Using the Internet as a Medium for Transfer of Knowledge and Technology between Countries

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Abstract: The paper presents results from an ongoing agricultural project where the Internet is used for efficient transfer of knowledge and technology between Denmark and the Baltic countries. Danish weather-based models for risk of crop diseases and pests have been validated under Baltic conditions and small weather stations have been installed in agricultural areas in the three countries. Web technology has being implemented for the presentation of weather and daily risk values of diseases and pests. The results of the project demonstrate that the Internet makes it possible to transfer knowledge and technology between countries with different stages of technological or economical development.

Keywords: Internet, World Wide Web, information system, technology transfer, weather, warning system, dynamic information

1 Introduction

With the World Wide Web it has become very easy to get access to information. The technological skills and the hardware and software required are manageable. One advantage with the Web is that it is indeed becoming World Wide, so also people from developing countries have access to information through this enormous source. With the emerging Internet cafÈs in many developing countries it is not even necessary to own a computer. In this way, the web can turn out to be a better medium than books and PC-based software for transfer of knowledge and technology to developing countries.

In many cases it is not sufficient to be able to access international information. It is important, that the information is valid locally, up-to-date and from a trustworthy source. This can be a problem in developing countries, since it is much more demanding to put information on the web, than to get access to it afterwards. It requires know-how, manpower and money to set up and maintain an Internet server and to set up and maintain the information of a web site. The information provided by web sites is usually static, but it may be dynamically generated, for example by user specified database queries or model calculations. Dynamic information is generated as the output of programs, which are executed by users, so it requires additional programming skills to provide this kind of information.

Pl@nteInfo (www.planteinfo.dk) is a web-based information and decision support system, which is mainly targeted towards Danish farmers and agricultural advisers [Je00]. Most of the information is generated dynamically, typically using weather-driven models. One example of information in Pl@nteInfo is up-to-date risk calculations of crop diseases and pests based on local weather data and weather prognoses.

The methods applied in Pl@nteInfo for fast propagation of valuable dynamic information to Danish farmers and agricultural advisors have been noticed in the neighbouring countries. Often these countries lack one or more of the mentioned requirements for a dynamic web service, and for this reason Pl@nteInfo has run a web service for these countries in a few cases. During the growing seasons of 1997 and 1998, Pl@nteInfo presented daily calculated risks of frit fly and potato late blight for Sweden. Since 1999 the technological development has enabled a Swedish service to be run independently of Pl@nteInfo. In 2000, a service for potato late blight has been developed and driven for Germany (www.web-blight.de).

Since 1999, Pl@nteInfo has run web sites for the Baltic countries, Lithuania (www.planteinfo.dk/lt), Latvia (www.planteinfo.dk/lv) and Estonia (www.planteinfo.dk/ee). The Baltic countries are not developing countries, but their technological and economical stages are still lacking behind most countries in Western Europe. The Baltic web sites are hosted on the Pl@nteInfo web-server in Denmark, and the necessary software, models and data to produce the dynamic web pages reside on the server. In spite of this, each web site is in the local language, and the information is supplied and maintained by researchers in the individual countries. This enables farmers, advisers and other target groups to have Internet access to locally maintained information services driven by foreign technology.

The paper presents results from the ongoing project where the Baltic web sites are developed. It describes the data flow, the models, and the user interface, and it discusses the use of the systems. The results of the project demonstrate that the Internet makes it possible to transfer knowledge and technology between countries with different stages of technological or economical development.

2 Materials and methods

Almost all web pages in the Baltic web sites are generated dynamically, i.e. the page is the output of a so-called *presentation program*, as illustrated in Fig. 1. When a user requests a web page, a corresponding presentation program on the web-server is activated with a sequence of parameters. The parameters may define the type of requested information, the language, the geographical locality etc. Depending on the program and the supplied parameters the program extracts data (often weather data) from a database and processes it to the information to be presented. The presentation program produces a temporary file on the server with HTML code, where the requested information is presented. When the file is completed it is sent to the user, where the HTML code is interpreted by the browser and displayed on the screen.

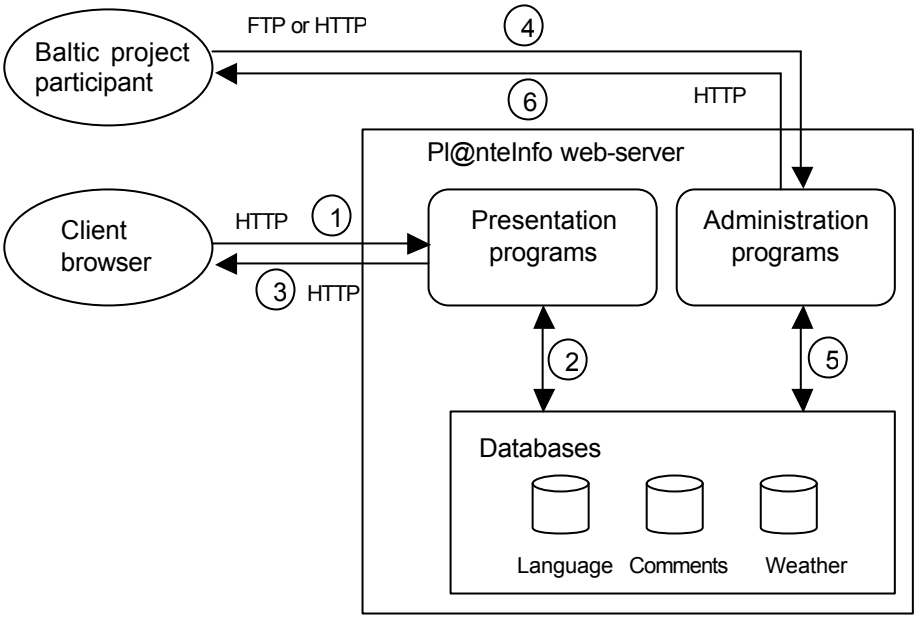

Figure 1. Data flow diagram. When a client requests a dynamic web page (1), a presentation program on the web-server is activated. The presentation program communicates with the databases (2), generates HTML output and returns it to the client's browser (3). The information is kept updated by Baltic project participants by uploading new data (4), activating an administration program. The administration program updates the databases (5), generates an HTML output and returns it to the project participant as a confirmation of the data upload (6).

The presentation programs reside on the web-server, like the weather database and other data resources for the presentation programs. The server also has certain *administrative programs* for maintenance and updating of these databases (Fig. 1). For example, when new weather data is sent from one of the weather stations to the server, an administrative program first validates the new data and updates the database to secure that the database integrity is maintained, and then sends an HTML output to the sender confirming the results of the data updating.

The software package SAS [Sa98] is used for data storage and processing, presentation programs, real-time generation of graphics and Internet communication between user and server.

3 Results

The three Baltic web sites are public and in local language. The data and the information are maintained locally, while the technical maintenance of the web sites is done in Denmark. The web sites have a similar design and use the same presentation programs.

The following types of up-to-date information is described below, but more facilities are under development:

Weather information (temperature, precipitation, relative humidity)
Potato late blight (risk of primary attack, field recordings)
Agricultural news

The target groups of the web sites are farmers, agricultural advisors and agro-businesses. Due to very limited Internet access among Baltic farmers, the main target group is agricultural advisors. A modern agricultural advisory service with Internet access has been established in Latvia and Lithuania, but not yet in Estonia.

3.1 Weather information

Much of the information of the Baltic web sites is based on local and up-to-date weather data. Therefore, 31 small weather stations, so-called metpoles, have been installed in agricultural areas in the three countries. Each metpole has 12 weather sensors, and data is logged and transmitted to a PC on the location every half-hour. On the PC the data are stored in a Paradox database with software supplied by the manufacturer of the metpole.

Software developed in the project to publish weather data to the web site is also installed on the PC. The software has been designed to be simple to use, even for people with limited experience with IT. The user interface allows the user to specify the metpole and the time period of the data upload. When a button is activated, a sequence of operations is activated, ending with the successful uploading of data, as described below.

First, the specified data are extracted from the database, processed and written to a text file in a standardised format. Only the three weather parameters used in the web sites are extracted, i.e. temperature, relative humidity and precipitation. A general program module [LH99] for import of weather data from different sources is used. To store the data in a standardised format the resolution of data is one hour, and missing data are interpolated, provided the sequence of missing data is not longer than 6 hours.

When the text file has been generated the file upload program opens a password secured FTP connection to a directory on the web-server and transfers the file with weather data to the server. The necessary specifications for the FTP connection have been hardcoded into the program, so no technical knowledge is demanded for the user.

Finally the file upload program opens a browser and executes an administrative program on the web-server by calling a URL. The administrative program reads the uploaded text file, stores the data in a weather database, and returns an HTML document to the sender. The browser shows the HTML document, which displays the uploaded data in a table as a confirmation of a successful upload. Immediately after, all information based on the uploaded data has been updated and is available on the web sites.

The weather data is presented on geographical maps with values of the current day for the weather parameters. Fig. 2 shows a map with the average daily temperature for the

localities where the weather stations have been placed. The map is clickable, resulting in a graph of the development over time for the selected locality and weather parameter.

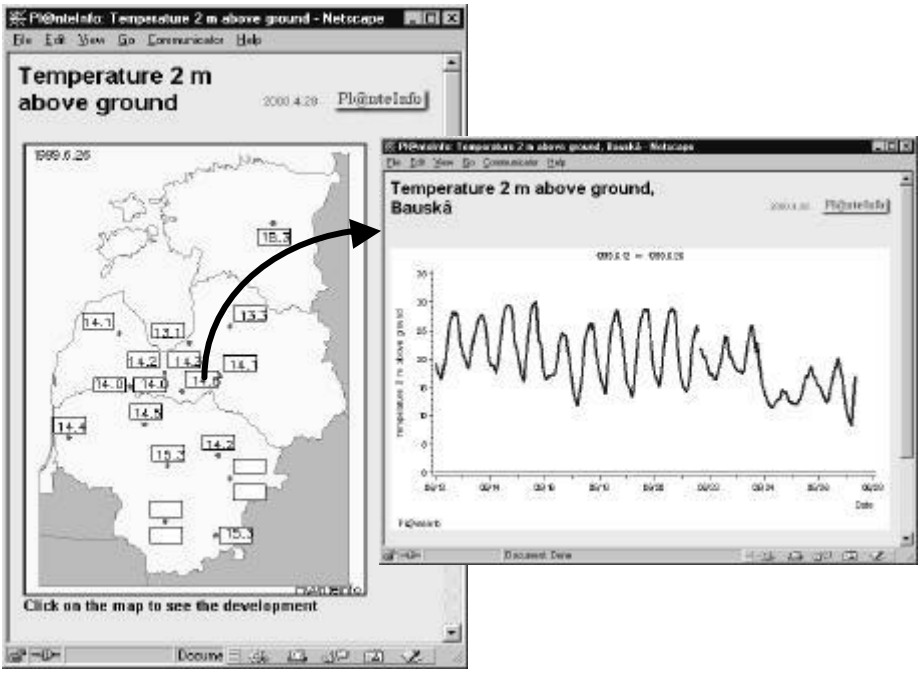

Figure 2. Temperature measurements shown on a map of the three Baltic countries. When a user clicks on the map a graph of the development of the temperature over time is displayed. The same presentation programs are used for the three countries, but the local language is used.

3.2 Risk of potato late blight

The weather data are also used to calculate the risk of primary attack of potato late blight. The model NegFry predicts the time when the weather conditions have been favourable for sporulation following a primary attack [HAH95]. It uses hourly values of temperature and relative humidity to calculate daily risk values, which are accumulated from the date of crop emergence. The model has been developed in Denmark, but has been validated for Baltic conditions [Ha99].

The risk values are presented on geographical maps (Fig. 3), where either the risk value of the current day or the accumulated risk can be observed. It is possible to adjust the calculation to personal field conditions by setting the date of crop emergence. By clicking on a locality the development over time of either the daily risk values or the accumulated risk values are presented.

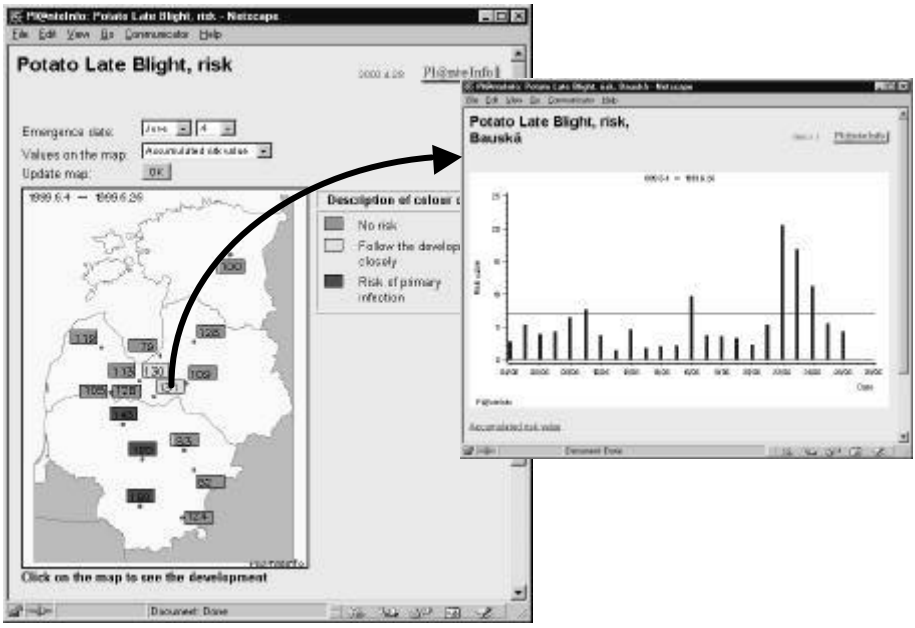

Figure 3. Risk of potato late blight. Daily risk index values are calculated from weather data and accumulated from a typical date for crop emergence. The map shows the current risk using both a simple colour code and the accumulated risk index. The map can be adjusted to local conditions by setting the emergence data. A map with the daily risk index can also be selected. By clicking on the map, the development of either the daily risk index or the accumulated index is displayed for the selected locality.

Pl@nteInfo contains several other weather-based models for calculation of the risk of crop diseases and pests [Je00]. After a local validation, these models could be implemented in the Baltic web sites.

3.3 Field recordings of potato late blight

Lithuania participates in an international project for monitoring of potato late blight, where the Internet is used to collect and present field recordings of potato late blight from the participating countries. The data are presented in a combined web site for all the countries (www.web-blight.net), as well as in national web sites. The Lithuanian field recordings are presented in the Lithuanian web sites, both as clickable maps and as a table, where the field observations can be sorted after different characteristics.

3.4 Language

The three Baltic countries have very distinct languages, and even though English is used for communication within the project, this language is generally not well known in the countries. Therefore, it was considered important to present the web pages in local languages. On the other hand, the Danish developers of the web sites did not want to maintain one Danish and three Baltic versions of each presentation program.

The solution was to replace text strings with variables in the presentation programs. When a presentation program is activated, it is supplied with a parameter specifying the requested language. Each text variable receives a value corresponding to the given language, and the text variables are resolved in the HTML output.

In order to have a smooth mechanism for maintenance of the language in the web pages, a technically very simple solution was found. A person in each country was appointed responsible for the language. These persons all understand English and they are acquainted with spreadsheets, so whenever maintenance is necessary they receive an email with a simple spreadsheet included. The spreadsheet has a row for each text variable and a column for each language. The cells with new text variables are pre-filled with text in English. Therefore, the language responsibles can go to the web pages and see the context of the new text they are going to translate. After the translation the spreadsheet is returned by email. A SAS program on the web-server is used to export the text information from the spreadsheet to a SAS dataset, which is used by the presentation programs.

3.5 Agricultural news

The entry page of each web site can contain locally maintained agricultural news. Likewise, the web pages with model calculations and the weather information can contain textual interpretations or comments to the generated information. These types of texts are written by local experts in ASCII or HTML format, for example using common word processing software. In order to be included in the web pages, the text documents are sent to the web-server through a facility for HTTP file upload. Since the facility for file upload is restricted to only a few trusted experts in each country, these persons have access to a login page, where they can authenticate themselves.

3.6 User acceptance

Table 1 shows the number of users on the Baltic web pages in the period from 16 June to 31 July 1999 (46 days). With a total for all three web sites of 50 different visits per day on average it follows that the number of users is not very high. There are large differences between the countries: The Lithuanian web site is most visited with 55 per cent of all requests, while the Latvian and the Estonian web sites account for 38 and only 7 per cent, respectively. There was no logging for the same period in 2000 due to a technical error.

Facility	Country			Total
	Lithuania	Latvia	Estonia	
Agricultural news	**75**	**63**	**11**	**149**
Weather	**437**	**348**	**37**	**822**
Temperature	255	151	15	**421**
Precipitation	115	99	13	**227**
Relative humidity	67	98	9	**174**
Potato late blight	**603**	**360**	**88**	**1051**
Risk	349	234	59	**642**
Field recordings	254	126	29	**409**
Total	**1115**	**771**	**136**	**2022**

Table 1. Number of visits on the different facilities from the different countries between 16 June and 31 July 1999. Numbers shown in bold are sums of sub-facilities, if any.

The usage pattern is similar for the three countries, however: Risk of potato late blight is most popular with about 30 per cent of the requests in each country, followed by temperature and field observations of potato late blight, both with about 20 per cent of the requests in each country. It is not possible from the data to get any information about the users, e.g. which of the target groups they belong to, if any.

4 Discussion

The three Baltic web sites have been developed through modifications of existing facilities from Pl@nteInfo. Only the facilities for upload of weather data and for maintenance of the three languages had to be developed from scratch. Once developed, the maintenance of the programs is limited. The daily updating of the information on the web pages is a result of the updating of weather data and local information, which is done entirely by the individual countries. Hence, the amount of work invested by the supplier of technical know-how has been limited in this case, and at the same time the suppliers of data from the individual countries find it time saving to publish information through the web sites.

The facility for maintenance of languages based on a simple spreadsheet has inspired to the development of a concept we call 'low-tech web databases'. Local experts maintain a spreadsheet with relatively static information, like characteristics of crop varieties or information about pesticides. In addition to the actual data, the spreadsheet also contains metadata for the presentation of the data. When the spreadsheet is uploaded a SAS program exports the data and the metadata from the spreadsheet to SAS datasets, and other SAS presentation programs are used to present the data in tables. The low-tech web databases are still under development in the Baltic web pages.

It is considered important that the maintenance of the information relies on the Baltic participants. There is no central control of the information updating, but if a local

weather station has not updated the weather data during the past 24 hours it automatically disappears from the maps. Likewise, it is important for the acceptance of the information, that it is obvious to the users that the information is local and up-to-date, in local language, and written by workers from trustworthy, national agricultural research or advisory institutes. The origin of the technical facilities to present the information is not important, so this has not been promoted clearly in the web sites.

The user acceptance of the three web sites is quite satisfactory, taking the low frequency of computers with Internet access and the slow Internet connections in these countries into account. The frequency of Internet access in the population does not describe the differences in popularity of the three web sites, however: According to Nua Internet Surveys (www.nua.net), 6.2, 9.7 and 21.6 per cent of the population in Lithuania, Latvia and Estonia, respectively, had access to the Internet by August 2000. It may seem surprising that the popularity of the Baltic web sites have been inversely proportional to the frequency of Internet access in the population. However, the popularity of the web sites follows the importance of agriculture in the three countries – increasing importance with decreasing latitude. Naturally, the establishment of agricultural advisory services in Lithuania and Latvia is also a consequence of the importance of agriculture, so the higher popularity in these countries could indicate that the web sites are being used by the main target group, advisors.

The differences in importance of agriculture are also reflected by the level of dedication to the project of the individual participating countries. For example, Estonia has invested in 3 metpoles, while Lithuania and Latvia have 17 and 11, respectively. Only Lithuania has participated in the potato late blight monitoring system, and only Lithuania has used the facility for upload of local information in 2000. This indicates that when local, updated and relevant information is available on a web site, users will demand the information, in spite of limited Internet access.

In the long run we consider it important that the Baltic countries become capable of maintaining their own web-servers with a range of decision support models. It is planned to have Danish decision support models implemented, for example for control of crop diseases and pests. These models will be implemented in a form, which makes it easy to export, adapt and combine them. This will be done with object-oriented principles using the platform-independent programming language Java. In this way, and following the object-oriented principle of specialisation, the Danish decision models can be adapted to local conditions without an entire re-programming. The specialisation of a general Java class only requires an overall insight in the model, so it can be done locally.

When such Danish Java models or Java model components have been developed they will be published on a web site, together with a full documentation, so that they can be downloaded and used as a template for web-based models in individual countries. The web site will also be open to similar models or components from external sources, promoting a further exchange of web-based knowledge and technology between countries.

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