A Framework for the Internationalization of Data-Intensive Web Applications

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Abstract. The globalization process makes it necessary to provide information in different languages in order to enlarge the audience of the information presented through the web. Therefore, it is often required to extend the web system for handling information in more than one language. This process is called internationalization of a system. An important requirement of this process is that it should be applied without a strong reorganization of the web application that implements the web site. We propose a general framework for the internationalization of data-intensive web applications based on the MVC-2 paradigm and a relational database system. This framework has been applied successfully at the University of Verona (Italy) for the internationalization of the web sites of all departments and all faculties.

1 Introduction

In the last few years the globalization process has influenced the activities of any kind of organization around the world. One effect of this process concerns the production of information in more than one language. In general we call the adaption of an application to support a multilingual environment *internationalization of an application*, while the process of adaption of an application for a specific region or language, by adding local-specific components and translating text, is called *localization of an application*.

The internationalization of a web application can be a hard task, in particular if the application architecture does not conform to a standard schema, like the Model View Control (MVC) paradigm, or does not separate at least the logic and the presentation in different modules.

In this paper we propose a general framework for the internationalization of data-intensive web applications [6,5] based on the MVC-2 paradigm [1] and one or more relational database systems. This framework can also be applied to existing web applications with a low impact on code restructuring as shown by the experience at the University of Verona.

Previous works on data-intensive web applications regards mainly the definition of a design methodology and the implementation of case tools [7,5,4,6]. Many other papers in the human-computer interaction area face the general problem

of internationalization and localization of data presentation in web sites, considering in particular aspects like symbols or color perception in different cultures, format conventions (i.e., date presentation), etc. [2]. To our knowledge, only in [8] a general approach for the internationalization of a web application including database schema extension is presented. In our approach, we extend the solution proposed in [8] by adding a general mechanism for queries specification and query results handling.

The paper is organized as follows. First, the problem of internationalization of a web application is described. Next, the proposed framework is presented by describing in details its components.

2 Problem Definition and Proposed Solution

In this paper with the term “web application” we refer to any software application that is accessible using a web browser. The internationalization of web applications regards *the implementation of a mechanism that is able to produce, for each page the web application generates (master page), a set of pages with the same content but each one in a different language (translated pages)*. This problem can have different solutions with respect to the architecture of the web application and the level of update between the master pages and the translated ones that we intend to maintain.

According to the architecture, different solutions of the internationalization problem can be applied. In particular, in *Static Web Applications* the replication of the static HTML files with the translation of their content in the languages of interest is the widely used solution; of course, the maintenance of the consistency between the different replications can become a time consuming work [3]. In *Data-Intensive Web Applications* the replication is still a chance but it requires to generate one or more copies of the whole system. An alternative solution is to make the application *language independent*. This can be achieved by a revision of the whole application consisting of the following three steps: (1) *Database extension*: the database has to be extended in order to store the translations of data that are subject to change with respect to the language; (2) *Queries rewriting*: the queries have to be rewritten to take into account the new tables containing data translations; (3) *Static text translation*: the static text inside script files (like JSP, ASP, etc.) has to be replaced by a call to a procedure that computes the right translation according to the required language.

We propose a framework for making a data-intensive web application language independent. In particular, the framework can be applied to applications adopting the MVC-2 paradigm [1] in order to obtain the following results: (1) it should make the application language independent in the sense that the application should work with a certain set of foreign languages and this set can be extended without requiring any code modification; (2) it should allow one to extend the set of attributes subject to translations without requiring any code modification; (3) it should require the minimal database extension, but, at the same time, the minimal effort in query rewriting and the minimal performance worsening in query processing.

Hereby we describe in details the proposed frameworks considering: database extension, queries rewriting and internationalization of state objects.

2.1 Database Extension and Queries Rewriting

A data-intensive web application interacts with one or more database servers, which provide dynamically the data to be published. This approach always guarantees web pages with up to date content. The internationalization process requires an extension of the database schema in order to store the translations of the information stored in the database.

We suggest the following general approach to extend the database schema, by supposing to adopt the Entity-Relationship model for the conceptual database design and a relational system for the database implementation:

1. For each entity type E with attributes $\{A_1, \dots, A_n\}$ having some attributes $\{A_{i_1}, \dots, A_{i_m}\}$ subject to translation, we specify a new entity type E_{trans} , weak entity of E , with the following attributes $\{\text{language}, A_{i_1}, \dots, A_{i_m}\}$. This implies the creation of a new table $E_{\text{trans}}(K_E, \text{language}, A_{i_1}, \dots, A_{i_m})$ where K_E is the set of attributes representing the primary key of E .
2. For each relationship type R among entity types $\{E_1, \dots, E_n\}$ with attributes $\{A_1, \dots, A_n\}$ having some attributes $\{A_{i_1}, \dots, A_{i_m}\}$ subject to translation, we replace R with a new entity type E_R , weak entity of $\{E_1, \dots, E_n\}$, with the attributes $\{A_1, \dots, A_n\}$ and we add a second entity type E_R_{trans} , weak entity of E_R , with the following attributes $\{\text{language}, A_{i_1}, \dots, A_{i_m}\}$. This implies the creation of a new table $R_{\text{trans}}(K_R, \text{language}, A_{i_1}, \dots, A_{i_m})$ where K_R is the set of attributes representing the primary key of table R .

Regarding database schema extension other solutions could possibly be considered as discussed in [3]. After database extension, a query rewriting is necessary in order to include the translated attributes in the result of each query. The properties of this rewriting technique are the following ones: (1) it preserves the result cardinality that the query had before the internationalization; (2) it uses only two languages L_1 and L_2 as query parameters (these two languages are obtained by applying a custom rule to the preference languages list coming from the HTTP request, see [3] for details); (3) it extends each query result schema by applying the following rule: for each attribute A subject to translation, we replace A with three attributes $L_0\text{-}A$, $L_1\text{-}A$ and $L_2\text{-}A$, containing its values in L_0 (master language) and its translations in L_1 and L_2 respectively.

Given a generic query, `SELECT  $E_1.A_1, \dots, E_k.A_n$  FROM  $E_1, \dots, E_m$  WHERE  $C$` , suppose that the table E_1 has a translation table $E_{1\text{ trans}}(K, \text{language}, A_1)$, then the query must be rewritten as follows:

`SELECT $E_1.A_1$ AS " $L_0\text{-}A_1$ ", $L_1.A_1$ AS " $L_1\text{-}A_1$ ", $L_2.A_1$ AS " $L_2\text{-}A_1$ ", $\dots, E_k.A_n$
FROM E_1 LEFT JOIN $E_{1\text{ trans}}$ AS L_1 ON $E_1.K = L_1.K$`

`LEFT JOIN  $E_{1\text{ trans}}$  AS  $L_2$  ON  $E_1.K = L_2.K, \dots, E_m$`

`WHERE  $C$  AND  $L_1.\text{language} = ?$  AND  $L_2.\text{language} = ?$`

Notice that, after the rewriting process, the resulting query contains some

parameters, represented as “?”, which stand for the requested language L_1 and the alternative language L_2 respectively.

This rewriting technique can be trivially extended to the general case in which table E_1 trans contains more than one attribute and there are other tables E_i having a corresponding translation table E_i trans. Moreover, given a query containing m tables with attributes subject to translation, the number of outer joins that have to be added to the query is equal to $2m$.

2.2 Internationalization of State Objects

In a MVC-2 data-intensive web application, state objects represent both the request from the browser and the data (often given by tuples of queries results) needed to build the response. Given the goal of applying language independent extensions, the more suitable way to do the task is to insert, for each object property A subject to translation, a new property A -lang that will contain the language code of the value stored in A . In this way a state object can store values in any language with a minimal impact on its type restructuring.

Given a tuple t of a query result Q , having translated values stored in the same tuple, a state object O is created and is populated by applying the following approach: (1) for each attribute A of Q subject to translation choose one translated value in t according to a custom rule; (2) put the chosen value in the corresponding property A_i of O and its language-code into property A_i -lang; (3) finally, put the other values belonging to attributes not subject to translation in the corresponding properties of O .

Therefore, each state objects constructor having a query result tuple as parameter, have to be modified according to the new proposed approach. Nevertheless, this process can be avoided if all constructors based on query result tuple are replaced with a single meta-method *Populate*. Method *Populate* works as follow: given a state object, a query result tuple, the requested language L_1 and one or more alternative languages, it fills the state object with tuple values according to L_1 and the alternative languages. *Populate* can be implemented under the following conditions: (1) the query result is written as described in Section 2.1; (2) the state object representing a tuple of a query result Q contains at least as many properties as the attributes of Q where each property has the same name of the corresponding attribute of Q and contains a property for the language-code A_i -lang for each property A_i subject to translation; (3) the programming language provides introspection mechanism for the state object and for the query result object as Java language provides with Reflection/Introspection mechanism. The pseudo-code of *populate* is shown in [3].

3 The Experience at University of Verona

The proposed approach has been applied for the internationalization of the web sites of the faculties and departments of the University of Verona (UNIVR). The UNIVR web system is organized as follows: (1) a portal site composed of static HTML files; (2) 8 faculties sites, each generated by a data-intensive web

application (Faculty On Line - FOL); (3) 24 departments sites, each generated by a data-intensive web application (Department On Line - DOL). Both FOL and DOL are developed according to the MVC-2 paradigm using Servlets and JavaServer Pages technology; all the data come from one database containing the information about the teaching and research activities of the whole University. We have applied the proposed framework for the internationalization of FOL and DOL during 2003 and now the faculties and departments sites can show pages in four foreign languages (English, French, German and Spanish) and Italian. The impact of the internationalization process of the UNIVR web system can be summarized as follows: the database schema, that contained 275 tables, now contains 340 tables and the Java classes of FOL (DOL) contain 117 SQL queries as before the internationalization and they contain about 5% code lines more.

4 Conclusions

In this paper we have illustrated a framework for the internationalization of a data-intensive web application. The proposed solution has been studied for an application based on the MVC-2 paradigm and interacting with a relational database system. The framework was successfully applied for the internationalization of the web sites of University of Verona.

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