A UNIFIED STRATEGIC MODEL FOR ISOLATED SYSTEMS INTEGRATION

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ABSTRACT

Several isolated systems are designed for the enterprise's integrated automation. These systems not only support automation of salient processes in the enterprise but also resolve issues related to functional or nonfunctional requirements of the academic and non-academic problems. It is inevitable and enforces organizations to change with respects to time to align the changing needs of the organization without retiring the legacy of systems. Several isolated systems are usually developed for different needs at different times using different platforms and technologies.

The current state of isolated systems consists of several challenges like data & operations redundancy, multiple authentication & authorization, system heterogeneity & complexity. This challenge leads to wastage of time, cost and efforts. Institutions are facing such challenges to establish a balance between uses of existing legacy systems along with adapting new systems in future expansion. As a case, Arba Minch University (AMU) is also facing such challenges where the study is focused to collect primary data for study and analysis. This research study is an effort to develop a unified strategic integration model for isolated systems with new features like Single-Sign-On, centralized common database, integration and inter-operability.

The study deeply investigated and analyzed the opportunities and challenges in terms of integration for single sign on, centralized database control and integration and interoperability. Finally, a unified strategic integration model for isolated systems USIMIS is designed with RESTful API and Centralized database for the functional modules using two selected systems i.e. simulated E-learning over Moodle and simulated SMIS over OpenSIS for functional demonstration and validation. The new knowledge based system was evaluated by user test data for its significance need, relevance and efficiency.

KEYWORDS

Software, Isolated System, Integration Strategy, SOA, Integration Model etc.

INTRODUCTION

Isolated Enterprise Systems are systems that are separate on the design, platform, business and technology to facilitate information flow in the enterprise. Developing countries universities like Arba Minch University (AMU) who are in first generation augmentation state and having financial limitations have different systems designed and deployed in the web portal are used to manage resources and services.

The major categories are: 1) Academic / Learning Management Systems: These software systems whose main goal is to manage data on courses, subjects, teacher, students, research, and E-learning. 2) Administrative / Management Systems: Such systems whose main goal is to help manage personnel and / or planning and management, and financial management at the university like SMIS, Humana Resource Management System, Financial management systems and Warehouse and Inventory Management Systems. 3) Support Service Systems: are used to manage users and access control of the infrastructure. The enterprise system is one of the system integration approach in which all isolated systems exist in the enterprise is integrated for the common goal. Educational enterprise system is a concept or an information technology solution that automates all the academic and non-academic services / resources of the institute.

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Typical academic services may include registration, admission, recruitment, and students' records. Non-academic or administrative functions include accounting, payroll, human resource, billing etc. (1). Today as a matter of facts, adaptation of enterprise systems is the biggest challenge (1). This is because; the adaptation enterprise systems should not affect the preexisting system's operations and business rule of the organization. The challenges arise when an educational enterprise's software systems need integration. The advantages are, no doubt, numerous like starting from the reduction in the costs of maintenance of several information systems upto simplification of workflows (2). For instance, if organization has several software developed for different process automations; and the software are running very well but gradually creates challenges like redundancy of data, duplication of efforts, multiple authentication and authorization on salient gateways. In case of universities of developing countries having procured ICT or software systems in phased manners in general and AMU in specific case under investigation this study; the researcher observed that universities have several well-developed, well-tested and implemented systems; and running successfully. Different organizations and developers using salient tools and technologies for different purposes developed these systems. As a technology trend, the existing systems consume lots of bandwidth on isolated system, which can be unified (3).

LITERATURE REVIEW

The two main approaches of system integration are adopted in this research study and that are enterprise system and the system integration. In the Enterprise system, systems are divided into traditional and web enterprise system, and the second system integration partitioned into 1) Enterprise Application Integration 2) component based software system 3) Standard interface and open system. System integration is a process whereby a cohesive system is created from components that were not specifically designed to work together. The term integration is the process of inter-connecting one system with another system in order to provide a useful exchange of information, data and/or control between the systems (4). Now-a-days organizations are using intranet platforms to integrate their isolated systems under single umbrella like project, management, control, and socialization of employees with single sign-on (5). For this research outcome case, we selected the second system integration approach to integrate E-learning with Simulated Student Information system. The main feature of isolated enterprise system are data redundancy and operations, multiple authentication and authorization, incompatibility, data integrity and system heterogeneity are the major issues of isolated enterprise systems.(6) Applications can use the single sign-on system to provide users with seamless access to content that is stored and managed in disparate systems without requiring the user to log on multiple times. The system includes an application-programming interface (API) for creating a single sign-on implementation and a service provider interface (SPI) for creating authentication plug-in modules that interface with existing authentication standards. The integration tool i.e. Web services integrate different middleware systems. Web service is used extensively and largely in distributed prototype system. Even in E-Governance web services, such systems have already introduced (7). The general schema for web service based software is publish, find and bind. Service-oriented data integration architecture has been proposed to provide a dynamically unified view of data on demand from various autonomous, heterogeneous and distributed data sources. Service providers publish their data sources as data access services, which may then be discovered, bound at the time they are needed and disengaged after use. Hence, the changes such as organization structures, backend data sources, data structures and semantics could be managed dynamically and potentially reduce the maintenance cost (8). Web service has three major protocols i.e. REST, SOAP and XML-RPC. REST web service protocol has been used to integrate for E-learning system and Open student Information Systems. Interoperability and integration is the challenging issue for isolated systems in the enterprise that are designed for different functionality and purpose with different technologies. (9)As interoperability is the capability of communication with peer systems and right to use functionality of isolated system. System integration may enable the decision makers to explore the full potential of decisions using data analytics (10). Integration enables sharing and exchanging of information to different isolated systems. The related work like Integration of Information and E-Learning Systems in Higher Education (11) focuses on CMSJoomla as the central portal to integrate other isolated systems (12). However, in our proposed study Moodle is the central portal to integrate simulated student information systems. The other work ENOSHA and Moodle: The Integration of two E-learning Systems (13) focuses on, Single Login for salient systems of enterprise was developed using eNOSHA system and Moodle system to speed up the flexibility and usability of inter system communication using XML-RPC protocol (14). The integration technology on the related XML-RPC is an old protocol related to our REST protocol, which is used in our proposed model. In related study, E-learning system also customized using old

Moodle 2.0 version, which is again challenge of limited plugins and features, but in this proposed study Moodle version 3.2.2, is used with extended features and plugins.

RESEARCH DESIGN AND METHODOLOGY

This research study is a constructive research because it develops a unified integration strategic model for isolated enterprise systems, which suggests a new knowledge about isolated system has to be integrated in unified ways. The research approach is also qualitative and quantitative approaches used to analyze the inputs from questionnaire.

The major primary data collection methods incorporated is: 1) Interview is conducted from domain experts called technocrats (ICT Directorate, System administrator team), and end users. The interview is purposely carried out to access isolated enterprise system needs integration and interoperability among each other. The researcher interviewed the technocrats with basic parameters of isolated systems. The basic parameters of isolated system considered in this research are multiple authentication, data redundancy and operation, system heterogeneity, system readiness assessment and data integrity. 2) Questionnaire: The set of questions were distributed and responded by respondents/stakeholders.

The questionnaire was mixed type questionnaire i.e. both open-ended and close-ended questions. This research study prepared online survey structured questionnaire using Google Forms. The structured Questionnaire sends to each respondents through their email. The respondents' response is stored on Google Spreadsheet and analyzed.

3) The document analysis data was collected from different sources such as software integration journals that provide concepts of software integration and unification, research papers, reports, E-books, white paper and literature review of reports.

4) Technical observation: is one the method of collecting research facts / data. Direct observation provides strong input for the research and lead to investigate how really the isolated system works in the enterprise. As the researcher personally observed the isolated systems that are not integrated and not interoperable.

5) Sample Size and Selection Strategy: The size of the sample is determined by the optimum number necessary to enable valid inferences to be made about the population. The sample size for this research study selected was forty (40) which depends on different conditions and criteria's set by researcher for selecting respondents for Open-ended interview and Online Survey. The sample size is purposive, because it was focused on the inputs of stakeholders and domain experts. The research study used selected tools and open source for data collection (cloud based Google forms), Data Analysis (SPSS), and Strategic Model simulation (Moodle & OpenSIS) and (web service) and tool integration method for integration. The two open source used in the research are: 1) E-learning system simulated over Moodle 2) Simulated SMIS over OpenSIS: new paradigm in student information management system. Both Web service and middleware is integration tool in servicer-oriented architecture. In our research study, we choose web service tool as the best integration tool relate to middleware technology using different parameters like platform dependence. Interoperability, reusability, heterogeneity and technology.

DATA ANALYSIS

The basic data analysis parameters used in this research study for unified integration strategy of the isolated systems, are 1) Single sign on, 2) centralization of access, 3) Interoperability, 4) Modular and Open Architecture 4) Service Oriented Architecture and Web services, 5) Data structure and Format , 6) Scalability, 7) Integration, and 8) Quality of Service.

Designing the Model, Validation and Evaluation

After detailed isolated enterprise system integration readiness assessment like 1) Integration readiness level metrics was used to measure the integration maturity between two or more components. In the selected isolated systems at AMU, Moodle was selected because of 1) open source nature and 2) built-in web service tool for integration with other systems. Therefore, Moodle is ready for integration purpose. The researcher observed with a technocratic view

that the systems like SMIS is not ready for integration purpose. 2) System Readiness Metrics is an innovative mechanism that provides a system level metrics to help reduce integration issues and leading causes of system development failures. Implementation of the System readiness assessment mechanism aids decision makers in identifying both programmatic and technical risk areas (15).

E-learning systems can be used in different environments such as in education, training and development, and business settings. Educational institutions use Moodle as a tool for creating online web sites for their students to conduct fully online courses. To build collaborative communities of learning, it includes many activities such as forums, databases, and wikis. It can be used as a way to deliver content to students and conduct continuous assessment through assignments and quizzes. Moodle considers the following main roles in its architecture (16).

The main actors of the E-learning system are: 1) Administrator: Can do anything in the system and in any course. 2) Course Designer: Can create courses, teach them, and assign other to teachers' roles. 3) Non-Editing Teacher – Can teach a course and evaluate students but is not allowed to change their activities. It can be represented as an assistant teacher or a part-time teacher. 4) Student – Can participate in activities created by teachers inside a course, either individually or in groups (when applicable), but cannot change them.

The student information system is customized from OpenSIS; an open source system to simulate the real SMIS exists in the Enterprise. The major actors of the system are Student, Parent, Administrator and Teacher. OpenSIS is web-based, open source, and comes packed with features that include student demographic info, scheduling, grade book, attendance, report cards, eligibility, transcripts, parent portal, student portal and more (Placeholder4). The selection of suitable integration strategy tool for system can make the systems to be integrated.

The major integration tool used is: 1) Data Integration: Is integration strategy, which uses the import /export feature of both systems and relies on the support common data format. 2) Application Programming Interface (API) Integration: This integration strategy allows users to benefit functions and web service API documentation directly from E-learning system. 3) The Tool Integration: Learning tool interoperability (LTI) is used to allow remote tool and content to integrate into Moodle LMS. The main usage of LTI is to build links between learning tool and LMS i.e. Moodle. The type of integration strategy is the most suitable for educational institution like Arba Minch University to integrate isolated systems in low cost and increase the suitability for the teaching and learning environment between instructor and students.

Figure-1: A Unified Strategic Integration model for Isolated Systems (Simulated Moodle and SMIS)
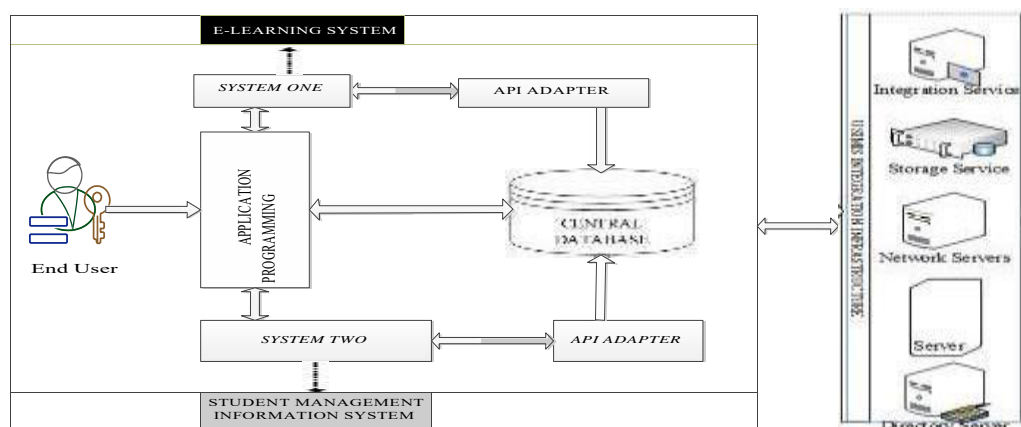
Sources: Authors Compilation

In order to mitigate data redundancy for the two isolated enterprise system i.e. E-learning System and Student Management information system, the common centralized database has been designed to store the commonly used database.
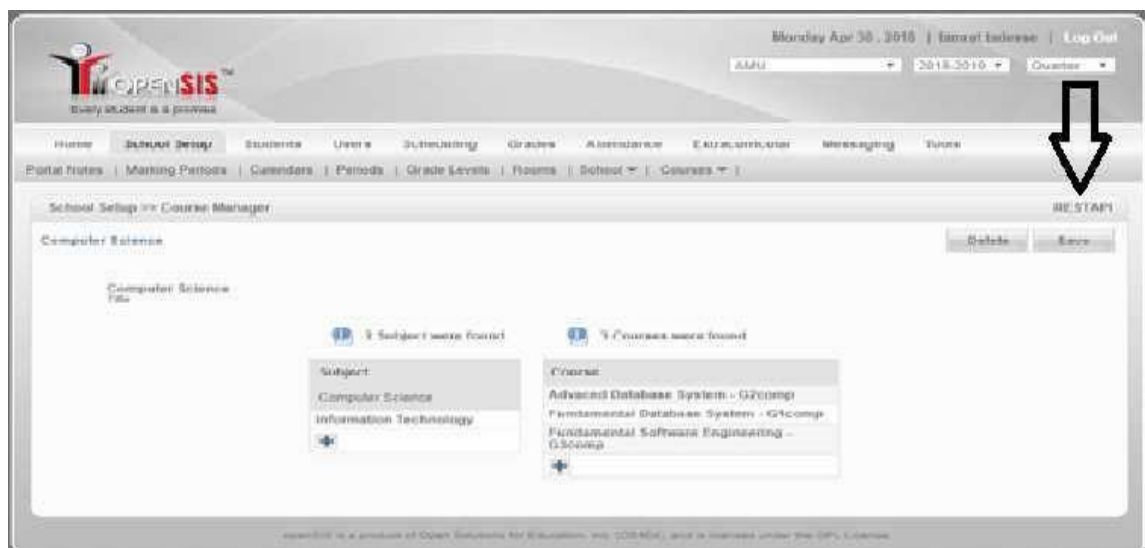
Figure-2: Designing Centralized Database for Functional Modules
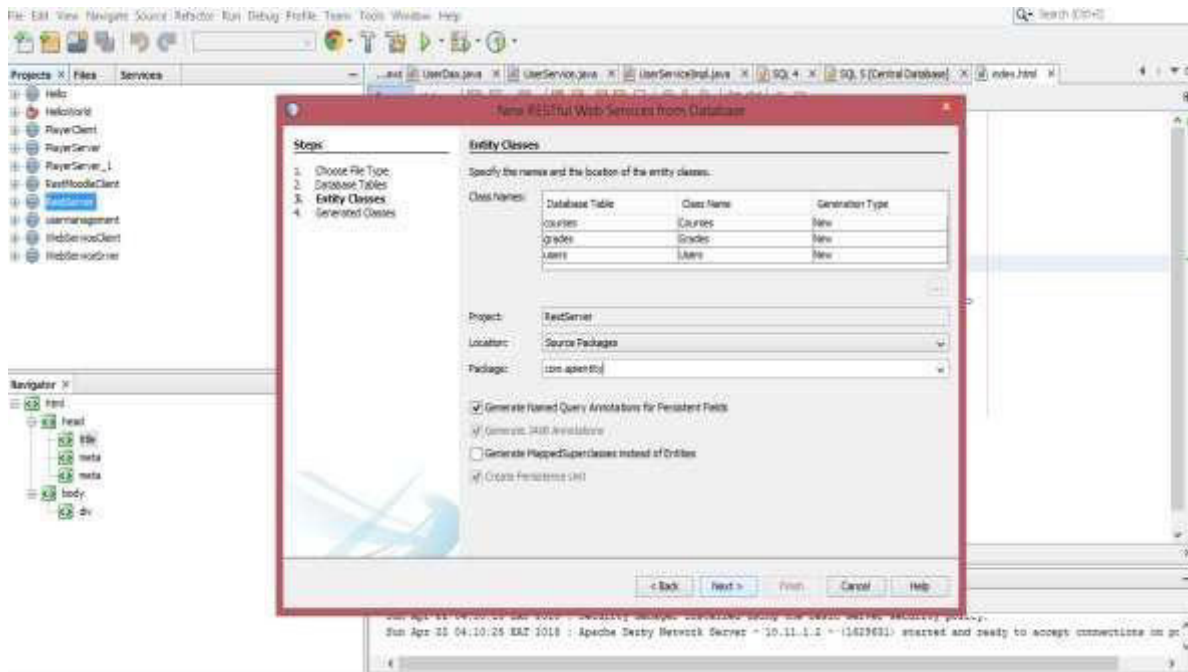
Sources: Authors Compilation

In the Simulated SMIS, the RESTful API interface is designed to single sign on from SMIS to directly to the API, which the common module. Without re authenticating the Simulated SMIS, the single sign on action is performed.
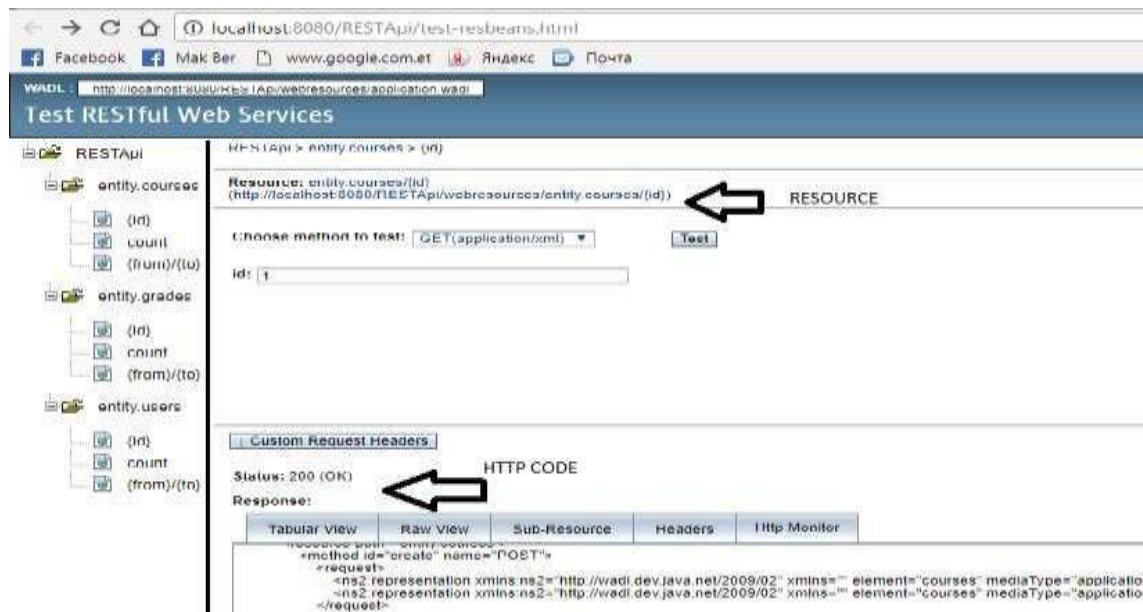
Figure-3: RESTful API over Simulated SMIS
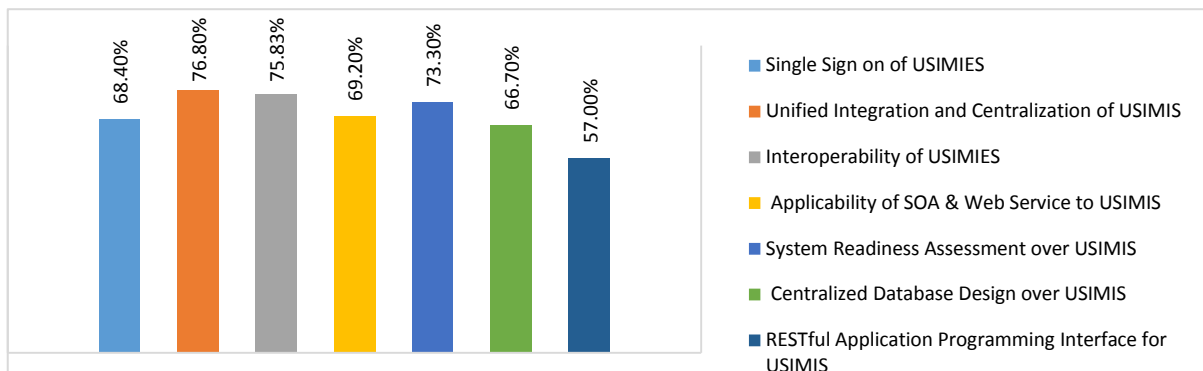

Sources: Authors Compilation

Interoperability aims to overcome the inconsistency between diverse systems of isolation in the enterprise like AMU. The interoperability feature of RESTful API used to reduce duplication of efforts and database.

Figure-4: Test Result of RESTAPI

Sources: Authors Compilation

Figure-5: Summary of Evaluation Results of USIMIS

Sources: Authors Compilation

Table-1: Comparative Analysis between Proposed Model (USIMIS) and Existing System Integration Models

S. No.	Parameter	ERP System	Enterprise Application Integration	USIMIS
1	Designing Centralized Database	In ERP System, common single centralized database is sandwiched to store data of all systems.	In this model, software systems' architecture style and legacy systems were integrated in the Enterprise using ESB.	Common Centralized Database designed for the model as general and specifically for the selected modules, the Centralized Database is implemented.
2	API	The System of ERP divided into front ended and back ended systems. The integration takes out in the data access layer.	Use Messaging Bus (Centralized Engine) to exchange the data.	The RESTful API is used which is as a between to the isolated systems and fetches the data from the centralized database.
3	Single Sign On	Use One Login.	Link business process.	API supports to single sign on in the proposed model.

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4	Inter-operability	ERP system both technological level and business level interoperable because the SOA and web service.	Since the Current EAI uses ESB, it is interoperable with not only with on premises system but also with third part systems.	Web service is cross boundary interoperable tool, which is used to make the isolated systems interoperable.
5	Integration Technology	The early ERP System uses Point to point integration method. Due to limitation of P2P, ERP system started to use integration adapter and ESB technology in the current situations.	(RMI, RPC, CORBA, and DCOM): this is traditional integration tools. This model use web service for better integration. Uses XML based Middleware.	Web services are used to integrate the isolated systems in proposed model. Web service (XML-RPC, SOAP and REST) the major protocols.
6	Scalability	ERP system supports scalability of different modules.	Since ESB is scalable and distributable, the modern EAI supports.	The new model uses Web service API that is scalable and common centralized Database, which can proposes a replica server in future.
7	Flexibility	ERP modules can be detached and integrated without affecting the existing modules.	Since ESB is easy to expand, EAI supports the flexibility.	Since RESTful API is designed from web service, and Supports both flexibility in modification and functionality.
8	Portability	In the current state of art, ERP uses the middleware and web service, which include portability.	The modern EAI is easily portable because it uses SOA, ESB, XML based Middleware.	Since web, services are the technologies, which are platform independent and can integrate different systems developed in isolated environments.
9	Security	Centralized security policies are applied to secure the systems.	It is easy to implement security over ESB.	The authenticated users only have right to access the proposed unified model based system when deployed.
10	Reusability	The modem ERP system supports Reusability because it uses the current integration technologies.	ESB which the combination b/n ESB and traditional middleware supports reusability.	SOA fully supports the reusability function and service.

Sources: Authors Compilation

CONCLUSION

This research study mainly focused on the integration of isolated systems in general and academic institutions like Arba Minch University (AMU) as a case of an educational institution. At the outset, two systems were selected for case based observation, analysis, design, development and deployment using salient platforms and technologies. The prime aim of this research was to observe, analyze and resolve the issues and challenges in terms of Unified Strategic Integration Model for Isolated Enterprise Systems to facilitate Inter-operability, Single Sign On and Centralized database Control. During the fact-findings through survey and observation, it was found that the features like future integration and interoperability with common centralized database control was ignored, as it was not the prime aim of the enterprise to develop and implement the aforementioned systems. These ignored issues are considered as the main thrust of this research study to design a unified strategic integration model for single sign on, centralized database usage and control with inter-operability. As case, AMU's systems like SMIS and E-Learning do not provide interoperability, single sign on and common database usage and control in teaching-learning, examining and grade submitting processes.

To make the research study significantly worth conducting and relevant, the researcher gathered and analyzed the facts collected using online survey questionnaire from students, academic staff and technocrats, interview of ICT officials and senior technocrats with technical observation of the selected isolated systems at the sites. The responses and their analysis with respect to aforementioned issues and challenges clearly reveals that the integration of selected isolated systems is worth doing and significantly important. In addition, it is important to ensure effective utilization of legacy systems in future for aligning the newly introduced systems to avoid undesired retirement of the legacy

systems. As a design science contribution in this research study, a unified integration model *"Moodle-OpenSIS USIMIS"* was designed. To validate the model, the Simulated E-learning System and the simulated SMIS were used. These two systems were designed, developed and integrated using Moodle for simulated E-learning System and OpenSIS for simulated SMIS. In order to functionally integrate and demonstrate the two systems, REST Web service was used to implement the RESTful API in this study.

In order to test the model i.e. *Moodle-OpenSIS USIMIS;* a functional demonstration and user evaluation for validation was successfully done using these two systems. In this process, these systems were customized for system integration. This new knowledge based model for 'unified system integration, single sign on and inter-operability with common database use and control' reveals that all other isolated systems or software components of any academic enterprise in general or AMU enterprise as specific, can be integrated without affecting system business rules and functions in cost effective manner. This new knowledge can preserve the legacy of systems on which many resources have been consumed. This will avoid unnecessary and illogical retirement of those legacy systems, which are working with well-tested efficiency and avoid costly retirement of these legacy systems. As a case base study and analysis, the AMU's isolated system integration readiness assessment was also carried out during technical observation. During technical observation and related document analysis; it was found that the isolated systems are being served and controlled via different servers with multiple authentication and authorization which is required to be reviewed, reorganized and restructured for smarter adaption of new technologies without forcefully retiring those systems which are working without any significant deficiency.

RECOMMENDATION

This research tried to achieve the objectives of the study but following activities are considered as recommendation for extension of this research or further studies: During fact-finding technique the researcher observed and investigated the AMU's Isolated Systems only then designed and implemented to solve the specific problems that exists in AMU only. This can be more generalized and extended for all types of institutions.

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