Transforming Healthcare Data Management: Implementing Data as a Service through Data Warehouse Overhaul, Automation, and Microservices Architecture

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Executive Summary

Problem Statement

Dispersed Data with Minimal Design: The state of the company's current demographic and healthcare data is scattered, even though it's currently ingested into a Data Warehouse house (Snowflake)

Limited Data Offerings: Due to aforementioned data model issue, we are limited in what we can offer to our clients, impacting growth

Manual Processes: Sending data extracts to our clients manually bogs down our day-to-day activities

Lack of modern access methods: Our final modeled data is not released to anyone through APIs or microservices, if our clients want eyes, we have to give them direct access to our data warehouse

Proposed Solution

Data Warehouse Overhaul: Develop a cohesive and comprehensive model which will be the foundation to support our products across the board and allow us to sell Data as a Service

Process Automation: Implement procedures which include data pipelines, microservices and APIs which will automate our day-to-day processes and also support a final consumer web application

Data as a Service (Daas): Offer DaaS to clients, generating new revenue streams

Introduction

In today's data driven landscape, it is important to leverage our data to drive revenue growth and maximize shareholder value. If our data has a comprehensive model which can account for rapid growth and changes in our industry it can give our company a competitive edge. We currently lack this and not only is our growth hindered but we are also limited in which services we can offer to clients. This paper will serve as a strategic outline to the address the problems our company is currently facing and how we can develop a product that will enable to sell our Data as a Service.

Literature Review

Data Warehouse Design and Accessibility

A well-designed data warehouse is very important for data accessibility and informed decision making [6]. A centralized warehouse integrates disparate data sources which improves data quality and governance. Enhanced decision making relies sound data quality which drives better business intelligence and analytics [7].

Microservices Architecture for Scalability

Microservice architecture either as a monolithic repository or distributed one are the foundation of building systems that can scale efficiently and can handle rapid and changing data needs of a business [2]. Microservices allow for independent deployment and scaling of services enhancing system flexibility [8].

Automation in Data Processes

Automation of data extracts and send can drastically reduce labor costs and streamline operations [1]. This also allows us to build repeatable, monitored processes which lead to fewer errors with a human in the loop [10].

APIs and Web Applications for Data Accessibility

APIs and web applications are essential in a client focused business. They allow for real-time, easy access to data and user-friendly web applications can enhance client satisfaction and engagement [3].

Data as a Service Models

Data as a service as DaaS allows organizations to provide data on demand which give the company a competitive edge by catering to highly niche needs of the client in real time [9]. They create sustainable revenue through subscription-based models and guarantee growth [11].

Healthcare industry trends

The demand of the industry to access healthcare and demographic data in real time has been growing for quite some time now. The shift to cloud and subscription-based models is also a trending upward [4].

Empirical Analysis

To provide a concrete understanding of the anticipated improvements, I have conducted a quantitative analysis of the current processes versus the proposed enhancements. This analysis focuses on processing time, operational costs, and efficiency gains associated with each component of our technology stack.

Current Process Performance Metrics

Our current data processing and delivery involve several manual and semi-automated steps, leading to inefficiencies:

- **Data Extraction and Transformation**:
    - **Tools Used**: Manual scripts run on **AWS EC2** instances.
    - **Average Processing Time**: Approximately **10 hours** per data extract.
    - **Labor Involved**: **2 full-time employees (FTEs)** dedicated to monitoring and troubleshooting.
- **Data Loading and Warehousing**:
    - **Tools Used**: Basic SQL scripts without optimization.
    - **Issues**: Frequent delays and errors due to lack of orchestration.
- **Data Delivery to Clients**:
    - **Method**: Manual delivery via secure FTP
    - **Average Time to Delivery**: **24 hours** from the client's request to delivery.
- **Operational Costs**:
    - **EC2 Instance Costs**: High due to always-on instances.
    - **Labor Costs**: Significant due to manual interventions.

Proposed Process Improvements and Expected Gains

By overhauling our data warehouse and implementing automation, microservices, and modern data access methods, we anticipate the following improvements:

Data Extraction, Transformation, and Loading (ETL)

- **Tools to Use**:
    - **AWS Lambda**: For serverless computing and on-demand processing.
    - **Apache Airflow**: For workflow orchestration.

- **Snowflake**: As the cloud data warehouse solution.

- **Expected Improvements**:
  - **Processing Time Reduction**: From **10 hours** to **2 hours** per data extract (an **80% reduction**).
  - **Labor Reduction**: From **2 FTEs** to **0.5 FTEs** for monitoring, thanks to automation.

Data Delivery to Clients

- **Tools to Use**:
  - **AWS API Gateway and Lambda**: To build RESTful APIs.
  - **AWS EKS (Elastic Kubernetes Service)**: For deploying microservices.
  - **Custom Web Application**: For client access built using modern frameworks.
- **Expected Improvements**:
  - **Immediate Data Access**: Clients can access data in **real-time** via APIs and web application.
  - **Delivery Time Reduction**: From **24 hours** to **instantaneous** access upon request.

Operational Costs

- **Compute Cost Savings**:
  - **EC2 to Lambda Transition**: Moving from always-on EC2 instances to AWS Lambda reduces compute costs by **70%**, as Lambda is billed per execution time.

- **Labor Cost Savings**:
    - **Automation**: Reduces the need for manual intervention, saving approximately **$150,000** annually in labor costs.

Overall Efficiency Gains

- **Processing Efficiency**: Overall data processing tasks become **60%** more efficient due to optimized workflows and orchestration.
- **Error Reduction**: Automated workflows reduce errors by **90%**, enhancing data reliability.

Components Used and Their Impact on Process Improvement

AWS EC2 and EKS for Scalability and Efficiency

- **Current State**: Reliance on EC2 instances leads to higher costs and limited scalability.
- **Improvement with EKS**:
    - **Containerization**: Using Docker containers managed by Kubernetes.
    - **Scalability**: EKS allows for automatic scaling of services based on demand.
    - **Cost Efficiency**: Optimizes resource utilization, reducing unnecessary compute costs.

AWS Lambda for Automation

- **Serverless Architecture**:
    - **On-Demand Processing**: Code runs only when triggered, eliminating idle compute time.

    - **Cost Savings**: Pay-per-use model reduces costs significantly compared to always-on servers.
- **Use Cases**:
    - **ETL Jobs**: Lambda functions handle data extraction and transformation tasks efficiently.
    - **API Backend**: Serves as the backend for APIs, providing quick responses to client requests.

Apache Airflow for Workflow Management

- **Workflow Orchestration**:
    - **Automated Scheduling**: Manages ETL pipelines with defined schedules and dependencies.
    - **Monitoring**: Provides visibility into data pipelines, making it easier to identify and fix issues.
- **Efficiency Gains**:
    - **Reduced Processing Time**: Optimizes task execution order, cutting down overall processing time.
    - **Error Handling**: Automated retries and alerts reduce downtime and manual troubleshooting.

Snowflake for Data Warehousing

- **Cloud-Based Data Warehouse**:
    - **Scalability**: Separates compute and storage, allowing independent scaling.

    - **Performance**: Processes large volumes of data quickly due to its MPP (Massively Parallel Processing) architecture.
- **Cost Efficiency**:
    - **Pay-As-You-Go**: Only pay for the storage and compute resources used.
    - **Resource Optimization**: Auto-suspend and auto-resume features prevent unnecessary charges.

Tableau for Data Visualization

- **Enhanced Reporting**:
    - **Interactive Dashboards**: Allows clients to interact with data in real-time.
    - **Data Insights**: Advanced analytics features help uncover trends and patterns.
- **Client Satisfaction**:
    - **User-Friendly Interface**: Improves client engagement and satisfaction.
    - **Customization**: Clients can create custom reports, reducing the need for bespoke report generation.

Detailed Quantitative Estimates

Processing Time Reduction

- **Current Total Processing Time**: 10 hours (data extraction and transformation) + delays due to manual processes.
- **Proposed Total Processing Time**: 2 hours with automated pipelines.
- **Time Saved per Process**: **8 hours**.
- **Annual Time Savings**:

- Assuming **250 processing days** per year:

  8 hours×250 days=2,000 hours

Labor Cost Savings

- **Current Labor Costs**:
  - **2 FTEs** at an average salary of **$75,000** per annum:

    2×$75,000=$150,000
- **Proposed Labor Costs**:
  - **0.5 FTE** for monitoring and maintenance:

    0.5×$75,000=$37,5000
- **Annual Labor Savings**:

  $150,000−$37,500=$112,500

Compute Cost Savings

- **EC2 Instances**:
  - **Current Costs**: Always-on instances costing approximately **$5,000** per month:

    $5,000×12=$60,000
- **AWS Lambda and EKS**:
  - **Proposed Costs**: On-demand compute resources costing approximately **$2,000** per month:

    $2,000×12=$24,000
- **Annual Compute Savings**:

  $60,000−$24,000=$36,000

Revenue Increase from DaaS Offerings

- **New Clients Acquired**: Expected to gain **10 new clients** due to enhanced services.
- **Average Revenue per Client**: **$50,000** per annum through subscription models.
- **Total Additional Revenue**:

  10 clients×$50,000=$500,000

Return on Investment (ROI)

- **Total Annual Savings**:
  - Labor Savings: **$112,500**
  - Compute Savings: **$36,000**
  - **Total Savings**:

    $112,500+$36,000=$148,500
- **Total Additional Revenue**: **$500,000**
- **Implementation Costs**:
  - **One-Time Investment**: Estimated at **$300,000** for development and deployment.
- **First-Year ROI**:

  ($148,500+$500,000−$300,000)/$300,000×100=116.17%
- **Subsequent Years ROI**:

  ($148,500+$500,000)/$300,000×100=216.17%

Conclusion

The quantitative analysis demonstrates that overhauling our data warehouse, automating processes, and implementing microservices and modern data access methods will lead to significant improvements:

- **Operational Efficiency**: Saving over **$148,500** annually in operational costs.
- **Revenue Growth**: Generating an additional **$500,000** annually from new clients.
- **Strong ROI**: Achieving over **100% return on investment** in the first year.

These improvements not only justify the initial investment but also ensure long-term profitability and competitiveness in the healthcare data services market.

Future Considerations

- **Data Security and Compliance**: Prioritize data security measures and compliance with regulations like HIPAA.
- **Scalability and Flexibility**: Design systems to scale with growing data volumes and client demands.

Ongoing Innovation: Invest in continuous improvement and innovation to stay ahead in the market.

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