

Cloud SAMS: Cloud Computing Solution for Public Schools within South Africa's 'Second Economy'

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Abstract: Cloud computing is coming of age; it involves on-demand access to a shared pool of configurable computing resources. There is an emerging consensus that cloud computing will play a critical role in redressing the digital divide especially in rural areas of Africa. In this paper, we report on a success story to this end; the use of cloud computing in expanding the access of students' records management system to resource-constrained schools in the Free State province of South Africa. This was motivated by the fact that despite the proven tight correlation between availability of data and quality of education, many schools that are considered part of the 'second economy' in South Africa continue to operate in uni-direction data flow arrangements that do not provide them with adequate data for critical decision making. We implemented and evaluated a Cloud based School Administration and Management System; hereby called 'Cloud SAMS' for these resource-constrained schools in the province (they account for over 80% of all schools). Starting off with 5 schools and later ramping it up to 50, 'Cloud SAMS' enables schools to securely and privately share one copy of the system maintained in the cloud; this brings on board several benefits - low cost, faster implementation and resilience to failures.

Keywords: Cloud computing; Students management information system; School Management Systems; CloudSAMS; Free State; 'Second Economy'

1. Introduction

South Africa's education system is one of the most unique in the world; among other reasons for this, is the notion of 'Second Economy' which the former president, Thabo Mbeki described in the "ANC Today, Letter from the President Characteristics of South Africa's first and third world economies" on 28th August 2003 [1]. The usage of this phrase (and its twin phrase; "two parallel economies") in the context of the country is different from the conventional meaning found in Development Theory. It instead describes actual living conditions that affect more than one third of the South Africa's population - it is undeveloped, isolated from the first economy (and global economy), includes both urban and rural poor. Besides, this section of the society contributes very little to the country's economy ([2], [3] and [4]).

As expected, this 'second economy' phenomenon has permeated all sectors of the Country's socio-economy; it is worse in the education sector. The inequality is so sharp; the wealthiest (made up of 20-25%) pupils achieve higher scores than the poorest (constituting 75-80%). To demonstrate this, the National School Effectiveness Study of 2007, 2008 and 2009 consistently showed that grade 3 pupils from former white schools scored higher marks on the same test than grade 5 pupils from former black schools [5]. Integrating these

two economies has been a top priority for the government since the dawn of democracy (1994); to this end, a number of policies have been developed and implemented. Three of the six policies proposed by Spaul [5], can easily be addressed through appropriate ICTs while the other three require properly captured, stored and analyzed data. Among all the initiatives towards this integration, improvement of the education system to provide useful skills ranks highly.

South African schools are classified into five quintiles. Quintile 1 represents the “poorest” schools (mostly form part of the “second economy”) and quintile5 represents the “richest” schools. According to the 2014 EMIS statistics, about 80% of schools in the Free State province fall in Q1 and Q2 (see Figure1 below).

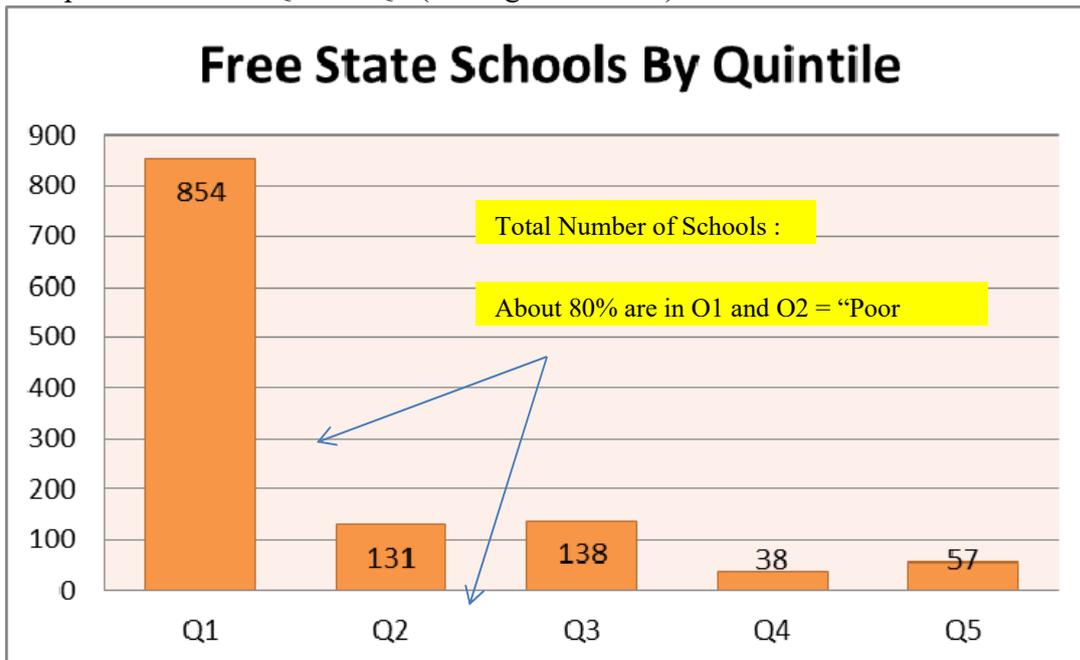


Figure1: Free State Schools by Quintile [23].

As mentioned earlier, the need to capture, store and analyze school data is an important element in driving an education policy that is responsive to the needs of the “second economy”. In recognition of this fact, in 2008, the South African Department of Basic Education (DBE) unveiled a lightweight, MS Access based system called South Africa School Administration and Management System (SA-SAMS)[10]. SA-SAMS was made available, at no charge, to all schools in South Africa.

1.1 An Overview of SA-SAMS

SA-SAMS was designed to enable school administrators to track operational data and make school life easier, while also creating a database of operational data for district, provincial and national use. The system’s core modules allow schools to record basic information about learners, teachers and the school. It also has modules for tracking task-level learner marks across different subjects, a finance module which allows schools to capture, track and submit fee receipts to their respective districts, a timetabling module for allocating teaching duties, a module to record and track Learning and Teaching Support Material(LTSM) as well as modules for transport and nutrition. The system also helps schools in compiling an annual school survey that is submitted to the DBE for important school statistics.

1.1.1 Current Setup of SA-SAMS

Figure 2 below illustrates the use of the current South African School and Administration System (SA-SAMS) in a typical school environment and how it links to the Provincial department of Education. In a typical setup, SA-SAMS is installed on a standalone computer in the school, and operated either by a school administrative clerk or a designated teacher. All data capturing tasks such as processing learner admissions, recording fee payments or capturing learner performance data are channelled through the single school clerk or the specified teacher. In addition to supporting operational tasks in the school, SA-SAMS is also designed to be the primary source of school data for the Department of Education (DoE). As shown in figure2, school data is extracted from SA-SAMS, put on CDs or flash disks and manually submitted to DoE. At DoE headquarters, the data is uploaded to a data warehouse, from where planning statistics are derived.

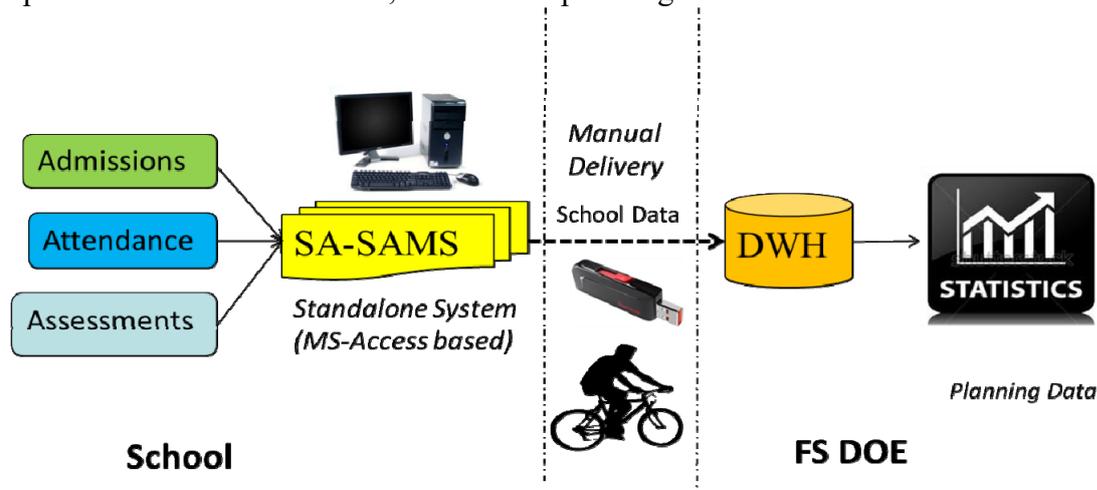


Figure 2. SA-SAMS Architecture

1.1.1 Problems with SA-SAMS

Given the fairly rich set of features available in SA-SAMS (that range from learner and staff management, timetabling, curriculum administration, through to transport and nutrition) [10], one would expect widespread acceptance and use of the SA-SAMS across the Country's public schooling system, particularly given that the system is free. However, a recent study conducted by the Susan and Dell Foundation on behalf of the DBE reveals that the adoption and use of SA-SAMS in SA public schools falls far below the initial expectations, with some provinces recording zero usage [8]. The study by Susan and Dell Foundation singles out lack of technical support and training as one of the most significant factors that has contributed to the low uptake of SA-SAMS across the country. Provincial departments of education struggle to get the resources (funds and staff) to support schools. Due to inadequate support personnel, schools are sometimes forced to endure lengthy delays, sometimes months, before their support requests can be addressed. These frustrations often lead to schools abandoning SA-SAMS and reverting to manual operations [8].

Low uptake aside, the current implementation of SA-SAMS suffers from several architectural challenges that collectively reduce its potential impact. Firstly, because it is a standalone installation (see figure 2 above), access is limited to very few users, typically an administration clerk who handles all data related tasks in the school. This puts significant strain on the lone operator, especially at the end of the term when schools need to process learner reports, often leading to frustrating delays. Secondly, because of the single access point, teachers have limited access to the system even for simple tasks such as recording

their assessment marks, and often end up wasting precious teaching time manually verifying marks in endless loops. This becomes clearer when one considers the agonizing steps incurred in accomplishing even a simple task of capturing and collating marks - teachers start by getting a blank learner list from the administration clerk. They manually record marks on the form, and once done, send it back to the administration clerk. The administration clerk captures the marks into SA-SAMS and prints the form with the scores on it. The form goes back to the teacher for verification; if there are errors, the concerned teacher corrects the errors and the form goes back to the administration clerk to make the corrections. It is not uncommon for additional errors to crop up along the chain. Collating marks introduces further frustrations. All these tedious tasks steal precious time from teachers, time that could be channeled to teaching. Opening up the system to cater for more users (e.g. teachers) and distributing the workload among them can help solve this problem. Unfortunately, SA-SAMS is ill-suited for this kind of distributed, multi-user access.

Because SA-SAMS is not linked to the systems at DoE, schools find it tedious and cumbersome to submit data to DoE. Schools extract requested data from SA-SAMS, copy it to CDs or flash disks and physically send it to DoE (see figure 2 above). On receiving data from the schools, the MOE embarks on another lengthy process of uploading the data to their data warehouse. This manual submission results in significant delays in releasing school statistics. For example, school statistics for the year 2013 were only released in March 2015[9]. Given the importance of timely data, these delays sometimes render these statistics meaningless, because both schools and the DoE cannot rely on it to timeously identify areas that need interventions.

In the recent study mentioned above [8], some of the responses bring out the utter frustration of schools:

- *“I spend about 60% of my time on administrative tasks – which are only being reported to the district.” – Deputy Principal*
- *“It would be like heaven if we could eliminate all the unnecessary paperwork that we have to do twice.” – Admin. Clerk*

In view of these challenges, the adoption and use of SA-SAMS as well as its impact on public schooling is not as high as initially envisioned. Richer schools with resources (read those in Q4 and Q5), have invested either in commercial school systems with enhanced capabilities or if using SA-SAMS, have employed additional staff to operate and maintain the system. Schools with resource constraints (Q1 and Q2), however, are often forced to abandon SA-SAMS and revert to manual operations if the system develops problems or if the person who was trained on the system leaves the school - in the process denying them access to the very tool that could help them streamline internal school processes.

The thesis perpetuated in this paper is that; migrating SA-SAMS to the cloud, where the system is offered as a service to thousands of under-resourced South African schools over the Internet from centrally managed data center(s), can alleviate the various challenges facing SA-SAMS and help accelerate the pace of adoption, and in so doing, assist in achieving the original vision of making the system available to every school, both poor or rich, across South Africa.

The rest of this paper is organized as follows. Section 2 provides a brief overview of the cloud computing model and discusses the benefits of migrating SA-SAMS to the cloud. Section 3 describes the research approach adopted in this paper. Section 4 describes the design of Cloud SAMS. Section 5 discusses the implementation of Cloud SAMS including the cloud platform used, the tools employed and the initial evaluation of Cloud SAMS using interviews conducted with participants drawn from the pilot schools. Section 6 concludes the paper. Section 7 gives the acknowledgements and section 8 lists the references.

2. The Cloud Computing Model

Cloud computing (CC) shifts the traditional model of viewing computing as a product that is owned and operated in-house to one that perceives computing as a service that is delivered to consumers over the Internet from large data centers or “clouds” [12, 13]. Although many definitions for cloud computing (CC) exist, [12, 13, 14], the one proposed by the US National Institute of Standards and Technology (NIST) has gained widespread acceptance. NIST defines cloud computing as “*a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g. networks, servers, storage, applications and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction*” [14].

In a CC model, services can be fully functional applications (Software as a Service (SaaS), development tools (Platform as a Service (PaaS) or raw computing resources (Infrastructure as a Service (IaaS) [14]. Examples of SaaS range from consumer applications such as Gmail or Facebook to cloud based Enterprise Resource Planning (ERP) systems such as Salesforce.com (a CRM application). A good example of PaaS is Google Apps Engine, while Amazon Elastic Compute Cloud and MS Azure are good examples of IaaS providers. Cloud services may be deployed using public, private, community or hybrid clouds [14]. Cloud SAMS is an example of SaaS and is deployed on a community cloud accessible to schools and the DOE.

2.1 Benefits of Migrating SA-SAMS to the Cloud

Figure 3 below illustrates the transition from SA-SAMS to Cloud SAMS. Whereas the current solution forces each school to install and operate a standalone copy of SA-SAMS on premise, Cloud SAMS makes it possible for thousands of schools to privately access and use a single, centrally managed copy of the system.

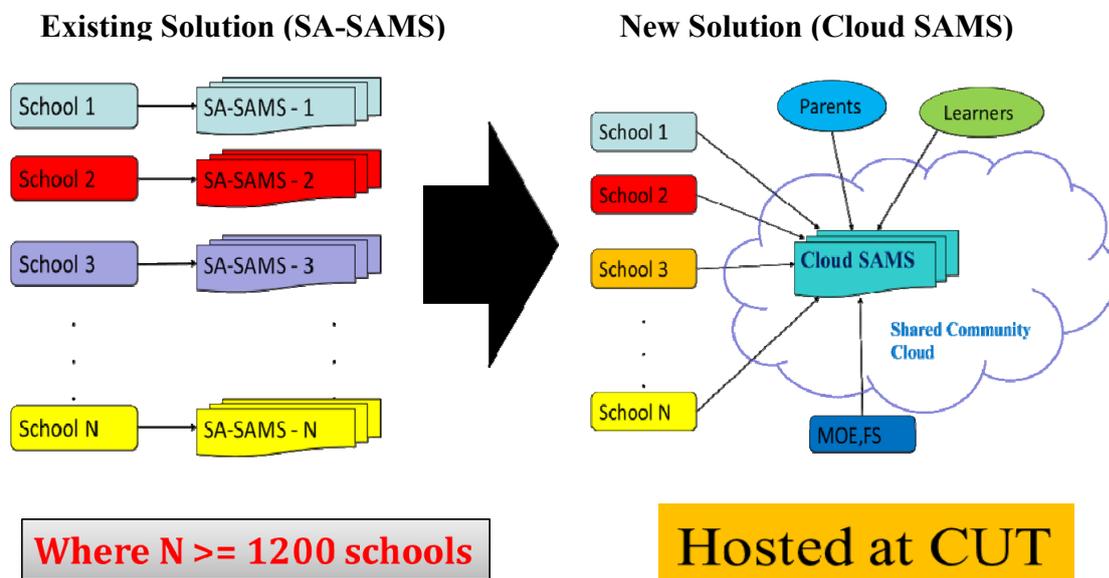


Figure 3: Architectural Differences between SA-SAMS and Cloud SAMS

The cloud model comes with a number of attractive benefits. One, the need for schools to individually install the application on school servers is eliminated, which reduces the costs incurred in acquiring and running SA-SAMS. All what a school needs is an internet connection. Secondly, the burden of support and maintenance is dramatically reduced. Physically sending technicians to schools for support and maintenance tasks is all but

eliminated. In fact, a small team of well-trained technical support personnel can cater for thousands of schools remotely. System upgrades are cheaper to effect and are immediately available to all schools, reducing downtime and alleviating the frustrations that schools undergo when SA-SAMS is down. Thirdly, ubiquitous (anything, anytime and anywhere) content access and collaboration will be enhanced; more users will have access to Cloud SAMS; teachers, learners, school management, parents and education officials at the district, provincial and national level. Crucially, schools no longer need to manually submit school data to the DoE on CDs and flash disks because the school data will be available online. A recent push from the government to extend Internet connectivity to schools through several initiatives, including exploiting “white space” bandwidth that will be freed after the country transits to digital broadcasting[11], makes the cloud solution for schools (even rural schools) even more appealing.

3. Research Methodology

The development of Cloud SAMS followed a Design Science Research (DSR) approach as formulated by March and Smith [16] and Hevner A.,R, March S T and Park J[17]. Hevner et al [17] characterizes Design Science Research (DSR) as being a problem solving paradigm that seeks solutions to important and relevant business problems. DSR comprises two distinct steps. In the first step, an artifact to address a specific problem is designed and built. In the second step, the artifact is rigorously evaluated to establish its efficacy and viability. The evaluation may trigger additional refinements to improve one or more aspects of the artifact. In the context of Information Systems (IS), artifacts may include constructs (vocabulary and symbols), models (abstractions and representations), methods (algorithms and practices) and instantiations (implemented and prototype systems) [17]. Constructs refer to the language in which problems and solutions are defined and communicated [17]. A model uses constructs to represent a real world situation –the design problem and its solution space [17]. Methods refer to processes (which may be mathematical algorithms or textual descriptions) that provide guidance on how to solve problems [17]. Instantiations show that constructs, models or methods can be implemented in a working system [16, 17]. Hevner et al[17] further argue that instantiations demonstrate feasibility, and enables the concrete assessment of an artifact’s suitability to its intended purpose. In addition, instantiations enable researchers to learn about the real world, how the artifact affects it and how users appropriate it.

Two key requirements of DS research are rigor and relevance [18]. Offerman et al [18] define rigor as the “*correct use of methods and analysis appropriate to the tasks-at hand*”. On the other hand, relevance denotes the ability of the research to be implemented i.e. relevant research is that which is “*prescribed in a manner that could be put to use (to some extent) in practice to exploit an opportunity or to resolve a problem*”.

The research question solved in a DSR may arise from a current business problem or opportunities offered by a new technology [17]. Further, the problem addressed in a DS project should be of interest to more than one entity (for example a company, government department)[18] and so as to distinguish it from routine system development, must address important unsolved problems in unique or innovative ways or solved problems in more effective or efficient ways[16,17]. The work proposed here is relevant and fits the bill of a DS project, because it addresses a significant business problem (*lack of access to affordable school management system to under-resourced schools in South Africa*), it proposes the development of an innovative artifact (*Cloud SAMS*) that seeks to exploit a new technology (*cloud computing*) and its solution is relevant to more than one entity (*multiple schools with resource constraints*).

In view of the foregoing, CloudSAMS is a software artifact that embodies a complete working system, whose efficacy and utility will be evaluated as part of this work. The

section that follows describes the design, implementation and testing of CloudSAMS. In pursuit of DSR, this was then followed by its evaluation to establish its efficacy and viability.

4. Design of Cloud SAMS

One key attribute of cloud computing that contributes to lowering of costs and improving operational efficiencies (such as support and maintenance) is multi-tenancy [20]. Guo et al [21] describe multi-tenancy thus:

“In a multi-tenancy enabled service environment, user requests from different organizations and companies (tenants) are served concurrently by one or more hosted application instances based on a shared hardware and software infrastructure”.

Multi-tenancy denotes sharing of resources and can theoretically be applied at all levels of a typical hardware and software stack. Single-tenancy denotes a case where no resource sharing takes place, such as SA-SAMS. Figure 4 below shows the different levels at which multi-tenancy can be applied. Applying multi-tenancy at a specific level implies that layers below that level are shared among tenants, but each tenant gets its own dedicated instance for all the layers above [22]. To achieve separation, this sharing applies to the application and data layer independently. For example, when multi-tenancy is applied at the database server level, all tenants share the hardware, virtual machine and operating system, but each tenant gets a dedicated database instance.

Cloud SAMS is a multi-tenant adaptation of SA-SAMS.

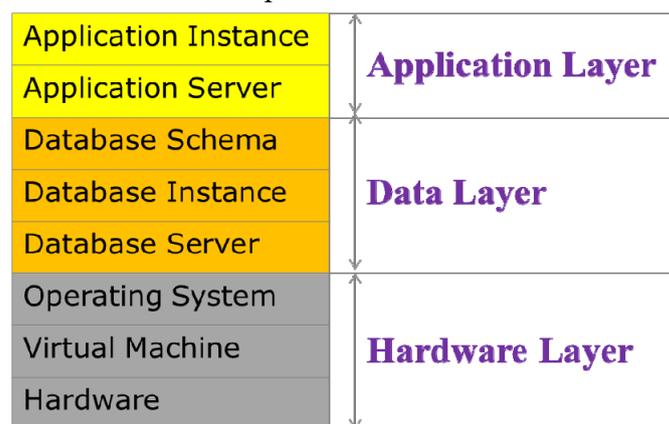


Figure 4 Hardware and Software Stack: (Adapted from [22])

Enterprise architectural designs usually separate a system into distinct application and data layers, each running on dedicated hardware server or virtual machine(s) of its own. In cloud based applications, the presentation layer is the standard web browser. Further to this, issues of the underlying infrastructure such as the hardware servers, the virtual machines and the operating system are handled by the cloud service provider and have little impact on the multi-tenancy architectural choices. The application layer and the data layer have the most significant impact when choosing a multi-tenant architecture [22]. In a way, the design of Cloud SAMS reduces to choosing a multi-tenant configuration at the application and data layer that best addresses the limitations observed in SA-SAMS (as discussed in the introduction section).

4.1 Key Desirable Attributes of Cloud SAMS

For Cloud SAMS to address the limitations observed in SA-SAMS, it needs to have the following key attributes:

- It should be easy to support and maintain. A small team of well-trained technical personnel should be able to support a large number of schools.

- Upgrades should be easy to implement. A single upgrade should automatically be available to all schools.
- It should be cost effective. Operating costs (such as annual licenses) should be kept as low as possible.
- A single server should support a relatively large number of schools.
- Schools should access only data that belongs to them. In other words, school data should logically be isolated.

In the following two sections, the possible multi-tenant configurations applicable at the data layer and the application layer are discussed, including the factors that influence the choice of each. This discussion will form the basis of the multi-tenant architecture we chose for Cloud SAMS.

4.2 Multi-tenancy at the Application Layer

When multi-tenancy is applied at the application layer, tenants can share either the application instance (in our case Cloud SAMS) or the Application Server. There are three different possible configurations at this layer.

Option AS1: Separate Application Server, Separate Instance for Each Tenant

This implies that each tenant (read school in our case) gets its own dedicated application server and application instance. Figure 5 below illustrates this scenario.

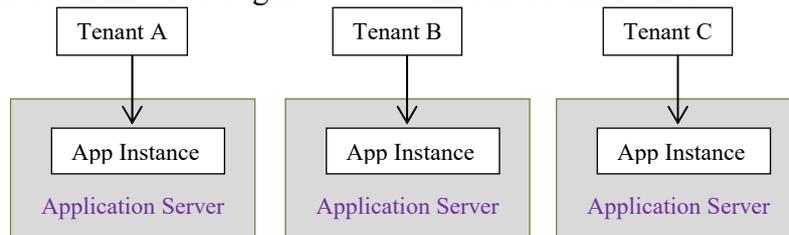


Figure 5. Each Tenant Gets a Dedicated Application Server and a Dedicated Application Instance

This option may be useful in cases where the number of concurrent users per tenant is very high. The application server licenses may be high.

Option AS2: Tenants Share One Application Server, But Each Gets a Dedicated Application Instance

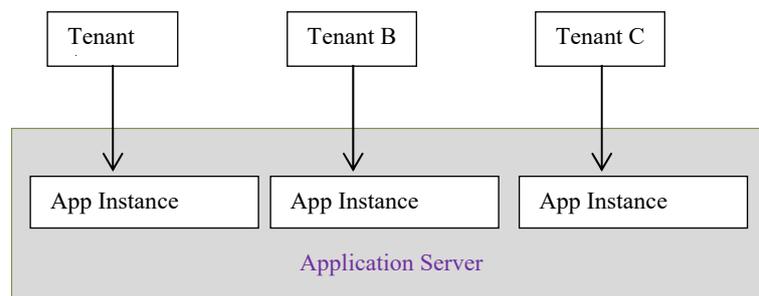


Figure 6. Shared Application Server, Separate Application Instance

This option is appropriate in moderately loaded application servers.

Option AS3: Shared Application Server, Shared Application Instance

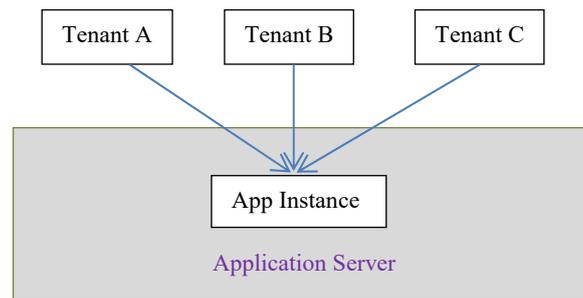


Figure 7. Shared Application Server, Shared Application Instance

This option is appropriate for cases where the tenants have only a few users each.

4.2.1 Which Option for Cloud SAMS?

Table 2 below analyses the three multi-tenant models described in this section using a set of criteria derived from the general requirements for Cloud SAMS discussed in section 4.1 above.

Table 2. Application Layer Level Multi-Tenancy Analysis

Criteria	Option		
	AS1	AS2	AS3
Support and Maintenance Costs	High	High	Low
Ease of Upgrades	Difficult	Difficult	Easy
Server Licensing Costs	High	Low	Low
Number of Tenants per server	Very Low = 1	High	High
Tenant Isolation	High	Moderate	Low

Based on the assessment criteria summarized in Table 2 above, option AS3, where all tenants share one application server and one application instance is the best option for Cloud SAMS. The Free State province has about 1200 schools. On average, each school has about 50 users. The load remains low most of time, peaking during admissions at the beginning of the year and at the end of the term when schools are processing marks. During periods of high volume transactions, more processing capacity can be added to pick up the load.

4.3 Multi-Tenancy at the Data Layer

At the data layer, tenants can share the database server, a database instance or a database schema. There are four possible alternatives, each of which is illustrated below.

Option DB1: Separate Database Server, Separate Database for Each Tenant

Here each tenant gets a dedicated database server, and a dedicated database instance.

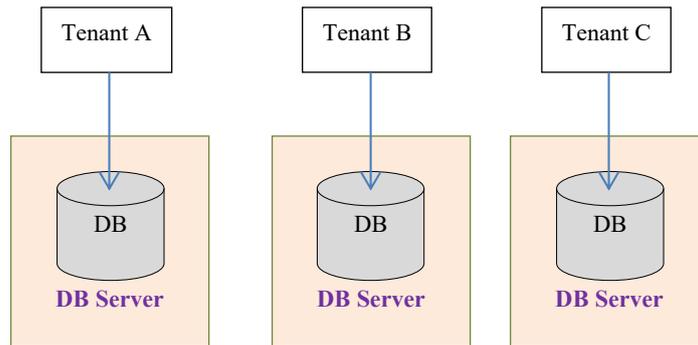


Figure 8. Separate Database Server, Separate Database Instance

This scenario represents a single tenancy approach and provides the best isolation between tenants. However, it incurs the highest costs because each tenant needs its own dedicated database server. It is closest to the on-premise approach (SA-SAMS).

Option DB2: Shared Database Server, Separate Database Instance

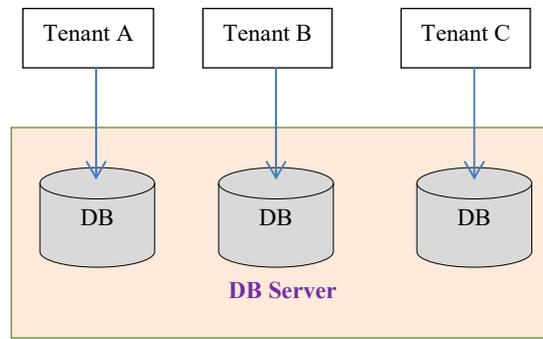


Figure 9. Shared Database Server, Separate Database Instance

In this configuration, all the tenants share one database server, but each tenant gets a separate database instance, maintaining good tenant isolation. This approach incurs less licensing costs than the previous case because all tenants share one database server.

Option DB3: Shared Database Server, Shared Database Instance, Separate Schema

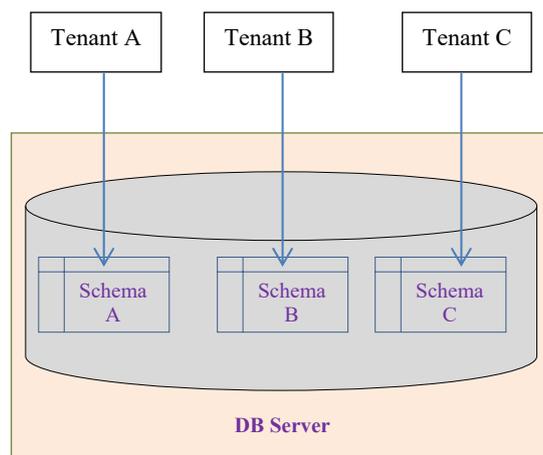


Figure 10. Shared database server, Shared database instance, Separate Schema

In this approach, multiple tenants share the same database instance but each tenant has its own set of tables that are logically grouped into a tenant specific schema [20].

Option DB4: Shared Database Server, Shared Database, Shared Schema

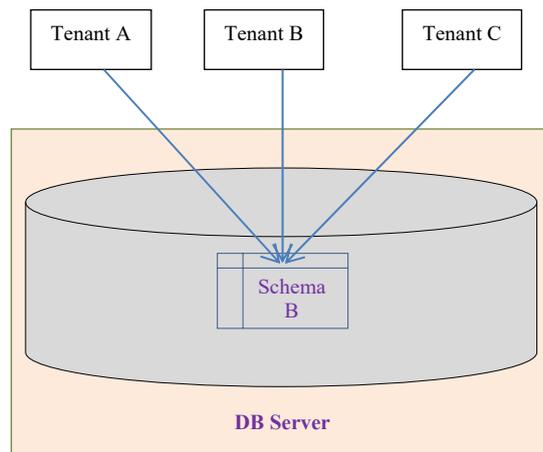


Figure 11. Shared Database Server, Shared Database Instance, Shared Schema

In this approach, multiple tenants share the same database instance and tenant data is stored in the same tables. A Tenant ID column is added to each table to help identify the owner of each row. Of the four approaches explained here, the shared schema approach has the lowest hardware and backup costs, because it supports the largest number of tenants per database server [20]. However, because multiple tenants share the same database tables, this approach may incur additional development effort in the area of security, to ensure that tenants can never access other tenants' data, even in the event of unexpected bugs or attacks. A common approach is to use tenant specific views by appending a TenantID filter to every query submitted to the database query processor

```
SELECT .....FROM .....WHERE TenantID =
```

4.3.1 Which Option for Cloud SAMS?

Table 1. Data Layer Multi-Tenancy Analysis

Criteria	Option			
	Option DB1	Option DB2	Option DB3	Option DB4
Support and Maintenance Costs	High	High	Moderate	Low
Ease of Upgrades	Difficult	Moderately Difficult	Moderate	Low
Server Licensing Costs	High	Moderate	Low	Low
Number of Tenants per server	Very Low (= 1 tenant per server)	Low	Moderate	High
Tenant Data Isolation	High	High	Moderate	Low

Based on the desired attributes for Cloud SAMS mentioned earlier, option DB4 seems the most appropriate.

4.4 Combined Cloud SAMS Architecture

Combining the multi-tenant configurations identified at application and data layer, Figure 12 below shows the multi-tenant, three-tier architecture for Cloud SAMS as implemented in this paper.

In this case all the schools (School A, School B, etc.) share one copy of Cloud SAMS. Both the Application server and the Database server are cloud based. All schools share the same schema, with a mandatory TenantID column added in each shared table to help identify the school that owns the row. Figure 13 below shows a partial snapshot of Cloud SAMS's E-R Diagram. Note the inclusion of a SchoolID column in each shared table to help identify the school to which an individual row belongs.

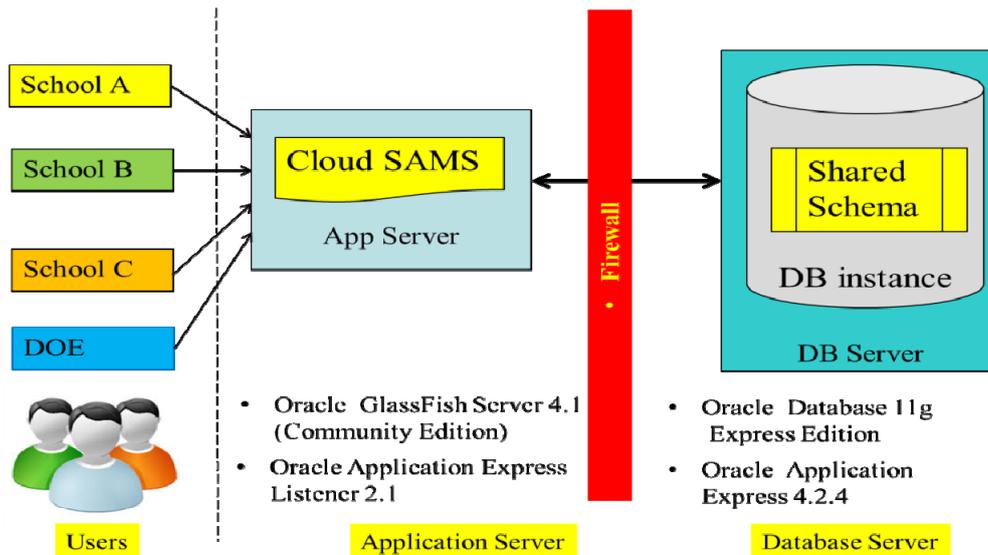


Figure 12. Three Tier Architecture for Cloud SAMS

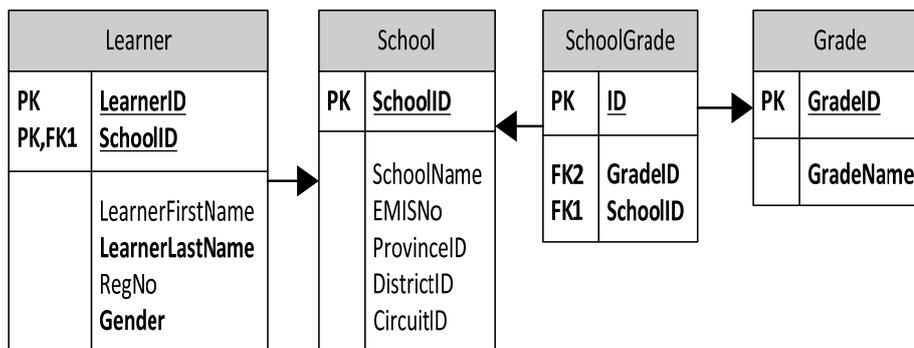


Figure 13. A Partial Snapshot of Cloud SAMS's E-R Diagram Showing the TenantID (i.e. SchoolID) Column

4.5 Cloud SAMS Authentication and Access Control

Cloud SAMS uses Role Based Access Control (RBAC) [22] to manage authentication and regulate access to the different application modules. User profiles (user names, roles, tenant identification etc.) are held in a set of tables. There are two main categories of users: school users and the ministry of education users. Ministry users can generally access data for multiple schools depending on their individual roles. For instance, an official at the district level only accesses data for schools in his district, whereas an official at the provincial headquarters is allowed access to all schools in the province. User profiles are highly configurable, and a user may be granted more than one role. School users have access only to data belonging to their school. The authentication module extracts the TenantID (in this case schoolID) and uses it to correctly determine which school this particular user belongs to. In addition, School users are classified into several roles: administrators, school principals, head of departments, educators, learners and parents. A similar process is applied to the Ministry Users. Each role is allocated access to different Cloud SAMS modules and sub modules depending on the individual tasks associated with the role. Once a user is authenticated, access to the application is granted. The user role determines which modules a valid user can access and which tasks the user can perform in that particular module. For example, if an admissions clerk from school 40001 logs in, he or she may only get access to the Learner Admissions module and not to the Exams Module. Further to this, he or she may INSERT new learners but is not allowed to DELETE them. In addition, the

schoolID field is embedded in each SQL request sent to the database as a filter to ensure a user only gets access to data belonging to his/her school. Figure 14 illustrates the security mechanism for Cloud SAMS.

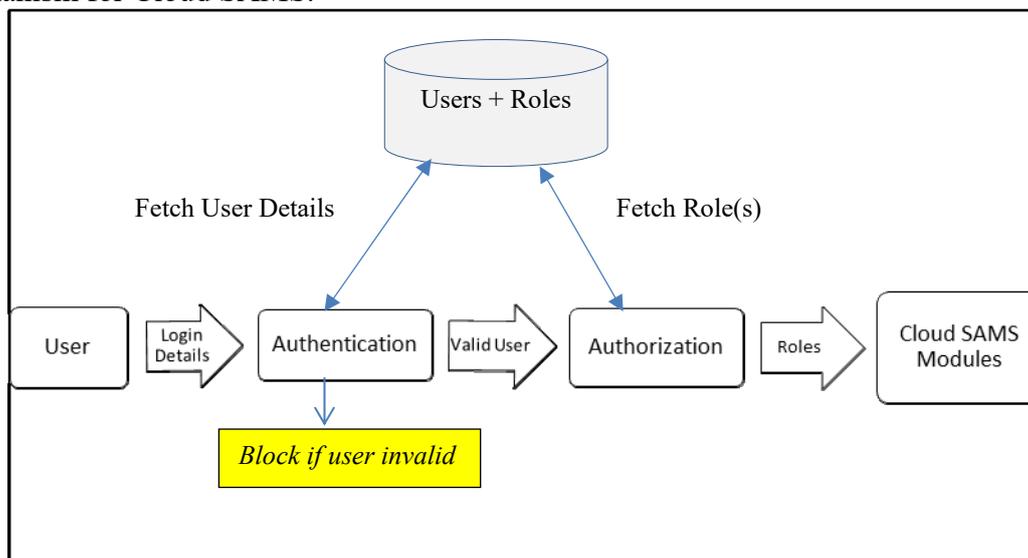


Figure 14. Authentication and Authorization architecture for Cloud SAMS

5. Implementation and Initial Evaluation

5.1 Cloud Platform and Pilot Schools

Cloud SAMS is hosted on a platform comprising 2 Virtual machines (VMs) running on VMware with 4GB RAM and a 200GB storage capacity. Access to Cloud SAMS was via standard broadband Internet connections (1Mbps to 2 Mbps).

The pilot run for Cloud SAMS involved 5 under resourced schools drawn from the Free State Province of South Africa. All five schools have at least 7 years' worth of data stretching back to 2008 when SA-SAMS was first released to schools. On average, each school has about 600 learners and about 50 teachers.

5.2 Evaluation through Qualitative Interviews

The initial evaluation of Cloud SAMS was carried out by interviewing some of the teachers and school administrative staff involved in the pilot phase. The core features of SA-SAMS are replicated in Cloud SAMS, so users find it easy to switch from the desktop based SA-SAMS to the web based Cloud SAMS.

5.2.1 Convenience and Time Savings

Teachers felt that Cloud SAMS simplifies some of their core tasks such as capturing data on assessments (assignments, homework, tests, and exams). On average, Cloud SAMS reduces the amount of time educators spend on working with assessments by almost 40%. Figures 15 and 16 below shows how Cloud SAMS makes this possible.

5.2.2 Technical Support and Maintenance

Regarding technical support and maintenance aspects, schools are happy that Cloud SAMS will eliminate the need for the hated "software patches" that have become synonymous with SA-SAMS. Patches are downloadable software snippets that are meant to upgrade SA-SAMS in case there are new extensions or in case of bugs. Most schools find these "Do it Yourself" software fixes problematic. Since Cloud SAMS is centrally hosted and shared by

all schools, installation, support and maintenance is faster and cheaper for the MOE. A small group of technicians supports all schools from one central location without making unnecessary physical visits to schools.

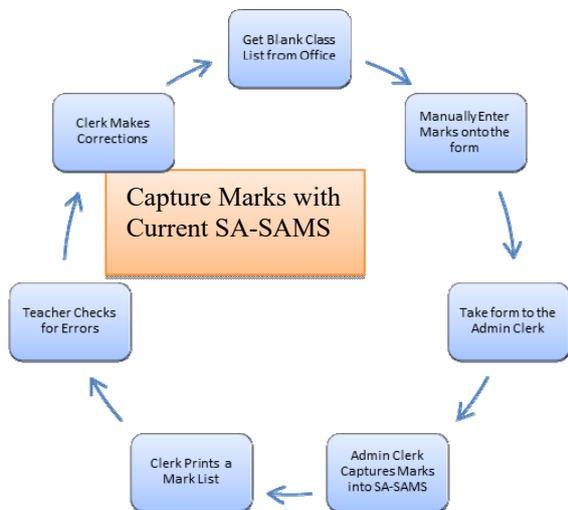


Figure 15. Capture Marks with Current SA-SAMS

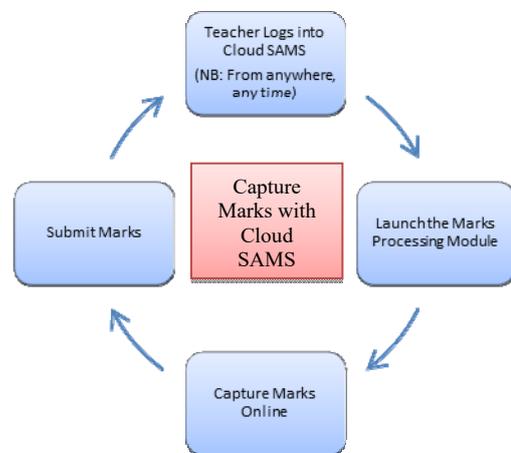


Figure 16. Capture Marks with Cloud SAMS

5.3 Convenience of Any Time, Anywhere Access

The convenience of accessing the system any time anywhere is also appealing to majority of teachers. They do not have to queue in the admin office waiting for mark sheets or attendance records. They can access these online.

5.3.1 No Manual Data Submission

Teachers and admin clerks feel that eliminating the manual submission of data to the MOE will improve their productivity in their primary roles.

6. Conclusions and Recommendations for Further Work

This paper discussed the development of Cloud SAMS; a cloud based school management system for South African public schools that replaces a legacy school management system called SA-SAMS. Most of the challenges that confront SA-SAMS can be attributed to its inferior architecture; a standalone implementation. Cloud SAMS, a single, shared application that is centrally managed, helps resolve most of challenges facing SA-SAMS; difficult and costly support and maintenance, limited accessibility and collaboration among key stakeholders such as teachers, learners and parents, cumbersome and tedious manual submission of school data to educational authorities as well as lengthy implementation cycles. By addressing these problems, Cloud SAMS makes it possible for all schools, even those with resource constraints, to access and use a system that they would ordinarily not be able to individually own and operate. Crucially, Cloud SAMS also streamlines the process of capturing, storing and analysing school data for the DOE, reducing the burden that schools face in this regard, and shortening the time required to process school statistics. This ability to quickly access quality school data when required, will not only improve productivity in schools, but also help the DOE identify problem areas (e.g. high student absenteeism) and institute timely interventions.

Initial evaluation shows Cloud SAMS will gain widespread acceptability among schools. Despite the benefits that Cloud SAMS bring, schools without Internet connectivity will obviously be unable to use it. But, current efforts from government in improving connectivity to schools offer great hope to thousands of schools (especially in rural areas).

The next step is to track the usage of Cloud SAMS, improve it by adding new features or improve existing ones. Another aspect is to evaluate how well it scales as more schools come on board, especially regarding response times. Extending it to incorporate a Business Intelligence (BI) component that makes it possible for schools and the DOE to better analyse data generated from Cloud SAMS is also an important next step.

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