D2.4
CS-AWARE Framework

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Principal author:	Veronika Kupfersberger, University of Vienna, veronika.kupfersberger@univie.ac.at
Co-author(s)	N/A

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Executive Summary

This deliverable describes the CS-AWARE Framework by defining the relevant building blocks, as well as the interfaces and information flows between them. By outlining the high-level relations between the modules and how they will be designed a basis for further development and more detailed specifications in the upcoming work packages is provided, all in-line with the agile software development methods applied to this project.

The first step in developing the framework was to assess the current technical specifications and degrees of flexibility of the technologies to be used. Since all tools are developed by consortium partners there were no limitations detected. Nevertheless, it was essential to define general requirements for the CS-AWARE solution and how information is to be shared among the components and which data transformations might be required. This is described in the framework by using diagrams of various abstraction levels – beginning with a high-level overview of the main technology concepts and providing more detail in thematically differentiated levels. A three-layered division based on the modules' functions was chosen to more optimally visualise the framework and the respective relations: Data Extraction, Data Transformation and Data Provisioning.

To ensure all partners share a common understanding of the interactions between their technologies, the interface definitions were specified on a high-level basis, defining their subcomponents and data formats to be used. These details are described in the framework based on the I/P/O model, input – process – output, for each component individually.

The CS-AWARE Framework is to be considered a basis for all further project related software architecture and implementation efforts. It describes the main components

System Dependency Analysis, Data Collection, Data Pre-Processing, Data Analysis and Pattern Recognition, Multi-Language Support, Visualisation, Self-Healing and *Information Sharing*

and their relations

data flow, control flow and *guidance*.

One of the first aspects analysed for this framework were the relations between the components and what defines them. It became clear that while all can be summarized under the term 'information flow' they differ in content. The differentiation was made between data and control flow, where the first describe actual data transfer for analysis purposes and the latter conceptual and logical information which has influence on the execution of the receiving component. The last relation, that of guidance, represents a relation where one component has an extensive effect on another and how it is to be setup.

As with any IT related project, the chosen formats and guidelines represent the current state-of-the-art and may be subject to change. Should this be the case, these alterations will be reflected in the deliverables of WP3 or WP4.

1 Introduction

The CS-AWARE Framework is the fundament of the CS-AWARE solution and is based largely on the piloting workshops in the local public administrations (LPA) of Larissa and Rome and the resulting deliverable D2.1 (D2.1 System and dependency analysis (first iteration) – Cybersecurity requirements for local public administrations). The aim of the framework is to provide a unified understanding of which components interact with each other and in what way this interaction is made possible. The framework provides a high-level overview of the main components, most of which are represented by one of the consortium partners, as well as a more detailed view of the main subcomponents or processes each of them consist of. Additionally, the relations between these components are defined as well as, in the case of data flows, the data format in which the exchange takes place. The high-level nature of the framework was crucial, since some technical details will only be specifiable during the projects implementation phase reflected in the upcoming work packages and will be substantiated in D4.1.

The CS-AWARE Framework consists of an information flow model which is described in detail in the following chapter, as well as individual interface definitions for each of the components. The information flow model is explained on two levels of detail in this deliverable. The first is a high-level, abstract view on how each of the separate technology components cooperates with the others, which can be found in Section 2, and in what relation they stand to each other. This might be data flows or also logical control flows between the modules.

To facilitate further analysis, the detailed investigation into the appropriate connections was based on the ETL structured diagram. ETL stands for Extraction (Section 2.1), Transformation (Section 2.2) and Load and is a process most commonly used for database warehouses. Extract stands for the gathering of the data from various sources, transform for cleaning and manipulation of data to ensure integrity and completeness, load for transferring the data into its target space (Bansal & Kagemann, 2015). Since the CS-AWARE solution is evidently not a database warehouse, the final layer load was adjusted to better suit the frameworks nature and renamed Data Provisioning Layer (Section 2.3). In our case the division into layers will be mainly applied to facilitate the structuring of the following, more detailed diagrams of the subcomponents, processes and their interrelations.

The Data Extraction layer covers all components responsible for defining relevant data and extracting it, as well as the sources themselves. The System Dependency Analysis (Section 2.1.1 – 2.1.4) is where the analyst defines relevant sources and data necessary for monitoring the LPAs systems. This information is fed into the Data Collection module (Section 2.1.5) via a control flow, which then extracts the data accordingly.

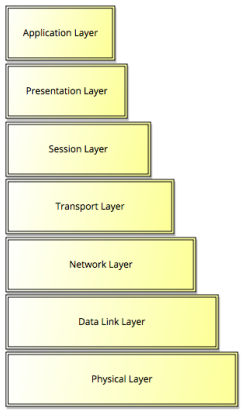


Figure 1 - ISO/OSI model

As will become clear in the detailed description of the LPA System Specific Sources (Section 2.1.3), the focus of the current design of CS-AWARE lies on layers 3,4 and 7, namely the Network, Transport as well as Application layers of the LPAs systems.

The Data Transformation layer summates all components tasked with transforming and analysing the data in some way. The first step is to filter and adapt the data as required before it can be, if necessary, run through the Natural Language Processing Information Extraction component (Section 2.2.1). The Data Analysis and Pattern Recognition (Section 2.2.3) and the Multi-Language Support module (Section 2.2.2) further process the data.

For visualising and sharing the detected incidents and data patterns, the Data Provisioning layer was defined. This is where all collected information is either visually presented to the end user (Section 2.3.1), shared with selected Information Sharing communities (Section 2.3.2) or used for Self-Healing Rule definition (Section 2.3.3). A complete overview of the three layers and all subcomponents can be found in Annex 1.

The Interface Definitions also remain high-level, defining data formats and schemas where possible, but leaving a degree of flexibility for allowing decisions to be made in the software development phase of this project. While the interfaces are fixed, the detailed data schema can in some cases only be defined during the development of the detailed software architecture. The approach chosen to present the CS-AWARE Framework interface specifications is based on the classical I/P/O - Input, Process, Output – model, where each component consists of as many input, process and output entities as is required.

For each component, all other building blocks providing data or control flows are summarized as inputs, including which data format they use. Additionally, each component has one or multiple processes or sub components that execute the respective logic of the module and are described in detail as well. Each sub process has inputting and outputting components. Finally, the output components are defined by the same information as the inputs; data format and which type of information flow they use.

In preparation of conceptualising the framework, various models and approaches were researched. In the end the CS-AWARE Framework was based on the information flows between the components. Nevertheless, it is in line with the NIST Cybersecurity Framework (NIST National Institute of Standards and Technology, 2015), which identifies five functions as its core: Identify, Protect, Detect, Respond and Recover. All five steps are covered by the CS-AWARE Framework, making it also compliant to the Italian Cyber Security Report, which is based on the NIST Framework (CINI Cyber Security National Laboratory, 2016).

2 Information Flow Model

The information flow model described in this deliverable is one of the key components in the final CS-AWARE Framework. It describes how each component is connected to the relevant other components as well as which type of relation they share. Based on this high-level overview of the CS-AWARE solution, the data formats and interfaces to be used in the framework were further specified.

The high-level version of the information flow model in Diagram 1 shows the interactions between the major technology modules of the CS-AWARE solution. Additionally, the type of the relations has been included, being either data or control flows, automated or manual. This visualisation also shows each of the layers, differentiating between the Data Extraction, the Transformation and the Provisioning components of CS-AWARE.

The first step in any implementation of the CS-AWARE solution is the analysis of the given LPA. For the pilot use cases this of course includes the primary evaluation of all Public Sources as well, which will be investigated thoroughly and selected for all LPA implementations homogenously. Information on these public sources will be kept up-to-date by CS-AWARE and new settings are distributed if required. During the pilot workshops, as described in D2.1, a set of LPA System Specific Sources which are generalizable, were determined.

After these sources are determined, this information is inserted into the System Dependency Analysis tool, which collects and represents interdependencies between entities. This information is then distributed among the other components, providing information on how and what to proceed - represented via control flows.

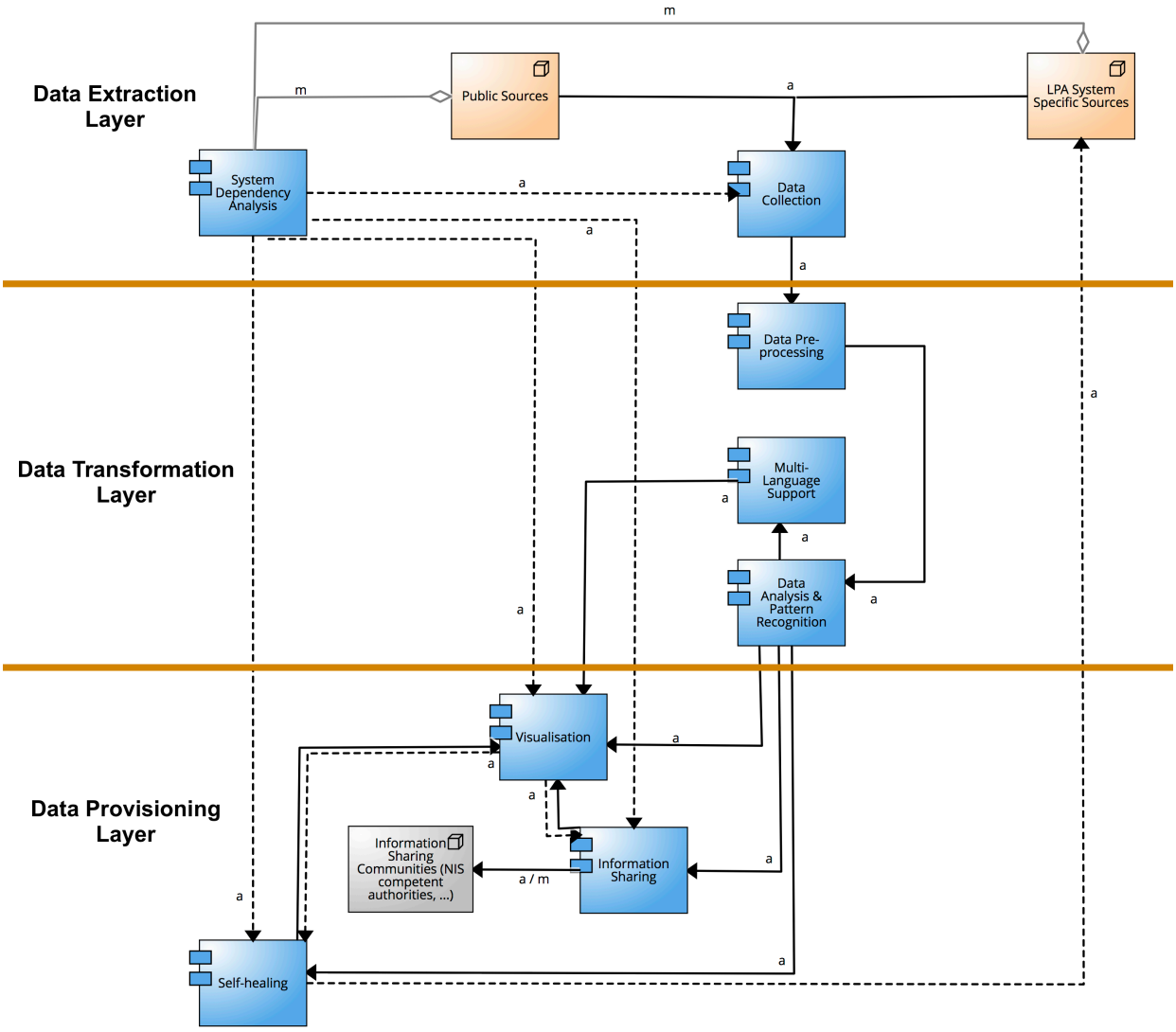


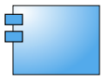
Diagram 1 - Overview Information Flow Model

Each of the tasks and relations that occur in any of the diagrams is explained in table 1.


External component


Manual tasks


External Information Sharing Communities


Subcomponents / Modules


Static data

Guides

conceptualization of one component is guided by composition of another


Data flow

data is transferred from one component to another

Control flow

logic and/or rules are initiated or defined by one component for another

Table 1 - Legend

The solid line represents the data flow that is being controlled by the outgoing component and the dotted line stands for information transmission from outgoing to the receiving component relevant to logical and or conceptual issues. This means that based on the information provided by the sending component, the receiving one adapts its settings and calibrations. The third relation represents that one component essentially guides the composition of another. Additionally, the manual ('**m**') as well as the automated ('**a**') connections are marked, each of which will be described in detail in the following chapters. One connection is described as semi-automated ('**a/m**') since the data being transmitted might require manual adaptations before sending.

The simple nature of the diagram offers an intuitive overview of the interaction between each of the components. Table 2 lists all high-level components which were identified to be the most relevant:

Component	Description
System Dependency Analysis	The System Dependency Analysis is performed by combining the Soft Systems Methodology and the GraphingWiki, resulting in a strategic implementation process for any Local Public Administration. Based on the pilot analyses, guidelines for future System Dependency Analyses will be developed.
Data Collection	The Data Collection component will be responsible for developing the data collectors for LPA System specific data as well as external sources.
Cybersecurity Information Exchange	This module is responsible for sharing information on detected attacks with authorities, according to the NIS regulations. The Cybersecurity Information Exchange will allow the user to individually authorize any transmission before it

	occurs.
Visualisation	The Visualisation component covers the final data manipulations required for graphically representing the collected information as well as the construction of the user interface.
Self-Healing	The Self-Healing component will receive information from the Data Analysis module and compose Security Rules based on the detected incident. These rules can then be applied to the LPA specific systems by the respective IT departments.
Data Pre-Processing	One of the pre-processing strategies is the Natural Language Processing for Information Extraction, which is a simplification process of textual information. This feature has been developed by the University of Passau and can be used to simplify collected data. Other possibilities would include the simple filtering of known irrelevant data or the transformation of data formats.
Multi-Language Support	Due to the European context of CS-AWARE, the final UI should include not only easily understandable visualisations but all text in either the native language of the end user or English.

Table 2 - Component Description

2.1 Data Extraction Layer

For each layer, diagrams were devised to further elaborate on the connections between the modules. As seen in Diagram 2, the extraction level is divided into the building blocks.

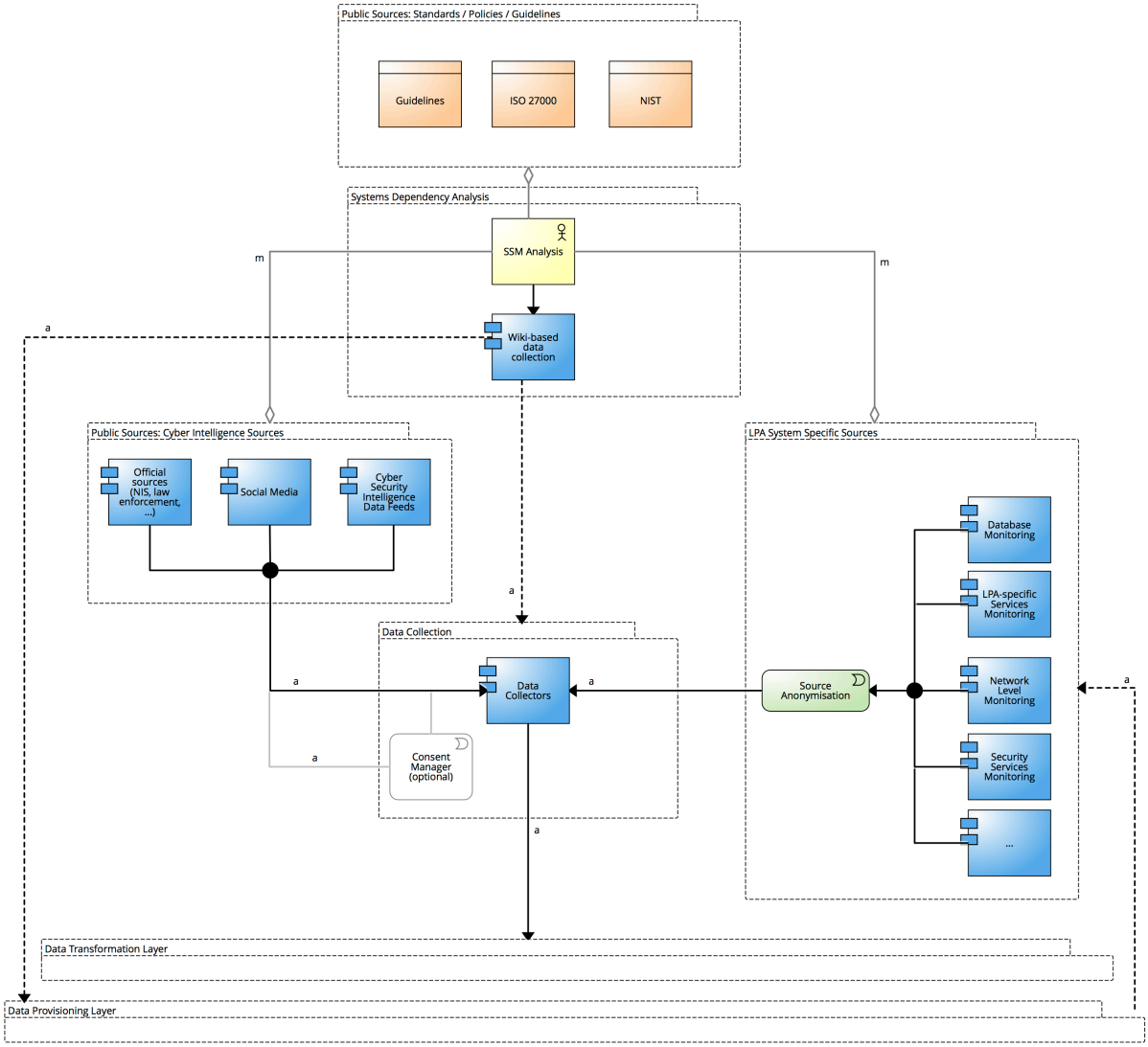


Diagram 2 - Data Extraction Layer

The Extraction layer combines the System Dependency Analysis, LPA System Specific and Public Sources, Guidelines and Policies as well as the Data Collection module. Their respective relationships to the other layers are only roughly represented in this diagram.

2.1.1 Soft Systems Analysis

This system component is the first step when implementing CS-AWARE. Using the Soft Systems Methodology, a method which aims to identify software issues by questioning their users directly and letting them visualise their views of the system using rich pictures (Checkland & Soles, 1990), the local public administrations' systems are analysed.

During the pilot first round of workshops in Rome and Larissa, the following questions proved to be most efficient to identify the most vulnerable components:

Define the critical applications

Without which data/ applications would the LPA not function?

- What are the backup capabilities of these applications?
- What are the existing monitoring systems for these applications?

Which monitoring systems are currently in place?

The System Dependency Analysis is strongly reliant on the analyst, in future either provided by the CS-AWARE team or an independent contractor. Not only the internal systems and the results of the workshop itself play a significant role but also public sources which will be selected during the pilot implementation of CS-AWARE and will be continually updated by the CS-AWARE team. The information collected by the analyst is inserted into the GraphingWiki, which allows a Dependency Graph representation, as well as a textual representation in JSON format, which will be used in multiple other components.

2.1.1.1 Standards, Policies and Guidelines

This component covers several different standards, policies and guidelines relevant to the Analysis phase as guiding principles for the analyst. The individual documents covered by this component may vary and will be regularly revised by the CS-AWARE team. The Guidelines mentioned are strategies for the analysis workshops identified during the pilot workshops, a summary of lines of questioning for directing the users in the correct direction as well as general principles of analysis. Policies and Standards will mostly cover judicial regulations or technical standards which need to be adhered to during the analysis process, such as the upcoming GDPR or NIS directive (General Data Protection Regulation, 2016) (Council, 2016).

It is assumed that the LPA in question has previously conducted a risk analysis and is aware of its main assets. One guideline to be used for such an analysis would be the BSI Catalogue (Federal Office for Information Security, 2017) should it not already have been conducted thus ensuring the compliance to Article 32 regarding the 'Security of Processing' of the GDPR (General Data Protection Regulation, 2016).

2.1.1.1.1 LPA System Specific Sources

As identified in the piloting Soft Systems Methodology workshops conducted in Larissa and Rome and described in deliverable D2.1, the most important LPA system specific sources are likely to be results of existing monitoring systems.

Database level

Depending on the LPA, their database structure will vary in size and complexity. Nevertheless, there are a few main database providers, which are most likely to be present in the LPAs. Such databases maintain logs on which users access what information and what is done to the data to guarantee access restriction and data integrity. These logs can be accessed by CS-AWARE and after anonymizing according to guidelines defined in deliverable 7.3 which is based on the GDPR standards, the data can be used and analysed for suspicious activities.

LPA-specific services level

This category covers the mission critical tools and services identified during the SSM workshops. While the responsibilities of an LPA are in general quite similar, each might have back-up strategies for different situations and/or services which another LPA might not. Identifying these critical services and implementing or activating monitoring functions is essential and will differ between the LPAs. Some of these systems might be handling citizen data and financial information or coordinate citizen or employee data, if either proves to be mission critical, it would be considered appropriate for constant monitoring. Many of these tools, as we discovered in the pilot workshops, already allow for monitoring of access and user interactions.

Network level

After identifying a single or at least main point of contact of all relevant and critical traffic, a possibility for monitoring said traffic must be identified. Usually routers offer such monitoring capabilities via built-in monitoring systems.

Security Services level

This level covers logs provided by any security appliance such as existing SIEM (Security Information and Event Management) systems, firewalls, Intrusion Protection Systems or Intrusion Detection Systems implemented by the LPA.

An additional potential source was identified but not included in the standard LPA system specific sources, namely the Client level, related to fleet management. The client level might not always be feasible to monitor. Nevertheless, it should be at least mentioned in the framework since it constitutes a major potential point of failure. Most successful attacks to an information system occur, as is commonly known, due to improper behaviour of users when using IT systems. Additionally, this component could potentially include the update status of the OS and any other relevant fleet management information that could be collected in the LPA.

The only requirement for the data format of these LPA system specific sources is that it must be textual, any other specifications are not yet determined and most likely will remain flexible. The most relevant aspect of internal data collection in LPAs is the anonymization of the data, which must occur at source. This is a process that is required by the EU for data protection purposes and will be implemented by the LPA individually with support by the CS-AWARE team and is specified in the CS-AWARE deliverable D7.3 and D7.4. This ensures the compliancy with the Article 25 of the EU GDPR (General Data Protection Regulation, 2016) that requires ‘Data Protection by Design and by Default’. This means that systems must be designed to protect data they handle as well as set all default settings to the most secure version.

Most fundamental LPA operations are similar so their systems can be expected to provide similar log results. 3rd Place will develop generalized data collectors, capable of collecting all relevant data after anonymization, which can be individually adapted according to the LPAs requirements and data structure.

While the actual information collected by the data collectors from the internal systems logs must be independently defined by the analyst before each individual CS-AWARE deployment, information on who accesses data at what time and for which purpose is likely to be essential. Therefore, it is advisable to consider the 5W1H model for questioning: who, what, where, when, why, and how? The sources selected during the System Dependency Analysis will provide data aimed at providing the answers to most of these questions.

2.1.1.2 Public Sources

As part of the conceptual phase of this project an analysis of potential information sources was conducted, results of which can be found in deliverable D2.1. Potential information sources in the following categories were identified.

NIS competent Authorities and Law Enforcement Agencies

Official sources include CERTs (Computer Emergency Response Team), CSIRTs (Computer Security Incident Response Team), Europol or other entities offering valuable information on cyber threats. These institutions offer selective information on cyber threats and will not only act as a source of information but also receive identified threats from CS-AWARE, thus complying to the NIS directive of the EU (Council, 2016), by the Information Sharing component. It is most likely that these sources will provide strategies, policies and guidelines for threat detection and prevention rather than raw data feeds. Nevertheless, these documents will provide meaningful guidelines for identifying and mitigating incidents and attacks.

Social Media and Cybersecurity visualisations

This information source is expected to result in early warnings on potential threats, albeit mostly unofficial. At the current point of development, it is most likely that CS-AWARE will commence with extracting data from two different Social Media platforms; Twitter and Reddit. Pre-defined keywords and/or users will limit the collected data and aim at ensuring high quality information.

Cyber Intelligence Sources and Information Sharing Tools (Open Source and Commercial), Cybersecurity Intelligence Data Feeds

This subcomponent covers not only the open source threat intelligence sources, but also commercial cyber security companies that collect relevant information. Some of the latter have been identified as using such data for their products and will be contacted by the consortium inquiring if a partnership and cooperation with this EU H2020 project would be of interest to them. While we aim at only utilizing open source data, this additional data would surely provide useful information, particularly during the development phase of CS-AWARE. The open source cyber intelligence data feeds that we came upon during the research for D2.1 all offer, as their name suggests, free and open data feeds.

Some sources offer their information as RSS feed, clear text files, while others provide APIs. The last group, the open source CTI sources, usually provide their information in STIX format via the TAXII mechanism. A more detailed description of the latter can be found in the chapter on data formats and transformations.

2.1.2 Data Collection

After the data sources have been identified and where necessary anonymized at source, the data collectors gather the resulting data. For the data collected from public sources, the framework has foreseen the optional implementation of a consent manager. This would allow citizens to contact CS-AWARE via the website and opt-out of their data being used for data analysis. An example for such a solution can be found at the SSIX project: **https://ssix-project.eu.** The necessity of such a consent manager will be evaluated in a later project phase.

2.2 Data Transformation Layer

This layer includes all components responsible for transforming the data in some way. All data used in this layer is provided by the Data Collection component in the Data Extraction layer.

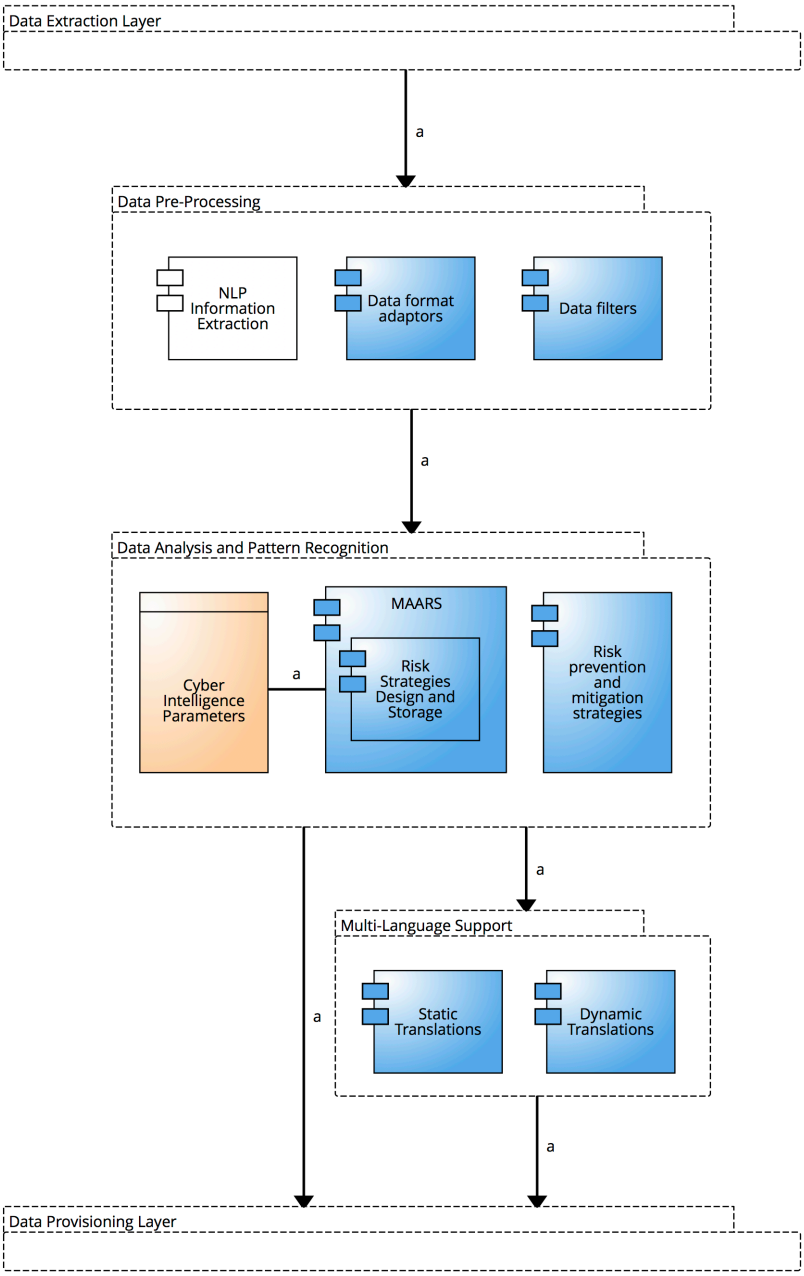


Diagram 3 - Data Transformation Layer

2.2.1 Data Pre-Processing

The Data Pre-processing step covers various methods which aim at structuring the data to a suitable format or excluding irrelevant information. This, of course, is only applicable for data that requires some sort of adaptation, all other data sets bypass the sub processes of this component. Additionally, these actions are required to optimize performance by constructing a more efficient data flow and limiting the amount of data passed on to the Data Analysis component. Currently, three main subcomponents have been identified: NLP Information Extraction, Filtering and Data adaptations, all of which are applied to the previously anonymized data. Natural Language Processing, provided by the University of Passau, will in this case be used to extract relevant information from a large data set. Due to the immense size of monitoring logs, information extraction and the consequential reduction of data will be advantageous. Another advantage is that this NLP information extraction process allows for information extraction from text in various languages, supporting the Multi-Language supporting characteristic of CS-AWARE. As

semantic interpretation requires large amounts of computational power, it is important to identify the exact use cases in which this module proves beneficial. The Filtering subcomponent covers the limitation of the original data set to the most useful information by simple filtering rules. It aims to ensure not all data is used by the data analysis component, thereby increasing cost and computation time.

Data adaptors will be used to transform any suboptimal data structure into a more preferential format for the data analysis component. Regarding data from cybersecurity related data feeds, this might be the adaptation of the actual data format or the transformation of STIX v1.x to its most recent version, currently STIX v2.0.

2.2.2 Multi-Language Support

This component, also provided by the University of Passau, will translate processed and analysed data before it is represented visually to the end user. This is mostly for usability purposes and will be applied to data depending on the type of visualisation deemed most optimal. An exemplary scenario would be to apply the automatic translation function to information from official governmental institutions, such as CERTs, and their recommendations for mitigating threats. The extent to which this function will be included in the final CS-AWARE solution will be tested and evaluated during the implementation phase in WP4.

Additionally, this component covers the provisioning of any standard translations required for the GUI, the graphical user interface.

2.2.3 Data Analysis and Pattern Recognition

The data analysis is a key feature of the final CS-AWARE solution and uses the MAARS technology by Peracton Ltd for automated cyber incident detection. The first step is to identify cyber incident parameters with which new information received by the component can be compared to. For this purpose, the MAARS algorithm, currently used for financial decision making support, will be adapted and applied to the cyber threat domain. In the end the appropriate risk handling recommendation, either added by CS-AWARE experts or collected automatically from official institutions such as CERTs, is selected and offered to the user.

2.3 Data Provisioning Layer

The data provisioning layer covers all components in which the transformed data is provided to an end user.

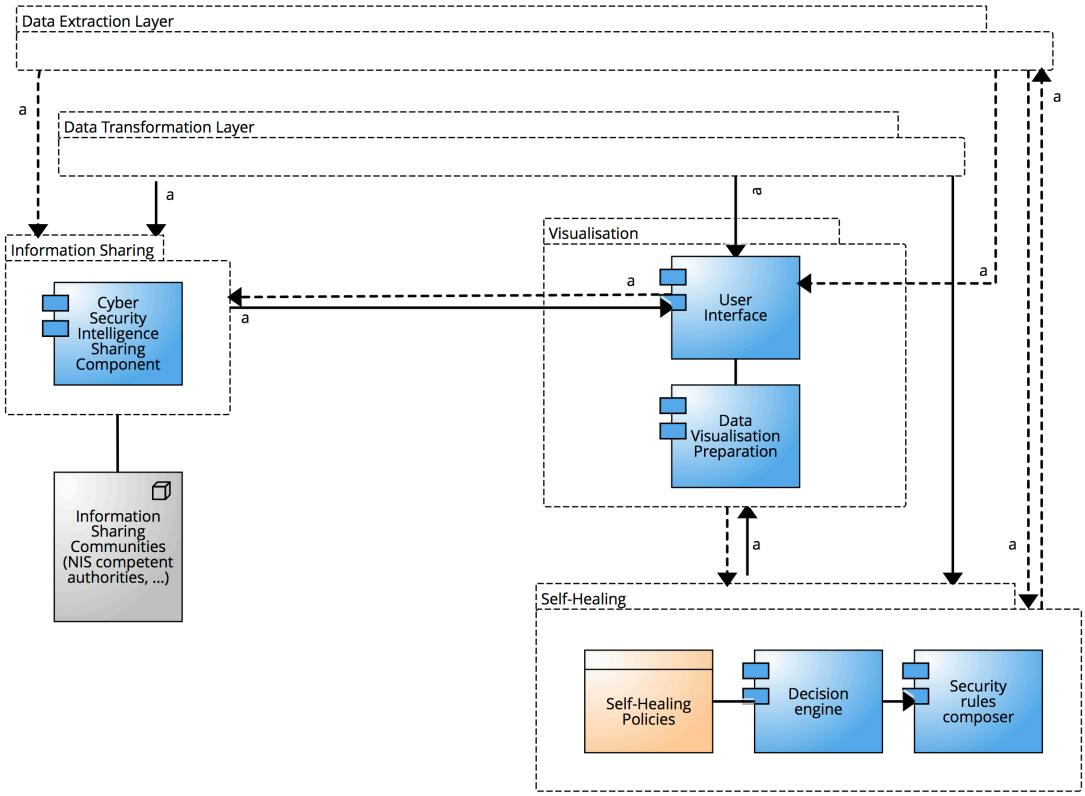


Diagram 4 - Data Provisioning Layer

2.3.1 Visualisation

This component is divided into two subcategories: the user interface and the data visualisation, both of which will be developed by CloudPartners.

The latter is responsible for formatting and preparing the data received from the Multi-Language Support and the Data Analysis and Pattern Recognition components for it to be presented to the end user. Next to these adaptations for presentation purposes, the main task of the Visualisation component is to, as the name suggests, visualise all output of CS-AWARE for the user. This does not only cover the analysis results, but also any administrative and reporting requirements. Part of the features available to administrative users is the opportunity to manage users and which rights they have. This will depend on their position in the company, employees from the IT department will require different function made available than those from the management level. Additionally, the administrative users will be able to import any information gathered in the GraphingWiki.

For LPA internal users the Visualisation component will make all relevant data available in a user-friendly and visually representable way. Also, it will provide updates on what can or should be shared with NIS competent authorities via the Information Sharing module as well as what steps should be taken to prevent attacks and mitigate incidents in the LPA's systems via the Self-Healing component. Both of which are described in more detail in the following subsections. Another vital part of this component is the triggering or authorization of above mentioned Self-Healing procedures and Information Sharing actions.

2.3.2 Information Sharing

This component covers the required sharing of detected cyber intelligence threat information with national institutions which are NIS competent authorities, so-called Computer Security Incident Response Teams (CSIRTs), in line with the Information Sharing requirements of the NIS directive

(Council, 2016). In today's cyber security threat intelligence community, the importance of sharing information is becoming more apparent. In accord to this trend, the sharing component of CS-AWARE will not only benefit each LPA individually but also the Data Analysis component and therefore the CS-AWARE community. Naturally, CS-AWARE will comply with appropriate source protection mechanisms, like anonymization of shared content according to the NIS and GDPR guidelines.

All data handled by the Information Sharing component will be exclusively in JSON format, following the STIX schema as closely as possible, both of which are described in more detail in the following chapter. This will ensure that receiving institutions and organizations can understand the information sent by CS-AWARE, as it follows a commonly used schema. The STIX-based objects will be sent via the TAXII protocol, details on which can also be found in the upcoming sections. As can be seen in the diagram, the Information Sharing component currently consists of one sub process, which is responsible for sharing the accumulated information.

2.3.3 Self-Healing

The Self-Healing component is responsible for matching the results of the Data Analysis module with data stored in the Self-Healing Policy subcomponent. This static index lists potential threats or incidents that might be detected by the Analysis module and the respective handling strategies. This is done in the decision engine, which initiates the composition of a rule if a match is found. These rules will be composed in a Security rules language comprehensible for the LPA to ensure they can be directly implemented. An example might be that based on the detected incident, an addition to the security appliance configurations, such as firewall policies is required. This alteration will be directly offered by the Self-Healing component to the user who can copy it to the settings with as little alterations required as possible. The subcomponent Self-Healing Policies module includes policies, context and authorisation information.

2.4 Data Storage

The diagrams of this framework focus on the dynamic flow of data and information between the components, excluding the static state of the data, the storage. Clearly, storage for each component is required both combined and individually, but the architecture to be applied has not yet been defined. One strategy is to centralize the data storage, allowing each component the read/write access it requires. In this case, each of the technologies is provided their logically separated space and access rights for the other components can be individually allocated, therefore ensuring every following component receives the data it requires.
The second strategy would be to de-centralize the data storage, where all technology providers are responsible for implementing and maintaining their own independent storage.
Both options will be evaluated based on their pros and cons and the final decision will be made during the software architecture development phase.

3 Interface Specifications and Data Transformations

3.1 Interface Specifications

The definition of the interfaces will facilitate future implementations of the CS-AWARE solution, and will therefore be required to follow a specified schema as shown in table 3.

Input	**Name of Component**
Source Module	Name of component
Data Format	Data format used by component
Description	must cover the following information: which type of incoming flow

Output	**Name of Component**
Destination Module	Name of component
Data Format	Data format used by component
Description	must cover the following information: which type of outgoing flow

Process	**Name of Process**
Module/s A	Name of input components
Module/s B	Name of output components
Process	Name of process
Definition	Description of what happens in this subcomponent
Data Input Format	Data format used by input component/s
Data Output Format	Data format used by output component/s

Table 3 - Interface Definition Schema

The interface definition schema was based on the classical I/P/O model, which is commonly used to describe processes by defining input, process and output. It was considered appropriate for this framework, since it allows to modularize inputs, processes and output and combine them flexibly to define one interface. In the following, each components' interfaces from the high-level overview framework diagram are specified by defining all input components, each subcomponent or process as described in the chapter before and finally all output components. Each building block of CS-AWARE can be described using 1..n inputs, 1…n outputs and 1…n processes. Additionally, this model directly and implicitly describes the data transformations necessary from the input to the appropriate outputs of each component.

3.1.1 System Dependency Analysis Interface Specification

Input	**Public Sources**
Source Module	Public Sources
Data Format	unstructured text
Description	manual analysis manual data flow

Input	**LPA System Specific Sources**
Source Module	LPA System Specific Sources
Data Format	unstructured text
Description	manual analysis manual data flow

Process	**SSM Analysis**
Module/s A	Input Public Sources Input LPA System Specific Sources
Module/s B	Process GraphingWiki
Process	SSM Analysis
Definition	LPA specific structures and systems as well as public sources are analysed and information on relevant data sources collected
Data Input Format	unstructured text
Data Output Format	unstructured text

Process	**Wiki-based data collection**
Module/s A	Process SSM Analysis
Module/s B	Output Self-Healing Output Information Sharing Output Visualisation Output Data Collection
Process	Wiki-based data collection
Definition	The information collected by the manual analysis is inserted in the GraphingWiki
Data Input Format	unstructured text
Data Output Format	JSON

Output	**Visualisation**
Destination Module	Visualisation
Data Format	

	JSON
Description	Information on what data to display automated control flow

Output	**Self-Healing**
Destination Module	Self-Healing
Data Format	JSON
Description	Definition of what can be healed and which authorization is required automated control flow

Output	**Information Sharing**
Destination Module	Information Sharing
Data Format	JSON
Description	automated control flow

Output	**Data Collection**
Destination Module	Data Collection
Data Format	JSON
Description	automated control flow

Table 4 - System Dependency Analysis Interface Specification

As can be seen in table 4, the System Dependency Analysis has two input components: Public Sources and LPA System Specific Sources. These two components guide the Soft Systems Methodology (SSM) Analysis process which is an essential part of the System Dependency Analysis. The analyst conducts a thorough analysis of the LPA specific systems and their properties as well as reviews the settings for the Public Sources data extraction. In the case of the System Dependency Analysis, one sub process directly triggers the next, where the analyst inserts all collected information into the GraphingWiki. This tool produces a visualisation of the dependencies of the analysed sources and the respective information they provide and is the basis for the LPA specific CS-AWARE implementation. As can be seen in Table 4, the output format of the dependency graph is a JSON file, which will be imported into the output components. The relationship to each of the output components is a semi-automated control flow, since the main purpose of the transferred JSON file is not to transmit data but control the logic and structure of the receiving component and must be manually triggered in the GraphingWiki.

3.1.2 Data Collection Interface Specification

Input	**Public Sources**
Source Module	Public Sources
Data Format	flexible format – no specification
Description	automated data flow

Input	**LPA System Specific Sources**
Source Module	LPA System Specific Sources
Data Format	flexible format – no specification
Description	automated data flow

Input	**System Dependency Analysis**
Destination Module	System Dependency Analysis
Data Format	JSON
Description	information on which sources to collect from and what data to collect automated control flow

Process	**Data Collection**
Module/s A	Input System Dependency Analysis Input Public Sources Input LPA System Specific Sources
Module/s B	Process Data Storing
Process	Data Collection
Definition	Data collected from public and internal sources as directed by results from System Dependency Analysis
Data Input Format	flexible format – no specification
Data Output Format	flexible format – no specification

Output	**Data Pre-Processing**
Destination Module	Data Pre-Processing
Data Format	flexible format – no specification
Description	all source-anonymized data automated data flow

Table 5 - Data Collection Interface Specification

The Data Collection component is responsible for retrieving data as is described in table 5. The components' extraction is defined by the information imported from the System Dependency Analysis.

Various data collectors will gather information from multiple sources before it is pre-processed by the subsequent component. Since the sources and their formats may vary, it was essential to remain flexible at this point in the data manipulation process. Therefore, there was no specification made on which data format must be used for the Data Collection. Based on the analysis conducted for deliverable D2.1 we can assume that the most commonly provided data formats will be JSON, CSV or unstructured text.

3.1.3 Data Pre-Processing Interface Specification

Input	**Data Collection**
Source Module	Data Collection
Data Format	flexible format – no specification
Description	all anonymized data automated data flow

Process	**NLP Information Extraction**
Module/s A	Input Data Collection
Module/s B	Output Data Analysis and Pattern Recognition
Process	NLP Information Extraction
Definition	Large text corpora collected can be reduced by applying natural language processing and thereby extracting information.
Data Input Format	JSON
Data Output Format	JSON

Process	**Filtering**
Module/s A	Input Data Collection
Module/s B	Output Data Analysis and Pattern Recognition
Process	Filtering
Definition	Data extracted by data collectors is run through filters to reduce amount of data analysed by the Data Analysis component.
Data Input Format	flexible format – no specification
Data Output Format	JSON

Process	**Data Adaptation**
Module/s A	

	Input Data Collection
Module/s B	Process NLP Information Extraction Output Data Analysis and Pattern Recognition
Process	Process Data Adaptation
Definition	Since the collected data is gathered from multiple sources there might be the necessity of adapting formats or schemas for further analysis. This is done in the Data Adaptation process component.
Data Input Format	flexible format – no specification
Data Output Format	JSON

Output	**Data Analysis and Pattern Recognition**
Destination Module	Data Analysis and Pattern Recognition
Data Format	JSON
Description	automated data flow

Table 6 - Data Pre-Processing Interface Specification

As can be seen in table 6, the Data Pre-Processing component receives the data collected and transforms it as required. While the Natural Language Processing process requires JSON as input format, there are no such requirements for any other subcomponents. To enable the NLP Information Extraction, the relevant data is transformed into JSON and only then used for NLP purposes. The rest of the data can be filtered as required, making sure that no irrelevant information is passed on to the Data Analysis component, to avoid unnecessary waste of time and costs. Any format transformation required by either the Data Analysis, the Visualisation or the Multi-Language component will be undertaken as part of the Data Adaptation subcomponent as well. Since the exact data formats made available by the sources is not yet clear, the definite transformation required cannot be determined either.

3.1.4 Data Analysis and Pattern Recognition Interface Specification

Input	**Cyber Intelligence Parameters**
Source Module	Cyber Intelligence Parameters
Data Format	JSON
Description	automated data flow

Input	**Data Pre-Processing**
Source Module	Data Pre-Processing
Data Format	JSON

Description	automated data flow

Process	**Risk Strategies and Design**
Module/s A	Input Cyber Intelligence Parameters Input Data Pre-processing
Module/s B	Process Risk prevention and mitigation strategies Output Information Sharing Output Self-Healing Output Multi-Language Support Output Visualisation
Process	Risk Strategies and Design
Definition	Compares data with cyber intelligence parameters
Data Input Format	JSON
Data Output Format	JSON

Process	**Risk prevention and mitigation strategies**
Module/s A	Process Risk Strategies and Design Input Data Pre-processing
Module/s B	Output Information Sharing Output Self-Healing Output Multi-Language Support Output Visualisation
Process	Risk prevention and mitigation strategies
Definition	Compares results of analysis with possible prevention and mitigation strategies
Data Input Format	JSON
Data Output Format	JSON

Output	**Multi-Language Support**
Destination Module	Multi-Language Support
Data Format	JSON
Description	automated data flow

Output	**Visualisation**
Destination Module	Visualisation
Data Format	JSON
Description	automated data flow

Output	Information Sharing
Destination Module	Information Sharing
Data Format	JSON
Description	automated data flow

Output	Self-Healing
Destination Module	Self-Healing
Data Format	JSON
Description	automated data flow

Table 7 - Data Analysis and Pattern Recognition Interface Specification

As shown in table 7, the Data Analysis and Pattern Recognition component is responsible for comparing the data with predefined parameters of cyber incidents and detect any suspicious occurrences. This is done in the MAARS component by using the Risk Strategies Design and Storage subcomponent. Risk prevention and mitigation strategies is where the detected incidents are matched and the resulting actions listed. This way the Data Analysis module triggers the correct steps and alerts the right components in the CS-AWARE solution.

3.1.5 Multi-Language Support Interface Specification

Input	**Data Analysis and Pattern Recognition**
Source Module	Data Analysis and Pattern Recognition
Data Format	JSON
Description	automated data flow

Process	**Dynamic Translations**
Module/s A	Input Data Analysis and Pattern Recognition
Module/s B	Output Data Visualization
Process	Dynamic Translations
Definition	The results from the data analysis and pattern recognition are analysed and translated, if required, into the native language of the user
Data Input Format	JSON
Data Output Format	JSON

Process	**Static Translations**
Module/s A	Input Data Analysis and Pattern Recognition
Module/s B	Output Data Visualisation
Process	Static Translations
Definition	Static text used in the GUI is translated manually beforehand and offered to the Visualisation component when required.
Data Input Format	JSON
Data Output Format	JSON

Output	**Visualisation**
Destination Module	Visualisation
Data Format	JSON
Description	automated data flow

Table 8 - Multi-Language Support Interface Specification

The Multi-Language Support component summarized in table 8, translates text into the LPA specific language if required and offers standard text for the graphical user interface in the appropriate language. This is a feature that will be used mostly for recommendations on mitigation and prevention strategies, which will be presented to the users depending on which incident was detected. For this

project, the two national languages of the piloting countries, Italian and Greek, will be made available in addition to the English vocabulary.

3.1.6 Visualisation Interface Specification

Input	**Data Analysis and Pattern Recognition**
Source Module	Data Analysis and Pattern Recognition
Data Format	JSON
Description	automated data flow

Input	**Multi-Language Support**
Source Module	Multi-Language Support
Data Format	JSON
Description	automated data flow

Input	**System Dependency Analysis**
Source Module	System Dependency Analysis
Data Format	JSON
Description	what to display and how automated control flow

Input	**Self-Healing**
Source Module	Self-Healing
Data Format	JSON
Description	automated data flow

Input	**Information Sharing**
Source Module	Information Sharing
Data Format	JSON
Description	automated data flow

Process	**User Interface**
Module/s A	Input Data Analysis and Pattern Recognition Input System Dependency Analysis
Module/s B	Output Self-Healing Output Information Sharing
Process	User Interface
Definition	This component visualises the results of the data analysis as well as all data which the analysts in the System Dependency Analysis decided

	should be presented to the user
Data Input Format	JSON
Data Output Format	JSON

Process	**Data Visualisation**
Module/s A	Input System Dependency Analysis Input Self-Healing Input Information Sharing Input Data Analysis and Pattern Recognition
Module/s B	Output Self-Healing Output Information Sharing
Process	Data Visualisation
Definition	This component covers the preparation of the data required to visually represent it optimally
Data Input Format	JSON
Data Output Format	JSON

Output	**Information Sharing**
Destination Module	Information Sharing
Data Format	JSON
Description	automated control flow

Output	**Self-Healing**
Destination Module	Self-Healing
Data Format	JSON
Description	automated control flow

Table 9 - Visualisation Interface Specification

The Visualisation component displayed in table 9 combines all the insights and data generated and analysed by the other components and visualises them for the end user. As mentioned in the chapter before, this component combines two sub processes; the User Interface and the Data Visualisation. The first will most likely be divided based on the end users' rights, offering different features to the Soft Systems Methodology analyst, the IT department of the LPA and an administrative or managerial employee. The Data Visualisation sub process will be responsible for providing useful, visually appealing and user-friendly data representations and actionable recommendations for mitigation and attack prevention purposes.

3.1.7 Self-Healing Interface Specification

Input	**System Dependency Analysis**
Source Module	System Dependency Analysis
Data Format	JSON
Description	automated control flow

Input	**Visualisation**
Source Module	Visualisation
Data Format	JSON
Description	automated control flow

Input	**Data Analysis and Pattern Recognition**
Source Module	Data Analysis and Pattern Recognition
Data Format	JSON
Description	automated data flow

Process	**Decision Engine**
Module/s A	Input Data Analysis and Pattern Recognition Input Self-Healing Policies Input System Dependency Analysis Input Visualisation
Module/s B	Process Security Rules Composer
Process	Process Decision Engine
Definition	The Decision Engine matching algorithm compares policies with detected threats and initiates required rule composition
Data Input Format	JSON
Data Output Format	JSON

Process	**Security Rules Composer**
Module/s A	Process Decision Engine
Module/s B	Output LPA System Specific Sources Output Visualisation
Process	Self-Healing Policies
Definition	

	The Security Rules Composer constructs rules based on the detected threats and the given LPAs systems. The rules are composed in such a way, that the IT department need only to implement it.
Data Input Format	JSON
Data Output Format	JSON

Output	**Visualisation**
Destination Module	Visualisation
Data Format	JSON, any required technical language
Description	manual data flow

Output	**LPA System Specific Sources**
Destination Module	LPA System Specific Sources
Data Format	any required technical language
Description	automated control flow

Table 10 - Self-Healing Interface Specification

The Self-Healing component shown in table 10 receives insights from the Data Analysis module and guidelines on what to do with which type of situation from the System Dependency Analysis component. The sub process triggered by the received data, the Decision Engine, compares the new data with the listed Self-Healing Policies and in case of a match triggers the Security Rules Composer process. This process builds a directly implementable rule in a technical language used by the LPA, which can be instantly used by the IT department. This rule is then shown to the end user via the Visualisation component and might, at some point, allow for user input to trigger the automatic implementation of said rule in the LPAs system via the Self-Healing module.

3.1.8 Information Sharing Interface Specification

Input	**Data Analysis and Pattern Recognition**
Source Module	Data Analysis and Pattern Recognition
Data Format	JSON
Description	automated data flow

Input	**Visualisation**
Source Module	Visualisation
Data Format	JSON
Description	automated control flow authorization of sharing of information

Input	**System Dependency Analysis**
Source Module	System Dependency Analysis
Data Format	JSON
Description	automated control flow Information on selected Information sharing communities

Process	**Information Sharing**
Module/s A	Input Data Analysis and Pattern Recognition Input System Dependency Analysis Input Visualisation
Module/s B	Output Information Sharing Community Output Visualisation
Process	Information Sharing
Definition	This subcomponent is responsible for distributing identified threats among the selected Information Sharing communities
Data Input Format	JSON
Data Output Format	JSON

Output	**Visualisation**
Destination Module	Visualisation
Data Format	JSON
Description	automated data flow

Output	**Information Sharing Community**
Destination Module	Information Sharing Community

Data Format	JSON
Description	automated or manual data flow

Table 11 - Information Sharing Interface Specification

The Information Sharing module describe in table 11 is responsible for forwarding detected threats to handpicked Information Sharing communities. These might be national NIS competent authorities such as CERTs/CSIRTs or individually selected Cyber Intelligence Sharing communities. Naturally, such a distribution of information would only occur with direct authorization from the LPA and after anonymization in accordance to the guidelines defined in D7.3 and D7.4

3.2 Data Formats and Transformations

Due to the large number of different sources the Data Pre-Processing component will be required to transform any incoming data format to JSON. The JavaScript Object Notation, JSON, is a standardized format for data-interchange and is state of the art in information system technology (Introducing JSON, 2017). One of the many benefits is that it is not only machine-readable but also humans can easily comprehend the structure and the transferred information. JSON is currently already the most commonly used notation for data exchange and the preferred data format of most CS-AWARE technical partners.

For the distribution of detected cyber incidents, the STIX schema and TAXII protocol will be used. STIX stands for Structured Threat Information Expression and is a JSON schema of rapidly growing importance for cyber intelligence threat description purposes (OASIS Open, 2017). It allows institutions to share information on detected threats more easily, due to a standardized format. STIX is structured using twelve Domain Objects:

Attack Pattern, Campaign, Course of Action, Identity, Indicator, Intrusion Set, Malware, Observed Data, Report, Threat Actor, Tool and Vulnerability

as well as two Relationship Objects:

Relationship, Sighting.

Objects and relationships can now describe any cyber threat identified by an observer in JSON format, which can be easily shared with other institutions using the TAXII standard. TAXII, Trusted Automated eXchange of Indicator Information, is an "*open transport mechanism that standardizes the automated exchange of cyber threat information*" (MITRE Corporation, 2017).

Any information generated by a CS-AWARE instance that leaves its originating location either to provide information to other CS-AWARE instances or a NIS national authority will be using the STIX and TAXII protocols. CS-AWARE ensures that all hardware and software used for any of the components are state of the art. Communication between each of the modules will be via SFTP/SHTTP and via SSL encryption, therefore ensuring data security in transport to the CS-AWARE servers.

4 References

Bansal, S. K., & Kagemann, S. (2015). Integrating big data: A semantic extract-transform-load framework. *Computer, 48*(3), 42-50.

BSI. (2016, January). *IT-Grundschutz*. Retrieved May 28, 2017, from Bundesamt für Sicherheit in der Informationstechnik: https://www.bsi.bund.de/DE/Themen/ITGrundschutz/ITGrundschutzKataloge/itgrundschutzkataloge_node.html

Checkland, P., & Soles, J. (1990). *Soft Systems Methodology in Action.* Chichester: John Wiley & Sons Ltd.

CINI Cyber Security National Laboratory. (2016). *Italian Cyber Security Report 2015 – A National Cyber Security Framework.*

Council, E. P. (2016). Directive (EU) 2016/1148 of the European Parliament and of the Council. *Official Journal of the European Union*, 1-30.

ENISA. (2014). *EP3R 2010-2013 - Four Years of Pan-European Public Private Cooperation.* Athens: ENISA.

Federal Office for Information Security. (2017). *The BSI*. Retrieved January 2, 2018, from https://www.bsi.bund.de/EN/TheBSI/thebsi_node.html

General Data Protection Regulation. (2016). Regulation, General Data Protection. "Regulation (EU) 2016/679 of the European Parliament and of the Council of 27 April 2016 on the protection of natural persons with regard to the processing of personal data and on the free movement of such data, and repealing Directive 95/46. *Official Journal of the European Union, 59*, 1-88.

Introducing JSON. (2017). Retrieved January 29, 2018, from json.org: http://json.org

MITRE Corporation. (2017). *TAXII Project*. Retrieved January 3, 2018, from http://taxiiproject.github.io/about/

NIST National Institute of Standards and Technology. (2015). *Framework for Improving Critical Infrastructure Cybersecurity.* NIST.

OASIS Open. (2017). *STIX*. Retrieved January 3, 2018, from cti-documentation: https://oasis-open.github.io/cti-documentation/

Zimmermann, H. (1980). OSI reference model -- The ISO model of architecture for open systems interconnection. *IEEE Transactions on communications*, 425-432.