinnest clients. HTML is the most widely accepted and supported language on the Web for defining page content. The HTML Viewer is the best solution when building a web site that incorporates one Image MapService. It does not need any plugin.

The service implemented in Droevendaal farm's case is an Image MapService which uses the Image Server. When a request is received, a map is generated by the Server and sent to the client as an image (JPEG format). A new map image is generated each time the client requests new information. For instance, when the information of parcel 1 in the farm is requested, ArcIMS generates a map image showing the farm with parcel 1 highlighted in yellow and send it back to as a JPEG file to show on the web browser as shown in Figure 11.

The web pages are written in ASP scripts which communicate with the map server via an ActiveX connector. This provides a dynamic and interactive capability to the website. It is dynamic because an update occurring in the database is automatically known to the corresponding web page that contains an ASP script retrieving data from the database. And it is interactive because the map server is able to display the map corresponding to the data retrieved by the ASP script.

In this research, according to the structure of the existing web site, the interface was classified into 3 main parts namely the map frame, the panel frame, and the attribute frame as shown in figure 11.

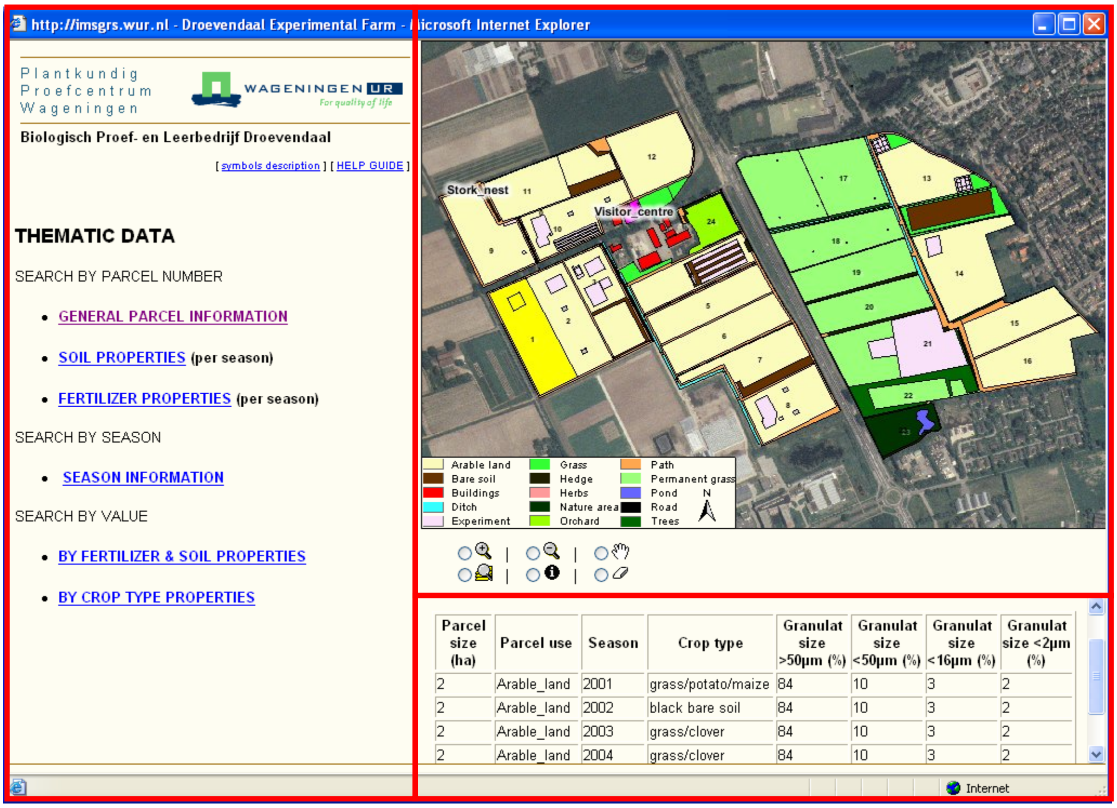

Figure 11. Structure of the existing system interface

The Map frame

The map frame displays the map. It provides some tools for basic navigation that allow users to zoom, pan, and select a particular parcel.

The Panel frame

The panel frame simply contains a menu for users to query the parcel and crop cultivation information. It is actually a web page inside the frame which has the same functionalities as a normal web browser. The menu is divided into 3 groups namely search by parcel number, search by season, and search by value as shown in Figure 11. Once the query is made by clicking an item in the menu, the thematic data is shown in the attribute frame and, in case the query relates to one of more parcels, the corresponding parcels are highlighted in yellow in the map frame.

The Attribute frame

The attribute frame is the area to display any web pages. In this case it is used to display attribute data of each query selected from the menu. Similar to the menu in the menu frame, it is actually a web page inside the frame which has the same functionalities as a normal web browser.

From this point onwards in this thesis research, the words "existing system" refers to the website that deploys ESRI's ArcIMS as the map server, connect to the DBMS by ActiveX connector via ASP script, make use of Image map service and HTML viewer, and has the interface structure as shown in Figure 11.

4.1.2 Google Earth

Google Earth is a free internet tool that provides the digital geography of the globe with some GIS functions. Based on the information on the official website of Google Earth (http://earth.google.com), Google Earth uses a streaming technology delivers the data to users as they need. It provides aerial and satellite imagery depicting cities around the world, some in high-resolution detail. In some place, the resolution of the image is good enough to see individual people. There is a local search that allows users to search for restaurants, hotels, and driving directions. Results show in a 3D earth view. Moreover, it is capable to layer multiple searches, save results to folders, and share with others. Layers can show parks, schools, hospitals, airports, shopping, and more. The data exchange format of Google Earth is Keyhole Markup Language (KML), which is based on XML, that allows users to share annotations and view data points created by Google Earth users.

Although Google Earth could be considered as the most successful spatial information product to date in terms of its global uptake and the commercial interest being shown in it, there has been technical concerns about its quality of the data including mismatched color imagery, variable resolution and currency, and inaccuracy of shape and position of its overlaid data themes such as roads and border (Hunter et al., 2007).

4.2 Methods

To evaluate the feasibility of using Google Earth as an alternative viewer for Droevendaal farm, the following methods were used:

4.2.1 Empirical study in Google Earth implementation

The empirical study was done firstly by studying Google Earth 4.0.2693 (Beta) which is a free version, build on December 15, 2006, to figure out the potential tools and functionalities that enabled implementing Google Earth as a viewer for the existing system. Then the implementation was done in such a way that (if possible) had the same or similar structure and did the same task as the existing system.

Study of Google Eearth

The main resource for studying of Google Earth was the official web site of Google Earth (http://earth.google.com).

The interface of Google Earth was classified into 3 main frames, named corresponding to those of the existing system i.e. the map frame, the panels frame, and the attribute frame as shown in Figure 12. Each frame consisted of some components which had funtionalities as described below.

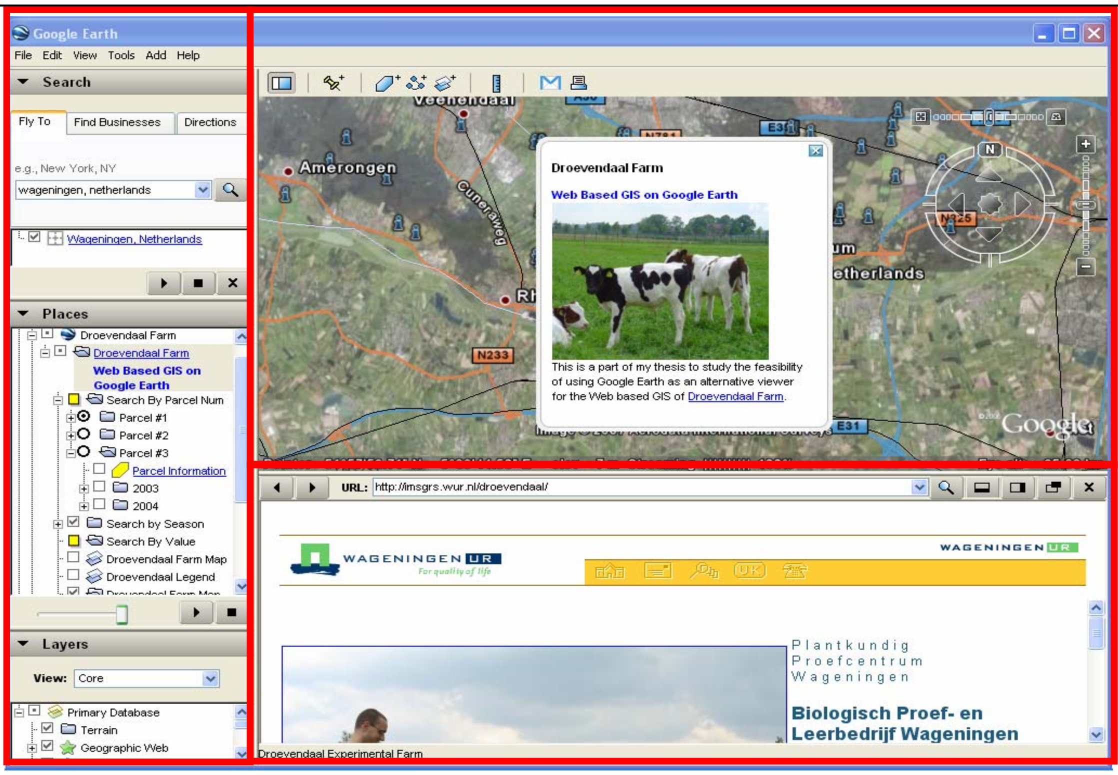

Figure 12. Structure of Google Earth interface

The Map frame

The map frame consists of a 3D viewer and a tool bar. The 3D viewer shows the imagery which covers the entire globe in 3D view. The imagery is derived from patches of satellite imagery and aerial photographs. Therefore the quality may vary from patch to patch. The resolution is mostly at 15 meters. In some cities such as Washington DC, London, and Den Haag the imagery's resolution is much higher, i.e. greater than 1 meter. Whereas in some area such as the ocean, the resolution is lower, i.e. 500 meter or less.

On the upper right corner of the viewer, there are navigation controls that allow users to zoom, pan, tilt, and rotate the map. The tool bar provides tools including hide/show sidebar (to conceal or the display the side bar), placemark (to add a placemark for a location), polygon (to add a polygon), path (to add a path, which is line or lines), image overlay (to add an image overlay on the Earth), measure (to measure a distance or area size), email (to email a view or image), and print (to print the current view of the Earth). The reference system used in Google Earth is World Geodetic System 1984 (WGS84). More information about WGS 84 could be found at http://earth-info.nga.mil/GandG/publications/tr8350.2/tr8350_2.html. The objects that lay over the 3D viewer is actually kept in KML format. Information about KML as described below in this chapter is mainly based on Google Earth KML 2.0 Tutorial (2006).

KML is defined as a file format used to display geographic data in an earth browser, such as Google Earth, Google Maps, and Google Maps for mobile. A KML file is processed in much the same way that HTML (and XML) files are processed by web browsers. Like HTML, KML has a tag-based structure with names and attributes used for specific display purposes. Thus, Google Earth and Maps act as browsers for KML files.

KML can be used for the following purposes:

- Specify icons and labels to identify locations on the planet surface
- Create different camera positions to define unique views for each of your features
- Use image overlays attached to the ground or screen
- Define styles to specify feature appearance
- Write HTML descriptions of features, including hyperlinks and embedded images
- Use folders for hierarchical grouping of features
- Dynamically fetch and update KML files from remote or local network locations
- Fetch KML data based on changes in the 3D viewer
- Display COLLADA textured 3D objects

KMZ is zipped KML. It is a compressed format of KML which includes the referenced objects such as images into one file. It is designed for data sharing.

A map/object can be laid over the Earth imagery by the following methods;

- Image overlay: It is used to lay the map image over the 3D viewer, the acceptable file extensions include JPG, BMP, TIF, TGA, PNG, JPEG, GIF, TIFF, DDS, PPM, and PGM.

- Polygon and path: It is used to create polygons or lines which are Google Earth's features. The coding behind them is in KML format.

- Placemark: It is a pin point to a location on the Earth.

- Network link: It is a Google Earth's feature that provides a way for multiple clients to view the same network-based or web-based KMZ data and automatically see any changes to the content as those changes are made. A network link allows for content publishing in a manner similar to web page/web browser content delivery as shown in Figure 13. The figure shows Google Earth's ability to view KML files from the WWW and automatically or manually reload the network link to view any change which is comparable to viewing HTML pages from by a web browser.

Making use of network link provides a way to get dynamic data. Firstly, a server has to provide the KMZ file to which users will connect via the network link. The users can specify how often to refresh the data in the file in either time based such as every one hour or view base such as whenever the region is in shown in the viewer. When the KMZ file is updated the users will get the new data in turn.

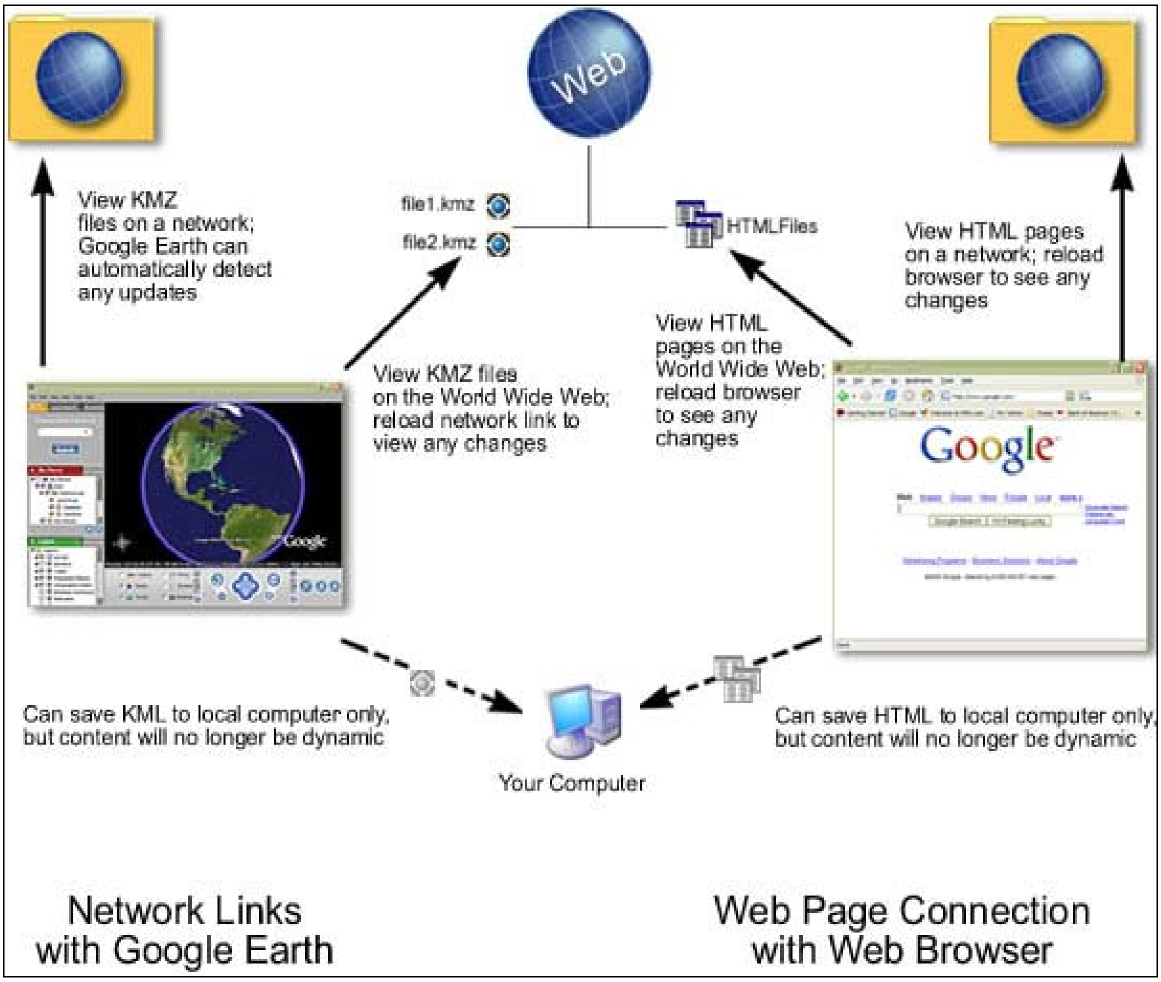

Figure 13. Parallels between web-based content and KMZ content via a network link using Google Earth (Google Earth User Guide, 2007)

- Image from Web Map Service (WMS): WMS is a service that provides maps, normally in image format such as JPEG, GIF and PNG, of spatially referenced data dynamically generated from geographic information. Google Earth has the ability to link to a WMS service to get the map overlaying the 3D viewer. An example of WMS server is http://cgdi-dev.geoconnections.org/cgi-bin/tomatlasmapper which provides several maps of Canada. Making use of images from WMS can get dynamic data in the same way as by network link.

The Panel frame

The Panel frame or side bar consists of 3 panels as described bellow:

- The search panel allows users to search for a place, either by name or by address, and fly to it. In addition to searching for a particular place, it provides ability to find the travel directions to go from one place to another place. In the bottom of the panel, there is the play tour button that allows viewing the map moving from one place to each of the consecutive place listed in the panel.
- The places panel is the area where users can manage their own menu. They can create, modify and delete the menu that link to geo-data including the placemark, the line and polygon features, the image overlay, the screen overlay, the network link, as well as the web page on the web frame. In the bottom of the panel, there are a play tour button that allows viewing the map moving from one place to each of the consecutive place listed in the panel and a slide bar that allows setting the transparency of an overlay.
- The layers panel provides the management to the data shown in the map. The data is provided in many layers such as terrain, roads, borders, and Google Earth community. Users can turn on and off each layer as they desire.

The Attribute frame

The attribute frame is the area to display any web pages that is initially called by normal hyperlink in either a popped up description window or a menu in the panels frame. It has the same functionalities as a normal web browser. In addition to show the web page on the bottom of the viewer, it can also be shown either on the right hand side or separately in an external browser.

Implementation

The author tried to implement the Droevendaal web based GIS by using Google Earth the viewer in such a way that could do the same task as it was in the existing system and, if possible, with the same or similar user interface structure. The implementation was done as the following:

Creating the map of the farm

- The Shape file (of the farm) was copied from the existing system. The original data was acquired using Real Time Kinematic (RTK) GPS equipment which had a cm-level accuracy.
- Because the file had no projection information, the Dutch National Grid (RD) was assigned to the shape file by using ESRI's ArcMap 9.1.
- The file was re-projected into WGS84.
- The shape file was converted to KML file by using KML Home Companion 3.1.0 which is an ArcMap extension available to download at http://arcscripts.esri.com/details.asp?dbid=14495 .
- Open the KML file in Google Earth.
- The image of legend was copied from the existing system.
- The image was added as a screen overlay to the viewer by coding in KML.

Creating the menu

- The menu was created in the Places panel firstly by add a root folder.
- Folders were added to group the menu items by type of query (search by parcel number, search by season, and search by value).
- In the search by parcel number folder, sub-folders were added to group the menu items by parcel number.
- In each of the sub-folder, a yellow polygon was created over the corresponding parcel to highlight the parcel when it was selected.
- The menu item for query was created by manual adding a placemark which contain a Hyperlink that link to the database server. The database after modification as mentioned in Chapter 3 was used for this implementation without any further modification. Parameters were passed by hard coding to the URL of the hyperlink.

Setting and displaying the attribute page

- The display option of Google Earth was set not to show web results in external browser.
- Once a menu item was clicked, the corresponding web page containing attribute information would show on the attribute frame. The web pages after modification as mentioned in Chapter 3 were used for this implementation without any further modification.

4.2.2 Criteria defining

First, criteria were defined to evaluate the software functionality of both the existing system and the Google Earth alternative. The criteria focus on the implementation case of Droevendaal farm.

The criteria were chosen based on the concept of usefulness of the system. Usefulness is the issue of whether the system can be used to achieve some desired goal which can be broken down into the two categories of utility and usability (Nielsen, 1994). Utility is the question of whether the functionality of the system in principle can do what is needed, and usability is the question of how well users can use that functionality (Nielsen, 1994).

On the one hand, software utility is clear to be understood as whether the software provides necessary utilities to perform tasks. On the other hand, software usability addresses aspects of the interaction expressed in terms of human action, and the nearest to an agreed standard is the ISO 9241 (Dillon, 2002).

Usability and its elements are defined by the ISO (DIS 9241-11) as follows (Folmer and Bosch, 2004):

Usability is the effectiveness, efficiency and satisfaction with which specified users can achieve specified goals in particular environments.

- Effectiveness is the accuracy and completeness with which specified users can achieve specified goals in particular environments.
- Efficiency is the resources expended in relation to the accuracy and completeness of goals achieved.
- Satisfaction is the comfort and acceptability of the work system to its users and other people affected by its use.

According to the necessity of the functionality to this specific case, the availability as well as the effectiveness of the items in Table 4 were defined as the criteria. The table also describes how the items were evaluated.

Table 4. Evaluation criteria and the measurement test

Item	Measurement test
Map	
To display a map in 2D and 3D	- Add and show a 2D object to the viewers. - Add and show a 3D object to the viewers
To support a variety of file types of the displayed map	- Check the acceptable file formats that can be added to the viewer - Inspect property of the display map by using Windows utility (right click over the map, and select properties)

Item	Measurement test
To display and customize a legend	- Create a legend, and add the legend to the map in the viewers
To support a variety of projections	- Add maps with various projection systems to the viewer
*Base map**	
To provide the base map	- Visually inspect whether a base map is provided
Accuracy of the base map	- Visually inspect the base map within the area of interest
Basic functions	
Availability of a zoom tool	- Visually inspect and, if provided, use the tool
Availability of a navigation tool	- Visually inspect and, if provided, use the tool
Availability of a selection tool.	- Visually inspect and, if provided, use the tool
Communication with database	
Communication between the menu and the database	- Make a query from the menu to the database - Dynamically retrieve data from the database to use as an item in the menu
Communication between the map and the database	- Make a query from the map to the database - Display the map corresponding to the database query result
Interaction with the map	
Interaction between the menu and the map (to query the map from the menu)	- Display the map corresponding to a selected item in the menu
Interaction between the users and the map (to query the map graphically)	- Retrieve the parcel related data by clicking on a parcel in the map
Ability to edit the map	
By developers	- Create and edit a map before publishing
By users	- Modify the published map within the viewer

Item	Measurement test
Other value added functions	
To develop and manage the map centrally	- Create and publish a map in an Internet server - Access the map from a PC connected to the Internet or the server - Update the map in the server - Access the map from the PC to check the updated data
To share/distribute the application	- Create an application - Distribute the application to another client - Run the application at the client
To work offline	- Disconnect the application from the Internet - Run the application
To search and go to a destination	- Search for a destination available on the map - Show the destination on the viewer

* Base map in this chapter refers to the imagery of the Droevendaal farm and the surrounding area.

4.2.3 Grade defining

Each of the items listed in Table 4 was graded according to the system shown in Table 5.

Table 5. Grading system for the assessment

Grade	Description
+ +	The software can perform all the functionality completely and accurately (if relevant)
+	The software can perform the main part of the functionality
+/-	The software can perform some part of the functionality
-	The software can perform little part of the functionality (insufficient to achieve the intentional task)
- -	The software cannot perform the functionality at all

4.2.4 Assessment based on the criteria and the empirical study

After defining the criteria and grades, and the empirical study, the assessment of the software was done by the author. A grade was given to each of the items in the criteria based on the facts and experiences from the empirical study.

4.3 Results

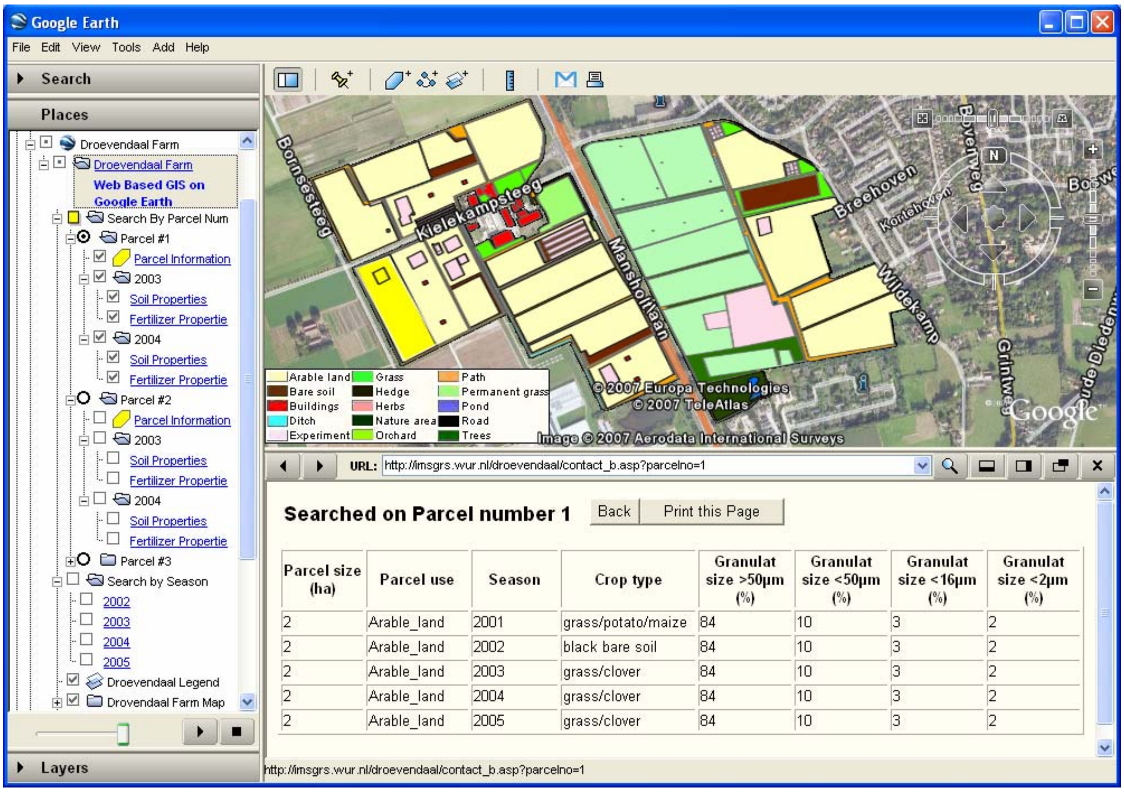

Figure 14. The result of implementation attempt from the empirical study

The result of implementation attempt from the empirical study is shown in Figure 14. The farm's parcels are overlaid as Google Earth's polygon on the 3D viewer. The menu can be expanded to show sub folders and items which provides links to the attribute pages. Each of the query types is described below.

- Search by parcel number: By selecting a parcel number folder, the corresponding parcel will be highlighted in yellow in the 3D viewer. By clicking the menu items, the corresponding webpage containing the attributes will be shown in the attribute frame.
- Search by season: By clicking the menu items, the corresponding webpage containing the attributes will be shown in the attribute frame.
- Search by value: It is problematic to implement.

Assessment

The result of the assessment is shown in the Table 6 and the grading is explained below the table.

Table 6. Assessment result

Item	Grade	
	Existing System	Google Earth
Map		
To display a map in 2D and 3D	+	+ +
To support a variety of types of the displayed map	+/-	+
To display and customize a legend	+	+
To support a variety of projections	+ +	-
Base map		
To provide the base map	-	++
Accuracy of the base map	N/A*	+/-
Basic functions		
Availability of a zoom tool	+	++
Availability of a navigation tool	+	++
Availability of a selection tool	+	-
Communication with database		
Communication between the menu and the database	+ +	-
Communication between the map and the database	+	-
Interaction with the map		
Interaction between the menu and the map (to query the map from the menu)	+ +	-
Interaction between the users and the map (to query the map graphically)	+	-
Ability to edit the map		
By developers	+ +	+
By users	- -	+
Other value added functions		
To develop and manage the map centrally	+ +	+/-
To share/distribute the application	- -	+ +

Item	Grade	
	Existing System	Google Earth
To work offline	-	+/-
To search and go to a destination	- -	+

*N/A = Not applicable

Explanations for the grading are described as the following:

Map

- To display a map in 2D and 3D

  The existing system allows showing the map only in 2D view whereas Google Earth allows showing the map in 2D and 3D views. The test of displaying a 3D feature is shown in Figure 15.

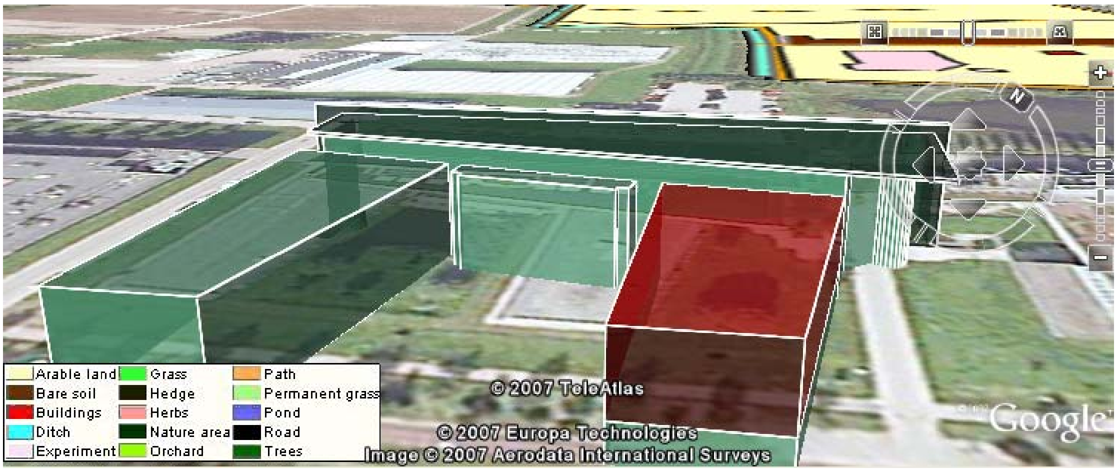

Figure 15. Displaying a 3D feature in Google Earth

- To support a variety of types of the displayed map

  The existing system, which employs ArcIMS Image MapService, shows the map only as a JPEG file whereas Google Earth can show the map in JPEG file format, and polygon and line which are Google's features (the code behind them is KML). However, the data source map of the existing system could be both shape file and image file such as TIF file format. For Google Earth, the data source map and the map shown on the website are in the same file format.

- To display and customize a legend

  Both system are capable of displaying and customizing the legend. However, for Google Earth, it is possible by using screen overlay which currently is not included in any panel or tool bar of Google Earth. The only way to do this is by coding directly in the KML file.

- To support a variety of projections

  For the existing system, the projection of the map is not fixed. A map with any projection system could be to publish. In contrast, the projection of the map has to be WGS84 for Google Earth. Therefore, to import data into Google Earth, a re-projection may be needed.

Base map

- To provide the base map

  In the existing system, no base map is provided. Users need to prepare themselves. ArcIMS threats the map and the base map as the same when they are composed but in different layers. In contrast, Google Earth provides imagery which covers the entire globe.

- Accuracy of the base map

  Because the based map is not provided for the existing system, the accuracy of the based map depends on the acquired data source. Therefore, it is not applicable to assess.

  For Google Earth, because the quality of the imagery may vary from patch to patch, accuracy of the base map depends on the location of the Droevendaal farm. Visual inspection of the Droevendaal farm area showed some data accuracy problems which can be seen in Figure 16. The figure showed the displacement of the Droevendaal farm which could be seen clearly by the shift of the pond of about 11 meter (measured by the Google Earth measure tool). In addition, there was also the displacement and poor geometry which could be seen clearly at the area of the roundabout. The roundabout in the base map shows a shift and distortion relative to the road (Mansholtlaan) around the roundabout which is in the roads layer (controlled by the layers panel).

Figure 16. An example of data accuracy problem in the area of Droevendaal farm

Basic functions

For the existing system, basic functions are provided namely zoom, pan, and selection whereas Google Earth provides the following functions; zoom, pan, tilt, and rotate. Zoom and pan functions of Google Earth work more smoothly than those of the existing system.

Communication with database

- Communication between the menu and the database

For the existing system, communication between the menu and a database is possible. Therefore, it allows queries of the thematic data. It simply works in the same way as a normal web application that communicates with a database via server side scripts. The menu frame and the attribute frame are both in a normal web browser, thus they all have the full capability of the web browser which enable html as well as scripts. Using some features in the menu such as combo box with connection to the database keep the menu updated dynamically as the database change. The interface design can be customized as the user desires.

On the other hand, for Google Earth, communication between the menu and a database is possible only via the hyperlink on the menu. The web page in the attribute frame can have the full capability of the web browser which enables html as well as scripts whereas the menu in the panel frame can have only limited functions of the web browser including some text functions, images, and hyperlinks. The dynamic update feature as mentioned in the existing system is not included in the panel frame.

- Communication between the map and the database

  For the existing system, communication between the map and a database is possible by a connector. In this case, it is the ActiveX connector which communicates to the database by ASP scripts as shown in Figure 10.

  On the other hand, communication between the map and a database is not possible directly for Google Earth. A possible way to communicate is via the hyperlink on a popped up description box as shown in Figure 12.

Interaction with the map

- Interaction between the menu and the map (to query the map from the menu)
  For the existing system, interaction between the menu and the map is possible. The menu is similar to a web page and it can have the same capability. Similar to the previous criteria, communication with the thematic database is achieved by an ActiveX connector which allows communication between the map and a web page via an ASP script. The map responds to a request submitted by a web page. Changing in the attribute data shown on the web page dynamically changes the display of the map correspondingly.

  For Google Earth, interaction between the menu and the map is possible but with more static approach i.e. to link the menu to image overlays, placemarks, or maps that were generated by Google Earth’s polygon and line features.

- Interaction between the users and the map (to query the map graphically)
  For the existing system, interaction between users and the map is possible. By using the selection tool, the users can click the map directly and get some information about that part of the map, e.g. parcel geometry information in case of Droevendaal farm. In contrast, interaction between users and the map is virtually not possible in Google Earth. Only a placemark on the map can give some information to the users via a popped up description box.

Ability to edit the map

For the existing system, the map is editable only by developers before publishing it on the website. In contrast, for Google Earth, both users and developers can locally add and edit placemarks, image overlays, screen overlays and Google Earth's polygon and line features to the map.

Other value added functions

The existing system has an ability to develop and manage the map centrally. The website, powered by the web server and map server, is managed centrally which is preferable for the case of Droevendaal farm. The users can visit the website via a web browser to see the information. In contrast, Google Earth is more sharing and distributing oriented. Firstly, the users need to install the Google Earth on the client side. After that the data can be shared or distribute to the others by simply sending a KML or KMZ file to the others. It is a different approach. However, a possible way to manage the map centrally is by setting up a server providing a KMZ of KML file so that all the users can link to the file by a networklink. Nevertheless, using a networklink in this kind of application is not practically effective. In addition, Google Earth has an ability to work offline, to some extent, depending on the cache size. Therefore, in some cases, users still can work without any internet connection. Moreover, search panel in Google Earth is handy. It provides easy way to search and fly to destinations on Earth. Together with the rich of information, users can have not only the information of the map of interest but also its context and direction. Play tour can simulate a travel follow the direction.

4.4 Discussion

The implementation of Google Earth for Drovenaal web based GIS is problematic because of the following reasons:

- Each menu item created by using a placemark with Hyperlink is static because parameters were passed by hard coding to the URL of the hyperlink. For instance, the URL http://esg1866/contact_revised01.asp?season=2003&parcelno=1 links to the parcel information of the parcel 1, year 2003. Thus it is not convenient to create, to keep track of changes with the database, and to maintain in practice. For instance, if there is data from a new season or there is a new parcel data added to the database, a new menu has to be created manually.
- It is not convenient if there are a lot of query parameters. For example, in case of search by parcel number, there are 24 parcels and it needs 24 folder to group. And each of these folders contains sub-folder for each year, etc., as shown in Figure 17. To illustrate this, it can be compared with the better usability in case of the existing system where a combo box that filled up the list with data fetched from the database was use as the menu.

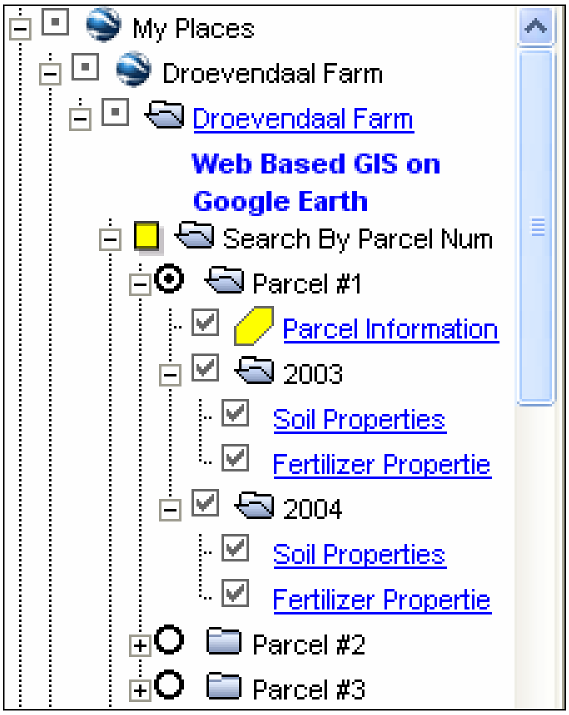

Figure 17. Menu structure of the implementation

- By all the normal tools provided by Google Earth, it is not possible to create dynamic map result for the query such as query by value. For example, the query result for the minimum fertilization for a particular year may be any parcel number, and can be more than 1 parcel that applied the minimum amount of fertilizer. This can not be done by Google Earth, even by static method unless the query result was known beforehand.

The result shows that using Google Earth as an alternative viewer for the case of Droevendaal farm faces two major problematic functions namely communication with the thematic database and interaction with the map. This is partly because of the complexity of the application that requires several queries and a lot of interaction with the database. The menu in the panels frame does not have the functions of a normal web browser. It is limited to some functions such as image, hyperlink, and text. Improvement of this menu (if any) in the future can give more capability to Google Earth and the communication between the menu and the database will be the same as that of the existing system. However, the interaction with the map is far behind that of the existing system.

Data accuracy of Google Earth has been doubt so far because of the evidences from practical usage. A study from Hunter et al. (2007) showed some an example of a data accuracy problem where roads in a region in south-east Australia were shown in Google

Earth some 500-900 meter off the true position. In addition, its overlaid data themes such as roads and borders were often shown clearly out of position and their shape may bear little resemblance to the real world. Similarly, visual inspection of the Droevendaal farm area showed some data accuracy problems which confirmed the example from the study of Gary Hunter. However, for the case of Droevendaal farm, this problem does not actually important for the application because the users mainly aim to get the thematic data, corresponding parcels as well as the farm map shown on the website. In this regard, accuracy of the based map is not a big problem. The little displacement of the map does not cause any effect for that aspect of purpose. However, it could be crucial in some other cases where high data accuracy is needed such as use for an application for subsidy or obligatory declarations of the parcel of land.

Nevertheless, let alone the two functionalities mentioned earlier as well as the accuracy of the data, Google Earth mostly shows equivalent and better effectiveness to the existing system. Some functions such as 3D capability, ease of file sharing, rich of information, and searching is powerful and possibly add more value to many kind of applications. In addition, keeping in mind the Google Earth is free software, it is still attractive to use for many other kind of applications. Therefore, applications that do not rely on communication with the database and the interaction with the map, and data accuracy is not important can be implemented using Google Earth as a viewer especially for those that deal with data with a spatial component overlaid on top of a background imagery of a portion of the Earth. Besides, if in the future, Google Earth has the same capability as a web browser, i.e. to parse HTML and web based scripts, it will be capable for using in a database intensive application. And it is recommended to consider the accuracy of the imagery of the area of interest beforehand.

In conclusion, the criteria for the evaluation were defined and the result of the evaluation shows that using Google Earth as an alternative viewer for Droevendaal farm is not feasible. The research questions 5.2 and 6 are answered.

5. Conclusions and Recommendations

To answer all the research questions, study of data integration between farm management system and web based GIS, based on the case of Droevendaal Farm, is done in three main parts namely XML/EDI and EDI Teelt, data integration, and use of Google Earth in the web based GIS. The corresponding answer to each question is listed respectively below:

1. An EDI Teelt message is a well-formed XML document. The message contains crop cultivation as well as necessary data to communicate with a counterpart including owner information, parcel information, soil information, soil analysis information, crop information and fertilization information. And all the elements are named in Dutch language. The main structure of the EDI Teelt is shown in Table 1 and the elements of the EDI Teelt are listed in the EDI Teelt schema (Appendix B).
2. XML/EDI is a standard framework that integrates XML and EDI. Implementation of the data integration using EDI Teelt can comply with the XML/EDI. However, currently there is no global repository which is a component of XML/EDI. The implementation is still possible but it will lose some benefits from the absence of this shared Internet dictionary.
3. The input data for the web based GIS consists of Parcel (parcel number, parcel size and land use type), Crop (crop type), Fertilization (period, fertilization amount, manure and date), Soil sample's properties (N,P, KHCL, Pw, PAL, C, orgstof, and pHKCL), and Soil texture (particle size distribution). Full information could be found in its XML schema (Appendix E, on CD). The data structure is different from that of EDI Teelt message.
4. XML/EDI was used as a framework to implement the data integration. XSLT is the tool that was used to transform EDI Teelt document into another XML document compatible with the web based GIS.
5. Potential improvements of the current web based GIS are described below:

   5.1 By applying database analysis based on relational database concept as well as the objectives of data integration, the database was modified and it improves data integrity, efficiency, and maintainability.

   5.2 Study of using Google Earth as an alternative viewer for the case of Droevendaal farm shows a negative result. Google Earth is not appropriate for this particular application.
6. The main criteria for measuring the feasibility referred to in question 5.2 are the availability and effectiveness of the following items; map, base map, basic GIS functions, communication with database, interaction with the map, ability to edit the map, and other value added functions.

According to some problems in the design of the existing database which may cause the data integration impossible or ineffective, the database had to be modified. It was done by database analysis applying the related relational database concepts. By study of the data schemas in both the sender and the receiver side, the finding shows different in both semantic and structure. The data exchange is done by convert the sender's schema to match that of the receiver. It is done by study of the XML schemas in both sides and then used XSL script as a tool to convert. The implementation is done by using a web page interface to get the input EDI Teelt document, upload it to the receiver's server, transform by XSL into the desirable format, and import to the database.

Although the method for data integration proposed in this thesis research is effective, it is not practically possible to implement in the Droevendaal farm now. Because the EDI message generated by the Droevendaal FMS is not complete. Some data in the FMS are not included in the EDI Teelt message. This is a bug in the software which is supposed to be solved in the next version. Apart from this problem, currently there is some mismatch between EDI Teelt message and its XML schema. This is not as crucial as the former problem. However, without the XML schema, the data can be prone to error because it lacks syntax and structure validation as well as the ability to keep track of change in EDI Teelt versions. In addition, it should be noted that ISAGRI's FMS generate a contract code in the EDI Teelt message which is only applicable for arable crop but not for non-arable crop such as pasture. Thus, only the arable crop cultivation data can be exported to EDI Teelt messages from ISAGRI's FMS. If the non-arable crop data is to be update in the web based GIS, i.e. to be included in EDI Teelt messages, this problem should be solved.

After these problems are solved, the implementation of the data integration for the Droevendaal farm is feasible. The database of the web based GIS can be updated by EDI Teelt message generated by the FMS. The data can be transferred to the web based GIS server by submitting the EDI document online via the web page. Then it is transformed and imported to the database automatically. Just before the data is imported, the primary key and foreign key constraints are applied to ensure the data integrity. This is done by DBMS itself, not by programming. It does not allow duplicate data to be imported. Therefore, to modify an existing data is not possible by EDI Teelt messaging.

Study of using Google Earth as an alternative viewer for the case of Droevendaal farm shows a negative result. Google Earth is not appropriate to this particular application because of the ineffectiveness of two important functionalities namely communication with the database and the interaction with the map. However, let alone these two functionalities as well as the accuracy of the data, Google Earth shows equivalent and better effectiveness to the existing system. Therefore, applications that do not rely on communication with the database and the interaction with the map, and data accuracy is not important can be well implemented using Google Earth as a viewer.

It is recommended for further study of the following topics;

- Trend and further development of Google Earth and other related software such as Google Maps, ESRI's ArcExplorer, Microsoft Virtual Earth, and NASA's World Wind: Although Google Earth is very polupar so far, it might be useful to keep an eye on other related software. Because they might have some different strength and weakness and some of them might be feasible to be an alternative viewer for the web based GIS. It is also recommended to keep pace with the future development and trend of Google Earth and those related software because they might add some more features into the software which may make the implementing of the software as a viewer for the web based GIS more feasible.

- The embodiment of XML/EDI: This thesis research studied only the XML/EDI framework. However, the ongoing embodiment of XML/EDI should be studied because it might influence the implementation of the existing standard EDI.

- Geometry issues in EDI: This thesis research does not aim to solve the geometry issue. However, the geometry problem does exist and there are some projects such as Geoboer that deal with this problem. Thus, it would be useful to study those projects as well as technologies that are related to these issues.

- Automatic approach for schemas matching: The schema matching used in this thesis research is manual approach. However, there have been some attempts to make the automatic schema matching which aims to transfer the schema matching burden to the machine. Thus, it might improve the data transformation mechanism.

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Appendix B : XML Schema corresponding to the EDI Teelt


```
<?xml version="1.0" ?>
 <!--  XML Schema created on 17-05-2006 14:49:18 by HS (ATC)
  -->
 <!--  W3C Schema Definition
  -->
 <xsd:schema xmlns:str="http://www.edi-teelt.nl/EDITEELTALG2006" xmlns:cdt="http://www.edi-teelt.nl/ETdomains2006" xmlns:xsd="http://www.w3.org/2001/XMLSchema" xmlns:ns1="http://www.edi-teelt.nl/EDI-TEELTALG-2006" targetNamespace="http://www.edi-teelt.nl/EDI-TEELTALG-2006" elementFormDefault="qualified" attributeFormDefault="unqualified">
  <xsd:import namespace="http://www.edi-teelt.nl/ETdomains2006" schemaLocation="DOMAINSEDI-TLT3_0.XSD" />
 <xsd:element name="Transaction">
 <xsd:complexType>
 <xsd:sequence>
 <xsd:element name="HeaderBericht" minOccurs="0">
 <xsd:complexType>
 <xsd:sequence>
  <xsd:element name="HdrVersienummerDatadic" type="cdt:TypeVersienummer" />
  <xsd:element name="HdrVersienummerBerichttype" type="cdt:TypeVersienrType" />
  <xsd:element name="HdrBerichttype" type="cdt:TypeTypeAanduiding" />
  <xsd:element name="HdrBerichtId" type="cdt:TypeIdBericht" />
  <xsd:element name="HdrDatumBericht" type="cdt:TypeDatum" />
  <xsd:element name="HdrRetourAdres" type="cdt:TypeAdres" minOccurs="0" />
  <xsd:element name="HdrTeeltjaar" type="cdt:TypeJaar" />
 <xsd:element name="Bedrijf" minOccurs="0" maxOccurs="99">
 <xsd:complexType>
 <xsd:sequence>
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  <xsd:element name="BdrVestigingsstraatBedrijf" type="cdt:TypeStraat" minOccurs="0" />
  <xsd:element name="BdrVestigingshuisnummer" type="cdt:TypeHuisnummer" />
  <xsd:element name="BdrVestigingspostcode" type="cdt:TypePostcode" />
  <xsd:element name="BdrVestigingsplaats" type="cdt:TypePlaats" minOccurs="0" />
  <xsd:element name="BdrVestigingsland" type="cdt:TypeCodeLand" />
  <xsd:element name="BdrKeuringsdatumStrooier" type="cdt:TypeDatum" minOccurs="0" />
```

```
<xsd:element name="BdrKeuringsdatumSpuit" type="cdt:TypeDatum" minOccurs="0" />
<xsd:element name="BdrBedrijfsquotumSuiker" type="cdt:TypeHoeveelheid" minOccurs="0" />
<xsd:element name="BdrAantalHaSuikerbieten" type="cdt:TypeAantal" minOccurs="0" />
<xsd:element name="BdrBedrijfsquotumZetmeel" type="cdt:TypeHoeveelheid" minOccurs="0" />
<xsd:element name="BdrBeroepsmatigGebruikInternet" type="cdt:TypeCodeJaNeen" minOccurs="0"
/>
<xsd:element name="Perceel" minOccurs="0" maxOccurs="99">
<xsd:complexType>
<xsd:sequence>
<xsd:element name="PrcCodePerceel" type="cdt:TypeCodePerceel" />
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<xsd:element name="PrcOppervlaktePerceel" type="cdt:TypeOppervlakte" />
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<xsd:element name="GrnLaboratoriumnummer" type="cdt:TypeLabnr" minOccurs="0" />
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