BIRMINGHAM CITY University

D2
BMW Case Study Report

Group Names

- William
- Adam
- Valeria
- Imogen
- Seehem
- Disha

Introduction

The BMW team would like a vehicle tracking program designed for them to work with their existing CCTV. This report will establish some of the preplanning done before further enhancement and talk with the BMW team.

BMW Requirements & Brief

BWM would like to monitor their logistic vehicles within one of their locations: Hams Hall Plant. They are unable to track their vehicles via GPS and do not want to outfit and pay for a Bluetooth solution. What they want to do is use their preexisting CCTV cameras to identify and locate their logistic vehicles. Additionally, they would like the Api to calculate whether vehicle routes are optimal or not.

Some more specific details involve the model utilizing X Y Z coordinates of each vehicle type in real time, distinguishing each vehicle and making all data pollable by the API as to overlay the tracking data into their Vehicle Management System.

Functional Requirements

FR ID	Functional Requirement Description
FR1	The system must track the location of each vehicle within the Plant Hams Hall Area, using only their preexisting hardware (CCTV).
FR1.1	The system must utilise CCTV footage to track the co-ordinate location or each vehicle.
FR1.2	The system must store the co-ordinate location of each vehicle in an XYZ format.
FR2	The system must be able to distinguish between vehicles using AI technology and QR codes that are to be placed on the roofs of each vehicle*.
FR3	The system must store data for the API to use.
FR3.1	The system must store this data in a JSON format.
FR3.2	The system must store data of each vehicle.
FR4	The system must be able to calculate the optimal route for a vehicle.
FR4.1	The system must calculate this optimal route using Dijkstra's algorithm.
FR5	The system must alert users of incidents within the warehouse.
FR5.1	The system must also alert users of incidents that are likely to happen.
FR5.2	The system must alert users when a vehicle has been damaged, needs repairing, or needs to be swapped out.
FR5.3	The system must also allow users to manually create alerts.
FR6	The system must allow manual data input of vehicle data.
FR6.1	The system must allow only System Administrators to input initial vehicle data.
FR6.2	The system must allow users to update the status of each vehicle (e.g. the vehicle needs refuelling).
FR7	The system must keep data secure to avoid outside parties / threats.
FR7.1	The system must only be accessible by those in the Logistics Operations team (and those of higher positions who need access to this data).
FR7.2	The system must have a login feature to ensure it and its data can only be accessed by those in the Logistics Operations team.

*We will be using QR codes alongside AI object recognition to distinguish between different vehicles of the same model or type.

Non-Functional Requirements

NFR ID	Non-Functional Requirement Description
NFR1	The system must process 5 CCTV frames every second.
NFR2	The system must achieve an object detection accuracy of at least 95%.
NFR3	The system must support multiple users querying real-time vehicle location data by ensuring a response time below 300ms to guarantee smooth system performance without any delays.

Ethical & Legal Issues

Issue ID	Issue Description	Issue Justification	Related Requirement ID
E1	Vehicle Tracking Inaccuracies	The performance of the system may not be optimised to its full potential due to delays in the operations, such as, taking longer to deliver. The API may misidentify or completely fail to track some vehicles, leading to data inaccuracies. This in turn leads to logistical problems and inaccurate vehicle route preferences.	FR1, FR2, FR3, FR4, FR5, NFR2
E2	Privacy & Consent Misuse of Data	Although the CCTV is used exclusively by the program to track logistic vehicles live, it may capture sensitive employee information. This could cause discomfort in the work environment, raising privacy concerns and even potential legal issues if not acknowledged. Moreover, using unauthorised footage of the users would lead to a violation of their privacy, potentially leading to serious consequences such as employees suing the company.	FR1, FR2, NFR2
L1	Intellectual Property Agreement	It must be ensured that third parties have correct licensing and abide by the same data protection rules. Failing to meet this requirement could result in legal issues and reputation loss.	FR3
L2	Incorrect Information provided by the System	This could cause incorrectly calculated optimised routes, accidents, increased consumption of fuel, and delays, leading to legal liability for the company. Inaccurate information could also lead to collision due to the system generating incorrect paths to the optimal routes. This could lead to incidents such as drivers unintentionally taking congested or paths, possibly causing incidents to occur. As a result, the company may be held liable and failure to provide accurate data could discourage other companies from working with them.	FR1, FR2, FR3, FR4, FR5, NFR1
L3	Employment protection law	All employees have the right to a safe and healthy work environment, including handling any incidents that occur at work. Furthermore, employees have the right to their privacy, hence, it is essential for the company to review employment contracts to ensure that monitoring practices[1] and permission to store sensitive information[2] are aligned with agreed terms and privacy regulations. If	FR1, FR2, FR5, NFR2

[1] https://www.gov.uk/monitoring-work-workers-rights
[2] https://www.gov.uk/personal-data-my-employer-can-keep-about-me

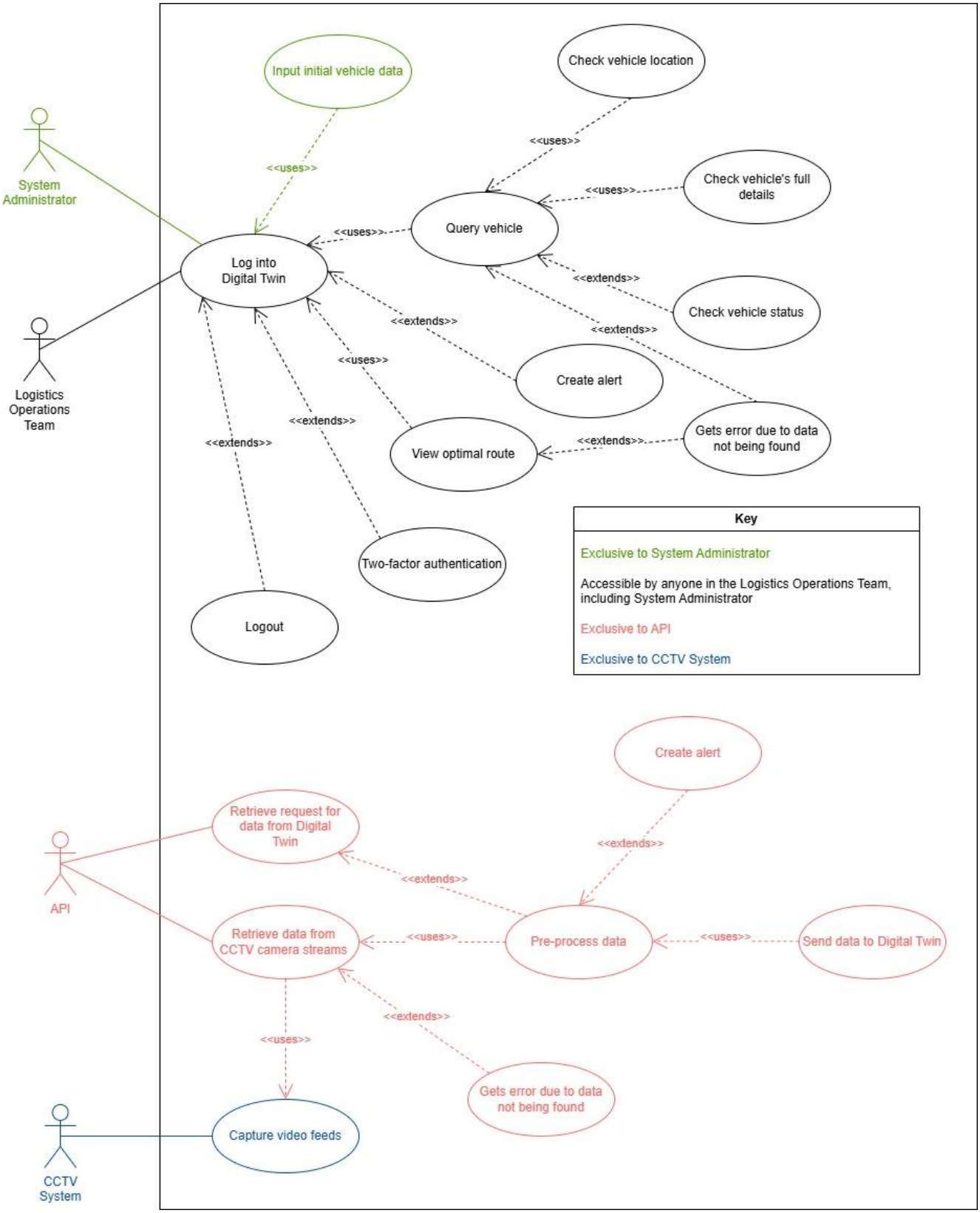
		employees do not consent to being monitored, they have the right to act against the company for violating their privacy, consequently damaging the company's reputation.	

Risk Assessment

Risk ID	Risk Description	Risk Category Scale (1 – 10, lowest - highest risk)	Risk Mitigation Strategy	Related Requirement ID
RI1	Confidential data may be intercepted by people with malicious intent and without correct authorisation. Attackers may intercept and tamper with the data and gain access to confidential information.	9	Make sure all transmissions are encrypted. Implement strict access controls, for example, have a login system that only users of the Logistics Operations	FR7, NFR, FR3
RI2	A high volume of requests might overload the system causing it to slow down or crash which may disconnect the Digital Twin from the API, losing the ability to retrieve real-time data such as vehicle locations.	5	Ensure that models are in continuous training to increase the accuracy, and that the building is well- lit. The system must also be regularly updated to prevent this from happening.	FR1, FR2, FR3, FR4, FR5, NFR1, NFR3
RI3	The CCTV camera feed may fail to monitor vehicles due to network failure or hardware malfunctions, leading to disruptions in logistics operations.	8	Implement backup camera feeds and redundancy measures.	FR1, FR2, FR3, FR4, FR5, NFR1
RI4	Vehicle misidentification may be caused by poor QR code visibility. Dirt, lighting, damage to the QR code,	7	Implement secondary identification, for instance, license plate recognition.	FR1, FR2, FR3, FR4, FR5, NFR1

	and objects within the warehouse may hide the QR code from CCTV, causing vehicle tracking failures or misidentification.			
RI5	The route optimisation system may make bias or incorrect routes in failure to account for sudden congestion and temporary blockages. Some vehicles may also take up bigger paths in the warehouse. This may lead to delays or potential incidents.	6	Implement vehicle dimensions to vehicle types or integrate real-time obstacle detection.	FR4, FR5

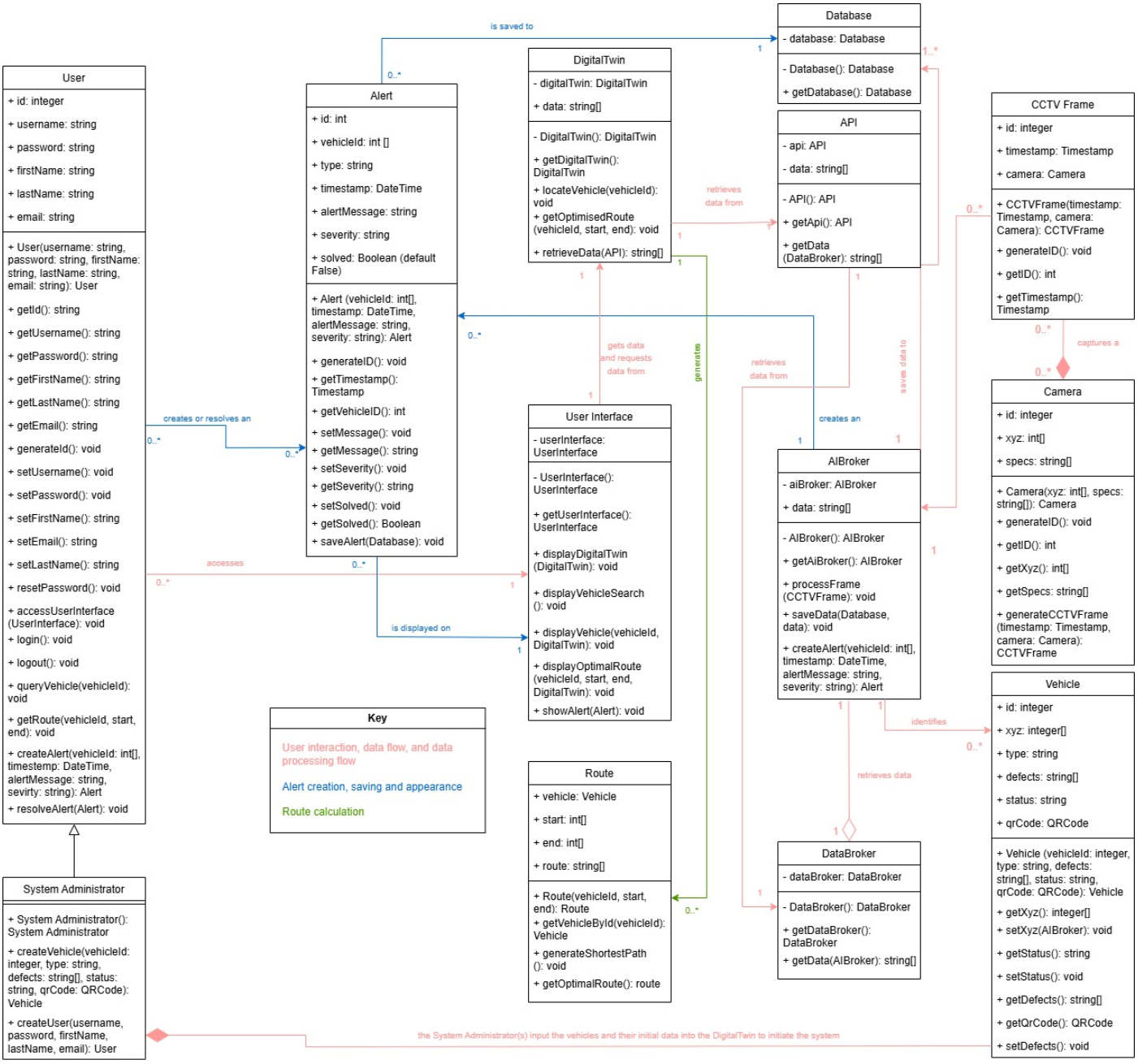
Use Case Diagram



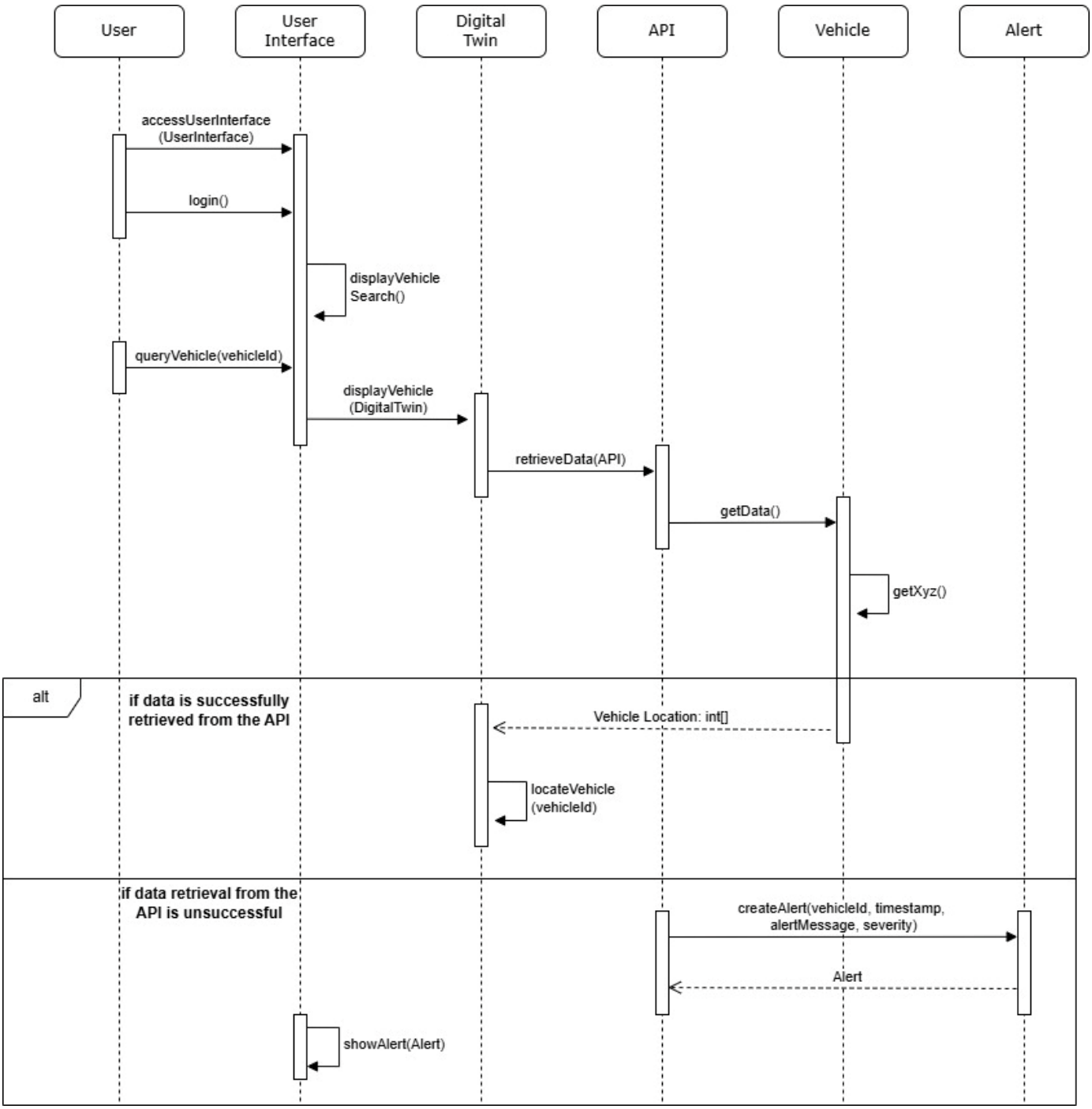
Use Case Specification

Name	Check vehicle location
Purpose	To allow authorised users, specifically users of the Logistics Operations Team, to check the real-time location of a vehicle using the Digital Twin system.
Prerequisites	"Query Vehicle" and "Log into Digital Twin" use cases completed.
Narrative	1. The user logs into the Digital Twin system. 2. The user queries for a vehicle in the search bar. 3. The Digital Twin requests the vehicle location from the API. 4. The API gets the request from the Digital Twin and retrieves the specified vehicle's location. 5. The Digital Twin receives the vehicle location.
Outcome	User successfully views the location of the selected vehicle on the user interface. As time passes and the specified vehicle stays the same, the location of the vehicle and its other details are updated in real-time.
Alternative Narrative	1. The user logs into the Digital Twin system. 2. The user queries for a vehicle in the search bar. 3. The Digital Twin requests the vehicle location from the API. 4. The API gets the request from the Digital Twin. 5. The API tries to retrieve the vehicle location data. 6. The data cannot be found.
Alternative Narrative Outcome	The user interface displays an 'Data cannot be retrieved' error. If the vehicle is offline, the system notifies the user and gives the last known location of the vehicle.

Class Diagram



Sequence Diagram



Appendices

- Dijkstra's algorithm – An algorithm that calculates the shortest path between two nodes. (W3schools, n.d.).
- 2FA (Two-Factor Authentication) - Security method that requires identification to check if it matches the data (Bing, 2021).
- User logs – keeps a track of the activities occurring within the system, including any errors and the overall behaviour of the user - ("Understanding System/User Logs: A Comprehensive Guide to Activity Tracking"). (SentinelOne, 2024).
- user queries – Data about an individual user saved in the database. (BRANDERMIND AI, 2025)
- user interface – a medium through which the user interacts with the machine, and this includes input devices such as screens. (Churchville, 2021).
- logistic vehicles – More specifically warehouse internal logistic vehicles such as forklifts, electric pump trucks and shunting tractor units. (Manutan, 2024).
- JSON (JavaScript Object Notation) - A file format for storing and transporting data (W3Schools, 2019).