<u>Digital Transformation in Supply Chain (D8L) - Towards Cloud-Based Transport Management</u>

Architecture of Information Systems (2023-2B) - Group 7

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1. Introduction

1.1. Overview

D8L, based in Rotterdam, is a Logistics Service Provider (LSP), which provides rail and road transportation solutions across the Netherlands and other European countries like Germany, Austria, Poland, and Italy. This extensive geographical presence underscores the complexity and scale of their operations. The logistics market is rapidly evolving, and to remain competitive, D8L aims to transform its operations digitally and transition to becoming a fourth-party logistics (4PL) provider. D8L functions with two main types of transport service contracts. Firstly, long-term fixed contracts, which constitute 87% of D8L's business, are established with long-standing clients and involve fixed consignments, loads, destinations, and costs. These contracts benefit from lower costs due to bookings that secure cheaper rates and result in better profits, although these clients often utilize other transport providers as well. On the other hand, one-off contracts make up the remaining 13% of the business. These contracts are typically acquired through networking, bidding, marketing, and word of mouth, involving the shipment of large consignments from Rotterdam to various inland European destinations. In this report we will be discussing the critical initiatives undertaken to improve the existing information Service Architecture of the company thus resulting in achieving D8L's aim of becoming a 4PL, achieving high profits and a good market share in the logistics industry.

1.2. Objective

The primary objective of D8L is to design and implement a comprehensive solution to transform the company's operational efficiency and competitiveness in the rapidly growing logistics industry. By integrating advanced Transport Management System (TMS) and Environmental Management System (EMS) solutions, they aim to streamline its core business processes, automate workflows and improve data-driven decision-making. The project will focus on leveraging big data and predictive analytics to improve route planning, fleet management, and customer service while ensuring compliance with environmental regulations and sustainability goals. In addition, the integration will strengthen data security and facilitate seamless communication between systems, ultimately positioning D8L as a leading 4PL provider able to quickly adapt to market changes and customer demands.

1.3. Scope

The scope D8L has is extensive and aims to integrate several critical systems to significantly improve operational efficiency and competitiveness within the logistics industry. Key requirements of this project include the implementation of a state-of-the-art Transport Management System (TMS) that will manage not only truck deliveries but also other modes of transport. This system will centralise transport orders, optimise route planning, manage the fleet and enable real-time shipment tracking. In addition, an Environmental Management System (EMS) will be integrated to monitor and manage the environmental impact of logistics operations and ensure compliance with sustainability regulations. The project also includes the enhancement of the Customer Relationship Management (CRM) system to provide better customer service, including real-time updates on order status and environmental conditions of the cargo. Advanced data analytics and predictive analytics tools will be used to harness large amounts of data for improved decision-making, forecasting and planning. This will involve real-time data collection using sensors and IoT devices, with data stored and analysed using business intelligence (BI) tools. The project will also improve communication and data exchange by migrating applications to the cloud, using publisher/subscriber messaging techniques using RabbitMQ, and implementing API gateways to manage communication effectively. Security and compliance frameworks will be strengthened to protect sensitive data and ensure compliance with regulatory requirements. The development will be executed in phases initially firstly we will be designing the baseline architecture of the existing system and then implement architectural improvements leading to the Target architecture, these phases will be happening with consecutive feedback iterations to the architecture for better refinement of the architecture design. Lastly, we would make an implementation and migration plan for D8L's Change management Processes which will include the timing, cost, resources, benefits, and milestones for the implementation.

2. Motivation

The logistics industry is rapidly evolving due to technological advancements and changing customer demands. D8L's CEO is concerned about stagnant profits and a lack of market share. To address this, D8L aims to transition into a Fourth-Party Logistics (4PL) provider, which involves managing complex supply chains. This requires short-term returns on technology investments, focusing on scalability, robustness, and security to protect high-value goods and sensitive data.

2.1 Goals

D8L aims to enhance operational efficiency by transforming applications into microservices with an n-tier structure, promoting scalability and flexibility. Workflow automation will reduce human error, speed up processes, and ensure consistency. Optimising route planning and fleet management will boost resource utilisation, reduce costs, and ensure timely deliveries, increasing productivity and profitability. Integrating a Transport Management System (TMS) and an Environmental Management System (EMS) is crucial. The TMS will centralise transport orders and provide real-time tracking, while the EMS will monitor environmental impact and ensure compliance with sustainability regulations, facilitating real-time data collection and operational efficiency.

Leveraging big data and predictive analytics from sensors and IoT devices will enable advanced demand forecasting and trend identification, improving competitiveness. Migrating applications to the cloud and using pub/sub integration techniques and API gateways will enhance real-time data exchange, improving coordination among operations, partners, and customers. Reducing carbon emissions through the EMS will optimise routes to minimise fuel consumption, ensuring compliance with environmental regulations. Improved customer service through advanced CRM systems will offer real-time updates and automated communications, boosting satisfaction and loyalty. Ensuring regulatory compliance via TMS and EMS integration will adhere to industry standards and environmental regulations. Expanding warehouse and rail transport capabilities will enhance storage capacity and logistics efficiency, supporting growth and diverse client needs.

2.2 Drivers

D8L is driven by the need to overcome stagnant profits and improve operational efficiency through streamlined workflows, automation, and optimised resource use. Increasing market share and profits is essential for growth, achievable by enhancing service offerings and customer satisfaction via better data analytics and integrated systems. International competition demands advanced technologies like state-of-the-art TMS and EMS to remain competitive. Additionally, modernising operations and automating tasks will attract younger, tech-savvy workers, addressing workforce challenges posed by an ageing population. The transition to sustainable energy practices is critical, with the EMS helping to monitor environmental impacts, track carbon emissions, and ensure compliance with sustainability goals. Meeting these sustainability targets is vital for regulatory compliance and responding to customer demand for environmentally friendly services.

After considering all the goals and drivers, Fig. 1 shows the consolidated motivation viewpoint modelled in Archimate.

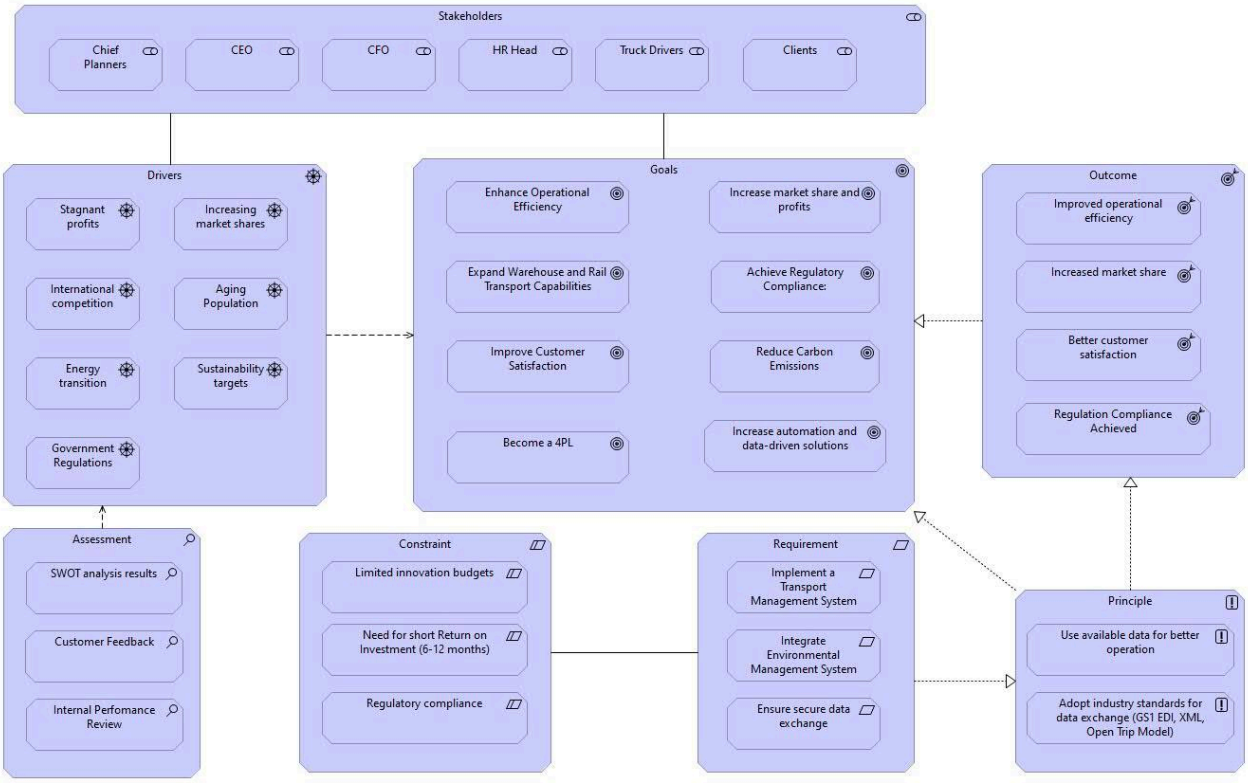

Fig. 1: Motivation Viewpoint

3. Baseline Architecture

3.1. Business Process and Applications

D8L operations consist of four core processes and three supporting processes. The business processes and their respective applications can be seen in Fig.2.

3.1.1. Ordering

D8L uses the ORDER-IN application to manage customer orders. Customers create a waybill on D8L's website, which sends an email alert to the planners. The planners review the order details and, if accepted, send a confirmation email to the customer. ORDER-IN then creates a contract file and an order file for tracking and adjustments.

3.1.2. Route Planning

At D8L, route planning is managed by PLAN-IT software, which contains the complete route map and updates automatically. The tool is primarily used for one-off orders to select the best route, providing multiple options where necessary. Experienced planners have the final say on route decisions and the software can mark routes as available or unavailable.

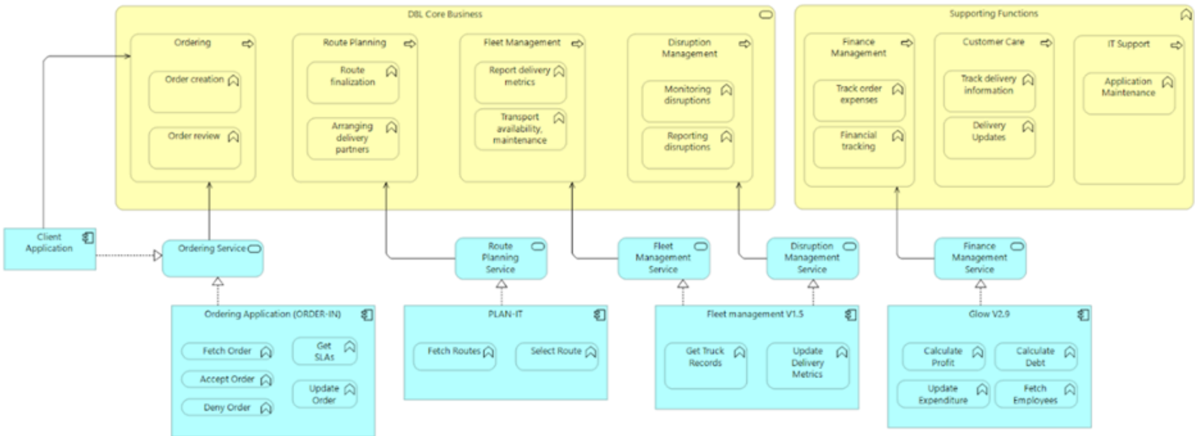

Fig. 2: Service realisation viewpoint

3.1.3. Fleet Management

D8L uses FManage Secure v1.5 fleet management software, which tracks available trucks, their maintenance schedules and orders When an order is completed, details such as distance travelled and time taken are logged into the system. This information helps with maintenance planning and future scheduling.

3.1.4. Disruption Management

Disruption management at D8L involves monitoring environmental conditions and infrastructure issues that could affect shipments. An employee records disruptions on an Excel spreadsheet, which is then uploaded to FManage Secure v1.5. In the event of significant disruptions, the planner may need to adjust current and future orders.

3.1.5. Finance Management

D8L manages its finances using the GLOW v2.9 application. It handles various financial operations such as invoicing, expense tracking, budget management and financial reporting.

3.1.6. Customer Care

Customer support at D8L is primarily conducted via telephone and email. If the customer wants to get updates on its delivery then customer support has to call the driver manually for updates which is then relayed to the customer.

3.1.7. IT Support

It involves providing technical support across D8L and is handled by a team of two people.

3.2. Technology Layer

All computers in D8L are password-protected to ensure security. Order entry data is saved on disk and backed up daily, with a comprehensive database storing all historic order data and financial payments, also backed up every night on a secondary server. This dual-server setup enhances security and resiliency, providing robust protection and redundancy for D8L's critical data and operations. D8L also has file-based interfaces established for six large customers using formats like EDI, XML, and .csv. The technological elements of D8L can be seen in Fig.3 below.

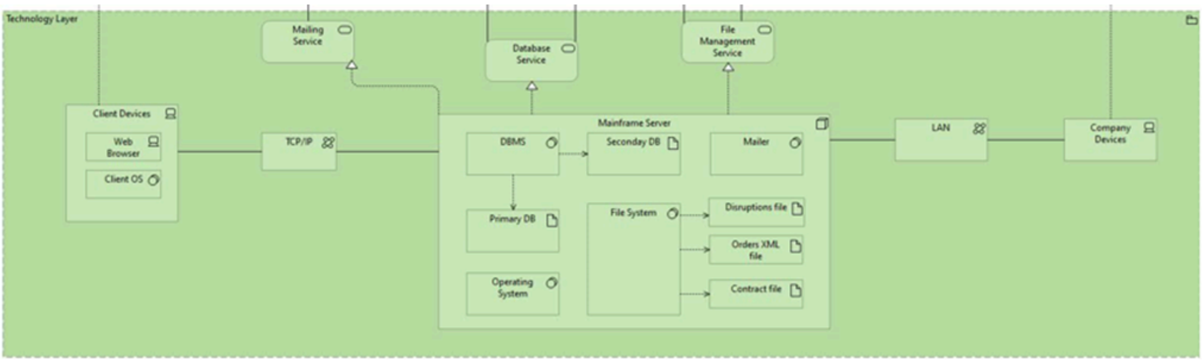

Fig. 3: Technology Layer

3.3. Organisational Structure

The organisational structure of D8L is shown in Fig.4 which includes the following roles:

- **Mentor:** Dirk, who has retired but still plays a role in mentoring and attending meetings with new clients.
- **CEO:** Dennis, who leads the company.
- **CFO:** Head of the finance department, along with her secretary Yolanda.
- **Chief Planners:** Responsible for planning and routing logistics operations.
- **HR Head:** Manages personnel and driver welfare, functioning as a one-man department.
- **IT Support:** Susan and Arthur handle IT-related tasks.
- **Assistant Planner/Trainee:** Ryan, who steps in when the chief planners are absent.
- **Disruption Reporting and Management:** Jan, a new employee on a two-year contract, working closely with Ryan and the chief planners.
- **Front Desk:** Sandra and Cristina manage front desk operations.
- **Truck Drivers:** Sometimes on contract, sometimes permanent, primarily on the road and not often present in the office.

3.4. Information Structure

In the D8L logistics framework, most order details are stored in an order file, which is accessed by the ORDER-IT application. This file contains Service Level Agreements (SLAs), order details and planning information such as routes, stops and modalities. The PLAN-IT application specifically accesses the planning information. Fleet management data, accessed by the Fleet Management V1.5 application, includes order allotment, distance travelled, time taken, maintenance schedules, truck availability and disruption details, the latter entered by employees in a disruption file. The financial data, which includes information such as profits, employee details, expenses and salaries, is managed by the Glow V2.9 application. Finally, the order status file, which is used by customer service for tracking purposes, includes the truck's location and recorded times. This integration of multiple data points across multiple applications ensures seamless operation and monitoring within D8L's logistics network. The Information Structure Viewpoint as Fig.5 gives an overview of the D8L logistics framework.

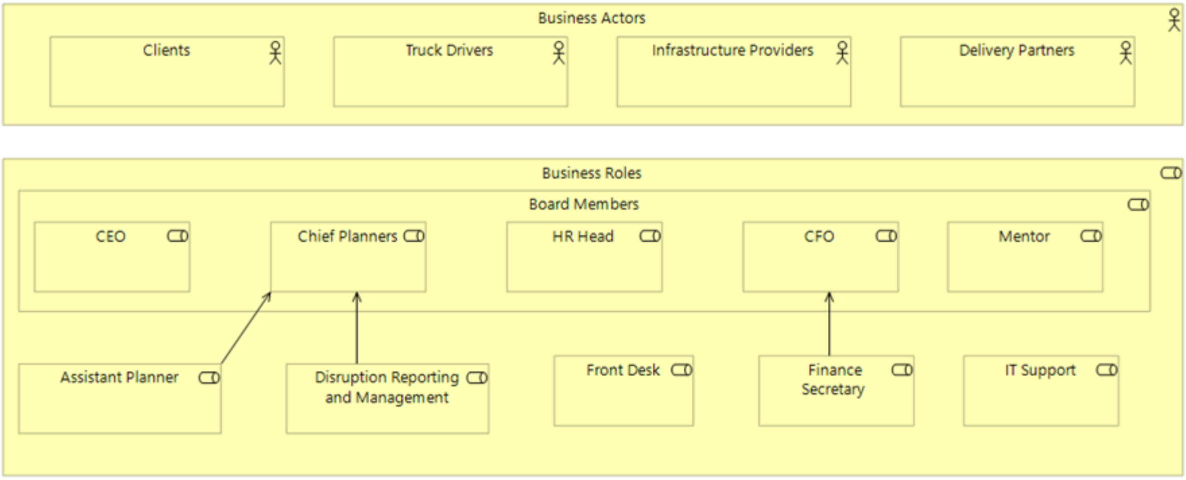

Fig. 4: Organization Structure Viewpoint

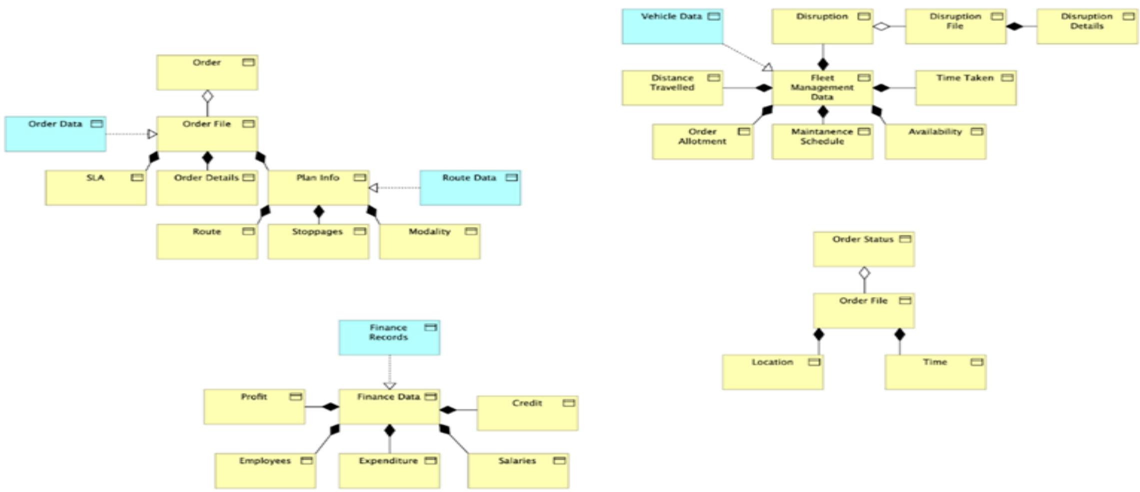

Fig. 5: Information Structure ViewPoint

3.5. Baseline Architecture Diagram

Fig. 6 shows the complete baseline architecture modelled in Archimate.

3.6. SWOT Analysis

3.6.1. Strengths

- Experienced Team: Skilled personnel with industry knowledge.

- Strong Relationships: Good ties with terminal operators and stakeholders.

3.6.2. Weaknesses

- Manual Processes: Reliance on file-based operations and high human intervention.
- Lack of Monitoring: No infrastructure for real-time monitoring or data collection.
- Security Concerns: Potential vulnerabilities due to current practices.

3.6.3. Opportunities

- Automation Potential: Room for introducing automation in various domains.
- Cloud Migration: Opportunity to modernise with cloud-based solutions.
- Resource Pre-Planning: Utilising trends for better resource allocation.
- Warehouse Development: Building facilities to leverage rail transport.
- Digital Transformation: Significant opportunities exist for D8L to implement advanced IT solutions to enhance operations and customer service.

3.6.4. Threats

- Change Resistance: Employee apprehension towards new technologies.
- Air Cargo Challenges: Need to improve service vs cost ratio for competitiveness.
- Competitive Market: The emergence of 4PLs and tech-savvy competitors like Navic Logistics threatens D8L's market share.
- Regulatory Challenges: EU regulations, including Sustainable Development Goals and Digital Product Passports could impact operations.

3.7. Key Takeaways from SWOT analysis

D8L Logistics should prioritise adopting advanced technologies like the Internet of Things (IoT) and cloud computing to enhance operational efficiency. Automating core workflows can improve productivity and accuracy by eliminating manual processes. For example, transitioning from file-based information sharing to techniques like pub/sub communication or remote procedure calls (RPCs) can streamline data handling and reduce human errors. These technologies will optimise resource use and contribute to environmental sustainability by reducing the company's carbon footprint.

Educating and motivating employees is crucial for integrating new technologies. Implementing training programs will help employees understand and effectively use new systems. IoT technologies in warehouses, for example, can facilitate monitoring conditions and operations, simplifying tasks and increasing efficiency. Emphasising the benefits of these technologies, such as easier workflows and increased profitability, will foster employee buy-in and a culture of innovation within the organisation.

Recruiting additional employees for IT support and innovation roles is essential. As IT systems become more efficient, there will be a reduced need for manual monitoring and reporting, freeing up manpower for strategic roles like developing predictive analytics tools. This shift allows the organisation to focus on innovation and growth while essential personnel are needed for tasks like monitoring truck locations or reporting disruptions.

Migrating all applications to the cloud will ensure better accessibility and data exchange, facilitating remote access and improving efficiency and collaboration. Developing an application to monitor truck delivery status will replace manual tracking, providing more accurate and real-time updates. Equipping delivery vehicles with sensors to track physical and environmental metrics will enhance the logistics process, providing real-time information and notifications about any changes in planning, ensuring timely adjustments and improved delivery accuracy.

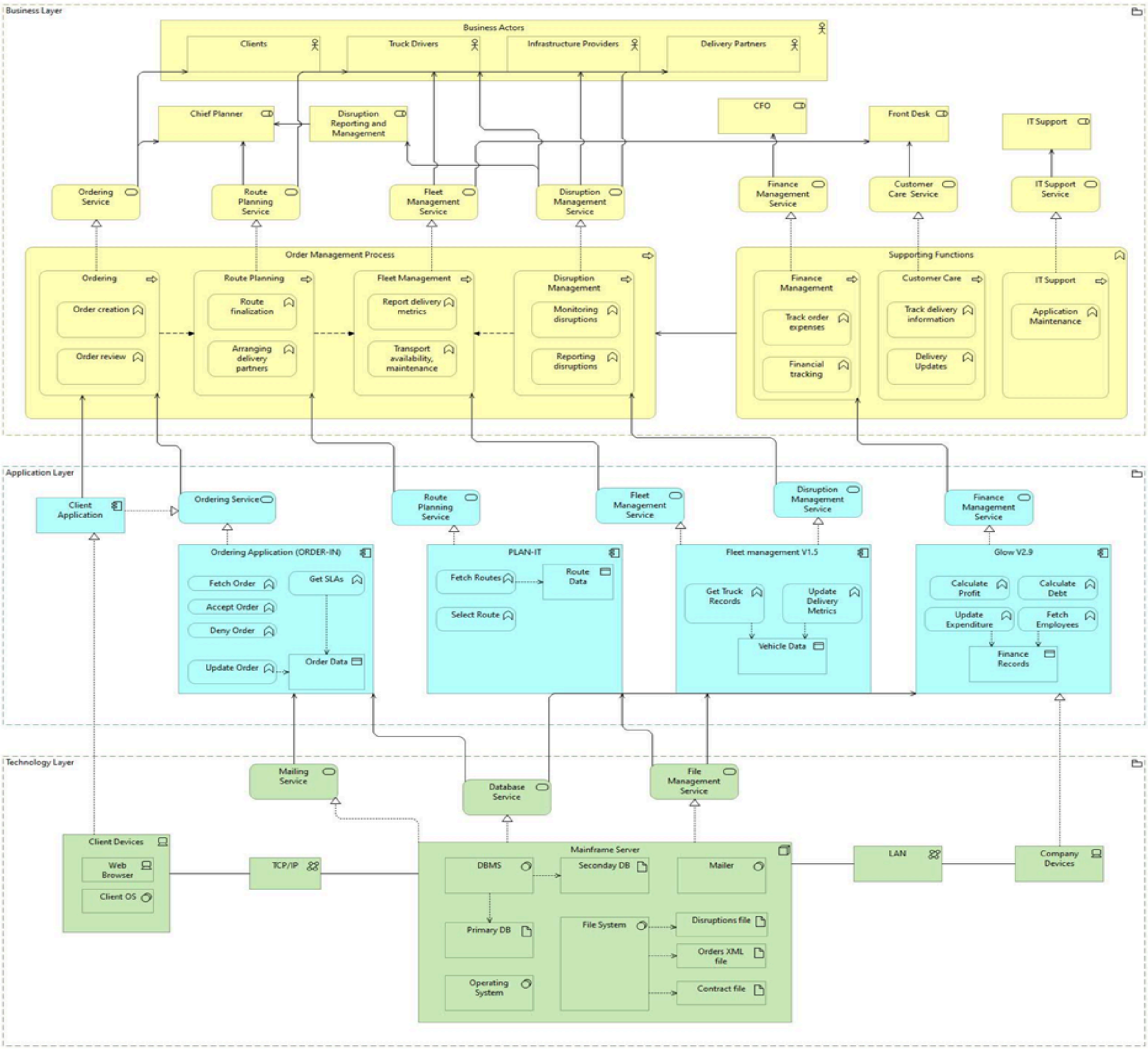

Fig. 6: Baseline Architecture

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To achieve its environmental goals, D8L must incorporate sustainability into its core operations. Implementing IoT and cloud technologies will minimise the company's carbon footprint through optimised route planning and reduced mileage. Predictive maintenance will ensure vehicles operate efficiently, reducing emissions. Training programs should include modules on environmental sustainability, helping employees understand energy conservation and efficient resource utilisation. Embracing these practices will enable D8L to work towards a greener and more sustainable logistics operation.

4. Target Architecture

To meet the requirements of becoming a 4PL and achieving the mentioned goals, we propose the following changes:

4.1. Business Process and Application Changes

Key Business Changes involve the inclusion of the Digital Bidding Planner process, Sustainability Initiatives, Warehouse Management and Data Analysis as shown in Fig.7. Also, there will be support present for each application developed by the software team.

4.1.1. Warehouse

To enhance its service offerings and have more authority over its supply chain operations, D8L Logistics wants to acquire a warehouse. Owning a warehouse will help D8L with applying customised storage solutions and streamline the process of receiving, storing and shipping items.

4.1.2. Digital Bidding Planner

The management of D8L wants to implement a Digital Bidding Planner, a tool that collects and evaluates bids from different carriers for delivery routes, ensuring that the most reliable and economical solutions are selected for their logistics network. By streamlining the complex bid management process, this technology enables D8L to evaluate multiple carriers based on factors such as cost, reliability and service quality. By using this planner to streamline the selection process, D8L can make the best carrier selection for each route. This improves the reliability and efficiency of their logistics operations and reduces transport costs. Fig.8 shows the implementation of Digital Bidding Planner through Archimate.

4.1.3. Automation and Microservices

Major processes like ordering, route planning, fleet management and disruption management will be automated with the help of TMS and EMS. We plan to convert all applications to microservices having an n-tier structure. Microservices have become essential in modern business applications because they enhance agility, scalability, and resilience. Minimal human intervention will be required compared to the current scenario where most communications are done manually by telephone or email.

4.1.4. Transport Management System(TMS)

A Transport Management System will be developed and implemented to oversee route planning, the transportation fleet, and the management of disruptions, which are currently handled by separate applications as shown in Fig.8. Also, all these processes will be automated by TMS. The TMS will be using a secure and safe method to exchange data between organisations called International Data Spaces (IDS). By integrating TMS into its operations, D8L aims to optimise route planning and ensure that deliveries are made most efficiently and cost-effectively. Real-time visibility into the movement of goods will be made possible by the TMS which will help in improving delivery tracking and management. Customer satisfaction will increase as a result, and delivery timeframes will be more accurate. TMS will also speed up the process of assigning drivers and trucks to particular routes, saving time and effort when it comes to manual scheduling. To further improve operational efficiency, it will also make it easier to gather and analyse vital data on things like driver performance, vehicle maintenance requirements, and fuel use. This will empower D8L to make data-driven decisions.

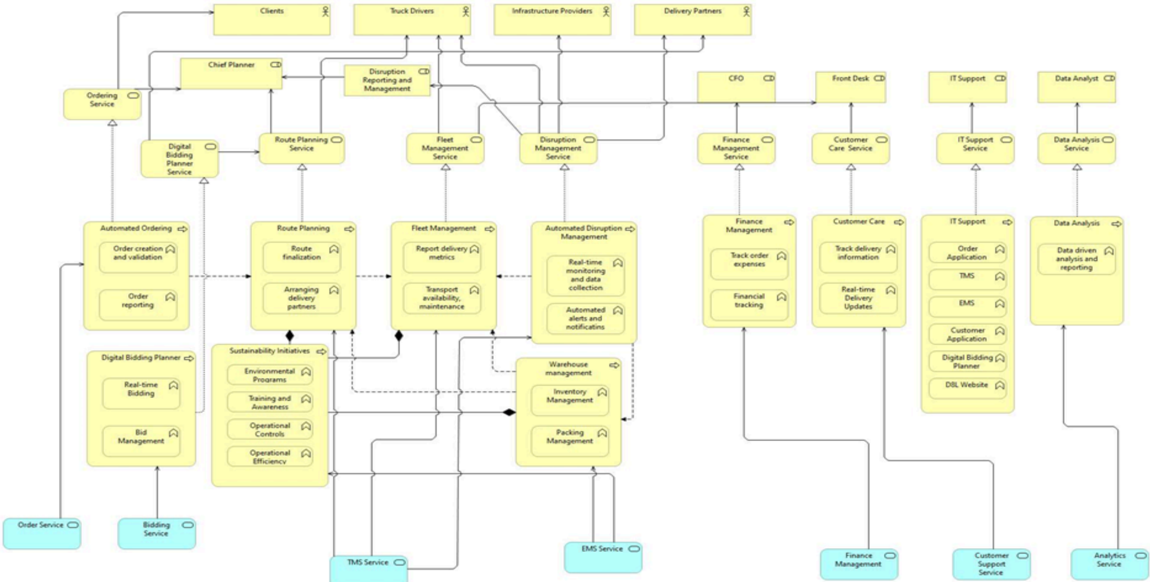


Fig. 7: Business Process Changes

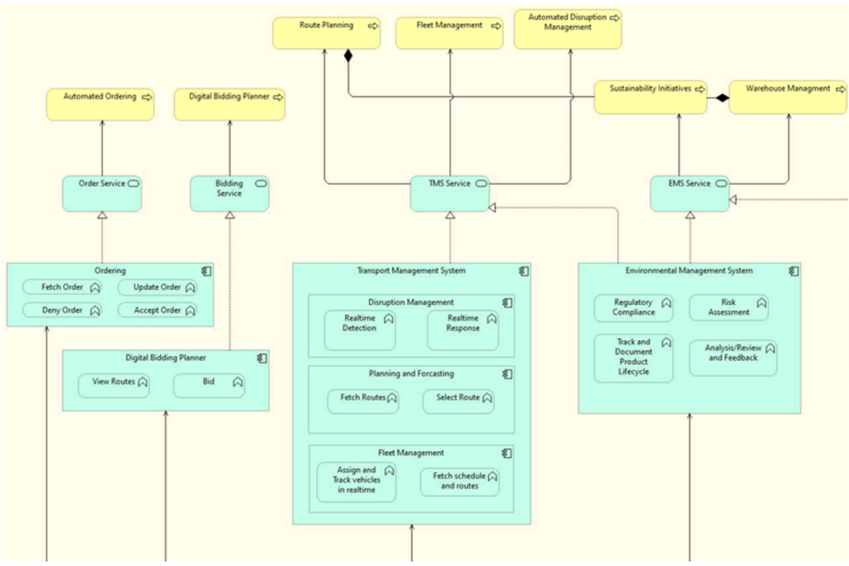


Fig. 8: Application Changes (Part - 1)

4.1.5. Environmental Management System (EMS)

A primary goal for D8L is to minimise its environmental impact and enhance sustainability. To monitor and analyse the organisation's environmental effects, we will develop and implement an Environmental

Management System. The EMS will be designed to track and measure the environmental footprint of D8L's operations, including emissions from its transport fleet, energy consumption, and waste generation. The EMS gathers and analyses this data to offer insightful information that guides strategy creation and decision-making intending to lower the company's overall environmental impact. For example, the technology may determine which mode of transport or routes are the most carbon-intensive, allowing D8L to invest in more fuel-efficient or alternative fuel vehicles and optimise route design. The data will be collected from trucks and warehouses using IOT devices and sensors for analysis. Fig.8 shows the implementation of EMS through Archimate.

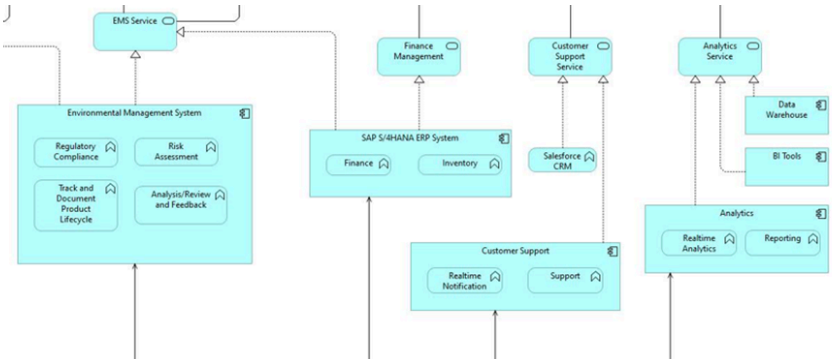


Fig. 9: Application Changes (Part - 2)

4.1.6. Customer Service

We plan to build a custom automated application to enhance customer service as seen in Fig.9. Customers will be getting real-time notifications about their delivery status and location without having to contact the truck driver or delivery person.

4.1.7. Enterprise Resource Planning System

We propose to use the SAP S/4HANA ERP system to manage financial and warehouse inventory data. SAP S/4HANA is a leading ERP solution that integrates multiple business processes and provides real-time analytics, making it an ideal choice for D8L. It can manage finance, supply chain, production, warehouse and inventory in a single system. ERP system implementation can be seen in Fig.9

4.1.8. Customer Resource Management System

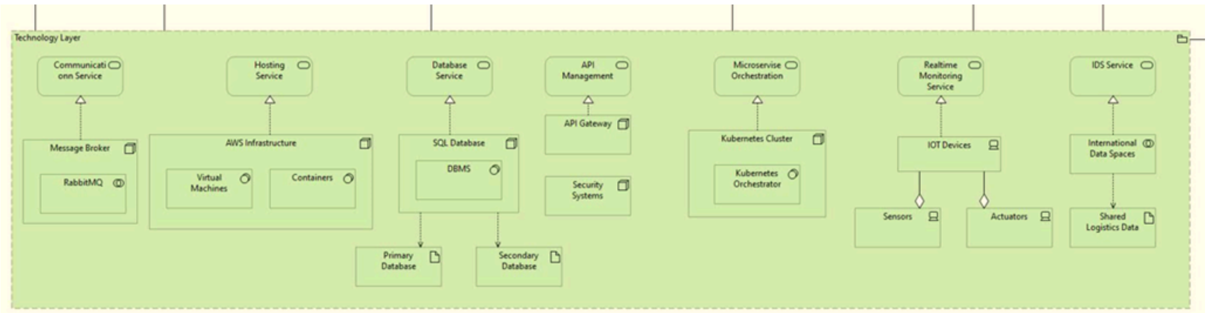
To manage customer-related data, we suggest using the Salesforce CRM system as seen in Fig. 9. Salesforce is a top-of-the-range CRM solution known for its comprehensive features and scalability. It offers excellent customer data management, sales automation, customer service and marketing capabilities. Salesforce's cloud-based platform provides greater accessibility and data sharing, facilitating remote access and collaboration. Its integration capabilities with other systems, including SAP S/4HANA, make it a seamless fit for D8L.

4.1.9. Data Analytics

Data from the past and in real-time will be used for analytics using BI tools for forecasting and planning and to improve overall business efficiency and profits. A team of data analysts will be hired to manage this process. The implementation can be seen in Fig.9

4.2 Technology Changes

Fig.10 shows the Technological Changes implemented in D8L.



Fig, 10: Target Technology Layer

4.2.1. AWS Infrastructure and Kubernetes Cluster

Amazon Web Services(AWS) and Kubernetes will be used to provide cloud services to support the deployment, scaling, and management of microservices-based applications. Also, all data will be stored in a SQL database supported by AWS.

4.2.2. RabbitMQ Message Broker

We will be using RabbitMQ Pub/Sub Message Broker as our middleware element for sending real-time data from sensors and IoT devices to various applications. RabbitMQ allows the transfer of low latency and complex message distributions which fulfils the organisation's requirement. In the future, message brokers like Kafka can be implemented to process high-throughput message streams.

4.2.3. API Gateway

We will be implementing the Kong API gateway which will function as a centralised entry point for all microservice communication, ensuring efficient, secure, and streamlined interactions between various components. Kong API Gateway is a widely used, highly scalable and reliable solution for managing, securing and orchestrating APIs and microservices. Kong integrates seamlessly with Kubernetes, which D8L plans to use to deploy and manage microservices, improving the overall robustness and scalability of the system.

4.2.4. IoT Devices and Sensors

We propose that D8L install IoT devices and sensors in their warehouse and trucks to monitor and manage inventory and delivery of goods. Real-time data such as location, speed, route deviations, engine diagnostics and fuel consumption can be captured by IoT devices in trucks. This can be used to optimise route planning and scheduling, improve fuel efficiency by identifying inefficient driving patterns or engine problems early, and ensure compliance with safety regulations and delivery schedules. In warehouses, IoT sensors can be used to monitor a range of environmental conditions such as temperature, humidity and inventory levels in real-time. For example, temperature sensors can help ensure that perishable goods are stored in optimal conditions, reducing spoilage and ensuring product quality.

4.2.5. International Data Spaces (IDS)

As mentioned in section 4.1.4 IDS will be utilised by TMS as a standardised architecture and methodology for secure and sovereign data exchange between organisations. IDS facilitates seamless and trusted data exchange between systems, ensuring that all participating entities can communicate effectively without compromising data security or integrity. The ability to access and share real-time data across organisational boundaries leads to significant operational improvements. Real-time data sharing enables better coordination and visibility across the supply chain, enabling proactive management of transport activities. For example, real-time traffic data and weather conditions can be shared between partners, enabling dynamic route adjustments and reducing delays.

4.3. Organization Changes

Based on the proposed changes, D8L will require a product team responsible for developing and implementing the applications. This team should include key roles such as a Project Manager, Developers, Testers, and Database Architect. We recommend using a single team to build all the custom applications in phases rather than having separate teams for each one. This approach will help D8L be more cost-effective, although it may extend the overall transition to a 4PL model. Each application-based microservice will be maintained by its own support team, as these microservices operate independently and may have unique requirements, dependencies, and potential issues. A dedicated support team will ensure each microservice is properly monitored, updated, and troubleshooted, which is crucial for maintaining the overall system's stability and performance. Additionally, a specialised team will be needed for data-driven analysis using advanced BI tools. We also recommend hiring a compliance officer to ensure that D8L adheres to Government and Environmental Regulations. Fig.11 shows the organization's viewpoint on implementing the above-mentioned changes.

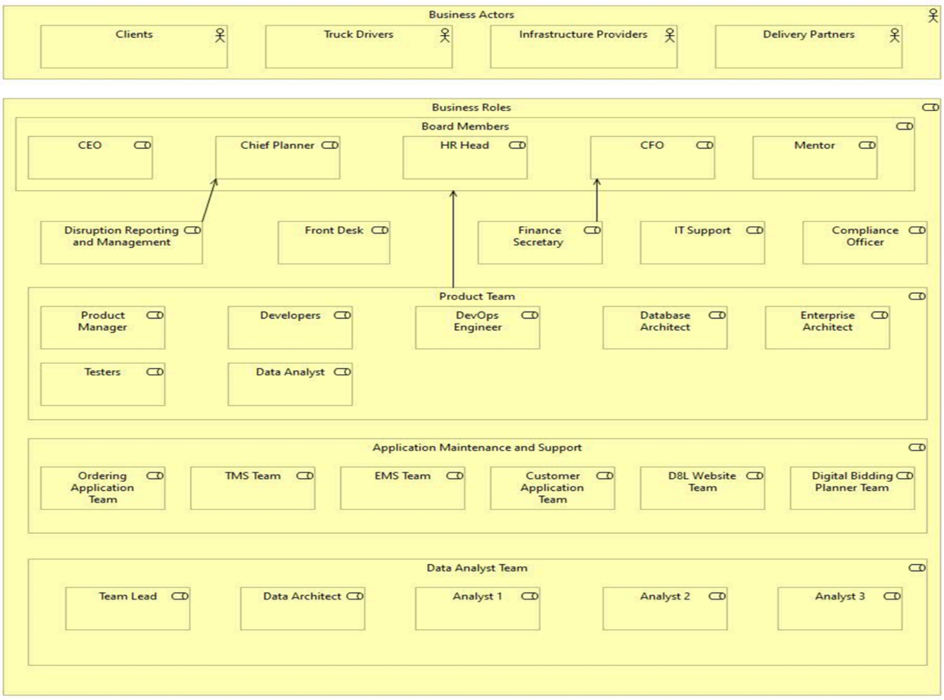


Fig. 11: Target-Organisational Viewpoint

4.4. Information Structure Changes

Based on the recommendations, there will be five key data domains. The Order Data domain contains vital details about the orders processed by D8L. Fleet Management Data is essential for monitoring the performance and upkeep of the vehicle fleet, aiding in tracking fleet status, identifying potential problems, and ensuring timely maintenance to reduce disruptions. The Route Data domain is dedicated to the logistics and planning of transportation routes. Lastly, Customer Data holds crucial information for understanding and managing customer relationships, offering a comprehensive view of each customer to enable personalised service and effective communication. Fig.12 shows the changes in the Information Structure of D8L.

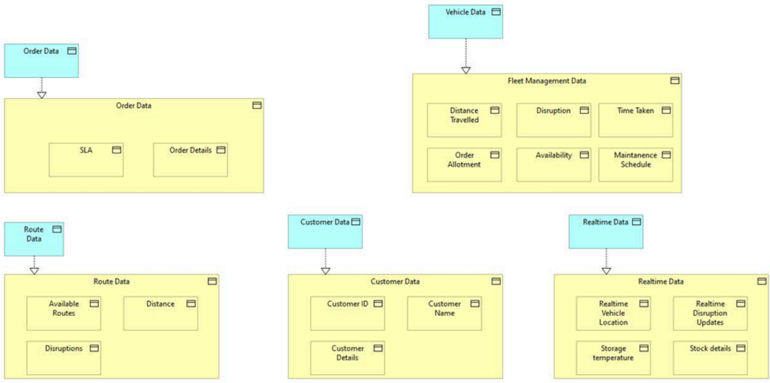


Fig 12: Target-Information Structure Viewpoint

4.5. Target Architecture Diagram

Fig 13. Shows the final target architecture diagram modelled in Archimate.

5. Implementation and Migration Plan

This section outlines the implementation and migration plan for D8L Logistics' digital transformation initiative, focusing on migrating from its current, on-premise architecture to a cloud-based transport management system. The plan is structured in plateaus, each representing a significant milestone in the overall transformation. Each plateau is explained concisely, outlining the gaps, work packages, deliverables, dependencies, risk assessment, deployment architecture, and monitoring & management plans. Here, Fig 14. shows the implementation and migration plan modelled in the Archimate.

5.1. Baseline Plateau

This phase focuses on understanding D8L Logistics' current operational landscape and setting the stage for improvement. D8L's existing monolithic legacy system presents challenges in scalability, maintainability, automation, real-time information, and analytics. These limitations hinder adaptability, flexibility, and efficiency. To address this, a project kick-off meeting initiates the process, followed by gathering detailed information about the current system and D8L's business needs. A skilled development team is recruited, and a comprehensive gap analysis is conducted. Current order management and route planning processes are meticulously documented, and a detailed migration plan is crafted, outlining the roadmap, timelines, and potential risks.

Key dependencies, such as the close relationship between the legacy Ordering and Planning systems and the reliance on external map APIs, are identified. Potential risks, such as employee resistance to change and integration challenges with existing ERP systems, are addressed through planned training programs, employee involvement, and engagement of integration specialists. The deliverables of this plateau include a clear understanding of D8L's current logistics operations, a detailed migration plan, a skilled development team, and a chosen technology stack.

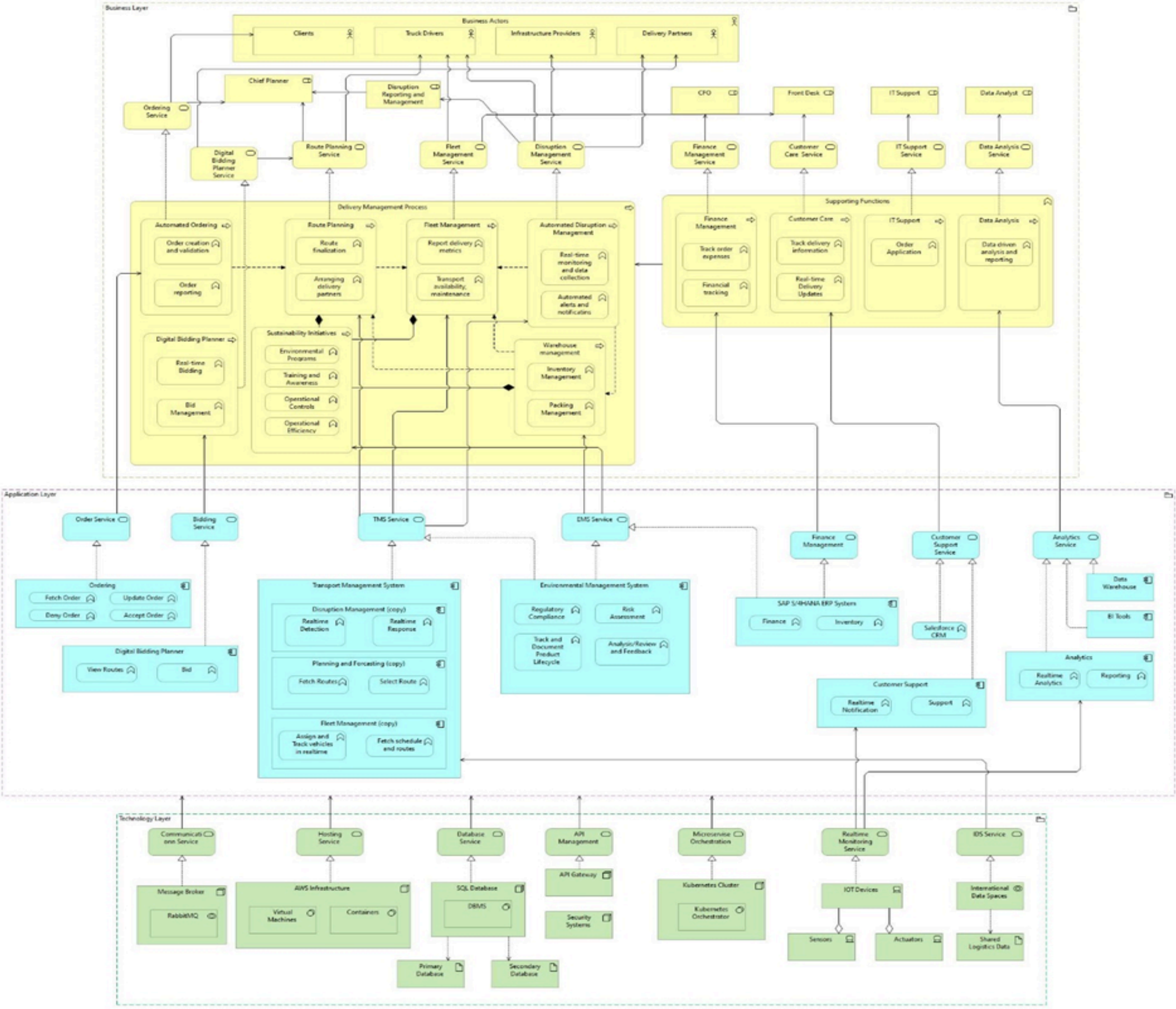


Fig. 13: Target Architecture

5.2. Initial Phase - Planning and Setup

This phase focuses on establishing the fundamental components of the new system—the basic Ordering and Routing services—which will be expanded upon in later stages. The basic Ordering Service will handle essential order management functions, potentially using a simple database like MySQL. Unit tests will be implemented to validate individual components of the Ordering Service. The basic Routing Service will focus on calculating routes, potentially leveraging external map APIs like Google Maps, and its accuracy will be validated through unit tests.

Dependencies involve the chosen database for the Ordering Service and the external map APIs for the Routing Service. A potential risk is performance bottlenecks due to limited functionality and scalability. This can be mitigated by designing the services with scalability in mind. Initial deployment will be on a development server, utilising virtual machines or containers like Docker. Basic monitoring tools will be implemented, and management will be primarily manual. This phase delivers operational basic Ordering and Routing services, deployed on a development server and ready for further development.

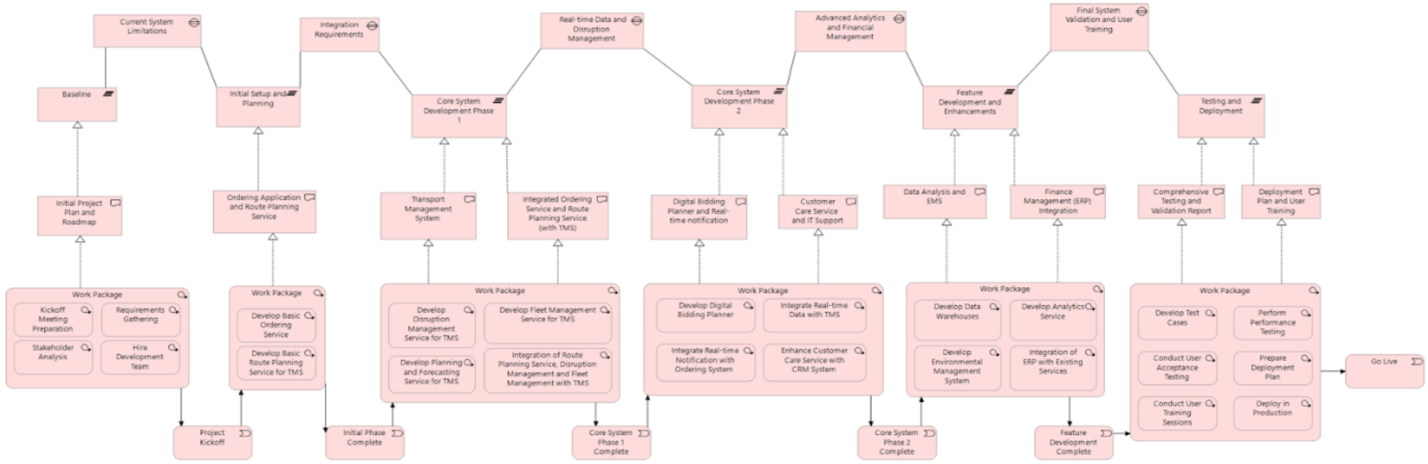


Fig 14. Implementation and Migration Plan to migrate D8L's baseline architecture to target architecture.

5.3. Core System Development Phase 1

This phase focuses on building a dedicated Transport Management System (TMS) and incorporating robust planning and decision-making capabilities. The work involves developing a Transport Management Service, which interacts with the Ordering and Routing services to handle order assignments, shipment tracking, driver schedules, and real-time updates. A disruption management service will be integrated within the TMS to manage and track potential disruptions during ongoing deliveries. The Planning and Forecasting service will introduce intelligence for route optimisation, and disruption management, and the Fleet Management service will be used for tracking fleet utilisation. These systems consolidated, forming a Transport Management System.

A comprehensive testing strategy is crucial in this phase. Unit testing will validate the individual components of both the Transport Management Service including the Planning and Forecasting, Routing and Disruption Management Service. Integration testing will be conducted to ensure seamless communication and data flow between the TMS, and Ordering Service.

Key dependencies exist between the Transport Management, and Ordering services. Integration with GPS tracking providers introduces an external dependency. The complexity of integrating these services is a potential risk, which can be mitigated by using message queues like RabbitMQ and APIs and conducting thorough integration testing. The TMS services will be containerized using Docker and deployed on a Kubernetes cluster for scalability and resilience. Technologies like Java Spring Boot, PostgreSQL, and RabbitMQ will be used. Monitoring tools like Prometheus and Grafana will provide insights into system health and performance. This phase delivers a functional TMS, integrated with the other core services and deployed on a Kubernetes cluster, capable of handling basic transport management operations.

5.4. Core System Development Phase 2

This phase expands the system with real-time data integration, a centralised data warehouse for analytics, a customer-facing portal, and a basic EMS. The TMS is enhanced with real-time data integration capabilities, incorporating GPS tracking, traffic data APIs, and real-time updates to other services. A data warehouse is built using a cloud-based solution like AWS Redshift or Snowflake, and a basic EMS is developed to track environmental impact. Additionally, a Customer Service portal is developed or an existing CRM system can be integrated, providing customers with real-time access to their order information and other self-service features.

Integration testing is essential in this phase to ensure data integrity and seamless data flow. The real-time data integration of the TMS with GPS tracking and traffic data APIs will be tested extensively. The data warehouse loading processes and data integrity will be validated, and the functionality of the EMS will be tested. The Customer Service portal will undergo thorough testing, including unit testing, integration testing, and UAT, to ensure its usability, functionality, and seamless integration with other systems.

This phase introduces interdependencies between the TMS, Ordering Service, data warehouse, and Customer Service portal. Relying on external providers for GPS tracking, traffic data, and CRM systems introduces external dependencies. Data security vulnerabilities in the data warehouse and real-time data feeds are a concern, requiring robust security measures like encryption and access control. The data warehouse will be hosted on a cloud platform, while the Customer Service portal will be deployed on a web server. Monitoring will be extended to include these new components. This phase delivers an integrated system with real-time data sharing, a functional data warehouse, a basic EMS, and a customer-facing portal, all deployed and monitored.

5.5. Feature Development and Enhancements

This phase focuses on adding financial management capabilities and deeper CRM integration. A dedicated Finance Management module is developed or an existing ERP tool is used, integrating with the Ordering Service and TMS to handle financial transactions and reporting. Integration with existing ERP systems using middleware like MuleSoft might be necessary. Deeper integration with the company's CRM system, potentially leveraging platforms like Salesforce or Microsoft Dynamics 365, will enable unified customer data management.

Unit and integration testing are crucial for this phase. The Finance Management module will undergo testing to ensure the accuracy of calculations, data consistency, and secure data exchange with ERP systems. The CRM integration will be tested to validate seamless data flow and synchronisation between the logistics system and the CRM platform.

The Finance Management system and CRM integration depend on the Ordering Service and TMS. Data inconsistencies between these systems are a risk, requiring data validation and reconciliation processes. The Finance Management module will be integrated into the TMS deployment on Kubernetes. CRM integration will use APIs provided by the used system. Monitoring is extended to cover these integrations, and detailed logging and auditing mechanisms are implemented. This phase delivers a comprehensive platform with robust financial management and seamless CRM integration, fully tested and monitored.

5.6. Testing and Deployment Plateau

This final phase ensures the quality, reliability, and usability of the new system before deployment. A comprehensive testing strategy is employed, involving various levels of testing. Unit testing will validate individual components of each service. Integration testing will ensure seamless communication between services and systems. System testing will validate the system's overall functionality and performance. Finally, user acceptance testing (UAT) will involve real users interacting with the system to provide feedback and validate its usability.

A detailed deployment plan will be developed, outlining the steps, timelines, and responsibilities for deploying the new system. A phased deployment approach will be employed to minimise risks and ensure a smooth transition. User training sessions will be conducted to ensure a successful adoption of the new system.

Successful deployment depends on the successful completion of all previous development and testing phases. A potential risk is unexpected issues or bugs during deployment, leading to service disruptions. This will be mitigated through a robust rollback plan and thorough pre-deployment testing and staging. The final deployment architecture will be determined based on chosen technologies and infrastructure requirements. Continuous monitoring, centralised logging, proactive alerts, and regular maintenance will be implemented for the deployed system.

This final phase delivers a thoroughly tested and operational system that meets all functional and performance requirements. The system will be actively monitored and maintained to ensure ongoing stability and security. Trained users will be ready to operate the new system effectively, marking the successful completion of D8L's digital transformation.

By following this phased approach, D8L Logistics can transition to a modern, cloud-native, data-driven logistics platform. This transformation will significantly improve operational efficiency, enhance customer satisfaction, and strengthen D8L's competitive advantage.

6. Impact Analysis

Analysing impact is critical during the transformation of the IT architecture of an organisation for several reasons. The first is cost management. Accurate impact analysis helps in budget planning by determining the cost required for transformation and can help mitigate unplanned expenses by foreseeing potential issues. Another crucial aspect is identifying potential risks. Risks can be either technical such as compatibility issues that may arise when integrating new systems with existing ones, or operational such as how business processes are affected due to these changes and whether they can result in operational disruptions. Moreover, impact analysis aids in ensuring a smooth transition from the baseline to the target architecture. Maximising ROI is another key benefit. Organisations can ensure that the investment in technology yields the maximum results from a long-term perspective. Lastly, impact analysis is key for aligning the IT transformation with the strategic goals.

The proposed transformation provides numerous benefits but also poses several challenges for the logistics company. The key impacts, both positive and negative, are identified as follows:

6.1. Positive Impacts

One significant advantage is better fleet and resource management, implementing a centralised Transport Management System (TMS) revamps fleet scheduling, route optimisation and enhanced decision-making, resulting in higher operational efficiency and reduced costs. The Environment Management System monitors the amount of resources used, thus providing insights for meeting environmental guidelines and for supporting greener practices.

Enhanced security and compliance are also notable benefits. Implementation of IDS ensures real-time threat detection and response safeguarding data security and operational continuity.

The transformation also promises improved scalability and performance while also enhancing flexibility and agility. Microservices enhance flexibility by allowing components to scale flexibly on demand, optimising resource utilisation. It decouples the system into smaller services which increases performance. Kubernetes further enhances this by automating the deployment and management of these microservices across clusters, ensuring consistent performance even during peak loads. Robust API management streamlines the integration of services and even external systems, enabling seamless communication and collaboration. Asynchronous communication with message brokers optimises performance by handling high volumes of requests and data, eliminating the formation of bottlenecks. Real-time data provides insights for efficient decision-making and real-time optimisation of logistics operations.

Improved customer experience is another significant benefit. The inclusion of a dedicated CRM and real-time customer data management facilitates personalised interactions and better service delivery. Real-time updates to customers increase transparency and customer satisfaction.

6.2. Negative Impacts

However, the transformation also poses several challenges. Increased complexity is a notable concern. The shift to microservice architecture with Kubernetes, API gateways and analytics increases overall system complexity. Additional personnel like developers, analysts and architects are needed to develop and manage the different components of the system. Further, the incorporation of components like RabbitMQ, IoT devices and multiple databases can be quite challenging and require significant effort.

The higher cost is another drawback. The migration process will require high initial costs for new infrastructure, software and skilled personnel. Ongoing maintenance, updates and support will require a far more talented set of individuals and costs in terms of money and time.

Training and change management are critical concerns as well. Employees will need to learn to use the new systems effectively. This training process can be costly and time-consuming. Staff accustomed to the old systems might resist change to the new one. Some change management strategies should be brought in.

Finally, potential downtime and disruptions pose risks. There is a risk of downtime and disruption of services during the migration process. This can be mitigated through proper testing and validation, implementing phased rollout techniques and having a backup and rollback plan in place. Transferring data to new databases and warehouses can pose a threat of data loss and inconsistency. This can be mitigated by using proper data cleaning and ETL processes to migrate the data in files and old databases by converting them to appropriate forms and formats and loading them to the new database.

In conclusion, there are various positive and negative effects of this proposed transformation. Ensuring the benefits outweigh the drawbacks is key. Initially, there seems to be a significant financial outlay in the form of software, licences, and personnel like developers. IT managers, architects, and analysts. However, in the long run, the reduction in running costs will outweigh these investments. For instance, the fuel costs will be cut. Several jobs like the disruption manager and planners will be redundant as these will be completely automated. Efficient planning will reduce the number of vehicles and trips needed to deliver, thus cutting down on trucks and drivers. Greater service quality and better customer support will lead to an increase in customer satisfaction. This will lead to a gain in new customers and will also help improve customer retention.

7. Proof-Of-Concept (PoC)

As a proof-of-concept, we have created two prototype applications: one for the truck and another for customers, communicating over the RabbitMQ message broker. The business process which addresses providing real-time notifications of truck location to customers is simulated.

7.1. PoC Considerations

7.1.1. Validation of Core Components

The primary focus of the Proof-Of-Concept is to validate the communication between the customer and the truck applications. Ensuring that the messages are routed correctly, the queues are properly bound, and the asynchronous communication is reliable is crucial for the system's robustness. By testing the message delivery under various circumstances, reliability and performance can be verified.

The location of an order is requested by the customer application using RabbitMQ. A location request is sent to a designated queue, and the application waits for a response, ensuring effective communication initiation and response handling.

Location requests from the customer application are handled by the truck application, which listens to specific queues, processes incoming requests, and sends back the requested location information.

7.1.2. Future Scalability

As the system grows, additional instances of the truck and customer application can be deployed. This involves configuring RabbitMQ to deliver messages to multiple instances, ensuring the system remains responsive under high traffic.

Increasing the resources, like CPU and memory to the existing instances will also help maintain performance as the demand grows, ensuring that each application instance can handle more requests efficiently.

Implementing a load balancer for RabbitMQ can distribute incoming messages evenly. This ensures high availability and reliability, maintaining consistent performance during peak loads.

7.1.3. Extensibility

While the current prototype focuses on two applications, other applications can be developed independently without disrupting the existing system using microservices. APIs with a focus on extensibility can also be developed which gives flexibility for evolving business needs.

7.1.4. Maintenance

Implementing centralised monitoring tools, such as Prometheus and Grafana, will track the performance and health of all applications. This enhances reliability by detecting issues and facilitates timely intervention. Centralised logging using tools like the ELK stack (Elasticsearch, Logstash, Kibana) will collect, analyse, and visualise logs from applications. This is essential to maintain the overall health of the system. Further, Continuous Integration and Continuous Development (CI/CD) pipelines can be brought in to automate building, testing and deployment, thus reducing manual intervention which in turn can reduce errors. Further, regular updates and patching of various applications can also be brought in which helps keep the application up-to-date, secure, relevant, and effective.