UNIVERSITY OF NAIROBI

PROJECT TITLE:

DESIGN AND IMPLEMENTATION OF AN ERP SYSTEM FOR MEDIUM OFFICE

PROJECT INDEX: PRJ047

BY

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F17/1431/2011

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Project report submitted in partial fulfillment of the requirement for the award of the degree of:

Bachelor of Science in Electrical and Electronic Engineering

DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

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DEDICATION.

I dedicate this project to my adorable, loving and zealous father, my uncles Lawrence and Samson, and my sisters Belin and Marceline.

Thank you for your unwavering love and support.

ACKNOWLEDGEMENT.

I would like to acknowledge the department of Electrical and Information Engineering for coming up with this project. I thank my supervisor, Prof. Mangoli for guiding me throughout this endeavor. His insightful guidance cannot go unmentioned.

I would also like to thank my family for their support and ensuring I had everything to facilitate my completion of this degree program.

I would also like to thank my friends and fellow classmates who encouraged and motivated me during the time I was carrying out this project.

Last but not least, I would like to thank God for the gift of life and health as well as all the blessings he has showered upon me to enable me finish this project.

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ABSTRACT

This project will endeavor to design and implement an ERP system for a medium office. It will do so by first defining what a medium office is and choosing an organizational structure which matches that definition. Different events taking place in the organization will be analyzed and from this an ERP system that focusses on these events will be developed. The event-driven ERP system will be built using a number of application development tools as well as different programming languages. This system will focus on surveillance and access control of the organization.

CHAPTER 1.

1.1 INTRODUCTION

An enterprise resource planning (ERP) software is an enterprise-wide application software package that integrates all necessary business functions into a single system with a common database. Enterprise resource planning (ERP) systems integrate and streamline the business processes of an organization across departmental and geographical borders.

In its basic definition, ERP is an enterprise-wide information system that integrates and controls all the business and technological processes in the entire organization. According to Chung & Snyder (2000), ERP is "a packaged business software system that enables a company to manage the efficient and effective use of resources (materials, human resources, finance, etc.) by providing a total, integrated solution for the organization's information-processing needs". This software facilitates, if well-implemented, the integration of all the functional information flows across the organization into a single package with a common database. Therefore, it allows easy and immediate access to information regarding inventory, product or customer data, prior history information, parking space, surveillance and access control

Today, many public and private organizations worldwide are implementing ERP systems in place of the functional legacy systems that are not anymore well-compatible with modern business environment. However, according to Ahituv et al., (2002), the process of moving from functional applications to an ERP system is difficult and challenging. Additionally, the switch to ERP system is expensive and it requires development of new procedures, training and converting data. Enterprise resource planning systems, also called enterprise systems (ES) are among the most important business information technologies that emerged during the last decade. While no two industries' ERP systems are the same, the basic concept of ERP systems is focused on standardization and synchronization of information, and as a result, improved efficiency. The benefits of ERP systems include coordinating processes and information, reducing carrying costs, decreasing cycle time, and improving responsiveness to customer needs.

The business environment is dramatically changing. Companies today face the challenge of increasing competition, expanding markets, meeting customer expectations and improving

security in the office environment. This increases the pressure on companies to lower total costs in the entire supply chain, shorten throughput times, drastically reduce inventories, expand product choice, provide more reliable delivery dates and better customer service, improve quality, and efficiently coordinate global demand, supply, and production. As the business world moves ever closer to a completely collaborative model and competitors upgrade their capabilities, to remain competitive, organizations must improve their own business practices and procedures. Companies must also increasingly share with their suppliers, distributors, and customers the critical in-house information they once aggressively protected. And functions within the company must upgrade their capability to generate and communicate timely and accurate information. To accomplish these objectives, companies are increasingly turning to enterprise resource planning (ERP) systems. ERP provides two major benefits that do not exist in non-integrated departmental systems: (1) a unified enterprise view of the business that encompasses all functions and departments; and (2) an enterprise database where all business transactions are entered, recorded, processed, monitored, and reported. This unified view increases the requirement for, and the extent of, interdepartmental cooperation and coordination.

1.2 PROBLEM STATEMENT

When a business grows beyond a certain a level, it becomes tedious and complicated to follow up all the processes taking place in it. Not only is it difficult to follow up the business processes of the organization such as accounting and inventory, it also becomes quite difficult to keep track of events such as parking and entry of people into the organization.

The events taking place in the organization can be tracked through surveillance and access control. This calls for the use of an event-based ERP system. It is a system that automates a number of events taking place in the organization such as parking and employee entry. This project set out to develop such a system.

1.3 OBJECTIVE

The project is meant to design and implement an Enterprise Resource Planning system for a medium office. This will be achieved in two steps as follows:

- Defining what a medium office is and coming up with the structure and operations of that office
- Designing and implementing an event-based ERP system for the organization based on the operations identified above.

CHAPTER 2

2.1LITERATURE REVIEW

The following section first explains the evolution of ERP system and some of its characteristics. It also explores the various modules available in an ERP software. Knowledge-intensive nature of ERP systems and ERP system adoption is also analyzed. Finally it looks into critical success factors for ERP system implementation as well as benefits of ERP implementation and use.

2.2 UNDERSTANDING ERP

The first part of this section describes the evolution, characteristics, and various definitions of ERP systems.

Most research studies view the evolution of ERP systems from a manufacturing perspective. In the late 1950s and the early 1960s, automated reorder point (ROP) systems were used for scheduling production, ordering materials, and shipping products within an assigned plant area. During the mid-1960s, computerized materials requirements planning (MRP) systems began to replace ROP systems. These systems represented the first off-the-shelf business application systems available in the market. They supported the creation and maintenance of master data and bill of materials (BOM) across all products and parts in one or more plants. BOM processors and forecasting algorithms along with computerized production reporting tools formed typical parts of the MRP system (Ahituv et al., 2002).

In the mid-1970s, manufacturing resources planning (MRP II) systems began to replace MRP systems. MRP II systems integrated materials as well as production capacity requirements in the calculation of overall production capabilities. In addition, advanced reporting capabilities enabled the efficient scheduling and monitoring the execution of production plans. The IT underlying MRP and MRP II systems focused primarily on automating transactions in order to increase the firm's operational efficiency (Poston & Grabski, (2001)).

The MRP systems typically ran on mainframes, reflected centralized computing, involved limited interactions between users and the system, and had low levels of functional integration.

The MRP II systems, in contrast, mainly used multi-user networks and ran on a variety of IT platforms. The late 1980s witnessed rapid advances in technology and MRP II systems were integrated with other systems such as computer integrated manufacturing (CIM), just-in-time (JIT), electronic data interchange (EDI), and manufacturing execution systems (Light et al. 2001).

In the early 1990s, ERP systems replaced MRP II systems. ERP systems extended MRP II system functionalities to include functions such as human resources, sales and distribution, and quality to create seamless, integrated information flows across the entire firm. ERP systems comprise of a suite of integrated products that use a common IT architecture and can be linked or de-linked and integrated with legacy and other application systems. These systems run on multiuser networks and allow the simultaneous aggregation, de-aggregation, and manipulation of real- 6 time data across functions. ERP systems now form the IT backbone of firms and their functionalities have extended to include inter-firm integration facilitated by business applications such as electronic-commerce (E-Commerce), SCM, and CRM (Light et al. 2001).

2.3 CHARACTERISTICS OF ERP

ERP systems collect data through a single comprehensive database and make it available to modular applications that support all of a firm's value chain activities across functions, business units, and geographical areas. These systems have emerged as the de facto operating standards for firms and represent generic but multi-level configurable and customizable solutions that incorporate best practices which basically reflect a series of assumptions about how firms operate in general (Poston & Grabski, 2001). Researchers have identified a number of key features that characterize ERP systems (Hong & Kim, 2001). ERP systems share the same data definition across all modules through the use of a data dictionary. They facilitate the maintenance of a single set of data across all business processes and hence provide common data access to all users. The use of client-server technology, middleware, and the Internet enables ERP systems to be configured according to the dynamic business needs of firms. An open system network architecture allows any module of the ERP system to be linked or de-linked from the system without affecting other modules. ERP systems also contain repositories, which capture all semantics in business processes, business objects, and firm structures. The discussion in the

preceding paragraph highlights the underlying philosophy of ERP systems as the leveraging of IT to achieve capabilities for harnessing intra-firm and inter-firm resources. ERP systems achieve this by integrating intra-firm and inter-firm activities through a combination of tools, technologies, integration mechanisms, and organization fit strategies (Hong & Kim, 2001). Integration helps in the coordination of business activities. ERP systems embed integration enabling technologies and adopt a process view of the firm. This enables the management of firm interdependencies, thereby enabling cross-functional information flows, language sharing, and cognitive integration among functional units (Parr & Shanks, 2000).

2.4 ERP MODULES

2.4.1 Business Modules

Financials (FI)

The financials module constitutes the operational aspects of the general accounting and financial information for the firm (Cameron & Meyer, 1998). This module meets global accounting standards and typically comprises of integrated multi-site and multicurrency financial solutions that allows for reconciliation of balance sheets, profit and loss statements, and cash flow figures over different corporate entities. Flexible components such as the general ledger, accounts receivable, accounts payable, asset management, treasury management, and investment management, automate and streamline key business transactions across a firm's supply chain. This module enables the firm to balance the needs of its various stakeholders by focusing on key areas throughout the supply chain such as financial and managerial reporting, strategic analysis and planning, corporate governance, and treasury and risk management

Controlling (CO)

The controlling module represents a firm's cost structures and the factors that influence them. This module focuses on areas such as cost control, product costs, production costs, and profitability analysis (Cameron & Meyer, 1998). Also, the module uses activity-based costing methods to track and aggregate work activities along different dimensions (function, process, and product). This enables management consolidation of reporting on profitability of investments and

processes as well as related cost structures (Parr & Shanks, 2000). This module also helps firms optimally monitor and control all performance relevant information in integrated supply chain environments with complete control over their profitability

Materials Management (MM)

The materials management module handles activities related to material acquisitions and their control. The key focus areas are purchasing, inventory, warehouse, and consumption based planning. This module enables centralized and decentralized order/contract management, offers vendor rating functionality to measure supplier performance and uses Web-enabled self-service facilities that allows employees to do their own purchasing with specified vendors (Parr & Shanks, 2000). The module further helps firms balance their inventory levels against customer demand and supplier requirements by providing visibility, monitoring, adjustment, and control capabilities. It also serves as an inventory-planning tool, and manages complex warehouse structures, storage areas, and transportation routes (Cameron & Meyer, 1998).

Production Planning (PP)

This module addresses the core logistics functions of a firm and coordinates manufacturing and supply efforts on customer orders. The module scope includes key areas such as the different phases, tasks, and methodologies used in production planning (types, material procurement, and time) and the production process itself. The typical components that form part of this module include MRP, capacity requirements planning (CRP), Kanban/JIT, master planning, assembly orders, production orders, service maintenance, sales and operations planning, and work order management (Cameron & Meyer, 1998; Parr & Shanks, 2000).

Sales and Distribution (SD)

This module is transaction-intensive and enables the management of all sales and distribution activities such as ordering, promotions, competition, marketing, sales leads, call 78 tracking, planning, mail campaigns, and billing. It allows for the definition and control of pricing structures, transportation and shipping routes, and foreign trade. Firms also benefit by faster communications due to the incorporation of EDI and Web-enabled features in this module (Cameron & Meyer, 1998; Parr & Shanks, 2000)

Supply Chain Management (SCM)

This module extends the scope of ERP systems to include planning and execution capabilities to manage inter-firm supply chains operations. The module helps firms manage their back-offices' linear, sequential, as well as adaptive supply chains, by providing firms with planning and execution capabilities to manage internal operations as well as extended inter-firm operations. The key components include order processing, inventory control, inventory planning and forecasting, distribution requirements planning (DRP), MRP, purchasing audit, customer order management, supply chain manufacturing, and supply chain planning (Comerford, 2000)

Human Resources (HR)

This module includes all business processes required to efficiently manage a firm's human resources needs – from recruitment to post termination benefits. The areas typically focused are personnel, payroll, e-recruiting, time management, training, benefits, workforce deployment and analytics, and self-service delivery. The module and its associated processes incorporate practices that adhere to specific country regulatory requirements concerning employment, taxation, and benefits (Cameron & Meyer, 1998).

Customer Relationship Management (CRM)

This module facilitates extension of the ERP system for automating and streamlining of front-office functions such as sales, marketing, collaborative order management, and customer service (Comerford, (2000)). Recent functionality additions include real-time availability checks, contract management, billing management, fulfillment visibility, and order tracking besides facilitating marketing planning, campaign management, telemarketing, lead generation, and customer segmentation.

2.4.2 Event-based modules

Parking

This modules ensures parking is managed in an orderly manner. Incoming vehicle's number plate is checked in the database. If number plate is found, the vehicle belongs to a company employee and so it is allowed to park in its usual parking space. For a number plate not found in

the database, the vehicle is either denied parking or the owner issued with a parking ticket to enable him park his vehicle.

Entrance

Anyone entering the company's building is subjected to a biometric test. If the details are found in the company's database, the individual is granted entry. In case the individual is not found in the company's database, he is denied entry or issued with a gate pass.

Restricted Areas

Every middle size company has certain offices/areas that are restricted to the general public or even to other employees unless they are given permission to do so. This module ensures that restricted areas such as the finance office or the director's office are not accessible to everyone. Individuals allowed in these areas have the entry master password hence can access these areas any time. To access such areas, one would need special permission and clearance to do so

Power Control

Energy conservation is what every business strives to achieve in order to ensure electricity bills do not go over the roof thereby keeping the company's running cost down. This module strives to achieve this. It ensures that when someone is the first person to enter a room, the sensors send signals to switch on the lights. When someone is last to leave, the sensors send signals to switch off the lights. This way energy is conserved and the company's running cost lowered.

Surveillance

There may be sensitive rooms in an organization. In order to be extra cautious, surveillance cameras may be installed so as to keep track of whatever happens in these rooms. The admin can access these cameras from any remote location by assigning IP addresses to them.

2.5 ERP SYSTEMS AND ERP SYSTEMS ADOPTION

An ERP system is a set of packaged application software modules, with an integrated architecture, that can be used by organizations as their primary engine for integrating data, processes and information technology, in real time, across internal and external value chains

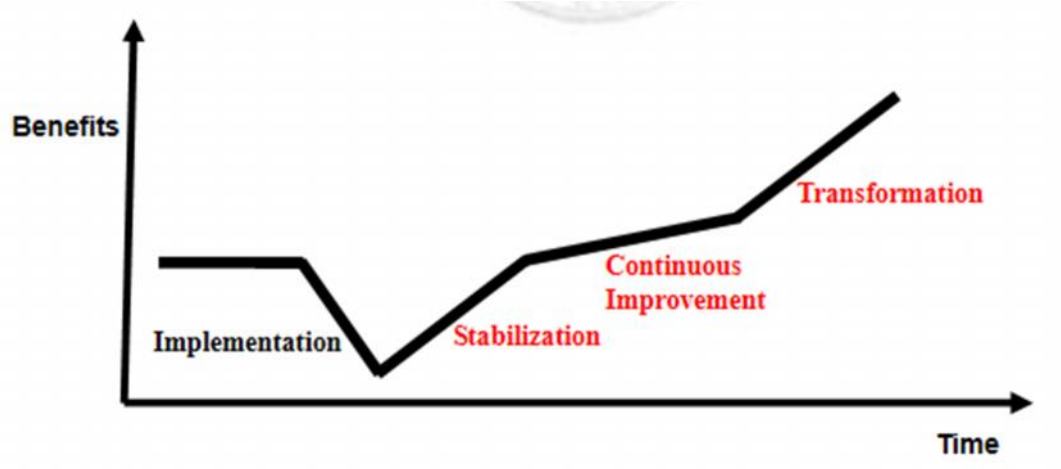
(Shields, 2001). It impounds deep knowledge of business practices that vendors have accumulated from implementations in a wide range of client organizations that can exert considerable influence on the design of processes within new client organizations (Shields, 2001).

The complex system functions cover an extensive array of business areas and involve comprehensive knowledge of both the implementation and the limitations of the software, and of how to manage processes and utilize information. This is knowledge that requires a considerable time to comprehend (Shields, 2001).

ERP systems enable organizations to share common information and activities across the entire organization, automate and integrate the critical parts of business processes, and access information in a real-time environment. Since ERP systems can facilitate the productivity and efficiency of firms, the majority of organizations implement ERP systems to increase organizational competitiveness (Parr & Shanks, 2000). ERP systems touch on many aspects of a company's internal and external operations and provide organizations with an overall view of the business through multidimensional information (Gefen and Ragowsky 2005; Ahituv et al., 2002). Consequently, successful deployment and use of ERP systems are critical to organizational performance and survival (Ahituv et al., 2002).

Nevertheless, the bulk of research on the implementation of ERP systems focuses on firms either prior to, during, or immediately after ERP software implementation (Hong & Kim, 2001). Conventional wisdom saw "going live" as the end of ERP implementation and ignored the second wave, the post adoptive stage, which refers to the actions that are taken after going live that help organizations achieve the full capabilities and benefits.

Many organizations and researchers have begun to pay attention to the post implementation stage (Ross & Vitale, 2000) in which firms begin to realize the impact of the ERP based organizational transformation (Clark et al. 2006) and continuous improvement, which in turn leads to the maximization of benefits from prior investment (Ross & Vitale, 2000). This study uses the model of Ross et al. (2003) shown in Figure 2.1 to depict the stage of the ERP post-implementation. Ross et al. (2003) proposed that after implementation, organizations may experience the stages of stabilization, continuous improvement, and transformation.



The post-adoption stage is the longest phase of the ERP project life cycle (Markus *et al.* 2000). It explicitly implies that organizations cannot stop advancing ERP systems even after completion of the ERP project. Many firms fail in the initial implementation, but after two or three years of effort and of defining the scope of what they want to accomplish, improvements may result (Hitt et al., 2002). Furthermore, significant improvements in ERP adopter firm performance are generally not realized until sometime after implementation (Hitt et al., 2002; Nicolaou 2004). Therefore, after ERP implementation, organizations must continuously carry out change activities, including restructuring of IT systems and organizational structures, in order to obtain maximum value from the ERP system (Markus *et al.* 2000). To summarize briefly, though ERP systems are designed to create advantages for organizations, organizations must not only learn how to implement systems successfully, but must also pay attention to the post-implementation period, and perform activities to achieve their expectations for the ERP system instead of just waiting for the systems to automatically reach the goals of the organization.

2.6 CRITICAL SUCCESS FACTORS FOR ERP SYSTEM IMPLEMENTATION

Research has demonstrated that organizations will obtain pay offs from ERP investment. In an independent survey of multinational companies who implemented ERP, 85% said that the system had been implemented successfully but only 25% said that they achieved the intended business benefits (Ahituv et al., 2002). Consequently, organizations may wonder how they can maximize the value of ERP system implementation and realize the payoff. One purpose of this study is to investigate the drivers of the beneficial use of ERP systems.

Light et al. (2001) found that an ERP experience could be an early success and a later failure. It is also possible be an early failure but a later success (Ahituv et al., 2002). Further, there is little evidence that bears on how well organizations actually assimilate ERP systems beyond the initial implementation. Thus, going live of ERP systems is not the end point. After implementing an ERP system, if organizations want to sustain success or reverse failure, they must continuously monitor and manage ERP systems. Since ERP systems are complex, no matter how competent the initial implementation, it is likely that many organizations will have a less than perfect fit, implying that organizations have to do more than just maintain the systems (Ross & Vitale, 2000). Therefore, in order to realize the full benefits for organizations from ERP systems implementation and use, several researchers proposed factors that affect how value is obtained. Some studies (Ahituv et al., 2002) have suggested that stabilization of systems is the essential of obtaining value from ERP systems. Thus, factors this study discusses in the following section affecting beneficial use of ERP systems does not include stabilization.

- *Organizational Culture*

Organizational culture refers to organizational practices that manifest themselves visibly among the firm's employees (Light et al. 2001). Implementing ERP systems causes major organizational transformations in firms. Studies indicate that communication, degree of control, people involvement, and empowerment are some of the key change readiness factors that help firms effect a change in their organizational culture accompanying an ERP system deployment (Lengnick-Hall, et al. 2004). Also, various studies suggest that changes in business processes, information transparency, employee attitudes regarding job role changes and downsizing are some of the issues that firms need to address to ensure organizational-ERP system fit.

- *User training*

Many studies argue that user training is critical in the ERP post-implementation context. Pre-implementation user training can make use of organizational experience, and shorten the time required to handle immediate post-go-live issues. However, the goal of user training in post-implementation is assimilating deeply and updating the knowledge needed. Post-adoption training enables users to fully understand the implications of the new system on their potential processes (Light et al. 2001) along with how their actions have impacted downstream operations (Lengnick-Hall, et al. 2004). It also permits additional updating of the ERP system's knowledge

base where it is concerned with the operation of new functions. Another form of user training is periodic meetings of system users which can help identify problems with the system and encourage the exchange of information gained through experience and increasing familiarity with the system (Sarkis & Sundarraj, 2003).

- *Documentation*

Documentation is another source of knowledge acquisition in ERP systems. One of the most important aspects of knowledge sharing is documentation in the form of process descriptions, operating guides, and system design manuals. Users can learn how to operate ERP systems, correct errors, and seek solutions from the documentation. Well-maintained documentation offers users impressive benefits, such as reductions in learning time, information overload and search effort (Comerford, 2000).

- *Communication*

Ongoing communication within the firm, between all organizational levels, throughout the ERP life cycle is crucial to ensuring implementation success. Researchers such as Chung & Snyder (2000) suggest that constant, open, and honest communication with various stakeholders throughout the ERP system life cycle is essential for ERP system success. An open information policy in turn results in greater understanding of organizational needs and hence quicker acceptance and effective usage of the ERP system.

- *Process optimization*

One recent study concluded that the way to obtain greater productivity and business performance from enterprise systems over the long term is process improvement (Chung & Snyder (2000); Ross & Vitale, 2000). Process optimization requires understanding the evolving capability of the software and needs of the organization, and strives to maintain a reasonable on-going level of fit between the software and changing organizational needs (Light et al. (2001)). Some organizations change processes radically in the early or pre-implementation stages, and subsequently stop improving processes. However, the initial fit between organizational processes and ERP systems will not represent the sustained fit years later because organizational processes will change over time. Thus, optimizing processes cannot cease even after the ERP systems go live. Furthermore, reengineering or process improvement should not be restricted to the back-

office. Operational processes that have been the primary focus of change processes in the past. Organizations should try to improve processes such as marketing, product development, and strategic planning, to provide the full picture of process optimization and consequently maximize the benefits from ERP system implementation and use (Light et al. (2001)).

- *Integration/ extension*

Integration is universally known for beneficial ERP use. However, implementing ERP systems does not indicate that it has successfully automatically integrated information, processes and systems of organizations (Markus *et al.* 2000). Hence, organizations can improve integration to realize value after ERP implementing by minimizing the number of ESs instances through consolidation and by integrating ERP systems with legacy systems (Light et al. 2001). Consolidating applications into a single global instance, such as integrate SCM, CRM and B2B e-commerce with ERP systems to share applications, hardware or core processes and then reduce costs of ESs' human and technical support (Hong & Kim, 2001). For organizations, integration is an ongoing activity that continues long after implementation of core ERP systems functionality (Koh & Saad, 2006). Thus, in order to speed up communications and improving decision-making, even after ERP implementation, organizations must continually integrate and extend ERP systems.

- *Project Management*

Project management refers to the ongoing coordination, scheduling, and the monitoring of project management tasks and activities to ensure that the objectives of the ERP system implementation are achieved (Koh & Saad, 2006). Excellent project management techniques with clearly defined scope, work plans, resource requirement plans, and milestones are essential to ERP system implementation success (Sarkis & Sundarraj, 2003). Researchers such as Weston Jr. (2001) further suggest that a well-documented project management design, which covers the entire ERP life cycle, contributes to the success of complex implementations.

- *Implementation Team*

Implementation team members who display a well-balanced mix of technical and business skills play a vital role in ensuring the success of ERP system implementations (Koh & Saad, 2006). Lack of understanding of user needs and project needs, and the non-deployment of best IT and

functional resources are major reasons for ERP system implementation failure (Motwani, et al., 2002). The empowered implementation team holds responsibility for creating the overall schedule as well as the detailed project plans besides making sure that necessary resources are made available when required (Koh & Saad, 2006).

- *Consultants*

Consultants play a vital role in facilitating and guiding ERP system implementations from project inception to system upgrades. As ERP system projects demand multiple product specific, business, and inter-personal skills, most firms outsource these skills rather than invest resources in developing them internally (Motwani, et al., 2002). Consultants are an integral part of ERP system implementation teams and their involvement with the ERP project includes transfer of their ERP expertise to the firm.

- *Data Accuracy*

Data accuracy refers to the integrity of data that is input into the ERP system as well as the output obtained from the ERP system (Motwani, et al., 2002). Due to the integrated nature of the ERP system, a wrong data entry has a domino effect throughout the entire firm and results in users unwilling to migrate to the ERP system. Processes to ensure data entry should be in place before the implementation starts and extend throughout the ERP life cycle (Sarkis & Sundarraj, 2003). Researchers such as Motwani, et al., (2002) further suggest that all employees play an active ongoing role in the maintenance of data integrity in the ERP system. Employees should understand the concept of integrated data in a manner that is consistent throughout the firm and also use this data accordingly.

- *User Support*

User support refers to the acceptance of the ERP system by all the employees of the firm. ERP system implementations are more about people rather than process or technology and involve major organizational structural and process changes. Firms have to initiate change management programs to overcome user resistance and ensure user support and commitment (Sarkis & Sundarraj, 2003). Researchers such as Kanungo and Bagchi (2000) suggest that user involvement, user participation, and hence user commitment are essential for quick acceptance of

the ERP system thus leading to more effective system usage and hence speedy benefits realization.

2.7 BENEFITS OF ERP IMPLEMENTATION AND USE

Since ERP systems affect so many parts of the organization, ERP systems can provide a huge range of benefits and problems, often with different benefits in different organizations (Ross & Vitale, 2000). Thus, organizations that have invested heavily in implementing ERP systems may want to know "Will our investment pay off?" The answer provided by several firm-level econometric studies is most likely "yes".

But after ERP implementation, what benefits can be gained by organizations? To answer this question, researchers have sought ways to evaluate investment in ERP systems. In the initial phases of this research, studies measured the benefits of ERP systems by economic revenue, yet revenue by itself cannot represent all the benefits of an ERP system. As a result, researchers began constructing more robust definitions of the benefits of adopting ERP, generally viewing them as having at least two dimensions: operational efficiency and strategic effectiveness (Poston & Grabski, 2001). In the Benchmarking Partners study (1998); respondent companies anticipated not only tangible but intangible benefits. The most significant intangible benefits related to strategic effectiveness include internal integration, improved information and processes, and improved customer service, while tangible benefits related to operational efficiency include cost efficiencies in inventory, personnel, procurement and the time needed to close books, as well as improvements in productivity, cash/order management, and overall profitability (Lengnick-Hall, et al. 2004). Poston & Grabski (2001), following the ideas of Cameron & Meyer (1998), argued that organizations trying to understand the value of the ERP investment should view it through two lenses: a fine-grained level analysis, and the intermediate benefits involved. Such intermediate benefits may include (1) higher quality data for decision making; (2) efficiency gains in business processes; and, (3) better coordination among different units of the firm. Further, the ERP systems benefits of Ross & Vitale (2000) cover the intermediate factors and extend the two dimensions (operation and strategy) to five dimensions, including the operational, managerial, strategic, IT infrastructure and organizational benefits. Operational efficiency relates to factors such as cost reduction, increased inventory turns;

managerial benefits refers to factors such as improved decision making and planning and better resource management; Strategic effectiveness refers to factors such as improved managerial decision making; IT infra-structure benefits related to IT flexibility and capability, and Organizational benefits refers to factors such as employee learning, and empowering workers. Table2.6 shows the dimensions and sub dimensions of ERP systems benefits.

Table 2.7 Dimensions of ERP systems benefits

Dimensions	**Sub dimensions.**
1.Operational	1.1 Cost reduction, 1.2 Cycle time reduction, 1.3 Productivity improvement, 1.4 Quality improvement, 1.5 Customer services improvement
2.Managerial	2.1 Better resource management, 2.2 Improved decision making and planning 2.3 Performance improvement
3.Strategic	3.1 Support for business growth 3.2 Support for business alliance 3.3 Building business innovations 3.4 Building cost leadership 3.5 Generating product differentiation 3.6 Building external linkages
4.IT Infrastructure	4.1 Building business flexibility for current and future changes 4.2 IT costs reduction 4.3 Increased IT infrastructure capability
5.Organizational	5.1 Changing work patterns 5.2 Facilitating business learning 5.3 Empowerment 5.4 Building common visions

CHAPTER 3

3.1 DESIGN

The flowchart of a middle-sized engineering business organization is shown in the subsequent pages. From the flowchart, a number of processes/ events/activities taking place in the organization can be derived. These activities will be presented as modules in the ERP system and they include:

- Parking
- Entrance to Company building
- Accessing restricted Areas/Rooms in the company
- Surveillance

3.1.1 Parking

Assumption will be made that the company is housed in a big building with the ground floor set aside for parking. The parking will have reserved and general sections set aside for company employees. The remaining section will be subdivided into VIP section and another general section for visitors. Vehicles belonging to company employees will be registered in the database. Any incoming vehicle will have its number plate checked in the database at the gate. If the number plate is found in the database, the vehicle will be allowed to access its usual parking space. Other vehicles not found in the database will be temporarily added into the database and a ticket printed out for them. This ticket will act as their gate pass. Visitors will be granted permission to park only if there will be space available for parking

From this module, one will be able to view the parking list and add vehicles to the company's parking list in the database

3.1.2 Entrance

This module will be able to identify the visitors getting into the company premises. The best way to implement this would have been to use a biometric scanner which would basically extract information from the individual and compare it with that stored in the database. Since a biometric scanner was not be used, a search box was created and the individual searched using

their ID numbers or job card numbers to mimic the use of a biometric scanner. If the information of the person being searched is found in the database, it would mean he is an employee of the company and he would thereby be allowed in. Those not found in the database are temporarily added into the system, their data printed out and this ticket acts as their gate pass.

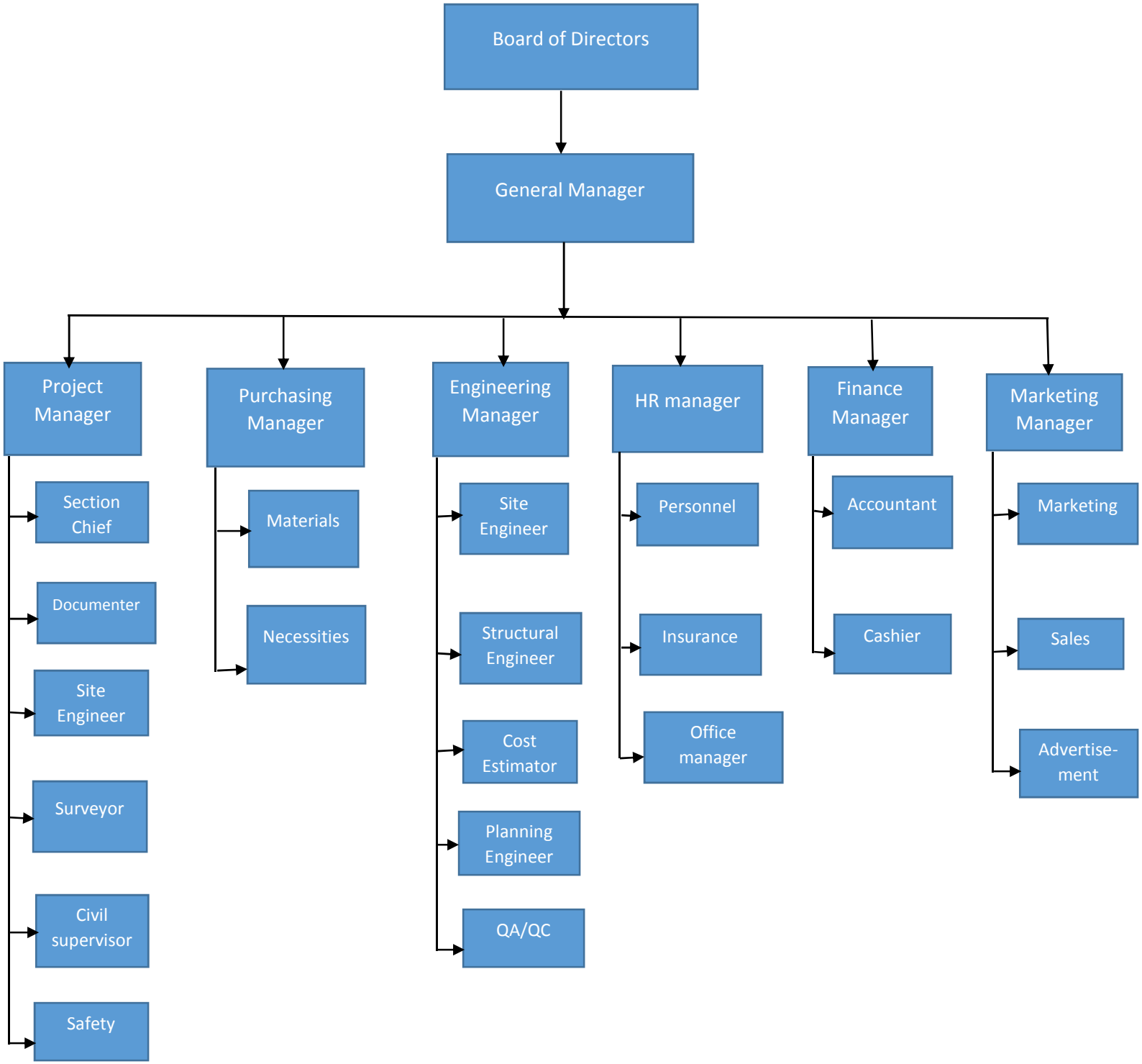
3.1.3 Restricted Areas

Certain sections of the company are not open for everyone to access. These sections include the general manager's office as well as the finance office. In order to access these rooms, one has to acquire special permission. This module will function in such a way that a master password will be included in the program and comparisons made to it whenever a password will be entered. If one enters the right code, they will be given entry into these restricted areas. On the other hand if they enter the wrong access code, they will be denied entry and the alarm will come on until the right access code is entered. This is meant to increase security of these sensitive areas.

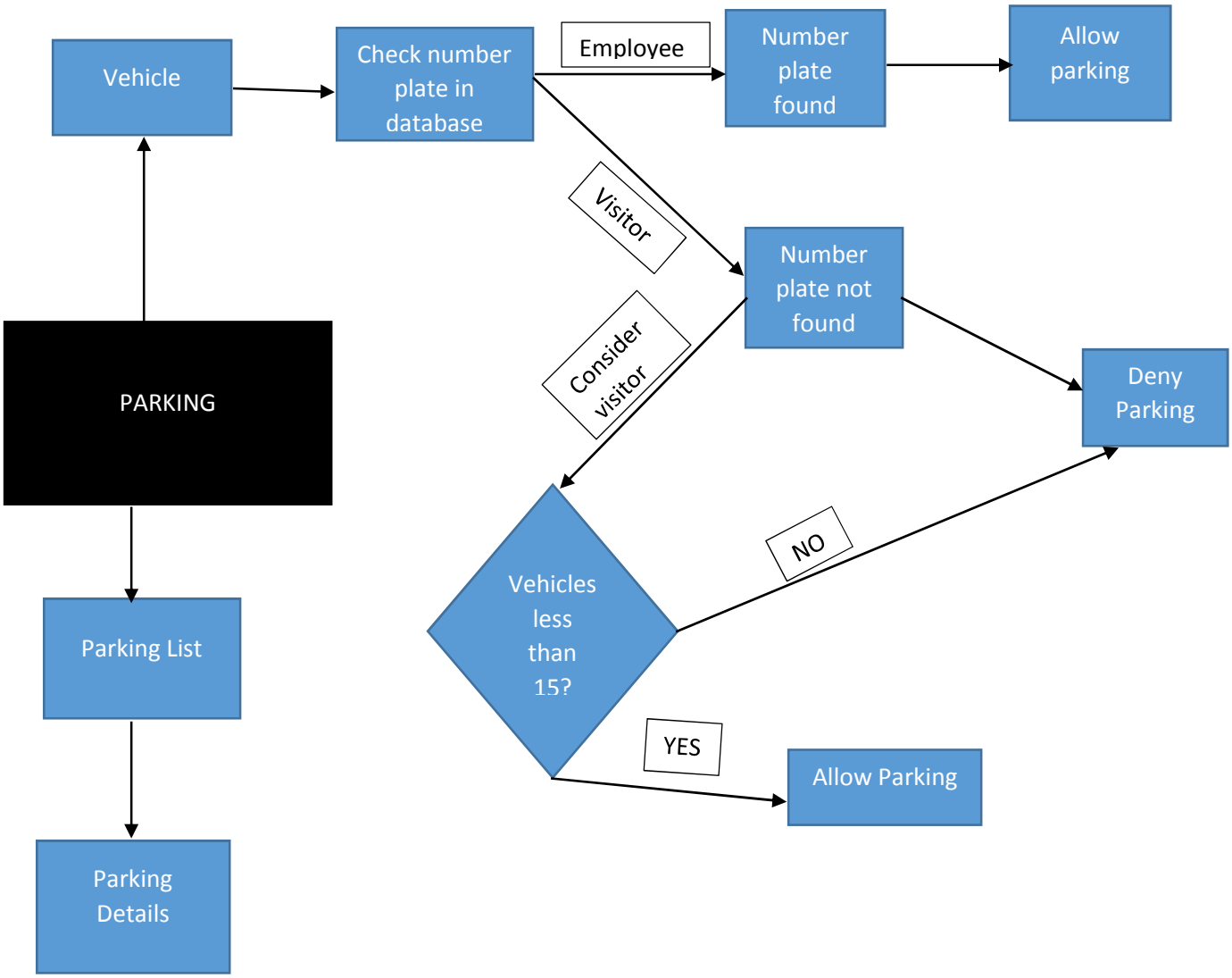
3.1.4 Surveillance

This section will employ the idea of using IP addresses of cameras over a server to keep track of events happening at the company especially in the restricted areas. Several cameras can be installed in the company and they can be accessed using their IP addresses. This way someone can log into the system and access company events from a remote location.

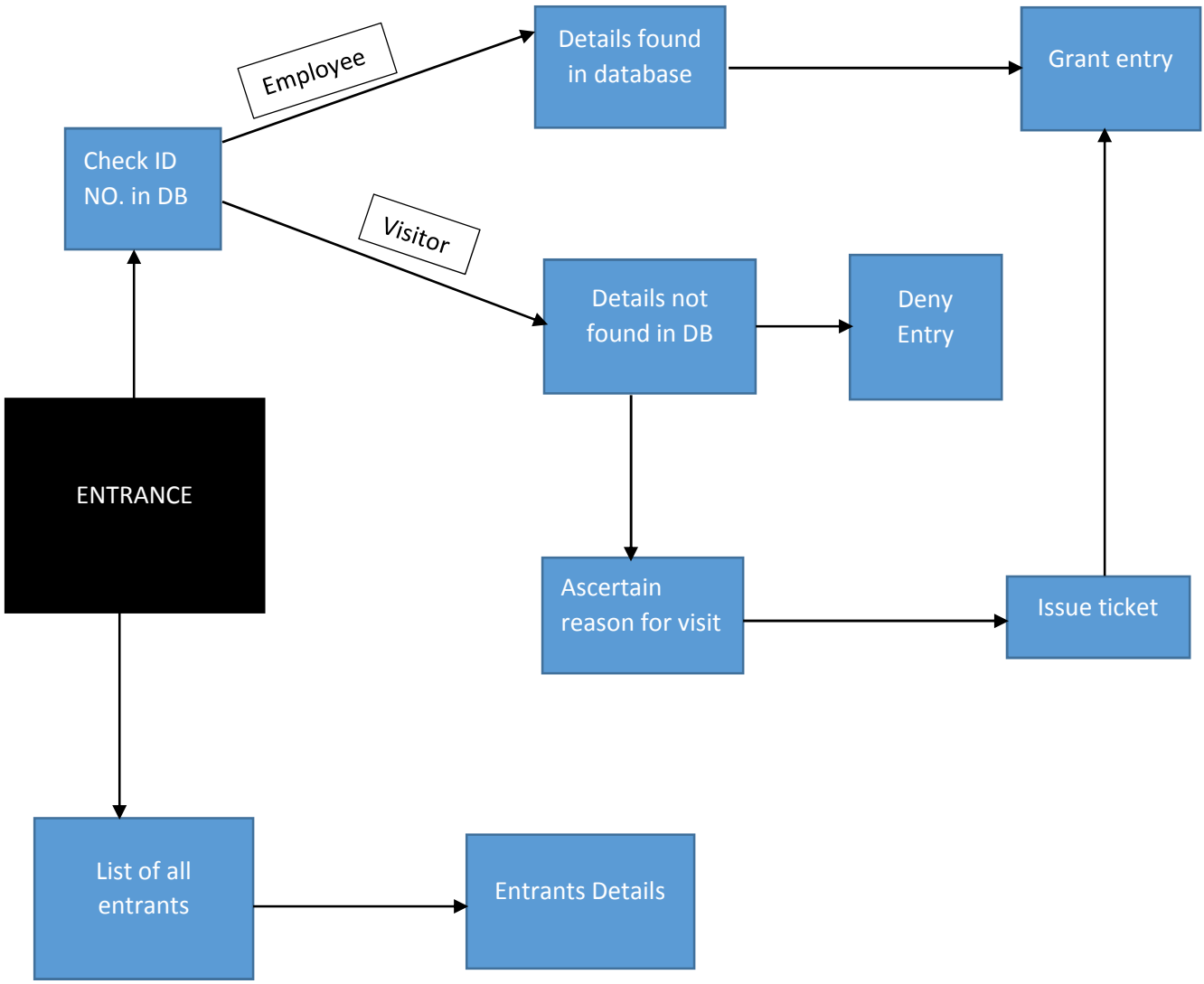
3.1 GEDOX ASSOCIATES ORGANIZATIONAL CHART



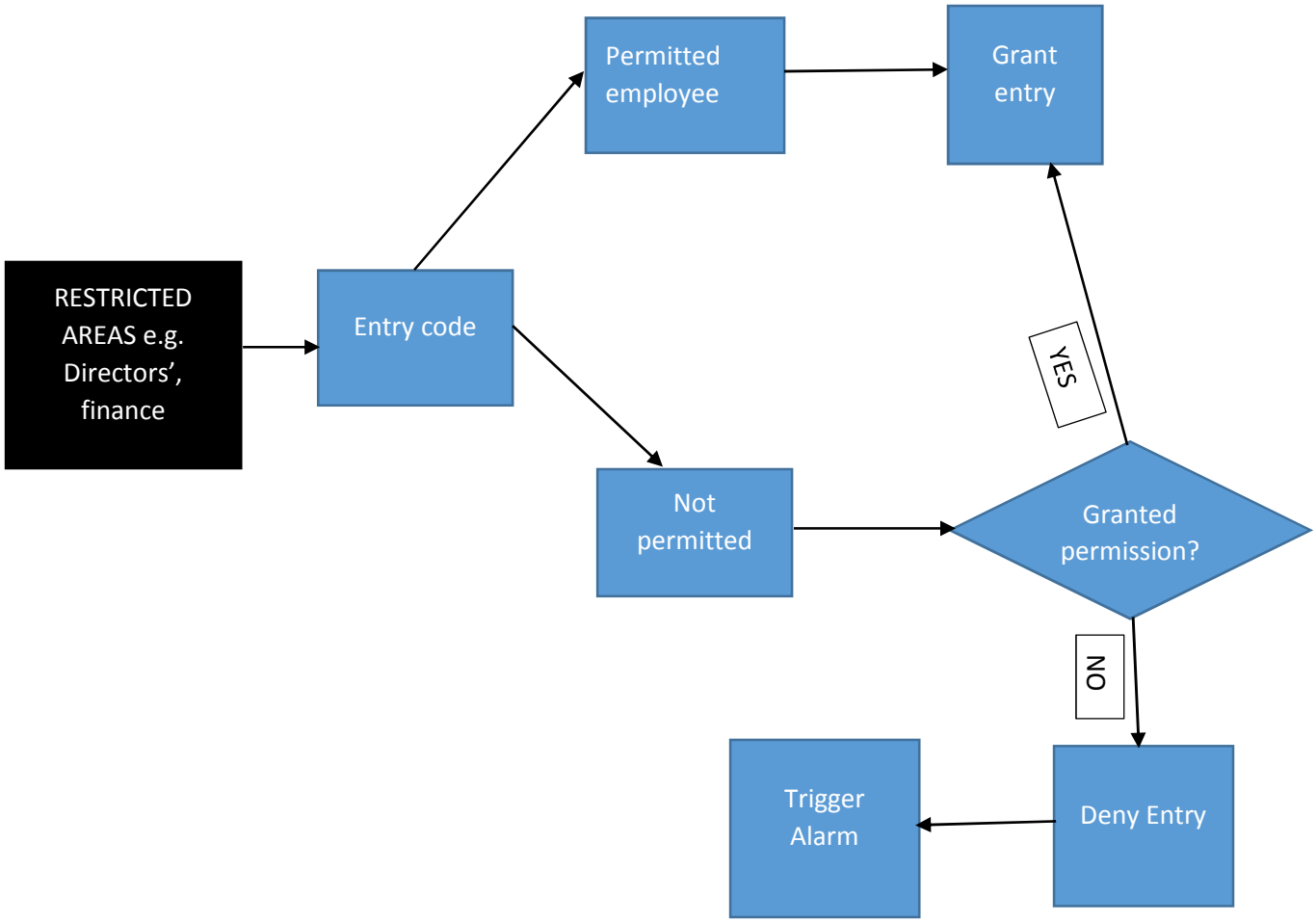
3.1.1 PARKING FLOWCHART



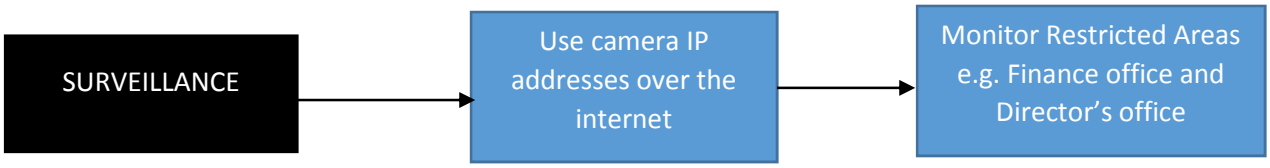
3.1.2 ENTRANCE FLOWCHAT



3.1.3 RESTRICTED AREAS FLOW CHART



3.1.4 SURVEILLANCE



3.2 METHODOLOGY

The following web development toolkits were used:

- Xampp
- Codeigniter
- Construct 2

The following were the programming languages used

- PHP
- HTML
- JavaScript
- CSS

3.2.1 XAMPP

XAMPP stands for Cross-Platform (X), Apache (A), MySQL (M), PHP (P) and Perl (P). It is a simple, lightweight Apache distribution that makes it extremely easy for developers to create a local web server for testing purposes. Everything one needs to set up a web server – server application (Apache), database (MySQL), and scripting language (PHP) – is included in a simple extractable file. XAMPP is also cross-platform, which means it works equally well on Linux, Mac and Windows. Since most actual web server deployments use the same components as XAMPP, it makes transitioning from a local test server to a live server extremely easy as well.

Apache: Apache is the actual web server application that processes and delivers web content to a computer. Apache is the most popular web server online, powering nearly 54% of all websites.

MySQL: Every web application, however simple or complicated, requires a database for storing collected data. MySQL, which is open source, is the world's most popular database management system. It powers everything from hobbyist websites to professional platforms like WordPress.

PHP: PHP stands for Hypertext Preprocessor. It is a server-side scripting language that powers some of the most popular websites in the world, including WordPress and Facebook. It is open source, relatively easy to learn, and works perfectly with MySQL, making it a popular choice for web developers.

Perl: Perl is a high-level, dynamic programming language used extensively in network programming, system admin, etc. Although less popular for web development purposes, Perl has a lot of niche applications.

3.2.2 CODEIGNITER

CodeIgniter is a toolkit for people who build web applications using PHP. Its goal is to enable one to develop projects much faster than they could if they were writing code from scratch, by providing a rich set of libraries for commonly needed tasks, as well as a simple interface and logical structure to access these libraries. CodeIgniter lets you creatively focus on your project by minimizing the amount of code needed for a given task.

CodeIgniter uses the Model-View-Controller approach, which allows great separation between logic and presentation. This is particularly good for projects in which designers are working with your template files, as the code these files contain will be minimized

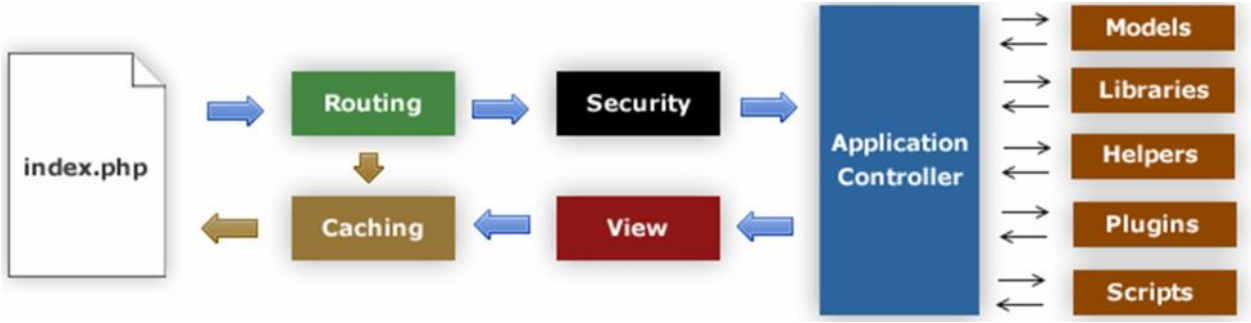
Model-View-Controller

CodeIgniter is based on the Model-View-Controller development pattern. MVC is a software approach that separates application logic from presentation. In practice, it permits your web pages to contain minimal scripting since the presentation is separate from the PHP scripting.

- The Model represents your data structures. Typically your model classes will contain functions that help you retrieve, insert, and update information in your database
- The View is the information that is being presented to a user. A View will normally be a web page, but in CodeIgniter, a view can also be a page fragment like a header or footer. It can also be an RSS page, or any other type of “page”.
- The Controller serves as an intermediary between the Model, the View, and any other resources needed to process the HTTP request and generate a web page.

3.2.2.1 Application Flow Chart

The following graphic illustrates how data flows throughout the system:



- The index.php serves as the front controller, initializing the base resources needed to run CodeIgniter**.**
- The Router examines the HTTP request to determine what should be done with it.
- If a cache file exists, it is sent directly to the browser, bypassing the normal system execution.
- Security. Before the application controller is loaded, the HTTP request and any user submitted data is filtered for security.
- The Controller loads the model, core libraries, helpers, and any other resources needed to process the specific request.
- The finalized View is rendered then sent to the web browser to be seen. If caching is enabled, the view is cached first so that on subsequent requests it can be served.

3.2.2.2 Creating databases

After the installation of Xampp, PhpMyAdmin page was accessed by typing the url http://localhost/phpmyadmin/ in the browser. From this page the first database was created and it was called gedox. A second database was created and it was called gedox_app. The first database houses the general application and contains information to do with login, users, addition and deleting of columns, gedox_app database and more. The second database, which is called gedox_app, contains information pertaining to the tables created in the application. The tables created in this case are company_vehicles, data, employees, entrance and parking. This is a perfect case of having a database within another database.

3.2.2.3 Connecting CodeIgniter to Xampp (Database)

In order to connect codeigniter application to the database, one needs to configure the connection details in the application/config/database.php file as follows

```
$db['default']['hostname'] = 'localhost'; //server
$db['default']['username'] = 'root'; //mysql username
$db['default']['password'] = ''; //mysql password
$db['default']['database'] = 'gedox'; //database name
$db['default']['dbdriver'] = 'mysql';
```

With this, the codeIgniter is now linked to the database.

A number of libraries were accessed from github repository in order to facilitate the functioning of this web application and one of them is Ion Auth for authentication purposes

Some of the codes used in the development of this web application are attached in the appendix

3.2.3 CONSTRUCT 2

Construct 2 is a powerful tool that uses HTML5 to create visual effects. It uses event system to bring out these visual effects. In creation of the ERP system, this tool was used to create the security systems namely; restricted area access and surveillance camera.

Restricted Area

In the creation of the restricted area module, an entry code was put in place. When someone enters a password, it is checked against the set code. If the password is right, the person is granted entry. In case the password is wrong, the person is denied entry and the alarm goes on to signify that an intruder is trying to access the restricted area. The alarm does not stop until the right code is keyed in.

Surveillance Camera

The surveillance camera in this case is meant to enable the admin keep an eye on the office proceedings from a remote location. In the creation of this module, IP addresses were created

and each one of them were to be attached to an IP camera. One IP address, 121.03.67.89, was attached to the webcam. On clicking this IP address, one is able to see the proceedings of the office from a remote location. It is assumed that the webcam is a camera located in the office.

CHAPTER 4

4.1 RESULTS

The ERP system application was created with the following modules

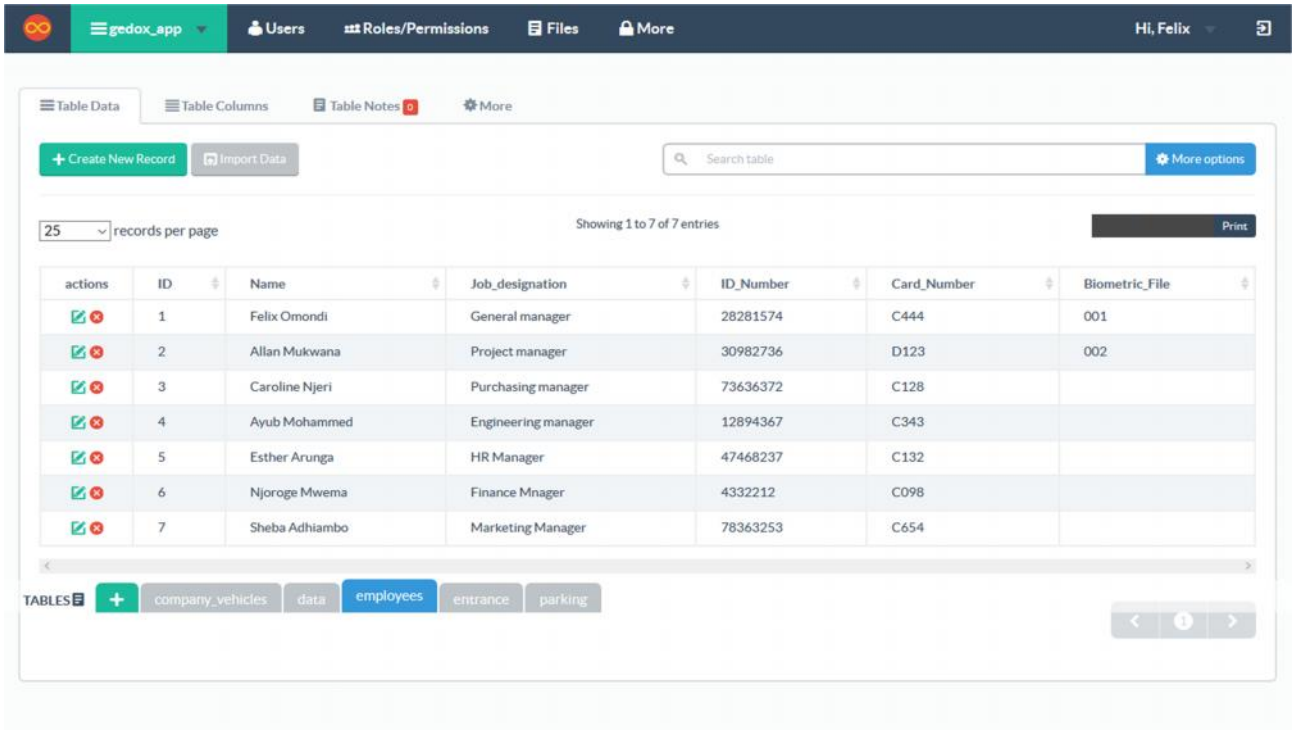
- Parking
- Entrance
- Restricted Area Access
- Surveillance

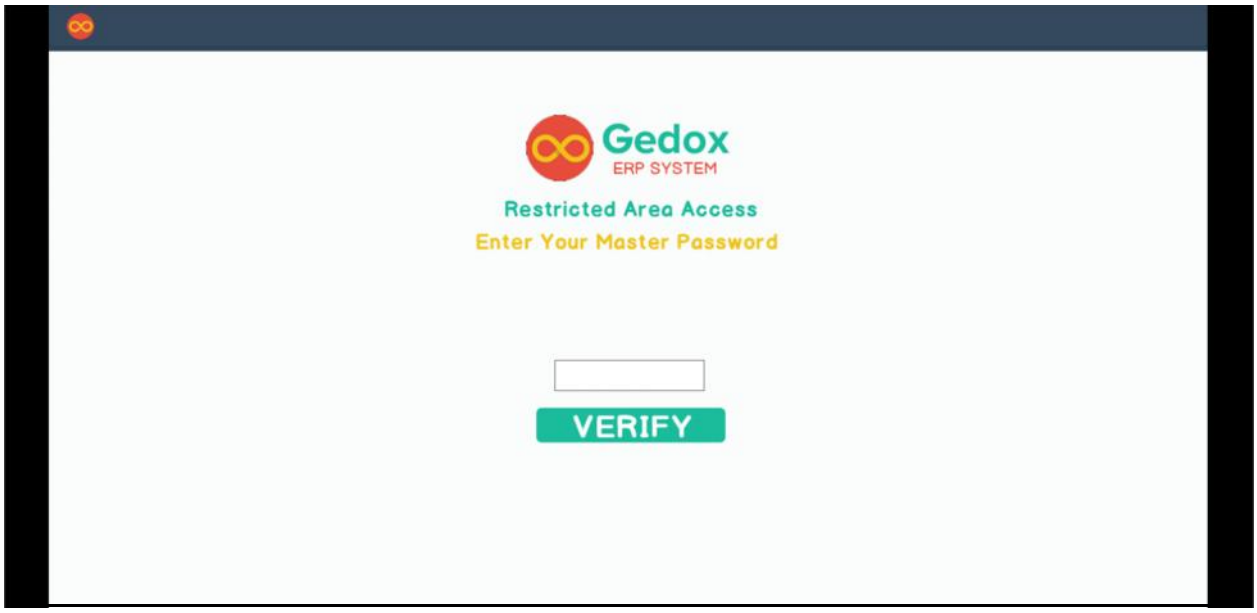
Each module was able to achieve the function it was intended to carry out.

1. The parking module ensures parking process of the organization is automated and makes tracking of vehicles much easier and faster.
2. Entrance module keeps track of the incoming visitors and their reason for visiting the company
3. Restricted area access ensures only authorized individuals are able to access sensitive sections of the company.
4. Surveillance module gives the admin/manager the ability to see what is happening in the organization from a remote location.

The screenshots on the next pages are of the ERP system developed showing the modules discussed above

4.1 SCREENSHOTS




Gedox
ERP SYSTEM
Restricted Area Access
Enter Your Master Password
VERIFY


Gedox
ERP SYSTEM
Surveillance System
Choose Camera IP
121.03.67.89
121.03.67.90
121.03.67.91
GO BACK

CHAPTER 5

5.1 CONCLUSION AND RECOMMENDATION

The objective of this project was to create an event-driven ERP system that would assist the organization to achieve surveillance and access control functions. Since the required ERP system was created, the objective of the project was met. It was possible to achieve access control and surveillance functionalities. However, though the adoption of this ERP system will be beneficial to an organization, it will require additional investment in hardware such as:

1. A biometric scanner so as to realize full automation in checking entry of people into the organization
2. An alarm system that will go on in the event an intruder tries to access a restricted area.
3. An automatic door that opens upon someone entering the right access code in restricted sections
4. Surveillance/IP camera to capture activities taking place in sensitive sections of the company.
5. Charges for hosting the system on a live server

For an organization to realize the full benefits of using this ERP system, it will have to invest on hardware materials discussed above.

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APPENDIX

Database model code

```php
<?php  if ( ! defined('BASEPATH')) exit('No direct script access allowed');

class DbModel extends CI_Model {

    function __construct()
    {
        parent::__construct();

        $this->load->database();
        $this->load->library('session');
        $this->load->library('ion_auth');
        $this->load->model('tablemodel');
        $this->load->model('usermodel');
        $this->load->model('revisionmodel');

    }


    /*
        the initialize function is required to be able to connect to an addional database (database other then the one
        used by the app)
    */

    public function initialize($db)
    {

        //manual dynamic database connection

        $config = array();

        $tempp = $this->db->from('dbapp_databases')->where('dbapp_databases_database', $db)->get()->result();

        $config['hostname'] = $this->db->hostname;
```

```php
    if( $this->ion_auth->is_admin() ) {//for admin/root access

        $config['username'] =  $this->db->username;
        $config['password'] =  $this->db->password;

    } else {//regular user access

        $decrypted_pass = $this->encrypt->decode($this->ion_auth->user()->row()->mysql_pw);

        $config['username'] = $this->ion_auth->user()->row()->mysql_user;
        $config['password'] = trim($decrypted_pass);
```

```
}

$config['database'] = $db;
$config['dbdriver'] = 'mysql';
$config['dbprefix'] = '';
$config['pconnect'] = FALSE;
$config['db_debug'] = FALSE;
$config['cache_on'] = FALSE;
$config['cachedir'] = '';
$config['char_set'] = 'utf8';
$config['dbcollat'] = 'utf8_general_ci';
$config['swap_pre'] = '';
$config['autoinit'] = TRUE;
$config['stricton'] = FALSE;

if( $this->db->port != '' ) {

    $config['port'] = $this->db->port;

}
```

```
    $this->theDB = $this->load->database($config, TRUE);
    $this->theDBname = $db;

}


/*
    returns all databases managed by the app
*/

function listAll($incl_tables = false)
{

    $dbs = $this->db->from('dbapp_databases')->get()->result();

    $return = array();

    foreach($dbs as $db) {

        if($this->usermodel->hasAccessToDb($db->dbapp_databases_database)) {

            //verify that this db exists on the mysql server
            if( !$this->dbmodel->exists($db->dbapp_databases_database) ) {

                $temp = array();
                $temp['error_message_heading'] = "Invalid Database";
                $temp['error_message'] = "The database: <b>".$db->dbapp_databases_database."</b> does not exist on this server. Please contact suppo
                <a href='mailto:".$this->config->item('support_email')."'>".$this->config->item('support_email')."</a>";
```

```
                die( $this->load->view('shared/alert', array('data'=>$temp), true) );

            }

            $temp = array();
            $temp['db'] = $db->dbapp_databases_database;
            $temp['id'] = $db->dbapp_databases_id;

            if($incl_tables) {

                $temp['tables'] = $this->tablemodel->listAllFor($db->dbapp_databases_database);

            }

            array_push($return, $temp);

        }

    }

    return $return;

}


/*
    returns all the MySQL databases on the server, exl certain databases and marks those which
    are enabled in the app and those which can't be enabled in the app
*/

public function listAllMySQL()
{

    $dbs = $this->db->query("show databases")->result();

    $return = array();

    foreach( $dbs as $db ) {

        if( $db->Database != $this->db->database && $db->Database != 'information_schema' && $db->Database != 'mysql' && $db->Database !=
        'performance_schema' ) {//reserved databases

            $temp = array();

            //is this db enabled
            if( $this->db->from('dbapp_databases')->where('dbapp_databases_database', $db->Database)->get()->num_rows() == 0 ) {

                $temp['enabled'] = 'no';

            } else {

                $temp['enabled'] = 'yes';

            }

            //does this db pass our test?
            if( $this->checkDB($db->Database) ) {

                $temp['allowed'] = 'yes';
```

```
            } else {
                $temp['allowed'] = 'no';
            }

            $temp['db'] = $db->Database;
            array_push($return, $temp);
        }
    }
    if( count($return) > 0 ) {
        return $return;
    } else {
        return false;
    }
}
```

```
public function getCell($db, $table, $column, $recordID)
{
    $cellArray = array();

    //get the primary key for this table
    $this->tablemodel->initialize($db);
    $primaryKey = $this->tablemodel->getPrimaryKey($table)->name;

    //value
    $cellArray['column'] = $column;
    $tempp = $this->theDB->from($table)->where($primaryKey, $recordID)->get()->result();
    $cellArray['value'] = $tempp[0]->$column;

    //max_length and type
    $columns = $this->theDB->field_data($table);
```

```
    foreach( $columns as $col ) {

        if( $col->name == $column ) {

            $cellArray['type'] = $col->type;
            $cellArray['max_length'] = $col->max_length;

        }

    }


    //possible FK data
    if( $this->tablemodel->hasFK($table, $column) ) {

        //grab the relation from the db

        $query = $this->db->from('dbapp_relations')->where('dbapp_relations_database', $db)->where('dbapp_relations_source_table', $table)
        'dbapp_relations_source_field', $column)->get();

        if( $query->num_rows() ) {

            $relation = $query->row();

            $cellArray['reference_table'] = $relation->dbapp_relations_reference_table;
            $cellArray['reference_table_key'] = $relation->dbapp_relations_reference_field;
            $cellArray['use_column'] = $relation->dbapp_relations_reference_use;
```

```
            //grab the referenced data
            $referencedData = $this->theDB->select($cellArray['reference_table_key'])->select($cellArray['use_column'])->from($cellArray['reference_table'
            ])->order_by($cellArray['use_column'])->get()->result_array();

            //die($this->theDB->last_query());

            $cellArray['referenced_data'] = $referencedData;

        }
    }

    //get additional columndata
    $cellArray['additional_data'] = $this->tablemodel->getColumnDetails($db, $table, $column);

    return $cellArray;

}


/*
    returns a single record
*/
public function getRecord($db, $table, $indexName, $recordID)
{

    $tempp = $this->theDB->from($table)->where($indexName, urldecode($recordID))->get()->result_array();

    $record = $tempp[0];

    $return = array();

    //initialize db connecttion for table model
    $this->tablemodel->initialize($db);
```

```
  foreach( $record as $col=>$val ) {

      $temp = array();
```

```
        //find possible foreign keys
        if( $this->tablemodel->hasFK($table, $col) ) {

            //grab the relation from the db

            $relation = $this->db->from('dbapp_relations')->where('dbapp_relations_database', $db)->where('dbapp_relations_source_table', $table)->where(
            'dbapp_relations_source_field', $col)->get()->row();

            if( $relation ) {

                $temp['reference_table'] = $relation->dbapp_relations_reference_table;
                $temp['reference_table_key'] = $relation->dbapp_relations_reference_field;
                $temp['use_column'] = $relation->dbapp_relations_reference_use;

                //grab the referenced data
                $referencedData = $this->theDB->select($temp['reference_table_key'])->select($temp['use_column'])->from($temp['reference_table'])->
                order_by($temp['use_column'])->get()->result_array();

                //die($this->theDB->last_query());

                $temp['referenced_data'] = $referencedData;

            }

        }

        //get additional columndata
        $temp['additional_data'] = $this->tablemodel->getColumnDetails($db, $table, $col);

        $return[$col] = $temp;

    return $return;

}


/*
    updates a single record
*/

public function updateRecord($db, $table, $indexName, $recordID, $data)
{

    //do we need to store any revisions then?
    $record = $this->getRecord($db, $table, $indexName, $recordID);

    //set up DB connection
    $this->revisionmodel->initialize($db);

    foreach($data as $key=>$value) {

        //is the new value different from the stored one?
        if( $record[$key] != $value ) {

            $this->revisionmodel->saveRevision($db, $table, $key, $indexName, $recordID, $value, time());
```

```
        }

    }

    $this->theDB->where($indexName, $recordID);
    $this->theDB->update($table, $data);

    //echo $this->theDB->last_query();

}
```

```
}


/*
    creates a new record in the given db/table
*/

public function newRecord($db, $table, $data)
{

    //remove the empties

    foreach( $data as $key=>$value ) {

        if( $value == '' ) {

            //unset( $data[$key] );

        }

    }

    $this->theDB->insert($table, $data);
```

```
    //update the ownership table
    $newRecordID = $this->theDB->insert_id();

    $user = $this->ion_auth->user()->row();

    $data = array(
        'dbapp_users_records_userid' => $user->id,
        'dbapp_users_records_database' => $db,
        'dbapp_users_records_table' => $table,
        'dbapp_users_records_recordid' => $newRecordID
    );

    $this->db->insert('dbapp_users_records', $data);

}


/*
    deletes a record from the given table in the given db
*/
```

```
public function deleteRecord($db, $table, $recordID)
{

    //get the primary key for this table

    $this->tablemodel->initialize($db);

    $field = $this->tablemodel->getPrimaryKey($table);


    //if there's any foreign keys pointing to this value, we'll need to destroy

    $config['hostname'] = $this->db->hostname;
    $config['username'] = $this->db->username;
    $config['password'] = $this->db->password;
    $config['database'] = "information_schema";
    $config['dbdriver'] = 'mysql';
    $config['dbprefix'] = '';
    $config['pconnect'] = FALSE;
    $config['db_debug'] = TRUE;
    $config['cache_on'] = FALSE;
    $config['cachedir'] = '';
    $config['char_set'] = 'utf8';
    $config['dbcollat'] = 'utf8_general_ci';
    $config['swap_pre'] = '';
    $config['autoinit'] = TRUE;
    $config['stricton'] = FALSE;
```

```
    if( $this->db->port != '' ) {

        $config['port'] = $this->db->port;

    }

    $this->theDB2 = $this->load->database($config, TRUE);

    $query = $this->theDB2->query("SELECT *
    FROM
      KEY_COLUMN_USAGE
    WHERE
      REFERENCED_TABLE_NAME = '$table'
      AND REFERENCED_COLUMN_NAME = '".$field->name."'
      AND TABLE_SCHEMA = '$db';");

    foreach( $query->result() as $row ) {
```

```
            $referencingTable = $row2->TABLE_NAME;
            $referencingColumn = $row2->COLUMN_NAME;

            //get referencing ID's

            $q = $this->theDB->from($row->TABLE_NAME)->where($row->COLUMN_NAME, $recordID)->get();

            foreach( $q->result_array() as $r ) {

                $this->theDB->where($referencingColumn, $r[$referencingColumn]);
                $this->theDB->delete($referencingTable);

            }
```

```
        }

        $this->theDB->where($row->COLUMN_NAME, $recordID);
        $this->theDB->delete($row->TABLE_NAME);

    }
```

```
    //destroy possible FKs
    $this->tablemodel->destroyForeignKey($db, $table, $field->name);


    $this->theDB->where($field->name, $recordID);
    $this->theDB->delete($table);


    //delete from dbapp_cellrevisions
    $this->db->where("dbapp_cellrevisions_database", $db);
    $this->db->where("dbapp_cellrevisions_table", $table);
    $this->db->where("dbapp_cellrevisions_indexname", $field->name);
    $this->db->where("dbapp_cellrevisions_indexvalue", $recordID);
    $this->db->delete("dbapp_cellrevisions");


    //delete from dbapp_recordnotes
    $this->db->where("dbapp_recordnotes_database", $db);
    $this->db->where("dbapp_recordnotes_table", $table);
    $this->db->where("dbapp_recordnotes_indexname", $field->name);
    $this->db->where("dbapp_recordnotes_indexvalue", $recordID);
    $this->db->delete("dbapp_recordnotes");


    //delete from dbapp_users_records
    $this->db->where("dbapp_users_records_table", $table);
    $this->db->where("dbapp_users_records_database", $db);
    $this->db->where("dbapp_users_records_recordid", $recordID);
    $this->db->delete("dbapp_users_records");

}
```

```
public function checkDB($db)
{

    $disallowedCharacters = '/[\'^£$%&*()}{@#~?><>,|=+¬\/ ]/';

    //check db name for non alpha characters
    if( preg_match($disallowedCharacters, $db) ) {

        return false;

    }


    //manual dynamic database connection
    $config['hostname'] = $this->db->hostname;
    $config['username'] = $this->db->username;
    $config['password'] = $this->db->password;
    $config['database'] = $db;
    $config['dbdriver'] = 'mysql';
    $config['dbprefix'] = '';
    $config['pconnect'] = FALSE;
    $config['db_debug'] = TRUE;
    $config['cache_on'] = FALSE;
    $config['cachedir'] = '';
    $config['char_set'] = 'utf8';
    $config['dbcollat'] = 'utf8_general_ci';
    $config['swap_pre'] = '';
    $config['autoinit'] = TRUE;
    $config['stricton'] = FALSE;
```

```
    if( $this->db->port != '' ) {

        $config['port'] = $this->db->port;

    }
```

```
$this->theNewDB = $this->load->database($config, TRUE);

//get all tables

$tables = $this->theNewDB->list_tables();

foreach($tables as $table) {

    //does the table have a primary key?
    $query = $this->theNewDB->query("SHOW INDEXES FROM `$table` WHERE Key_name = 'PRIMARY'");

    if( $query->num_rows() > 0 ) {

        //check table name for non alpha characters
        if( preg_match($disallowedCharacters, $table) ) {

            return false;

        } else {//so far, so good

            //check column names

            $fields = $this->theNewDB->list_fields( $table );

            foreach ($fields as $field) {

                if( preg_match($disallowedCharacters, $field) ) {

                    return false;

                }

            }

        }

    } else {

        //die($table);

        return false;

    }
```