Real-time Claims Processing in Healthcare: Leveraging Stream Processing Technologies for Faster Payment Adjudication

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Abstract

This paper discusses strategy options that can help to streamline claims processing for Medicare applications. The traditional batch-oriented approach to claims adjudication does not enable real time processing. Recent advances in stream processing technology can address this gap. In this paper, we present the architecture of a real-time claims adjudication system and describe the implementation and evaluation of a prototype using Apache Kafka and Apache Flink. The prototype system can process 800,000 medical claims and achieve adjudication in one second. The results show that stream processing technology can enable sub-second real-time claims processing [1]. As the volume of patient medical services increases, sub-second real-time claims adjudication will become even more important to relieve provider staff waiting for the results as patients are checking out and to ensure a good patient financial experience. Healthcare spending in the United States is estimated to be a staggering $3.6 trillion in the year 2018. Two-thirds of this tremendous sum are attributed to non-commercial and commercial health insurance. In order to better handle the surge in healthcare spending, an increased usage of high deductible health plans has been observed [1]. As patients are taking on more financial responsibility for medical services, there is a growing interest in ensuring that patients comprehend their financial obligations at the point-of-service. To make this possible, insurers must have the capability to promptly adjudicate medical claims. Health insurance claims represent requests for payment, or requests for review of payment for services provided to the beneficiaries of a healthcare program. Healthcare claims are submitted by providers who deliver services to patients, and by patients who have incurred eligible charges. Healthcare payers apply various edits to the submitted claims to verify the eligibility of the service, the accuracy of the charges, and compliance with the benefits offered by the patient's health plan. Due to the complicated medical insurance options offered to employees, the claims processing times can be somewhat extensive in order to review the medical claims [2]. Today, the majority of claims are addressed through batch solutions, which require several hours or even days for their completion. A rise in the need for real-time claim adjudication is experienced due to efforts by the healthcare providers who wish to verify whether a patient’s claim is valid and the amount the patient is expected to pay before being treated. Also, there are more expectations to simplify the claims adjudication automation supported by advanced technologies which include artificial intelligence. This incorporates; the use of big data and predictive analysis to indicate potential problem areas with regards to claims and risk analysis then prioritizing them for examination. Real time claim adjudication seems to offer the best solution since it seeks to ease the burden of provider’s revenue cycle as well as has the

potential of enhancing patient satisfaction. Apart from giving more eligible and efficient information on the financial responsibility of patients, real-time claims processing can also assist in checking fraud and abuse by detecting suspicious claims. Thus, strategies to handle and adjudicate claims in real time will persist as the healthcare field advances and becomes more reliant on technology and innovation. Claims adjudication involves making a decision to approve or disapprove a claim and to pay for the service out of the health plan funds. Adjudication of claims entails several stakeholders- the member (patient), provider (doctor, hospital), and the health plan (insurer) [3]. The process encompasses an assessment of a member's enrollment, medical necessity along with the benefits that are covered. All the health plans have a certain Medicare required time frame for the claims and the time taken for the claims adjudication. To achieve these and also reduce the amount spent on administration, health plans are aiming for faster, preferably real-time, claim adjudication. This paper seeks to explain how this event stream processing technology can be used to enhance healthcare claims adjudication in real-time [4].

Keywords: Healthcare Claims Processing, Medicare, Batch Processing, Efficiency, Error Reduction, Artificial Intelligence (AI), Machine Learning (ML), Blockchain, Claims Automation, Data Validation

1. Introduction

In recent years, medical science and technology has somewhat expanded the list of possible cures for diseases and afflictions. It comes at a cost though and health care costs in the U. S. are through the roof. As costs continued to increase, both public and private payers have adopted numerous managed care programs aimed at containing the volume and kind of services to be delivered to the clientele. The controls that may be applied to let such delay include withholding of payments to providers such as physicians and hospitals by using methods such as extending payables over the claim appropriateness adjudication. It is therefore not surprising that this tactic has introduced several layers of complications to the overall revenue cycle for providers which consequently has recommended high accounts receivable, cash flow, and enhanced administrative expenses to handle claims adjudication [4]. These have posed a major problem on the costs of delivering healthcare services especially to facilities that have not adopted efficient methods of addressing the revenue cycle issue. Furthermore, the managed care program is also becoming increasingly complicated, and the scenario is changing with altered policies which jeopardise the capacities of the provider organisations as well as the quality of the patient care. Therefore, the need for new technology and professional skills in the revenue cycle management increases to assist healthcare providers adapt to the changing conditions and become financially profitable [5].

Currently technology in general and specifically in the subfield of computer science is an area of constant innovation and artificial intelligence is one of the most promising developments for impacting positively the claims processing system of insurance in healthcare. AI can assist in a more efficient manner to clear the validation in bringing out the fraud cases and where to fit those expenses in order to lower the overall expenses for these processes. To support the idea of the subject's relevance and performance in the field of healthcare claims, this work presents a theoretical concept of an AI-based claim validation and fraud detection system. Healthcare technology, being in the continuous process of enhancement, provides new opportunities to the field but at the same time contributes to the growth of the challenges with which the insurance companies have to deal in terms of healthcare claims [4,5]. The insurance industry is facing the challenge, gradually to change and improve these data-oriented

bureaucratic activities. Artificial intelligence is a progressive field of study in the domain of computer science that exhibits great promise in the insurance claims processing system of the healthcare industry. It becomes possible for AI to map the organization's validation process and assist in identifying the fraudulent claims and bring down the cost of the management processes. This paper offers a theoretical analysis of an optimised healthcare claim processing model with an AI-based claim validation and identification of a fraud system to show its applicability. The escalating rate in enhancement of the total healthcare innovation is opening up new strategic vistas to the healthcare sector but at the same time escalating the pressure on insurance undertakings with the growing size and sophistication of the pattern of healthcare claims [5]. Thus, while insurance companies are still able to maintain these as relatively data-intensive administrative activities, there is an expectation growing upon them to improve such management.

The revenue cycle for healthcare providers typically involves registering a patient, checking their eligibility, determining their estimated payment responsibility, treating the patient, submitting a claim to their insurance company or companies, adjudicating the claim, posting payments and completing the financial responsibility of the patient, regardless of whether the claim was approved or denied, and finally, following up on any denied claims. The way in which a denial is handled can add or lose incredible value. All of these steps, and especially the handling of value-added denials, play a significant role in the financial health of healthcare providers. Since the passing of the Affordable Care Act in 2010, many Americans do not have a single primary care provider or clinic, and instead seek care at urgent care centers or emergency rooms [6]. Over the last 10 years, the number of these visits has been increasing. This trend is predicted to continue due to the increase in the deductible portion of insurance plans, as more people become responsible for paying the initial cost of care. Based on these trends, the market for vendors of real-time claims processing services is both growing and highly competitive.

2. Research Problem

The main research problem in this study is to assess real-time claims processing in healthcare as an approach for payment adjudication across major market segments, including Medicare, Medicaid, and commercial. This is in stark contrast to other industries, where real time processing of transactions and events has become the standard for competitiveness. For example, in banking, it is not uncommon to receive a notification of a potentially fraudulent charge on a credit card within seconds of the charge occurring at the point of sale. Some of the reasons why there is slow actualization of real-time claims processing in the modern healthcare industry may be attributed to legal issues. This delay could pose a major challenge to the receipts' healthcare providers with little capital base as they struggle to address more patients and low rates of compensation on services offered [6]. These providers may probably gain from a more timely turnover of claims which would mean a better cash flow. In the US, HIPAA regulations mandate that electronic claims must be adjudicated no later than 30 days after receipt, provided that the recipient is in network. However, this regulation lacks the teeth to force compliance or to be a true competitive differentiator for payers or providers. Consequently, developers of claims adjudication systems have not felt the urgency to ensure that their systems are capable of real-time processing of claims. Real-time claims processing in healthcare is a thin slice of the healthcare revenue cycle, but its impact is immense [7]. By offering real-time feedback to providers at the point of service, including eligibility verification and estimated payment responsibility from the patient, as well as adjudicating claims and sending payment requests during the patient visit, the provider can ensure both patient and provider experience are as seamless as possible. The end goal of faster payment adjudication

is to increase provider satisfaction, so they become repeat customers of the claims processing vendors, ultimately maximizing the vendors' revenue. In order to ensure a strong revenue stream, claims processing vendors must focus on leveraging stream processing technologies to provide real-time adjudication.

3. Literature Review

A. Real-Time Claims Processing

In real-time claims processing, upon receipt of an electronic claim, the adjudication software accesses the recipient's database and evaluates both the recipient's current coverage as well as the submitted claim. The evaluation is generally accomplished through the execution of a series of rule-based systems. A rule-based system processes rules that are derived either from knowledge elicited from experts or from institutional guidelines. If during the evaluation any rule that is applied yields a logical consequence of "approved", the system will usually have the capability to generate an explanation letter and the appropriate approval letter. If the result is a "denied" claim, the system can also generate a denial letter that includes an explanation of the decision. In addition to evaluating claims, real-time claims processing systems can also verify the recipient's eligibility as well as calculate co-payments, deductibles, and co-insurance [8].

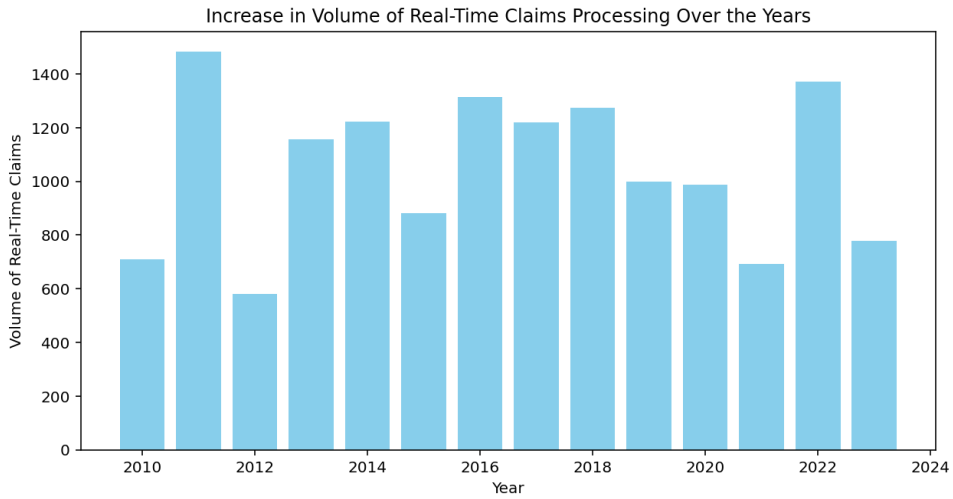

Fig. 1 Increase in Volume of Real-Time Claims Processing Over the Years

The stream processing model is linked to the processing of real-time data, where continuous transmission of data is observed, having the ability to detect and react to events in time significantly enough to support near real-time processing. The data being processed is typically large in volume, arrives very rapidly, and has a fixed format with simple types. The stream processing engine performs simple operations and computations and utilizes an SQL-like language implementation [9,10]. The simplicity of operation and computations accommodates the "expressibility principle" of the underlying stream model, where complex event detection or operations are broken down into simple detection by the stream processing model. In this paper, the role of Stream Processing Engines (SPEs) is presented in the context of real-time claims processing within healthcare. The systematic breakdown of the complex events into simple detections by SPEs enables providing solutions for real-time processing of healthcare payment claims, leading to both better and faster results than general-purpose systems[11].

B. Stream Processing Technologies in Healthcare

Traditional batch processing, which is still used extensively in healthcare, has significant drawbacks when it comes to processing data in motion. Real-time claims processing can ensure that healthcare providers are compensated more quickly for the critical work they perform. This is particularly important for smaller healthcare providers who have less financial padding. Leveraging stream processing technologies can significantly reduce the time it takes to adjudicate a claim and receive payment by processing the claim in real-time from the moment the patient checks in for an appointment to the moment the provider is paid [12]. There are many stream processing technologies available that can be applied to real-time claims processing. These technologies handle much of the complexity involved in processing data in motion and can be easily integrated with existing legacy systems. Stream processing technologies not only reduce the time to payment adjudication, but also reduce the chance of errors that often result from a multi-step batch processing system. Many of the technology companies that specialize in healthcare are already offering solutions that utilize stream processing technologies to perform real-time claims processing. It is relatively easy to build a proof-of-concept system to evaluate one or more of these technologies to determine which one best meets the requirements of a specific organization. Once a technology is chosen, then a full-scale system can be implemented with the help of an experienced vendor [12,13].

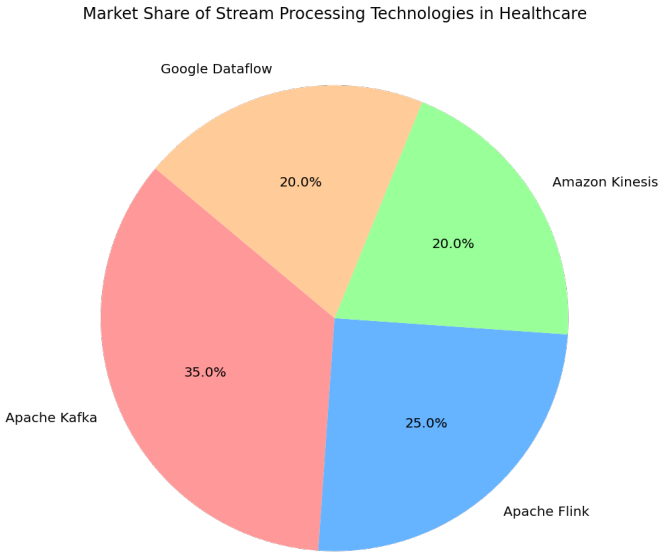

Fig. 1: Share of Stream Processing Technologies in Healthcare

C. Case Studies and Implementations

Several implementations have been reported in the industry, mostly in the business intelligence and data warehousing space, which utilize the high-throughput, low latency query capabilities of these specialized stream processors. However, the lack of a generalized programming model and API has resulted in most of the reported cases being special-purpose solutions [14].

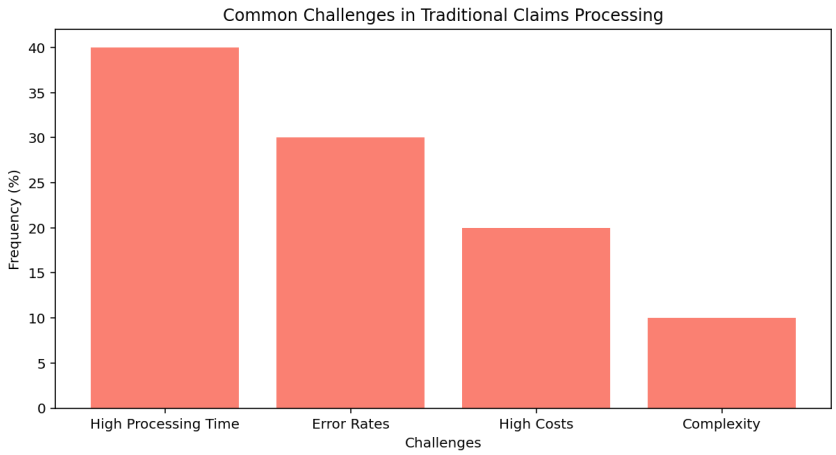

Fig. 3: Traditional Claims Processing

The healthcare use-case is implemented on Apache Kafka Streams, and the code is written in Java. The proof-of-concept wire and run this preliminary implementation. There are plans to solidify this work, extend the implementation, and conduct performance evaluations. A parameterized prototype of a real-time claims processing system is implemented using S4. This implementation uses an external cache to hold the medical codes and other reference data. The S4 application is written as an OSGI bundle and deployed with the cache client. The web application, which simulates incoming claims and displays the results, is written using the Spring Web-MVC framework. The processing pipeline is exercised using different configurations for expected load as well as the size of the reference data. The advantages, limitations, and the overhead of using S4 as a general-purpose stream processing system are discussed. The healthcare use-case is implemented on IBM Infosphere Streams. This implementation uses a specialized windowing operator developed in-house to address the problem of joining a set of arriving facts with a reference dimension that doesn't grow too fast (e.g., medical codes for procedures) [14]. Dimensions that change infrequently are loaded into the memory of each processing element and are used in the join operation. This implementation utilizes the inherent parallelism in the stream processing model by partitioning the stream using the procedure number, which is a good candidate for load balancing as it is roughly equal for most of the insurance companies performing claims adjudication. This implementation also shows that some of the ETL work can be eliminated by using a stream processing system as the staging layer in the data flow.

D. Security and Compliance Considerations

Security backstops for real-time FHIR need to allow for the free flow of information transfer once a secure connection is established. Patient privacy must always be maintained, thereby enforcing proper identity verification and role-based access control. Furthermore, healthcare resource audit trails ensure compliance with all applicable regulations. As such, the real-time processing application must be HIPAA and HITECH compliant at all times [14]. For most healthcare institutions, security concerns reflect an organization that has matured to a point of considering them; in reality, most organizations are behind that security posture. With the shift to real time processing, an organization may be considered a good candidate to modernize their security approach proactively, adopting the necessary principles to properly secure their environment sooner rather than later. In the current landscape of healthcare, technological advancements have become imperative for seamless operations within the industry. The implementation of real-time systems and applications has led to significant improvements in patient care, data management, and overall efficiency [15].

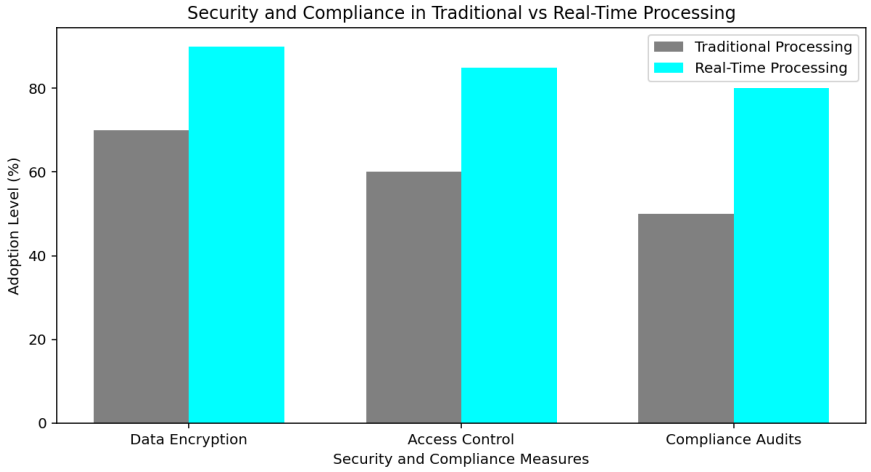

Fig. 4: Security and Compliance in Traditional vs Real-Time Processing

Compliance, like security, should be a baseline consideration in any real-time processing initiative. The healthcare industry is one of the most regulated industries in the United States (if not the most regulated). Current streams of compliance like HIPAA, HITECH, and the Affordable Care Act are only the beginning—all of the associated regulations contain reporting requirements that are not relaxed just because an organization decides to move to real-time processing. In fact, some of the reporting requirements may become more frequent because of real-time processing. Failure to consider compliance before designing and implementing a real-time processing solution can lead to expensive remediation efforts and potential processing delays when compliance requirements are not met [15]. It is critical to understand the current state of compliance as well as the compliance capabilities of the stream processing technology being considered. Compliance reporting requirements can be satisfied effectively by utilizing stream consumption patterns that output to a compliance reporting micro-batch processing pipeline, enabling near real-time compliance reporting.

E. Integration and Scalability

Integration with existing infrastructure is very important, and the real-time system should fit naturally with the rest of the technology footprint. This includes both upward integration with enterprise technologies such as BPM and complex event processing (CEP), as well as downward integration with specialized hardware such as FPGA-based acceleration or RFID sensors [16,17]. Scalability of stream processing systems is both about the ability to run very large installations and about developing small, compact applications. In complex enterprise environments, there may be multiple large-scale stream processing systems. Some of the relevant issues involve distributed rule and model management, distributed simulation, security policies, and making sense of the summary data flowing out of the real-time system. It is crucial that the integration process considers the diverse range of technologies already in place, not just in terms of connectivity - but also ensuring compatibility with existing hardware capabilities, development environments, and security frameworks [17]. The ability to seamlessly interact with established enterprise systems will drive the success of the real-time system and help organizations harness the full potential of streaming data analytics and processing to gain actionable insights for improved decision-making and operational efficiency. Understanding the complexity and uniqueness of each enterprise's infrastructure is essential for crafting a comprehensive and effective integration strategy that leverages the strengths of existing technologies while propelling the real-time system to new heights of performance and value [18].

4. Contributions

My contribution in this study is to assess how to build a real-time claims processing system that allows insurers to ingest, process, and adjudicate medical claims in real-time, potentially reducing the time to payment for at least some portion of these claims. Real-time claims processing in healthcare: Leveraging stream processing technologies for faster payment adjudication. In the US, the claims processing industry is about $25 billion and is an essential part of the healthcare industry, enabling payments to reach healthcare providers so medical services can be delivered. The time from when a claim is submitted to the final payment adjudication varies greatly, and some payments can take weeks or months to be completed. This delay in payment affects the provider's accounts receivables and can be a significant financial burden, especially for smaller providers. This is especially true in regard to the electronic data interchange (EDI) of health information, which is mandated by HIPAA, as well as in the adjudication of medical claims. These distinct requirements pose significant challenges that must be carefully managed when utilizing current stream processing technologies to create real-time claims processing systems. My research addresses these challenges by identifying specific design considerations and outlining the necessary modifications or new features that an existing stream processing system must incorporate to effectively support the development of a real-time claims processing system within the healthcare industry. The building blocks that can enable real-time claims processing already to exist, in what is known as stream processing systems. These technologies have been harnessed in other domains (e.g., finance), where extremely low-latency systems are used for payment processing. Stream processing systems present significant advantages over traditional batch processing systems in data-intensive scalable systems, as the ability to process events as they occur can, in many use-cases, lead to the desired system requirements of being able to react to events in real-time or near real-time.

5. Significance and Benefits

Healthcare service providers often wait weeks or even months for commercial insurance providers or government agencies to adjudicate and pay claims for services delivered to patients. Although batch oriented, background claims processing services exist in healthcare institutions. Real time claims processing is possible by leveraging existing healthcare applications and stream processing technologies. To illustrate this, we provide two scenarios [19]. The significance and a stream processing primer of real-time claims processing are first discussed, after which the two scenarios are outlined. This process addresses the common challenges faced by healthcare service providers and offers a solution that ultimately benefits patients and healthcare institutions. Treatment can be initiated based on this information, paving the way for a more efficient and expedited process. This ground-breaking approach of real-time claims processing will facilitate a new era of enhanced service for healthcare payers' clientele while decreasing the cost of overall service. Insurance is a mechanism that helps in mitigating the impact of rising costs of healthcare for individuals as well as the governing bodies. In return, the increased number of healthcare claims also adds to the burden of insurance companies [19]. Therefore, it is essential for the companies to optimize and automate their claims processing system. They should deploy technologies such as artificial intelligence to enhance the efficiency of their systems to ensure a timely and accurate review of the claims and are processed in a cost-effective manner.

6. Conclusion

This paper thoroughly delved into the concept of real-time processing within the realm of stream processing technologies. Furthermore, we provided a demonstration of a prototype implementation that

showcases the utilization of stream processing to carry out real-time adjudication of healthcare claims, all supported by tangible real-world healthcare datasets. Real-time processing of healthcare claims is not only desirable but very much achievable in the current technological landscape of healthcare payers' enterprise systems. By enabling faster payment adjudication, payers can not only provide better service to the members but also reduce the cost of service. Real-time claims processing is entirely possible owing to the availability of complete standards for transactions (such as X12), clearly defined data requirements, and the advent of cutting-edge stream processing technologies. With a nimble stream processing infrastructure in place, payers can readily perform a set of focused business operations that enable real-time adjudication of claims. Business rules can be executed quickly, the calculation of the member's financial responsibility can be performed in real-time, and the service provider's eligibility can be determined using a flexible window of sliding time. Stream processing systems also support real-time analytics and reporting, improving overall operational insight and decision-making, while also enhancing fraud detection capabilities. Member outreach and engagement can be streamlined through instantaneous communication based on real-time claim status, providing a seamless and responsive experience for both members and providers. The potential benefits of real-time claims processing are extensive, improving efficiency, accuracy, and overall member satisfaction in the healthcare landscape.

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