

# A DISTRIBUTED WEB-BASED K-12 MANAGEMENT SYSTEM

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**Abstract:** The project "Rent@School - Bringing the Future to the Education" is a research effort to study and prototype information system architectures to support, standardize, and facilitate the management of K12 schools at a national scale. It looks for the sharing and dissemination of relevant information among different stakeholders, based on the ASP model and also on a novel architecture, which we called "distributed and multi-instance web architecture". This architecture means that beyond the existence of a unique central/national Rent@School instance, multiple Rent@School instances can be installed at local/regional scale, in a way that autonomy, performance and flexibility of all the system can be improved. This issue is introduced and discussed in this paper from two complementary perspectives: from the organizational and management information systems perspective; and from the integration and large-scale interoperability.

## 1 Introduction

Education is considered by modern societies to be one of the most important and strategic factors that contributes for the development, wealth creation and solidarity of any Nation [1,5]. In this context, Rent@School (RS) is a research project where we will propose and discuss organizational and information system architectures to support, standardize, and facilitate the management of K-12 (from kinder garden till 12<sup>th</sup> year) schools at a national scale, as well as, the sharing and dissemination of relevant information among the different stakeholders, such as students, teachers, schools' administrators, parents, and Ministry of Education' support and technical employees. This project is particularly oriented by the Portuguese educational public system (the educational private subsystem has some facets and requirements that we deliberately did not consider).

The RS project is being developed in the context of the ISG (Information System Group of INESC-ID) where we are interested on two main research topics. First, to study organizational systems, architectures and patterns, in particular those with complex, dynamic and distributed features which can be found in different areas of the economy and society, such as public administration, education, transports, logistics, or tourism. Second, to study the best information systems architectures and patterns to support the referred systems, following a technological perspective.

RS is based on the ASP (application service provider) model, however, adopting a novel architecture, which we called "distributed and multi-instance web architecture". This architecture means that beyond the existence of a unique central/national RS instance, multiple RS instances can be installed at local/regional scale, in a way that autonomy, performance and flexibility of all the system can be improved. This issue is particularly interesting and novel and it is introduced and discussed in this paper from two complementary perspectives. First, following the organizational and management information systems perspective. Second, following a more technical perspective, in particular regarding issues of application integration and large-scale interoperability based on the web services concepts.

The main novel contributes of this paper can be summarize in three points. First, we propose and discuss the interest of an information system that can support, standardize, and facilitate the management of K-12 schools at a national scale. Second, the proposed architecture is not restricted by itself to the classic and central ASP model because it allows the installation and configuration of multiple instances promoting, in that way, the autonomy, flexibility and performance of the overall system. Third, we propose and discuss the importance to develop this kind of system with public and open interfaces, promoting integration and large-scale interoperability among different systems.

This paper is organized in 6 sections; including this one (Section 1) that describes the context, the motivation and its main contributes. Section 2 describes briefly the Portuguese educational system, and in particular the subsystem of public K-12 schools. Section 3 identifies the most relevant (functional and non-functional) requirements that the RS design and prototype should take into account. Section 4 presents and discusses issues related to the information system architectures that support the RS, as well as, related to the application integration and large-scale interoperability. Finally, Section 6 refers some considerations related the future work and the research aims.

## 2 Portuguese Educational System

The educational system in Portugal, like in most of the developed countries, is organized in classical training and/or professional levels. The following educational levels exist in Portugal: pre-primary; primary - 1st cycle (1st to 4th years); 2nd cycle (5th to 9th years); secondary-high school (different areas, like classical, artistic and professional are available); and higher education (divided in University and Polytechnic). The Portuguese educational system is available, at all different levels, either Public or Private. Quoting the official source INE regarding year 2000/2001, the education K-12 has a total population of 1.261.603 students (approximately 12% of the Portuguese population) distributed by 16.984 educational facilities or schools.

The RS formulates his proposal for all K-12 schools and other performers acting in the Public educational sub-system. In Portugal this sub-system is organized as shown in figure 1.

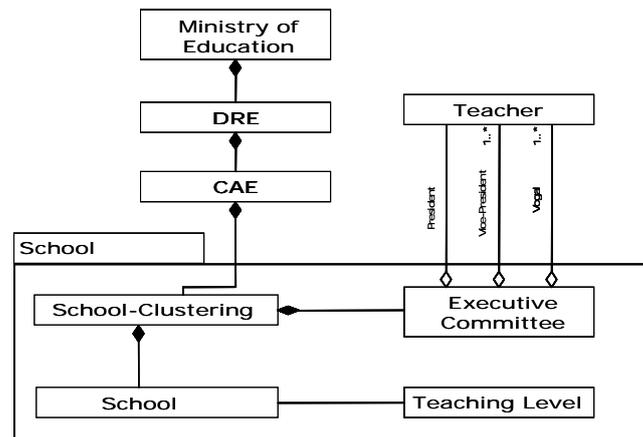


Figure 1: Organization of Portuguese educational system for the first degrees levels.

Schools are the elementary unit of educational activities. For financial reasons, regarding the level of performance on administrative tasks, the schools are organized in groups, called “school-clustering” or just “clusters”. Each school can provide and manage more than one educational level. The main objective of the cluster structure is the possibility of different schools sharing a package of resources (e.g., human, technical and others) obtaining a better global costs system performance. The Ministry of Education is responsible for the planning, promotion, follow up and evaluate the available resources for the public education sub-system. This sub-system is divided in various responsibility levels namely the Educational Regional Delegations (DRE) as 1st hierarchical level. As the 2nd level there is Educational Supporting Centers (CAE). Each school is associated to a certain CAE (and therefore to a certain DRE), besides the cluster they belong to.

## 3 General Requirements of Rent@School

In this section we summarize the main requirements that should be supported by the RS system. Namely, we identify two major groups of requirements: functional requirements, that match the use cases; and non-functional requirements, that match the common needs that the system should satisfy independently of specific functionalities.

### 3.1 Functional Requirements

RS provides a personalized service for different types of stakeholders. It can be seen as a “multifaceted portal for the Portuguese K-12 teaching system”, becoming the personalized portal for schools, students, parents, teachers and administratives. We identify the main functionalities of the RS based on these stakeholders: **Administrator**, **MinistryOfEducation-User**, **School-SuperUser**, **School-Executive**, **School-Administrative**, **School-ClassDirector**, **Student**, **Teacher** and **Parent**.

Like other ASP applications, the responsibilities of each user are based on the chained delegation approach and profile management. The “Administrator” actor is the user with more power on the RS, in particular she can manage schools, and for each school she can manage the School-SuperUser accounts. The “School-SuperUser” actor is responsible for the configuration of school data and for the management of other school users, such as “School-Executive” or “School-Administrative” that performs very important roles in school administration and management.

“Student”, “Teacher” and “Parent” are not school-level users; they are global-level users. This means that students and teachers should have a global identification, independently of the current school association. The same should be verified for parents: independently of the number of students associated, and the different school registrations, the parent should not have to manage various system user-accounts to access the data of their dependent students.

This issue of global identification of students, teachers and parents (independently of the school and the academic year) is novel and we expect that it can bring a real impact in the quality level regarding the management of the education system. Namely, it can bring the following contributes (1) a better and simple

way to record history and curriculum of the different actors; (2) a more integrated and personalized service can make possible a simpler, direct and easier interaction; and (3) a significant simplification in the administrative processes such as school registrations, student transfers and evaluation.

### 3.2 Non-Functional Requirements

Non-functional requirements have to do with general aspects of the system like performance, robustness, liability, distribution, security, integration with the Internet and opening to standards. We identify in this project the following non-functional requirements: **Usability, Performance and scalability, Local and access type independency, Privacy and confidentiality, Openness and integration with other systems, Messages and alerts delivered through multiple channels.**

## 4 Rent@School Architecture

In this section we discuss important topics related the RS architecture, as well as its mechanisms to support open-interface and interoperate with other systems.

### 4.1 Distributed Single Instance Architecture

In order to satisfy the general requirements identified in Section 3, in particular the non-functional requirement of “local and access type independency”, RS should have necessarily to be developed based on a web information systems architecture.

RS follows the typical ASP model, in a way that it provides several functionalities to a selected range of actors that have previously subscribed to the system. Additionally, those functionalities are supported by a complex information system, kept and managed by a credentialed entity and responsible by supporting a number of quality of service parameters, such as performance, security, privacy and confidentiality of data, and liability. This entity – the RS manager – can be a telecommunications operator and/or an institute related to the Ministry of Education.

The main advantages present in this model resides in the fact that the participant actors never have to be worry about technological issues, such as: installation, licensing and configuration of applications; data quality; backups; availability of computing systems; or even issues concerning the updating of new versions. On the other hand, this model requires that the support computing architecture provides extremely large performance and scalability levels (thinking on the huge number of potential users), and doesn't allow for an eventual decentralization and autonomy of the information systems at the regions level (e.g, at DRE and CAE level) or even at the school level.

### 4.2 Distributed Multiple Instance Architecture

In order to solve the problems referred on the previous paragraph, we propose (to be developed in the second phase of the project) a novel architecture based on multiple instances of RS.

This architecture consists in multiple instances of RS, which can be installed at different management levels of the public education system hierarchy. For example (without considered the central/national level): at regional level (e.g., at all DRE); at school-clustering level; or even in a mixed way, such as at the central level and at the school-clustering level for the ones that may have technical conditions to operate one RS instance.

Although there are some variants in the way the deployment and configuration of the several instances are performed, we assume in this article for the sake of simplicity, that the various instances would be installed at the school-clustering and therefore, every school belonging to its school-clustering share the same RS infrastructure.

The main aspects that this architecture intends to improve, relatively to the single-instance architecture, are:

- *Performance and scalability of the global system*: The fact that there would exist multiple instances has as direct consequence in the multiplication of access points, as well as in the distribution of the total charge of the system along those different points, and so the overall system would provide a better performance and a better scalability.
- *Decentralization and autonomy*: This is one of the main advantages of this architecture, which would allow that RS's instance configuration and management would be as close as possible to the communities that most use it: the schools. Among other factors, we may work in a more productive way and answer more quickly and in a more agile way to the identified requirements. In case the central/national instance would be temporarily deactivated, the regional/local instances could be working adequately in the schools. It is important to notice that although a very significant number of functional requirements (e.g., most use-cases that are performed by teachers, students, class directors and school administrative) the accesses are performed directly on the regional/local RS's instances; other functional requirements (e.g., the parents authentication, the teacher record and historic search) will still require access to the central/national RS's instance.

On the other hand, in spite the several advantages, this architecture requires significant issues that should be adequately analysed and supported in a concrete implementation of the system. Namely (1) every instance should be installed on machines that have a permanent connection to the internet; (2) the existence of adequate technical support, preferably provided by an entity that is external to the schools; and (3) the existence of adequate management support (typically developed by the school's executive committee).

### 4.3 Interoperation Mechanisms

One important and complex aspect for the success of the distributed architecture is the existence of interoperation mechanisms between the central/national and the regional/local instances, in the support of the adequate distribution and information management and of some general use-cases.

On the other hand, in order to support normal complementarities between RS and other information systems in the education domain, and in order to satisfy the non-functional requirement “openness and integration with other systems” (§3.2), it is relevant the public specification and exposal of a basic set of interfaces and services according to the common Internet technologies, actually designated as “web services” [6, 7].

There are some ways to describe the concept of “web service”. Maybe the simplest one is the following: “a set of operations that are available at the global scale through an electronic address of the type URL”. One other one, more generic, defines a web service as “an interface that describes a collection of operations that are accessible from the network through a mechanism of XML standard messages”. The web services underlying technology is strongly based on the Internet, its technology and standards, such as TCP/IP, URL, XML, HTTP or SMTP. The TCP/IP, HTTP and SMTP protocols take the general role of guaranteeing the transport of messages between the web services; other protocols may also be used, such as FTP, MQ or IIOP. However, due to its ubiquity, HTTP takes the role of the *de facto* standard as a transport protocol of the exchanged messages between web services. On the other hand, to some levels, XML plays a basic role in web services, such as a mechanism of description of the data independently of the programming languages, operating systems, and computer architectures.

## 5 Rent@School Current state

As previously referred, RS is a project in development, being on its first iteration, in which a first prototype is being developed based on the distributed single instance architecture, but already with support for the generality of the actors and representative use-cases. For the second iteration we aim to explore the multi-instance architecture and mechanisms related to openness and interoperation.

According our plan, the first iteration takes place until September of 2002 (started in September of 2001), and the second iteration would be developed between May of 2002 and December of 2003. It is still left open the possibility of transferring the RS technology to an institutional or enterprise context that would promote and adequately support it. For more details regarding the utilization or evaluation of the RS's state the reader can consult [2, 3, 4].

## 6 Conclusion and Future Work

In this paper we propose and discuss the main ideas of an ambitious project that can contribute to a better future for the management of the Portuguese education system.

The RS presentation in this paper was deliberately positioned at a high level, particularly by drafting its main requirements, possible information system architectures, and integration technologies. Other documents describe the current state of the project at a detailed level, namely: the “requirements and business analysis” document [3] or the “end-users point of view” document [4].

We plan the development of this project, in research and prototype terms, along the next sixteen months and based on two iterations. The first iteration has already started and is expected to finish on September of 2002. Its main objective will be the development of a prototype application, based on the distributed and single-instance architecture, to demonstrate the original concept.

The second iteration should start next months and it is expected to finish on December of 2003. Its main interest would be the design and implementation of the RS's open and public API, as well as, the research and discussion related to organizational and information system architectures.

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