Thesis

NHL Stenden University of Applied Sciences

In the department of:

ICT & CT Information Technology Bachelor Emmen

In association with:

Quality ICT B.V.

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Summary

Q-ICT is a small cybersecurity consultant firm based in Emmen, Drenthe, the Netherlands. It is a partner of Pax8, which is a Microsoft distributor, therefore they handle all cybersecurity related to Windows and Microsoft products. They have over 400 clients, all spread throughout the Netherlands, and their main target audience is small to medium-sized businesses. Recently, as of last year with the assistance of their partner, Pax8, Q-ICT has purchased the rights to a SentinelOne subscription. Since then, they have been utilizing the product to provide better endpoint security to their clients.

SentinelOne is a cybersecurity company based in California, United States that has a product of the same name. It is an EDR platform, which purpose is to detect and respond to threats of an endpoint in real-time, replacing the traditional AV. It utilizes AI and ML on an Agent to detect and respond to threats, and it is deployed on the endpoint itself. The purpose of an EDR platform is to have a centralized location to monitor and respond to threats on all endpoints in a network, in a company. SentinelOne has Agents that act as a replacement for the traditional AV. The traditional AV relies heavily on signature-based detection, which requires identifying a unique string of bytes (signature) from known malware, usually stored in a DB. This method struggles against new, unknown (zero-day) threats and malware that changes frequently. SentinelOne, on the other hand, and similar next-generation solutions use behavioural analysis to identify malware based on its actions rather than its code. This allows them to detect and respond to new, unknown threats that traditional AV solutions would miss.

The QaaS app is an internal system of Q-ICT, serving as an ERP web application to manage their clients, products, and services. The QaaS itself has already 5 APIs connected to it, which are: N-Central, Bodyguard.io, Resello, Snelstart, and PerfectView. N-Central is used for monitoring and managing the clients' networks. Bodyguard.io is used for email security, to prevent any malicious downloads from phising e-mails. Resello, which is a product of Pax8, is used to manage the clients' Microsoft subscriptions. Snelstart is used for the financial administration of Q-ICT. PerfectView is used for the CRM of Q-ICT. Together, these APIs provide Q-ICT with the tools to manage their clients, products, and services. A client that has one of Q-ICT's subscription, can access the QaaS app and see their subscription, and the status of their network, and the status of their endpoints.

The integration of the SentinelOne API into the QaaS app is possible through SentinelOne REST API, with the use of QaaS app existing framework and services, Flutter and Firebase. Once a SentinelOne Agent is properly installed on an endpoint, create a new SentinelOne account with appropriate read permissions, and store the generated API key in Google Secret Manager, where it is there in the cloud, secured and encrypted. Therefore, required Firebase Cloud Functions are created to interact with the SentinelOne API to retrieve the data from SentinelOne, and store it in Firebase Firestore. The Flutter client then will interact with the Firestore to retrieve the data from SentinelOne, and display it to the user.

Based on comparing to other existing EDR platforms, a visualization is necessary, to provide a better understanding of the data. The visualization should be as simple as possible, so as not to overwhelm the user with too much information. The users should be able to customize the visualization widgets to their liking, choosing what kind of data they want to see, and how they want to see it. The visualization regarding SentinelOne should be able to show the status of the endpoints, the threats detected, and the actions taken by the SentinelOne Agent. The type of data that can be visualized are limited, normally it requires an index and a value (e.g., number or date time) to be visualized. Flutter itself already has 3 packages that can be used to make visualization charts, which are: fl_chart, charts_flutter, and syncfusion_flutter_charts.

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Glossary

API is a software intermediary that allows two applications to talk to each other. In other words, an API is the messenger that delivers request to the provider that was requested from and then delivers the response back (**Wikipedia, n.d.-b**) . 9

CAPTCHA is a type of challenge-response test used in computing to determine whether or not the user is human (*Wikipedia, n.d.-d*) . 22

CRM is a process or strategy that companies use to manage and analyze customer interactions and data throughout the customer ' lifecycle. CRM technology is a software system that helps organizations easily track all communications and nurture relationships with their leads and clients *Wikipedia, n.d.-f* . 17

ERP is a type of software that organizations use to manage core day-to-day business activities needed to run a company such as accounting, finance, procurement, project management, manufacuring, risk management and compliance, HR, and supply chain operations (*Wikipedia, n.d.-h*) . 17

JSON is a lightweight data-interchange format that is easy for humans to read and write while being also easy for machines to parse and generate too. It is based on a subset of the JavaScript programming language and is commonly used for representing structured data. JSON is often used for transmitting data between a server and a web application, as well as for storing configuration data (*Wikipedia, n.d.-j*) . 14

NoSQL is a category of DB that provides a mechanism for storage and retrieval of data that is modelled in ways other than the tabular relations used in RDMS (*MongoDB, n.d.*). NoSQL DBs are typically designed to handle large volumes of unstructured or semi-structured data, such as JSON, XML, or binary objects, and they offer a flexible data model that can evolve over time. Both databases in Firebase, Firestore, and Real-time Database are NoSQL databases. . 18

Pentest A.K.A. ethical hacking, is a simulated cyberattack where professional ethical hackers break into corporate networks to find weaknesses (Wikipedia, n.d.-m) . 10

REST is a software architectural style for providing standards between computer systems on the web, making it easier to communicate with each other. It is often characterized by how they are stateless and separate the concerns of client and server (**IBM, n.d.**) . 17

RESTful API is an API that follow REST principles (Fielding and Taylor, 2000). It considered the gold standard for scalability and are highly compatible with microservice architecture. It is the often used protocol in the context of building APIs for web-based applications . 17

RMM is a software platform that helps MSPs remotely monitor and manage their clients' endpoints, networks, and computers (Wikipedia, n.d.-n). 17

SOAP API is an API strictly based on XML for the message structure and HTTP for the protocols (*Indeed, 2023*) . 17

XML is a markup language that defines a set of rules for encoding documents in a format that is both human and machine-readable. It provides a way to structure data in a hierarchical format using tags to define elements and attributes within those elements (*Wikipedia, n.d.-o*) . 17

Cron Job is a job scheduler responsible on scheduling tasks on repeated schedule on a server (*Taylor, 2024*) . 23

Network TAP is a simple device that connects directly to the cabling infrastructure to split or copy packets for use ion analysis, security or general network management (*Wikipedia, n.d.-l*). . 27

reCAPTCHA is a CAPTCHA system owned by Google to enable web hosts to distinguish between human and automated access to websites (*Wikipedia, n.d.-e*) . 22

Threat Hunting A.K.A. cyberthreat hunting, is a proactive approach to identifying previously unknown, or ongoing non-remediated threats, and searching for signs of potential cyber threats within an organization's network or system (*Wikipedia, n.d.-g*) . 26, 29, 34

Acronyms

2FA Two-Factor Authentication. 4, 18, 20

A.K.A. Also Known As. 26, 32

AI Artificial Intelligence. 1, 9, 26, 27, 30, 31, 49, 57, 58

APA American Psychological Association. 10

API Application Programming Interface. 1, 4, 9, 10, 14–18, 20–24, 26, 29, 31, 41, 42, 45, 46, 48, 49, 51, 52, 55–58, 60, 61

ARP Address Resolution Protocol. 29, 30

ASCII American Standard Code for Information Interchange. 49

AV Anti-Virus. 1, 11, 26, 27, 29, 34, 57

AWS Amazon Web Services. 27, 34

B.V. Besloten Vennootschap. 0, 14

BaaS Back-end as a Service. 18

CAPTCHA Completely Automated Public Turing test to tell Computers and Humans Apart. 4, 18, 22

CDR Content Disarm and Reconstruction. 17

CISO Chief Information Security Officer. 10

CMEK Customer-Managed Encryption Keys. 23

CRM Customer Relationship Management. 1, 17

CSV Comma-Separated Values. 61

CT Creative Technology. 0

CVE Common Vulnerabilities and Exposures. 46, 58

DB Database. 1, 11, 22, 23, 26, 57, 58

DHCP Dynamic Host Configuration Protocol. 30

DNS Domain Name System. 27

e.g., exempli gratia. 1, 30

EDR Endpoint Detection and Response. 1, 9, 14, 26, 27, 29, 30, 34, 36, 57

EPP Endpoint Protection Platform. 26, 34

ERP Enterprise Resource Planning. 1, 17, 26

etc., et cetera. 17, 18, 27

ETDR Endpoint Threat Detection and Response. 26

GB Gigabyte. 20

GCP Google Cloud Platform. 18, 23, 24

GUI Graphical User Interface. 27

HTML HyperText Markup Language. 49

HTTP Hypertext Transfer Protocol. 16, 17, 20, 22, 31, 41, 45

HTTPS Hypertext Transfer Protocol Secure. 18

i.e., id est. 12

IAM Identity and Access Management. 24

ICT Information and Communication Technology. 0, 14, 17

ID Identifier. 29, 49, 58

IDS Intrusion Detection System. 24, 27

IoT Internet of Things. 26, 29

IP Internet Protocol. 30

IPS Intrusion Prevention System. 27

IT Information Technology. 9–11, 14, 17, 24, 26, 27, 31, 34, 57

ITIL Information Technology Infrastructure Library. 10

JS JavaScript. 18, 42

JSON JavaScript Object Notation. 14, 15, 17, 46, 47, 49, 61

MAC Media Access Control. 30

MCDA Multi-Criteria Decision Analysis. 15

MDR Managed Detection and Response. 27, 30

MFA Multi-Factor Authentication. 22

MGMT Management. 27, 29, 31

MIB Management Information Base. 30

MIME Multipurpose Internet Mail Extensions. 49

MKB Midden- en Kleinbedrijf. 4, 11–13

ML Machine Learning. 1, 9, 26, 27, 57

MS Microsoft. 11, 12, 17

MSP Managed Service Provider. 17

NDR Network Detection and Response. 27

NGAV Next-Generation Antivirus. 26, 27

NGES Next-generation Endpoint Security. 26

NGFW Next-Generation Firewall. 26

NIC Network Interface Controller. 30

NIST National Institute of Standards and Technology. 4, 12, 46

NoSQL Not Only SQL. 18, 58

NPM Node Package Manager. 41, 45

OAuth Open Authorization. 23

OS Operating System. 36, 46

OTP One Time Password. 18

PDF Portable Document Format. 49, 60

Pentest Penetration Testing. 10

Pub/Sub Publisher/Subscriber. 23

Q-ICT Quality ICT. 0, 1, 4, 9–18, 23, 26, 29, 31, 34, 41, 46, 49, 57, 60

QaaS Quality as a Service. 1, 4, 9, 11, 12, 14–18, 20–24, 26, 31, 36, 41, 48, 49, 57, 58, 60, 61

RAM Random Access Memory. 20

REST Representational State Transfer. 1, 17, 22, 31

RMM Remote Monitoring and Management. 17

SaaS Software as a Service. 17

SDK Software Development Kit. 22, 31

SEM Security Event Management. 27

SIEM Security Information and Event Management. 27

SIM Security Information Management. 27

SME Small and Medium-sized Enterprises. 10, 17

SOAP Simple Object Access Protocol. 17, 61

SOAR Security Orchestration, Automation, and Response. 27

SOC Security Operations Center. 27, 30, 34, 36

SWOT Strengths, Weaknesses, Opportunities, and Threats. 15

TAP Test Access Point. 27

TS TypeScript. 18, 42

UI User Interface. 60

URL Uniform Resource Locator. 49

UX User Experience. 18, 32, 48, 58

vCPU Virtual Central Processing Unit. 20

VLAN Virtual Local Area Network. 29

XML Extensible Markup Language. 15, 17, 61

YAML Yet Another Markup Language. 61

Chapter 1

Introduction

1.1 Project Background

In today's rapidly evolving digital landscape, cybersecurity remains a paramount concern for organizations across all industries. With the proliferation of sophisticated cyber threats and the increasing complexity of IT infrastructures, business are constantly seeking new and innovative ways to protect their digital assets and fortify their defences and safeguard sensitive data. In this pursuit, cybersecurity consultant firms have emerged as a critical ally for organizations, providing expert guidance and support in the development and implementation of robust cybersecurity strategies, playing a pivotal role in offering expertise and guidance to help organizations navigate the intricate realm of cybersecurity.

One of the key strategies employed by cybersecurity consultants is the integration of third-party security APIs into their arsenal of tools and technologies. These APIs provide invaluable functionalities, ranging from vulnerability assessment and security scans to device health monitoring and threat intelligence analysis by AI. By leveraging these APIs, cybersecurity consultants can enhance their capabilities and provide a more comprehensive and effective security solution to their clients, streamline their operations, provide clients with robust, proactive security measures, and improve their overall service delivery.

SentinelOne emerges as one of the leading organizations in the cybersecurity real, offering cutting-edge endpoint protection and threat intelligence solutions. It leverages advance AI and ML algorithms, providing comprehensive protection against malware, ransomware, and other cyber-threats. It is one of the must-have protection tools for business organizations looking to bolster their cybersecurity posture and safeguard their digital assets.

As the main topic of this graduation work placement project, the author has been tasked to integrate SentinelOne endpoint protection capabilities into the client company internal application, the QaaS app. The main objective of this project is to promote transparency more into Q-ICT clients by providing them with real-time data and visibility into their organizations, enabling them to make informed decisions and take proactive measures to protect their own digital assets and mitigate security risks.

1.2 Problem Statement

The company currently manages numerous third-party APIs for the above-mentioned purposes. Currently, Thus, the company has tasked the author with the development of the SentinelOne security threat platform integration for continuous cybersecurity monitoring within the QaaS app as the main topic of his graduation work placement project.

1.3 Project Objectives

In the end of this project which consist of 90-99 working days, the following objectives should be achieved:

1. Effectively integrates and leverages the SentinelOne EDR platform for continuous cybersecurity monitoring within the QaaS app.
2. The QaaS app should have a way to visualize the data retrieved from the SentinelOne API in a user-friendly manner in order for the client users helpdesk support, financial department, cybersecurity department, software development department, and other employees within Q-ICT departments to see the data easier.

1.4 Reading Guide

This report is structured as follows:

- **Summary**: provides a brief and concise overview of the entire report, including the research questions, key findings, and conclusion. Its purpose is to provide readers with a quick and comprehensive understanding of the report.
- **Introduction**: provides an overview of the project background, the research topic of the company, and the project objectives. It introduces the context of the research and outlines the structure of the report.
- **Research Design**: outlines the methodologies employed during the research process. It describes the research approach, data collection methods, selected measuring instruments, data analysis techniques used to address the research questions, reliability, validity, and general applicability.
- **Research Results**: presents the research results, including the research methodology, the findings, and the analysis of the research questions. Firstly, it describes the methodologies employed during the research, and then it provides a detailed account of the research process and the outcomes of the research.
- **Realization**: provides a detailed description of the software end-product developed during this work placement project. It outlines insights into design, development, and implementation phases. It also highlights key features, functionalities, and technology specifications used in the project.
- **Conclusions and Recommendations**: the Conclusion summarizes the key findings and results achieved during the research and realization phases. The Recommendation section outlines the proposed next steps and future research areas to further enhance the project and address any outstanding issues. It discusses potential areas for further exploration or refinement.
- **References**: lists all the sources cited in the report following the appropriate to APA 7th edition citation style.
- **Appendices**: includes any additional supplementary information, data, or materials that are relevant to the report but not included in the main body of the report.

1.5 The Company

Q-ICT, is a small cybersecurity consultancy based in Emmen, northeast of the Netherlands. The company follows a flat organizational structure, which means that there are few or no levels of middle management between the staff and everything communication directly goes with the director. It recognizes the critical importance of proactive API monitoring in safeguarding its clients' digital assets. Their customers are SME companies with employees ranging from 1 to 100. Q-ICT is therefore asked to monitor their clients' devices and ensuring the overall security of their systems, IT infrastructure, and digital assets. As of now, Q-ICT has over 400 active customers. Some of the notable clients are: Kigpolis Verzekeringen, CLS Europe, and Heli Holland.

Departments

The company consists of multiple departments in its behalf, each with their own functions and responsibilities. Those departments are the following:

1. *Service Help Desk Department*: it serves as a frontline support function responsible for addressing client inquiries, troubleshooting technical issues, and providing guidance and support to clients in resolving their technical challenges. It contains 2 subdepartments, the first level help desk and the second level help desk. The First Level Help Desk is the first point of contact for clients seeking technical assistance and support, and it is responsible for managing and resolving client issues in a timely and efficient manner. The Second Level help desk is responsible for providing more advanced technical support and troubleshooting for complex technical issues and consists of Senior System Engineers. It has 2 services, mainly the indoor and outdoor customer services. With the indoor customer services, the company provides remote support to clients, while with the outdoor customer services, the company provides on-site support to clients.
2. *Cybersecurity Department*: it's responsible for implementing procedures that will be used throughout the company's system, especially in Help Desk Department, to ensure that the company's information technology infrastructure is secure. It also develops methodologies and best practices related to cybersecurity, as well as integrating ITIL principles and product management practices into the company's operations. Conducting regular security scans for clients' networks, systems, and applications to identify vulnerabilities and security risks and performing Pentest that involves simulating cyberattacks to identify weaknesses in the client's defences and assess their ability to withstand and respond to real-world cyber threats. This department mainly consist of IT managers, Pentesters, CISOs, and cybersecurity specialists.
3. *Software Development Department*: it addresses Q-ICT clients' need by creating custom software solutions tailored to their specific requirements. It consists of software developers that work closely with clients to understand their unique cybersecurity challenges and design solutions that effectively address those concerns, while utilizing their expertise in programming languages, software frameworks, and cybersecurity principle to develop secure and reliable applications. This is the department where the author

is currently working on his graduation workplacement project. Mainly, this department uses Dart with Flutter as the main front-end development framework, and Node.js with TypeScript template as the main back-end development framework. Furthermore, it utilizes Google Firebase as the main cloud solution for the applications it develops as it works together with Flutter, but it expresses its desires to expand more into MS Azure in the future.

4. *Financial Department*: it is responsible for managing the financial aspects of the company to ensure its financial health and stability. It includes Accountant and Financial Advisor, and they are responsible for analyzing financial data, identifying trends, and making strategic financial decisions to support the company's growth and objectives.

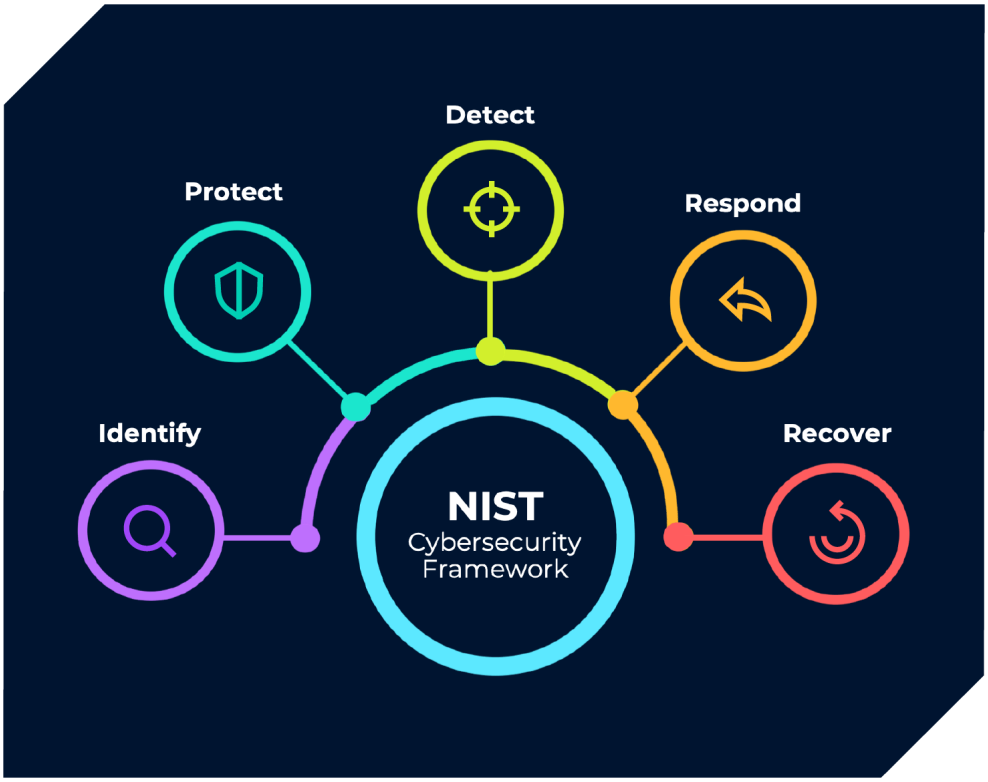


Figure 1.1: NIST working methodology that is followed by Q-ICT

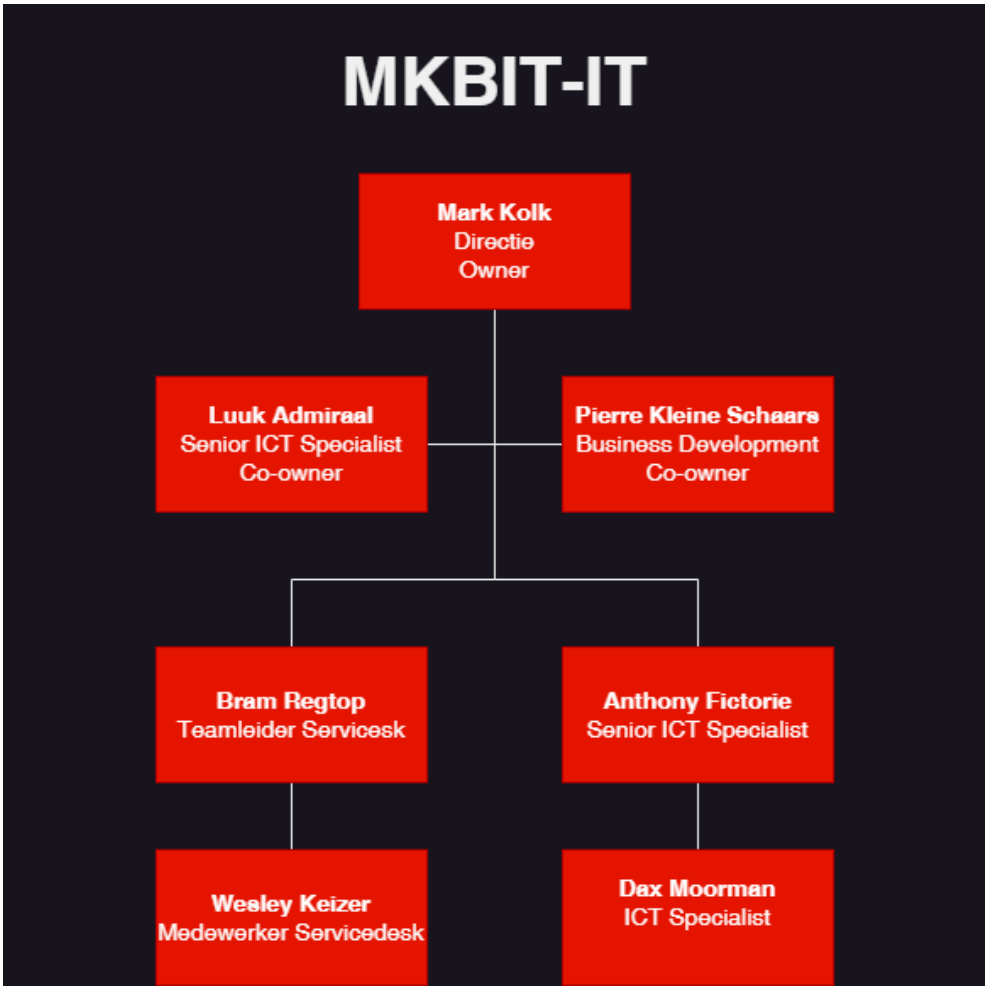


Figure 1.2: Level of structure of MKBiT

Figure 1.3: Flat (hierarchical) structure of Q-ICT

Chapter 2

Research Design

2.1 Research Topic

In research, it is paramount to have the formulation of a clear research topic, research main question, and research sub-questions. The main question serves as the focal point around which the research revolves, encapsulating the primary objective or purpose of the study. The following main research question will be used throughout the research:

"How can Quality ICT B.V. effectively integrate and leverage SentinelOne EDR platform for continuous cybersecurity monitoring?"

2.2 Research Sub-Questions

The research sub-questions are then used to function as a pathway that dissects the main question into smaller, more manageable components, which can then be addressed individually. This approach allows for a more comprehensive and in-depth analysis of the research topic, ensuring that all relevant aspects are covered and that the research is conducted in a systematic and organized manner. This research main question is therefore expanded in the following research sub-questions:

1. What is the current situation of the QaaS app of Quality ICT B.V.?
2. What is SentinelOne EDR platform, and how does its integration enhance the cybersecurity monitoring capabilities of the QaaS app?
3. How can SentinelOne be integrated into the QaaS app environment, while still utilizing their key features and capabilities in context of cyber-threat detection and remote IT infrastructure management?
4. What are the most suitable visualization techniques for displaying the data processed and received by SentinelOne API in Flutter compared to other Security Threat Platforms to ensure clear and insightful representation of threats?

2.3 Research Methodology

In this research, different research methods have been used to answer the research questions. This research will be based on the six ICT research methods defined by HBO-I (Vogel, 2023). A research method for each sub-question is then defined along with how the results are considered valid and reliable:

2.3.1 Method of Data Collection

- Sub-question #1: desk research of Literature Study will be conducted, with the goal of creating infrastructure information that displays the structure of the QaaS app and all its dependencies. Furthermore, Interview with key stakeholders involved in the development, maintenance, and usage of the QaaS app will be conducted to gain insights into the current situation of the app.

- Sub-question #2: Literature Study on various articles on the Internet, interviews, expert reviews, and requirement elicitation techniques such as use case analysis and user stories. Analysis on the current QaaS app and its capabilities.

- Sub-question #3: technical assessments and will be conducted, under the supervision of the Company Supervisor, to evaluate the technical feasibility, compactibility, and alignment of SentinelOne's features with the QaaS app environment.

- Sub-question #4: research into existing visualization techniques for JSON data coming from SentinelOne API through Literature Study. Analyze existing data visualization tools and platforms that are available in Flutter and Firebase. Gather requirements from project stakeholders regarding data visualization preferences and usability and do data analysis and usability testing.

2.3.2 Selected Measuring Instruments

- Sub-question #1: structured interview guide, document report checklist analysis and review, observation, analysis tools for codebase and logs, and quite possibly supplemented by surveys or questionnaires.

- Sub-question #2: document analysis tools for literature review. Structured questionnaires for requirement interviews regarding functionality rating scale and compare the response against industry standards and best practices. Observation of existing API monitoring tools. Prioritize functionalities based on importance, feasibility, and impact on the QaaS app.

- Sub-question #3: technical assessments and requirement workshops will be conducted. Furthermore, API documentation review, document analysis tools, security impact risk assessment, and feasibility checklist assessment with the Company Supervisor will also be overseen.

- Sub-question #4: the selected measuring instruments for this sub-question will be through observation of existing data visualization tools, literature review through reading the studies of the best visualization suitability matrix techniques, structured questionnaires to end-user interviews, and usability testing heuristics.

2.3.3 Method of Data Analysis

- Sub-question #1: a qualitative thematic SWOT analysis of interview transcripts and documentation for operational insights to identify strengths, weaknesses, and areas for improvement in the current situation of the QaaS app.

- Sub-question #2: comparative analyze survey/interview responses using MCDA and compare against industry standards and best practices. Prioritize functionalities based on importance, feasibility, and impact on the QaaS app.

- Sub-question #3: evaluate the technical feasibility, compactibility, and alignment of SentinelOne's features with the QaaS app environment. Analyze potential integration challenges and mitigation strategies and assess the performance of the integration through prototyping and testing. Technical analysis for the API documentation and thematic analysis for interview data.

- Sub-question #4: technical tool analysis by reviewing and evaluating the suitability of different visualization techniques for representing the data processed and received by the QaaS app in XML and JSON formats from the API considering factors such as clarity, interpretability, and user engagement. Do a user-centered design and cognitive load analysis by analyzing feedback from company stakeholders, supervisor, and end-users.

2.3.4 Reliability, Validity, and General Applicability

- Sub-question #1: the reliability of the data can be ensured by triangulation of data from multiple sources and conducting interviews with stakeholders from different departments with structure questionnaires to ensure that the data is consistent and accurate. The validity of the data will be ensured by cross-referencing with the existing literature or industry best practices or other sources and through information obtained from interviews with the QaaS app developers to ensure that the data is accurate and reliable. The general applicability of the data will be ensured by ensuring that the information obtained is relevant and applicable to the research question and that it can be used to draw meaningful conclusions and make informed decisions, furthermore by comparing findings with industry standards and best practices or similar case studies or projects.

- Sub-question #2: ensure reliability through sampling techniques and representative stakeholder involvement, with comprehensive literature review and multiple sources of information. Validate priorities against real-world scenarios or case studies involving diverse expert panel, like the Company Supervisor. General applicability can be assessed by comparing prioritization with similar projects or frameworks and considering scalability and adaptability of the integration with representative user samples.

- Sub-question #3: the validity of this sub-question will be through pilot integration unit testing or proof of concept documents and ensuring alignment with cybersecurity standards and best practices. The reliability will be to consider future needs such as adaptability and scalability of the integration, and focus on Q-ICT user context and needs. General applicability can be assessed by comparing integration strategies with industry standards or expert opinions such as from the Company Supervisor.

- Sub-question #4: reliability can be defined by ensuring future adaptability with comprehensive literature review and multiple sources of information. Validity can be achieved through validating visualization choices through data-driven approach in usability testing or prototyping, ensuring alignment with best practices in data visualization and involving the expert, like the Company Supervisor on the field. General applicability can be assessed by accessibility considerations by comparing proposed visualization techniques with similar applications or domains.

2.3.5 Research Limitations

The project and research in general will be limited on the API request methods, in which the author is allowed to do only GET requests. This is due to the fact that the author is not allowed to do any PATCH, POST, PUT, DELETE, or any other HTTP request methods that could potentially change the state of the QaaS app or the API that is being requested. This limitation is because the author is not a full-time employee of Q-ICT and is not allowed to make any changes to the QaaS app or the API that is being requested. Therefore, the author is limited to do research in the best practices of SentinelOne integration for the GET request method only.

The author is also limited in showing the SentinelOne dashboard data, as it contains clients' sensitive information, and Q-ICT has over 400 clients. Therefore, if any part of the SentinelOne dashboard is shown, it will be with blurred sensitive information.

Moreover, the author is also limited to the non-disclosure agreement signed within the initialization period of the graduation work placement. This means that any confidential information that the company deems as confidential will not be disclosed in this research. This includes any information that is not publicly available, such as any financial data or security data pertaining to the internal system or the QaaS app internal code.

Chapter 3

Research Results

3.1 Introduction

This chapter presents the results of the research conducted to answer the research questions. The chapter is divided into two sections, each corresponding to one of the research questions. The first section presents the results of the research conducted to answer the first research question, while the second section presents the results of the research conducted to answer the second research question.

3.2 Research Sub-Question #1: What is the current state of the QaaS app?

The QaaS app is an ERP web application that is used by Q-ICT and its clients. For Q-ICT's clients, it is a SaaS that is used to see what kind of information are available regarding their ICT infrastructure, based on the subscriptions that they have with Q-ICT. For example, a customer that subscribes on N-Central and SentinelOne will be able to see the status of their devices from N-Central API, and the health of their devices from SentinelOne API. For Q-ICT employees themselves, it serves as an internal system that is used to manage the clients and their ICT infrastructure. It is made in Dart with Flutter as the front-end framework. There are 2 main parts of the QaaS app, the front-end and the back-end. The front-end is made in Flutter, and the back-end is made in Node.js with TypeScript as the template. The back-end is hosted on Firebase Cloud Functions which are used to connect and make HTTP calls to the internal APIs, and the front-end is hosted on Firebase Hosting.

APIs and Technologies

The QaaS app also utilizes several APIs and technologies to help with its operations. It needs to manage and make connection different sort of APIs to help with the operations of the ERP application. Those APIs are the following:

- Resello: is used for Q-ICT MS subscriptions owned by Pax8 (*LinkedIn, n.d.*). It is a cloud marketplace that simplifies the way SMEs buy, sell, and manage cloud solutions through automation. It provides a single platform to manage the entire cloud customer lifecycle, from quote to cash to support, thus simplifying the process of buying, selling and managing cloud solutions. Furthermore, it normally uses SOAP API for its communication.

- SnelStart: is used for Q-ICT automation of financial and accounting system software, such as managing invoices, etc., for SMEs. It offers a range of products and services to help businesses manage their finances, including accounting software, invoicing software, and financial management tools.

- Bodyguard.io: is a CDR tool used for security tab. It is a product from a Dutch company that filters and scrutinizes downloads from web browsers to detect and prevent malicious files with real-time download scanning capabilities. It normally uses RESTful API for its communication.

- N-Central: is a product from N-Able and is used for monitoring clients' devices and ensuring the overall security of their systems, IT infrastructure, and digital assets. It is a RMM platform designed to help MSP and IT professionals to remotely monitor and manage their clients' devices and networks. It provides a comprehensive set of tools and features for monitoring, managing, and securing clients' devices and networks, including remote monitoring and management, patch management, antivirus, backup and disaster recovery, and network topology mapping. The return response from this API is in XML and JSON format, making it both a REST and SOAP API.

- PerfectView: is used for CRM software (*PerfectView, n.d.*). It is designed to improve business relationships with customers, assist in customer retention, and drive sales growth. In the QaaS app, it is used to manage the relationships and interactions with the app's users, which could include tracking user interactions, man-

aging customer support requests and analyzing user data to improve the app's functionality and UX.

Besides all the 5 internal APIs that Q-ICT uses, the company also uses several technologies to help them with their operations. Those tools are:

- Computicate (now newly named Acronis): is used as their ticketing system, providing ticketing solution services to customers for a wide range of events and activities (*Acronis, n.d.*).
- TOMTelecom: is used for their company's phone system. It is responsible for structured process of call routing on incoming calls from customers to the appropriate department or individuals, ensuring effective communication and issue resolution (*TOMTelecom, n.d.*).

3.2.1 The QaaS App Infrastructure

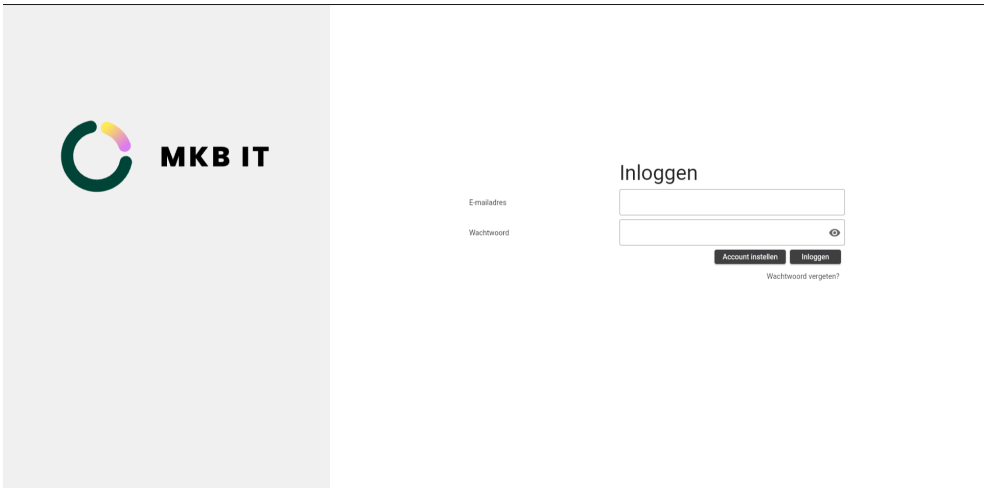


Figure 3.1: The login page of the QaaS app, implementing Google 2FA and reCAPTCHA

Firebase

Firebase is a comprehensive platform for developing and managing web and mobile applications, created by Google and is party of GCP. It was originally an independent company founded by Firebase, Inc. in 2011. It was then acquired by Google in 2014. Since then, it has become an integral part of Google's broader ecosystem of cloud services (Wikipedia, n.d.-i). It is a BaaS that provides developers with a variety of tools and services to help with both back-end infrastructure and front-end capabilities without worrying about managing servers or infrastructures. The services offered by Firebase (*Firebase, n.d.-e*) are many, but for this thesis, it will only discuss the ones that are used by the QaaS app. They are listed in the following:

- Authentication: is an easy-to-understand authentication services that support various authentication methods like email/password, phone number, with identity providers such as Google, Facebook, Twitter, Apple, GitHub, etc., along with utilizing 2FA authentication factors to enhance security by requiring additional factor, such as an OTP code that is sent to the user's phone or security key.
- Database:
  - Firestore Database: Firestore is a NoSQL database that is part of the Firebase platform. It is a flexible, scalable database for mobile, web, and server development. It keeps data in sync across client apps through real-time listeners and offers offline support for mobile and web, so the developers can build responsive apps that work regardless of network latency or Internet connectivity.
- Cloud Functions: often just called Functions in the Firebase console, it allows developers to run back-end code in response to events triggered by Firebase features and HTTPS requests. The code is stored in Google's cloud and runs in a managed environment. It is a serverless framework that allows developers to build and deploy serverless functions that automatically scale up and down based on demand. The available programming languages are Node.js (JS and TS), Python, Go, Java, and .NET (C#). Cloud Functions offers 2 product versions: the original version (1st gen), and the 2nd gen which is built on Cloud Run and Eventarc to provide an enhanced feature set.
  - 1st Generation: Most of the Firebase Cloud Functions that are used in the QaaS app is in this version. The company wishes to migrate all the functions to the 2nd generation in the future. Furthermore, for the integration of SentinelOne with the QaaS app, the company wishes to utilize the 2nd generation of Cloud Functions.

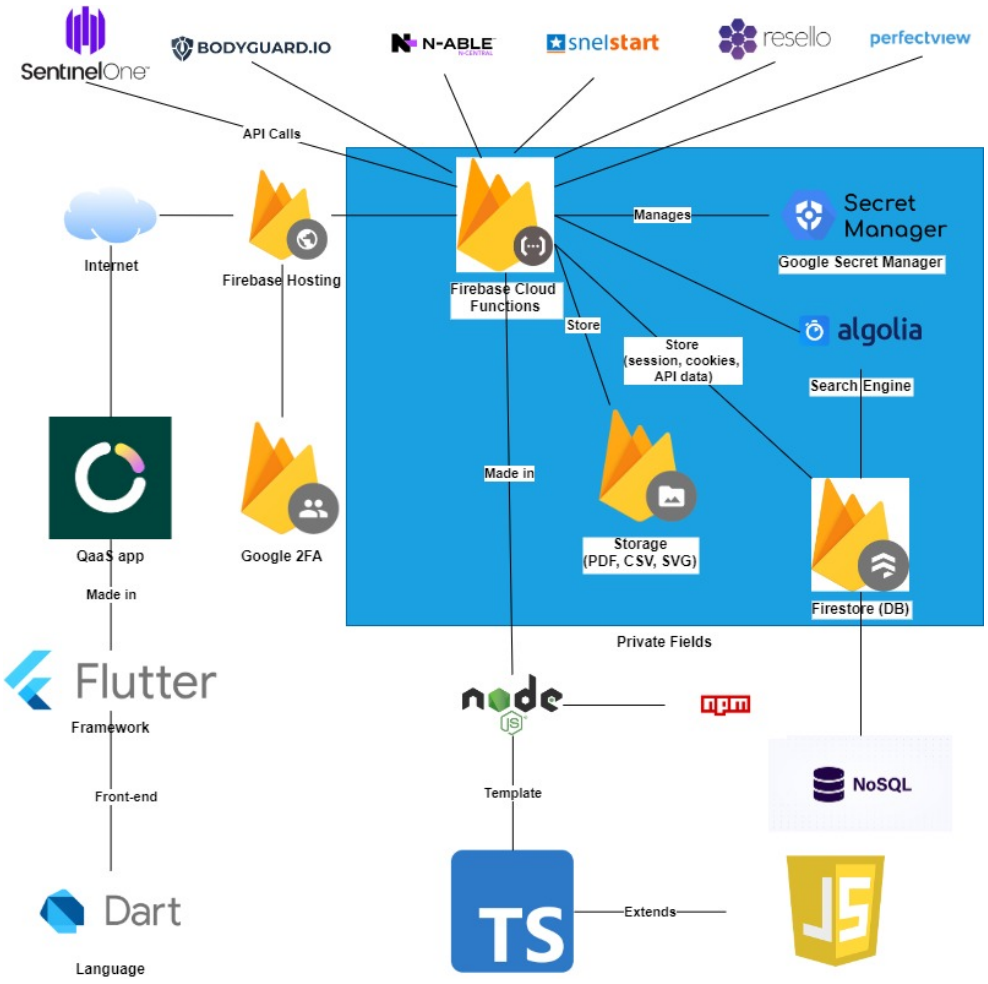


Figure 3.2: The infrastructure of the QaaS app

– 2nd Generation: The company wishes that the author's graduation project will utilize the 2nd generation of Cloud Functions. Features in the 2nd generation including:
  * Longer request processing times
  * Larger instance sizes
  * Traffic management
  * Eventarc integration
  * Broader CloudEvents support

Cloud functions are the main back-end infrastructure of the QaaS app. It is used to connect and make HTTP calls to all the internal APIs. There are different types of functions in Firebase Cloud Functions, and they will be discussed later. Some functions are called within the app, and some outside of the app. Some functions are also used to listen to the Firestore collections, in case of any changes in the data.

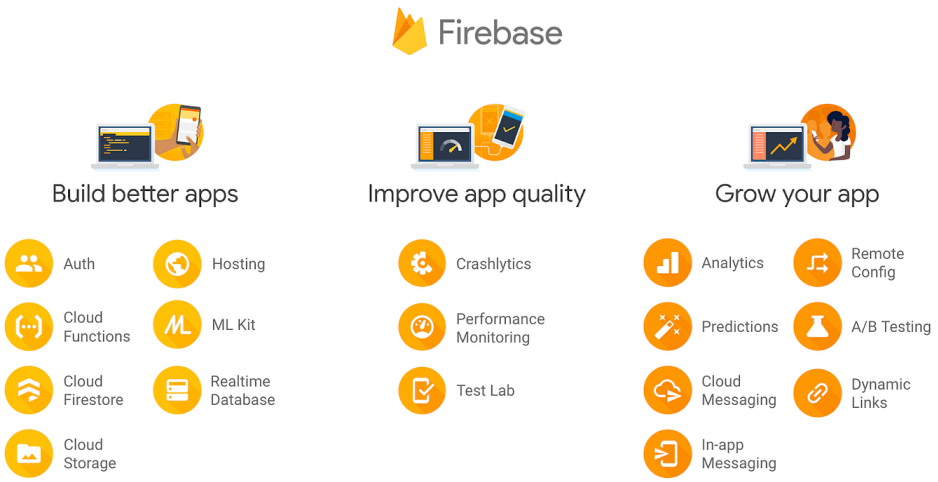


Figure 3.3: All of the products offered by Firebase (*Kubernetes, 2018*)

Feature	1st Gen	2nd Gen
Image registry	Container Registry or Artifact Registry	Artifact Registry only
Request timeout	Up to 9 minutes	• Up to 60 minutes for HTTP-triggered functions • Up to 9 minutes for event-triggered functions
Instance Size	Up to 8GB RAM with 2 vvCPU	Up to 16GB RAM with 4 vCPU
Concurrency	1 concurrent request per functions instance	Up to 1000 concurrent requests per function instance

Table 3.1: Comparison between the 1st and 2nd Generation of Cloud Functions

- Hosting: a service that allows developers to host static websites, dynamic web apps, mobile apps, and microservices on Firebase's infrastructure. The QaaS app is currently hosted on Firebase Hosting.
- Cloud Storage: offers secure, scalable, and reliable file storage and sharing for Firebase apps. It is designed to help developers quickly and easily store and serve user-generated content, such as photos or videos. It is used by the QaaS app to store and serve user-generated content, such as profile pictures, documents, and other files.
- Extensions: it consists pre-built, open-source software packages that extend the functionality of a Firebase project (*Firebase, n.d.-c*). They are designed to automate common development tasks, such as sending notifications, integrating with third-party services, and performing back-end operations, without requiring users to write custom code. The QaaS app uses the Extension mainly for Algolia.
- App Check: it is a security feature that, on top of Firebase 2FA Authentication, that helps protect the project from abuse, such as billing fraud or phishing,

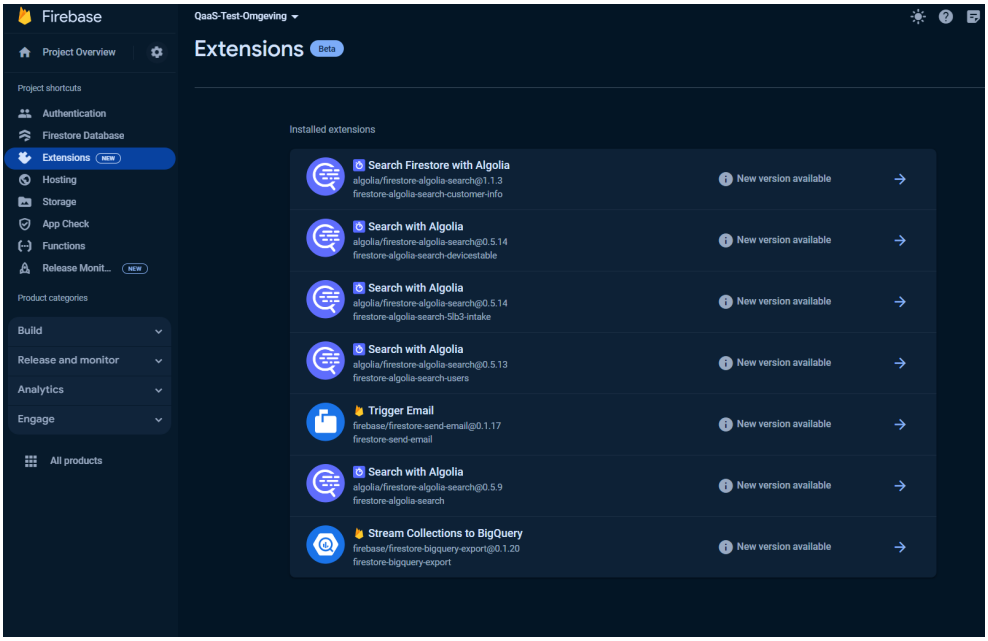


Figure 3.4: All the extensions that are used in the QaaS app, mostly about Algolia

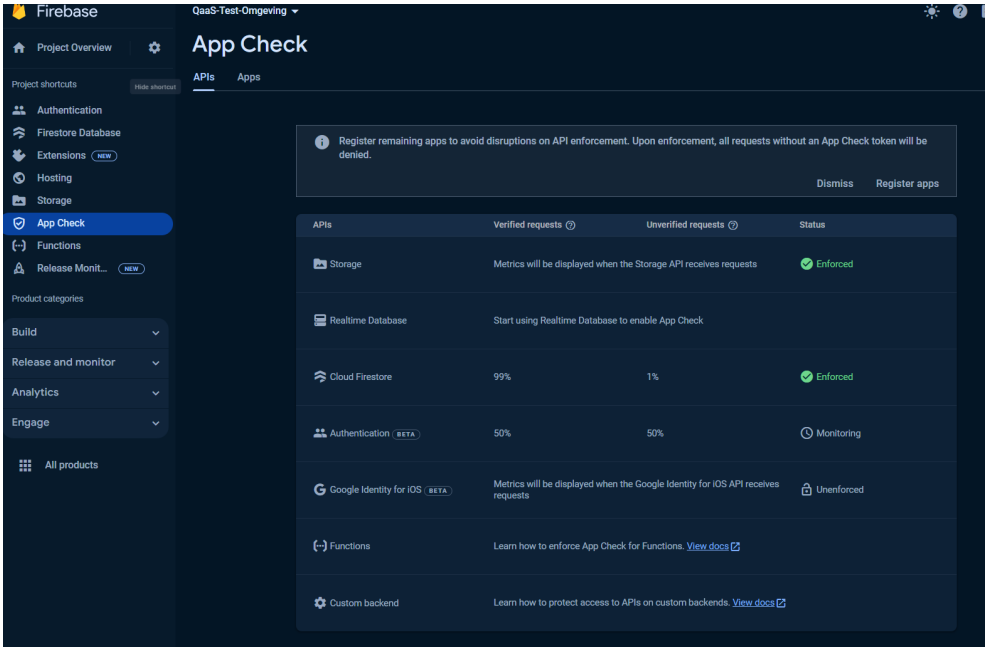


Figure 3.5: The App Check feature in the QaaS app

Figure 3.6: The function in the QaaS app that is scheduled to run every 7 days to keep the API data up-to-date (*Cronitor, n.d.*)

by ensuring that only the app that is registered can have access to the Firebase project's resources (*Firebase, n.d.-b*). In the case of the QaaS app, it uses it reCAPTCHA to ensure extra protection in the MFA.

Different Types of Cloud Functions in Firebase

Firebase has a lot of different types of Cloud Functions that developers can use. Just like the previous Firebase product explanation, this thesis will only focus on the following types of Cloud Functions that are used in the QaaS app:

HTTP Triggers: these are functions that are triggered by HTTP requests. They are used as API endpoints of the QaaS app, allowing server-side logic execution in response to HTTP requests from client-side applications or external services. The requests are GET, POST, PUT, DELETE, and PATCH, and they are used to creating, reading, updating, and deleting data in either the Firestore DB or the correlated API environment itself.

- onRequest: this method is used to create an HTTP function that is triggered by an HTTP request. They are more general-purpose compared to Callable Functions and can be used to create RESTful APIs, handle form submissions or perform any other server-side operations that require HTTP requests. Unlike Callable Functions, onRequest functions do not handle authentication or data serialization, so the developers need to manage this aspect manually. This functions only accepts `Request` and `Response`, but not `NextFunction`. In the context of QaaS app, this function is only used for testing purposes, and the developer will need to migrate to onCall when deploying on the Live environment.

- onCall: is a little different from onRequest. Instead of using Request and Response, it uses data and context. In version 2.0, it only accepts requests as `CallableRequest<any>` that can get any headers and body of the request sent by user. It is used to create Callable Functions, and they are designed to be called directly from client applications, such as mobile or web apps. They automatically handle authentication and data serialization, making it easier to secure call backend code from client applications, and this is what the QaaS app primarily uses for calling its internal APIs as it ensures that the client is authenticated and authorized to make the call. Callable functions are triggered by an HTTP request but are specifically designed to be called from Firebase client SDKs.

Listing 3.1: Example of a typical onRequest function

```
import { Request, Response } from 'express';
import * as functions from "firebase-functions/v2";

const region = "europe-west1";

export.getData = functions.https.onRequest({ region: region }, async (request: Request, response:
    Response): Promise<any> => {
     try {
          const response = SentinelOneAPICall();
          return response.status(200).json(data: response.data);
     } catch (ex: unknown) {
          if (error instanceof Error) {
               // Error object, log message and stack if available
               console.error(`[${context}] An error occurred: ${error.message} \n Stack:
                   ${error.stack}`);
          } else {
               // Non-Error object, log with a generic message.
               console.error(`[${context}] An unknown error occurred:`, error);
          }
          response.status(500).send("Failed to retrieve agents");
     }
});
```

Listing 3.2: Example of onCall function with authentication check

```
import * as functions from "firebase-functions/v2";
const region = "europe-west1";

const getData = functions.https.onCall({ region: region }, async (request: CallableRequest<any>) =>
    {
     try {
          // Checking that the user is authenticated.
          if (!context.auth) {
               // Throwing an HttpsError so that the client gets the error details.
```

```
                    throw new functions.https.HttpsError('failed-precondition', 'The function must be
                        called while authenticated.');
               }
               const response = SentinelOneAPICall();
               return {
                    data: response.data,
               };
          } catch (ex: unknown) {
               if (error instanceof Error) {
                    // Error object, log message and stack if available
                    console.error(`[${context}] An error occurred: ${error.message} \n Stack:
                        ${error.stack}`);
               } else {
                    // Non-Error object, log with a generic message.
                    console.error(`[${context}] An unknown error occurred:`, error);
               }
               throw new functions.https.HttpsError("unknown", "Failed to retrieve agents", ex);
          }
     });

     async function SentinelOneAPICall() : Promise<any> {
          const apiUrl = 'https://sentinelOne.example.com/users/123';

          // Define the request parameters
          const requestOptions = {
               method: 'GET', // HTTP method (GET, POST, PUT, DELETE, PATCH, etc.)
               headers: {
                    'Content-Type': 'application/json', // Set the content type of the request
               }
          };

          // Make the API request
          fetch(apiUrl, requestOptions)
               .then(response => response.json())
               .then(data => console.log(data)) // Process the response data
               .catch(error => console.log('error', error)); // Handle any errors that occurred during
                    the request
     }

     export = getData;
```

Pub/Sub Triggers: are the functions triggered by messages published to a Pub/Sub topic. It is a messaging service that enables decoupling of applications by sending messages between independent components.

Schedule functions: this is a Firebase's own term for Cron Job (*Firebase, n.d.-h*). They are used within the QaaS app to run tasks at regular intervals, such as sending reminders, keeping data up-to-date with the internal APIs (like customer list), or performing maintenance tasks.

Algolia

Algolia is used for search functionality. It is a search-as-a-service platform that enables developers to integrate and build fast, relevant search functionality into their applications and websites (*Wikipedia, n.d.-a*). It provides a range of features and capabilities for building and managing search functionality, including full-text search, typo tolerance, and relevance tuning, as well as analytics and monitoring tools to help developers understand how users are interacting with their search functionality in real-time.

The reason as to why Q-ICT uses Algolia is that the nature of Firebase search engine is quite often proven to be inaccurate and slow.

Google Secret Manager

It is a fully managed service provided by GCP that allows developers and organization to securely store, access, and manage sensitive information such as API keys, passwords, certificates, OAuth credentials, DB credentials and other credentials used in throughout the lifecycle of their applications (*Google, n.d.*). It is not part of Firebase, and it helps the QaaS app to centralize and secure its secrets in scalable and easily manageable way. Key-features of Secret Manager include:

- Secure Storage: it encrypts the secret values using CMEK, ensuring the sensitive data is protected both at rest and in transit.
- Audit Logs: it provides and manages audit logs that record all access and modification of activities, helping developers meet compliance, better accountability and regulatory requirements.
- Versioning and Automatic Rotation: it supports versioning of secrets, allowing developers to store multiple versions of the same secret. This means that the developers get to keep multiple versions of secrets

and easily revert or roll back to a previous version if needed, which will help in auditing and tracking changes to secrets over time. This feature enables automatic seamless rotation of secrets at regular intervals without disrupting the applications, which improves the security part of the application by ensuring that secrets are regularly updated without manual intervention.

- Access Control: it provides fine-grained access control using Google IAM, allowing developers to specify who can access and manage the stored secrets and what they can do with them.
- Centralized Management: it stores and manages all secrets in one place, simplifying access and control.

Google Secret Manager comes from GCP, and GCP and Firebase are a separate cloud solution. But, because both are part of Google, Firebase Cloud Functions can typically access GCP Secret Manager by editing that specific function that the developer wanted to grant access to.

Modules and User Tags of the QaaS App

The QaaS has several user tags that are used to build the app. The tags can be interpreted as level of access to the app, showing what permission a user has to the app. Because of coding inconsistency, there are 2 naming of functionality, which are user tags and user roles, both serving the same purpose. User tags can be assigned or revoked to a user by the IT admin willingly.

Modules are the page division of the QaaS app. They are interlinked with User Tags to create the navigation logic of the app. All pages will have different functions, corresponding to its interconnected API. Examples of modules in the QaaS app are:

- Klanten Koppeling
- IDS Systeem
- Budget Overzicht
- Intake Overzicht
- Account Beheer
- Periode Vergelijking
- Klanten
- Security (Bodyguard.io)
- Apparaten (N-Central)
- Abonementen
- Facturitatie
- Intake
- Pakbonnen

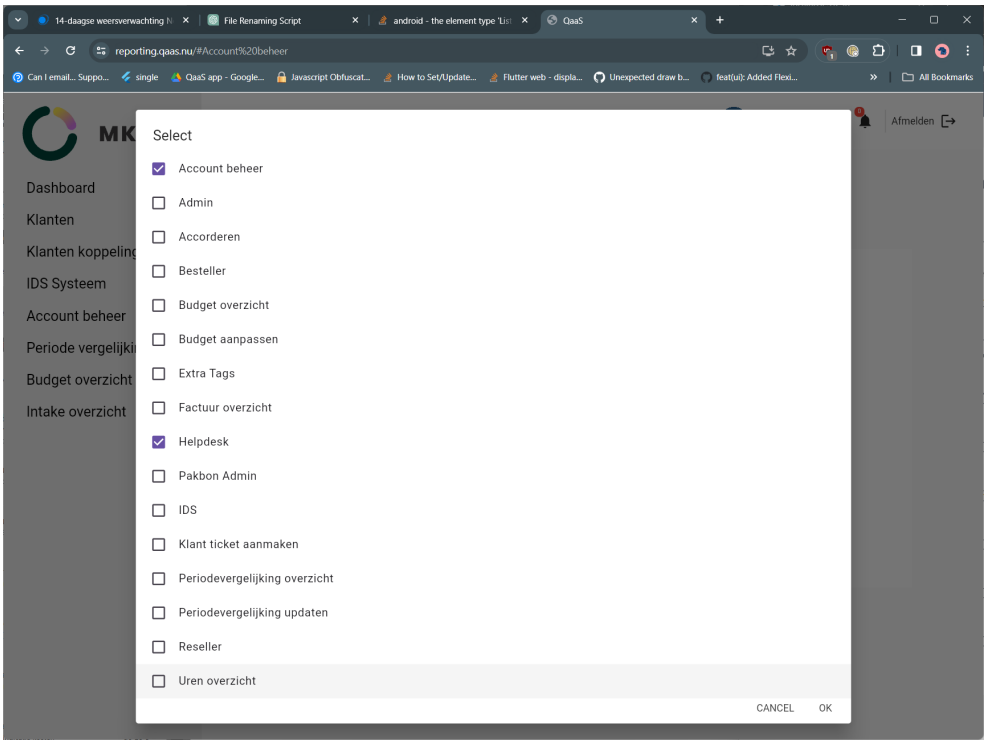


Figure 3.7: Different user tags in the QaaS app in which the IT admin can determine which pages can be accessed by which user tags

```
if (user!.tags!.contains('SentinelOne'))
  Expanded(
    child: Container(
      height: double.infinity,
      color: colors[6],
      child: TextButton(
        child: Row(
          mainAxisAlignment: MainAxisAlignment.center,
          children: <Widget>[
            Icon(
              Icons.shield,
              color: buttonColor,
              size: iconSize,
            ), // Icon
            Text(
              accountStylingManager.changeStringMobile(
                  'SentinelOne', '', changeTextWidth),
              style:
                  TextStyle(color: buttonColor, fontSize: fontSize),
            ) // Text
          ], // <Widget>[]
        ), // Row
        onPressed: () {
          Navigator.push(
```

Figure 3.8: An example of how a user tag can access certain pages in the Flutter code

```
function checkTag(myTag){
 return request.auth.uid != null && myTag in getUserTag() && getUserDisabled() != true;
}

function isHelpDesk(){
 return request.auth.uid != null && "Helpdesk" in getUserTag() && getUserDisabled() != true;
}

function isUser(){
 return request.auth.uid != null && "User" in getUserTag() && getUserDisabled() != true;
}
```

Figure 3.9: Check for the appropriate user tags in Firebase for extra database protection

3.2.2 Conclusion

The QaaS app is an ERP web application that is used by Q-ICT and its clients. It is made in Dart with Flutter as the front-end framework, and Node.js with the back-end framework with TypeScript as a template to ensure type safety. The back-end is hosted on Firebase Cloud Functions, and the front-end is hosted on Firebase Hosting. The app uses several internal APIs and technologies to help with its operations, such as Resello, SnelStart, Bodyguard.io, N-Central, and PerfectView. The app also uses several Firebase products, such as Authentication, Firestore Database, Cloud Functions, Hosting, Cloud Storage, Extensions, App Check, and Google Secret Manager. The app also uses Algolia for search functionality. The app has several templates and modules that are used for the authentication and authorization of the app. The templates control what 3 different types of users can do in the app, they are Clients, Helpdesk, and IT Admin. The modules help with the control of the app's features and functionalities, and the IT Admin has the highest level of access and control over the app.

3.3 Research Sub-Question #2: What is SentinelOne EDR Platform?

SentinelOne is a cybersecurity platform that provides endpoint protection, detection, and response capabilities to help organizations defend against advanced cyber threats. It leverages AI and ML to analyze and respond to security threats in real-time, providing organizations with comprehensive protection against malware, ransomware, and other cyber threats. It also provides visibility into clients' IT systems and infrastructure, enabling organizations to gain insights into potential security risks and vulnerabilities and take proactive measures to address them.

Some terminology that the readers need to be familiar with before diving deeper into SentinelOne:

Endpoint

Endpoint can be defined as any remote computing devices that receives incoming communications and sends outgoing messages to the network it is connected to. Examples of endpoints include desktops, laptops, smartphones, tablets, servers, workstations, and other IoT devices that is connected to a network. They are the first-line of defence for the Blue Team today.

Examples of endpoints are:

- Computer (workstations, desktops)
- Laptop
- Server
- Mobile devices

EDR

EDR A.K.A. ETDR, is a group of integrated endpoint security solutions that combine data collection, data analysis, forensics, and Threat Hunting with the end-goal of identifying and stopping any potential security breaches in due time. EDR solutions can recognize any suspicious patterns that can be investigated later, as they have been purposefully created to detect and respond in an active manner to advance malware, ransomware, and other cyber threats (the Response EDR). EDR, as the name suggest, were developed specifically for endpoints, and not networks (**??**), thus operate only on endpoint level.

The number one thing that sets apart EDR from traditional AV is that traditional AV relies on signature-based detection, usually having a defined set of list in their DB, where known malware signatures are compared against files or processes to identify threats. EDR on the other hand, uses a combination of signature-based detection, such as behavioural analysis, machine learning, and anomaly detection to identify and respond both known and unknown threats. EDR solutions focus on detecting malicious activities at the endpoint level, including file modifications, process execution, and network connections, focusing on malicious behaviour compared to only concerning with malicious software like what traditional AV does. While this seems similar to NGAV, what sets apart EDR from NGAV is that EDR solutions are more focused on detecting and responding to threats after they have infiltrated the network, whereas NGAV aims only to prevent threats from executing in the first place through advanced detection techniques, a functionality that is crucial in an AV.

SentinelOne Console

SentinelOne MGMT Console is the GUI provided by SentinelOne for managing and administering the platform. It serves as the primary dashboard for security operators and administrators to interact with SentinelOne product suite, enabling them to monitor, configure, and respond to cybersecurity threats across their organization's endpoints, servers, and cloud environments.

Global

The Global tab refers to the environment of the highest level of advisors. It consists of organizations that have access to global level that propagate down to the tenant level, which means they can put policies, scripts, and other configurations that will be applied to all consoles and all their customers.

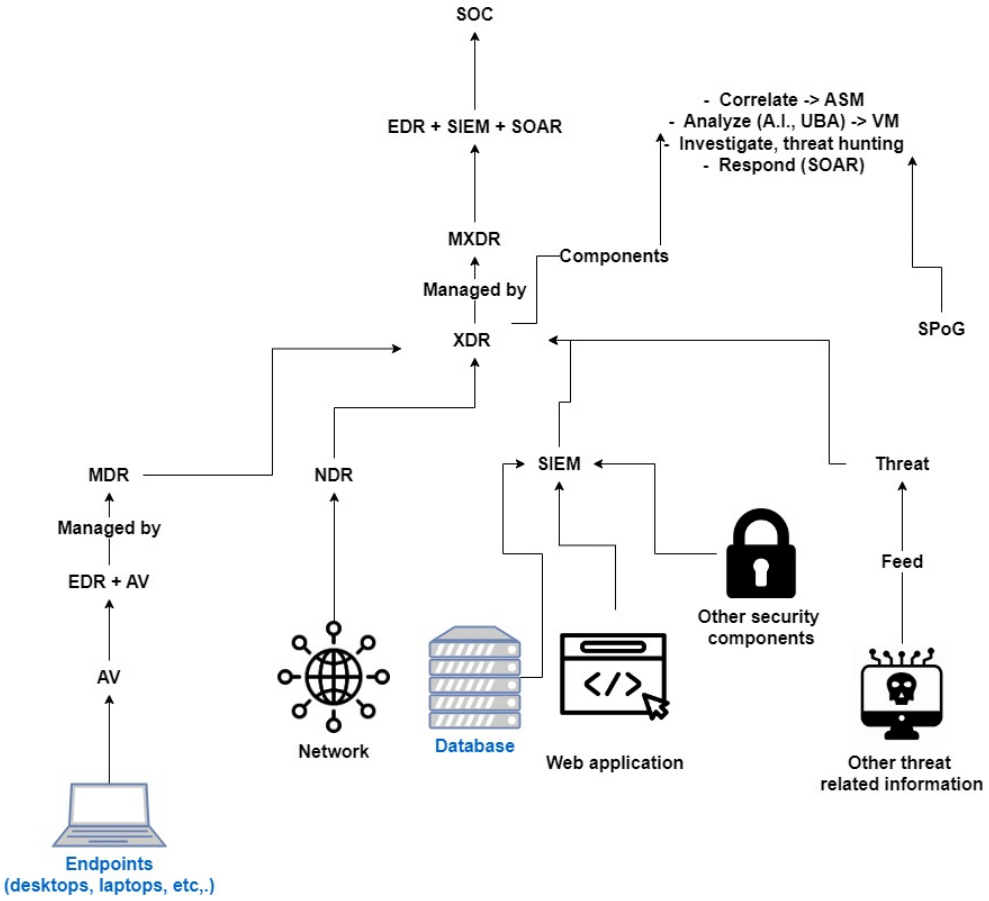


Figure 3.10: How all terms related to various technologies in cybersecurity connected to each other

Site

Site is just a name that refers to logical grouping of devices that are managed together under a single administrative domain, or a company. A company customer can have multiple sites, and each site can have multiple devices. Each site ID is unique and is used to identify the site in the SentinelOne console.

Group

Group refers to logical grouping of devices within SentinelOne MGMT Console. It is a way to organize and manage collections of endpoints, servers, and other entities within the platform. It allows admins to apply policies, deploy agents, and perform other management tasks across a defined set of assets in an organized and efficient manner. This hierarchical structure is crucial for managing large-scale deployments and ensuring that security policies and configurations are consistently applied across relevant assets. Groups can be created and deleted by the admin user, and devices can be moved between groups. An example of a group in Q-ICT site is:

- Default Group
- Laptops
- Workstations
- Servers

Agents

An Agent is a software program, part of SentinelOne product, that is deployed to each endpoint, including desktop, laptop, server or virtual environment, and runs autonomously on each device, without reliance on Internet connection, enabling data gathering, detection, and response to actions. Agents can be interpreted as an AV, collecting relevant security telemetry such as:

- Running processes
- Connected servers
- Open files

This information can be useful to detect the presence of a threat or to use in forensic analysis and investigation after an attack has occurred (Recovery).

Ranger

Ranger is an add-on SentinelOne product that provides a way of detecting other devices (computers and IoT devices) that are on the client's computer network. If a malicious attacker comes in and plugs his device into the network, all the other SentinelOne agents are going to read the network traffic, determine and classify whether that is a new device or a rogue device. If a device has Ranger on that network subnet, SentinelOne can gather and detect technical information regarding the device.

- Not reviewed
- Not trusted
- Under analysis
- Allowed

Ranger is designed to detect and take out malicious actors that are in the local subnet, as they can a lot of information about the devices (*see ARP Poisoning Wikipedia, n.d.-c and man-in-the-middle-attack Wikipedia, n.d.-k*). In the real-business scenario, a lot of the times, a company has a very secure perimeter firewall (*the big outer castle wall in castle-and-moat network security model Taylor, 2021*), but the inside network are wide open (unless they are doing logical separations of their local network, such as using VLAN) for attacks inside the network.

Unfortunately for this project scope, Ranger API calls are off limit, as the company is still..., therefore displaying all the Ranger ability to scan and the API call of the author's account.

Sentinels

Sentinels refer to a term that describes SentinelOne ability to deploy and manage security agents on endpoints within an organization, not part of SentinelOne product, like Ranger. This is part of the SentinelOne EDR capabilities, where the user admin can deploy the agents on the endpoints and manage them from the SentinelOne console. The admin can also create policies, scripts, and other configurations that will be applied to all the agents in the network.

Visibility

Unfortunately, Q-ICT does not have Visibility turned on its tenant, thus this feature is also off limit for this project scope. But in general, Visibility allows users to do deep querying to be able to identify different things, such as attributes of a machine. It is useful when user is looking for threats or any additional information in Incident Response or Threat Hunting, which in most cases is proactive, Visibility can give the user a lot of power to use queries, and interrogate all the information or telemetry that SentinelOne has pulled off from the connected machines.

Incidents

Incident is just the name of a page in SentinelOne dashboard that provides a list of cyber-incidents overview that have happened on all endpoints detected by Agents in the network connected to SentinelOne by Ranger. The page typically offers an overview of all detected security incidents, categorized based on severity levels of types of threats.

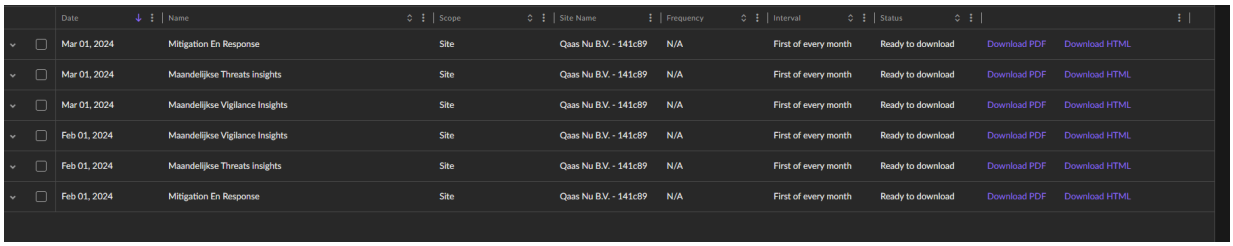
Once a threat is detected, the user can take the following actions in the dashboard, if they have enough privileges to do so:

- Kill: stops all processes related to that threat
- Quarantine: encrypts and moves the threat and its executables
- Remediate: deletes all files and system changes created by the threat
- Rollback: restores files and configuration that the threat changed. This step is usually taken when a malware has executed its script and has made changes to the system, e.g., a ransomware has encrypted all the files and asked for a ransom. By taking this step, all the three previous steps will also be undertaken as well. This will then reboot the system and restore it to the safe state before the malware has been executed.

Reports

The reports in SentinelOne provide users with insights into the security posture and threat landscape across their organization's endpoints. The reports offer customizable reporting capabilities, allowing users to generate reports tailored to their specific requirements. Users can then choose from a variety of predefined report templates or create custom reports based on their unique needs.

Furthermore, the users can also choose for the report to be made automatically, instead of manually filling them themselves. They can schedule automated report generation at regular intervals, such as daily, weekly, or monthly.



Date	Name	Scope	Site Name	Frequency	Interval	Status		
Mar 01, 2024	Mitigation En Response	Site	Qaas Nu B.V. - 141c89	N/A	First of every month	Ready to download	Download PDF	Download HTML
Mar 01, 2024	Maandelijkse Threats insights	Site	Qaas Nu B.V. - 141c89	N/A	First of every month	Ready to download	Download PDF	Download HTML
Mar 01, 2024	Maandelijkse Vigilance Insights	Site	Qaas Nu B.V. - 141c89	N/A	First of every month	Ready to download	Download PDF	Download HTML
Feb 01, 2024	Maandelijkse Vigilance Insights	Site	Qaas Nu B.V. - 141c89	N/A	First of every month	Ready to download	Download PDF	Download HTML
Feb 01, 2024	Maandelijkse Threats insights	Site	Qaas Nu B.V. - 141c89	N/A	First of every month	Ready to download	Download PDF	Download HTML
Feb 01, 2024	Mitigation En Response	Site	Qaas Nu B.V. - 141c89	N/A	First of every month	Ready to download	Download PDF	Download HTML

Figure 3.11: Examples of automatic reports that can be downloaded in SentinelOne

3.3.1 Conclusion

SentinelOne is a cybersecurity organization that provides EDR solutions for endpoint protection, detection, and response capabilities to help organizations defend against advanced cyber threats. It leverages AI and machine learning to analyze and respond to security threats in real-time, providing organizations with comprehensive protection against malware, ransomware, and other cyber threats. SentinelOne provides a wide range of features and capabilities, including endpoint protection, detection, and response, as well as visibility into clients' IT systems and infrastructure. SentinelOne has multiple components, such as Agents that are responsible for collecting security telemetry of an endpoint, Ranger that is responsible for detecting other devices on the network, and other components that work together to provide comprehensive security solutions for organizations. It is famous for its autonomous features and cloud-native architecture, make it well-suited for securing modern IT environments against evolving cyber threats.

3.4 Research Sub-Question #3: How can SentinelOne be integrated with the QaaS app?

SentinelOne provides an API to allow users to integrate SentinelOne with other security tools and systems. Additionally, SentinelOne also provide an SDK enables organizations to scan files and detect malicious content among them, called Nexus Embedded AI (*Anfalovas, 2022*), but this thesis will focus solely on SentinelOne APIs.

SentinelOne also provides a comprehensive documentation for its RESTful API that allows users to interact with the SentinelOne platform programmatically. The API provides a wide range of functionalities, including the ability to retrieve information about devices, incidents, and threats, as well as the ability to perform actions such as quarantining devices, remediating threats, and generating reports. The API is designed to work with the Agents, Sentinels, Ranger, and other components of the SentinelOne platform.

The API sends requests to the associated Management Server and responds with the data that the management pulled from the Agents or from the management database. Therefore, all the data that is displayed in the SentinelOne Console dashboard is also available through the API.

API Token

To be able to access SentinelOne APIs, the user needs to have an API token to prove their identity and that their organization has SentinelOne subscription, therefore has right to access data. API tokens can be created in the SentinelOne MGMT Console.

The API token will be shown only once; therefore, the

user needs to store it in a secure place. The token generated by the user is time-limited. To renew the token, the user must generate a new one with the same above-steps.

3.4.1 Conclusion

SentinelOne provides a RESTful API that allows users to interact with the SentinelOne platform programmatically, enabling integration with other security tools and systems. The API provides a wide range of functionalities, including the ability to retrieve information about devices, incidents, and threats, as well as the ability to perform actions such as quarantining devices, remediating threats, and generating reports. The author will use the official SentinelOne API documentation to integrate SentinelOne with the QaaS app to display the data of Q-ICT and its 400 clients in the QaaS app. The functionality such as filtering, sorting, and pagination will also be considered to make the data more user-friendly. The author will utilize different kinds of Firebase Cloud Functions (HTTP onCall, Pub/Sub Triggers, Schedule functions) to call the SentinelOne APIs and display data. Firestore will also be used to store the user's preference from the QaaS app, such as the user's choice of what data they want to see, and visualization types. The author will also utilize Google Secret Manager to store the API token and other sensitive information securely, so it will not be displayed in the code to avoid any security risks. Furthermore, AI powered search engine Algolia will be used to search for specific data in the QaaS app, as well as Firestore to make the search faster and more accurate.

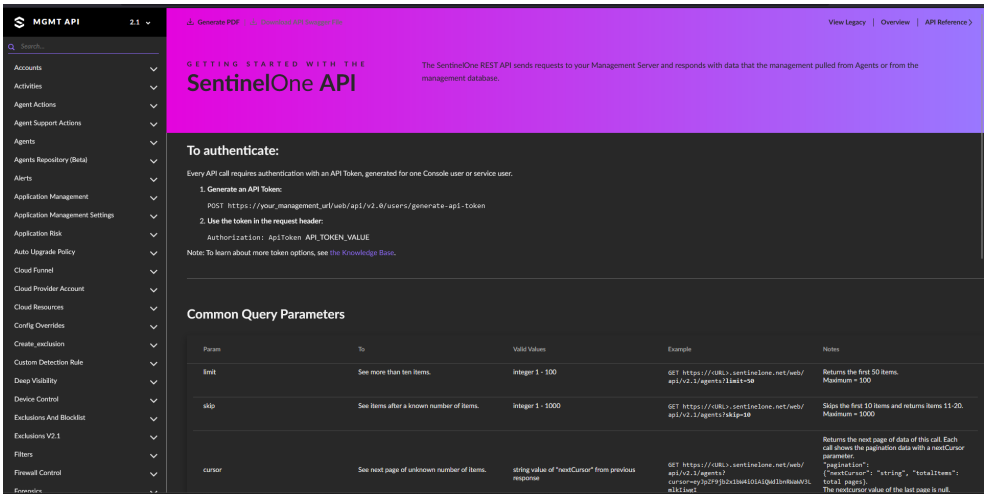


Figure 3.12: SentinelOne API Documentation

3.5 Research Sub-Question #4: What are the best data visualization techniques for SentinelOne?

Data visualization is the process of representing complex data (in the form of text and numbers) into a graphical representation, such as: interactive charts, dashboards, pie charts, and so on. In the context of this project, the displays should be able to tell interesting stories and share findings with diverse audience (the client, helpdesk, and cybersecurity analysts).

3.5.1 Data Visualization Widgets in Flutter

In Flutter, there are 3 famous library that supports a wide range of chart types, fl_chart, syncfusion_flutter_charts, and flutter_echarts. Each chart type is suitable for a specific kind of data and provides a different way to visualize the data. Types of charts in both libraries include 30+ plotting series:

- Line chart: is used to display data points connected by straight line segments. They are commonly used to show trends over time.
- Bar chart: it uses rectangular bars to represent data. The length of each bar corresponds to the value it represents. Bar charts are useful for comparing quantities of different categories.
- Pie chart: represents data in the form of slices of a pie. Each slice corresponds to a category of the data, and the size of the slice is proportional to the quantity it represents.
- Scatter chart: uses dots to represent data points on a two-dimensional plane. They are useful for showing the relationship between two variables.
- Radar chart: A.K.A. spider chart or star chart, is a way of comparing multiple quantitative variables. This

makes them useful for seeing which variables have similar values or if there are any outliers among each variable.

Figure 3.13: Chart types in Flutter fl_chart

Each chart type is easily configured with built-in support for creating stunning visual effects, and any number of series can be added to the chart. Features such as markers, data labels, data label builder, animation, gradient fill, dashes, sorting, and annotations are easy to incorporate and customize.

Several main components of each chart type are:

- Chart data: the most important part is the data that wanted to be displayed. This could be a simple list of numbers, or more complex data structure, depending on the type of chart.
- Chart type: the second most important part is to specify the type of chart.
- Axes: the x and y-axes of the chart. The axes provide a reference frame for the data points and can be customized to suit the user's needs.

- Grid: the grid lines on the chart. These lines can help users better understand the data by providing a reference frame.
- Touch response: the way the chart responds to user's touch events. It can be customized by providing different types of interactivities, such as highlighting a data point when it is touched.

Axis Types

Axis features such as label intersecting, edge label placement, label rotation, axis opposition, inverse axis, and multiple axis allow users to customize axis elements to make an axis more readable. Four of the axis types that are supported are:

- Numeric
- Category
- Date-time
- Logarithmic

User Interaction

The packages greatly enhance UX by adding the following functionalities:

- Zooming and panning
- Crosshairs
- Trackballs
- Drilling down
- Events
- Selection
- Tooltips

Legend

The packages also support legends, which display additional information about a chart series. The legends can be used to collapse the series and can be wrapped or scrolled if items exceed the available bounds.

3.5.2 Comparison to other EDR solutions

To determine the best visualization techniques for SentinelOne, a comparison to other EDR solutions is needed. In this section, the author has looked into other alternatives to SentinelOne, which are a single EPP/EDR solution, created as a complete replacement of legacy AV. Please keep in mind that in this sub-question, only visualization techniques and features of the solutions will be assessed, compared, contrasted, evaluated, and discussed. Factors such as pricing and technologies will not be discussed in this sub-question. The author also does not have access to the actual dashboards, therefore pictures of the dashboards are likewise taken from the Internet or are available from the official website. This is because Q-ICT is not utilizing these solutions, setting up an account and getting access to the dashboards will raise the project's budget, which is not feasible.

CrowdStrike

CrowdStrike is an American cybersecurity company based in Austin, Texas, that provides cloud workload and endpoint security, threat intelligence, and cyberattack response service. In the dashboard, CrowdStrike offers fully customizable widgets to ensure that the various roles on security teams are provided with the information that they need. The dashboard allows static prebuilt widgets that can be moved around on a page, and customizable data views that enable each individual widget to be tailored for the users.

Features of CrowdStrike dashboard including:

- **Role assignment**: allows the user to assign roles to the users, so that they can see the data that is relevant to their role. For example, IT admins are allowed to have an eye on the status of the CrowdStrike Falcon Sensors within the environment. This enables them to understand if there are any gaps and allows them to remediate any issues. A SOC analysts, executives, and vulnerability analysts can easily see any security threats detected or blocked.
- **Fully customizable**: widgets can be customized to display just the right data needed. Users can add filters and change the lens with which to view the data, from donut to line charts.
- **Advance dynamic filtering options**: filters can be applied dynamically to the dashboard, with data from a single source. This could help analysts focus on the most important criteria in their Threat Hunting.
- **Customized Scheduled Reports**: reports based off dashboards or other data sources can be generated and sent automatically on a specified schedule.

Trend Micro

It is an American Japanese cybersecurity software company, providing cloud and enterprise cybersecurity in environments like AWS, Microsoft, and Google Trend Micro Apex One has customizable contents and layout of their dashboard. Workload Security uses Session to save user's settings and remember the last view of the dashboard the next time the user logs in. The colour shown in the dashboard is more basic compared to the other solution with only the typical red, green, blue, and yellow. Components of the Trend Micro dashboard

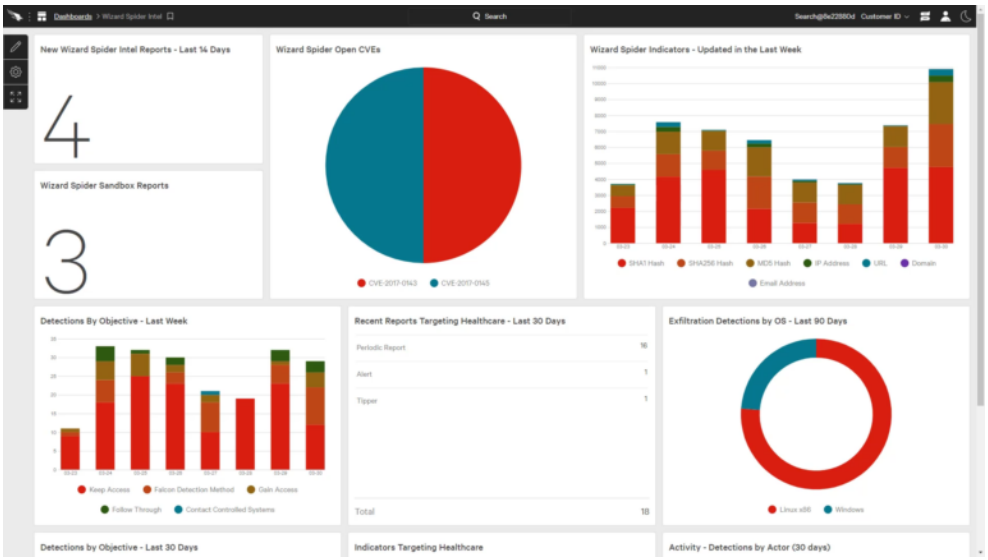


Figure 3.14: Visualization widgets in CrowdStrike

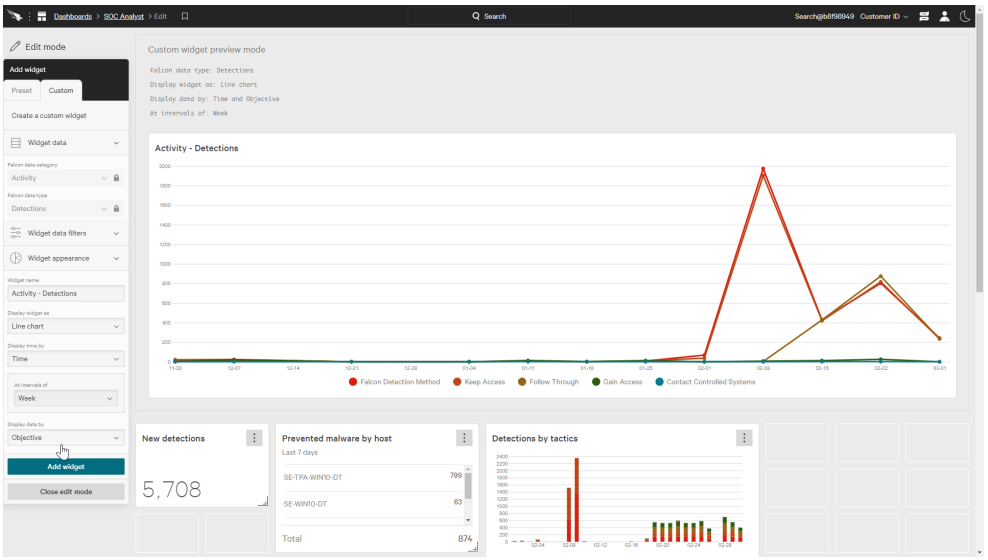


Figure 3.15: Adding a widget in CrowdStrike

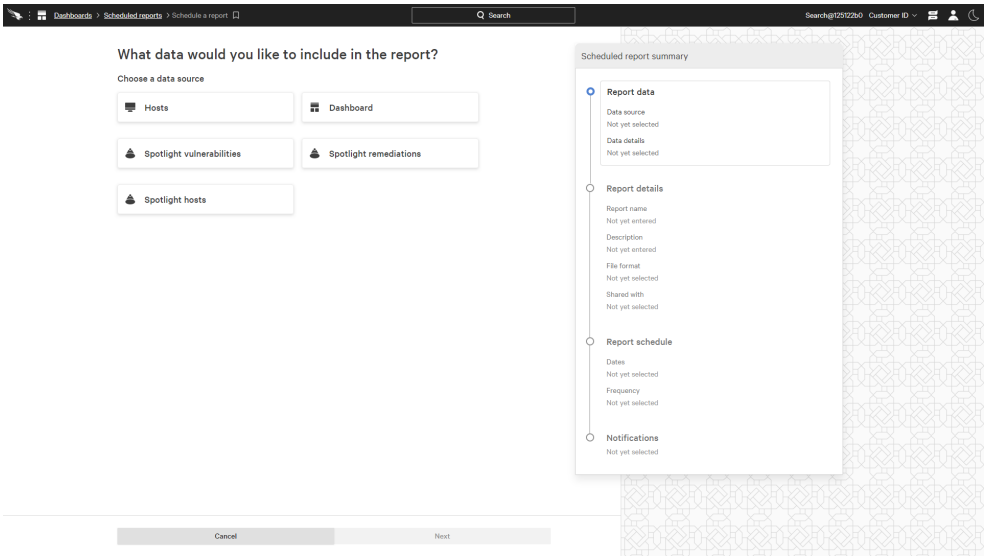


Figure 3.16: Create scheduled report in CrowdStrike

is:

- **Tabs**: are the container for widgets. Tabs can be added or modified as needed. A dashboard can support up to 10 tags, and each tab can hold up to 10 widgets.
- **Widgets**: like other solutions, widgets represent the core components of the dashboard. They contain visual charts and graphs that track threats and associate them with log statistics aggregated from one or several gateways.
- **Event**: contains a log of record when a protection module rule or condition is triggered by Deep Security Agents. CrowdStrike Agents and Deep Security Manager also records when administrative or system-related events occur (a ”system event”), such as administrator logging, or agent software being upgraded. Even data is used to populate the various reports and graphs in Deep Security Manager.
- **Filter by tags**: in CrowdStrike Deep Security®, a tag is a unit of meta-data that can be applied to an Event to create an additional attribute for the Event that is not originally contained within the Event itself. Tags can be used to filter Events to simplify the task of the Event monitoring and management. A typical use of tagging is to distinguish between Events that require action and those that have been investigated and found to be benign.
- **Filter by date and time range**: allows the user to filter the data by date and time range. For example, data can be displayed from either the last 24 hours, or the last 7 days.

3.5.3 Conclusion

In Flutter, there are three main libraries that support a wide range of chart types, which are: fl_chart, flutter_echarts, and syncfusion_flutter_charts. Each chart type is suitable for a specific kind of data and provides a different way to visualize the data. The SentinelOne data will mainly be displayed by using pie chart and bar graph because the data is categorical and numerical. Comparing to the other EDR platform, the dashboard of the QaaS app should have customizable widgets, allowing users to choose which data they want to display, how they want to display it, and where they want to display it on the dashboard. The dashboard should also store user’s preferences and settings, so that the user can see the same view the next time they log in. The colour of visualization charts should not be more than the typical red, green, blue, and yellow, as it can be overwhelming and confusing to the user. Red colour is usually used to indicate a problem or a threat, green colour is used to indicate that everything is okay, while grey colour is used to indicate that the data is neutral or not critical, or that the data is not available. Different colours such as purple, blue, and yellow will also be used to indicate different categories of data. Additionally, the dashboard should also have a legend to display additional information about the chart series. Filtering, sorting, and searching the data should be added to the dashboard to make the data more user-friendly and interactive.

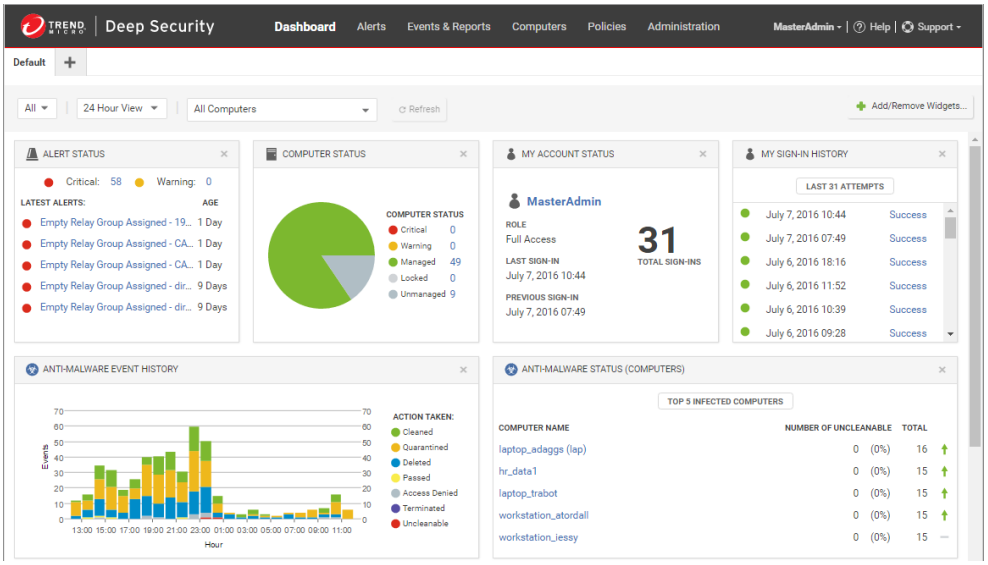


Figure 3.17: Dashboard in Trend Micro

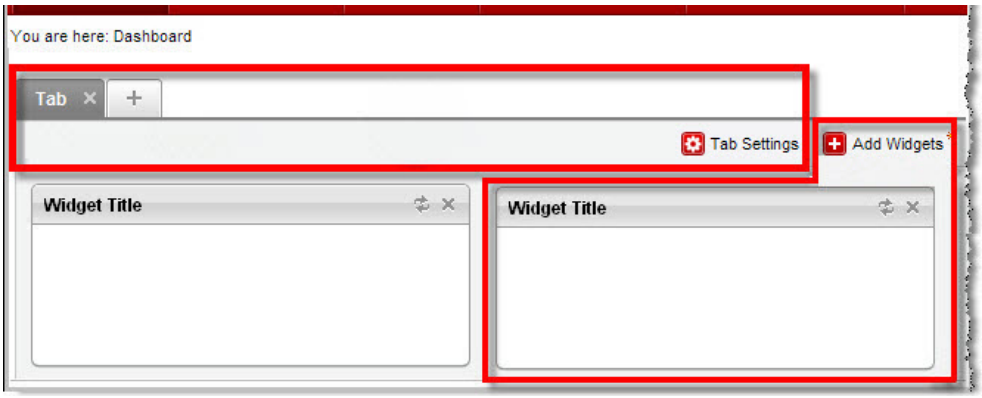


Figure 3.18: A Tab in Trend Micro can contain up to 10 widgets

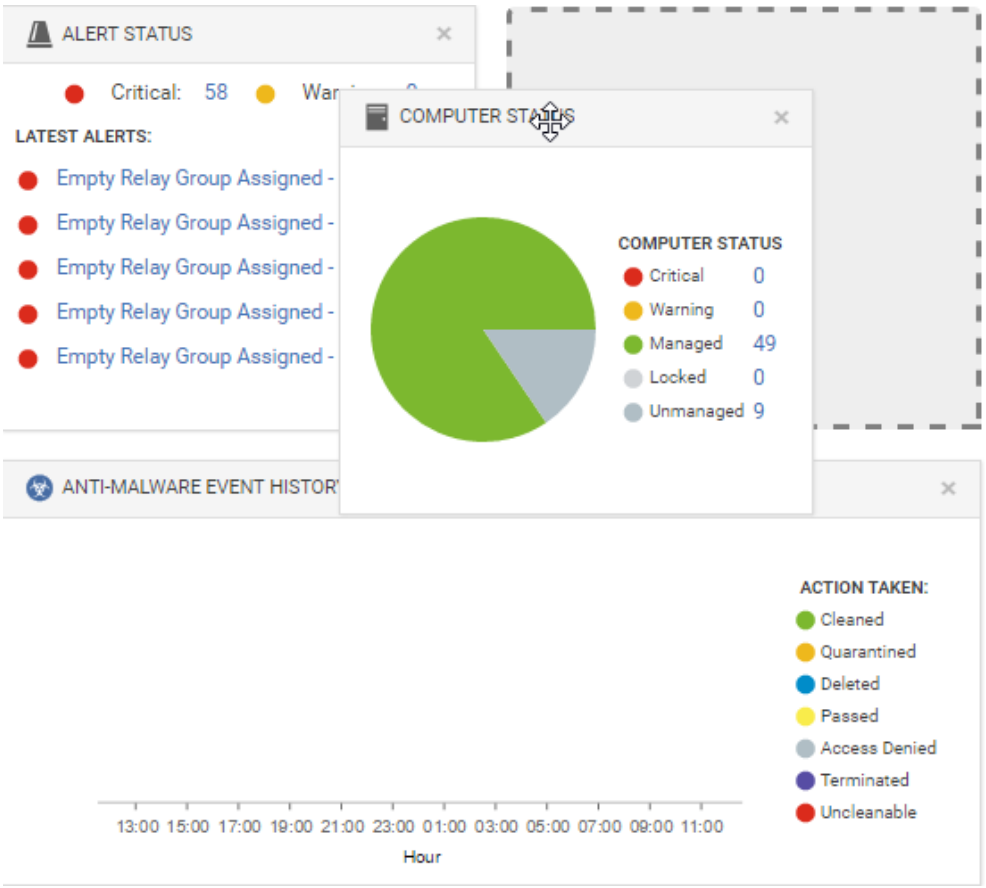


Figure 3.19: Change the layout of the dashboard in Trend Micro by dragging and dropping the widgets

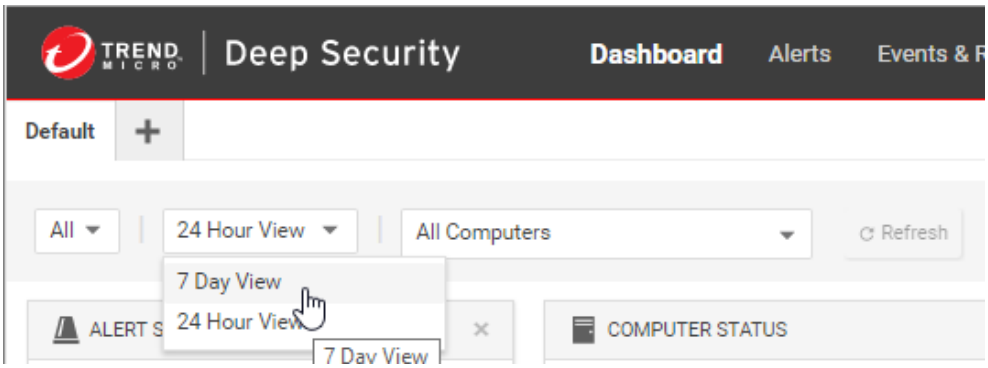


Figure 3.20: Filter the data by date and time range in Trend Micro

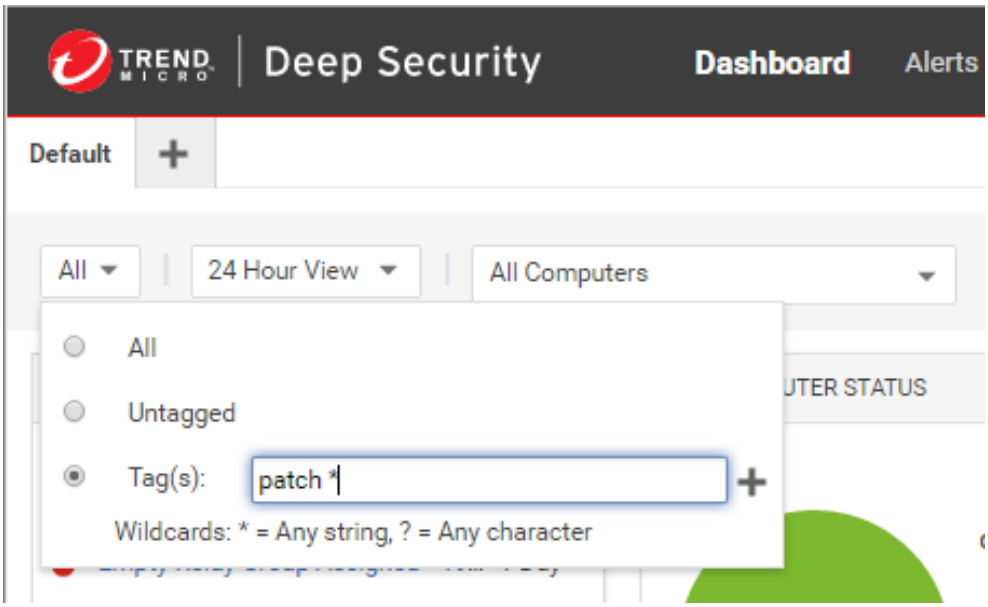


Figure 3.21: Add a tag to the data in Trend Micro

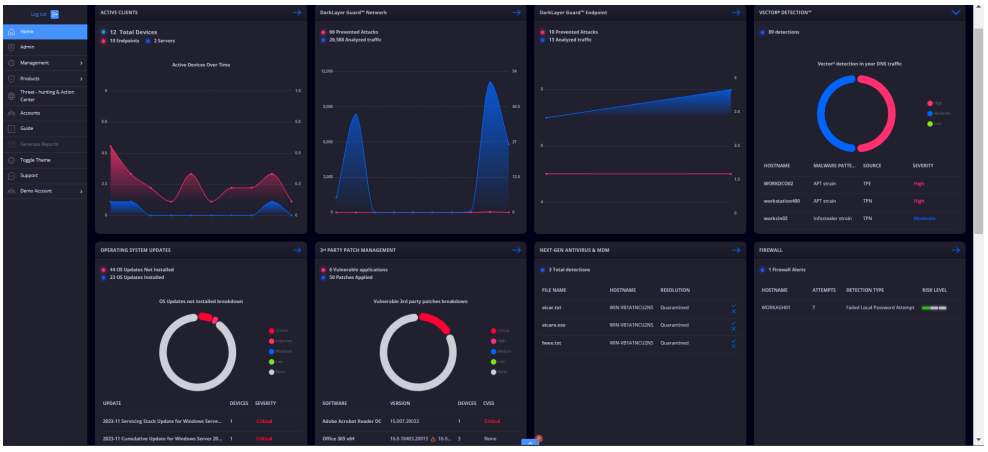


Figure 3.22: The dashboard of Heimdal®

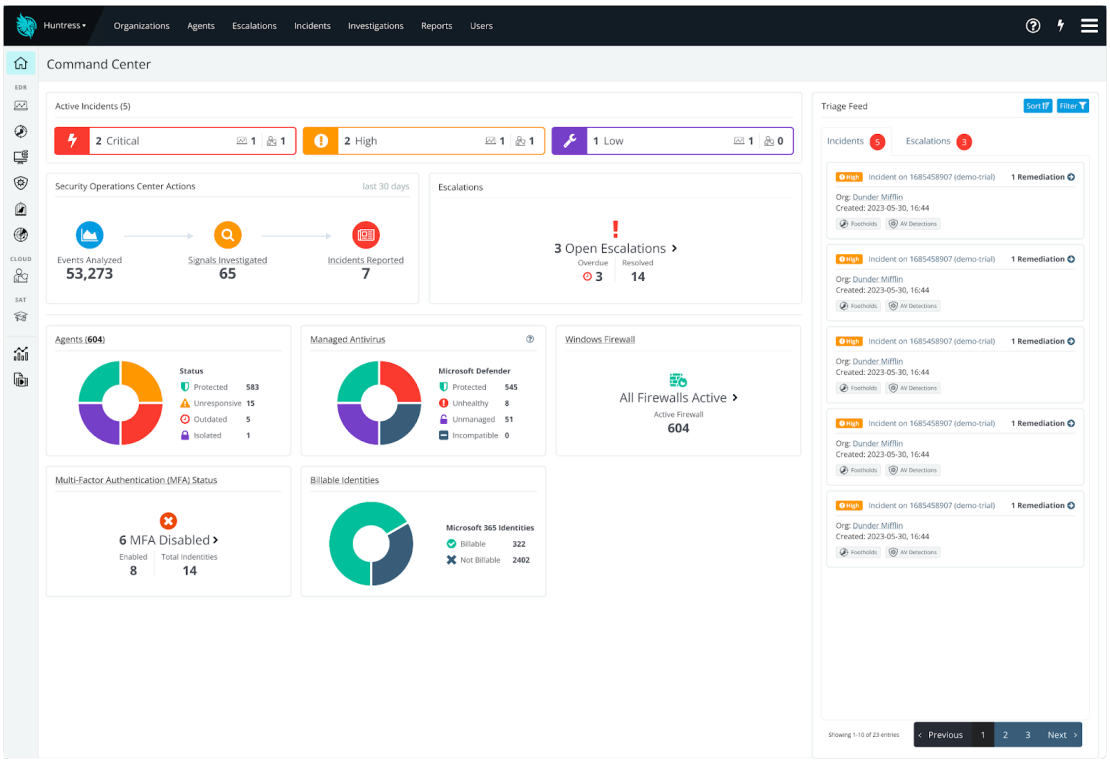


Figure 3.23: The dashboard of Huntress

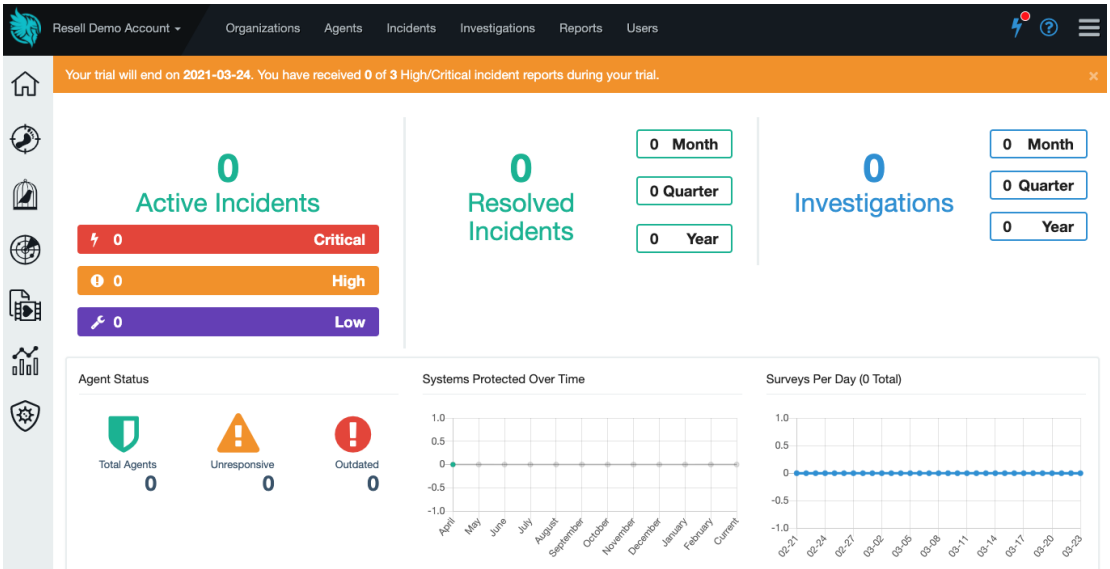


Figure 3.24: Seeing incidents in Huntress

Chapter 4

Realization

Because the QaaS web application itself is already built on top of existing frameworks, libraries, and technologies, the integration of the SentinelOne was relatively straightforward. The API itself provided by SentinelOne is well-documented, and the NPM packages also have ample online resources on the Internet and easy to use. The only challenge was understanding and reading the already existing front-end codebase, the JSON data structure of the SentinelOne API, choosing the right and more important data to display, modelling it in the QaaS database, and then displaying it in the web application.

4.1 The Back-end

Firebase Cloud Functions and Cloud Firestore were the main technologies that build the infrastructure of the back-end of this project. The types of functions that are used throughout the project are the following:

- `onCall`: This type of function is used to handle callable functions, which are called from the client-side. It is used to handle requests from the client-side. This is the main function in which the SentinelOne data is fetched and processed.
- `onRequest`: This type of function is used to handle HTTP requests, which are called from the client-side. It is mainly for initial testing, as setting this function up is easier and faster. However, the author does not recommend using this in the production, as it lacks authentication and security for the end-user.
- `onSchedule`: This type of function is used to handle scheduled functions, normally called cron-jobs, which are called at a specific time. It is used to handle scheduled tasks that need to be executed at a specific time. There is only one scheduled function in the project, which is used to replace the old SentinelOne API key with a new one that is securely stored in Google Secret Manager, therefore ensuring proper connection and access to the secret vault, every month.
- `Cloud Firestore Triggers`: this function is used for the Algolia extension, which is used to listen to changes in the Firestore database and update the Algolia index accordingly. This function is used to keep the Algolia index up-to-date with the Firestore database, ensuring that the search functionality works correctly.

4.1.1 Setting up permissions with Google Secret Manager

Because every call to the SentinelOne API requires an authorization through a valid SentinelOne API key, it is crucial to store this key securely on the Internet, where not everyone can access it. Following the guideline from the Company Supervisor, in whom is not a big fan of storing sensitive information in .env files or directly in the code, the author stored the SentinelOne API key in a Secret within Google Secret Manager. The number one reason as to why is because Firebase Cloud Functions work well with Secret Manager, as they are both Google Cloud products. Therefore, the author can easily edit the settings of a specific cloud function to have access to the latest version of a specific Secret, providing that they are stored within the same project directory.

Service Account

The first crucial step in setting up the permissions with Google Secret Manager is to create a Service Account. A Service Account is a special type of Google account that belongs to the application or a virtual machine, instead of to an individual end-user. It is used to operate and manage services without sharing user credentials (*Firebase, n.d.-f*). Whenever a function is created in Firebase, it is automatically assigned a Service Account, the admin can edit the permissions of the Service Account to have access to the Secrets stored in the Secret Manager. With the proper access level granted to a specific Service Account assigned to a desired function, the author can then easily configure on which Secrets his cloud functions can have access to.

4.1.2 Firestore database structure

Inside the Firestore, there are various collections (tables) that hold different data. Most of the collections are used to store the data that is fetched from the SentinelOne API, and one collection is used to store the user's session and preference data. SentinelOne data itself is divided into 2 categories: general SentinelOne data and specific data, both can have varying fields depending on how SentinelOne structures the data in its JSON format. General SentinelOne data only has 1 specific field in common, which is the siteId. The idea is to store all the clients' data in one collection, therefore differentiating the data based on client's company, an index of client's site ID (which is unique from each other) is used to separate the data.

The second category is the specific SentinelOne data, win which the data does not only belong to a specific site ID, but also to a specific ID from another SentinelOne data. For example, each threat can have their own unique timeline of events that have happened. Therefore, another field is required that is used as a second index to reference the desired data. The first and second category will then have different logic in the cloud function to fetch the data.

User Preference

A special table in Firestore is created to store the user's preference, each document' ID is the user's ID, therefore ensuring uniqueness. In a document, there are 3 different fields:

- timestamp: containing date time in the format of timestamp. It is used as a reference for the Cloud Function to know when the data is last updated, and if it exceeds a certain threshold, the Cloud Function will fetch the data from the SentinelOne API again. This will be the field that the fetching cloud function needs to do its if-check first to determine if the data is outdated.
- widgetIds: containing an array of strings, each string is the ID of the widget that the user wants to see in the dashboard. This is used for the convenience of adding, updating, and deleting widgets.
- widgetTitle: containing also an array of strings, which serves as the title that the user chooses for their widgets. A widget title can have the same name as another widget, if the widget ID is different.
- widgets: containing a map of 3 different fields:
  - category: containing a string, which is the category of the widget. The category is used to group the widgets in the dashboard, so the user can easily find the widgets that they want to see. Currently, there are 3 categories: "Threats", "Endpoints", "Applications", and "Miscellaneous". In the future, additional 2 categories can be added: "Ranger (Network Discovery)" and "Rogues". Ranger is a feature that is used to discover the network of the client's machine, and Rogues is a feature that is used to detect any unauthorized devices that are connected to the client's machine. These 2 features are currently deactivated in the Q-ICT site environment for internal reasons, thus the author does not include them in the project.
  - graphicType: containing a string, which is the type of the graphic that the user wants to see in the widget. Currently, the graphics that the user can utilize are: "Doughnout", "Pie Chart", "Vertical Bar", "Stacked Vertical Bar", "Horizontal Bar", "Stacked Horizontal Bar", "Line Chart", "Scatter", "Bubble", "Pyramid", "Funnel", and "Table".
  - widgetType: Inside the 4 main categories, the selection is further divided into separate types according to which categories that wanted to be visualized. Agent category can show the status of the agents, such as the number of agents that are connected, disconnected, or in quarantine. Threats category can show the status of the threats that are detected by SentinelOne, such as the number of threats that are detected, resolved, or in quarantine. Applications category show the number of outdated applications that can potentially be a threat to the client's machine, according to the latest CVEs from the NIST and MITRE. The widget categorization is divided as follows:
    * Endpoint: Agent versions, pending updates, agent by OS, console migration status, domains, encrypted applications, endpoint connected to management, connection status, endpoint health, endpoint list, endpoint summary, installers, load saved filters, local configurations, location IDs, machine types, manual actions required, network health, OS arch, pending uninstall, and scan status.
    * Threats: Analyst verdicts, confidence levels, engines, external ticket exists, failed actions, incident status, initiator, mitigated preemptively, note exists, pending actions, reboot required, threat classification, threat list, threat status, threat summary of the week, and unresolved.
    * Applications: Risk levels, and most impactful applications according to SentinelOne Vulnerability Score.
    * Miscellaneous: SentinelOne news feed, and free text.

4.1.3 Modelling in the back-end

The JSON data is modelled in the back-end first, then in the front-end, to ensure that the data is consistent across the application. The data is modelled using interfaces

and classes, which are defined in the Models directory. The interfaces define the structure of the data, and the classes provide methods to serialize and deserialize the data. This ensures that the data can be easily converted to and from JSON.

```
match/SentinelOne_UserPreference/{firebaseId} {
  allow read, write, update: if isHelpDesk() || isUser();
}
```

Figure 4.1: Granting access of read, write, and update from User Preference collection to users in the Firebase Console

Listing 4.1: Model class in the back-end

```
1
2
3   export interface Customer {
4   customerId: string;
5   customerName: string;
6   orgUnitType: string;
7   parentId: string;
8   city: string;
9   stateProv: string;
10  country: string;
11  county: string | null;
12  postalCode: string;
13  contactEmail: string;
14 }
15
16 /**
17  * Class for CustomerModel.
18  */
19 export class CustomerModel {
20   private readonly firestore: FirebaseFirestore.Firestore;
21   private readonly collectionName = "customers";
22   private readonly context = "CustomerModel";
23
24   /**
25    * Constructor for CustomerModel.
26    */
27   constructor() {
28     this.firestore = admin.firestore();
29   }
30
31   /**
32    * Serializes a Customer object to a JSON string.
33    * @param {Customer} customer The Customer object to serialize.
34    * @return {string} The serialized JSON string.
35    */
36   serializeCustomerToJson(customer: Customer): string {
37     return JSON.stringify(customer);
38   }
39
40   /**
41    * Deserializes a JSON string to a Customer object.
42    * @param {string} json The JSON string to deserialize.
43    * @return {Customer} The deserialized Customer object.
44    */
45   deserializeJsonToCustomer(json: string): Customer {
46     return JSON.parse(json) as Customer;
47   }
48
49   /**
50    * Creates a new customer in Firestore.
51    * @param {Customer} customer Customer to add to Firestore.
52    * @return {Promise<FirebaseFirestore.DocumentReference<FirebaseFirestore.DocumentData>> | undefined}.
53    */
54   async createCustomer(customer: Customer):
       Promise<FirebaseFirestore.DocumentReference<FirebaseFirestore.DocumentData> | undefined> {
55     try {
```

```
      return this.firestore.collection(this.collectionName).add(customer);
    } catch (ex: unknown) {
      logError(ex, this.context + ".createCustomer");
    }
    return undefined;
  }

  /**
   * Retrieves a customer by its ID from Firestore.
   * @param {string} customerId The ID of the customer to retrieve.
   * @return {Promise<Customer | undefined>} A promise that resolves with the customer object if found,
       or undefined if not found or an error occurs.
   */
  async getCustomer(customerId: string): Promise<Customer | undefined> {
    try {
      const doc = await this.firestore.collection(this.collectionName).doc(customerId).get();
      if (!doc.exists) {
        return undefined;
      }
      return doc.data() as Customer;
    } catch (ex: unknown) {
      logError(ex, this.context + ".getCustomer");
      return undefined;
    }
  }

  /**
   * Updates an existing customer in Firestore.
   * @param {string} customerId The ID of the customer to update.
   * @param {Partial<Customer>} customer The partial customer object containing updates.
   * @return {Promise<void>} A promise that resolves when the update is complete.
   */
  async updateCustomer(customerId: string, customer: Partial<Customer>): Promise<void> {
    try {
      await this.firestore.collection(this.collectionName).doc(customerId).update(customer);
    } catch (ex: unknown) {
      logError(ex, this.context + ".updateCustomer");
    }
  }

  /**
   * Deletes a customer from Firestore.
   * @param {string} customerId The ID of the customer to delete.
   * @return {Promise<void>} A promise that resolves when the customer is successfully deleted.
   */
  async deleteCustomer(customerId: string): Promise<void> {
    try {
      await this.firestore.collection(this.collectionName).doc(customerId).delete();
    } catch (ex: unknown) {
      logError(ex, this.context + ".deleteCustomer");
    }
  }

}
```

4.1.4 Setting up permissions with Firestore

This has got to do with the Firestore database and the access level of permission that a Firebase Cloud Function has. In the SentinelOne integration project, the table that contains SentinelOne data cannot be changed by the client, only by fetching new data from the SentinelOne API and replacing the old data. Therefore, only one table remains that can be changed accordingly by the user, the User Preference table. This table can be changed freely by the user if they remain logged in to the QaaS app.

4.1.5 Connection to Algolia

As originally stated, the author and Company Supervisor directly intended on using Algolia search as the SentinelOne API search, although far from being bad, does have type intolerance. The purpose of this is to enhance the UX because not all users can remember the exact name of the data they want to search for and makes the search more accurate and faster even with false inputs.

Q-ICT itself already has the test environment project set up in Algolia, because they are also using it in every search functionality that they have in the QaaS app. For this specific project, the author's work Q-ICT Microsoft

e-mail account was invited to join the project. In there, the author can already see all the duplicate indexes coming from Firestore that serves as the point of reverence when letting the AI Algolia engine to do the searching. From Algolia dashboard, several default API keys can be seen, including:

- Application ID: unique application identifier
- Search API key: usable for search queries and for listing the indices.
- Write API key: is used to create, update, and delete indices. Cannot be used to manage other API keys.
- Admin API key: like write keys but can be used to manage other API keys.

The way the extension itself works is that it acts as a pre-written cloud function like Cloud Firestore Triggers (*Firebase, n.d.-a*), where it listens to the collection in a Firestore. When the data changes this cloud function passes it through Algolia. It is a script Firebase made together with Algolia. On this extension, 2 parameters are needed to be included: the Application ID and the API key. The Application ID is used to point to the right project in Algolia. The API key is used to authenticate the connection between Algolia and Firebase. For every Algolia extension, it is recommended to create a separate API key and not to use the admin key, so that the key can be revoked if needed. The author is using the custom API key that was made by the Company Supervisor, that has restriction on the index that it can access, and the operations that it can do.

4.2 The Front-end

In the front-end side of this project, it is just a matter of calling the Cloud Functions, modelling the JSON response coming from the Cloud Functions (whether it is from Firestore or SentinelOne), making the visualization graphs using the available Flutter package, setting the logic on how to navigate between pages passing the correct data, the logic for how to display the data correctly in paginated data tables and visualization widgets, and lastly, the searching, filtering, and filtering functionality.

After ensuring that the logic of the front-end works perfectly for showing the data, the last step that was needed to be undertaken was polishing, which includes: checking for bugs and translation error, unit testing, making sure that the malfunctioning part that were not yet fixed due to time constraint are not shown and testing for responsiveness on different devices. The last part was proven to be quite a long process, because almost every widget that the author has created needed to be wrapped around another Flexible widget that can expand and shrink based on the screen size, and to make sure that there is no infinity width or height that can cause the widget to be cut off or not shown at all.

4.3 Deploying everything to the Live environment

In the final phase of the project, after making sure that everything works and tested properly, the author needed to deploy the project from the test environment to the live environment, so that other users can also access it. Below are the steps undertaken to deploy the project to the live environment:

1. Make sure to log in to the admin account of the Firebase Console.
2. Make sure to select the right environment.
3. Create a specific branch in the Azure DevOps repository for the live environment (live-*date*).
4. Switch the firebase options to the live environment in the Flutter new client.
5. Make sure there are no debug app check tokens in the index.html of the Flutter project.
6. Build the Flutter client project.
7. Deploy the new Flutter client code to Firebase, now the front-end is updated.
8. Add/ update/ delete any Firebase cloud functions for the new version to get added into the live environment.
9. Create API secrets in the live environment if needed.
10. Allow secret access to the specific cloud functions.
11. Make sure the Firebase security rules are up-to-date in the live environment.
12. Mirror Cloud Firestore data in Algolia if needed.
13. Change allowed Algolia indexes in Algoia API key functions, this decides which indexes the developers are allowing to search on with this specific Algolia search API key.
14. Build Firestore indexes if needed, for where/ orderby queries, this is usually done before client deployment.

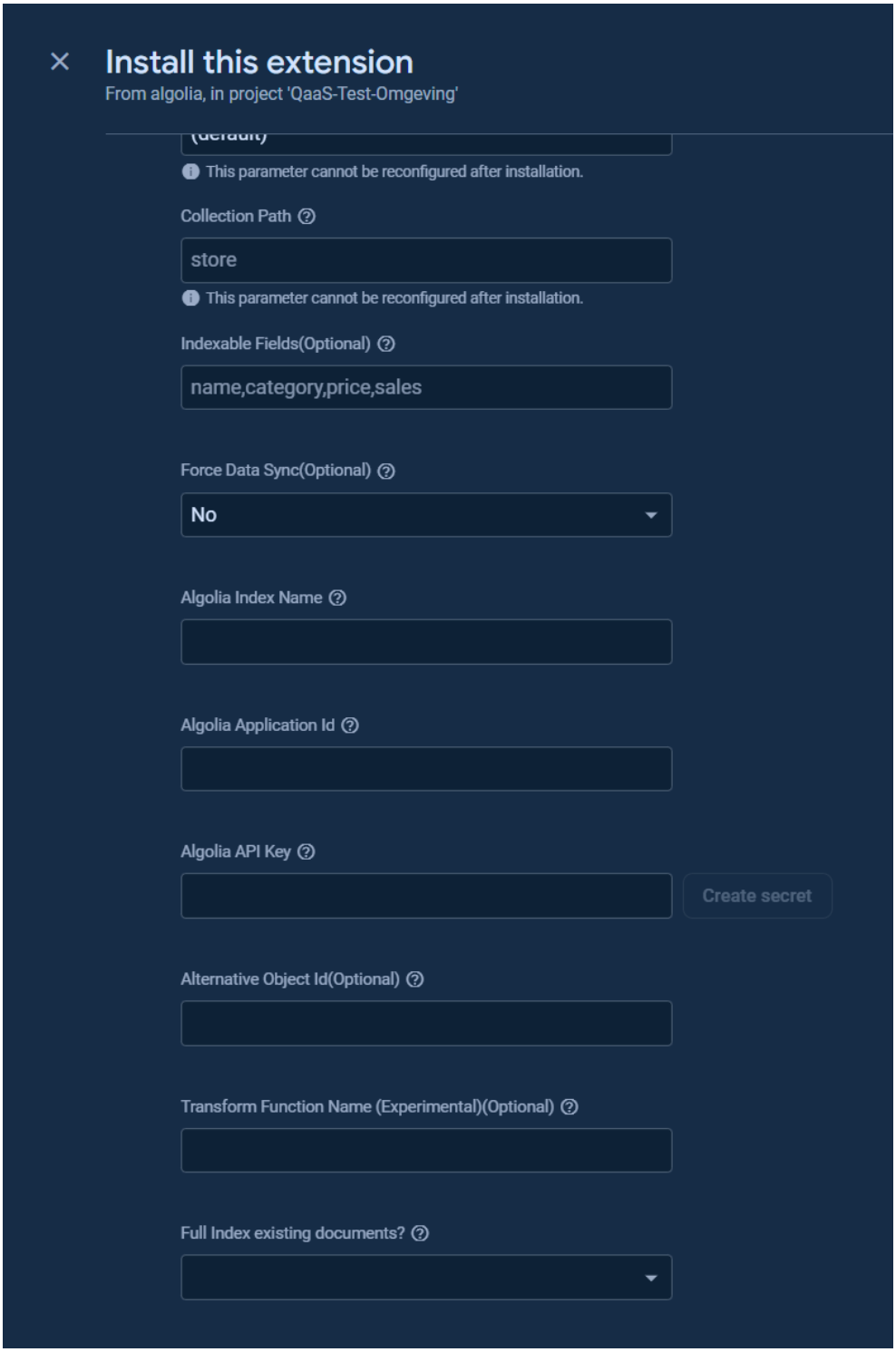


Figure 4.2: The Algolia configuration when installing the extension in the Firebase Console

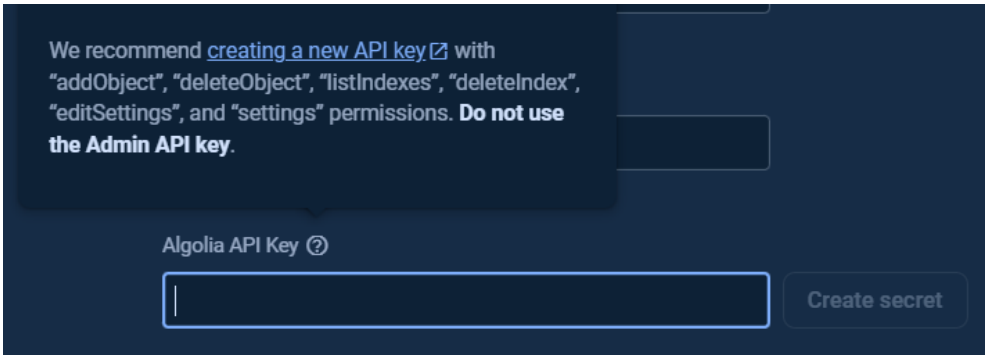


Figure 4.3: The Algolia API key that is needed to be included in the Firebase Console when installing the extension

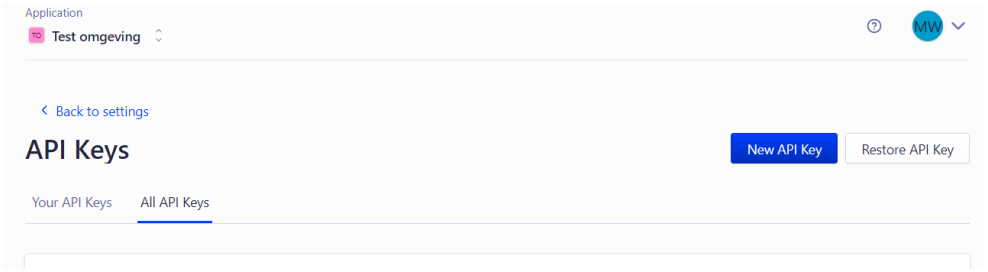


Figure 4.4: Creating a new Algolia key to use in the Firebase Extension

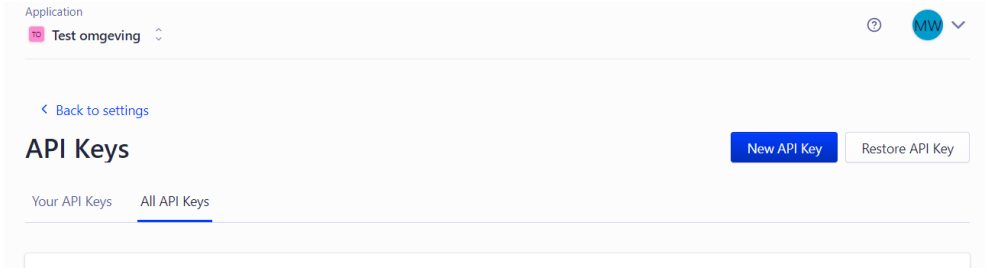


Figure 4.5: Creating a new Algolia key to use in the Firebase Extension

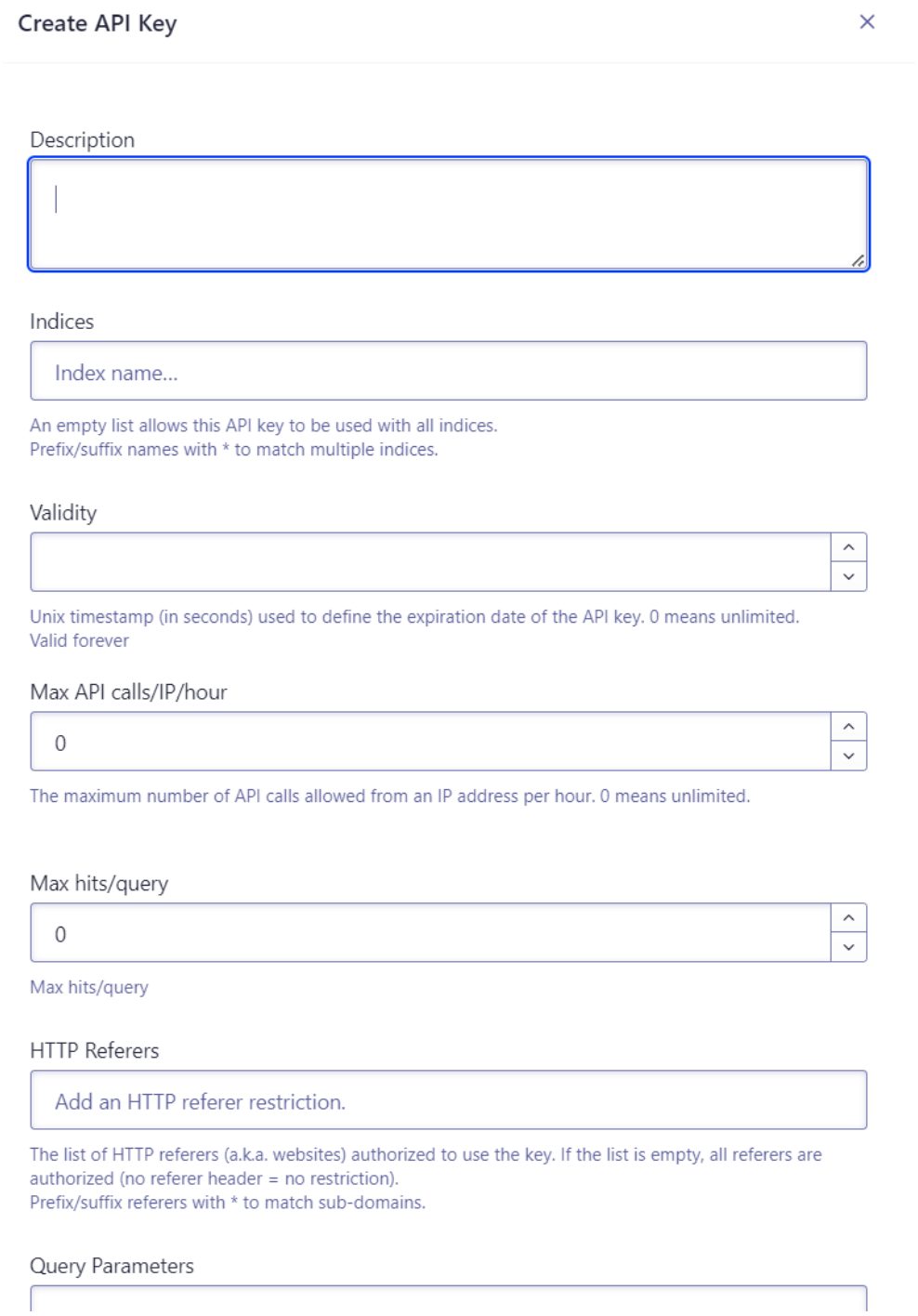


Figure 4.6: Algolia API key restrictions that can be set up when creating a new key

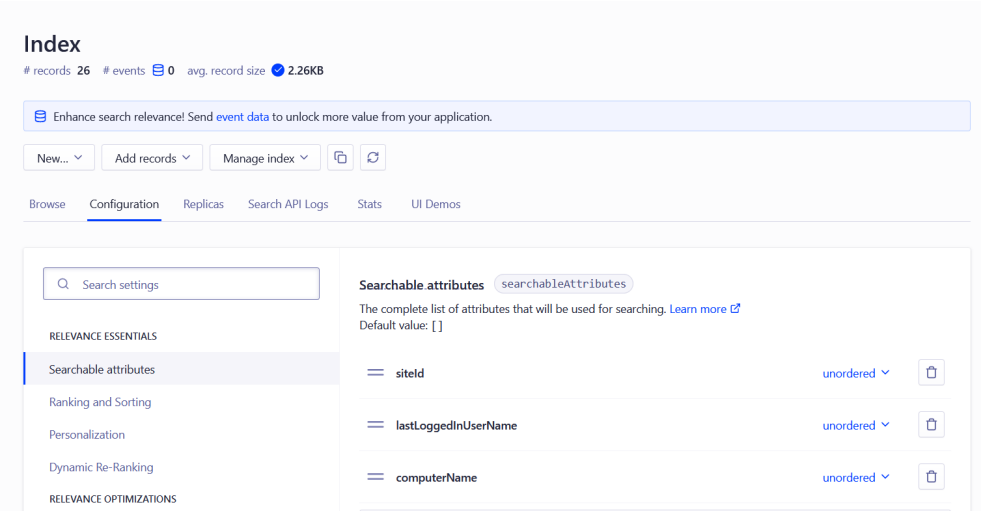


Figure 4.7: All indexes need to have a configuration in which what searchable attributes that the user can search for, based on the modelling of the JSON data structure

Chapter 5

Conclusion and Recommendation

5.1 Conclusion

Cybersecurity is a complex field and threat actors are ever evolving their tradecraft in clever ways. Every single running business is not too small to be attacked, but they may be too small for them to make the news. Therefore, transparency to the clients is important, because lack of visibility to the clients can lead to a loss of trust. This graduation project serves as the first iteration by Q-ICT about the integration of SentinelOne to its internal application, the QaaS app.

The QaaS app is a cloud-based application that is used by Q-ICT to provide a better service to their clients. The app itself is a multi-tenant application, meaning that it can be used by multiple clients at the same time. The app is made using Flutter, a cross-platform framework that is developed by Google, and Firebase as the back-end cloud solution. The app itself has several modules that are used by different user roles, such as the clients, the helpdesk, and the IT admins. The app is also integrated with several APIs, such as the N-Central, Resello, Snelstart, Bodyguard.io, and PerfectView. The app also uses Algolia, an AI powered search engine, to make the search faster and more accurate by allowing typos.

The QaaS app itself has 3 different user roles in its system: the clients, the helpdesk, and the IT admins. Alongside that, there are also modules, user tags, and templates. Modules are basically the page view of the app, assigning modules to an appropriate user role is done by the IT admins. User tags are assigned to a user to give them permission to see or edit certain modules. Templates

SentinelOne is a cybersecurity company based in California, United States that has a product of the same name. It is an EDR platform, which purpose is to detect and respond to threats of an endpoint in real-time, replacing the traditional AV. It utilizes AI and ML on an Agent to detect and respond to threats, and it is deployed on the endpoint itself. The purpose of an EDR platform is to have a centralized view of all the endpoints that are connected to the platform, and to provide real-time monitoring of the threats that are detected by the Agent. The platform itself is also integrated with several APIs, such as the API for the Agents for endpoints, the Rangers for networks, and the application management, each data is uniquely processed and stored in separate DBs.

SentinelOne EDR platform is possible to be integrated with the QaaS app, which was made in Flutter with Firebase as the back-end cloud solution, utilizing SentinelOne API to fetch the data. In order that this API to be able to send the correct data, the necessary Agents and Ranger need to be set up properly in a client's machine. This Agent will then gather the data from the client's machine and send it to the management DB, providing real-time monitoring. Additionally, a SentinelOne account with the necessary rights to read the data with its API key is also needed to be configured. Lastly, a SentinelOne API key that is based on a SentinelOne account needs to be set up with a proper role to read the data, and secured in the cloud where it is encrypted like Google Secret Manager or Azure Key Vault.

Based on comparison with other EDR platforms, it is concluded that when making a visual representation for the users, it is important that the images are understandable and user-friendly to the users to create a strong message when displaying a complex data or information. The visualization widget also needs to be customizable, so that the user can choose which data they want to see in the dashboard. The colours of these visualization widgets do not need to be too flashy, as it can distract the user from the data itself. Instead, opting for colour that is more suitable to the general theme of the app is preferable. In the front-end, the visualization is done using the Flutter framework. The framework itself have several packages that can do this: *fl_chart*, *syncfusion_flutter_charts*, and *flutter_echarts*. The author chose to use all the three packages as all of them have their own strengths and weaknesses, along with making customization options for the user to choose which types of visualization and what data they want to see.

In the back-end, several functions with different functionalities need to be created to handle the data that is fetched from different SentinelOne API endpoints. The user's session and preference data are stored in the Firebase Firestore DB, and as well as AI powered Algolia search engine to make the search faster and more accurate. Additional features such as filtering, sorting, and pagination will be handled by inputting the correct headers to the API request.

5.2 Recommendation

5.2.1 Integration with N-Central data

In the research phase of this project, the Company Supervisor mentioned that there are some issues regarding the data coming from N-Central API (which also one of the API used for security) that sometimes can cause data discrepancy. The author has looked into some N-Central data and noticed some similarities with some SentinelOne data structure. The idea of this recommendation is to combine the data from SentinelOne and N-Central that have similar structure, to then make the data to be more accurate and reliable.

For example, N-Central has one API that can automatically check for an update of an application of a device, given the correct application ID and device ID. If a device has an outdated application, it can either update the application automatically, or notify the corresponding user. If the device also has a SentinelOne Agent installed, the Agent can then detect all the applications that are installed and know immediately if there is an outdated application, with checking for the outdated application that may pose a security risk according to the fastest CVE database. Combining two of these functionalities would then make sense, as SentinelOne can then prioritize outdated applications on a device, and N-Central can then notify the user to update the said application. This way, the user can then have a more secure device, and the QaaS app can then provide a more comprehensive security solution to the user.

5.2.2 Redis middleware NoSQL database caching

Redis is a powerful tool for DB that uses in-memory data structure to provide caching and message broker. It supports various data structures (*Redis, n.d.*), such as strings, hashes, lists, sorted sets, with range queries, bitmaps, hyperlogs, geospatial indexes with radius queries, and streams.

Because the main idea in Redis is to provide caching of the data, coupled with the fact that it is a NoSQL DB, Redis is exceptionally fast to query due to its in-memory nature in contrast to traditional disk-based DBs. This makes it suitable for use cases where low latency and high throughput are required, making it perfect for getting and storing data that is frequently accessed.

The idea is to put SentinelOne data into the Redis DB too, with the limit of 5-10 minutes before the cache is deleted, and then fetch the data from the Redis DB instead of directly fetching it from Firestore and SentinelOne API constantly. Implementing Redis will make querying the data faster than Firestore, providing better UX for the users.

However, there is one potential downside that the author sees when using Redis in this project. According to these articles (*Trollope, 2024*, and *Shams and Valderrama, 2024*), as of March 2024, Redis is no longer open source. They changed the official licence for all future versions. This has serious consequences for the open-source community and some companies providing managed Redis. Therefore, the initial development of the Redis middleware to this project can no longer use the free version of Redis from a Redis provider without a direct partnership with Redis. Nonetheless, with a direct paid subscription to Redis, the author believes that in the long run, using Redis as a means of caching the data will be beneficial for the QaaS app, especially when the number of customers have grown and the SentinelOne data gets called more frequently.

5.2.3 Compacting everything into one function

In the initial phase of the development, the author thought that it was a good idea to make just one function for fetching all data related to SentinelOne, for the purpose of simplicity for other developers, as there are already more than 50 functions that the QaaS app has. However, near the end of the development, the author realize that this may not be the best approach because of the number of requests that one user can make when navigating in the SentinelOne page of the QaaS app. In essence, when landing through the dashboard, 4 requests already need to be made to fetch the necessary data to be displayed. And every time the user refreshes that page or navigate back by using the header button in which the traversal process is done by pushing another route to the navigation stack, therefore calling the `FutureBuilder` of that page again and making the same 4 initial requests. After much research, the author found out that Cloud Function v2.0 has no limit on the number of requests that can be made, (*Firebase, n.d.-g*). As for the costing, the price can be increased after the limit of 2 million requests per month has been exceeded by $0.40 per million requests (*Firebase, n.d.-d*).

It seems that the issue is not going to make any significant damage to the app, if none. However, if the author needs to be critical and if given the chance to start over

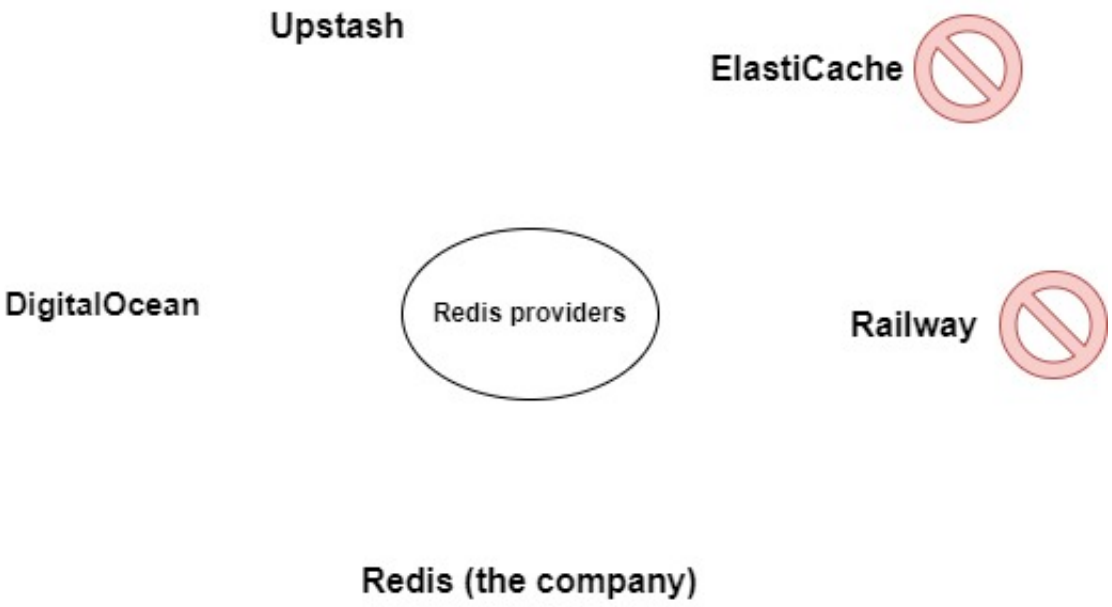


Figure 5.1: Redis providers now cannot distribute Redis anymore without a direct partnership with Redis, thefore Redis itself controlling the pricing.

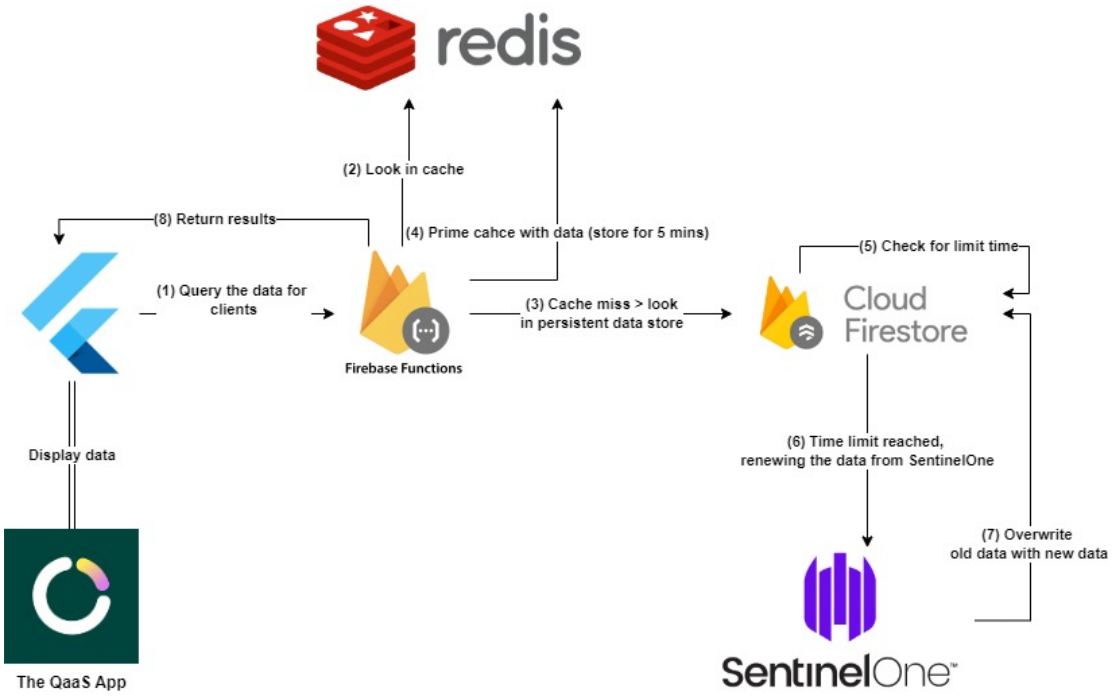
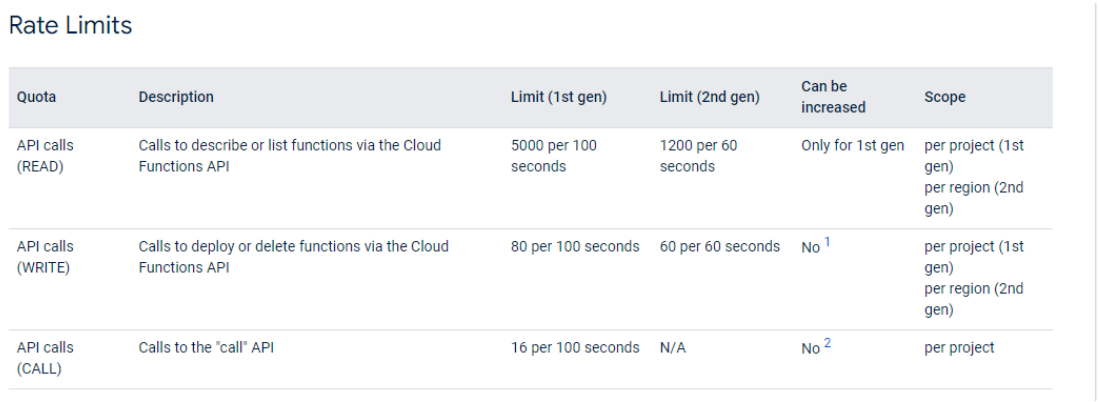


Figure 5.2: How the infrastructure would look if Redis is implemented

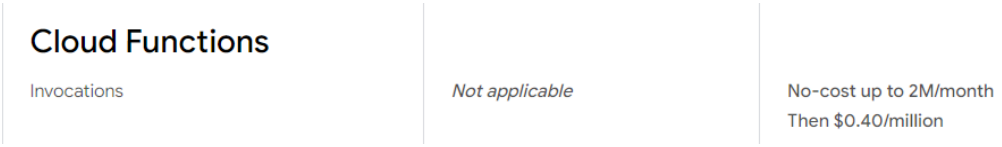
again, the author would have gone to a slightly different approach by separating the cloud functions into few parts to reduce the number of responsibility that a function must do. This way, the author can optimize the performance of the app, and make the code more readable and maintainable.



Rate Limits

Quota	Description	Limit (1st gen)	Limit (2nd gen)	Can be increased	Scope
API calls (READ)	Calls to describe or list functions via the Cloud Functions API	5000 per 100 seconds	1200 per 60 seconds	Only for 1st gen	per project (1st gen) per region (2nd gen)
API calls (WRITE)	Calls to deploy or delete functions via the Cloud Functions API	80 per 100 seconds	60 per 60 seconds	No [1]	per project (1st gen) per region (2nd gen)
API calls (CALL)	Calls to the "call" API	16 per 100 seconds	N/A	No [2]	per project

Figure 5.3: The table comparison from the article (*Firebase, n.d.-g*) showing that Cloud Function v2.0 has no limit on the number of requests that can be made.



Cloud Functions

Invocations	*Not applicable*	No-cost up to 2M/month Then $0.40/million

Figure 5.4: The pricing information for Cloud Function v2.0 (*Firebase, n.d.-d*).

5.2.4 SentinelOne Aggressive Mode

SentinelOne has a lot of features that can be beneficial for an organization, such as its ability to detect and respond to threats in real-time. This, however, does not come without its own potential downsides. SentinelOne Agents often exhibit aggressive behaviour, flagging benign and legitimate files or processes as threats and take actions such as quarantining or mitigating them. This makes them susceptible to false positives, especially in their default configuration. This can lead to unnecessary disruptions, loss of productivity, and distrust in the security protocol. Organizations may need to invest some time and resources in investigating and resolving false positives alerts. The author therefore would suggest Q-ICT to treat it very carefully and to make sure that the SentinelOne Agents are configured properly to avoid unnecessary disruptions.

Bibliography

Acronis. (n.d.). Computicate. *solutions.acronis.com*. https://solutions.acronis.com/en-us/integrations/computicate/

Anfalovas, I. (2022). What is address resolution protocol? a beginner's guide to ar. *Ipxo*. https://www.ipxo.com/blog/address-resolution-protocol/

Cronitor. (n.d.). Crontab guru. *contab.guru*. https://crontab.guru/#0_0_*/7_*_*

Fielding, R. T., & Taylor, R. N. (2000). Architectural styles and the design of network-based software architectures. *University of California, Irvine*. https://ics.uci.edu/~fielding/pubs/dissertation/top.htm

Firebase. (n.d.-a). Cloud firestore triggers. *Firebase.google.com*. https://firebase.google.com/docs/functions/firestore-events?gen=2nd

Firebase. (n.d.-b). Firebase app check. *Firebase.google.com*. https://firebase.google.com/docs/app-check

Firebase. (n.d.-c). Firebase extensions. *Firebase.google.com*. https://firebase.google.com/docs/extensions

Firebase. (n.d.-d). Firebase pricing. *Firebase.google.com*. https://firebase.google.com/pricing

Firebase. (n.d.-e). Firebase products - google. *Firebase.google.com*. https://firebase.google.com/products-build

Firebase. (n.d.-f). Firebase service accounts overview. *Firebase.google.com*. https://firebase.google.com/support/guides/service-accounts

Firebase. (n.d.-g). Quotas and limits. *Firebase.google.com*. https://firebase.google.com/docs/functions/quotas

Firebase. (n.d.-h). Schedule functions. *Firebase.google.com*. https://firebase.google.com/docs/functions/schedule-functions?gen=2nd

Google. (n.d.). Google cloud. *Secret Manager*. https://cloud.google.com/security/products/secret-manager

IBM. (n.d.). What is a rest api? *CyberHoot*. https://www.ibm.com/topics/rest-apis#:~:text=A%20REST%20API%20(also%20called,transfer%20(REST)%20architectural%20style).

Indeed. (2023). What is soap api? (plus comparison to rest api and benefits). *Indeed Editorial Team*. https://www.indeed.com/career-advice/career-development/what-is-soap-api#:~:text=SOAP%20API%2C%20or%20simple%20object,Extensible%20Markup%20Language%20(XML).

Kubernetes. (2018). Cronjob. *kunbernetes.io*. https://kubernetes.io/docs/concepts/workloads/controllers/cron-jobs/#:~:text=A%20CronJob%20creates%20Jobs%20on,schedule%2C%20written%20in%20Cron%20format.

LinkedIn. (n.d.). Resello: Powered by pax8. *LinkedIn.com*. https://www.linkedin.com/company/resello-bv/

MongoDB. (n.d.). What is nosql? *MongoDB.com*. https://www.mongodb.com/nosql-explained

PerfectView. (n.d.). Pefectview crm online | krachtige nederlandse crm. *PerfectViewCRM.nl*. https://www.perfectviewcrm.nl/

Redis. (n.d.). Data structures. *redis.io*. https://redis.io/redis-enterprise/data-structures/

Shams, K., & Valderrama, T. (2024). Redis adopts dual source-available licensing. *momento*. https://www.gomomento.com/blog/rip-redis-how-garantia-data-pulled-off-the-biggest-heist-in-open-source-history

Taylor, C. (2021). Castle-and-moat network security model. *CyberHoot*. https://cyberhoot.com/cybrary/castle-and-moat-network-model/

Taylor, C. (2024). Castle-and-moat network security model. *CyberHoot*. https://cyberhoot.com/cybrary/castle-and-moat-network-model/

TOMTelecom. (n.d.). Wie zijn wij. *tomtelecom.nl*. https://www.tomtelecom.nl/wiezijnwij/

Trollope, R. (2024). Redis adopts dual source-available licensing. *redis.io*. https://redis.io/blog/redis-adopts-dual-source-available-licensing/

Vogel, J. (2023). Ict research methods — methods pack for research in ict. *HBO-i, Amsterdam*. https://ictresearchmethods.nl/

Wikipedia. (n.d.-a). Algolia. *Wikipedia, free encyclopedia*. https://en.wikipedia.org/wiki/Algolia

Wikipedia. (n.d.-b). Api. *Wikipedia, free encyclopedia*. https://en.wikipedia.org/wiki/API

Wikipedia. (n.d.-c). Arp spoofing. *Wikipedia, free encyclopedia*. https://en.wikipedia.org/wiki/ARP_spoofing

Wikipedia. (n.d.-d). Captcha. *Wikipedia, free encyclopedia*. https://en.wikipedia.org/wiki/CAPTCHA

Wikipedia. (n.d.-e). Captcha. *Wikipedia, free encyclopedia*. https://en.wikipedia.org/wiki/ReCAPTCHA

Wikipedia. (n.d.-f). Customer relationship management. *Wikipedia, free encyclopedia*. https://en.wikipedia.org/wiki/Customer_relationship_management
Wikipedia. (n.d.-g). Cyber threat hunting. *Wikipedia, free encyclopedia*. https://en.wikipedia.org/wiki/Cyber_threat_hunting
Wikipedia. (n.d.-h). Enterprise resource. *Wikipedia, free encyclopedia*. https://en.wikipedia.org/wiki/Enterprise_resource_planning
Wikipedia. (n.d.-i). Firebase. *Wikipedia, free encyclopedia*. https://en.wikipedia.org/wiki/Firebase
Wikipedia. (n.d.-j). Json. *Wikipedia, free encyclopedia*. https://en.wikipedia.org/wiki/JSON
Wikipedia. (n.d.-k). Man-in-the-middle attack. *Wikipedia, free encyclopedia*. https://en.wikipedia.org/wiki/Man-in-the-middle_attack
Wikipedia. (n.d.-l). Network tap. *Wikipedia, free encyclopedia*. https://en.wikipedia.org/wiki/Network_tap
Wikipedia. (n.d.-m). Penetration test. *Wikipedia, free encyclopedia*. https://en.wikipedia.org/wiki/Penetration_test
Wikipedia. (n.d.-n). Remote monitoring and management. *Wikipedia, free encyclopedia*. https://en.wikipedia.org/wiki/Remote_monitoring_and_management
Wikipedia. (n.d.-o). Xml. *Wikipedia, free encyclopedia*. https://en.wikipedia.org/wiki/XML

Appendix A

FD (Functional Design)