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A Management Information System for Portuguese Schools

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A MANAGEMENT INFORMATION SYSTEM FOR PORTUGUESE SCHOOLS

Declaração de autoria de trabalho:

Declaro ser a autora deste trabalho, que é original e inédito. Autores e trabalhos consultados estão devidamente citados no texto e constam na listagem de referências incluída.

ABSTRACT

Over the past two decades, school management information systems have become essential to the operation of schools throughout the world. In Portugal, recent changes to the organizational structure of schools, notably the move towards mega-clusters, have presented new challenges for such systems, which for the most part have not yet been met.

This project, carried out at the behest of a Portuguese software development house (Singlecode LDA), proposes a new school management information system for Portuguese school mega-clusters. A system is designed using an iterative and incremental methodology, proposing solutions for many of the problems identified and attempting to meet the needs of the modern school. The system was partially implemented and evaluation was performed by potential users, with positive feedback.

KEYWORDS

Management Information Systems, School, Software Engineering

RESUMO

Sistemas informáticos de administração escolar têm-se tornado indispensáveis para o bom funcionamento das escolas pelo mundo fora nas últimas duas décadas. Devido às recentes reestruturações do sistema organizacional das escolas, em Portugal, nomeadamente o aparecimento dos mega agrupamentos têm apresentado novos desafios para os tais sistemas, alguns dos quais ainda não foram alcançados.

Este projeto, desenvolvido a pedido de uma empresa Portuguesa de produção de software (Singlecode LDA), propõe um novo sistema informático de administração escolar para os mega agrupamentos. Um sistema que é elaborado com uma metodologia crescente e iterativa, propondo soluções para a maioria dos problemas identificados e tentando ir de encontro às necessidades das escolas modernas. O sistema foi parcialmente implementado e a sua avaliação foi feita por potenciais utilizadores, sendo este feedback positivo.

PALAVRAS-CHAVES

Gestão de Sistemas de Informação, Escola, Engenharia de Software

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CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ACRONYMS

AJAX	Asynchronous JavaScript and XML
CSS	Cascading Style Sheets
DBMS	Database Management System
EJB	Enterprise Java Bean
GEPE	Gabinete de Estatística E Planeamento da Educação (Office of Education Statistics and Planning)
GUI	Graphical User Interface
HTML	HyperText Markup Language
ICT	Information and Communications Technology
IDE	Integrated Development Environment
JSF	Java ServerFaces
MIS	Management Information System
POJO	Plain old Java object
POS	Point of Sale
PTE	Plano Tecnológico da Educação (Education Technology Plan)
RFID	Radio-frequency identification
SaaS	Software as a Service
SASE	Serviço de Acção Social Escolar (School Social Action Service)
SEN	Special Educational Needs
SMS	Short messaging service

1 INTRODUCTION

1.1 CONTEXT AND MOTIVATION

Management information systems (MIS) are a necessity in modern organizations. They process and provide the vast amounts of information that are needed to manage an organization effectively. Schools are no exception. There are vast amounts of information generated by and required for their operation, and advancements in technology mean that an ever-increasing number of aspects of school life can be aided by the use of such systems. Thus, in the 1980s, the first school management information systems began to appear on the market. Driven by demand and the increasing availability of the technology required to operate them, the market has grown to the point where it is almost impossible to find a school that does not use such a system.

Given the ubiquity of such systems in schools, what is the motivation for the development of a new system? This thesis proposes that changes to the organizational structure of schools in Portugal combined with advancements in technology have left the most popular of the existing school MIS unsuitable for the environment in which they operate, leaving them difficult to maintain. This thesis attempts to design and develop a product that fills a gap in the market, by developing a modern, extensible and scalable application that implements the functional areas that Portuguese schools require. The project was designed and developed with co-operation and feedback from various members of staff in Portuguese schools, primarily from *Agrupamento Albufeira Oriental* and *Agrupamento Albufeira Poente.*

This project is being developed for Singlecode Innovation Lda[1], a small software development house in Portugal. Singlecode proposed the development of a new school MIS system, to be called *SC School*, imposing some general non-functional requirements on the project that are described in chapter 5. Contact with the company was maintained throughout, by way of progress reports and build demonstrations. All of the work documented in this thesis was carried out solely by the author.

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1.2 STRUCTURE

This document is organized into several chapters. Following this introduction (chapter 1), chapter 2 documents a survey of existing school MIS products found on the market. It then goes on to examine the Portuguese Education System in order to understand the environment in which a new product must operate. Based on this research, the problem that is to be solved and the methodology used to solve it is described in chapters 3 and 4 respectively.

Given the huge number of functional areas that can encompass a school MIS, chapter 5 documents the system requirements of a subset of functional areas that were prioritised by the company. Based on these requirements, chapter 6 proposes a design for the system. Chapter 7 describes the implementation of two of the modules identified during the design. Finally, chapter 8 concludes the work by discussing the success and failures of the design, and identifying future work to be performed.

2 BACKGROUND AND RELATED WORK

2.1 INTRODUCTION

The first half of this chapter examines the use of school MIS, and analyses a number of existing products on the global market. The second half of this chapter focuses more specifically on the Portuguese Education System, examining its organizational structure, historic use of ICT, and identifying challenges specific to these schools.

2.2 MANAGEMENT INFORMATION SYSTEMS

An MIS is generally thought of as an integrated, user-machine system providing information to support operations, management, and decision-making functions in an organization (Davis & Olson, 1985). Their origins have been traced back as far as 1959 (Laudon & Laudon, 2012). The term is now used to describe a broad range of systems, with each catering to the needs of different types of organization.

2.3 SCHOOL MANAGEMENT INFORMATION SYSTEMS

School MIS are branch of MIS that began to appear in the 1980s as the hardware required for their operation became more accessible. Products labelled as School MIS can range from smaller solutions to meet the needs of specific types of school (e.g. Primary, Secondary) in specific countries, to large products that aim to meet as many requirements as possible to any school.

MIS systems are now widely used in schools throughout the developed world. In a 2005 report in Britain (BECTA, 2005), the British Educational Communications and Technology Agency, a public body funded by the British Ministry of Education, described School MIS as "crucial to institutional effectiveness," referring to the potential to "improve efficiency and performance," and identifying the following ways that school MIS achieve this:

- Reduce the administrative burden on school staff.
- Making more efficient use of expensive teacher time through more effective timetabling.

- Facilitating a more individualised learning approach by matching curriculum resources to particular teaching and learning activities
- Making a wide range of assessment and analysis tools available to teachers so that they can better understand the attainment of the pupils in their care
- Online access for parents as part of a wider initiative to improve home–schools links and thus enhance the contribution parents can make to their children's education.

2.4 CONCEPTS

To understand the problems that school MIS are attempting to solve, it is important to understand some concepts that relate to, and functions that exist in, a typical school.

2.4.1 Varieties of School

The phrase "a typical school" is somewhat open to interpretation. For most countries with compulsory formal education, we can consider that formal education in schools includes the following stages:

- Pre-school (e.g. Nursery school)
- Primary Education
- Secondary Education
- Tertiary Education (e.g. University)

In some countries, each stage of education may involve more than one school, and the age ranges that define each stage may vary by several years. In the interests of gaining a broad understand of existing school MIS products, this research will review products from more than one country, but focussing only on the Primary and Secondary phases of education. Thus, "a typical school" refers to a primary or secondary school in a country with compulsory formal education. Issues specific to Portugal and Portuguese schools, which are the focus of this project, are discussed later in the chapter.

2.4.2 Stakeholders

Although a school may have a wide variety of stakeholders, ranging from the students through to the government, for the purpose of analysing School MIS from a variety of countries and schools, we can identify common stakeholders present in all schools who

are directly affected by the system and are likely to have day to day interaction with it. These are:

- Students
- Students' parents/guardians
- Teaching staff
- Non-Teaching staff, for example:
    - Directors/Headmasters
    - Administrative staff
    - Canteen Staff
    - Security Staff

A more detailed look at the organizational structure of specifically Portuguese schools can be found in section 2.7.

2.4.3 Functional Areas

A wide variety of different functions are performed within a school. On the whole, they are functions which have been performed in schools well before the invention of MIS systems, but have since been facilitated by the adoption of such systems. In 2010, a detailed survey of school MIS was carried out in Britain for a report analysing the market for such systems (BECTA, 2010). Based on extensive information provided by the developers of the six different school MIS systems, as well as product analysis and interviews with school stakeholders, a modular definition of a school MIS was developed. Although this survey focused predominantly on British products, the vast majority of the high-level functional areas are relevant to school MIS throughout the world, and as a result, will be used as the basis for the functional areas identified in this product survey.

Three functional elements have been ignored due to being relevant only to British schools. Two functional areas, Canteen/Point of Sale and Gate Access, have been added due to their existence in several products surveyed.

- Admissions Management
- Assessment and Attainment Management
- Attendance Management
- Behaviour Management

- Curriculum Planning
- Data Transfer
- Examinations Management
- SEN Management
- Student Personal Records
- Timetable Construction and View
- Timetable / Academic Staff cover
- Workforce Management
- Finance
- Asset Management
- Data Mining, Trend Analysis and Predictions
- Web Access to Appropriate Data For Stakeholders
- Student Progress Report Generation
- Library / Resource Management
- Gate Access Control
- Canteen/Point of Sale

2.5 SURVEY OF SCHOOL MIS

In this section, existing proprietary and open source school MIS systems on the market are surveyed. Their functional areas and other relevant information have been identified using various techniques, including analysis of user manuals, hands-on product analysis, discussions with existing users, and consultation of marketing information. User opinions were obtained from face to face discussions with teachers and other school staff in the case of Portuguese software, and online discussion forum comments in the case of other products.

The products were selected for the survey with the intention of demonstrating a wide range of what is available in the school MIS market. Thus, the survey includes not only the products with the largest market share in their respective countries, but also several newer and more recent products with a smaller share.

It became apparent in the early stages of research that the school MIS market is highly localised, some reasons for which are explored in section 2.6. As a result, the proprietary

products surveyed are from both the Portuguese market (in order to analyse the direct competition), and for comparison, the British market, which has a well-established and well researched market from which information can be drawn.

For each product, following an overview, a table is presented showing features that the product offers based on the functional areas identified in section 2.6. Each product may implement these features in a slightly different way, with a varying degree of functionality. If the implementation of the functional area requires qualification, this is described in the comments section.

2.5.1 Proprietary School MIS

2.5.1.1 JPM & Abreu LDA Software para Gestão e Administração Escolar

Targeted at Portuguese schools and in development since 1994, this product suite (colloquially referred to by school staff as simply 'JPM'), according to the developer, can be found in more than 95% of Portuguese state schools (JPM & Abreu, LDA, 2013). Discussions with 4 teachers with a combined experience of teaching in 21 different schools appeared to back up this claim, with JPM used in every case to some degree. However, it was pointed out by teachers that many schools use it only for a small number of functions (i.e. using the *Alunos* module to record absence) and use additional software to perform other functions.

JPM is a suite of several different applications. Several of the applications can be used as standalone products, although some are dependent on others. Each application performs a different function within the school and can be purchased at a cost of 500€ per application per year, with bulk discounts available for schools that purchase 2 or more of the following applications:

- *Alunos (Students)* - Student information management, assessment, attendance, enrolment statistics, success / failure at school, and recording communication with parents.
- *GIAE – Gestão Integrada para Administração Escolar (Integrated Management for School Administration)* - Access control, canteen sales using RFID cards, attendance monitoring of students and teachers, and access to an online web portal

for parents to view information relating to attendance, timetables, grades, balance, and messages from the teaching staff.

- *GPV – Gestão de Pessoal e Vencimentos (Personnel and Salary Management)* – Workforce Management, staff timetable cover, payslips and related tax declarations.
- *Contab* - Budget management and accounting, can work in conjuction with GPV.
- *SASE – Ação Social Escolar (School Social Action)* - Functions for inventory management and calculation of the associated costs.
- *Horários (Timetables)* – Timetable generation and management
- *BibTeca* – School library management
- *CIBE* – Asset management
- *Oficiar* – Document auditing, digitalization, and email.

JPM applications are fat client, thus each application in the suite must be installed on each client individually (other than the web portal found within GIAE). Microsoft Windows is required on the client and server.

Table 2-1 summarises the functional areas implemented by JPM.

Table 2-1 - Functional Areas of JPM

Feature	Available	Comments
Admissions Management	No	
Assessment and Attainment Management	Yes	If *Alunos* module is purchased
Attendance Management	Yes	If *Alunos* module is purchased
Behaviour Management	Yes	If *Alunos* module is purchased
Curriculum Planning	No	
Data Transfer	Yes	If *Privagest* module is purchased
Examinations Management	No	
SEN Management	No	
Student Personal Records	Yes	If *Alunos* module is purchased
Timetable Construction and View	Yes	If *Horários* module is purchased
Timetable / Academic Staff cover	Yes	If *GPV* module is purchased
Workforce Management	Yes	
Finance	Yes	If *GPV* module is purchased
Asset Management	Yes	If *CIBE* module is purchased
Data Mining, Trend Analysis and Predictions	No	

Web Access to Appropriate Data for Stakeholders	Yes	If *GIAE* module is purchased
Student Progress Report Generation	Yes	If *Alunos* module is purchased
Library / Resource Management	Yes	If *BibTeca* module is purchased
Gate Access Control	Yes	If *GIAE* module is purchased
Canteen/POS	Yes	If *GIAE* module is purchased

2.5.1.2 Sistema Integrado de Gestão de Escolas (SIGE)

SIGE is a Portuguese School MIS developed by Input I/O since 2001. It is used in more than 300 schools in Portugal (Micro I/O, 2011). The most recent commercial release (v3) at the time of writing it offers a core *Gestor* (Manager) application and 7 additional modules that can be purchased to allow its use in various departments. Most of the functionality is based around the use of an RFID card which all students and staff require.

Beyond the *Gestor* core application, the additional modules provide the following functionality:

- *Porteiro (Porter)* - The *Porteiro* module of SIGE allows staff and students to register their entrance to and exit from the school using an RFID card. An application is provided for a member of staff to monitor the entrances and exits (alerting staff to unauthorized exits), allow guests to be registered, and view logs.
- *Portal Web (Web Portal)* - This application allows read-only view of information useful to parents, such as timetables, lunch menu, attendance and grades. Teachers are able to send messages through to parents, and parents are able to request meetings with teachers.
- *Refeitório (Canteen)* - This module controls access to the canteen and allows users to reserve their meals in advance.
- *Ponto de Venda (Point of Sales)* - This module is software specifically for tills, allowing canteen staff to calculate the cost of the meal and deducting this from the student's balance using the RFID card. It also allows stock control and inventory management in the canteen.
- *Facturação (Billing)* - Provides functionality for accounting, emission of invoices and receipt of payments for a variety of reasons (such as school trips).

- *Serviço SMS (SMS Service)* - Allows parents to be notified via SMS of events concerning their child, such as lateness or truancy.
- *Gestor de Dados (Data Manager)* - Performs backups and maintenance operations on the database.

SIGE uses client-server architecture, with a fat client installed on each machine. The client is developed using Microsoft's *.net* framework and requires Microsoft Windows on each machine.

Table 2-2 summarises the functional areas implemented by SIGE.

Table 2-2 - Functional areas of SIGE

Feature	Available	Comments
Admissions Management	No	
Assessment and Attainment Management	No	
Attendance Management	Yes	
Behaviour Management	No	
Curriculum Planning	No	
Data Transfer	Yes	
Examinations Management	No	
SEN Management	No	
Student Personal Records	Yes	
Timetable Construction and View	No	
Timetable / Academic Staff cover	No	
Workforce Management	Yes	
Finance	Yes	If *Facturação* module is purchased
Asset Management	No	
Data Mining, Trend Analysis and Predictions	No	
Web Access to Appropriate Data for Stakeholders	Yes	If *Portal Web* module is purchased
Student Progress Report Generation	No	
Library / Resource Management	No	
Gate Access Control	Yes	If *Porteiro* module is purchased
Canteen/POS	Yes	If *Refeitório* module is purchased

2.5.1.3 Truncatura

Truncatura is a Portuguese company that publishes a suite of school MIS applications. The suite as a whole does not have a name. Instead, each application has its own name and can be purchased and run separately, or together sharing the same data. The suite has been in development since 1999, when *WinGA* was launched.

Applications include:

- *WinGA - Gestão de Alunos (Student Management)* – Permits the management of student data, including personal information, attainment, absence reporting. Can import data from SIGE to determine absences.
- *TProfessor* – A web portal for teachers that allows register of absences, evaluations, a calendar function, and storage of personal information.
- *WinEstat – Estatística e Gráficos (Statistics and Graphs)* – produces reports and graphs based on student population demographics, attainment, and other data. Requires WinGA.
- *SEnCE – Sistema de Envio de Comunicações Escolares (System for Sending School Communications)* – allowing the bulk sending of evaluations, exam results, absences and school news to subscribers, via SMS or e-mail. Requires WinGA.
- *GestASE - Gestão de A.S.E. (School Social Action Management)* – allows the management of subsidies for students, insurance, school transport and bursaries. Also offers inventory management. Can import data from SIGE. Requires WinGA.
- *GestRec - Gestão de Recursos Humanos para a Educação (HR Management)* – Responsible for the management of staff (both teaching and non-teaching). Allows the storage of personal information, absence management, payroll management, and the exporting of data.
- *GestContEsc - Gestão de Contabilidade Escolar (School Acconting Management)* – Treasury management software, including balance sheet management, emission of receipts and document management. Can import data from, and export data to GestRec.
- TProfessor is the most recent addition to the suite, and represents the first move towards a web application. All other applications use Microsoft's *.net* framework

2.0. Data is stored in an MS SQL database. Both client and server applications require Microsoft Windows to be installed.

Table 2-3 summarises the functional areas implemented by Truncatura's software.

Table 2-3 - Functional areas of Truncatura

Feature	Available	Comments
Admissions Management	Yes	
Assessment and Attainment Management	Yes	
Attendance Management	Yes	
Behaviour Management	Yes	
Curriculum Planning	Yes	If *TProfessor* is purchased
Data Transfer	Yes	
Examinations Management	Yes	If *TProfessor* is purchased
SEN Management	No	
Student Personal Records	Yes	
Timetable Construction and View	No	Teacher timetable can be displayed in *TProfessor* if entered manually, but cannot be constructed by the application.
Timetable / Academic Staff cover	No	If *GestRec* is purchased
Workforce Management	Yes	
Finance	Yes	If *GestContEsc* is purchased
Asset Management	Yes	If *GestASE* is purchased
Data Mining, Trend Analysis and Predictions	Yes	Limited to data mining and trend analysis, does not perform predictions
Web Access to Appropriate Data for Stakeholders	Yes	For teachers only
Student Progress Report Generation	Yes	
Library / Resource Management	No	
Gate Access Control	No	Can import data from SIGE
Canteen/POS	No	Can import data from SIGE

2.5.1.4 Capita SIMS

SIMS, developed by Captia Group, is used by "the vast majority" of schools in Great Britain, currently holding an 80% market share (BECTA, 2005; BECTA, 2010). Having been continuously developed since 1982, with a first release in 1984, it covers a wide range of functional areas.

SIMS requires the Microsoft Windows Platform to function, with the latest versions being based on the .net framework and an MSSQL database.

The cost of SIMS to schools can vary significantly based on school size, modules used, and support. The distribution model used in Britain means that schools generally purchase licences and support through the local council. Ballpark figures obtained from Essex County Council suggest that schools can expect to pay an initial fee of between £5000 and £20000 depending on their size, plus an additional fee per student (£6.85 in the case of secondary schools for 2012).

The SIMS core suite allows the management of database records for both staff and students. It allows information on grades, behaviour and attendance to be stored electronically. In addition to the Core Suite, schools can purchase additional modules for SIMS, such as:

- *SIMS Learning Gateway* - This module allows teachers, parents and students to access a student's records (grades, timetable, attendance) via a web based front end.
- *SIMS InTouch* - This module allows SMS and email notifications to be sent to parents from the school. It also creates and stores an audit trail of communications between the parents and the school staff.
- *SIMS Dinner Money* - This module allows schools to take and record payments (via cash, credit card, cheque, etc) from parents for dinner money. It allows notifications to be sent to the school canteen advising them of the number of students who will be dining in the canteen on a given day, based on information from the core module. It does not include any software for Point of Sale.

Further modules include software for Admissions (SIMS Registration and Admissions), Financing (SIMS Financial Management System), Curriculum management (SIMS Curriculum Management), Data Mining (SIMS Discover), and Education Plans (SIMS IEP Writer) and student assessment (SIMS Assessment and Reporting).

To capitalise on the large market share held by SIMS, third party developers have released software which can integrate with it, adding new functional areas. One such example is VeriCool, a product for schools developed by VeriCool Ltd in Britain. VeriCool does not

intend to offer a full MIS solution for schools, but instead can use an existing SIMS database for student data to provide school gate access control, attendance, and canteen "cashless catering". VeriCool's modules require students and staff to have one of the following identifiers:

- Biometric (specifically fingerprint scanning)
- Proximity (RFID) Card
- Barcode Scan
- Pin Code

VeriCool is made up of several modules:

- *VeriCool Cashless Catering* - Cashless catering allows parents to pay in advance for their child or children's dinner by either cheque, cash (using an on-site machine equipped with a finger-print reader that accepts coins and notes), or e-payment via a third-party web application, *ParentPay*. VeriCool provides Point of Sale software for catering staff to calculate the bill and manage stock, and payment is then taken using one of the four identifiers listed above.
- *VeriCool Multi-Lesson Registration* - This module allows students to register their presence in each lesson using one of the four aforementioned methods.
- *VeriCool School Reception* - This modules records entrance and exit to and from the school by staff and students, once again using one of the aforementioned identifiers. It can provide logs, guest registration and a list of all current people "on site" which can be useful in the event of an emergency.

VeriCool and similar products have met with significant opposition in Britain amidst accusations of "Big Brother" surveillance and data protection concerns (BBC, 2012). The British government have since ruled that schools may not collect biometric data without parental permission (Department for Education, 2013), which may have an impact on the desirability of such systems in the future.

Table 2-4 summarises the functional areas implemented by SIMS.

Table 2-4 - Functional areas implemented by SIMS

Feature	Available	Comments
Admissions Management	Yes	If *Registration and Admissions* is purchased
Assessment and Attainment Management	Yes	If *Assessment and Reporting* is purchased

Attendance Management	Yes	
Behaviour Management	Yes	
Curriculum Planning	Yes	If *Curriculum Management* is purchased
Data Transfer	Yes	
Examinations Management	Yes	
SEN Management	Yes	
Student Personal Records	Yes	
Timetable Construction and View	Yes	If *Curriculum Management* is purchased
Timetable / Academic Staff cover	Yes	
Workforce Management	Yes	
Finance	Yes	If *Financial Management* module is purchased
Asset Management	Yes	
Data Mining, Trend Analysis and Predictions	Yes	If *Discover* module is purchased
Web Access to Appropriate Data for Stakeholders	Yes	If *Learning Gateway* module is purchased
Student Progress Report Generation	Yes	If *Assessment and Reporting* module is purchased
Library / Resource Management	No	
Gate Access Control	No	Third party software such as VeriCool can add this functionality
Canteen/POS	No	Third party software such as VeriCool can add this functionality

2.5.1.5 Pearson Fronter

Pearson Fronter, developed by Pearson Education Limited, is a web application that is available to schools using the SaaS delivery model (Pearson Education Limited, 2013). As of 2010, it had a 3% market share in the UK (BECTA, 2010).

Phoenix is made up of several components:

- *e*[1] – Organizational and administrative functions
- *Fronter* – Platform for teachers and students, with learning and assessment tools.
- *e*[1] *Finance* - An accounting package.
- *Report Writer* – Report generation tool

Fronter is unique amongst the software surveyed in providing an e-learning platform that can integrate with the MIS functionality.

Based on information obtained from Norfolk County Council, schools can expect to pay between £2.80 and £3.20 per student per year (Norfolk County Council, 2011) although this may vary between councils.

Due to the cloud-hosted, web-based nature of the application, it is compatible with any browser.

Table 2-5 summarises the functional areas implemented by Pearson Fronter.

Table 2-5 - Functional areas implemented by Pearson Fronter

Feature	Available	Comments
Admissions Management	Yes	
Assessment and Attainment Management	Yes	
Attendance Management	Yes	
Behaviour Management	Yes	
Curriculum Planning	Yes	
Data Transfer	No	
Examinations Management	No	
SEN Management	Yes	
Student Personal Records	Yes	
Timetable Construction and View	No	
Timetable / Academic Staff cover	Yes	
Workforce Management	Yes	
Finance	No	
Asset Management	No	
Data Mining, Trend Analysis and Predictions	Yes	
Web Access to Appropriate Data for Stakeholders	Yes	
Student Progress Report Generation	Yes	
Library / Resource Management	No	
Gate Access Control	No	
Canteen/POS	No	

2.5.1.6 ScholarPack

ScholarPack, published by Histon House Ltd in the UK, was originally an open source SMIS published under the GNU Affero licence. The company's business model was

centred around generating money from adverts on the parental portal module. However, due to the growth of ad-blockers, recent versions are hosted by Histon House Ltd using the Software as a Service (SaaS) model, as explained by Histon House's CEO in an online discussion (Addington, 2011). Prices are described by SchoolPack as "competitive", although at present they have not replied to a request for information on prices.

As with Pearson Fronter, ScholarPack is entirely web based and the server uses the CentOS distribution of Linux. No additional software is required client-side. The advantages of this are that there are no issues regarding client OS compatibility, and installation and maintenance can be handled entirely by the supplier. Disadvantages include the latency that comes with hosting being on an external site, and indeed ScholarPack has been criticised in a product review for not using AJAX (Berthelemy, 2010), meaning page reloads are frequent. Additionally, the lack of any client side software presents some technical restrictions, such as the use of biometric and RFID card readers such as those found in VeriCool in schools; hence ScholarPack does not offer this functionality.

Scholar Pack offers various functions aimed at administrators (i.e. secretaries), managers and teachers, including:

- Student Information Management
- Attendance
- Timetable/Calendar (Although this does not include timetable generation)
- Assessment
- Behaviour Management
- Reporting

A web portal for parents is available as an additional module for a fee.

Table 2-6 summarises the functional areas implemented by ScholarPack.

Table 2-6 - Functional areas implemented by ScholarPack

Feature	Available	Comments
Admissions Management	Yes	If *Admissions module is purchased*
Assessment and Attainment Management	Yes	
Attendance Management	Yes	
Behaviour Management	Yes	
Curriculum Planning	No	

Data Transfer	No	
Examinations Management	Yes	
SEN Management	Yes	
Student Personal Records	Yes	
Timetable Construction and View	No	
Timetable / Academic Staff cover	No	
Workforce Management	No	
Finance	No	
Asset Management	No	
Data Mining, Trend Analysis and Predictions	Yes	
Web Access to Appropriate Data for Stakeholders	Yes	If *Parents Portal* module is purchased
Student Progress Report Generation	Yes	
Library / Resource Management	No	
Gate Access Control	No	
Canteen/POS	No	

2.5.2 Open Source School MIS

In addition to the proprietary solutions available in the market, there are several open source solutions available to schools as open source software. In each case the software can be installed by schools free of charge, but either comes with limited support, or full support only for a fee. Unlike the proprietary solutions discussed above, these solutions tend to be less orientated towards a specific country's market.

2.5.2.1 SchoolTool

SchoolTool is an Open Source School MIS project managed by the Shuttleworth Foundation, a non-profit organization, and released under the GNU GPL v2. It is not designed for schools in a specific country, but its website emphasizes its commitment to providing a viable School MIS for countries in the developing world. The SchoolTool website cites examples of its use in a variety of countries, ranging from Cambodia and Nepal, to USA (SchoolTool, s.d.). No statistics were available for the number of downloads at the time of writing.

SchoolTool is a web application developed using python and recommended/supported for use on an Ubuntu server. The SchoolTool stack is available through the Ubuntu Software Centre, making it relatively simple to install. Support is available through extensive documentation, a mailing list and an IRC channel.

Table 2-7 summarises the functional areas implemented by SchoolTool.

Table 2-7 - Functional areas implemented by SchoolTool

Feature	Available	Comments
Admissions Management	No	
Assessment and Attainment Management	Yes	
Attendance Management	Yes	
Behaviour Management	No	
Curriculum Planning	No	
Data Transfer	Yes	Import/Export via CSV files
Examinations Management	No	
SEN Management	No	
Student Personal Records	Yes	
Timetable Construction and View	No	
Timetable / Academic Staff cover	No	
Workforce Management	Yes	
Finance	No	
Asset Management	No	
Data Mining, Trend Analysis and Predictions	Yes	
Web Access to Appropriate Data for Stakeholders	No	If *Parents Portal* module is purchased
Student Progress Report Generation	Yes	
Library / Resource Management	Yes	Limited to resource booking for staff
Gate Access Control	No	
Canteen/POS	No	

2.5.2.2 FreeMIS

FreeMIS is an Open Source school MIS developed by Robert Jones, a British secondary school teacher, and released under the GNU General Public Licence. The project was initially developed for the school in which he teaches, where it is still used, and subsequently released for any other schools who wish to use it.

FreeMIS is a Ruby-on-Rails web application that uses a MySQL database. No support is offered other than limited documentation, and therefore by the author's own admission, it is not easy to set up. Development has currently stalled, as the author feels that it is not possible for FreeMIS to compete with the various commercial MIS systems available on the market (Jones, 2010).

The author explains that as of April 2009 it had been downloaded 6831 times, but he is unaware as to how many schools had actually deployed it. FreeMIS is available as a single application with no extra modules.

Table 2-8 summarises the functional areas implemented by FreeMIS.

Table 2-8 - Functional areas implemented by FreeMIS

Feature	Available	Comments
Admissions Management	No	
Assessment and Attainment Management	Yes	
Attendance Management	Yes	
Behaviour Management	No	
Curriculum Planning	No	
Data Transfer	No	
Examinations Management	No	
SEN Management	No	
Student Personal Records	Yes	
Timetable Construction and View	No	
Timetable / Academic Staff cover	No	
Workforce Management	Yes	
Finance	No	
Asset Management	No	
Data Mining, Trend Analysis and Predictions	Yes	
Web Access to Appropriate Data for Stakeholders	Yes	Limited. Teachers could potentially access from outside the school depending on server configuration. The system is not designed for student or parent access.
Student Progress Report Generation	Yes	
Library / Resource Management	No	Limited to resource booking for staff
Gate Access Control	No	
Canteen/POS	No	

2.5.2.3 OpenSIS

OpenSIS is an open source School MIS developed by OS4Ed (Open Solutions for Education). The "Core System" of OpenSIS, available to download as OpenSIS Community Edition is available under the GNU GPL2 licence and can be downloaded for free and deployed on a local server in a school. Further versions, the OpenSIS School Edition and the OpenSIS District Edition, are available with some extra features, support and remote hosting for a fee.

Although IS4Ed are based in USA, OpenSIS is developed by an online community and not specifically orientated towards schools in any specific country. To achieve this, it offers a degree of customization and multilingual support.

OpenSIS is a web application developed in PHP and using a MySQL server. As a result, it can run on a wide range of severs and no client side software is required.

Table 2-9 summarises the functional areas implemented by OpenSIS.

Table 2-9 - Functional areas implemented by OpenSIS

Feature	Available	Comments
Admissions Management	No	
Assessment and Attainment Management	Yes	
Attendance Management	Yes	
Behaviour Management	Yes	
Curriculum Planning	No	
Data Transfer	No	
Examinations Management	No	
SEN Management	No	
Student Personal Records	Yes	
Timetable Construction and View	No	
Timetable / Academic Staff cover	No	
Workforce Management	No	
Finance	No	
Asset Management	No	
Data Mining, Trend Analysis and Predictions	No	
Web Access to Appropriate Data for Stakeholders	Yes	
Student Progress Report Generation	Yes	

Library / Resource Management	No
Gate Access Control	No
Canteen/POS	No

2.5.3 Summary

2.5.3.1 Functional Areas

Table 2-10 shows a compilation of the functional areas presented in this section to allow side-by-side comparison of the products and their features. Figure 2-1 shows the number of products implementing each functional area.

Table 2-10 Summary of functional areas

Feature	SIGE	JPM	Truncatura	SIMS	Pearson	ScholarPack	SchoolTool	FreeMIS	OpenSIS
Admissions Management			Yes	Yes	Yes	Yes			
Assessment and Attainment Management		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Attendance Management	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Behaviour Management		Yes	Yes	Yes	Yes	Yes			Yes
Curriculum Planning			Yes	Yes	Yes				
Data Transfer	Yes	Yes	Yes	Yes			Yes		
Examinations Management			Yes	Yes		Yes			
SEN Management				Yes	Yes	Yes			
Student Personal Records	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Timetable Construction and View		Yes		Yes					
Timetable / Academic Staff cover		Yes		Yes	Yes				
Workforce Management	Yes	Yes	Yes	Yes	Yes		Yes	Yes	
Finance	Yes	Yes	Yes	Yes					
Asset Management		Yes	Yes	Yes					
Data Mining, Trend Analysis and Predictions			Yes	Yes	Yes	Yes	Yes	Yes	
Web Access to Appropriate Data for Stakeholders	Yes	Yes	Yes	Yes	Yes	Yes		Yes	Yes
Student Progress Report Generation		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Library / Resource Management		Yes					Yes		

Gate Access Control	Yes	Yes
Canteen/POS	Yes	Yes

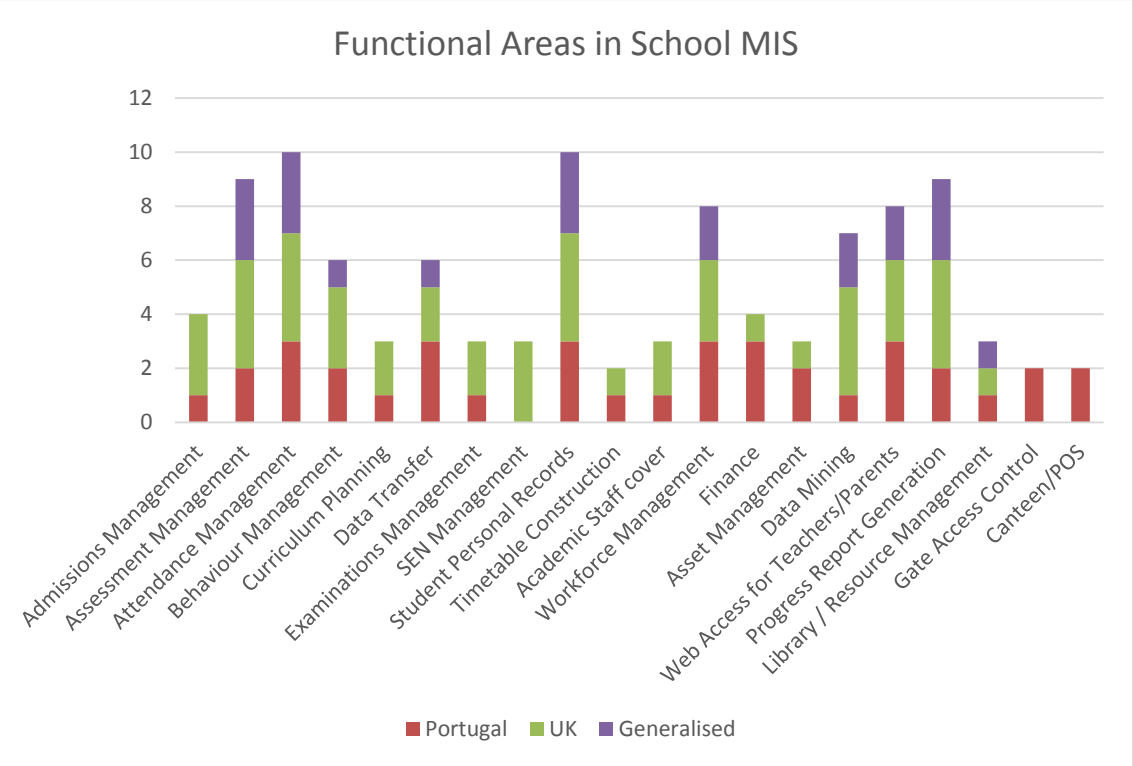

Figure 2-1 - Functional Areas in surveyed School MIS

We can conclude that, the most common functional areas found in School MIS relate to the storing of students' personal records and associated data relating to assessment and attendance. SIGE is the only product surveyed that did not focus on this area. Considering the established use of the JPM *Alunos* module in the vast majority of Portuguese state schools identified during research, it is possible that SIGE aims to focus on providing other functionality and work with existing JPM installations rather than attempting to compete on this particular front.

The recurrence of access for parents and staff in the form of a web portal shows the importance schools and parents place on using modern technology to improve communication. For teachers, such a portal can also facilitate working off-site, which discussions with teachers suggests is a common occurrence when it comes to assessing work.

In relation to the use of technology to control access to the school and operate the canteen using a form of ID, it is apparent that the demand for this is much stronger in Portugal. The use of ID cards in Portuguese schools is discussed further in section 2.7.4.

2.5.3.2 Architecture & Deployment

Each product surveyed used a form of client/server architecture, summarised in Table 2-11. However, variations existed in the type of client and the hosting.

Table 2-11 - Architecture of school MIS products surveyed

	Client	Server	Comments
SIGE	Fat	Local	Has web portal component
JPM	Fat	Local	Has web portal component
Truncatura	Fat	Local	Has web portal component (for teachers only)
SIMS	Fat	Local	Has web portal component
Pearson	Web	Remote	
ScholarPack	Web	Remote	Open source locally hosted version previously available, superceded by newer versions
SchoolTool	Web	Local	
FreeMIS	Web	Local	
OpenSIS	Web	Remote /Local	Cloud hosting available for a fee, locally hosted "Community edition" available free of charge

It is notable that the two products with the highest market share in their respective countries, SIMS and JPM, both use fat client applications (aside from bolt-on web portals with limited functionality) that must be installed on each workstation that requires their use. These two products are also two of the oldest surveyed, developed before web applications were able to provide as rich a user interface as standard applications. In a 2011 interview, the head of marketing at SIMS' developer Capita suggested that their large market share required a more conservative approach to adopting newer technologies (Cooper, 2011), and would undoubtedly be a time-consuming undertaking for the developers. The "younger" systems on the market favour the web environment, which, whilst limiting some aspects of design, is generally easier to deploy and maintain.

The choice of hosting varies between local hosting, where the database and other server-side components are hosted in the school, versus remote hosting, which in all of the

software surveyed referred to “cloud” hosting offered by the developer. From the point of view of the developer, this choice is generally dictated by the company’s business model. Cloud hosted web applications are sold using the “software as a service” model, as opposed to the traditional model of selling the software with an up-front cost and optional support, which is generally the case for locally hosted MIS systems.

2.6 FACTORS AFFECTING CHOICE OF SCHOOL MIS

In order to understand the weaknesses in existing products, it is necessary to understand some of the factors schools consider in making the decision. Previous work from Sahay and Gupta (Sahay & Gupta, 2003) has identified Primary and Secondary drivers in the selection of software, which although originally based around business supply chain systems, has since been applied to information systems in general (Bocij, Greasley, & Hickie, 2008). These drivers can thus be used to consider some of the key factors that schools may consider in their choice of MIS.

2.6.1 Primary Drivers

According to Sahay and Gupta, these are the drivers which form a set of essential requirements which, if not met, mean that the software solution is not suitable for the organization.

2.6.1.1 Features

The school must consider the functional areas that the system implements. As the previous chapter has shown, whilst there are features common to all School MIS (e.g. the ability to store student information), certain requirements, such as the ability to use RFID cards to control access to the school grounds, are simply not available with many systems.

Another example in this area may be the type of school the system is targeted at. Each school throughout the primary and secondary stages of education is likely to have different requirements. For instance, in the first few years of education, it is almost always the case that children will have one teacher for all subjects, whereas later, it is more common for a class to have a different teacher for each subject. This has significant implications for several functional areas of a School MIS, such as timetabling and recording marks.

2.6.1.2 **Technology**

The school must consider whether their existing hardware can support the software, and what new hardware may be required. This could influence the choice between remotely hosted systems and locally hosted systems described in 2.5.3.2, as locally hosted systems likely require a higher initial investment for server components.

2.6.1.3 **Support and Services**

System failure can have a significant impact on the operation of schools that depend on their MIS for areas such as attendance management and gate access control. The server hosting can play a large part when considering the support offerings. Technical support for remote "cloud hosted" systems is largely handled off-site by the developer, which eases the burden on school ICT staff but requires schools to put a large amount of trust in the developer's support service. Support for locally hosted solutions provided by a developer can also suffer from being time consuming in the case that support staff need to travel to the site. However, locally hosted servers can also mean quicker resolution of problems if the school has ICT staff capable of solving issues themselves.

In addition to technical support, schools may also wish to consider services such as training provided by the developer or vendor. Several roles within schools have not traditionally required a high level of ICT competency, and therefore users' levels of experience may vary significantly.

2.6.1.4 **Cost**

As shown in chapter two, the cost of School MIS ranges from free (for open source systems) to annual five-figure sums. Clearly, this limits choice for some schools. The varying budget of schools from country to country and region to region is also partly responsible for the vast range of prices in the market.

2.6.1.5 **Customisation**

The degree of standardisation in Portuguese and British state schools means that the level of customisation required is reduced somewhat. For example, all Portuguese students at between years 5 to 9 nationally are graded on a scale of 1-5, therefore allowing the possibility of creating additional scales for these age groups is only required if a Portuguese developer intends to market beyond national state schools.

Of all the products surveyed, the open source SchoolTool had the highest level of customisation, offering the possibility to adapt many aspects of the system including the fields in student/teacher profiles, mark schemes and reports. The fact that SchoolTool is not intended for schools in a particular country is likely one of the key motivations for offering this level of customisation. Lack of customisation along with a desire to have a system that is readily prepared for the school environment in which it will operate is likely one of the reasons that proprietary school MIS systems are rarely marketed outside the country for which they are targeted at.

2.6.2 Secondary Drivers

In addition to the drivers stated above, Sahay and Gupta also identified secondary drivers as follows:

- Vendor strength
- Vender vision
- Industries covered
- Other (e.g. usability, versatility, security)

As the first three drivers are largely beyond the control/scope of this thesis, they are not considered. However, there are other secondary drivers that are important for schools to consider.

2.6.2.1 Usability

As previously mentioned, a school MIS will be used by a wide range of users (teachers, students, administration staff, parents, etc.), potentially with a wide range of skills and experience. As well as the aforementioned value of training, it is undoubtedly important that a system is intuitive and easy to use. During the product survey, when interviewing teachers and reading online comments, no complaints were found about a system being very difficult to use, suggesting that the existing products have recognised the importance of this.

2.6.2.2 Localisation

As discussed, the majority of the existing products analysed in the survey, particularly the proprietary software products, are targeted at a specific market. It is interesting to note

that even more mature products such as Capita SIMS (released almost three decades ago) have not attempted to enter international markets. The degree of customisation required to adapt to differences in country's education system, combined with the challenge of providing overseas support, is likely to be a factor here.

2.7 THE PORTUGUESE EDUCATION SYSTEM

The goal of this project involves developing a School MIS for Portuguese schools. In this section, some aspects of the Portuguese education system and its schools are considered in more detail. Understanding the current reality for schools in the country is important in understanding the requirements of schools in relation to MIS products.

2.7.1 Education System Structure in Portugal

Education in Portugal is compulsory between the ages of 6 and 18[2]. Since the reform of the Portuguese Education System in 1986[3] children in Portugal who complete primary and secondary education in its entirety will attend the following schools:

- Basic Education (*Ensino Básico*)
    - 1st Cycle – Age 6-10
    - 2nd Cycle – Age 10-12
    - 3rd Cycle – Age 12-15
- Secondary Education (*Ensino Secundário*) - Age 15-18, one of the following:
    - Secondary School
    - Vocational/Professional Course

This means that a child could attend four different schools in four different geographical locations, although in many cases the schools that make up Basic Education, particularly in the 2nd and 3rd cycles, are often grouped together. Products that are not specifically designed for the Portuguese market are unlikely to be aware of the nuances in the way each of these schools operate, and therefore may not meet all of a school's needs.

[2] Decreto-Lei n.º 176/2012 de 2 de agosto

[3] Decreto-Lei n.º 46/86 de 14 de outubro

2.7.2 School Organizational Structure

The administration and management of schools in Portugal, most recently defined in a 2008 law[4], consists of the following bodies, shown in Figure 2-2.

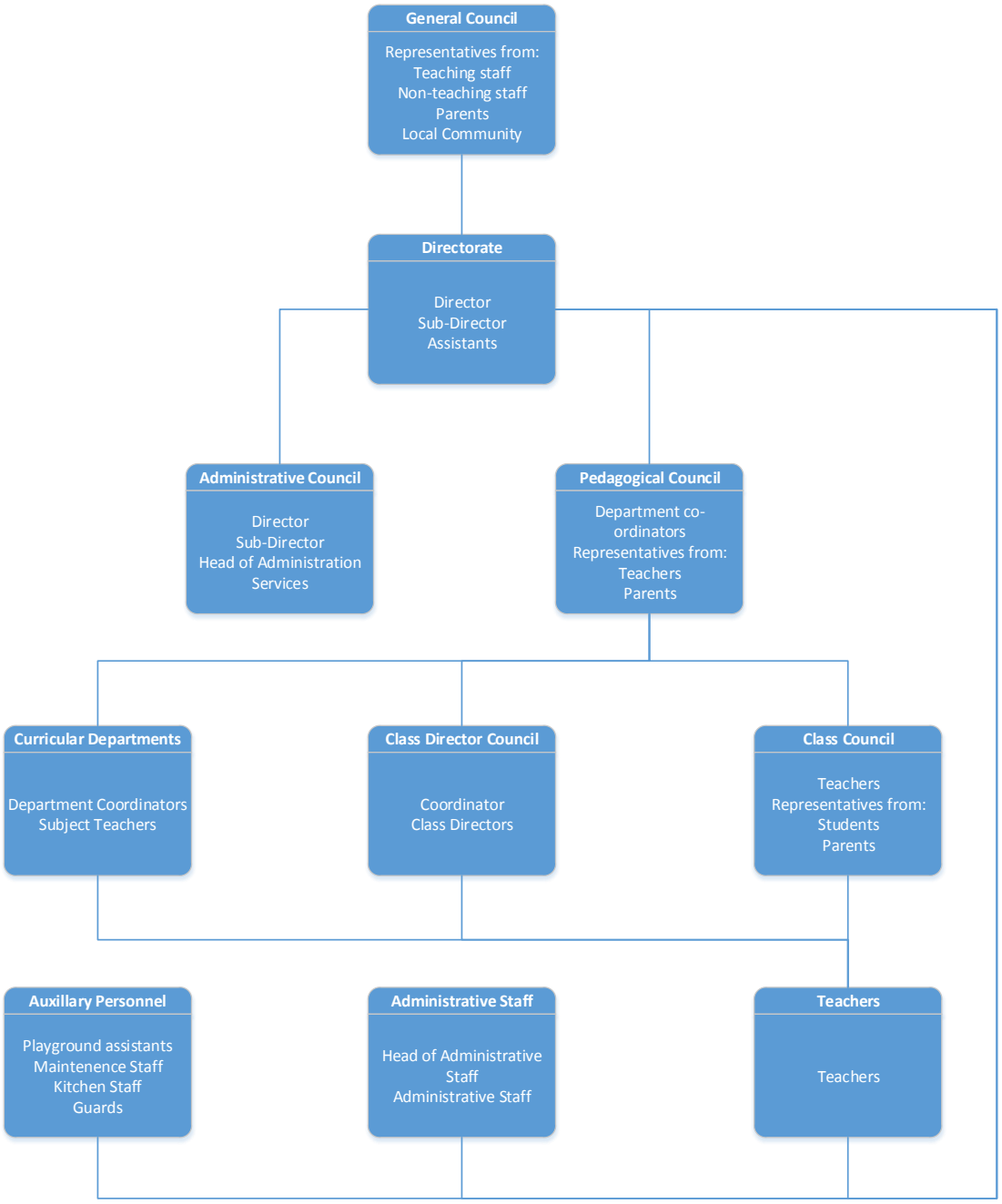

Figure 2-2- Organizational structure of Portuguese schools

[4] Decreto-Lei n.º 75/2008 de 22 de abril

In 2000[5], Basic Education schools were organized into *agrupamentos* (clusters), whereby local schools of different cycles would be operated through the same management body, creating consistency and continuity as students pass through each cycle. These clusters were almost entirely vertical, meaning a cluster would consist of one 1st cycle school, one 2nd cycle school, and one 3rd cycle school, which in many cases were located on the same site (European Commision, 2009).

2.7.2.1 Mega-Clusters

In accordance with the 2008 reform, schools have recently been re-organised intro *mega-agrupamentos* (mega-clusters) whereby existing clusters of Basic Education schools in an area have been grouped together, usually with Secondary schools, into larger groups in a wider area. The administration and management body described now runs a much larger group of schools, and multiple schools of the same cycle can be part of the same mega-cluster. For example, the former cluster *Agrupamento Vertical de Ferreiras* consisted of the *Escola Basica Integrada de Ferreiras*, containing all three cycles of Basic Education on one site. This is now the headquarters of a group of 11 schools up to 15km apart. This new mega-cluster, *Albufeira Oriental*, merged three of the old vertical clusters. This has some consequences for organization and staff, as interviews suggest that it's now not uncommon for teachers to be required to teach at multiple schools within the same cluster. There are also consequences for School MIS – at the beginning of the 2012/13 school year, each of the original clusters within Albufeira Oriental used their own separate MIS system, which does not reflect the new organizational structure.

2.7.3 Information Technology in Portuguese Schools

When analysing the potential of School MIS systems, it is important to consider the environment in which they will operate and the possibilities this implies. In Portugal, driven by a number of initiatives and projects, the use of information technology across many areas of school life has grown since the 1980s. Some of the most notable projects include:

- Projecto Minerva (1985-1994) - The first major Ministry of Education project to introduce computers into Portuguese schools.

[5] Decreto-Lei nº 12/2000 de 29 de agosto

- Nónio Século XXI (1996-2002) – A Ministry of Eduation project promoting the introduction of the new technologies in education, through the continuing training of teachers in this field, the production of educational software, development of network infrastructure and international cooperation[6].

In September 2007, the *Plano Tecnológico Educação (PTE)* (Gabinete de Estatística e Planeamento da Educação, Ministério da Educação, 2008) was approved by the Portuguese Government[7]. This plan outlined a commitment to "The Technological Modernisation of Schools", explaining that "It is essential to value and modernise schools, to create the physical conditions that favour educational success among students."

One of the stated goals of the project was to "Reinforce and modernise the ICT equipment of most Portuguese schools, to increase speed of Internet connections and to build structured and efficient local area networks." The project finished in 2010 and statistics published in 2010 (summarised in Table 2-12 and Figure 2-3) show that the number of computers available in schools rose significantly during that time (Gabinete de Estatística e Planeamento da Educação, 2010). According to the same report, approximately 7.03% of computers in Portuguese schools are for administrative use.

Table 2-12 - Number of computers with internet access in Portuguese schools

School Level	2005/06	2006/07	2007/08	2008/09	2009/10
1st Cycle	15731	18774	29084	374787	379494
2nd Cycle	15149	19621	25400	40873	45585
3rd Cycle	23601	30107	38631	60425	67918
Secondary	18770	22853	29417	47086	52621
Total	73251	91355	122532	523171	545618

[6] Despacho Ministerial 232/ME/96 de 4 de Outubro de 1996

[7] Resolução do Conselho de Ministros n.º 137/2007, de 18 de setembro

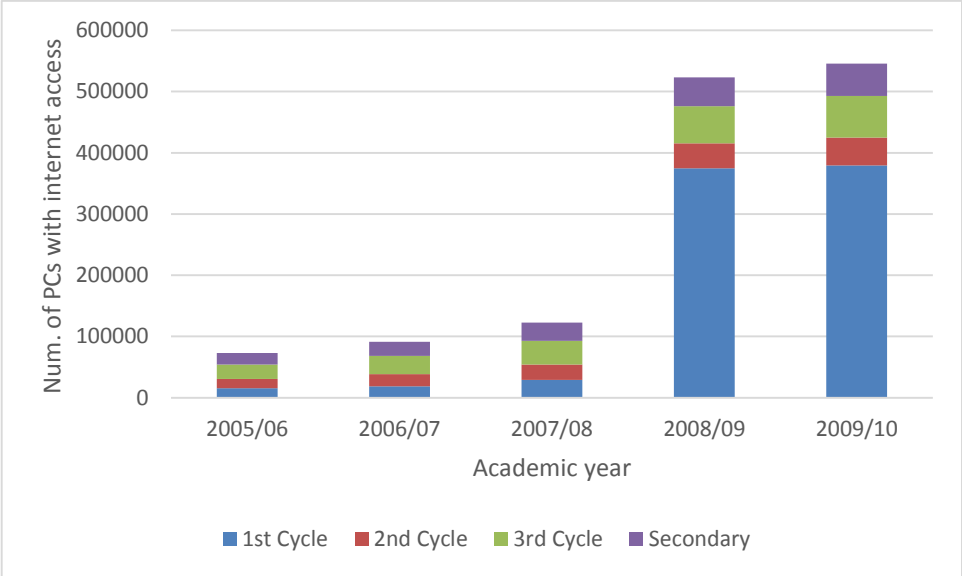

Figure 2-3 - Number of computers with internet access in Portuguese schools

In addition to the increased number of computers available, as a result of the PTE, 100% of Portuguese public schools have broadband access, with WLAN available in 75% of classrooms (Plano Tecnológico Educação, 2011). In the schools visited, several PCs with internet access were available in each staff room, but interviews conducted with teachers showed that it is common for them to bring their own devices, owing to the fact that teachers often prepare work at home and bring their work to school. As a result of a PTE incentive aimed at training staff, 27% of Portuguese teachers have been certified in *Competências Digitais -Nível 1* (Digital Competencies - level 1) (Plano Tecnológico Educação, 2009).

One issue identified during discussions with two ICT teachers was that in Portuguese schools, there are no full time ICT technicians. Instead, ICT teachers are expected to perform this job in addition to their pedagogical activities. An implementation study for CATE (Centro de Apoio TIC às Escolas), a project set up to tackle this problem, reported that, "Most schools lacks specialized technical support for the maintenance of ICT infrastructure, with 75% of schools pointing this as a major obstacle to modernizing education." (Gabinete de Estatística e Planeamento da Educação, 2008). CATE was eventually made available to schools in 2011, offering a remote technical support service. However, it has been criticised heavily, both by the teachers interviewed and in the media, being described as "bureaucratic and slow," with one school director commenting that,

"For us, CATE doesn't exist," leaving ICT teachers finding it easier to perform their own ICT technical support, despite the large workload this implies (Jornal i, 2012).

2.7.4 ID Cards in Portuguese Schools

One of the "Key Projects" outlined as part of the aforementioned *Plano Tecnológico Educação* was the *Cartão da Escola* (School Card) project. In Portuguese schools, it has long been common for students to carry paper ID cards, containing the student's name, number, and the times they were allowed to leave the school. This project proposed to modernize this concept. The goals of this project were stated as follows:

- To promote the use of technology, supplying all schools with student card platforms.
- To increase school safety, ensuring the availability of access control and electronic purse functions.
- To increase the efficiency of management processes, ensuring the general implementation of compatible platforms that allow the follow-up of students' records during their stay at school.

This was to be achieved through the development and implementation of a homogenous electronic card ("E-Card") system to be deployed nationwide for all schools in the 2nd and 3rd cycles of Basic Education, as well as Secondary Schools. The report claimed that such a system "represents a major efficiency gain for schools," fulfilling needs such as:

- The suppression of cash exchange.
- The control of student entrances and exits.
- The ability to consult the administrative process, academic record or student consumptions.

A separate report published in 2009 contains an analysis of the number of schools already using a card system during the 2007/2008 school year (Gabinete de Estatística e Planeamento da Educação, 2009). Of the 11,820 schools in Portugal at the time, a total of 1,015 had a card system, equivalent to 9%. Most of these schools were at the levels that the government were targeting: Of the 1,207 schools that make up the 2nd cycle, 3rd cycle, and Secondary levels, 62% had an E-Card system in place.

The Education Technology Plan stated that the existing private E-Card systems used by schools were inefficient, due to difficulties in electronic information exchange between schools as well as inconsistency in the key functions that the cards could perform. A summary of those functions is shown in Table 2-13.

Table 2-13 - Functionalities associated with E-Card (Gabinete de Estatística e Planeamento da Educação, 2009)

Function	%
Canteen Payments	92
Bar Payments	91
Stationary Payments	90
School Gate Access	79
Photocopy Payments	78
Kiosk Payments	70
Student File Consultation	22
Attendance Registering	11
Use Outside of School	3

In 2010, the government abandoned the *Cartão da Escola* project, declaring the 18m€ cost to be "incompatible with current phase of fiscal restraint," as reported in newspaper *i* (Guerra, 2010), and confirmed in a statement issued to shareholders by developer Novabase the following day (Novabase, 2010).

The E-Card project fiasco had a significant effect on existing Portuguese School MIS products. As the report in *i* explains, when the government announced the national scheme, Portuguese developers halted further development of their E-Card systems and schools postponed investing in such systems. However, the promotion of the project combined with long established concept of ID cards in Portuguese schools, did much to convince schools of the benefits of such a system, hence the fact that of the products surveyed, Access Control and Canteen systems are repeatedly seen in the Portuguese products surveyed but far less common in products from other countries.

3 PROBLEM STATEMENT

3.1 INTRODUCTION

Having reviewed existing systems on the market and examined the Portuguese education system in the previous chapter, this chapter explores the rationale behind the development of a new product.

3.2 WEAKNESSES IN EXISTING PRODUCTS

3.2.1 Incompatibility With the Modern Organizational Structure of Portuguese Schools

The recent shift towards mega-clusters means more to existing Portuguese School MIS systems than simply adding more students into the database. With the current state of existing systems, various stakeholders are impacted in negative ways.

Mega-clusters require a system that will operate reliably over a potentially large area. For system administrators, who already double as ICT teachers and thus have a high workload, fat-client architecture becomes impractical when administrators have to travel to numerous sites and workstations to perform installation, updates and maintenance operations. A web application would significantly reduce the workload on administrators, requiring only a browser on the client and allowing updates to be rolled out on the server.

Teachers, who must now frequently travel between schools, should be able to update students' records from any location, without having to be in the school that the class is part of. Additionally, for schools that use a form of access control or canteen payment system (i.e. RFID cards), it is not convenient for teachers to require different cards depending on which school they are teaching in next.

3.2.2 Restrictions Caused by Choice of Technology

The use of a fat-client, as seen in JPM and SIGE, is incompatible with the fact that many teachers bring their own devices to School, which do not have the client installed. Many modern devices such as tablets and smartphones, which do not use Windows OS, have no way of running the Windows executables that many older systems rely on, which is

inconvenient for staff. A web application would allow greater compatibility with modern devices, functioning on any device with a browser.

3.3 Opportunity Presented by Failed E-Card Project

The planned implementation of a publically funded E-Card system for schools, outlined in PTE and discussed in the previous chapter, left developers of existing systems with little reason to continue developing this area. However, the collapse of this project combined with the improved ICT infrastructure as a result of the PTE, opens up opportunities for new products. For schools in Portugal, these cards remain the obvious replacement for the existing paper ID cards, and offer a lot of potential for improved efficiency and safety. The research conducted shows that some functional areas, such as the use of cards outside of schools (e.g. in local cafés and restaurants) are still lacking in development, which a new product could take advantage of.

3.4 Conclusion

Portuguese schools would benefit from an MIS designed with the new organizational structure of schools in mind, and built with modern technology to improve the user experience for all potential users. The collapse of the government's project and the recent improvement in ICT infrastructure means that the potential exists for a newly developed system to succeed in the market.

4 METHODOLOGY

4.1 INTRODUCTION

For a system of this size, with a large number of potential features, a "code and fix" approach is not appropriate (Fowler, The New Methodology, 2000). Therefore, it is important to identify and follow a methodology to improve efficiency. An iterative and incremental development (IID) methodology was used for this project. This section explains this methodology, the reason it was chosen, and gives on overview of how it was applied, from requirements elicitation through to implementation.

4.2 CHARACTERIZATION OF DEVELOPMENT ENVIRONMENT

Having studied the use of agile methodologies as their popularity grew in the early 2000s, Boehm and Turner concluded that both agile and plan-driven methodologies had their own home ground. Accordingly, they presented a framework to determine the suitability of each methodology for a project, shown in Table 4-1 (Boehm & Turner, 2004).

Table 4-1 – The Five Critic Agility/Plan Driven Factors, adapted from (Boehm & Turner, 2004)

	Agile	Plan Driven
Criticality	Low criticality	High criticality
Personnel	Senior developers	Junior developers
Dynamism	Requirements change often	Requirements do not change often
Size	Small number of developers	Large number of developers
Culture	Culture that responds to change	Culture that demands order

Under Boehm and Turner's definition, the system can be considered to be of **low criticality**, as despite its importance in the School's operation, its continued operation does not directly affect safety.

SC School is being developed by a **lone developer** for a Portuguese software development company. During initial planning, the company indicated that their business requirements, in terms of which modules and features should be prioritised and implemented, were **liable to change** depending on the priorities of potential clients the company may negotiate with during development. In addition to this, the organizational

structure of Portuguese schools is continuously being overhauled, particularly with recent public sector budget cuts, therefore the system must be able to adapt to this changing environment.

Given these factors, it can be concluded that an agile methodology is appropriate for this project.

4.3 ITERATIVE AND INCREMENTAL DEVELOPMENT

IID is an adaptive, evolutionary approach to development, whereby systems are developed through repeated cycles with more functionality added each time. This is in contrast to sequential, predictive processes such as the classic Waterfall model. The practices of IID have been traced back to "plan-do-study-act" (PDSA) cycles designed for quality improvement (Larman & Basili, 2003; Shewhart, 1939).

IID is a key part of the various agile methodologies such as Extreme Programming (Beck, 1999) and Scrum (Nonaka & Takeuchi, 1986) which have gained popularity over the past decade. The majority of these methodologies are focused on IID used collaboratively within self-organising, cross-functional teams. In this project, as there will only be one developer, many of the practices described in these methodologies are superfluous. Therefore, a simple IID outlined in Figure 2-1Figure 4-1 was used.

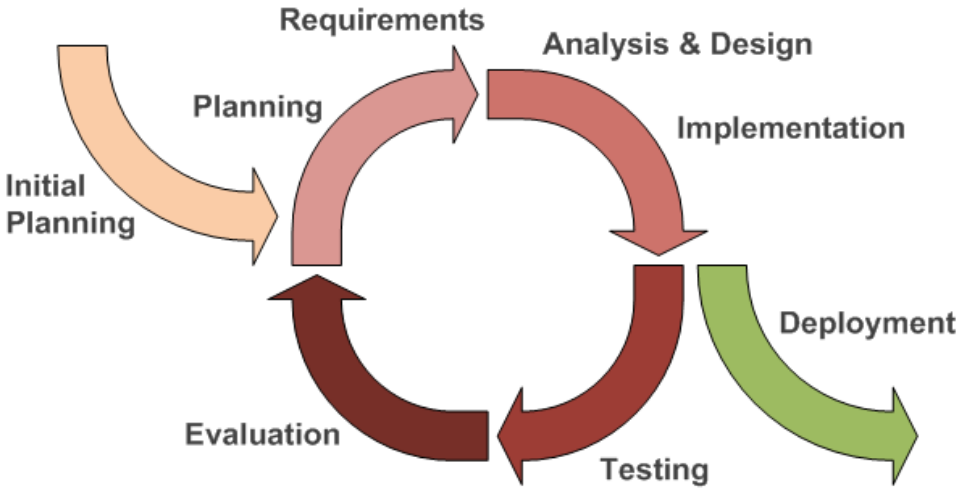

Figure 4-1- Iterative and Incremental Development (Agile Development Tools, 2013)

4.4 REQUIREMENTS METHODOLOGY

The requirements phase was broken down into elicitation and specification.

4.4.1 Elicitation

In order to elicit requirements, to begin, existing systems were analysed to gain a general idea of how such systems are applied in both Portugal and the rest of the world, and what functional areas they encompass. Research was conducted to understand the structure of the Portuguese education system and the schools therein, as discussed in chapter two. Further insights were gained from visits to local school groupings[8], where informal interviews were conducted with different potential users, with the goal of performing task analysis and gaining user feedback about the difficulties of existing systems. Some details on policy were obtained from existing school cluster websites. As part of the iterative process, this process was repeated with staff as the system was developed, enabling continuous refinement of requirements.

In addition to identifying and refining the requirements of potential users, continuous contact was maintained with the developer company in order to meet their business requirements through meetings, discussions and build demonstrations.

4.4.2 Specification

In this stage, functional and non-functional requirements were specified formally based on the information gathered in the elicitation stage. They were initially specified at a high level, and organised into analysis packages in order to group similar requirements together. Each requirements was subject to refinement at each iteration based on feedback and analysis, allowing for lower level requirements to be identified and implemented.

4.5 DESIGN AND IMPLEMENTATION

Based on the requirements, a proposed architecture was developed for the system. Technologies that could fulfil the requirements were identified, and architectural patterns

[8] Agrupamento de Escolas Albufeira Poente, Agrupamento Albufeira Oriental

were chosen based on what synergised well with those technologies and the system as a whole.

System modules were identified based on the requirements. Specific modules were prioritised for implementation based on business needs and code dependencies.

4.6 TESTING AND EVALUATION

Initial testing was focussed around unit and integration testing. Test harnesses were created and outputs were verified. As the system was developed, usability testing was performed with potential users in order to gain feedback, which was used for further improvements.

5 REQUIREMENTS

5.1 INTRODUCTION

Having established the usefulness and feasibility of the system, this section determines the requirements for the system. The structure of this requirements document is adapted from IEEE/ANSI 830-1998 (IEEE, 1998).

5.2 GENERAL DESCRIPTION

5.2.1 Product Perspective

SC School is a Management Information System for public Basic and Secondary schools in Portugal developed for Singlecode LDA. The long term aim of the project is to integrate the system into all areas of school life, providing a complete technology solution for schools. Initial development will focus on an extensible core system with a number of functional areas considered "key" by Singlecode, with the system to be extended in the future.

5.2.2 Product Functions

Key initial functional areas to be developed initially, are:

- Workforce management
- Student personal records
- Gate access control
- Canteen lunch purchasing
- Assessment and attainment management
- Web Access to appropriate data for stakeholders

In order to give this thesis a reasonable scope, the requirements section will focus on information gathered that relates to these areas.

5.2.3 Human Actors

The following section gives an overview of the various human actors that will use the system based on the functional areas specified in 5.2.2. The information presented in this section was obtained as part of the project's requirements elicitation phase.

5.2.3.1 Secretary

Secretaries are members of the non-teaching staff in a school. Since the introduction of mega-clusters, most secretaries operate in a centralized secretary's office that manages administrative operations for all schools in the cluster, although interviews suggested that in some cases, a secretary may also be kept on site in other schools within the cluster to help with local administration.

The work of secretaries covers several areas. One such area is human resources, which includes the management of staff and student records. For school staff, this includes information related to the teacher's contract, career, medical and disciplinary record. For students, the information that secretaries manage includes personal, parental, and medical information. An important part of the role secretaries perform when managing student information is SASE (School social services), which involves the attribution of subsidies and bursaries to children who meet the requisite criteria (largely related to household income, etc.), and has implications in many areas such as discounted lunches, transport, and school materials.

Other work areas that secretaries perform involve the admissions process, treasury management and inventory management. However, the analysis of these areas is beyond the scope of the thesis.

Interviews suggested that different mega-clusters have different ways of dividing this work between the secretaries. For example, in *Agrupamento Escolas Albufeira Poente*, one secretary administers staff; another administers students, and so on. However, in *Agrupamento Albufeira Oriental*, each Secretary is assigned a number of teachers, a number of students, etc.

Information Technology has been a part of the work performed by secretaries in Portugal since the 1990s, and it is expected that they have ICT skills as a condition of their employment.

5.2.3.2 Teacher

Interviews were carried out with several teachers from schools in three different mega-clusters in Portugal to discuss their work. The main activities of a teacher can be divided into teaching and assessment. Teaching consists of the planning and teaching of lessons to students, and the work completed by students therein. Assessment consists of marking work, and using marked work and observation to assess the performance of students. This also includes assessment of a student's behaviour in class.

Further to the role of a teacher in the 2nd and 3rd cycles of Basic Education, as well as at Secondary level, some teachers also fulfil the role of class director. In addition to the task described above, class directors are responsible for the students in their designated class, defined as a group of 26 students in the 1st cycle and 26-30 students in the 2nd and 3rd cycles as well as secondary level[9]. Class directors are the main point of contact with parents of the students in their class (for discussion of performance, behaviour, etc.). Indeed, parents are encouraged to treat the class director as the first point of contact for most issues, even if an issue relates to a specific subject taught by another teacher.

Interviews and research revealed that teacher's roles do not significantly vary between different mega-clusters of schools, but do vary to some extent between different types of schools. The most significant example is the difference between the roles of a 1st cycle teacher, compared to teachers in the later cycles. In the 1st cycle, a class has one teacher who teaches all subjects, as well as acting as the class director. In the later cycles, students have one class director, as well as a teacher for each subject.

Teachers from the 2nd cycle upwards work within a department, that is, a group of teachers who teach the same subject or area. In interviews, teachers explained that sometimes they collaborate, using the same work and mark schemes, but sometimes work alone.

The ICT competency levels of teachers vary, although thanks to various initiatives implemented in schools discussed in chapter 2, the number of teachers with certified ICT competencies continues to increase.

[9] Ministry of Education Dispatch n.º 5048-B/2013

5.2.3.3 Parent

Parents (or legal guardians) of students have several duties to perform in relation to the school. They are responsible for making sure their child attends, but subject to school approval may give permission for the child to leave school at certain times, such as an afternoon where a student has no further lessons. They may also provide funds for the purchase of materials and meals. In the case of meals this may also involve pre-purchasing meals for a given date. Finally, parent-class director interaction is encouraged in order for the parent to remain informed about their child's education.

The ICT competency levels of parents can vary vastly, from expert users to non-users.

5.2.3.4 Gate Attendant

The gate attendant's primary role is to control entrances and exits to the school. As students and staff pass through the gate, the gate attendant verifies who is passing through, and if they have permission to do so. Based on the schools visited with an E-card system already in place, staff may freely enter and leave, although their entrance and exit is always logged. Students may only leave at specific times, which is based on their schedules and parental permission.

The gate attendant also assigns "guest passes" to authorized guests, allowing them to enter, and in schools with an electronic card system, manually records access for students who have misplaced or damaged their card, and can issue temporary replacement cards.

Until the introduction of e-card systems, ICT use was not traditionally a part of this role, therefore users may have limited ICT skills.

5.2.3.5 Canteen Attendant

The canteen attendant is responsible for overseeing the purchase of school lunches and the redemption of pre-paid lunches in the canteen. He/she verifies that users are using the system correctly, and helps with any issues that may arise.

Food for staff and students is available from two places in Portuguese schools, the canteen and the bar. The school bar sells drinks and snacks to students, rather than full meals. Customers pay a price per item, and the total is calculated and taken at a point of sale.

In the canteen, the base price of a school lunch is set nationwide, regardless of what is consumed, with one price for students (currently 1,46€) and another price for staff (currently 3,80€). Students or their parents are encouraged to book in advance the days that they or their child will have school lunches. In most cases, a surcharge of 0,30€ is applied if the meal was not booked beforehand. This is at the school's discretion; in one school visited during research, students without a pre-booked meal were not able to eat lunch.

Traditionally, the students or their parents purchased vouchers, representing a pre-purchased lunch, from either the bar or secretary's office.

This system is administered by various existing members of staff rather than an individual assigned to the role. As a result, ICT competency levels may vary.

5.2.4 Operating Environment

Computers provided to public schools in Portugal, potential clients of the system, run Microsoft Windows operating system. It is common for staff to use their own devices in school to work, such as laptops, which can potentially run any operating system.

5.2.5 Assumptions and Dependencies

The requirements are developed on the assumption that RFID cards and readers are to be used by staff and students as a form of identification. This could potentially be substituted by another form of identification, such as biometric (i.e. fingerprint scanner) or smart cards/readers. The choice of technology is discussed further in 6.4.3.2.1.

5.3 SPECIFIC REQUIREMENTS

This section defines the system requirements - the system's functions, services and operational constraints in detail (Sommerville, 2007).

Based on the knowledge gained during the elicitation process, a domain model was developed to show the various entities within the school that are relevant to the functional areas being implemented, and the relationship between them, as shown in Figure 5-1. A

domain model forms the basis for developing a specification and provides a focus for understanding the design task (Easterbrook, 1993).

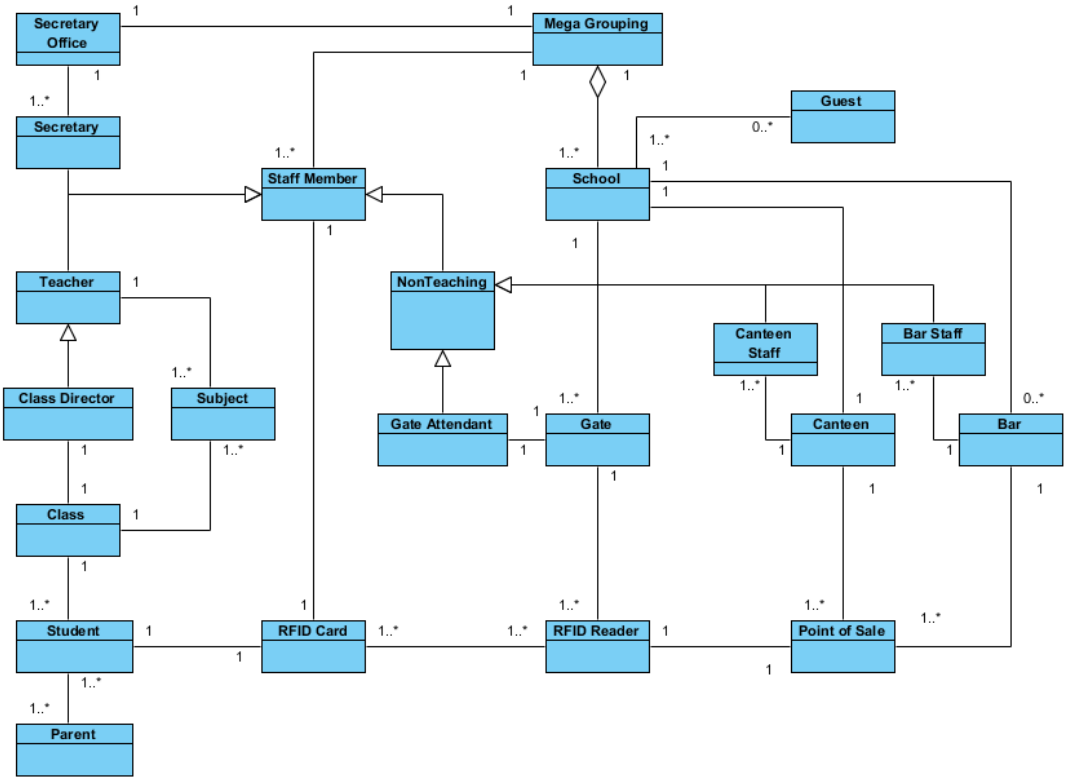

Figure 5-1 - School Domain Model

Considering the functional areas of the system that are to be developed, as stated in 5.2.2, a number of analysis packages have been identified. These packages aid the organization of the requirements into functional areas of the system but do not necessarily reflect the final design in terms of the modular structure of the system. The packages identified are:

- Personnel Management
- Gate Access Control
- Assessment
- Parent/School Interaction
- Canteen Payments

5.3.1 Functional Requirements

Functional requirements are “Basic statements of the system’s capabilities, services and behaviour” (Bass, Clements, & Kazman, 2003). In this case, the requirements stated are high level requirements that serve as a reference for the main features of the system. As part of the iterative process described in chapter 4, these were refined in greater detail as the system was developed. The templates used for the requirements are adapted from structured language specifications, published by Sommerville (Sommerville, 2007). The advantage of using such templates is that requirements are given a greater degree of uniformity than natural language specifications.

5.3.1.1 Personnel Management

The requirements for this module are derived from the staff and student management tasks performed by secretaries, described in 5.2.3.1. The information gathered during elicitation was used to develop a use case diagram, shown in Figure 5-2. Use-case diagrams are a scenario-based technique for requirements elicitation (Sommerville, 2007), which were first introduced in the Objectory method (Jacobson, Christerson, Jonsson, & Overgaard, 1992).

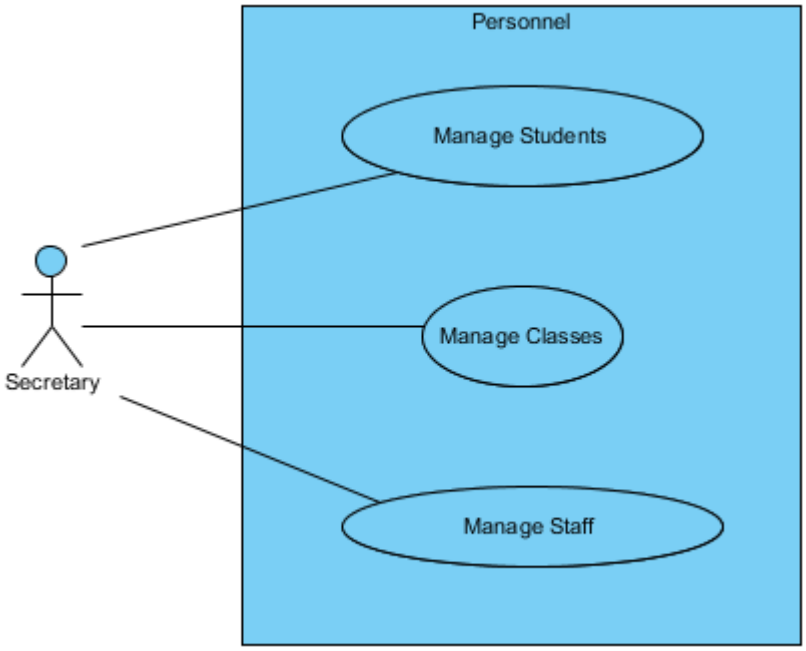

Figure 5-2 - Personnel Management use case

SEC1	Manage Classes
Function	Create / Read / Update / Delete class data
Description	Secretary shall have the ability to perform Create/Read/Update/Delete operations on class data. The secretary uses this to assign and remove students to and from a class, as well as a class director and subject teachers to and from a class. In addition to this, classes can be created and deleted. This data is sent to the data store.
Inputs	Year Group, Class ID, Teacher, Class Director, Students
Source	Secretary
Outputs	Class information
Destination	GUI
Action	User selects existing class to edit or creates a new class. Details are stored in DBMS and displayed to user.
Requires	Staff and Students must exist in system in order to be added to class.
Pre-Condition	None
Post-Condition	Class director and students are not assigned to more than one class.
Side Effects	None

SEC2	Manage Students
Function	Create / Read / Update / Delete student data
Description	Secretary shall have the ability to perform Create/Read/Update/Delete operations on student data. Enables the storage and maintenance of data stored on each individual student, collected during their registration at the beginning of the school year.
Inputs	Student Identification, Parent/Guardian identification, Student/School information in past year, Other information (health, transport etc)
Source	*Dados de Matrícula* form (Submitted to secretary by class director). Parents.
Outputs	Student information
Destination	GUI
Action	User selects existing student to edit or creates new student. Details are stored in DBMS and displayed to user.
Requires	None
Pre-Condition	None
Post-Condition	None
Side Effects	None

SEC3	Manage Staff
Function	Create / Read / Update / Delete staff data
Description	Secretary shall have the ability to perform Create/Read/Update/Delete operations on staff data. Enables the storage and maintenance of data stored on each member of staff.
Inputs	Staff identification, qualifications, contractual information
Source	Ministry of Education, staff member, secretary.
Outputs	Staff information.

Destination	GUI
Action	User selects existing staff member to edit or creates a new staff member. Details are stored in DBMS and displayed to user.
Requires	
Pre-Condition	None
Post-Condition	None
Side Effects	None

5.3.1.2 Assessment

These requirements aim to identify the assessment needs of teachers and class directors. As class directors may also be teachers of a subject to a given class, they inherit the functions of a teacher. However, whilst a teacher only manages marks of the subject they teach, class directors need to be able to see the overall performance of their class across all subjects, hence the additional functionality. These requirements are summarised in a use case diagram, shown in Figure 5-3.

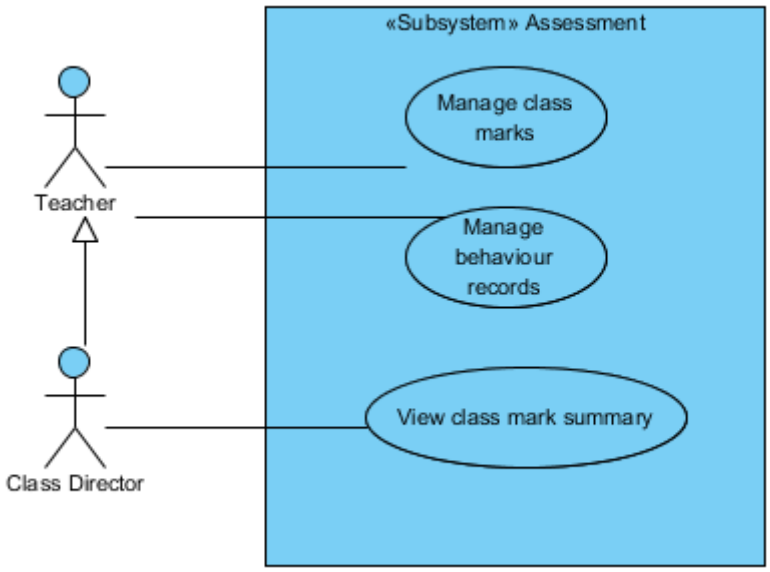

Figure 5-3 - Assessment use case

TEA1	Manage class marks
Function	Record and view marks attained
Description	Teachers shall be able to enter marks for work that has been corrected. This information can be stored and used for analytics.

Inputs	Student, assignment, mark, date.
Source	Teacher
Outputs	Grades
Destination	GUI
Action	User chooses student whose mark is to be recorded, and enters assignment details and mark. This information is saved to the DBMS and displayed to the user.
Requires	Student information
Pre-Condition	None
Post-Condition	None
Side Effects	None

TEA2	**Manage Behaviour Records**
Function	Record and view student behaviour
Description	Teachers shall be able to log record incidents relating to student's discipline
Inputs	Student, behaviour report, date
Source	User
Outputs	Behaviour record, notification
Destination	Data store
Action	User chooses student whose behaviour is to be recorded. Enters behaviour information and date of work. This is saved to data store.
Requires	Student information
Pre-Condition	None
Post-Condition	None
Side Effects	Notification sent to class director whenever a student's behaviour record is updated

TEA3	**View class mark summary**
Function	View marks across all subjects
Description	Class directors shall be able to view complete data of all marks in their class, presented in various forms for analysis
Inputs	None
Source	None
Outputs	Students, subjects, marks
Destination	GUI
Action	User selects class from list, mark information is retrieved and displayed to user
Requires	Marks, students, class
Pre-Condition	None
Post-Condition	None
Side Effects	None

5.3.1.3 Parent Interaction

These requirements are aimed at meeting the needs of parents, discussed in 5.2.3.3 and summarised in the use case diagram shown in Figure 5-4. The goal of these requirements are to both provide parents with information (in the case of marks and attendance), and make certain operations easier to perform (in the case of paying for lunches or contacting the class director).

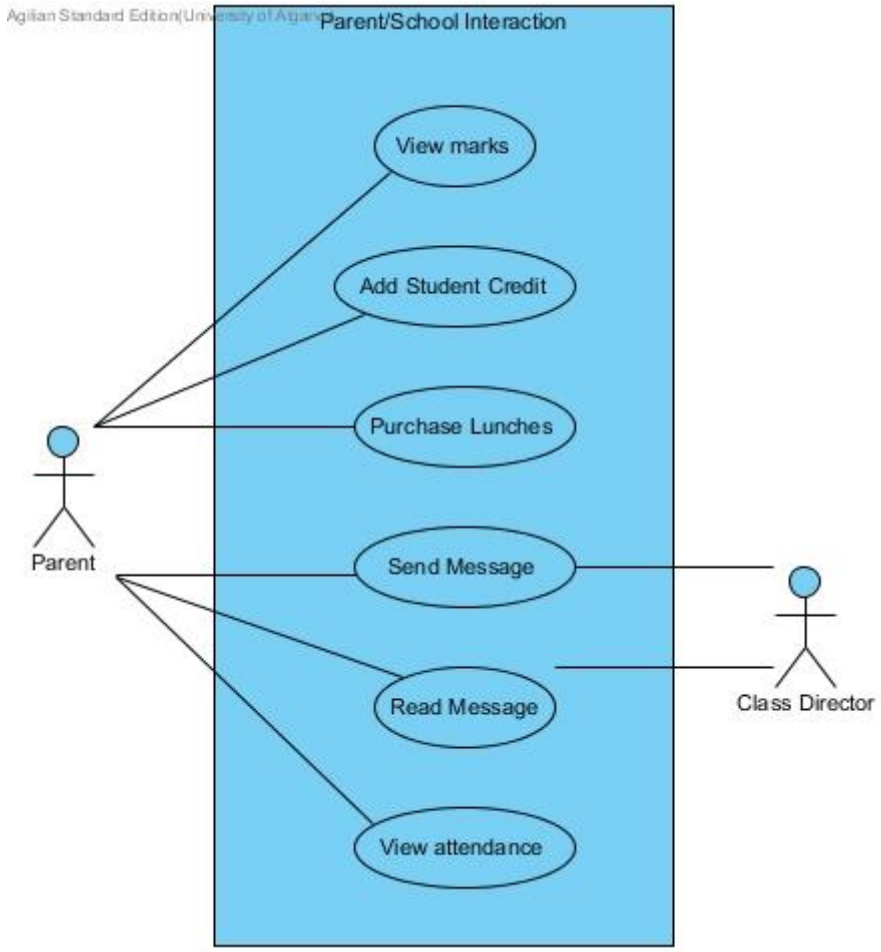

Figure 5-4 - Parent Interaction use case

PAR1	View marks
Function	Parents can view their children's marks
Description	Parents shall be able to view statistics and graphs can be generated to show a student's progress over the course of a school year.

Inputs	None
Source	None
Outputs	Marks, student information
Destination	GUI
Action	All marks for parent's child are retrieved from dbms, and displayed on screen/plotted to graph as appropriate.
Requires	Marks, student
Pre-Condition	Teacher assessment module is present
Post-Condition	None
Side Effects	None

PAR2 and PAR3 concern the purchasing of credit and pre-purchase of lunches. The separation of these activities reflects the current procedure used in all schools, whereby lunches can be pre-purchased in advance for a fixed price, but money is required for other locations such as items in the bar.

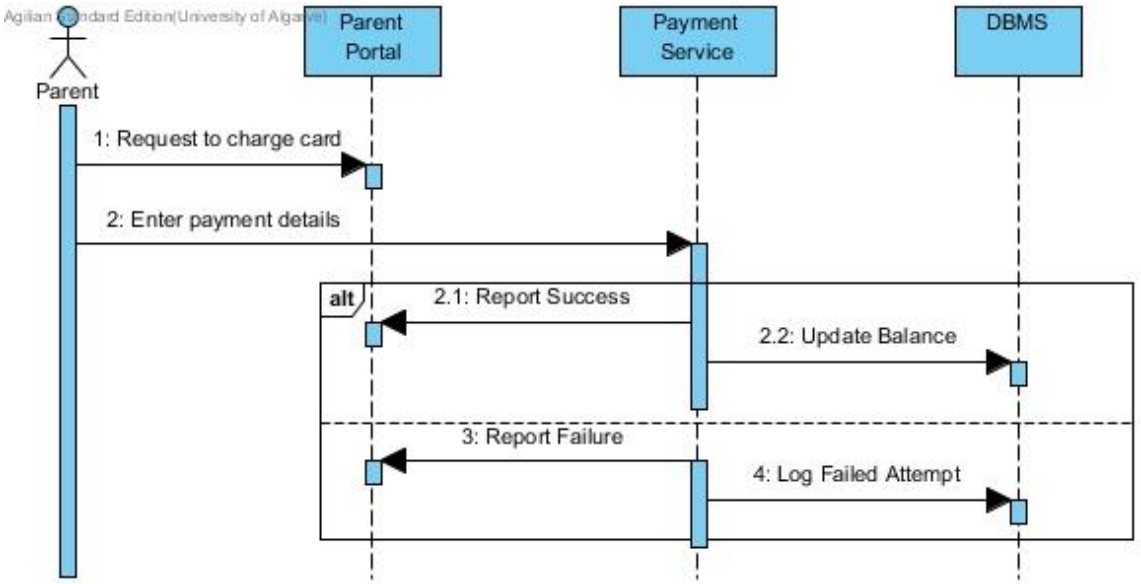

Figure 5-5 - Online school lunch pre-purchase

PAR2	Charge Balance
Function	Parents can charge their child's balance
Description	Parents shall be able to add money to their child's balance, allowing the children to purchase items at the bar, and stationary using their RFID cards. This is performed via a third party payment service and is further illustrated in the sequence diagram shown in Figure 5-5.
Inputs	Charge amount

Source	User
Outputs	Updated balance
Destination	GUI
Action	Parent requests to charge balance. Request is processed by payment service. Confirmation of transaction success is returned to system. Updated balance recorded in DBMS.
Requires	Payment service
Pre-Condition	Payment service verifies transaction
Post-Condition	None
Side Effects	None

PAR3	**Purchase lunches**
Function	Pre purchase of student lunches by parents
Description	Parents shall be able to pre-purchase lunches for their children at a fixed price, which is cheaper than if the child purchases lunch on the day. This does not increase the child's balance (unlike PAR1).
Inputs	Date(s)
Source	User
Outputs	Cost
Destination	GUI
Action	Parent requests to charge balance. Request is processed by payment service. Confirmation of transaction success is returned to system. Updated balance recorded in dbms.
Requires	Payment service
Pre-Condition	Payment service verifies transaction Canteen module is available
Post-Condition	None
Side Effects	None

PAR4 and PAR5 reflect the need for communication between parents and the school, particularly between parents and class directors. The advantage of this functionality being part of SC School is that an audit trail of communications exists, which can be used for legal purposes, which is not the case when more informal methods of contact are used.

PAR4	**Send message**
Function	Users can send messages
Description	Parents shall be able to contact Class Directors through system, and vice-versa. Messages are stored within system.
Inputs	Message
Source	Parent, class director
Outputs	Message
Destination	Parent, class director

Action	Parent enters message. Message is sent to class director of student. Message is stored in DBMS.
Requires	
Pre-Condition	None
Post-Condition	None
Side Effects	Email notification is sent to recipient

PAR5	Read message
Function	Users can read messages
Description	Parents shall be able to receive and view correspondence from the school (including class directors and other departments)
Inputs	None
Source	None
Outputs	Message
Destination	GUI
Action	If messages exist for user, they are displayed
Requires	Message, parent, class director
Pre-Condition	Number of messages received > 0
Post-Condition	None
Side Effects	None

PAR6	View attendance
Function	Parents can view their child's attendance at school
Description	Using data collected from the Gate Access Control module as per GA1 and GA2 (if module is present), parents shall be able to see the times that their child entered and left the school grounds on each day. Late arrivals and absences are flagged.
Inputs	None
Source	None
Outputs	Student entrance/exit times
Destination	GUI
Action	Based on given date range, entrance and exit times are retrieved from system logs.
Requires	Attendance logs, student
Pre-Condition	Gate access control module is present.
Post-Condition	None
Side Effects	None

5.1.1.1 Gate Access Control

The functional requirements for the gate access control module, summarised in Figure 5-6, are aimed at meeting the needs of several different users, in particular the Gate

Attendant. This system should allow the control of access to and from the school. The system should help the gate attendant in their work by making it clear if a student attempts to leave outside of his/her permitted schedule.

The information gathered by this system can be used to generate reports that interviews suggested may be useful to the school (e.g. lateness reports) or help with safety (e.g. a "head count" of everyone that is on site, useful in the event of a fire).

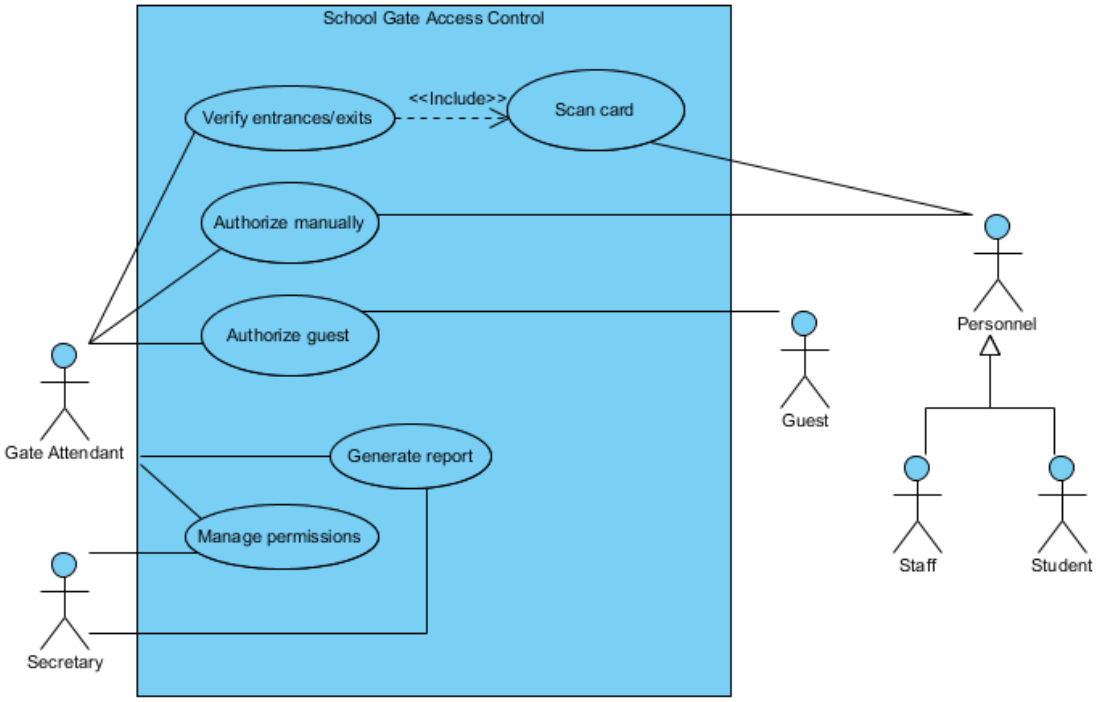

Figure 5-6 - Gate Access Control use case

The activity diagram shown in Figure 5-7 gives an overview of the functionality required for entrances and exits with the use of an RFID card, as detailed in requirements **GA1** and **GA2**.

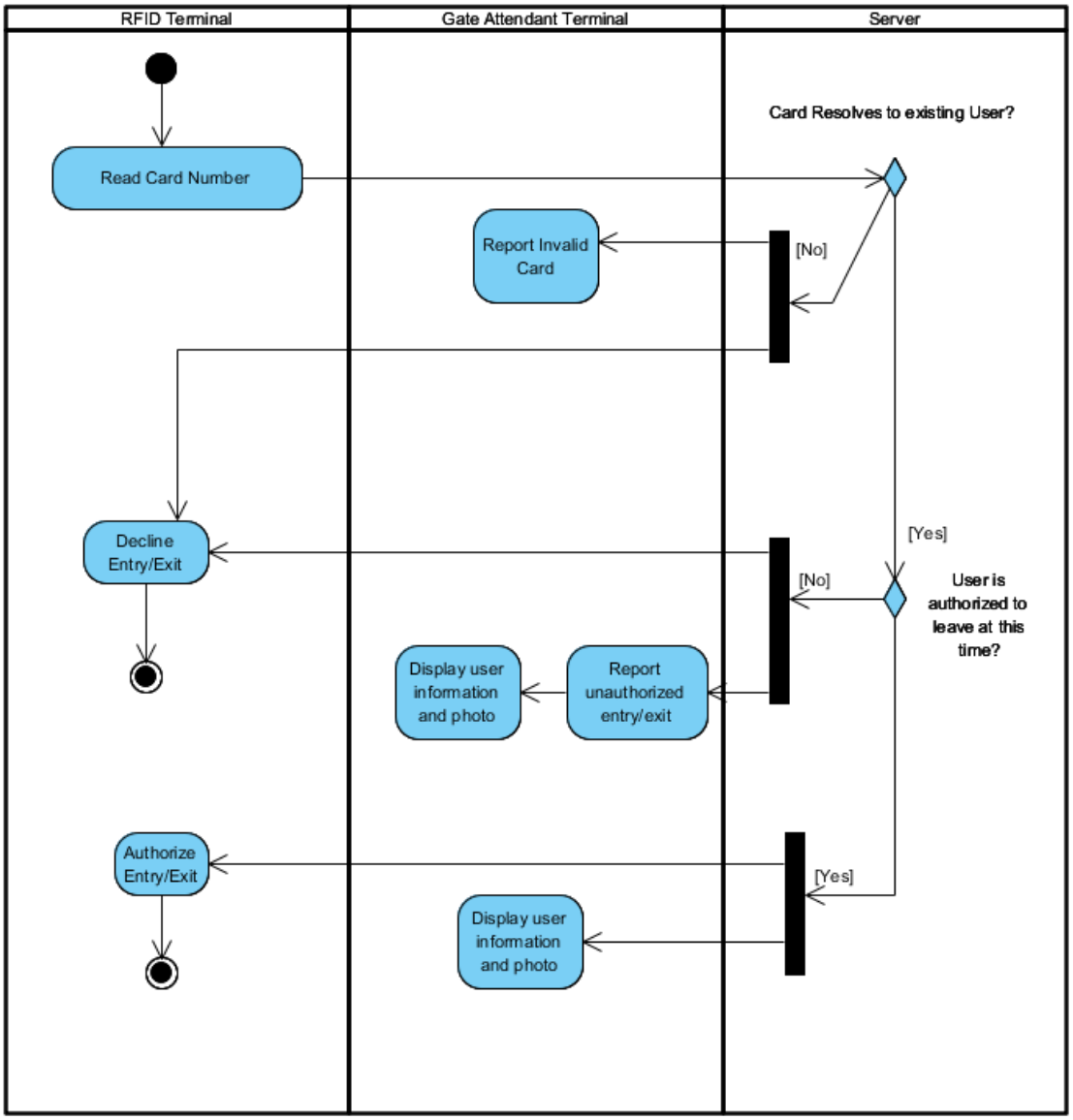

Figure 5-7 - School gate access control activity diagram

GA1	Scan card
Function	User submits identity to system
Description	When passing through the school gate, school personnel shall be able to scan their RFID card at the reader to request authorization to enter or exit. Authorization is either rejected or accepted, with visual feedback (such as red/green LEDs) displayed on the RFID reader panel.
Inputs	RFID Card Number
Source	RFID Card
Outputs	Authorization result
Destination	Reader Panel
Action	User places RFID card in proximity to RFID reader. Reader sends RFID number to server. Server obtains person's information and checks permissions. Authorization result is displayed on RFID panel.

Requires	Student / Staff Access Schedule
Pre-Condition	
Post-Condition	If user status was *in school*, status is *out of school* If user status was *out of school*, status is *in school*
Side Effects	Student/Staff information sent to Gate Attendant RFID number and timestamp sent to log

GA2	**Verify Entrances/Exits**
Function	Display details of each user entering or exiting through school gate.
Description	Gate Attendants shall be able to view details on each person passing through the school gate, an event which is triggered by the use of an RFID card. Photos will be displayed to verify identity, and persons attempting to enter or leave outside of authorized hours will be flagged.
Inputs	RFID Card Number
Source	RFID Reader
Outputs	Student/Staff information, timestamp, authorization status
Destination	Gate attendant terminal GUI
Action	Person places RFID card in proximity to RFID reader. Reader sends RFID number to server. Server obtains person's information and checks permissions. Information is displayed on Gate Attendant terminal
Requires	Student/Staff Access Schedule
Pre-Condition	None
Post-Condition	None
Side Effects	None

GA3	**Authorize manually**
Function	Manually sign in users who do not have their RFID card.
Description	If a user wishes to enter or leave the school but is not in possession of their RFID card or the reader fails to function, the Gate Attendant shall be able to manually authorize their entrance/exit by entering their student/staff details and verifying their identity and access permissions.
Inputs	ID Number
Source	Student/Staff member
Outputs	Staff/Student information, timestamp, authorization status
Destination	Gate attendant terminal GUI
Action	Person gives ID number directly to gate attendant. Gate attendant enters ID number into system. Person details are displayed on the screen, including photo and permissions. Gate attendant may either authorize or not authorize person's entrance/exit.
Requires	Staff/Student has access permissions set up.
Pre-Condition	None
Post-Condition	If user status was *in school*, status is *out of school* If user status was *out of school*, status is *in school*
Side Effects	RFID number and timestamp sent to log

GA4	Authorize Guest
Function	Register guests and grant them temporary access to school.
Description	Gate attendant shall have the ability to grant temporary access to an unregistered person. Their details will be logged in the system with an expiry date.
Inputs	Name, Identification information, visit reason, start date, expiration date.
Source	Gate attendant, guest
Outputs	None
Destination	None
Action	Guest gives personal information to gate attendant. Gate attendant may either authorize or not authorize guest. If gate attendant grants access to guest, guest's personal information is logged in the system. For guest entry and re-entry, gate attendant will manually authorize guest.
Requires	None
Pre-Condition	None
Post-Condition	Guest authorized to enter school.
Side Effects	None

GA5	Generate Reports
Function	Generate reports related to entrance/exits
Description	The gate attendant and secretary should be able to generate reports based on access data, such as persistent lateness/absence, and a list of all personnel currently on school grounds.
Inputs	Report Parameters
Source	User
Outputs	Report
Destination	GUI
Action	User enters parameters (date, filters), report is generated on screen
Requires	Staff/student information, access logs
Pre-Condition	None
Post-Condition	None
Side Effects	None

GA6	Manage Permissions
Function	Assign schedules and permissions for student access
Description	Student's exits from school are restricted. Students may only leave the school premises during lunch time or before the end of the school day if their parents grant permission. Parents shall advise the secretary if they wish to give permission. The secretary shall be able to add this information to the student's profile. Gate attendants may view the permissions but not change them. This requirement does not apply to staff, who may pass gate at any time.
Inputs	Access Schedule (Day, Times)
Source	Parent, Secretary
Outputs	None
Destination	None

Action	Parent gives information to secretary. Secretary inputs information to system and saves to data store.
Requires	None
Pre-Condition	None
Post-Condition	None
Side Effects	None

5.3.1.4 Canteen

These requirements are aimed at assisting in the operation of the canteen, potentially used by all personnel to redeem pre-purchased lunches, and overseen by a member of staff who is designated to be a canteen attendant on a given day.

Given that school policy regarding the pre-purchase of lunches may vary, the requirements are designed to offer flexibility. In the case that a user has failed to pre-purchase a lunch, the attendant has two options: Deduct the fee from the credit balance associated with the RFID card, or take a payment manually (i.e. the customer hands over cash). Schools may choose to make neither option available.

Users should pre-purchase lunches via the secretary. A requirement from the point of view of parents was previously identified (PAR3), but the system should also make this function available within the school for staff and students to pay with cash, rather than restricting this operation to be “online-only”.

Based on this information, a use case was developed, shown in Figure 5-8.

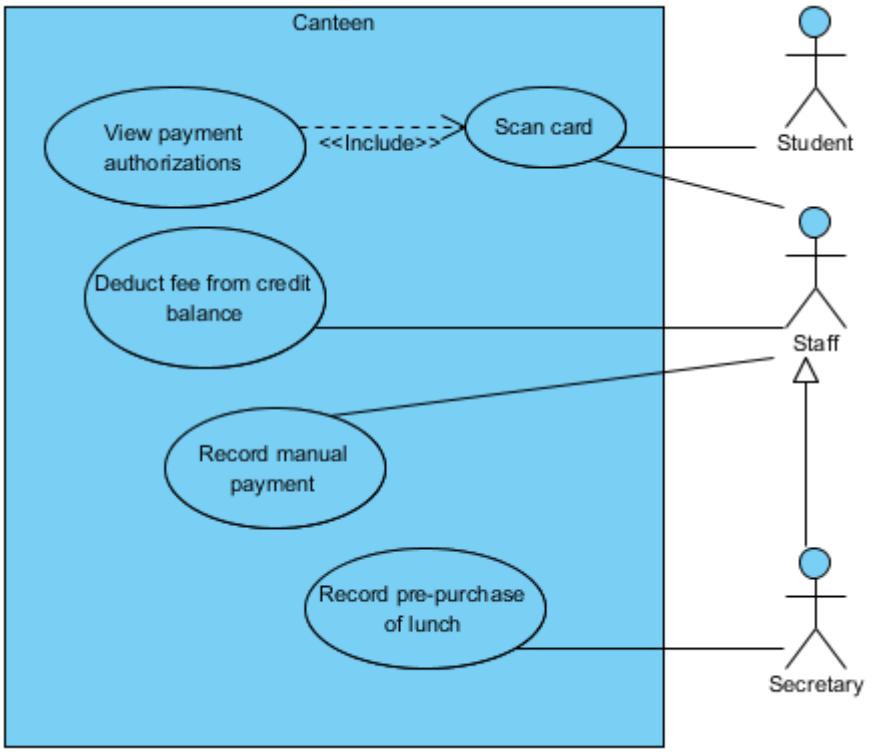

Figure 5-8 - Canteen use case

The operation of the requirements specified in CA1, CA2 and CA3 are further illustrated in the activity diagram, shown in Figure 5-9.

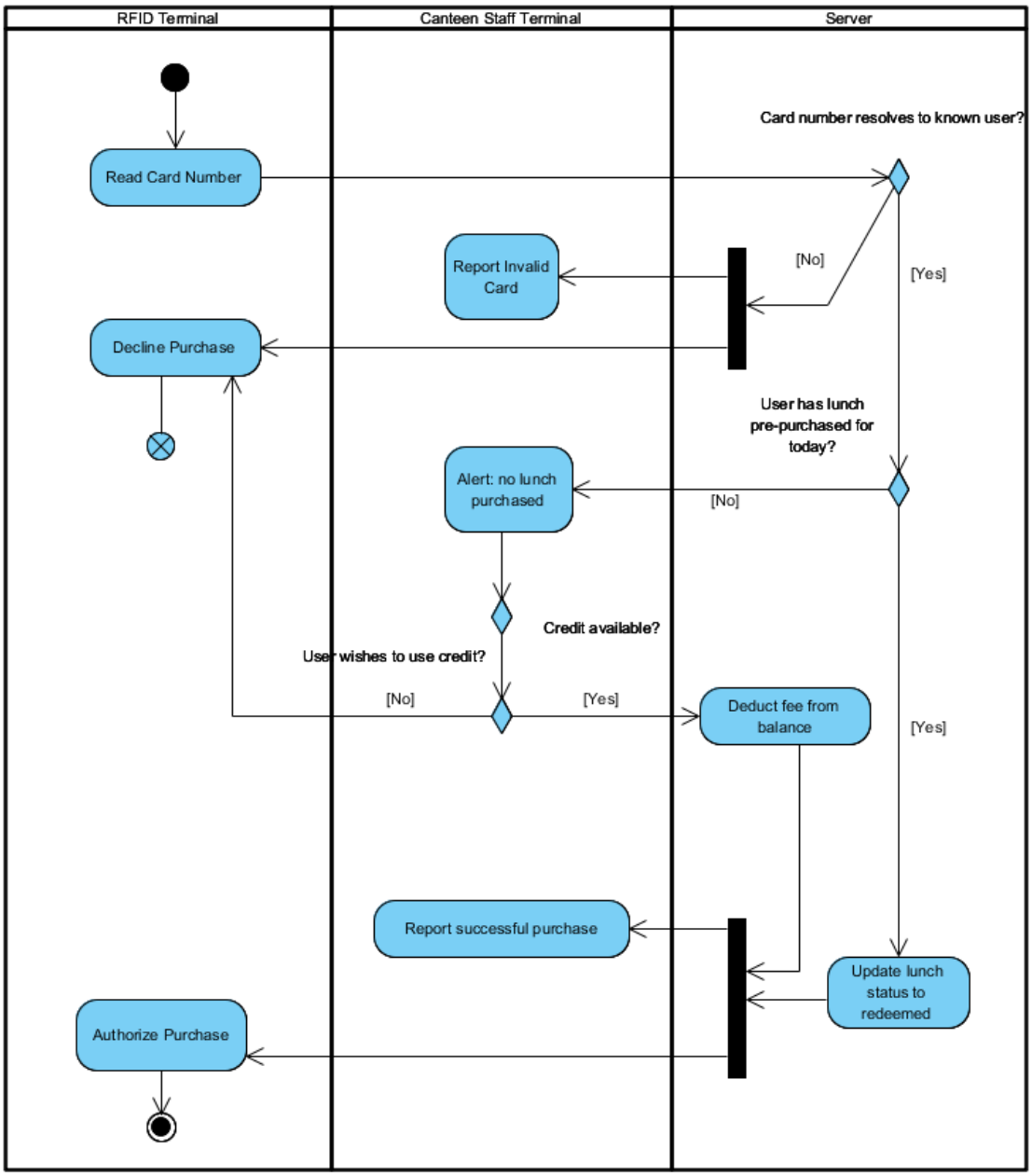

Figure 5-9 - Canteen activity diagram

CA1	Scan card
Function	User submits identity to system
Description	When redeeming pre-paid lunches, school personnel shall be able to scan their RFID card at the reader to request authorization to enter or exit. Authorization is either rejected or accepted, with visual feedback (such as red/green LEDs) displayed on the RFID reader panel.
Inputs	RFID Card Number
Source	RFID Card
Outputs	Authorization result
Destination	Reader Panel

Action	User places RFID card in proximity to RFID reader. Reader sends RFID number to server. Server obtains person's information and checks if lunch has been pre purchased or not. Authorization result is displayed on RFID panel.
Requires	Student / Staff Access Schedule
Pre-Condition	To receive authorized status, user must have pre-purchased lunch for specified date, and must not have already redeemed this lunch.
Post-Condition	Pre purchased lunch status for date is "redeemed"
Side Effects	Student/Staff information sent to canteen attendant RFID number and timestamp sent to log

CA2	**View payment authorizations**
Function	Display real time information on payment authorizations to canteen attendant
Description	The designated member of staff shall be able to view details on each person paying for lunch. Details are retrieved based on an RFID card number. Photos will be displayed to verify identify, and failed transactions from users who have not pre-purchased lunch or do not have a recognised card will be flagged on screen.
Inputs	RFID Card Number
Source	Student/Staff
Outputs	Identification Information, balance.
Destination	GUI
Action	As shown in Figure 5-9 - Canteen activity diagram
Requires	RFID Reader
Pre-Condition	None
Post-Condition	None.
Side Effects	None

CA3	**Deduct fee from balance**
Function	Charge a fee for lunch from user's balance
Description	In the event that a user has not pre-purchased lunch, a lunch fee may be deducted from the user's balance on the card instead. This option is available at the school's discretion.
Inputs	RFID, date
Source	Canteen attendant
Outputs	Authorization result, updated balance
Destination	GUI
Action	As shown in Figure 5-9 - Canteen activity diagram
Requires	None
Pre-Condition	None
Post-Condition	None
Side Effects	None

CA4	Record Manual Payment
Function	Record purchase of lunch using cash
Description	If a lunch has not been pre-purchased, a user can pay in cash, and the transaction is recorded in the system. This function is available at the school's discretion.
Inputs	Student/Staff/Guest information, date
Source	Student/Staff/Guest
Outputs	None
Destination	None
Action	User gives lunch fee to canteen attendant, canteen attendant records amount taken in system with details of user who made purchase.
Requires	None.
Pre-Condition	None.
Post-Condition	None.
Side Effects	None.

CA5	Record Pre-Purchase of Lunch
Function	Record pre-purchase of lunch
Description	Students, their parents, or staff may attend secretary's office and pre-purchase lunches.
Inputs	Date
Source	User
Outputs	None
Destination	None
Action	Secretary records the date(s) for which lunch has been pre-paid
Requires	None.
Pre-Condition	None.
Post-Condition	None.
Side Effects	None.

5.3.2 Non-Functional Requirements

Non-Functional Requirements are constraints on the services or functions offered by the system. They include timing constraints, constraints on the development process and standards (Sommerville, 2007). They also include quality attributes, which are considerations to the system that are over and above functional requirements. (Bass, Clements, & Kazman, 2003)

Based on research conducted, the following quality attributes were identified as non-functional requirements for the system.

NFR1. Usability – The system will be used by school staff with varying levels of ICT experience; therefore the system shall be intuitive.

NFR2. Security – The system will hold personal information on students and staff, therefore the system shall be appropriately secured.

As discussed in chapter one, this project is being developed for a software house, Singlecode Lda. As a result, there are some organisational and product requirements imposed from the company in order to fit its business model and policies.

NFR3. Extensibility - The system shall be modular, allowing schools to choose which modules to purchase where possible, and facilitating the implementation of further modules in the future.

NFR4. The system shall be developed using free or open source programming languages/frameworks (e.g. GPL license)

NFR5. Schedule – The information management and gate access control functional areas should be implemented by summer 2013, with further modules to be completed and deployed in the future.

In order to meet the goals discussed in the problem statement, the following requirement must be met:

NFR6. The system should be a web application wherever possible.

6 DESIGN

6.1 INTRODUCTION

This chapter presents a Software Design Description for the SC School system to meet the requirements as described in the previous chapter.

6.2 SYSTEM ARCHITECTURE

The requirements for the project state that the project must be a web application wherever possible (NFR6), which will help it scale well even within large mega-clusters. This requirement implies the use of client-server architecture. There are a number of different architectural styles that can be applied when using the client-server architecture, but since the rise of the web and the object orientated approach to design, the three layer model is by far the most commonly used (Brown, et al., 2003; Fowler, Patterns of Enterprise Application Architecture, 2002). This style allows for the separation of presentation login, domain logic, and the data source. Such a separation is important to *SC School* in order to meet its requirements, given that the system must be modular (NFR3). A failure to separate business logic from presentation logic would result in large amounts of duplicated code within each module, making extensibility more problematic.

The specific patterns that can be implemented in each layer of the three layer architecture are influence by the technology platforms used. These will be further discussed in the following chapter.

6.3 USERS

Based on the requirements, the following user roles have been identified, summarised in Figure 6-1.

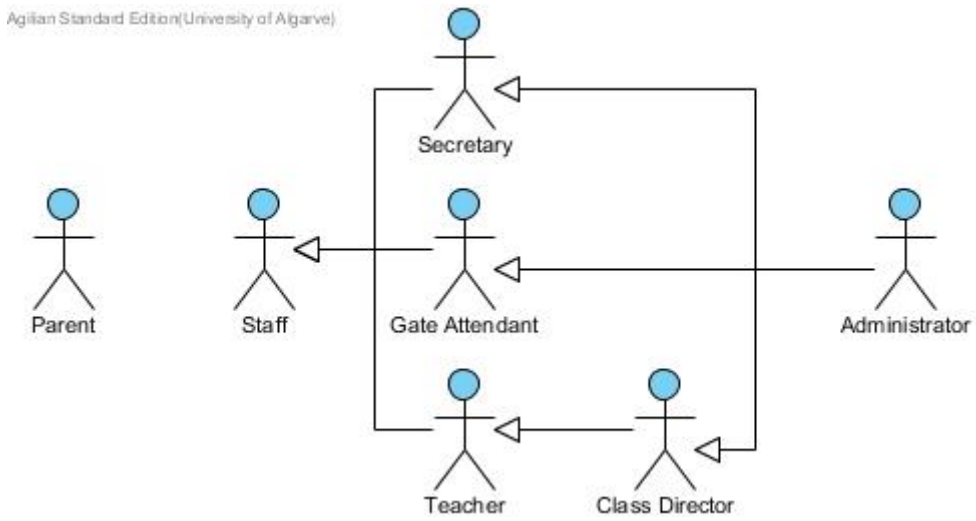

Figure 6-1 - User roles in SC School

The user types *Secretary*, *Gate Attendant*, *Teacher*, *Class Director*, and *Parent* correspond directly to the roles of staff members in the school and their permissions in each module are documented in chapter 7 . In addition to these, two further categories were created:

Staff is a user class with limited user permissions. It is used for all members of staff who do not fall into the specific classes created for the modules being implemented. This is because some areas of the system – (e.g. parts of the canteen module), can be operated by any member of staff in the school.

Administrator does not represent an existing role within the school. The user class was created to separate elements of system configuration from activities that make up the day-to-day use of most staff. For example, the canteen module configuration contains the base price of a school lunch, and whilst schools need to be able to change this from time to time, it is a rare event that ought not to be available to all staff at all times. Schools will be left to manage which member(s) of staff are able to access the system in this capacity, in order to offer flexibility and reflect the fact that there is no legally defined role of System Administrator in Portuguese schools.

Naturally, the development of further modules for the system in the long term may necessitate the creation of additional user classes. However, the roles defined here allow

for all users to have appropriate permissions for the modules that are to be developed in the short term.

6.4 MODULES

In the interests of meeting the system requirements and in keeping with the well-established principles of modular design and separation of concerns, several distinct modules were identified.

As identified in NFR3, it is desirable from both the perspective of the developer company and the stakeholders that the system is as flexible as possible in terms of the modules that can be purchased to meet school and user needs. For example, it is clear from the research conducted that secretaries perform a very broad range of tasks that would encompass several functional areas of the system, e.g. accounting, inventory, and personnel management. To implement these functional areas as separate modules that can run largely independently with as few dependencies on other modules as possible, but can also integrate if more than one is present, helps to achieve extensibility and modifiability.

With this in mind, and based on the current scope of the project, the following modules were identified:

- Personnel Management
- RFID Reader
- Canteen
- Gate Access Control
- Parent Portal
- Teacher Portal

A detailed description of each module is available below.

6.4.1 Dependencies

Considering this need for modifiability, it was important to limit the dependencies for each module. Techniques to avoid code dependencies are discussed in the following chapter, with the discussion of the technical platform used. However, consideration of data dependencies strongly influenced the design. For example, a module to monitor

access to the school grounds as described in the requirements may *execute* without the presence of any other module, but without any students or staff in the database, it will not be able to provide any useful functionality. The goal of this design is to limit this situation as much as possible, hence, a decision was made to make Personnel Management a required module. This way, the concepts of students and staff - fundamental to the operation of any school, will be available to all modules. As a general rule, core data on staff or students that is required by more than one module (E.g. person name) will be managed from this module, whilst data that is specific to a particular module (e.g. the time that a student may leave school on a Monday) would only be managed from the specific module that makes use of it. Figure 6-2 shows the dependencies in terms of data as opposed to code. In some cases, notably the parent portal, additional dependencies may exist in order to provide additional functionality within the module – these are detailed later in the chapter.

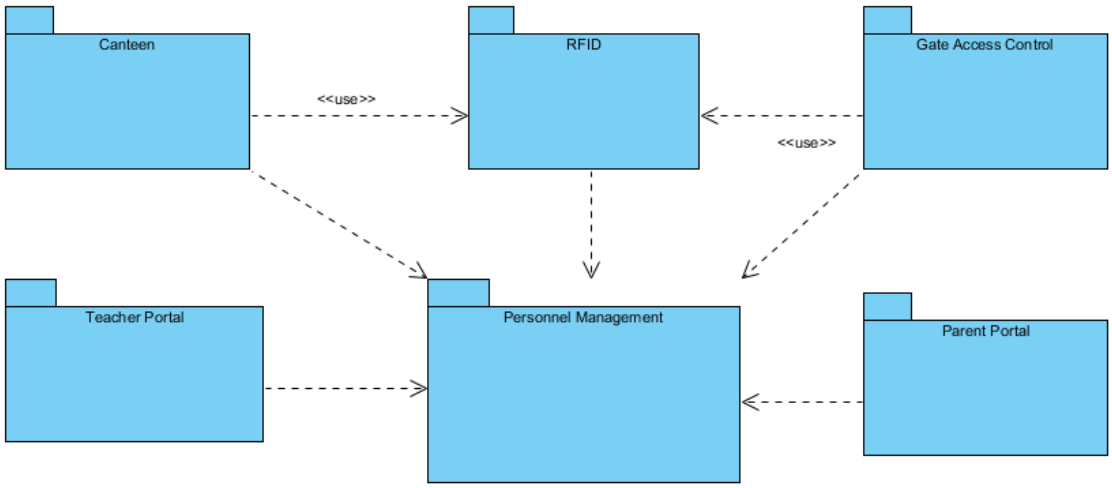

Figure 6-2 - Data dependencies in SC School

6.4.2 Personnel Management

6.4.2.1 Overview

The Personnel Management module is aimed primarily at meeting requirements SEC1, SEC2 and SEC3, meeting the student, staff, and class management needs of secretaries.

6.4.2.2 Structure

The *Staff Management* sub-module provides an interface for users to perform CRUD operations on staff, meeting the needs described in SEC3. *Student Management* provides an interface for users to perform CRUD operations on staff, meeting the needs described in SEC2. All input is entered by the secretary using this front end.

Class Management allows classes to be created, and for the personnel created in student and staff management to be assigned to, or removed from, created or existing classes. Students may only be in one class at a time, and so may only be added from a pool of students who are not currently assigned to any class. Likewise, a class director may only be the class director of one class. Teachers however, may teacher multiple classes. These restrictions enforced by the system reflect the organization of personnel in Portuguese schools.

The *Configuration* sub-module provides a number of options related to the module, such as the maximum photo size (in kb) for staff/students, and the maximum number of students in a class and the possibility of creating new subjects, amongst others.

6.4.2.3 Data Types

Below are some of the key data types managed from this module.

6.4.2.3.1 Staff

Represents each member of staff, allowing all relevant data to be recorded by secretaries. This can be divided into several categories:

- Personal Information – e.g. Name, photo, nationality, ID Number etc.
- Contractual Information – e.g. Position, salary, contract length etc.
- Academic Information – e.g. Degree/institute, subjects qualified to teach, etc.
- System User Information – e.g. RFID Number; username, role

6.4.2.3.2 Student

Allows the storage of information on each student, which can be subdivided into the following categories, including:

- Personal Information

- Parental Information

Parental (and/or legal guardian) information is important to provide schools with points of contact. It is important to remember that parents may have multiple children within the school, and that the number of parents may vary when relations such as step-parents are included. To avoid redundancy, parents are considered as a separate entity. To reflect the fact that parents may or may not cohabit, address (and landline number) is also separated, as shown in Figure 6-3.

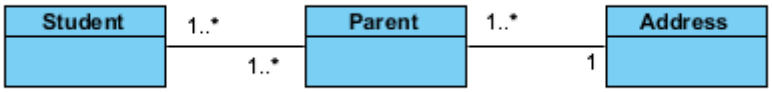

Figure 6-3 - Student/Parent/Address entity relationship

6.4.2.3.3 Class-groups and Subject Classes

Class-groups consist of a group of students and a class director. They are uniquely identified by a year-group and character (e.g. 5A represents for 5th year group A). The rules regarding the number of students contain exceptions, and have historically changed on several occasions, therefore the business logic warns users when the number of students falls outside this number, but not strictly enforce it. The module's configuration sub-module must also allow for the permitted sizes to be adjusted for when the rules are changed.

Beyond the 1st cycle, where class-groups have a separate teacher for each subject, a *subject class* entity is defined (Figure 6-4). This allows a class-group to have multiple subjects and teachers associated. It also allows the flexibility to add and remove new subjects from the system. Business logic disables this option for 1st cycle classes.

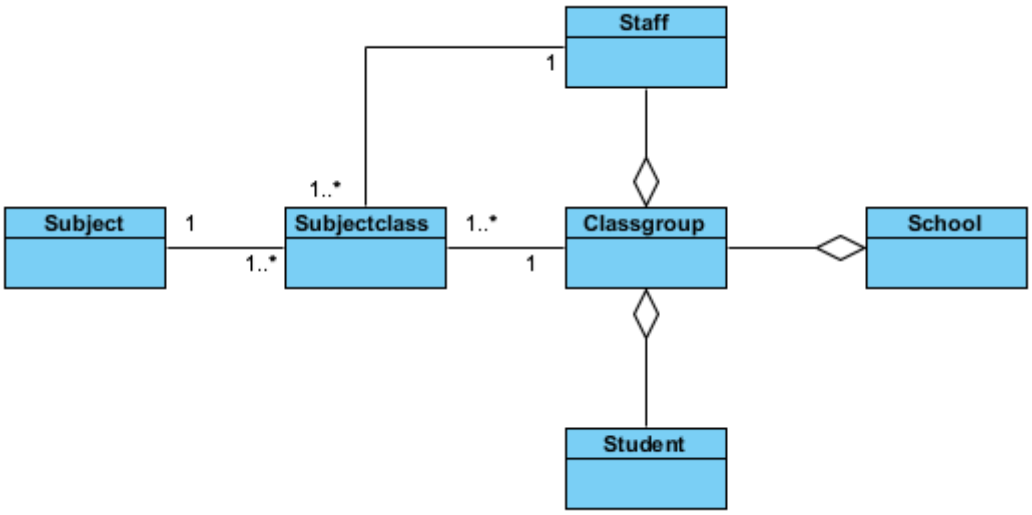

Figure 6-4 - Class entity relationships

6.4.2.3.4 School

This entity represents a school within a mega-cluster, and is vital in order to meet one of the overall aims of the project: Developing a system appropriate for mega-clusters. As teachers are employed to the mega-cluster and can be assigned to teach within any school therein, they have no direct relationship with this entity. Instead, each class-group is associated with one school. Given that students may only be assigned to one class-group, this allows students to belong to one school within the mega-cluster.

6.4.2.4 Users

Secretaries and Administrators are the only user groups with write access to this module. As a convenience, teachers are given read access to students, which may be useful for viewing parent contact information etc. The authorizations that each user has are shown in the user interface CRUD matrix in Table 6-1.

Table 6-1 - Personnel Management CRUD matrix

	Teachers	Secretary	Administrator
Staff		CRUD	CRUD
Students	R	CRUD	CRUD
Classes	R	CRUD	CRUD
Configuration		R	RU

6.4.3 RFID Reader

6.4.3.1 Overview

This module implements requirements GA1 and CA1, providing a method for which users can have their RFID cards read. It has no user restrictions.

6.4.3.2 Structure

The module consist of two components, a client side component and a server-side component. The client can be configured to operate as a *canteen reader* or *gate reader* (the types of reader can be extended as needed for future development), and contains code that interacts with the hardware, receiving a scanned RFID number. It then sends a synchronous request for authorization to the remote interface of the RFID Service on the server. This is summarised in Figure 6-6.

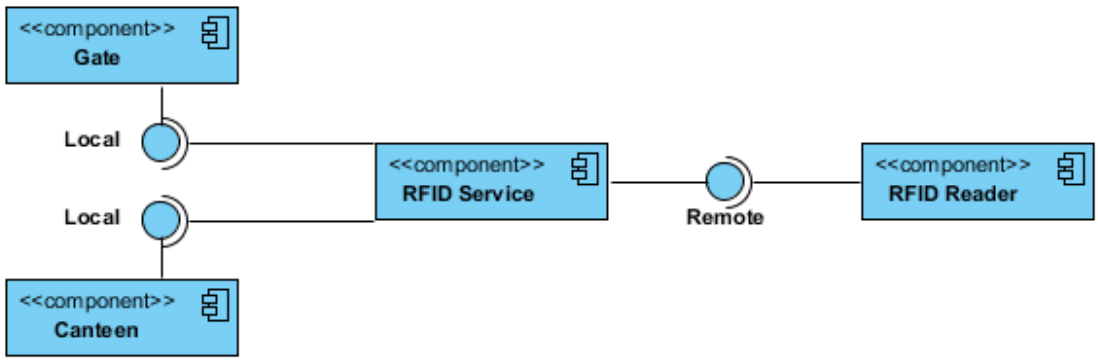

Figure 6-5 - RFID reader components

The role of the RFID service is to resolve the RFID number to a staff member or student. If this is successful, then based on the type of reader, it can pass the person's details to the gate or canteen components, which contain the logic for determining if a person has purchased lunch, or if a person may enter/leave school.

The response that is returned to the client is used to give a visual indication to the user as to whether the operation was successful or not, using, for example, greed and red LEDs on the reader or similar.

This process is summarised in Figure 6-6.

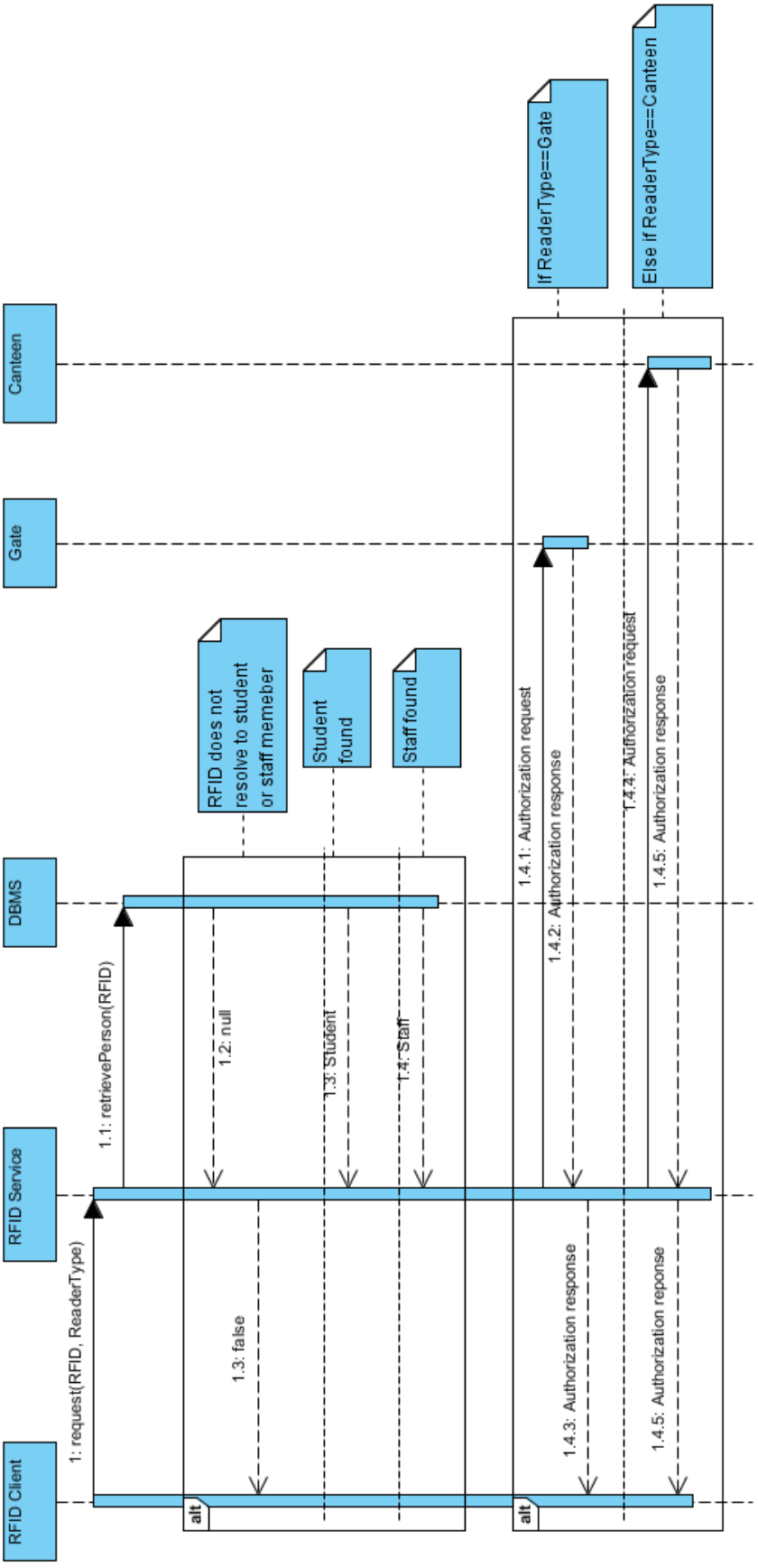

Figure 6-6 - Sequence diagram showing use of RFID reader

6.4.3.2.1 Forms of Identification

In the course of discussions with the Gate Attendant and observation made during the requirements elicitation phase, it became clear that a large volume of students and staff that can potentially pass through the gate in a relatively short space of time during the beginning and end of the school day. In this case, performance is very important. RFID cards offer can be read quickly, and are potentially more cost-effective than many alternatives (such as fingerprint readers), especially because the design of SC School is such that read-only RFID cards can be used, with all corresponding information being stored on the database.

6.4.4 Gate Access Control

6.4.4.1 Overview

The primary objective of the Gate Access Control module is to assist the gate attendant's job of monitoring who enters and leaves the school, and whether or not they are permitted to do so. This is determined based on a student's access permissions, which are defined by secretaries. This module has been designed to meet requirements GA2, GA3, GA4, GA5 and GA6.

6.4.4.2 Structure

6.4.4.2.1 Gate Attendant GUI

Like Personnel Management, the GUI of Gate Access Control is a web application. Primarily, this web application allows the gate attendant to view the details of students and staff passing through the gate (GA2). The details of each person passing through the gate appears on screen based on the lookup performed using the RFID number, with a clear graphical indication as to whether or not their action is authorized (i.e. unauthorized persons should be highlighted in red).

As this GUI will be updated frequently, and is such a significant part of the work gate attendants perform, a priority for the design of the Gate Access Control web application component is to make sure as many tasks as possible can be accomplished without navigating from or reloading the page. Technologies such as Ajax and jQuery can be used to retrieve and display additional information, either with a "show/hide" button for some additional information, or a pop up if a large amount of information needs to be displayed,

such as a full timetable showing when a student *is* allowed to leave. Manual sign-in is also available for cases when the RFID reader component is not functioning, or a person without an RFID card wishes to enter the school (GA3).

6.4.4.2.2 Log/Reports

A searchable log that can be used to generate reports, as described in GA5, is available on a separate page to the Gate Attendant's main GUI. This page is also designed to be used by secretaries. It allows records of all entrances/exits to be viewed, and filters to be applied such as "late arrivals only" or "unauthorized exits".

6.4.4.2.3 Permissions Management

This page is designed for secretaries to edit a student's entrance/exit schedule, as described in GA6. This schedule consists of a set of intervals that determine when the student should be in the school, preventing him/her from leaving if the current time falls within such an interval. The relationship between these entities is shown in Figure 6-7.

It allows the creation of schedules that can be applied to one or more students. Some students may also have their own specific schedule.

To improve usability, two types of schedule are made available.

- Simple: uses only one "day" entity and assumes all 5 days use the same intervals.
- Advanced: Allows for different intervals to be set up on each day over the course of a 5 day school week.

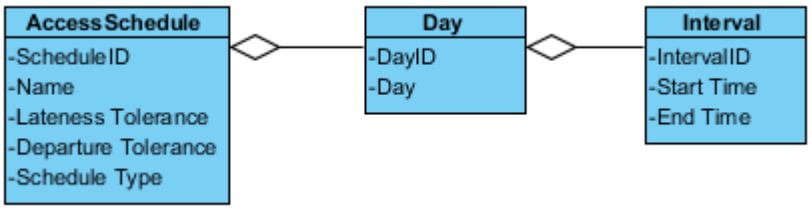

Figure 6-7 - Access Schedule entity relationships

Additionally, secretaries can apply a "tolerance" to a schedule, allowing a specified number of minutes of leeway as to when a student can leave school before the started time, or arrive without being reported late.

6.4.4.3 Users

Secretaries, Gate Attendants, and Administrators have access to this module. The CRUD matrix in Table 6-2 shows the permissions each of these users have.

Table 6-2- Gate access control CRUD matrix

	Gate Attendant	Secretary	Administrators
Entraces/Exits	CRUD		CRUD
Guests	CRUD		CRUD
Log	R	R	CRUD
Permissions	R	CRUD	CRUD
Configuration	R	R	RU

6.4.5 Canteen

6.4.5.1 Overview

The primary objective of the canteen module is to meet the needs of the canteen attendant, taking advantage of RFID technology to offer a facility for students and staff to pay for their lunches without the need to have cash with them.

6.4.5.2 Structure

The structure of this module is similar to that of the Gate Access Control module, using RFID readers and their client application to provide information to the application server, which apply the business logic and provide an answer, occasionally prompting the attendant for further information.

In order to meet CA5, the web application provides a facility for lunches to be purchased in advance by a student. As previously described in chapter 2, in Portuguese schools this is typically performed at the secretary's office or bar, as these locations have the ability to record the financial transaction and give change if required. Using the SC School system, given that all personnel have a *Balance* attribute stored in the database, staff can pre-purchase lunch for themselves or students using their balance (if sufficient), removing the need for this operation to be performed in a specific place. The price charged is a base price, (set in the module configuration), minus any *SASE* discounts that might be application in the case of students, as set in the Personnel Management module. The operation is logged allowing it to be traced back to the member of staff that performed it.

Having received their lunch, a person scans their card as described in 6.4.3. When this occurs, the Canteen component system first checks if there is a pre-purchased lunch booked for the current day, and verify that it has not already been redeemed. If this is the case, the purchase is confirmed as successful. If not, the system may take the base price of a lunch, apply any discounts that the person is entitled to (based on the *SASE* information configured by secretaries in the personnel management module), add the surcharge for the lack of a pre-booking, and verify if the person has sufficient balance to pay the total, implementing requirement CA3. Note that this function can be disabled by the school, as described in the original requirement.

The web application aims to provide a very similar interface for staff performing the role of canteen attendant to that which the Gate Access Control module provides for gate attendants – that is, an interface which receives real-time updates as students pay for lunches, and can provide further information on each student if required without navigating away from the page. This interface also includes the ability to manually record payments, as described in CA4.

Additional classes in this module allow the logs to be viewed and searched, in order to see a history of payments made. This module is also be able to generate reports, so that the school can analyse the average number of students eating per day, and provide the number of pre-paid lunches for a given day, which is useful for catering staff.

6.4.5.3 Users

The canteen attendant is not a legally defined role within the school, and potentially any member of staff can be on hand to assist. Therefore, any user of type "staff" has access to this module. The permissions are shown in the CRUD matrix in Table 6-3.

Table 6-3 - Canteen CRUD matrix

	Staff	Secretary	Administrators
Pre-Purchase lunch for student	R	CRUD	CRUD
Pre-Purchase lunch for self	CRUD	CRUD	CRUD
Purchase/redemption	CRUD	CRUD	CRUD
Logs	R	R	CRUD
Configuration	R	R	RU

6.4.6 Teacher Portal

6.4.6.1 Overview

This module has been designed as a portal for teachers, aimed at aiding teachers with the assessment aspect of their job, and also aiding class directors with their communication with parents.

6.4.6.2 Structure

This module is implemented as a web application, as per NFR6. In the *Assessment* sub-module, teachers are presented with a list of classes that they teach, along with the subject. Having selected a class, teachers are presented with an interface where they may create a new assignment/test, using the data type *work* described below. Once created, each student may be given a score for each work assignment based on the chosen mark scale. This is presented in the form of a matrix.

Within this section, teachers also have the option to plot graphs to show student performance. Teachers are able to select individual students or the whole class. To help with performance analysis, teachers are also be able to plot the class average onto the graph.

A separate section of the web application exists for teachers to record behaviour issues with their students (TEA2).

As identified in the requirements, class directors have additional functions to perform, in addition to their teaching duties. These functions are accessed through a separate "My Class-group" page, which is not be available to teachers. As class directors are responsible for monitoring the progress of their students, they are able to view all marks and behaviour incidents from all subject classes that their class-group is associated with (TEA3). An additional section allows messages to be sent to and received from parents (PAR4/PAR5), if the parent portal module is present.

6.4.6.3 Data Types

6.4.6.3.1 Work

This data type represents assignments or tests that the teacher wishes to store the mark of, with various fields to help the teacher organize and identify the assignment (e.g. description, date).

6.4.6.3.2 Scale

This entity reflects the fact that a variety of mark schemes are used in Portuguese schools. For example, some teachers use a score of 1-5 for work, others may prefer a percentage. Sometimes it may depend on the assignment in question. A variety of default scales are provided and the configuration section allows for custom schemes to be created by administrators.

Some of the entities related to *work* and some of their more important attributes are shown in Figure 6-8.

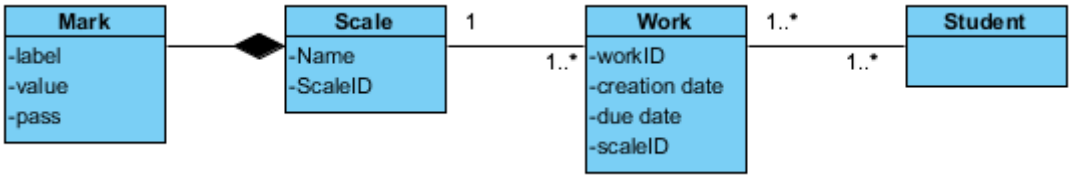

Figure 6-8 - Work entity relationships

Scales are composed of a list of *mark* entities, which use a *value* to determine their order, and a Boolean to store if this grade is considered a *pass* or a *fail*.

6.4.6.3.3 Behaviour Incident

This data type allows teachers to record behaviour incidents for each student. It consists of a date, the username of the teacher who recorded the incident, and comments.

6.4.6.4 Users

This module is be accessed by teachers, class directors, and administrators. The following CRUD matrix shows their permissions.

Table 6-4 - Teacher portal CRUD matrix

	Teacher	Class Director	Administrator
Assessment	CRUD	CRUD	CRUD
Class-group Summary		CRUD	CRUD
Behaviour	CRUD	CRUD	CRUD
Parent/Teacher Message		CRUD	CRUD
Configuration	R	R	RU

6.4.7 Parent Portal

6.4.7.1 Overview

This module offers parents a convenient method of remaining informed about their child's progress, and allows them to perform a variety of functions.

6.4.7.2 Structure

The Parent Portal is implemented entirely as a web application. Using technology and the data the school has available, this module can improve communication between class directors and parents, and help involve parents in their child or children's education.

Based on the requirements, one of the issues with this module is the number of dependencies that exist on other modules. For example, PAR1 requires data from TEA1, and PAR6 is not useful unless GA1 or GA3 is implemented. In order to give flexibility to both users and Singlecode, the module as a whole only depends on the Personnel Management module that has previous been described (without this, there would be no parents known to the system). However, several of the modules that make up this module have dependencies on one or more of the modules described above. This way, the Parent Portal will always function, but the number of operations available to parents is limited based on the modules that the school has purchased.

Student Information allows parents to view the personnel information stored on their children, including address and telephone number. Parents are not be able to edit this information directly, as in Portuguese schools this must be done by a secretary, but seeing the information stored helps prompt parents to keep their details up to date. Aside from the Personnel Management module that Parent Portal depends on to function, no additional dependencies are required for parents to access this information.

A *Finance* module is available to parents, which contains the implementation of PAR2 (always) and PAR3 (if canteen module is available). Parents can perform operations to purchase lunches and credit their child's balance. Transactions are carried out using an online payment service. Initially, as no point of sale software has been designed, credit can only be used to purchase lunches that are not pre-paid. However, the existence of this field has many potential uses as the system is developed in the future.

An attainment page allows parents to view their child's performance, by accessing both the raw mark data and the same data plotted onto graphs and displayed on the user interface to show performance over time. This functionality is dependent on the presence of the teacher portal module. (PAR1)

Parents are also able to view the times that their child entered and left school, using data from the Gate Access Control module. This allows parents to see any absences (PAR6).

Finally, a messaging system allows parents to contact class directors (PAR4 & PAR5).

A summary of the dependencies is shown in Figure 6-9 - Parent portal modular dependencies.

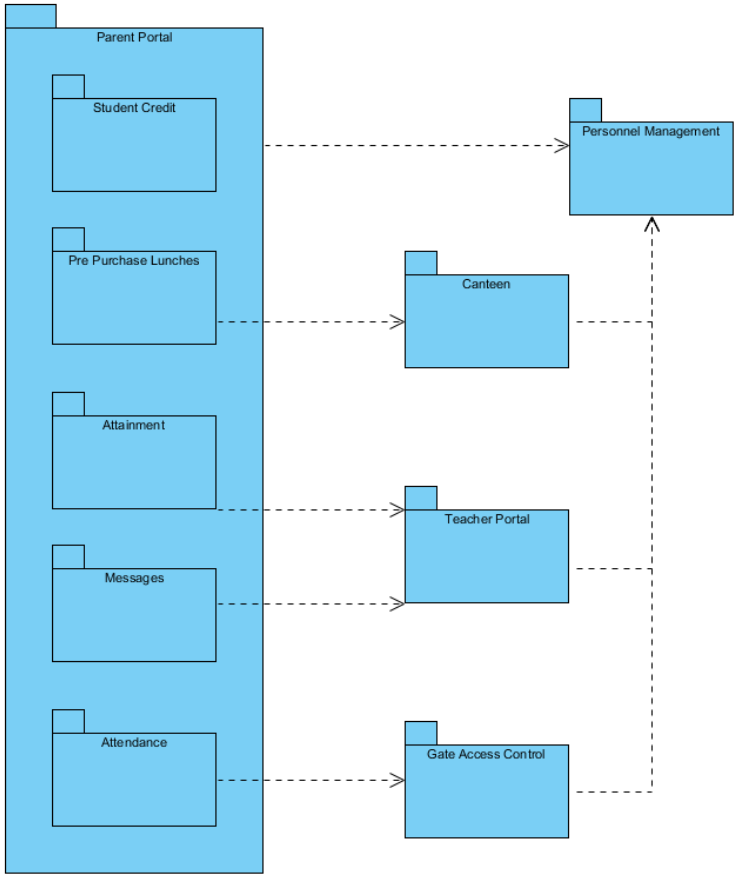

Figure 6-9 - Parent portal modular dependencies

6.4.7.3 Users

This module is used only by parents. Parents are provided with a password to access this module, generated and managed in the Personnel Management module, where parent details are entered and can be linked with one or more students.

7 IMPLEMENTATION

7.1 INTRODUCTION

This section discusses the implementation of the SC School system. The system is an ongoing project for the company, who intend to continue developing the project for many years in order to continue to meet the needs of schools and their employees. For the purpose of this thesis, the personnel management and gate access control modules have been implemented, along with a partial implementation of the RFID reader module. The implementation includes relevant data access layer components and security. This chapter discusses details of the implementation of these modules.

7.2 TECHNOLOGY PLATFORM

Based on the requirements and design, a decision was made to use the Java Enterprise Edition[10] platform to implement the system. The choice of Java EE explicitly fulfils the business requirement for use of a free platform (NRF4). It enables the development of modular web applications (NFR3, NRF6), and application clients (GA1, CA1) and contains many libraries and APIs that facilitate the implementation of common enterprise application requirements such as Security (NFR2).

A Java EE application can consist of a number of components, that in their execution environment, are distributed across a number of tiers, as shown in Figure 7-1. SC School makes use of every component shown in this diagram in some way as part of its implementation.

[10] JSR 316: Java™ Platform, Enterprise Edition 6 (Java EE 6) Specification

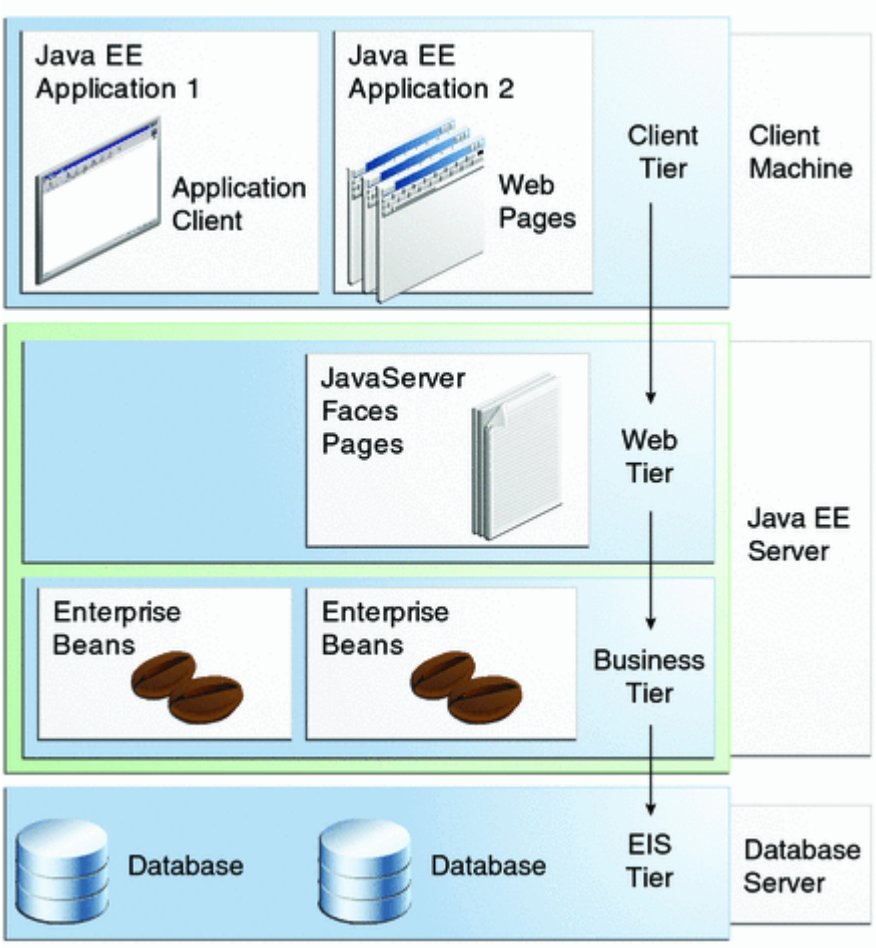

Figure 7-1 - Java EE multitier applications, from (Jendrock, et al., 2010)

7.3 PRESENTATION LAYER

For the presentation layer in the web application components of SC School, the Java ServerFaces 2 (JSF) framework was used. This is a component based Model-View-Controller (MVC) framework, which allows the MVC pattern to be applied in Java EE applications. MVC was first used in the late 1970s (Reenskaug, 1981), and encourages separation of concerns. MVC as a presentation layer architectural pattern in Java EE can fit into the 3 layered model as shown in Figure 7-2:

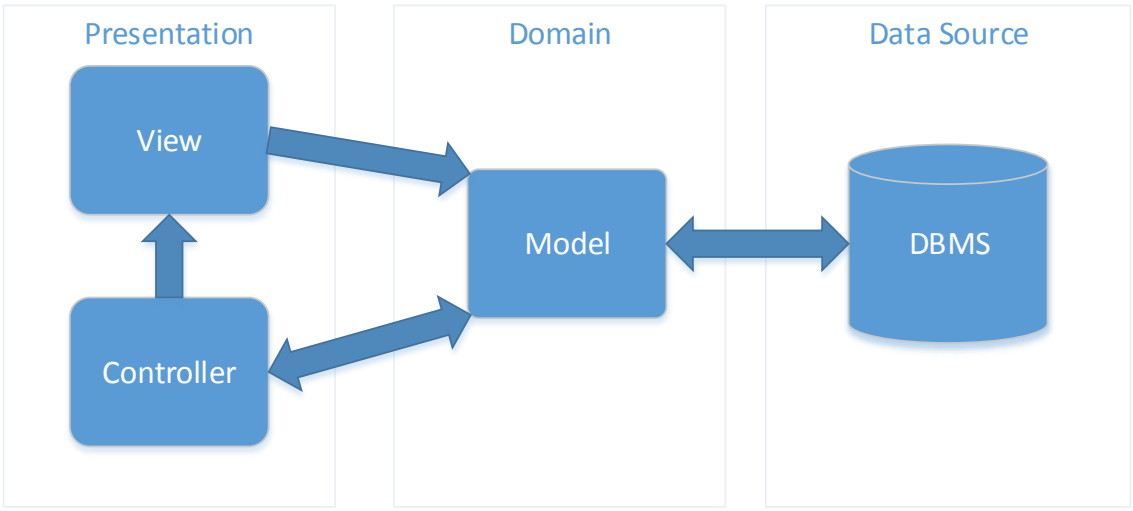

Figure 7-2 - MVC in three layer model

The view represents the domain in the user interface. In JSF, this is implemented using XHTML pages with Facelets components (or other component libraries), supported by backing beans containing additional presentation logic if necessary.

The controller manipulates the model and causes the view to be updated based on http requests from the user. In the case of JSF, this is implemented by the framework in the form of a Java servlet, *FacesServlet*, and as a result does not need to be implemented by the developer, only requiring some basic configuration.

The model refers to the business logic and data access, which are discussed in the following sections.

In a Java EE project, the various components of a web application presentation layer module can be packaged into a WAR file, which can then be included as part of a large Java EE project. WAR files are executed in the web container of the Java EE server.

As discussed in 5.2.3, the potential users of the system have varying skill levels in relation to ICT. In order to help give the application a familiar feel, the popular Bootstrap front-end framework developed by Twitter was used (Bootstrap, 2013). Bootstrap's look and formatting can be applied to Java ServerFaces components using CSS to give the site a consistent look and feel. Additional components such as modal dialogue prompts and

togglable tabs make use of jQuery and HTML5 to offer a richer front-end than traditional web applications could provide, minimizing page reloads and improving usability.

This framework also has the advantage of a grid-based system to automatically adjust page layout based on the user's display size, meaning that the application is accessible from modern smartphones and tablets. To aid consistency, several JSF XHTML template pages were created, and pages within each web application used these templates throughout.

An example of one of the most frequently used templates in SC School, adapted from bootstrap's own "Fluid Template", is shown in Figure 7-3:

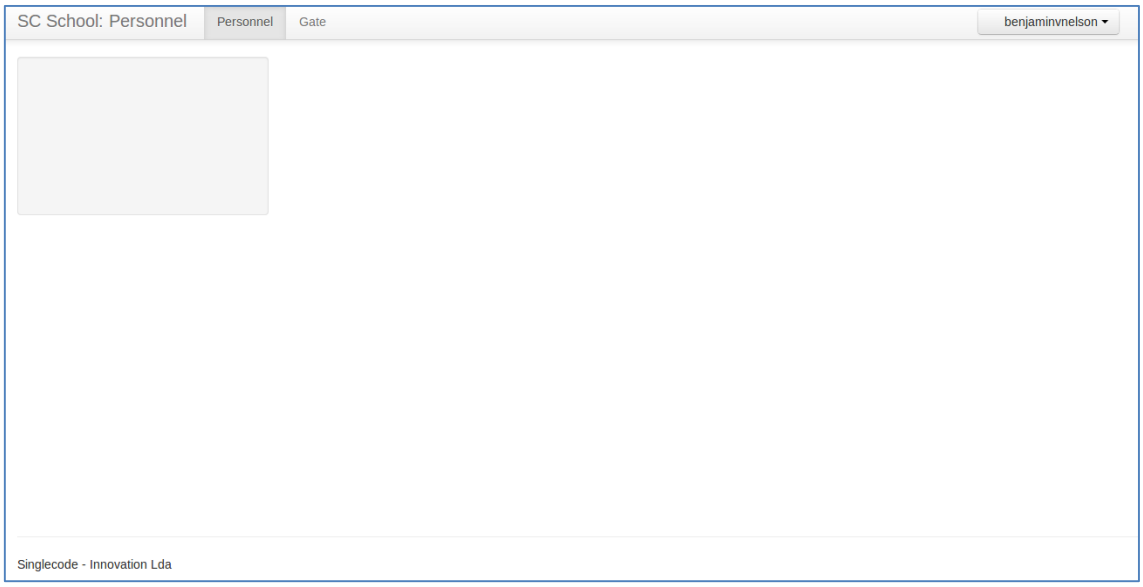

Figure 7-3 – Example of an SC School template, adapted from Bootstrap "Fluid template"

The template includes a top menu bar, for navigation between modules (where permission exists). The top left box can contain a menu for operations within the page, and the large white space holds the content.

A very basic colour scheme was used, but because of the use of CSS, which separates the style/colours from the page logic, it is trivial for the company to adapt this to suit the company's own theme.

7.4 DOMAIN LAYER

For this project, the domain model pattern was chosen for the domain layer. A domain model is defined as an object model of the domain that incorporates both behaviour and data (Fowler, Patterns of Enterprise Application Architecture, 2002). The domain model encourages an object orientated approach to the business logic, which for a large project such as this one, will encourage code reuse and reduce duplication compared to a pattern such as transaction script.

In Java EE, the entity classes that comprise the domain layer are generally implemented using POJOs (Plain old Java objects). They are executed in the business tier (Enterprise Java Bean Container) on the Java EE server. For SC School, the entity classes, their attributes and appropriate setter and getting methods, were generated automatically from the database schema using the NetBeans IDE. It was then only necessary to add business logic to the generated classes.

7.5 DATA SOURCE LAYER

The data source layer is responsible for communications with other systems that carry out tasks on behalf of the application, most commonly, databases.

For this project, the data mapper pattern was used. This pattern consists of "a layer of Mappers that moves data between objects and a database while keeping them independent of each other and the mapper itself" (Fowler, Patterns of Enterprise Application Architecture, 2002). The advantage of this pattern is that the domain objects do not require any knowledge of the data store, encouraging separation of concerns. This pattern works well in conjunction with the domain model pattern, which was also a contributory factor in its selection.

SC School's data source layer contains abstract mapper class, which has basic implementations of *create*, *edit*, *remove* and *find* methods. Each entity class in the domain layer has its own mapper class, which extends this class and contains more specific find methods required by various functions (i.e. A student mapper class with *findBySurname*, returning a collection of students with a given surname). Using the Netbeans IDE, the mapper classes can be generated automatically, with the additional find methods

implemented by the developer. Each mapper class has local and, where required, remote interfaces which are also generated by the IDE.

The majority of SC School's Database is stored in a relational MySQL database. MySQL was selected, as it is a well-supported open source DBMS. The framework used to implement the Data Mapper pattern for the relational database was the EclipseLink implementation of the Java Persistence API 2.0 standard (EclipseLink Project, s.d.). This framework allows entities in the domain model to be easily mapped to the MySQL database.

Redis, a No-SQL database was also used as part of the system, to take advantage of the fact that different forms of data store are appropriate for different types of problems. This technique has been dubbed Polyglot Persistence (Fowler & Sadalage, NoSQL Distilled: A Brief Guide to the Emerging World of Polyglot Persistence, 2012). It is essentially used to implement hash tables that store a list of students and teachers who are in each school of the mega-cluster in any given time, and is ideal for this task due to the fact that lookups are always performed using the primary key (student or staff id). It can give an extremely quick answer as to whether the student or member of staff is in the school (i.e. is found in the hash table) or not. It scales extremely well, so if a large number of people are within the school, performance does not drop as much as would be the case in a MySQL database.

A third type of datastore used was Apache Jackrabbit, a content repository which is the reference implementation of the Java Content Repository v2 specification (Apache Software Foundation, 2013; Nuescheler, 2009). This is used to manage staff and student photos that are uploaded. This was chosen to avoid photos being stored in the relational database (i.e. in BLOB form), which consume significant amounts of database space, whilst still allowing the photos to be stored securely.

7.6 MODULAR STRUCTURE

In order to meet requirement NFR3, it is important that modules are easy to add and remove, limiting the dependencies between them. Taking advantage of the framework provided by Java EE, each module will be packaged as a WAR file, containing the presentation logic for that module. The entity classes and their logic that make up the

domain layer will be stored together in an Enterprise Java Bean. This way, there are no dependencies between WAR files and the addition of a new module requires only an additional WAR file to be added, with possibly an update of the EJB if any new data types or business logic are needed. The component diagram in Figure 7-4 shows the system dependencies purely in terms of code.

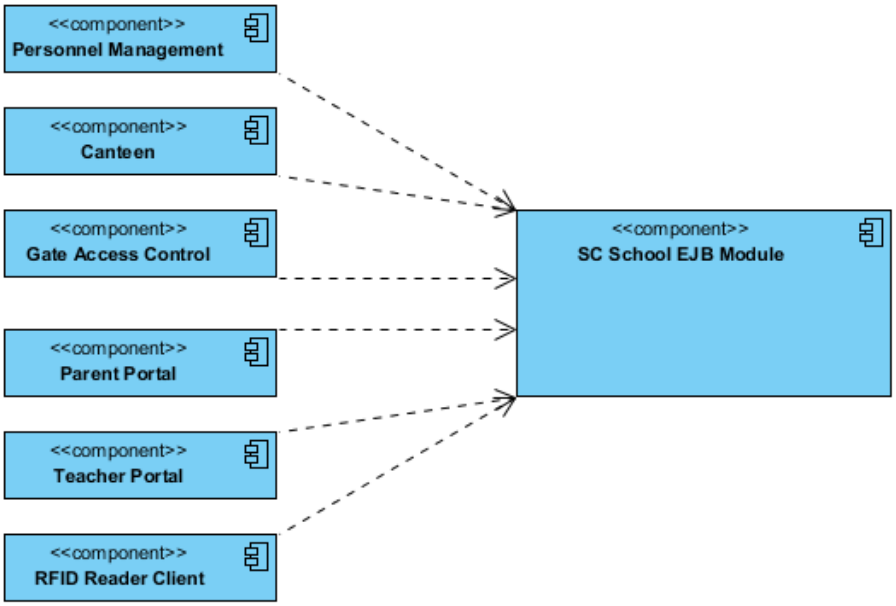

Figure 7-4 - SC School components

7.7 PERSONNEL MANAGEMENT

This module, described in section 6.4.2, was the first of the web modules to be implemented due to the data dependency other modules have on it, described in the previous chapter.

7.7.1.1 Current Status

This module has been almost entirely implemented, save for the configuration page, simply because of time constraints and prioritisations. At present, new system "roles", new subjects, and other configuration needs are performed by directly modifying the database. The current status of each sub-module of the module is summarised in Table 7-1.

Table 7-1 – Personnel Management implementation status

Module	Implemented?	Comments
Manage Students	Yes	
Manage Staff	Yes	
Manage Classes	Yes	
Configuration	No	

7.7.1.2 Graphical User Interface

As the front end with which the user will be interacting, this is an important part of the application. Taking the JSF Facelets templates based on Twitter Bootstrap, discussed in section 7.3, interfaces were designed for secretaries to perform various operations in a straightforward manner.

Figure 7-5 shows the main menu, which attempts to provide links to each section in a clear manner, with small graphics and descriptions helping to define each section.

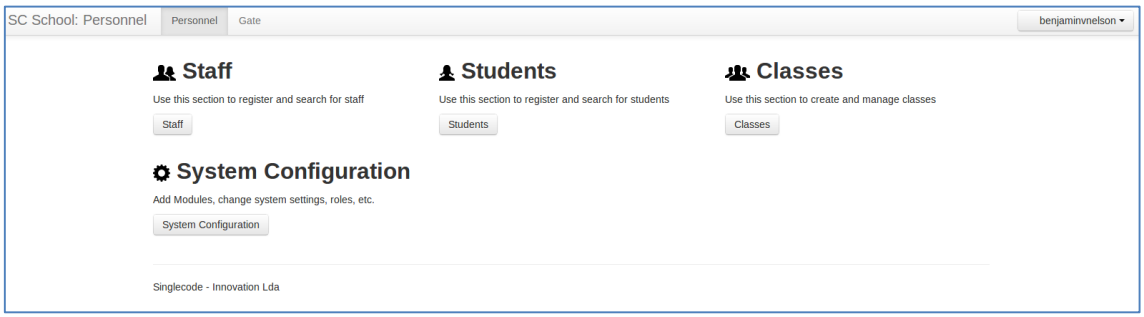

Figure 7-5 - Personnel Management, main menu

Figure 7-6 and Figure 7-7 show screenshots the "Manage Student" and "Manage Staff" modules. Each contains a "search" section at the top, allowing student/staff data to be loaded by either entering their unique ID, or selecting from a drop down menu. There is scope to develop further search functionality allowing search by name etc. However, due to time constraints this simplified method is used at present.

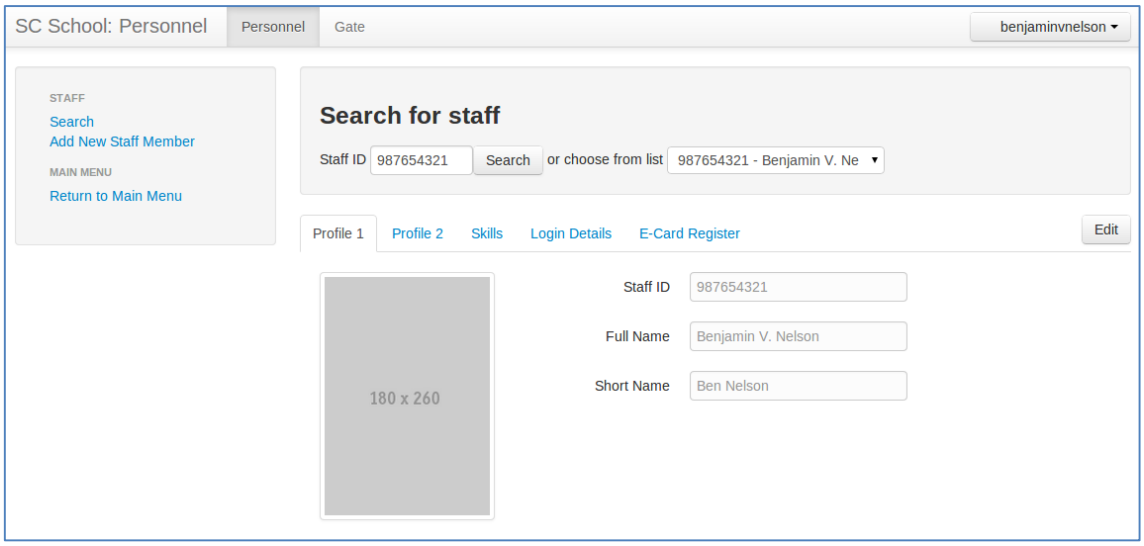

Figure 7-6 - Manage staff module GUI (with write disabled)

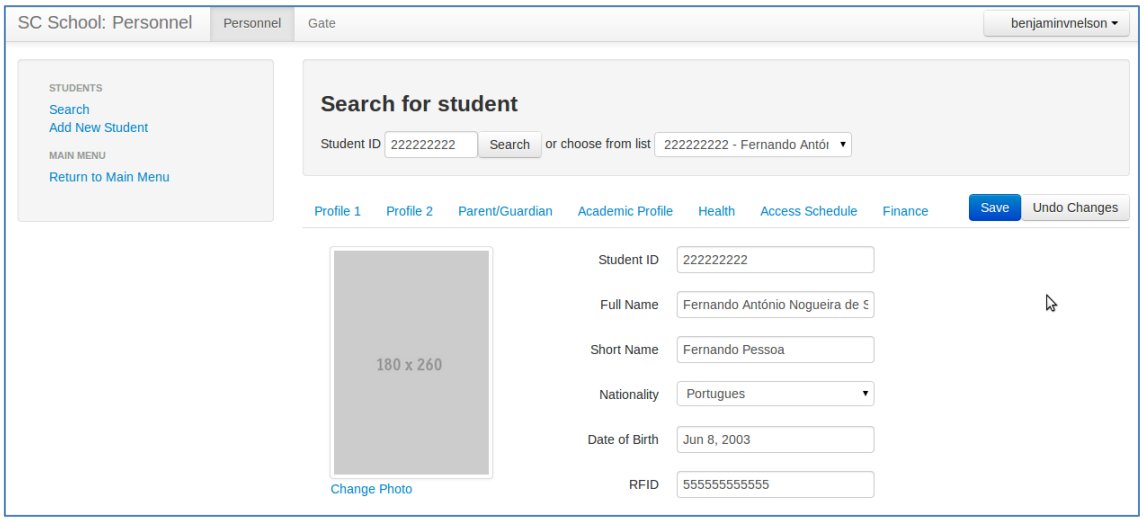

Figure 7-7 - Manage student module GUI (with write enabled)

Staff/Student profiles are displayed in a tabbable component, which uses jQuery to allow users to open each tab without requiring a page reload. The use of this component allows various fields to be organized into categories. The component has an "Edit" button (as seen in Figure 7-6), which only appears for those with write permissions. If "Edit" is selected, fields are re-rendered as text inputs using Ajax and can be modified. A "Save" and "Undo" button are rendered in place of the edit (as seen in Figure 7-7).

The “Access Schedule” tab allows selection of an existing Gate Access Control permission schedule, and is present in the “Manage Student” for convenience. It only appears in the event that the Gate Access Control module is installed. Creation of schedules and assigning them to multiple students at a time can only be performed in the Gate Access Control module.

7.8 GATE ACCESS CONTROL

This module was the second to be implemented, as a result of requirement NFR5.

7.8.1 Current Status

At present, this module is almost entirely implemented, save for the management of guest details, which have not yet been implemented due to time constraints. Also, a tool for schedules to be assigned “en masse” to a large group of students for improved usability is yet to be implemented. This is summarised in Table 7-2.

Table 7-2 - Gate Access Control implementation status

Module	Implemented?	Comments
Entrances/Exits	Yes	
Manual Sign-in	Yes	
Guest Management	No	
Schedule Management	Yes	Schedules can be created here, but currently only assigned in Personnel Management
Reports/Logs	No	

7.8.2 Graphical User Interface

The interface designed for gate attendants to monitor entrances and exits is demonstrated in Figure 7-8. The top section allows a particular student/staff member to be highlighted, and includes a photo. By default, this shows the most recent person to scan his/her card. Other users in the list can be highlighted using a mouse click.

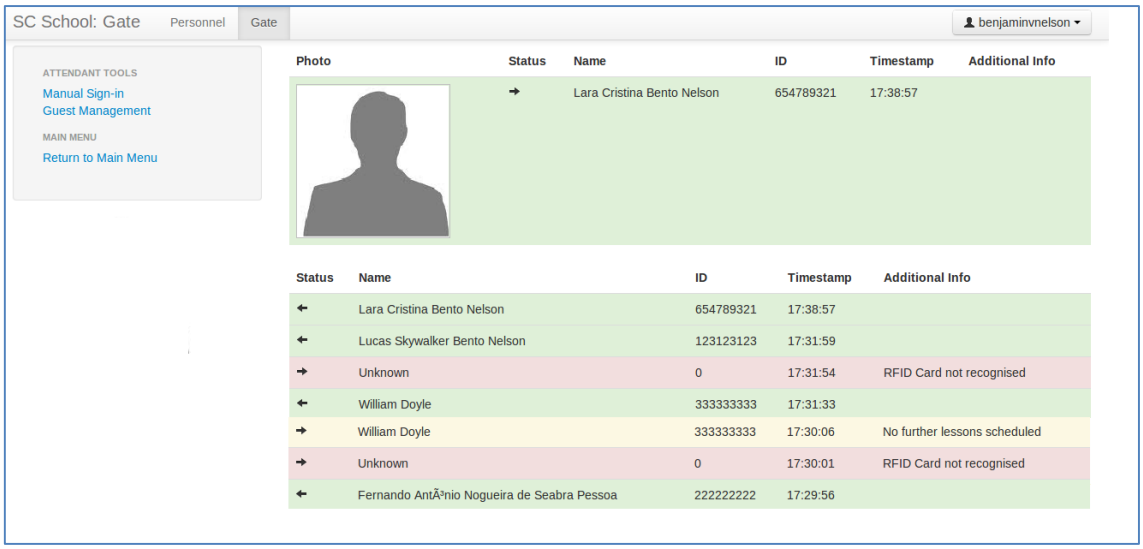

Figure 7-8 - Entrance/Exit monitoring GUI

Each row in the table displaying entrances/exits is colour-coded to help highlight issues.

- Green – Person is known and has permission to enter/leave
- Yellow – As green, but is either late, is entering despite not being scheduled to enter on this day, or has permission to leave but has a lesson due to begin shortly (i.e. an interval has a start time within the next 5 minutes).
- Red – RFID card is not recognised or student does not have permission to leave.

In addition to this, an arrow icon is used to indicate whether a user is entering or leaving, with a left pointing arrow signifying leaving, and a right pointing arrow signifying entering.

In order to reduce the latency between the user scanning a card and the information appearing on this page, long polling is used. When the page is initialized, a polling request is sent to the server. Unlike traditional polling, if there is no new information, the request remains open (as opposed to an empty response being returned, as is the case in traditional polling). This way, when a user scans their RFID card and the gate algorithm executes, updated information is immediately sent to the page using the open polling request, rather than having to wait for the next interval. As soon as a response is received, a new polling request is sent to wait for a reply, and the process repeats. Using Ajax, the page can be updated with this new information without the need for a page refresh.

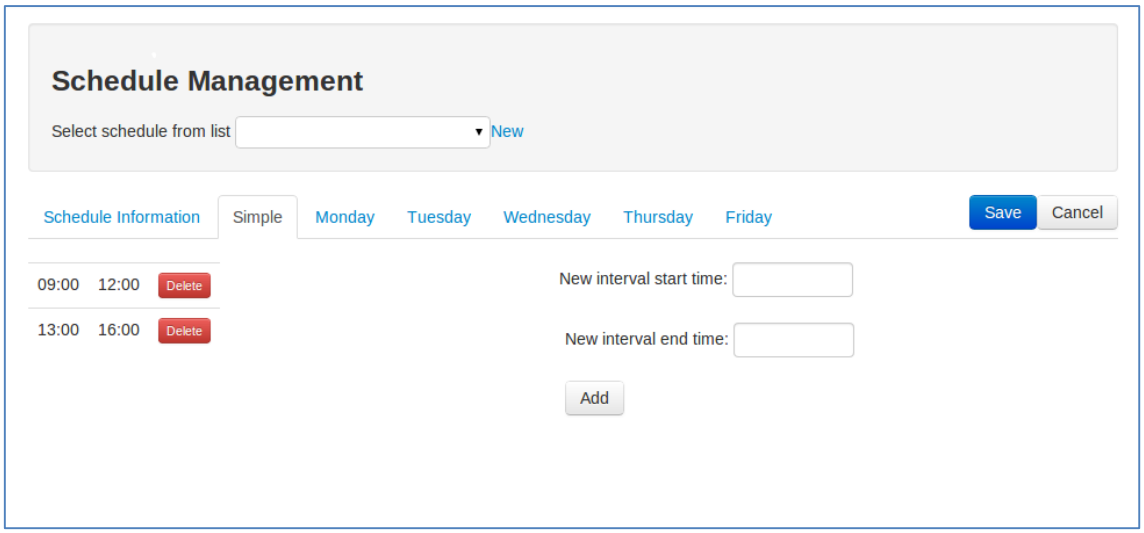

Figure 7-9 - Schedule Management GUI

Schedule Management, shown in Figure 7-9, allows CRUD operations to be performed on Access Schedules, which can either be applied to one or multiple users. Intervals, times at which the student is expected to be on school grounds, can be added and removed. Business logic ensures that these do not overlap. Users enter times in written form (i.e. 9:00) and using convertors that are built into JSF, these are automatically converted to times.

7.9 RFID READER

In order to allow users to have their RFID card read, the design for SC School included an RFID reader module. The server side code for this, which resolves an RFID card number to a user, was implemented and is contained in the Enterprise Java Bean. It provides a remote interface for RFID Reader clients to connect to.

The client has been implemented as a Java Enterprise Application Client. At present, Singlecode has not yet chosen the hardware it wishes to use for the RFID reader. As a result this client currently simulates the reading of a card by functioning as a console application where the user can enter a number. Once hardware is provided, the client can read directly from the hardware, using existing hardware-agnostic Java libraries, such as Java-RFID (SmartLab, 2013).

7.10 SECURITY

Security, highlighted as a requirement in NFR2, was implemented using Apache Shiro, an open source security framework for Java (Apache Software Foundation, 2013). Shiro is able to perform authentication, authorization, cryptography, and session management, all of which are used in the SC School project.

Authorization is required to access each web application module, using a login form. SC School stores a salted hash of users' passwords in its database, using the SHA-256 hashing algorithm provided in the cryptography library (NIST, 2002). An advantage of Shiro is that it offers Single Sign-on (SSO) functionality, whereby even when users switch between different modules contained in different WAR files (e.g. a secretary switches from the personnel management module to the Gate Access Control module), he/she remains authenticated, although at present SSO has not been fully implemented in SC School due to time constraints. Shiro can also use cookies to implement "remember me" functionality, making the application more user-friendly.

Authentication is role-based. Methods can be annotated with the role required to execute them, reporting an error if a user attempts an unauthorised function. Ideally the user should never see this error, as rules have been included in the presentation layer to make sure that options the user does not have permissions to perform are not made available to him/her in the first place.

7.11 DEPLOYMENT

Figure 7-10 shows a deployment scheme for the system. The RFID reader client is deployed on-site at each school in the mega-cluster. The servers could potentially operate either locally (i.e. on-site at one of the schools in the mega-cluster), or remotely (i.e. on Singlecode's servers, offsite). This decision has both performance and business implications (i.e. latency, cost burden for infrastructure, ease of providing support). Having considered the requirements and business needs, a decision was made to host the application locally. The rationale behind this decision is driven by the use of an on-site client for reading RFID cards. Remote hosting would increase the latency between the RFID being read and the server returning a response, which would have a significant effect on some areas of the school, such as the speed at which students can enter.

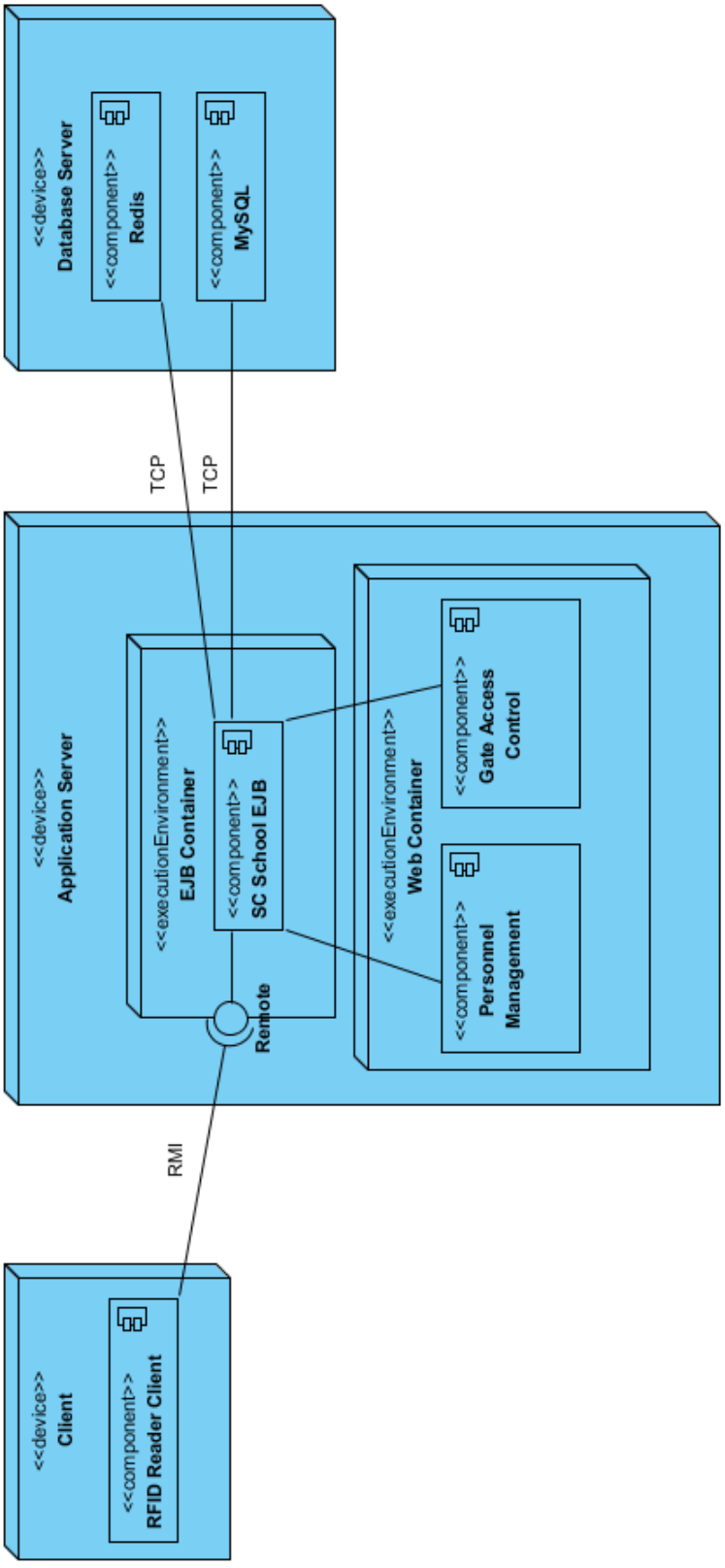

Figure 7-10 - SC School deployment diagram

7.12 TESTING

As discussed in 4.6, during each iteration, various forms of testing were performed. Unit testing was carried out using Junit, which allows test harnesses to be created for each method (Junit, 2013).

7.12.1 Usability

As the interface was developed, usability testing was carried out with potential users of the system. This was used to refine the system as it was developed. Some comments about the most recent iteration are found below.

7.12.1.1 Personnel Management Comments

Users were positive about the menu structure and layout of the interface. As a result of feedback, the attributes under each tab of staff and student profiles were organized to reflect the way that schools tend to organize the data on forms.

It was suggested that using a graphical calendar to enter dates as opposed to having to enter them in written form, with form validation reporting errors, would make the interface more user friendly. Some users also found the behaviour of the *Save* button confusing, as it saves updates made to every tab as opposed to just the visible tab. However, technical restrictions in the way Ajax executes forms mean that this requires a significant time investment to modify.

7.12.1.2 Gate Access Control Comments

The interface for monitoring entrances and exits was praised as being clear and easy to understand, particularly with colour-coded feedback. It was suggested that the schedule management interface, which once again relies on entering times using the keyboard, could benefit from a more graphical approach.

7.12.1.3 General Comments

Users were positive about being able to use a web application. A demonstration was given to a member of the school ICT staff, who despite not being a specific end-user of the modules implemented, would potentially have responsibility in system administration. The teacher agreed that a web application would reduce her workload with regards to providing support for school staff. With regards to the system being hosted locally, the

teacher emphasised that it was important for Singlecode to offer strong technical support, as ICT staff in schools generally do not have knowledge of application server configuration.

7.12.2 Acceptance

Where possible, acceptance testing with potential end users has been carried out for each requirement. However, due to the incomplete nature of the system, this process is not complete.

8 CONCLUSION

Having identified several reasons why current School MIS systems on the market in Portugal do not presently meet the current needs of schools, this thesis set out to design and begin the implementation of a new MIS system for Portuguese schools. The problems identified were largely related to the move towards mega-clusters and the problems this posed for the outdated technologies used in existing School MIS systems available in Portugal.

SC School was proposed as an attempt to solve this problem, and was developed largely as a web application to reduce the workload of school ICT teachers, and increase its availability to staff in all schools of the mega-cluster. In this regard, it can be considered a success, availability is significantly improved over fat client applications whilst simultaneously reducing workload in terms of maintenance. At the same time, the architecture allowed for client applications to be used when needed (i.e. for RFID readers) to allow the system to implement the functional areas that are demanded in Portuguese schools. This was also successful in terms of functionality, but the requirement for this technology to use a client application does come at the cost of creating some potential on-site issues within the mega-cluster for ICT teachers to solve.

The system met the needs of the business in terms of extensibility and implementation within the desired timeframe. However, to develop and implement the system fully, meeting all the functional areas that schools require (including those that were beyond the scope of this thesis) would require significant resources and time, more than what can be reasonably achieved with a lone-developer.

It is interesting to note that one of the mega-clusters visited and included in the research, Agrupamento Alubfeira Oriente, purchased and installed a new product released in 2012, after the commencement of this project... *Inovar+* is a pure web application that can either be installed on local servers or remotely on Inovar's servers. Although it currently has limited functionality compared to some of the most commonly used suites, with three modules (Student Management, HR Management, Accounting and Operation Management), and still relies on working with SIGE to meet needs relating to the use of identity cards, it's adoption by the mega-cluster replaced the fragmented use of several

independent instances of *JPM* and has been well received by many teachers. This represents a positive step towards the adaptation of the market to meet new challenges.

8.1 FUTURE WORK

Whilst the large number of functional areas identified in existing products during chapter two show obvious potential for further development of SC School, it is perhaps more pertinent to consider areas that aren't currently widely found in existing products.

It was notable during school visits that since the PTE, information technology is now being frequently used for educational activities, as opposed to just school management. Both of the mega-clusters visited in Albufeira had recently begun using the learning management system *Moodle* for publishing assignments, class notes and marks. In addition to this, reports from GEPE show that between 2007 and 2010, the number of schools with interactive boards in the classrooms rose from 5% to 26.9% (Direção Geral de Estatísticas da Educação e Ciência, 2011). Almost all of the products surveyed had an attainment management system for recording marks and analysing performance, but only one of the systems surveyed (Pearson e1) had any kind of interaction with an e-learning platform. This could be an interesting area to explore, saving time for staff and providing more opportunities to analyse student performance.

As well as the implementation of new functional areas, it is also important to consider what could be done to improve the areas that have already been implemented. Given that schools already use MIS systems, one important area to consider is data transfer between them. In both England and Portugal, there are now approved frameworks for the transfer of data between school MIS systems. In Portugal this is handled by the Ministry of Education, which operate a certification program for software that conforms to this framework that has been defined in several ministerial dispatches[11]. Implementing this functionality and gaining this certification would be helpful to schools and also help Singlecode from a marketing perspective.

[11] Despachos nº 26377/2005, 2ª Série, nº 243, de 21 de Dezembro de 2005, nº 7505/2006, 2ª Série, nº 67, de 4 de Abril de 2006, e nº 18707/2007, 2ª Série, nº 160, de 21 de Agosto de 2007

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