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Best Practices for Data Transformation in Healthcare ETL

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ABSTRACT

The practice-based approach is used to construct a big data analytics-enabled transformational model that shows the causal links between business values, benefit dimensions, IT-enabled transformation practices, and big data analytics capabilities. Optimizing methods to enhance the ETL process might be very beneficial for real-time data analysis. A number of circumstances might lead to ETL optimization. The easiest is to increase the process's frequency. More than ever, healthcare businesses depend on data, thus gathering and processing data is essential for any business. Daily technological advancements have resulted in an increasing amount of data, making it challenging for a business to handle using the tools and methods available today. Big data has emerged as a result of these realities in almost every company that handles data and customers. Therefore, in order for any company, including healthcare organizations, to satisfy its current and future objectives, new methods that focus on organizing and extracting valuable information from the data gathered are required. A critical clinical care concern involving divergent yet coexisting information systems is enhancing the interoperability between healthcare information systems. However, like data warehouse firms, healthcare organizations also have to deal with the challenge of selecting the best ETL tool and design style. An overview of the most recent ETL solutions for integrating healthcare data is provided in this article. Furthermore, we provide three ETL procedures for clinical data integration that map data from many data sources (like MEONA and ORBIS) to multiple standards (like FHIR and open EHR) utilizing various ETL tools and design patterns. To increase team productivity, we choose our ETL tool and software architectural pattern based on the technical needs of the project.

Keywords: - Optimizing Techniques, ETL Tools, Boost Team, ETL Processes, Business Values, Big Data Analytics, Healthcare Information, Healthcare Organization, Technical Requirements.

INTRODUCTION

Many sectors and the businesses that operate inside them face previously unheard-of potential and new challenges as the "Age of Big Data" dawns [1]. Researchers and consultants in technology (or vendors) have identified many advantages of integrating big data analysis into company operations [1, 2]. It is well known that big data analytics can help healthcare administrators handle the increasing amount of clinical data that supports evidence-based medicine and enhances the effectiveness and quality of healthcare delivery [1, 2]. Big data proponents in the US assert that when used appropriately, data analytics in the healthcare sector reduces costs by $300 million yearly, enhances the management of diseases brought on by lifestyle choices, simplifies administrative burdens, and enhances customer-provider interfaces [3, 4]. The typical data management skills of a healthcare organization are really challenged by rapidly growing amounts of data in diverse forms from several sources. A significant portion of their extensive dataset of electronic medical records is [2],

"Seen as a consequence of providing healthcare rather than a primary source of competitive advantages".

In order to completely reap the benefits of big data analytics, the emphasis must be shifted from technological tools to analyse and illustrate the strategic, managerial, and economic effects of big data analytics. Additionally, the best way to use big data analytics to generate business value for medical institutions must be explored [3, 4]. The function of big data analytics capabilities and its direct impact on corporate performance have been the main subjects of research on big data analytics. Nevertheless, renowned academics have critiqued that IT resources and capabilities by themselves may not unquestionably improve business performance [3, 4]. Similarly, research on the IT productivity conundrum has shown that IT may not immediately result in significant increases in healthcare productivity [3, 4].

To fill this knowledge gap and assist academics and practitioners in comprehending how the essential components of practice interact with IT technologies, the Practice-Based View (PBV) has proved developed. In order to provide healthcare professionals comprehensive views on how IT resources might be utilized to improve clinical procedures, experts have embraced this viewpoint in the particular context of healthcare [3, 4]. Therefore, we contend that implementing PBV will provide a more comprehensive understanding of how analytics on large amounts of data can be used to generate corporate value [3, 4]. However, increasing our knowledge of how analysis of large amounts of data affects organizational operations and business processes has received little attention up to this point [4, 5]. By creating the conceptual framework of Big Data Analytics-Enabled Transforming (BDET) based on the PBV, we aim to close this gap. Use this as a platform to investigate how analytical capabilities for big data help healthcare businesses' business value by facilitating IT-enabled transformation methods [4].

Tools, constructions, databases, warehouses of data (DW), performance management, techniques, and other components that are all integrated into a single software suite [5, 6] are all included under the general term of business intelligence (BI) [4, 5]. Data may now be sent directly to professional staff members who can utilize it the most, bypassing administrative offices, thanks to the health care industry's use of business intelligence [3]. When business intelligence (BI) is used in healthcare, decision-making becomes more efficient and users may access any kind of information with a quick and reliable response time [3, 6]. BI is used by healthcare organizations to create management dashboards that support the monitoring of clinical and financial KPIs (key performance indicators) and the management of business operations [6, 7].

Clinical data [3, 4], patient behaviour data, pharmaceutical data, and insurance data are the four categories into which healthcare data may be divided. Information regarding individuals' health and the medical treatment they get during different time periods is represented by clinical data [5, 6]. Data on patient behaviour is gathered using wearable technology and monitors to provide a precise and comprehensive picture. Drugs, dosages, effects, and clinical trial findings are all included in pharmaceutical data [6, 7]. Among other things, insurance data include total insurance premiums, both employer and worker premium shares, cost-sharing plans, enrolment numbers, and total medical expenses [5, 6]. Given the enormous volume of data that should be stored in databases, data analytics is crucial to assisting the healthcare industry in making almost ideal selections [6, 7].

Proposed Bi Framework for Healthcare Analytics

Kaiser Permanente is well known across the world for using cutting-edge procedures and technology, such as adopting the big data idea, to enhance the effectiveness and calibre of healthcare provided to patients [6, 7]. He has shown how all healthcare practitioners may increase patient care efficiency by using consent-based integrated health information. According to a 2009 study, having instant access to comprehensive, integrated, and up-to-date patient data—including imaging and pharmacy data, as well as inpatient and outpatient data—was linked to a 26% decrease in inpatient visits and an eight-fold increase in the number of telephone consultations that could be held [6, 7]. As stated in this introduction, the primary goal of this article is to help healthcare companies make better choices by using an integrated BI platform for healthcare analytics [6, 7]. The suggested design, as shown in figure 1, is often made up of six tiers: the data source tier, the Extract Transform and Load (ETL) tier, the data storage tier, the analytics tier, the optimization tier, and the presentation tier [8]. The BI framework's fundamental design serves as the foundation for the suggested framework [7, 8].

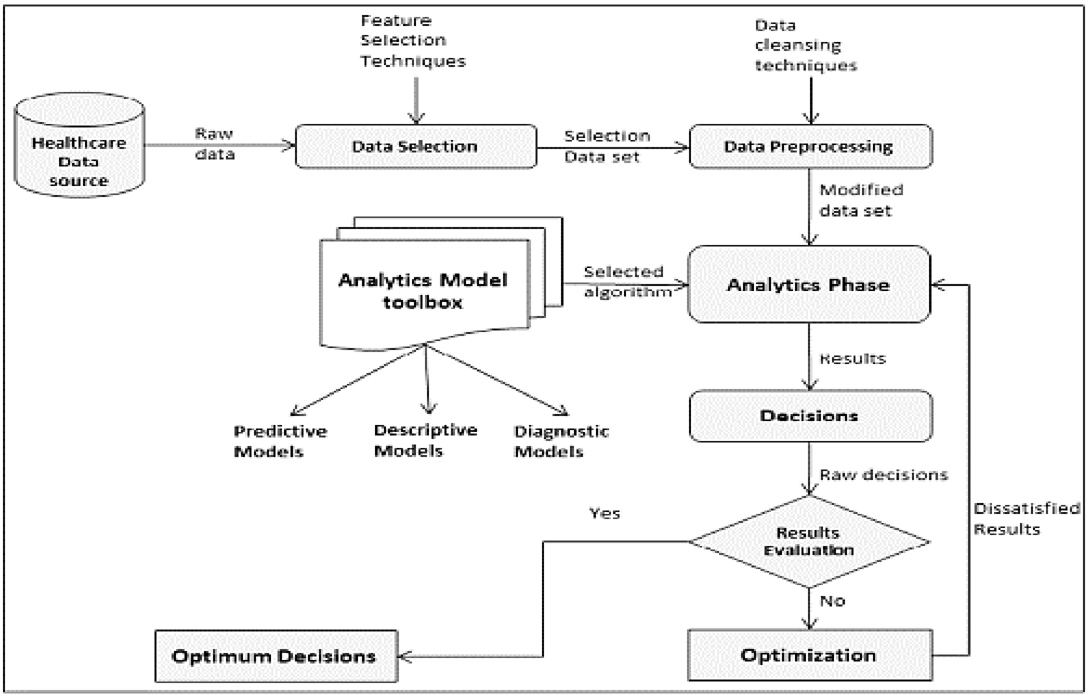

Fig. 1 The structure of the Analytics tier. [8, 9]

Big data in healthcare

As the term implies, big data is used to describe vast amounts of data that are impossible to handle with conventional software or online platforms. Three distinct proportions—velocity, [9], diversity, and volume—are present in big data. 3Vs stand for significant data qualities. As with big data, the amount of the data is a good indicator of its scale. The pace or rate at which data is gathered, made available for various studies, and used in other contexts is known as velocity [6, 9]. Lastly, [9], diversity is employed in big data with respect to the many types of structured and disorganized data, including text [9, 10], log files, audio, video, and transaction-level data [6, 9].

The Electronic Healthcare Record (EHR) is a crucial piece of infrastructure in the healthcare industry that supports doctors and other professionals in providing care services by giving an overview of a patient's health state [9, 10]. It gathers common clinical records from many previous systems and repositories created for various specializations, objectives, and organizations (e.g., hospital and laboratory information systems, GP's record) [9, 10]. According to our perspective, the EHR may serve as a primary information source for the data warehousing [9, 10]. Given that data gathered in the EHR is organized using a common schema based on the HL7 CDA, which codes data using standard nomenclatures and dictionaries, this method makes designing ETL methods easier. Nevertheless, the design and execution of ETL processes need the standardization of various document formats via explicit CDA requirements [9, 10], shifting the integration problem from a source system perspective to a document template perspective [10, 11].

Typical formats for exchanging healthcare data include:

1) FHIR,
2) Open EHR via
3) Integrating

Cross-enterprise document sharing (XDS) is a profile of the Healthcare Enterprise (IHE) [11, 12].

1) Resources (individual information packets) may be developed and transferred quickly and simply with the help of rapid healthcare interoperability resources (FHIR), which divides information into distinct and independent data parts utilizing the REST methodology [12, 13].
2) Open EHR explains how archetype-based electronic healthcare records (EHRs) are used to organize, store, retrieve, and share health data [14, 15]. By referring to certain Reference Models (RMs) that provide potential data arrangements that correlate to logical points of information and groups for a domain issue, archetypes offer semantic modelling [16, 17].
3) By distinguishing between metadata (organized and searchable object attributes) and document content (such as unstructured PDF documents), XDS allows actors to communicate with each other via SOAP and SOAP with Attachments [17, 18].

Concept

We demonstrate standard ETL tools for healthcare data for the conceptual design of data transformation. Furthermore, we use three ETL procedures from our MeDIC as real-world examples and look at the sources of our data [18, 19] as well as the systems and data formats that need to be transformed and published.

Common ETL Tools for Healthcare Data

In general, there are two types of ETL tools: source code-based and tool-based [17, 18]. With the use of a Graphical User Interface (GUI), tool-based ETL procedures make it easier to create workflows for ETL tasks and automate their execution [17, 18]. The following are some of the open-source data integration solutions that perform well and reach high degrees of maturity in healthcare use cases:

Although it is an open-source technology, Talend is not a complete BI package [18, 19].

- It employs a code-generating methodology. In addition to its high data connection, it enables the creation of more personalized Java and SQL queries using its own graphical user interface [18, 19].
- Apache Ni Fi automates data flow across systems and offers scalable data routing. Its user interface is web-based [19, 20].

Additionally, it makes it possible to create customized processors that expand the fundamental capabilities. For instance, a data science platform routes data flow using Nifi [20, 21]. With features for reporting, analysis, dashboards, data mining, and ETL, Pentaho Data Integration (PDI) is an open-source business intelligence tool [20, 21]. PDI is used in several projects at Loma Linda University Health Care, Remedy Partners, and the University of Oklahoma Tulsa to handle medical data [20, 21]. Additionally, Clover DX (Clover ETL) offers automated and visual control over data flows [21, 22].

The benefit of source-coded ETL systems, on the other hand, is that they allow developers to be more flexible in handling new needs and developing unit tests. However, they put a strain on the project as a whole and need a particular degree of programming and maintenance abilities from the development team [22, 23]. Python and Java are often used languages by ETL developers:

- Java is an object-oriented, general-purpose programming language. Because it is a compiled language, it is often quicker and more effective [22, 23].
- Spring Boot, on the other hand, is an open-source Java framework that facilitates the simple development of standalone, high-quality apps [23].
- Python, on the other hand, is an interpretable and dynamically typed language.
- According to some, Python has a lower initial learning curve than Java [23].

ETL Processes

We gather three ETL procedures with various technical specifications:

1) ETL Process 1:
2) Converting CSV exports from MEONA databases to FHIR ETL Process 2:
3) ETL Process 3: Mapping ORBIS HL7 to Templates Data [22, 23], Documents (TDDs:

Building SOAP envelopes with TDD encoded in order to use IHE XDS to access EHR [23].

Source Systems:

1) MEONA and
2) ORBIS
    1) MEONA is clinical software that facilitates the whole course of drug therapy. MEONA provides: Effective recording of measurements and reports at the touch of a button, safe prescription and administration of medications [23], [23, 24].
    2) ORBIS is a tool for managing healthcare facilities, administration, and medical processes. Currently, UKSH exchanges data to and from ORBIS using a modified version of HL7 v.2, the most popular healthcare format for electronic data exchange in the clinical area. [23].

Target Systems: The HAPI FHIR JPA server is a relational database-based FHIR server that manages the logic for storage and retrieval. Other FHIR servers, such as Blaze, Firely Server, IBM FHIR Server, [22, 23], and others, are available on the market in addition to HAPI FHIR. Furthermore, Better Platform is a for-profit Clinical Data Repository (CDR) made to store and administer EHRs in accordance with the open EHR specifications [22, 23].

Our goal for ETL Process 1 is to translate data from the MEONA database into FHIR R4 resources as output CSV files [22]. We utilize medical data to improve clinical treatment and identify drug issues as part of the MMI use case POLAR_MI [9, 11]. CSV files are used to export the data. Analysis script from the POLAR_MI collaboration will then assess the outcome once it has been placed into a self-hosted HAPI FHIR server [11].

ETL Process 2 (part of the HiGHmed use case Cardiovascular) maps a combination of standard HL7 messages (ADT and BAR) and bespoke ORU reports into Template Data Documents (TDDs) in an effort to identify decompensation in heart failure patients [11, 12] [11, 12].

The ETL procedure outlined in ETL Process 3 may use these TDDs. using encoded TDDs to "IHE XDS. b Affinity Domain in conjunction of open EHR clinical data repository," we create SOAP envelopes in ETL Process 3 [12].

Implementation ETL

Java and Spring Boot are used in the development of Process 1 [12, 13]. The application, domain, and data access layers make up the three-layered structure in which its ETL components are arranged. The next higher layer receives services from each layer [13, 14]. The requested thread is executed by the application layer. Using the HAPI FHIR library, we specify the source entities and the mapping procedures in the domain layer [14, 15]. FHIR resource delivery and data access are handled by the infrastructure layer [15].

Two ETL tools, Nifi and Talend, are linked as a "broker pattern" utilizing the streaming platform Apache Kafka in order to complete the mapping of ETL Process 2 [15, 16]. Because of its extensible customization capability, Nifi is responsible for receiving HL7 messages in pipe format, translating the HL7 format to XML-based, and aggregating a unique identification in the form of a Master Patient identification (MPI). In order to distribute messages on various topics, Nifi then sends the messages to Kafka, where the Kafka topics are designated by the HL7 message type [18].

Each Talend job then reads from the relevant topic, adds terminologies from the terminological server [18, 23], transfers the HL7 data into open EHR templates, and enhances it via querying [24].

We use Talend to create SOAP envelopes in a pipe-filter design for ETL Process 3 [24, 25]. We separate our operation across many "filters," such as encoding the result TDDs from ETL operation 2 and querying the terminology server's XDS Value Sets [14, 23]. A more apparent method of mapping different XDS information and creating "filters" is provided by Talend's GUI [23, 25].

Lesson Learned

The ETL tools, the data sources, and common healthcare data interchange formats are presented as three crucial elements of a general ETL process in healthcare data integration [25, 26]. In addition to providing this summary of the state of healthcare data interchange, we also provide three ETL procedures that use various ETL tools to meet our MeDIC's data conversion needs into resources in newly announced formats [26, 27]. Selecting the appropriate ETL tools is heavily influenced by data from various sources and the desired output formats [27, 28]. Every ETL tool has benefits and drawbacks, and not all needs can be met by a single tool.

For example, ETL Process 1 [28,29] generates the required output classes of FHIR resources using the Java package HAPI FHIR Structures FHIR R4. Java may also be used to construct ETL process 2 in the similar manner [30]. It was difficult to map from HL7 to open EHR using Talend. In that regard, [30, 31], we ran across the issue that the target XML templates could be too big for the Talend engine to manage [31,32] when we were developing ETL Process 2. The team's unequal talent distribution was another issue. Understanding both software development and information related to healthcare was a hurdle for our engineers [32, 34]. For example, certain clinical specialists are more used to standard terms such as LOINC and SNOMED CT [33]. Conversely, technical specialists concentrate more on software engineering and infrastructure communication [34]. By selecting and combining the appropriate tools, this issue may also be resolved [34]. The graphical elements of Talend, such as tXMLMap, provide pipelines that are visible and simple to comprehend for developers and analysts of non-source code [34].

Nifi is a nice middle ground since it has a comparatively straightforward graphical interface for managing ETL pipelines and enables us to expand its capabilities by dynamically developing additional source-code-based custom processors [34]. Therefore, in ETL Process 2, we employ both Talend and Nifi simultaneously. We work with Nifi to create new features and utilize Talend to manage intricate healthcare data conversions without source code. Well-designed architectural patterns may improve the degree of abstraction and, therefore, team productivity and workload management, in addition to helping developers choose the best ETL solutions [25, 29].

By processing incoming TDD files from many processes and employing "filters" to query "Value Set" from a terminology server, ETL Process 3 demonstrates the benefits of a pipe filter design. In conclusion, choosing the right ETL tools and design patterns may save a lot of time and effort, but it also relies on the development team's expertise and the goal of the project [29, 30].

The healthcare company must create a road map that details the plan for infrastructure, data systems, end data warehouse structure, procedures, resources, and timescales in order to successfully deploy an ETL approach [31, 32]. The key component of ETL is data integration and consolidation. Mapping all the key variables to each table and combining data from many data source systems, including financial, medical, pathology, etc., is crucial [33].

Creating views and integrating this data from several sources is an essential part of the ETL process. However, this procedure has several issues that make ETL quite challenging overall. Because several databases are kept, it might be difficult to access data from different systems [33, 34]. distinct EMRs have distinct backends, and data integration becomes difficult if a healthcare facility has external records or documentation from several EMRs [34].

Problems with data quality provide another difficulty for the ETL process. Dealing with blob files, text files, and free text fields may be challenging, particularly when it comes to querying and creating a discrete variable for the data. It is well established that non-discrete data, in particular, is not very useful for reporting. As the author of [34, 35], I believe that businesses have a strong chance of making money out of this free text data by turning it into discrete variables or into data that can be used for business reporting [3, 9].

In order to convert these clinical notes' unstructured data into structured data, the NLP algorithm was recently introduced and used in the healthcare industry [29]. Even in these situations, the issue is that different doctors and nurse practitioners write notes in different ways, and it might be difficult to understand these distinct instances and incorporate them into NLP algorithms [11]. In order to enable real-time data analytics procedures, essential elements of the ETL process should provide incremental uploading of the data into warehousing [32].

CONCLUSION

In order to arrive at an integrated framework for BI, several experiments have been completed. However, they really focused on DW, the hospital information system, for diseases like diabetes, heart attacks, and influenza. Numerous biomedical and healthcare technologies, including sensors for smartphone apps, genomics, and mobile biometrics, have been crucial in producing vast amounts of data. As a result, several approaches that may access and use this data must be developed. Research in medical informatics is advanced when healthcare data sharing is developed effectively, which is made possible by appropriate ETL tools and design patterns. Since it is exceedingly difficult (and costly) to modify an architecture after it has been established, selecting the appropriate tools and architectural pattern is essential.

The tools and design patterns used in the demonstrations may be modified for use in future ETL projects with related goals. However, ETL operations should also take into account other subjects like data provenance, virtualization, unit testing, and assessment.

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