AC 2012-3306: ISPR: AN INFORMATION SYSTEM FOR PHYSICIANS RESOURCES

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Business, graphic arts, politics, music, and computer technology have always been Preston Jay Mendoza's main interests. His undergraduate years have been a long filtration of those many interests, which ultimately led him to enroll in the Computer Information Systems program at National University. From this program, he further enhanced his business and computer skills in project management and data management systems. These skills were used to develop the capstone project, which includes the corresponding paper.

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ISPR: An Information System for Physicians Resources

Abstract

The information system detailed in this paper was designed and developed for Physician Partners. Scripps Mercy Physician Partners is a physician business organization and medical group with a 6-year track record of helping our 600+ members to increase the viability of their private practices. Their goal is to provide member physicians with an organization that improves fee-for-service contract reimbursement and offers the cost benefits of a large group, while respecting the independence of each physician practice. Physician Partners has developed select strategic business partnerships that offer physician practices opportunities to decrease overhead costs and access new revenue-producing services. Physician Partner approached us with a request to update its existing physician information system to a more advanced, scalable and extensible, distributed database which can support concurrent use, high numbers of records and potential web based secure access. Students from our CIS (Computer Information Systems) program were then given this challenging task of designing a new system for Physician Partners. The student, using the knowledge and skills they learned in the courses, proposed a new ISPR system that supports the current system functionality to existing levels of service, more scalable in terms of time, data, location and users, i.e. a higher number of records, a higher number of concurrent user. The system is based on a normalized, extensible SQL (Structured Query Language) compliant data model able to generate or provide the relevant data to support the generation of reports in a more flexible and open way. It uses an SQL based database which allows the traceable evolution of both the schema and the content data. Some light transactional semantics introduced to the system to trace and follow changes to the database over time and secure the data at multiple levels at the user, database, OS and network levels. It was great learning experience for students and exposure as well a chance to test their abilities.

1. Introduction

Scripps Mercy Physician Partners is a physician business organization and medical group with an 8-year track record of helping its 600+ members increase the viability of their private practices. Their goal is to provide member physicians with an organization that improves fee-for-service contracting and offers the cost benefits of a large group, while respecting the independence of each physician practice. Physician Partners has developed select strategic business partnerships that offer physician practices opportunities to decrease overhead costs and access new revenue-producing services.

Information Systems are a critical enabler in meeting a company's tactical, operational, and strategic objectives. Physician Partners is no exception to this modern reality. With this fact in mind, Physician Partners approached the National University School of Engineering, Technology, and Media with a request to update its existing physician database system based on the Microsoft Access® application, based on Microsoft Access on a PC. The group intends to transition to a more modern, scalable and extensible distributed database which can support concurrent use, high numbers of records, and web based secure access. In addition an

architecture that can be extended to being securely supported in the cloud. This paper presents background of the current system, design rationales, used in development efforts, ISPR Implementations, discussion and conclusion.

2. Background

2.1. Current Legacy System

The current Scripps Mercy Physician Partners database management system uses information from both the group's physicians and their insurance carriers to produce a series of Current Procedural Terminology (CPT) codes and associated billing rates for those codes as to what a physician may charge a patient for a particular procedure based on the patient's medical insurance carrier. CPT codes are numbers assigned to every task and service a medical practitioner may provide to a patient including medical, surgical and diagnostic services. They are then used by insurers to determine the amount of reimbursement that a practitioner will receive by an insurer. Since everyone uses the same codes for the same services, uniformity across carriers is ensured. It should be noted; however, that uniformity in understanding what the service is, and the amount different practitioners get reimbursed will not necessarily be the same. The estimated systems size at present is approximately 12000 records and growing. A typical set of records for a physician may hold details on: Physician name and contact information, Medical Specialty, Board certifications and licensure information, Board certifications expiration dates, Physician Schools attended, Physician License details, Specific billing information and a list of CPT codes detailing the procedures that physician performs.

Physician Partners current system maintains physician information and insurance carrier information with a list of CPT billing codes that every subscribing physician's office uses for billing purposes. Physician Partners then produces monthly reports for the insurance companies which tell them how to pay their physicians. Physician Partners Medical Group also produces reports based on other factors such as the status of their doctors' credentials. The system is composed of a Microsoft Access® application .mdb file stored on a network drive which is backed up through a manual batch driven process. The Access database contains information about physicians, medical groups, contractors, and other physician business service providers contracted with Physician Partners. It shows how these groups are related to each other and provides methods for collecting information about them. The Physician Partners Database Management System uses a relational database, which means that the information is stored in separate "stacks", or tables of logically-related data. Relationships are defined to show how the different tables are related to each other. This type of database aims to reduce redundancy of data and provides flexibility, simplicity, and ease of management.

2.2. Proposed New System

In devising a new design for the Physicians partners it was decided to break the problem down into two principal areas and tackle these separately inline with industry known practices of separating concerns and then looking to apply a layered solution. The problem was then broken down and could be amply solved by fulfilling following two key requirements

i. Provide a new open canonical and extensible data model of the legacy data upon which the current system was based – a foundational data model

ii. Provide a means by which the logical business intelligence applications that currently functioned over the old legacy data could use this new foundational data model so as to provide the current users with the same sought after use cases – in essence provide a means to furnish clients of the foundational data model who would realize the same utility as on the older legacy system

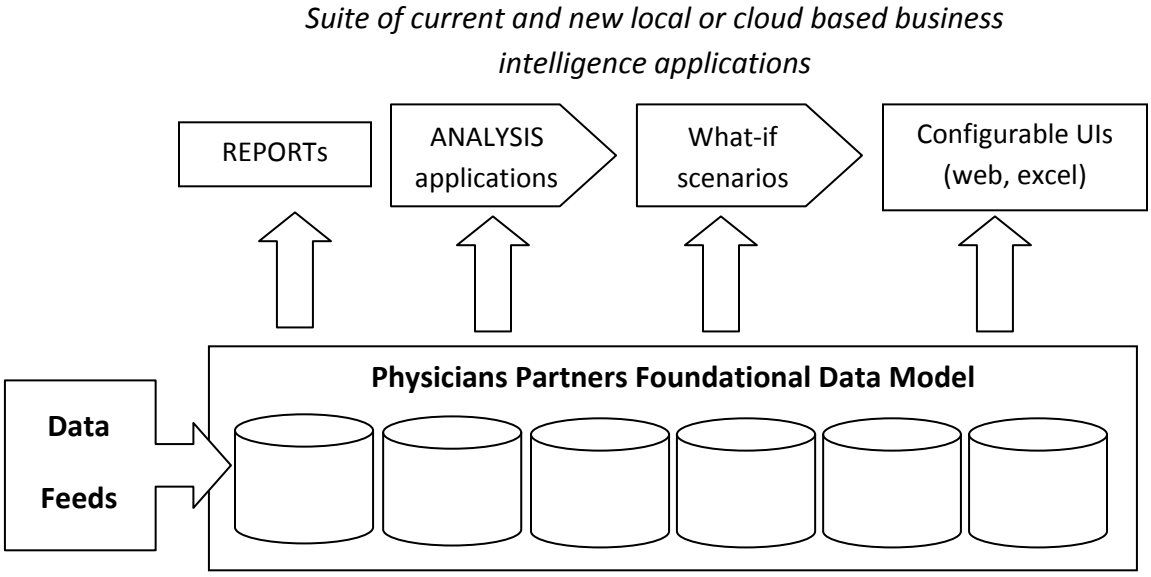

Figure 2.1 – Goals for NU Physicians Partners Project

In addition, the design rationale for providing solutions to these two separate elements warranted an approach that must be viable;

(a) Lower the clients initial capital expenditure (CAPEX) at inception and deployment of any new system proposed, and
(b) Exhibit significant reduced long term operational expenditure (OPEX) in terms of maintenance and enhancement of the data and its schemas.

The proposed ISPR system upgrade currently builds on the existing capabilities provided by the MS Access database through the retention of existing system functionality and levels of service of its legacy UI (User Interface) but with a newer backend data infrastructure furnished through user specific view. In Addition, it will provide enhanced scalability in terms of time, data fidelity, number of records, and support to a higher number of concurrent users. These enhanced capabilities will be enabled through the development of a normalized, extensible Structured Query Language (SQL) compliant data model that can be expanded to accommodate greater number of records and/or more detailed records as required by the users. The SQL data model will also provide a stable, interoperable, open source platform that will retrieve relevant, tailor able data for timely dissemination of reports to form business decisions.

In order to control and manage risk, initially and during development, a strategy was utilized where a layered and decoupled architecture and decoupled User Interface (UI) would result in the avoidance of tight coupling between the data and any dependent business application. In addition it was decided to keep the old legacy MSAccess available and operational but it could be pointed to work from either the MSAccess DB or point to the newly developed SQL compliant RDBMS. Some open source products, such as, mySQL allow Access Graphical User Interface (GUI) to be used as the front end UI of mySQL backend data store. This dual approach is illustrated in figure 2.2.

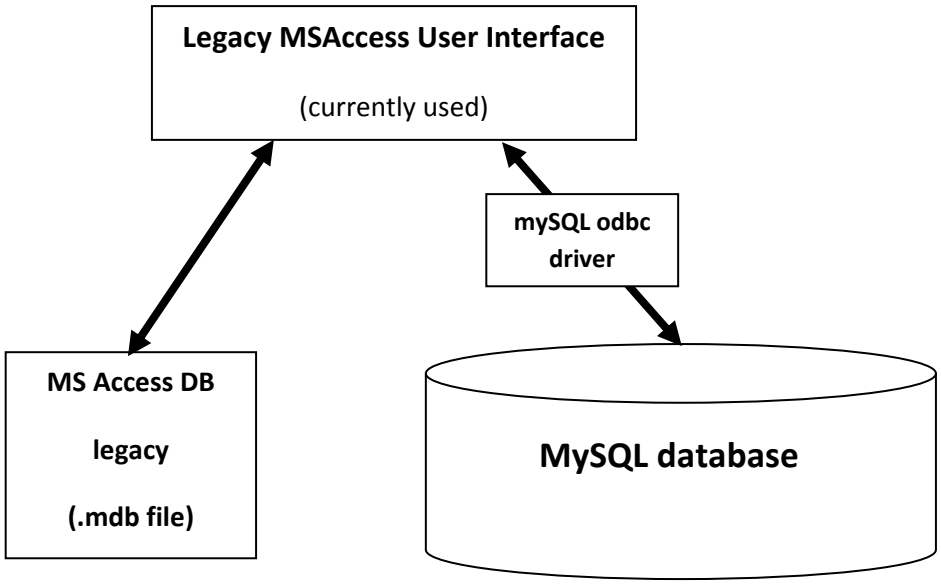

Figure 2.2 Risk mitigating dual pronged approach to achieve successful acceptance testing

This would also help the customer who could compare results, and ease of use by comparing the two (legacy and new) backend DBs and also a new front end that was being implemented by another developer team. In acceptance testing the client will have the opportunity to select the particular UIs that suit their needs in different scenarios of usage by different groups of end users.

3. ISPR Development

3.1. Conceptual Architecture of new system

Once it was decided to provide a layered, distributed, and highly decoupled (in the sense of application data and UI) two teams were formed. One team focused on providing the data model only while the other focused on devising example business intelligence applications to lay over the data model that is designed by the first team. In addition in devising the new architecture the use of three principal design patterns was used based on the work of Fowler [1] and Hohpe and Woolf [2]. These were Separated Interface [1], Aggregator [2], and Canonical Data Model [2]. In addition we used a variation of the Model View Controller (MVC) pattern along with a three schema architecture approach to implement the Separated Interface pattern. The use of the separated interface pattern [1] was made whereas we defined the public interface of a SQL package or module was defined in a separate place from its implementation – in effect we adopt

a strategy of separating users accessible interface (this may be a view, a stored procedure or just a simple result) from the detailed low level logical and physical implementation schema elements. This allows the new database architecture to add new view (to furnish UI screen, reports or whole new business applications) by either creating a new or aggregating linear combinations of existing views. The aggregator pattern [2] is used when building end user specific view based in the legacy system. The idea is that a series of SQL views may be aggregated into a single UI screen that can be used for analysis by the end user.

The canonical data model [2] reduces the legacy MS Access database to a form that is independent of any specific application or UI, and is therefore used as mechanism to minimize dependencies. This means that the data is in a form that allows multiple separate applications to use the data by virtue of each having and individual transformation to interact with the data – in our case we use custom views as the mechanism for effecting that transformation. The cutting face was chosen to be an SQL View to which the team developing UI could couple business intelligence application screen, but would allow the data models internal conceptual and internal physical schemas to evolve and continue to be optimized. This approach required the use of open standards based approach the use of COTS, meaning that a fully compliant SQL 92 RDBMS would need to be used as well as tried and tested to support application infrastructure technology that was cheap to maintain and deploy if needed. Therefore a cost benefit analysis was done mySQL was chosen as the platform upon which to implement the foundational data model. In effect, using MVC with three schema architecture the data model will change minimally at its core, but may provide newer additional interfaces via new views in future years based on new requirements.

The principal extensibility and canonical requirement in the design of the foundational data model is fulfilled using the Canonical Data Model pattern which then provides the data foundation upon which the Physicians group can then deploy numerous future generations of business intelligence applications as their and their member's requirements change and evolve over time. Therefore, in addition to generating reports, which is a common use in the legacy system, the new system would permit additional business intelligence applications that would permit the devising of and running 'what if' scenarios, gathering and analyzing trends in billings, rates, or analysis of statistical distributions of more complex aggregate functions thus providing new services to their member physicians.

3.2. Database Tool Selection

A trade study was devised to evaluate best options that lowered costs initially and in the long term to develop and support the new database. MySQL option provides several freely available high quality CASE tools such as MySQL Workbench that reduced development time, complexity and likelihood of errors in schema design. To meet the requirement of developing an open architecture SQL compliant data model, the open source MySQL database was selected as the ISPR database software suite deployment platform. The MySQL database's high performance, high reliability and ease of use make it one of the most popular open source databases throughout the IT industry. MySQL also runs on most operating platforms including Linux, Unix, Windows, and the Mac OS. The flexibility, prevalence, and support offered by MySQL combined with the zero cost formed the basis for the selection of MySQL Workbench

software development suite. Lastly it is very easy to find plentiful consulting support for MySQL given its pervasive nature in the industry at very reasonable rates.

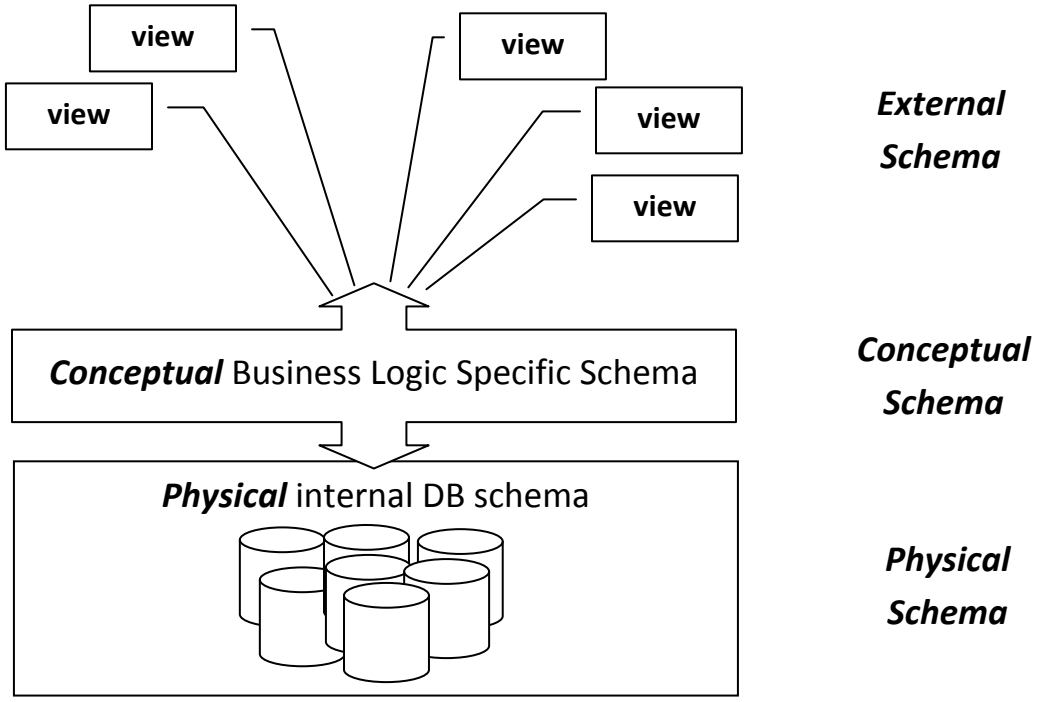

Figure 3.1. The three schema approach

3.3. Schema Development Approach

To facilitate the reuse of existing data and to save time in a compressed development cycle, we imported the existing Microsoft Access database tables into MySQL from a copy of the .mdb file. The intent of importing the Access tables into MySQL was to form a baseline understanding of current system requirements and relationships and to have a starting point to begin the normalization process and creation of the Entity Relation (ER) diagram. In developing the schema the designers sought to maintain

1) Use of CASE based COTS approach using MySQL Workbench to aid in the design.
2) Strict adherence to the SQL92 standard and careful avoidance of any vendor specific solution elements – e.g. nonstandard data types.
3) Aim to protect the customers investment by writing portable schema .
4) Aim for a high degree of scalability to allow growth in future in the number records without seeing discernible differences in time to generate reports or perform any sorts of trend analysis or what if searches and scenarios.
5) Continue with the approach (where practical from the performance point of view) of using the three schema approach.
6) Maintain separation of responsibilities or concerns by either layering or appropriately structuring tables (see figure 3.1), and view interfaces from low level implementations.
7) Separation of interface from implementation by partitioning the schema into Views at the upper most level couple to user specific screens and use cases and use of highly normalized base tables at the lowest level.

8) Use of Stored Procedures to enter data in a safe and controlled manner
9) Use of Views that are editable via stored procedures.
10) Simplicity of design enabling customer to realize long term reduced expenditure in maintenance and support.

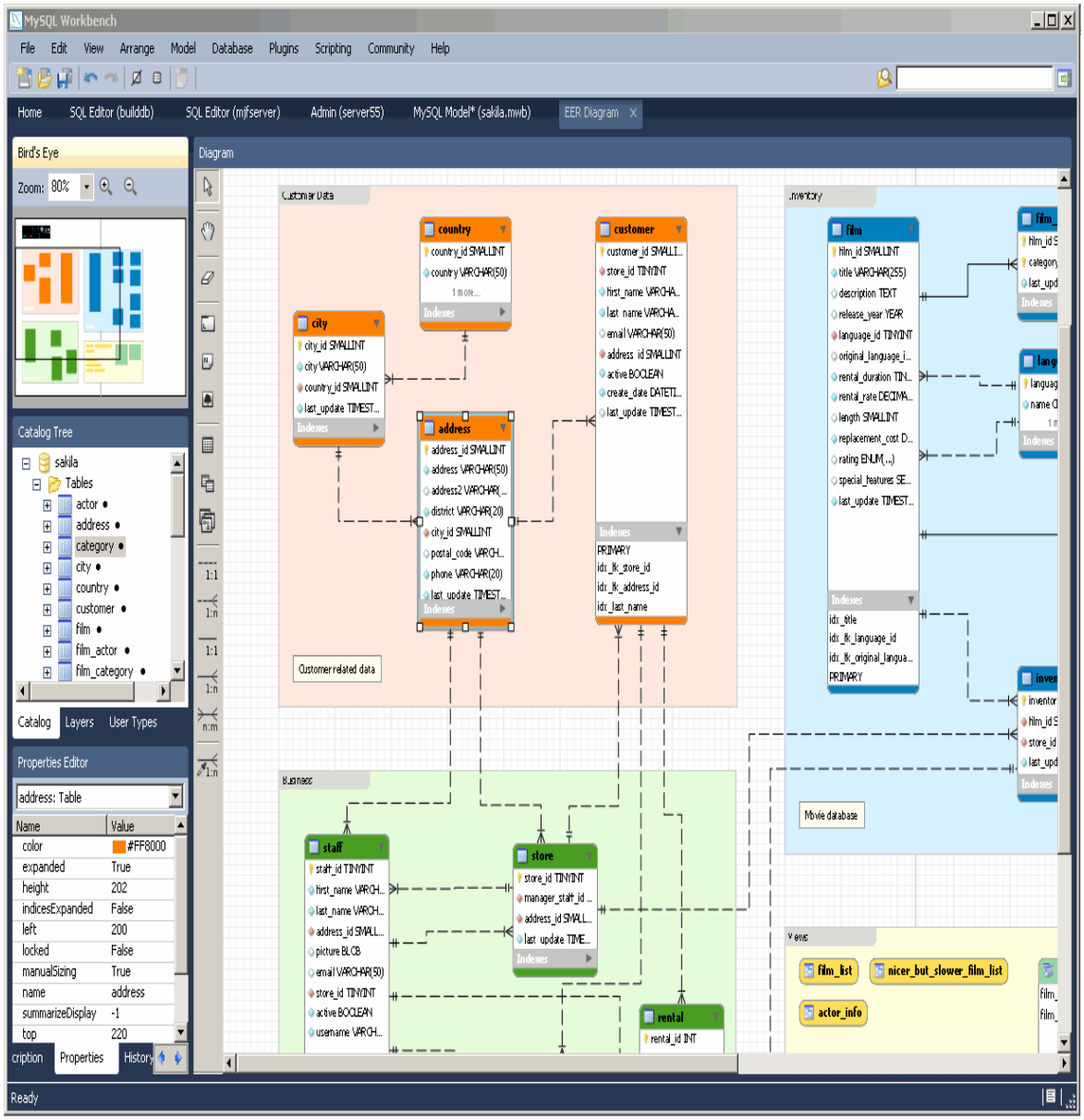

Figure 3.2 Example of MySQL Workbench 5.2 Schema Design Tool

3.4. Table Normalization and the ER Diagram

The process of organizing data to eliminate redundancies and avoid integrity problems is called normalization. Much of this process involves decomposition of larger tables with inconsistent or irregular relationships into smaller tables to produce well structured, logical relations throughout the schema. Much of the normalization process of the ISPR schema involved breaking up larger

tables from the Access database into more manageable, decomposed tables with improved data isolation. In some cases, fields were renamed and primary/foreign keys were altered or assigned to create strong relations between entities. The ultimate goal was to create a schema that would support single point field modifications that would, in turn, propagate throughout the entire schema. Database normalization was captured and annotated while creating the ER diagram within the MySQL workbench. Again, in some cases the original Access database tables were altered (fields re-named, keys reassigned, etc.), broken-up into smaller tables, or removed entirely in order to strengthen relationships, reduce redundancies, and isolate data. Figure 3-2 shows how the schema, for example, was partitioned into separation of concerns in the data model.

3.5. SQL Script Generation

After base lining the normalized ER diagram, SQL script was automatically generated from the ER diagram tables to create the baseline schema within the MySQL workbench. After some semantic error checking and correction, the SQL script was executed within the MySQL environment and a text file, along with the MySQL schema and ER Diagram, were retained for configuration control purposes and posted in a web-based shared repository for team collaboration.

3.6. Data Entry and Queries

Once the schema SQL script was executed, error free, within the MySQL workbench environment, test data was entered. The original queries were taken from the Access database and altered (both in their commands and semantics) to fit the newly created schema residing in the MySQL environment. Ultimately, the results of the queries populate the reports generated in the web-based User Interface (UI) application or "front-end" for the database user to complete the task. The intent was to retain the original capability of the Access database (i.e. keep all the queries for report generation) but use an open source SQL schema and a web-based application for user presentation. In addition it was planned that any user based data entry if not scripted using bulk load utilities should be provided going forward through the use of stored procedures that would check for any business data or constraint/rule violations ahead of any table insertions.

4. ISPR Implementation

Successful implementation of the new database management system requires more than just the creation of a SQL-compliant schema within the MySQL workbench. New server hardware and software need to be pursued to realize the full potential and scalability desired by Physician Partners. The following sections outline recommendations for database optimization tailored to Physician Partners needs.

4.1. Recommended Operating Environment – Trade study performed

To expand beyond the current limitations of using an Access database on a shared network drive, Physician Partners could invest in a relatively inexpensive database server with updated software. Based on the desired capabilities and financial parameters described by Physician

Partners representatives, we made hardware selection based on the processing power, memory, scalability and cost

Processing Power: Even for relatively small databases, a multiple core processor is an advantage in the CPU-intensive environment encountered in most database management systems. Therefore, the new server should have a minimum of quad cores.

Memory: A minimum of 12 Gigabytes of main memory with 12 Megabytes of cache memory should be sufficient. Redundant Array of Independent Disks (RAID) 1 should also be implemented to ensure that data is saved concurrently on two hard disks to reduce the possibility of lost data in the event of drive failure.

Scalability: Any selected system must allow for future growth if required.

Cost: Affordability is arguably the most important factor in choosing any new system. As with most business decisions, tradeoffs must be analyzed and given appropriate weighting factors when making an IT investment.

Although all the manufacturers' products listed can meet the recommended specifications listed in table 4.1, the Dell PowerEdge M710HD Blade Server requires little to no special orders and is the least expensive. Also included with the Dell PowerEdge M710HD Blade Server is the Microsoft Windows Server 2008 Operating System. The prevalence and support offered by Microsoft along with interoperability with other Windows-based products makes Windows Server 2008 the recommended Operating System for the Physician Partners ISPR database.

Attribute	Hewlett Packard ProLiant	IBM BladeCenter HS12	Dell PowerEdge M710HD
Processor	Intel Xeon Processor 2.50 GHz	Intel Xeon 2.83 GHz	Intel Xeon 2.4 GHz
	2 Quad Core processors	1 Quad Core processor	2 Six Core processors
Memory	12 GB main memory	12 GB main memory	12 GB main memory
	6 MB cache	6 MB cache	12 MB cache
	No hard drive	146 GB hard drive RAID 0 or 1 standard	146 GB hard drive RAID 1 standard
Scalability	Supports Expansion	Supports Expansion	Supports Expansion
Cost	$3,152.00	$2,319.00	$1,812.00

Table4.1. Three of the leading server manufacturers' standard blade server packages with the metrics listed above.

4.2. Backup and Recovery Options

Like any other IT system it is important to back up database so that data is recoverable in case problems occur, such as system crashes, hardware failures, or users deleting data by mistake. Backups are also essential as a safeguard before upgrading any SQL installation, and they can be used to transfer a SQL installation to another system or to set up replication servers. There are several back-up options available at varying costs. For example, Symantec Systems Backup Exec offers relatively low-cost (basic license and 3 year support ~$1,300) back up software for servers running SQL-compliant databases. While some backup schemes require additional backup drives (either tape or additional hard drives) cloud-based (off-site) backups are offered by companies like Symatec as well. In any case, a comprehensive data protection plan is recommended across the Physician Partners enterprise. Due to cost and off-site redundancy, a cloud-based, "all-in-one" solution from well-known venders like Symantec Systems or Redgate is the preferred choice for the Physician Partners ISPR.

5. Discussion

The new system is currently in test and more work is being done on the UI and on creating layers of stored procedures that can be aggregated to provide higher level applications. Several of the design goals sought in the inception phase were successfully realized. We list a few below:

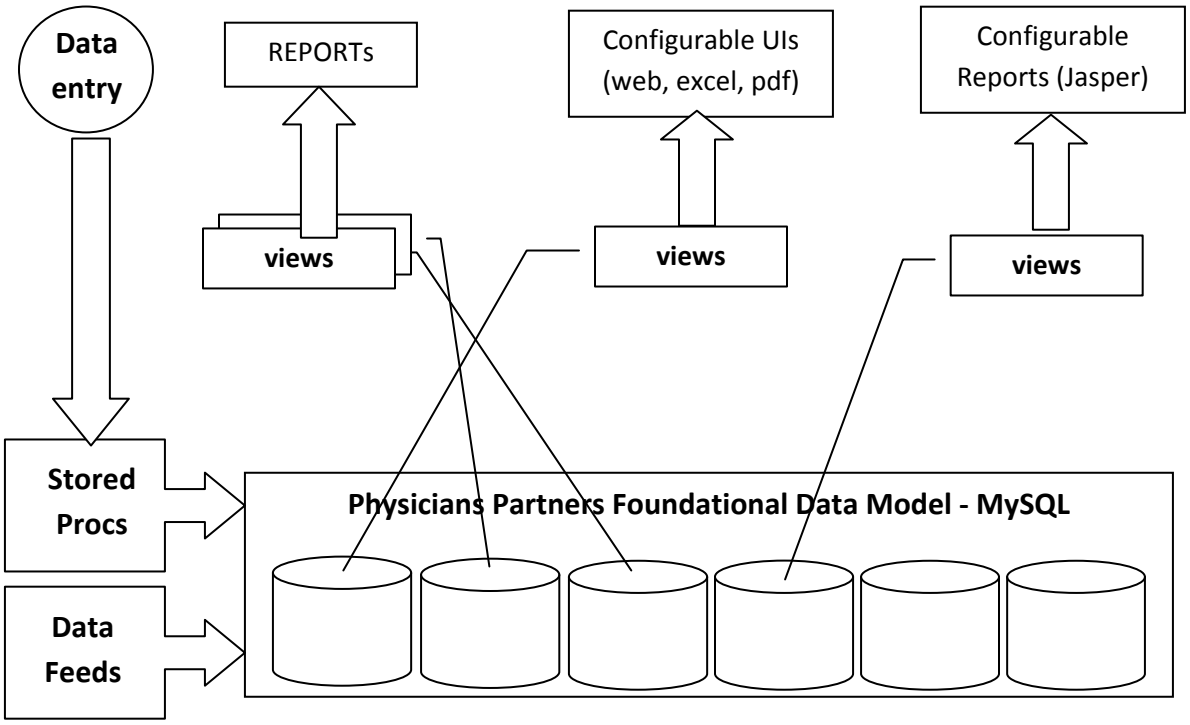

Figure 5.1 Current Physican Partners mySQL based Data Model and application infrastructure

1. We have successfully achieved UI design that is independent and decoupled from the main low level physical schemas of the data model. UI is only coupled to Views defined by business needs as show in Figure 5.1**.**

2. The team successfully reduced risk of development by allowing Access to still act as the front end to the new DB in the interim for the client to get comfortable with the new backend without having to learn a whole new front end UI at the same time also – thus learning curve time in acceptance test has been reduced.
3. Additional new extensible and fully secure yet distributable new UI developed by a second team working with WaveMaker and Jasper report have created what can now be a system that can be deployed into the cloud or over a wider more distributed internet based deployment landscape.
4. The end user has a choice of using old Access UI to access new DB, or use the new UI or use simple PHP-Javascript web pages to access the database concurrently.
5. The architecture is designed to allow read only access via views for reports and configurable UIs and configuration of report generation activities via Jasper reports.
6. Future and new data-entry is now to be performed either via stored procedures that perform business rules checks before inserting data into the database or bulk uploads via mySQL bulk load utilities.
7. All transformations in the mySQL RDBMS are now transactional, recorded, traceable and subject to audit thereby creating a more secure, traceable and easily manageable information datastore that can be recovered, repaired, or rebuilt by virtue of the transactional semantics of mySQL operating at all times.

6. Conclusions

The CIS program student team has achieved their goal of designing an open low cost standards based SQL solution for Physicians Partners which is also scalable, and openly extensible to support future generations of advanced business intelligence applications. The simplicity of approach and design makes it now possible for this stable, robust, foundational data model with low initial CAPEX to allow its owners to enjoy significantly reduced long term total cost of ownership of this system. All of the students participating in the project, in their feedback wrote that enjoyed the experience and learned a lot.

Acknowledgement

We would like to that Ted Steuer, Executive Director Physician Partners and Natalie Nelson, Manager of Physician Services for their excellent consistent support, time and understanding for this project.

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