beAWARE

Enhancing decision support and management services in extreme weather climate events

700475

D7.2

System requirements and architecture

Dissemination level:	Public
Contractual date of delivery:	Month 10, 31 October 2017
Actual date of delivery:	Month 10, 31 October 2017
Workpackage:	WP 7: System development, integration and evaluation
Task:	T7.1 - System Requirements and Architecture
Type:	Report
Approval Status:	Final Draft
Version:	1.0
Number of pages:	52
Filename:	D7.2_ System_Requirements_and_Architecture _2017-10-31_v1.0.pdf

Abstract

The main goal of this document is to explain in detail the architecture of the proposed platform including main requirements driving it and the way the proposed design will enable achieving the ambitious goals set out at the proposal.

Co-funded by the European Union

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 700475

Document History

Version	Date	Comments
V0.1	25/02/2017	Initial version and assignments distribution
V0.2	10/09/17	Second version with skeleton information within
V0.3	07/10/17	Incorporate information from MSIL, PLV, FBBR, HRT
V0.4	15/10/17	Incorporate information from UPF, CERTH
V0.5	20/10/17	Incorporate information from AAWA, including review suggestions
V0.6	24/10/17	Incorporate information from HRT, including review suggestions
V1.0	31/10/2017	Consolidate a final version

Author list

Organisation	Name	Contact Information
IBM	Benny Mandler	MANDLER@il.ibm.com
CERTH	Anastasios Karakostas	akarakos@iti.gr
CERTH	Stefanos Vrochidis	stefanos@iti.gr
CERTH	Dimitris Liparas	dliparas@iti.gr
CERTH	Kostas Avgerinakis	koafgeri@iti.gr
UPF	Stamatia Dasiopoulou	stamatia.dasiopoulou@upf.edu
MSIL	Yaniv Mordechai	yaniv.mordecai@motorolasolutions.com
PLV	rubenbleda@gmail.com	Rubén Fernández
FBBR	amjan@fbbr.dk	Amalie Janniche Baneborg
HRT	m.meliadis@hrt.org.gr	Miltiadis Meliadis
HRT	Iosif Vourvachis	projects@hrt.org.gr
IOSB	Moßgraber Jürgen	juergen.mossgraber@iosb.fraunhofer.de
IOSB	Hylke van der Schaaf	hylke.vanderschaaf@iosb.fraunhofer.de
IOSB	Philipp Hertweck	philipp.hertweck@iosb.fraunhofer.de
AAWA	Daniele Norbiato	daniele.norbiato@adbve.it

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 700475

Executive Summary

This deliverable brings forth the main systems requirements as they were gathered using the use case requirement as a starting point. Building on top of the requirements, the system architecture is depicted. The architecture is devised from the core services making up the system, along with infrastructure services that enable the core services to perform their main task. A few exemplary flows through the system are provided to better illustrate the connection between the different components and provide an initial glimpse as to the combined capabilities of the system. Finally, a brief description of the use cases and the way they relate to the requirements and architecture presented herein is provided.

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 700475

Abbreviations and Acronyms

API	Application Programming Interface
ASR	Automatic Speech Recognition
CI	Continuous Integration
DTr	dynamic texture recognition
DTstL	Dynamic Texture spatio-temporal localization
GUI	Graphical User Interface
IoT	Internet of Things
ISO	International Organization for Standardization
JSON	JavaScript Object Notation
K8s	Kubernetes
KB	Knowledge Base beAWARE component
M2M	Machine-to-machine
ObjD	object detection
OGC	The Open Geospatial Consortium
PaaS	Platform as a Service
PSAP	Public-safety answering point
SOA	Service-oriented architecture
STL	Spatio-Temporal localization
TLc	traffic level classification
WP	Work Package

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 700475

Glossary

- BlueMix – a public cloud hosting platform provided by IBM
- Cloud Foundry – an open and extensible Platform as a Service offering
- Consumable - Designing an easy to use product
- Mongo DB – Scalable document oriented NoSQL data store
- ElasticSearch - high-performance indexing and search system that can be integrated with the CouchBase scalable data back-end.
- External applications – Independent applications that are developed and hosted outside the platform but internally make use of beAWARE components.
- JSON - (JavaScript Object Notation) is a lightweight data-interchange format often used in web applications
- Kafka – A messaging middleware mostly used to connect between different components
- Kubernetes – Containers orchestration service: an open-source system for automating deployment, scaling, and managing containerized applications.
- OASIS – standardization body: advancing open standards for the information society
- OWL - The Web Ontology Language is a family of knowledge representation languages for authoring ontologies
- Platform-as-a-Service - a cloud computing concept which offers the developer and deployer of cloud based applications the infrastructure, both HW and middleware, needed for creating and deploying successfully such applications on a cloud environment.
- PSAP – Command and control centre to serve authorities, first responders, and citizens, mainly during crisis situations
- RDF - A standard model for data interchange on the Web. Used in beAWARE for storing entities description in a searchable manner.
- RESTful service – A web service adhering to the REST protocol for information exchange among services, specifying the operations and associated data payload.
- SPARQL – an RDF query language.
- WebSockets – Communication protocol providing full-duplex communications channels over a single TCP connection; used for bi-directional communication between the beAWARE platform and applications.

This project has received funding from the European Union’s Horizon 2020 research and innovation program under grant agreement No 700475

Table of Contents

This project has received funding from the European Union’s Horizon 2020 research and innovation program under grant agreement No 700475

List of Figures

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 700475

List of Tables

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 700475

Introduction

The beAWARE project aims to perform research leading to the development of a system that supports handling of weather related crisis events. The envisioned system covers areas of a crisis lifecycle taking place in the past, present, and future. Namely, there are provisions and components that help with the forecast of future events, there are components that help to provide a current accurate understanding of the crisis event at hand and help handling the event. Finally, there are components that accumulate knowledge of past events to help handling future events, as such beAWARE can be viewed as a learning platform which makes use of knowledge from previous incidents to help respond better to a current incident.

The system main stakeholders are authorities that manage crisis events. In addition, first responders and citizens are important stakeholders, mainly by providing input to the system that helps to understand the current situation, and by receiving information and instructions from the authorities.

The main goal of this document is to explain in detail the architecture of the proposed platform including main requirements driving it and the way the proposed design will enable achieving the ambitious goals set out at the proposal. This document was devised and written with the requirements document (D2.1 - Use cases and initial user requirements) in mind.

This deliverable describes the design, intended use, and validation of various aspects of the project, via the use cases. This document describes the main components along with the interactions among them. An iterative approach led to this version of the document, after laying out the foundations early on and fleshing in more details as the implementation and understanding has advanced and matured.

In this document, we start from fleshing out the main system requirements stemming from the use cases requirements. Based on that, a high-level description of the architecture is proposed, followed by and delving into more detailed explanation of the different components, and the interactions thereof. In addition, the main ideas and interactions are demonstrated through the introduction of the platform as viewed by the main stakeholders, as well as by mapping the intended use-cases to the proposed architecture.

This project has received funding from the European Union’s Horizon 2020 research and innovation program under grant agreement No 700475

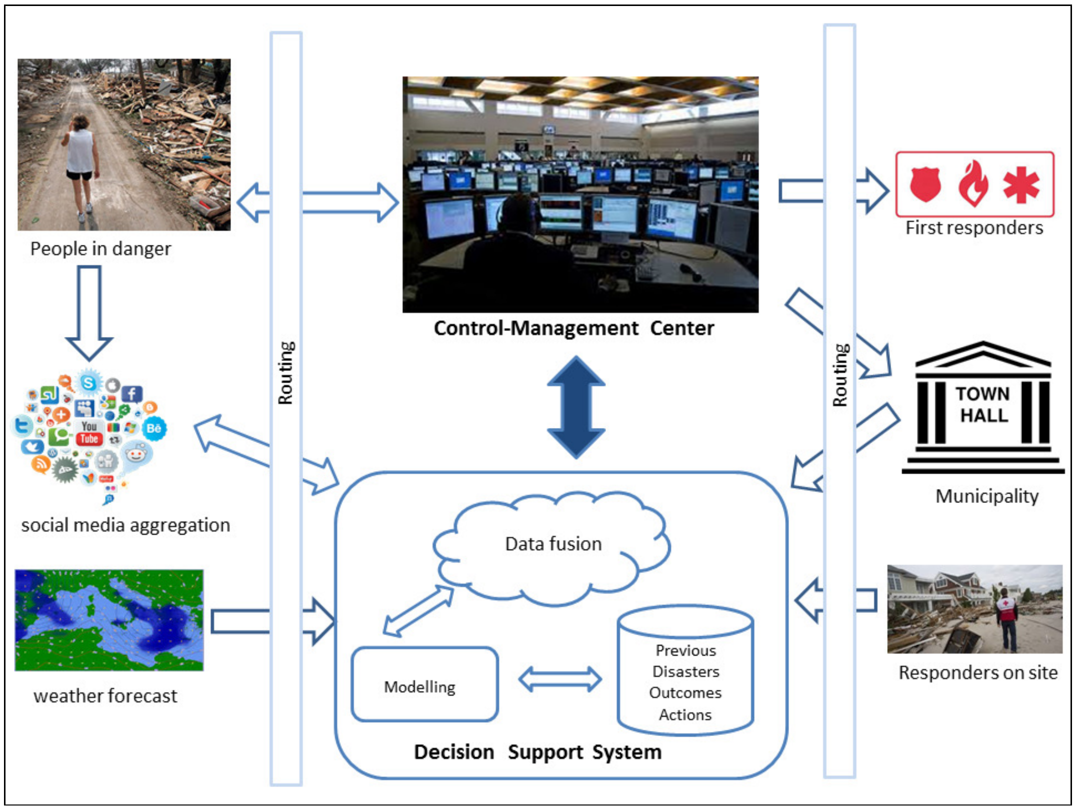


Figure 1: High Level View

1.1 Major System requirements

beAWARE aims to provide a wide range of capabilities to different stakeholders. Thus, the system requirements elicitation process was stages and took into consideration the points of view of the major stakeholders. The process began with a thorough exploration of the use cases and their requirements, as the use cases are the representatives of the scenarios that the beAWARE system strives to support. As this is a use case driven project, the first stage was to understand the use case scenarios and their requirements, and during the project lifetime the use cases will serve as a sanity check for the overall design of the system and its components, and finally to validate that the system built serves its purpose. Once the use case requirements were in place, a process of generating corresponding system requirements began, with a summary of the findings enclosed below, and a more detailed view can be found in Appendix 1.

The most prominent of the beAWARE non-functional related requirements leading to the presented architecture is that of consumability, namely making the system easy to interact with external entities. This requirement drives the way in which internal components are designed and operate, with as much automation, and multi-modal semantic support starting from the provided services, all the way to the design and deployment of the run-time hosting the platform.

The beAWARE system is required to support the submission and analysis of various kinds of media: such as audio, video, and text. Input into the system is expected in a variety of modalities, and the system is required to understand the different formats, and be able to deduce useful and relevant information out of the raw data flowing in from various sources.

The requirements for usability and multi-modal support lead immediately to the requirements set around semantics support. The platform intends to semantically enhance in a guided or an

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 700475

automated manner to the extent possible, information concerning the different entities residing in the system, starting from incoming data while augmenting past derived knowledge.

Location information is of essence to beAWARE kinds of scenarios, thus it is expected that the system will be able to work with geo-location information.

As the system is to be deployed in various countries, speaking different languages, it is expected that the system will support both input and output in a variety of languages. That support is expected both for text and audio based data.

One of the input sources to beAWARE consists of a variety of IoT devices, thus the system should be able to ingest, process, store, and act upon incoming IoT data, and make it available to additional components upon need.

The system is required to support bi-directional communication with the authorities on the one hand and citizens and first responders on the other hand. The mode if interaction of citizens and first responders with the system shall be different. The app itself through which the interaction shall take place shall be different, and internally the system treats incoming information differently based on the information source.

Since beAWARE intends to support a large amount of entities and data, scalability of the platform is important. The communication infrastructure employed to connect and provide services to different entities running within the platform, along with a scalable data management component are of essence.

The flow of control and data within the system requires interaction between different system components operating independently. Thus, there needs to be a way for components to interact with each other, and alert other interesting components of interesting events that have taken place. In essence, some of the main flows within beAWARE are event based. Thus, there needs to be a way for components to notify other components of such events. Since the system is distributed in development and deployment it calls for a non-monolithic approach, and for a manner of interaction which does not call for tight coupling between components. These are the requirements behind the microservices approach and the message bus at the centre of the system, which implements the publish / subscribe mode of interaction.

A comprehensive description of the beAWARE requirements can be found in deliverables coming out of WP2 (mainly D2.1). A detailed extraction of gathered system requirements can be found in Appendix 1.

Table 1: Summary: Requirements - Architecture mapping

Requirement	**Respective architectural element**
Consumability / usability	End-user applications; report generation
Support submission and analysis of different kinds of media: audio, video, text, tweets	End-user applications, analysis components
Information extraction	Various analytics modules
Semantic support	Registry; multi-modal analysis
Data processing / management	Offline and online data processing
Communicate position information	End-user applications; PSAP
Multilingual support	Data processing; report generation, end-user applications
Dynamic data sharing	Cloud service bus; central data repository

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 700475

Notifications among system components	Cloud service bus
IoT data ingestion and processing	IoT and data ingestion and processing
Bi-Directional communication with the authorities	PSAP, report generation, crisis classification, end-user applications
Distribute notification to the public	PSAP, Report generation, end-user applications
Scalability	Run-time; cloud service bus; data management

2 Architecture High Level View

The forming architecture is formulated with the ultimate goal of providing accuracy and functionality for decision support systems to be able to respond well to weather related disaster scenarios.

The architecture is roughly made up of the following layers:

1. **Ingestion** layer, containing mechanisms and channels through which data is brought into the platform;
2. **Internal services layer**, is comprised of a set of technical capabilities which are consumed by different system components. This layer includes services such as generic data repositories and communication services being used by the different components;
3. **Business** layer, containing the components that perform the actual platform-specific capabilities;
4. **External facing** layer, including the end-users' applications and PSAP (Public-safety answering point) modules, interacting with people and entities outside the platform (end-users of the platform).

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 700475

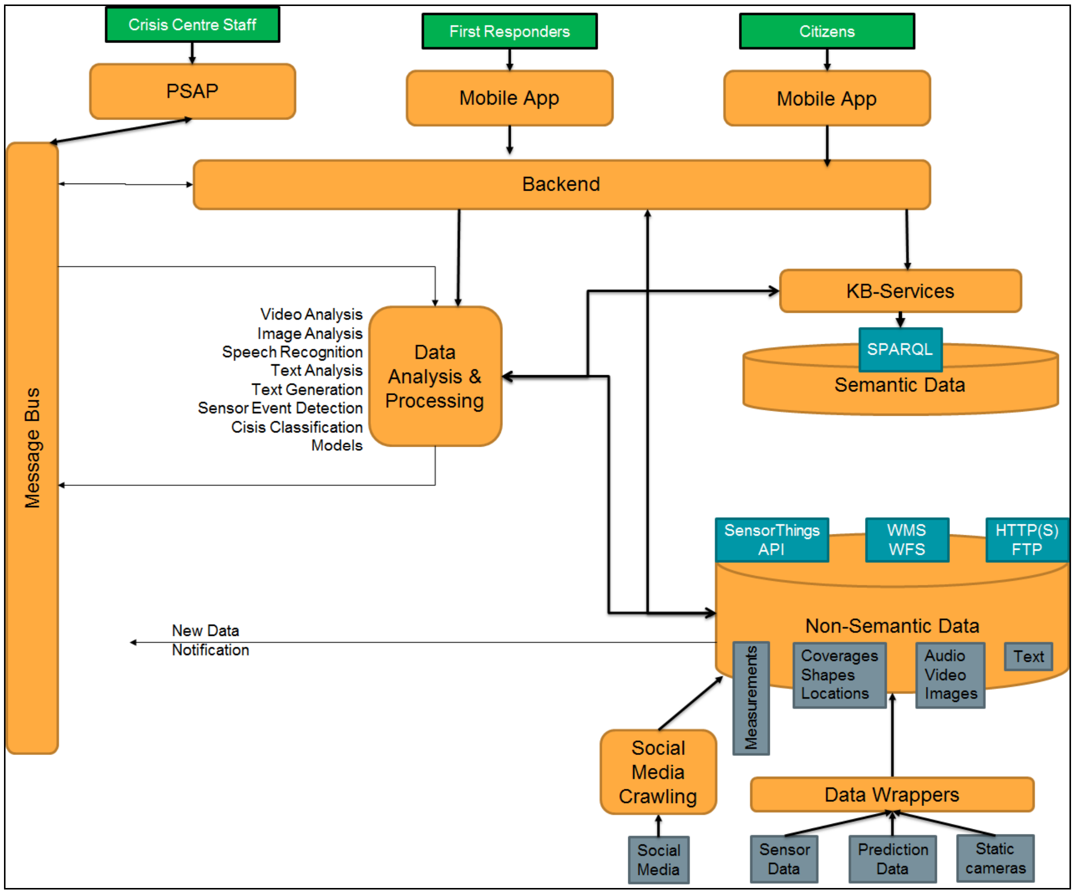


Figure 2: Architectural high-level view

2.1 Description

As can be derived from Figure 2, the first step in a generic flow of the platform consists of new data being pushed into the platform. That step acts as a trigger to potentially many internal components which are interested in the newly acquired data, or further processing thereof. The new data can originate from specific beAWARE applications used by civilians (end-users) or by first responders. Note that these applications may be bi-directional as they can serve to communicate back with the users upon need. Moreover, incoming data to the platform can originate from other sources as well, such as IoT devices, social media pots grabbed by crawlers, and weather data, just to name a few.

Once a new piece of data is successfully ingested into the system, the data is stored in a temporary raw data store and the availability of the new piece of data is broadcasted to all interested components using a specific topic of the messaging bus service. There shall be a separate topic for each kind of information flowing into the system, such that only components which are interested in that specific kind of data will be made aware of the arrival of a new relevant piece of data.

All interested parties will receive the information, which includes a pointer enabling to access the data, and shall perform their specific analysis on the new data. Note, that the result of such an analysis may in turn create a new piece of data which is of interest to other components, that once again will be made aware and access the data in the same manner explained above,

This project has received funding from the European Union’s Horizon 2020 research and innovation program under grant agreement No 700475

providing input services for the crisis classification which in turn activates the early warning module.

The end results of the analysis can be added to the knowledge base, and if required will notify PSAP related components of the identification of a new state.

The PSAP in turn may use beAWARE components, including apps to manage and alert the different stakeholders (citizens, first responders, and authorities).

2.1.1 Platform components

Ingestion layer – Serves as the input mechanism into the platform. Different kinds of information can serve as input to the system. For example, IoT devices and additional input mechanisms, such as dedicated applications, can produce different kinds of data such as measurements (time series), pictures, videos, audio, and more. An additional source of incoming information is weather related data. Typically, once a new piece of data has been ingested into the platform, it is stored temporarily in a raw storage system, and a proper notification is sent via the service bus to the interested parties. Within this layer we can classify the following components:

- Social media – mainly monitor tweets seeking for relevant information
- IoT – data from a variety of sensors
- Weather data – meteorological data

Internal services – These services are used internally for the proper functioning of the capabilities provided by the various components. These are typical middleware services which are tailored for the specific use of the beAWARE system. These services are used mostly for data storage and communication. Some generic data analytics and processing services may be used as well. Examples of this layer include a central (raw) data repository, a central message bus, and a generic knowledge base. These services will be accessible to all platform components.

A particular kind of an internal service used throughout the system relates to handling semantic information. This includes extracting semantic information, storing it, and inferring new information based on accumulated data. This group of services includes:

- Knowledge base – component and service
- Semantic reasoners – component and service

Business layer – This layer encompasses the components that provide the actual platform specific capabilities. The bulk of the platform is concentrated at this layer, which interacts in turn with all additional layers.

A particular group of components in this layer tackles the analysis of different kinds of data flowing into the platform. A main aspect of the components in this category is the extraction of semantic information from various kinds of input data flowing into the platform from various different sources. Among this group we can find the following components:

- Social Media Analysis Services
- Image analysis
- Video analysis
- Automatic speech recognition - Audio analysis
- Sensor analysis

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 700475

These components help to determine the current crisis classification and drive the detection of events which leads in turn to meaningful decision support.

A second group of components deal more specifically with the analysis of weather-related data. Among these components are:

- Climate Emergency Modeling and Prediction Services
- Weather Forecast Services
- Flood Prediction Services

A third group of related components deal mostly with text, both at the input and output aspects. Namely, incoming text messages, from social media, mobile applications and transcribed calls, possibly in a variety of languages, are processed and analyzed, and outgoing text messages that need to be delivered by the platform are prepared:

- Multilingual Report Generator
- Multilingual Text Analyzer

Finally, these components aim to serve two important generators of system output, namely the crisis classification module, which in turn drives the early warning capabilities of beAWARE.

External layer – This layer handles the interaction of the platform with external entities, both as input providers and output recipients. There are two main groups of components making up this layer, namely:

- Mobile applications
    - Civilians Mobile Application
    - First Responder Mobile Application
- Control centers
    - Public Safety Answering Point (PSAP)
    - Local Control Centers at the deployment sites

2.1.2 Stakeholders

beAWARE main stakeholders include the following groups:

- Authorities – crises handlers. Use beAWARE as a decision support system, which provides an accumulated up-to-date and accurate view of an unfolding crisis. The presented information is provided based on many different kinds of data sources which are fed into the system. Moreover, it is a learning system which holds knowledge from previous incidents to help with a current incident. In addition, the system may help with the interaction with external entities such as citizens.
- First responders – use the system bi-directionally, namely they can provide input to the system from the field, and on the other hand they reive updates and assignments from the authorities (via the PSAP). Information being introduced to the system by first responders can be of different types, such as video, IoT data, voice, and more. This information is fused by the system and help to generate a comprehensive understanding of the current state in the field.
- Citizens – citizens also participate as input providers to the system. Once again, the input can come in a variety of types to be analysed by the system. In addition, the system can alert the citizens and provide information concerning the crisis at hand and

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 700475

actions to be taken by the citizens. All the bi-directional communication is achieved via a dedicate mobile application

- Platform providers – the entity which is in charge of providing the system, with specific configuration and deployment, which make it customized to each and every installation.

3 Platform Core Components

Platform core components represent the main aspects which are required to.

3.1 Ingestion Layer

3.1.1 Social Media Monitoring module

The aim of the social media monitoring module is to collect posts from Twitter that appear to be relevant to the three main pilots, i.e. floods, fire, and heatwave, in their respective geographical locations. The crawling process needs to be real-time and effective, able to handle large streams of data, especially when keywords such as "fire" have multiple meanings and needs disambiguation. The module collects tweets in English, Greek, Italian and Spanish, that are published by any citizen, civil protection organization or online news website, aiming to provide relevant information about crisis events, clustered by location and delivered through a periodic Twitter report.

In order to gain access to Twitter's global stream of data, we have exploited the Streaming APIs[1], a streaming client that receives tweets the moment that they are published. Compared to Twitter's REST APIs[2] , this option offers a real-time stream of tweets instead of constantly making requests and thus overriding any rate limiting, i.e. maximum number of requests. The only limitation when using the Streaming APIs is that each account is allowed to create only one standing connection.

There are various streaming endpoints that can be divided into the following categories: Public streams, User streams, and Site streams. In our case, the "POST statuses/filter" endpoint of public streams is the most suitable, since it focuses on public data flowing through Twitter that matches one or more filter predicates. Specifically, the "track" field can be used to define up to 400 search keywords, combined with an OR operator, so that the API will return tweets matching any of these keywords.

1 https://dev.twitter.com/streaming/overview

2 https://dev.twitter.com/rest/public

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 700475

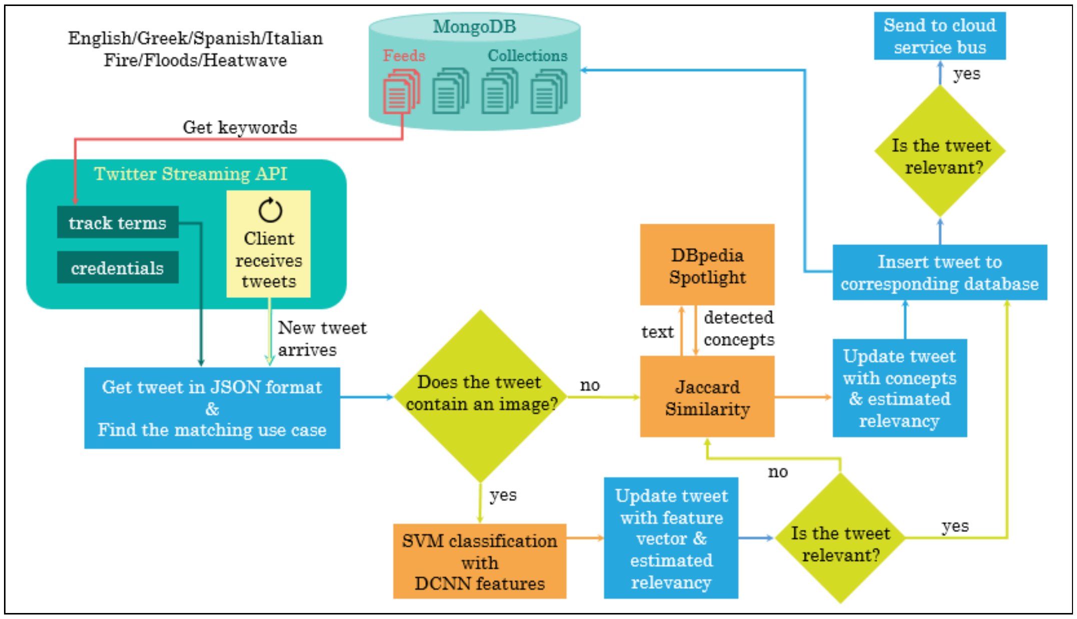

English/Greek/Spanish/Italian
Fire/Floods/Heatwave
MongoDB
Feeds
Collections
Get keywords
Twitter Streaming API
track terms
credentials
Client receives tweets
New tweet arrives
Get tweet in JSON format & Find the matching use case
Does the tweet contain an image?
no
yes
SVM classification with DCNN features
Update tweet with feature vector & estimated relevancy
Is the tweet relevant?
no
yes
DBpedia Spotlight
text
detected concepts
Jaccard Similarity
Update tweet with concepts & estimated relevancy
Insert tweet to corresponding database
Is the tweet relevant?
yes
Send to cloud service bus

Figure 3: Allocation of Twitter posts to their proper data collection

To consume Twitter's Streaming API, we chose to adopt the Hosebird Client (hbc)[3], an open-source and easy-to-use Java HTTP client. A required parameter is the user account's credentials, while an optional parameter is the track keywords. For each combination of pilot and language we sustain a separate collection in a MongoDB database to store the crawled tweets. In addition, there is a "Feeds" collection where we define a set of relevant keywords to serve as track terms during the crawling procedure.

After connection with the Streaming API is established, the client constantly receives newly created tweets in JSON format. We choose to maintain the structure provided by the API, since the JSON format fits well with a MongoDB database. Every time a new tweet is retrieved, we examine which one of the track terms exists in the tweet's text. In this way we can match the tweet to the corresponding language and pilot (e.g. "inundación" matches to Spanish and floods), in order to insert it to the respective collection.

Before the insertion to the database, we determine whether the new tweet is relevant or irrelevant to the matching use case, so only the relevant posts proceed to the beAWARE analysis component, aiming mainly to extract locations and to detect key events. If an image was uploaded along with the tweet, we use the URL of the media to extract visual features based on Deep Convolutional Neural Networks (DCNN[4]) and then feed them to a pre-trained SVM classifier which returns a binary score, i.e. 1 for relevant and 0 for irrelevant. Please note that this classification is language-independent, since only visual characteristics are taken into account. Then, the JSON object containing all the information of the tweet is updated to include the DCNN features and the estimated relevancy. In the case of flood events, the annotated images of beAWARE were enriched with the MediaEval2017-DIRSM[5] task for training.

If the received tweet does not include an image or the SVM classifier returns that the tweet is irrelevant, we use the actual text of the status update in order to estimate the relevancy, by

[3] https://github.com/twitter/hbc

[4] Simonyan, K., & Zisserman, A. (2014). Very deep convolutional networks for large-scale image recognition. arXiv preprint arXiv:1409.1556

[5] https://multimediaeval.github.io/2017-Multimedia-Satellite-Task/

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 700475

comparing it with tweets in the database that were manually annotated. A dedicated interface demonstrates all social media collections and offers the annotation option as relevant/irrelevant, stored as a binary attribute in the MongoDB. To enhance text comparison, we utilize the DBpedia Spotlight[6], where natural language is converted to known concepts of DBpedia, e.g. a tweet that mentions "Heavy rain and flood threat in northern Italy" will be converted to concepts "Rain", "Flood", and "Italy". Relevancy is estimated by performing Jaccard Similarity[7] between extracted concepts of the received tweet and the pre-detected concepts of every tweet of the targeted collection that was annotated as relevant. If there is an adequate number of annotated tweets, namely more than 20, and the maximum calculated similarity is larger than a constant "epsilon" (currently set at 0.3), the new tweet is considered as relevant; elsewise as irrelevant. Afterwards, the JSON object is again updated to include the extracted concepts and the estimated relevancy.

Finally, the updated JSON is inserted to the corresponding collection. In case that it has been estimated as relevant, either from the SVM classifier or the Jaccard Similarity method, it is pushed to the cloud service bus as a message that consists of the tweet's unique identification, the matching use case, and a timestamp. All subscribers can access the marked Twitter post directly from the MongoDB database using the id provided in the message.

3.1.2 Monitoring machine sourcing information from IoT and M2M platforms module

Sensor data is crucial for tracking the onset and progress of a crisis. There is a large variation in sensors and an almost equally large variation in interfaces to access the data from those sensors. The aim of this module is to collect time-series sensor data from various on-line sensors and make this sensor data, and the sensor metadata, available through a standardised interface.

A modern, RESTful interface for accessing time-series sensor data and sensor metadata is The OGC SensorThings API[8]. It specifies a data model, a JSON data format for transferring the data, and a RESTful interface for accessing the data. The data model is based on the ISO/OGC Observation and Measurement (O&M) model. The data format and RESTful interface is based on the OASIS OData Version 4.0 specification. Several implementations of the SensorThings API exist, both open- and closed-source.

The sensor data will be fed into the system through data wrappers that mediate between the (often proprietary) interface of the sensor and the SensorThings API. The module will contain an extension for setting thresholds and for sending notifications through the communication bus (WP7) when thresholds are passed.

3.2 Business Layer

3.2.1 Semantic modelling, integration and aggregation

This component addresses the collection, aggregation and semantic integration of content relevant to emergency information in order to facilitate decision support and early warnings generation. This is accomplished through: (i) the social media monitoring module, (ii) the module responsible for monitoring machine sourcing information from IoT and M2M platforms, (iii) weather and hydrological forecasts, and (iv) the semantic representation and reasoning module.

The Semantic representation and reasoning module has overall responsibility for semantic extraction and storage capabilities in the system. and consists of the following components: (a)

[6] https://github.com/dbpedia-spotlight/dbpedia-spotlight
[7] https://en.wikipedia.org/wiki/Jaccard_index
[8] http://docs.opengeospatial.org/is/15-078r6/15-078r6.html

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 700475

the beAWARE Knowledge Base (KB), also referred to as “ontology”, (b) the KB Service, (c) the semantic enrichment and reasoning framework. More information on these components is given in the following subsections.

- Knowledge Base (KB)

The semantic KB, or ontology, constitutes the core means for semantically representing the pertinent knowledge and for supporting decision-making. Based on a well-defined formalism (OWL– Web Ontology Language), the beAWARE ontology will encompass, amongst others, information regarding domain knowledge (types of crises, risks and impacts), multimodal input (image, video, text and speech) and contextual information, climate and environmental conditions, geolocations, aspects relevant to events and time.

Typical constructs stored in an ontology contain the classes representing the main entities in the domain, the instantiations of these classes (i.e. objects) and the relations between the entities. The content of the ontology will be updated according to up-to-date needs arising from the pilot deployments.

In order to conform to a more modular approach, the beAWARE ontology will consist of a set of interconnected sub-ontologies, one per class of crises (flood, fire, heatwave). Additionally, existing standards and ontologies will be adapted or extended according to beAWARE needs.

After the basic schema of the ontology is finalised, the input to the ontology will come (in the form of instances) from various other beAWARE components, like e.g. the component extracting concepts and conceptual relations from text (T3.2), or the component retrieving concepts and events from multimedia (T3.3). Since we are expecting massive volumes of instances to be added into the ontology in the case of a crisis event, the choice of a scalable ontology repository is of utmost importance.

- KB Service

For semantic integration beAWARE makes use of the KB Service component. The KB Service is responsible for accessing and updating the ontology content, by providing a RESTFul API service. Calls to the API from end-users will be translated to appropriate SPARQL 1.1 queries, which will then be submitted to the triple store maintaining the ontology. Thus, this component is responsible for the ontology’s semantic integration, i.e. semantically integrating information that is the output from other modules into the ontology.

Other aspects that will be investigated (and potentially added to the KB Service) include ontology population and ontology enrichment. The former process involves the addition of objects/instances from external sources into the ontology, while semantic enrichment refers to the process of augmenting the semantics of an ontology by establishing links to external sources and by appending new knowledge retrieved from those sources.

- Semantic Reasoning component

This component is responsible for performing semantic reasoning on the ontology, which refers to the process of inferring implicit knowledge from the explicitly asserted facts residing in the ontology. The reasoning mechanisms will support sophisticated interpretation tasks relevant to the management of multimodal incoming information and to the retrieval of information pertinent to the users’ needs.

A critical issue for beAWARE involves handling uncertain information. To tackle this challenge, we will rely on fuzzy and/or non-monotonic reasoning approaches, in order to cope with incomplete and inconsistent information and to resolve conflicts and prioritize the proposed actions. Existing reasoning engines will be the baseline for the semantic reasoning activity and will be effectively extended, in order to mitigate their current limitations, like

This project has received funding from the European Union’s Horizon 2020 research and innovation program under grant agreement No 700475

e.g. scalability issues, and non-seamless integration with ontologies (in the case of uncertainty reasoning engines).

3.2.2 Early Warning

This component addresses the provisioning of the necessary technological solutions to enable the beAWARE framework to provide early warning and decision support to the PSAP. This is accomplished through: (i) the crisis classification module, (ii) the multilingual text analysis module, and (iii) the concept/event detection from multimedia and (iv) automatic speech recognition modules.

- Crisis classification module

The beAWARE crisis classification module deals with the identification and classification of crisis events, in terms of risk levels, based on (1) weather and hydrological forecasting data, (2) data from heterogeneous sources (e.g. photos, written text, social media, real measurements from sensors, etc.). (3) domain knowledge specific to the affected area such as population, infrastructure, etc. The module serves as a two-layered crisis classification system (namely, early warning of upcoming crisis events, followed by real-time monitoring of an identified crisis event's severity level.

- Multilingual text analysis

The concept and conceptual relation extraction components implement the multilingual text analysis functionalities of beAWARE, enabling to process textual inputs in the targeted languages (English, Greek, Italian and Spanish) and abstract them into structured, semantic representations that faithfully capture their meaning, and can be subsequently reasoned upon for intelligent decision making.

  - Concept extraction component

  The concept extraction component tackles the recognition of named and nominal entities (objects, locations, etc.) and events from the pertinent to beAWARE textual inputs (i.e. social media posts, SMS messages, transcribed language, etc.), their disambiguation, and their mapping to existing structured lexical and knowledge resources such as BabelNet[9] and DBpedia[10]. It serves as the first step of the beAWARE semantic, multilingual text analysis.

  - Relation extraction component

  The relation extraction component deals with the identification of semantic frames, i.e. relational contexts that denote events / situations between entities (frame participants) and the semantic roles (frame roles) of the participating entities. It serves as the second step of the beAWARE semantic text analysis.

- Concept and event detection from multimedia module

This module consists of several components that deal with several aspects of concept and event detection. More specifically, the concept and event detection from multimedia module comprises the following components: (a) The dynamic texture recognition (DTr), (b) the object detection (ObjD) in video frames and images, (c) the traffic level classification (TLc) and (d) the Dynamic Texture spatio-temporal localization (DTstL) component.

  - Dynamic texture recognition (DTr) component

[9] http://live.babelnet.org/
[10] http://wiki.dbpedia.org/

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 700475

The dynamic texture recognition component is responsible for analysing video samples and determining whether they contain a fire, smoke, flood or traffic incident. It is used as a prerequisite before running the object detection and traffic classification components.

- Object detection (ObjD) component

Object detection will take place on video samples that have been indicated by the dynamic texture component to include a fire, smoke, flood or traffic incidents. Object detection will also take place on images that the text retrieval module which analyses tweeter posts has indicated that they contain fire, smoke of flood incident.

- Traffic level classification (TLc) component

The traffic level classification component will be responsible for classifying the traffic incidents that have been detected by the dynamic texture component. Traffic level incidents could be classified as light, medium or high-density ones. The algorithm could work twofold so that it can classify both images and video input files. On the one hand, the component will count the number of cars by using the object detection component to classify image files, while on the other hand it will use dynamic texture representation features to clarify the motion pattern that the cars exhibit and distinguish the traffic level in videos.

- Dynamic Texture spatio-temporal localization (DTstL) component

The spatio-temporal localization component will analyse video files so as to identify the start and end boundary detection frames where a critical event occurs (dynamic texture temporal detection). Afterwards, spatial localization will take place to identify this incident specifically in each frame (dynamic texture frame-based spatial localization). This component will produce a more detailed analysis of where a critical event occurs inside a long hour video sample.

- Automatic Speech Recognition (ASR) module

The automatic speech recognition module provides a channel for analysis of spoken language in audio and video files. The module considers both audio extraction and audio transcription functionalities. The former deals with the extraction of audio, in the case that the input to the module is a video file. The latter deals with the conversion of the audio input into written texts. The module is able to accept audio and video input in various formats and encodings. Within beAWARE, ASR is performed for three languages, namely Italian, Spanish and Greek, and English as a reference language.

3.2.3 Multilingual report generation

This component addresses the generation of emergency reports and messages that should be communicated to the different types of stakeholders that beAWARE considers (authorities, first responders, citizens, etc.) during an emergency in order to provide them with tailored support. It accomplishes this through the following two modules.

- Text planning module

The text planning module deals with the selection of content from the semantic repository (KB) and the creation of a discourse plan for the reports and messages that are to be generated. It serves as the first step in the beAWARE emergency report and message generation pipeline, and it is responsible for tailoring contents selection and their structuring to the information needs pertinent to the specific target user group and context.

- Multilingual linguistic generation module

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 700475

The multilingual linguistic generation module deals with the verbalization of emergency reports in the language of end user groups targeted in the beAWARE pilots. It takes as input the abstract (conceptual) representations produced by the text planning module and successively produces all the layers foreseen by the Meaning-Text Theory through a pipeline of graph transducers and classifiers.

3.2.4 PSAP

The objective of this component is to serve as a means for public safety answering points (PSAP) to obtain situational awareness and a common operational picture before and during an emergency, and to enable efficient emergency management based on a unified mechanism to receive and visualize field team positions, incident reports, media attachments, and status updates from multiple platforms and applications.

PSAP provides services for the following four roles:

1. **Strategic Decision Maker** – governor, mayor, head of emergency operations, etc., who oversees the preparation and ongoing response to the emergency, and is required to define strategic priorities, plans, and policies, as part of preparation in advance and in response to early warning.
2. **Emergency/Crisis Manager** – senior professional in the area of crisis and disaster management, who oversees the ongoing execution of response plans, team efforts, and overall state of the population, infrastructure, and critical assets.
3. **Operations Officer** – professional person tasked with collecting information on the whereabouts and status of units in the field, engage them in activities, oversee their progress, and handle their requests (e.g. for reinforcement, replacement, equipment, supplies, etc.)
4. **Incident Manager** – professional person tasked with managing one or more incidents as they emerge and evolve, while receiving support from field teams, input from information sources, and guidance from senior officers and officials, throughout the incident and until it is eliminated as a live situation requiring attention and response.

As such, PSAP's Functional Architecture consists of the following Components:

1. **Dashboard** – an integrated desktop of metrics and charts, which can be displayed based on streams of information from external information and data providers, which reflects the current and historic state of key situation indicators to Decision Makers and Crisis Managers, before and during the emergency.
2. **Operational View** – an integrated operational user-interface based on an on-map display of incoming incidents, unit positions, and reports. This interface serves as an operational real-time overview for Operations Officers and Incident Managers.
3. **Incident Manager** – an operational interactive interface for incident management, status tracking and changing, task assignment and tracking, and incident-related information acquisition (e.g. video, image, social media reports, etc.)

PSAP capabilities

The following capabilities are planned as part of the PSAP functionality:

Capability	**Implementing Component**
Pre-Emergency Decision-Supporting Risk Visualization PSAP shall display pre-emergency risk assessment and crisis classification to	Dashboard

the decision makers.	
Emergency Incident Collection and Display PSAP shall display emergency incident information to the emergency control center operators	Operational View
First Responder Position Collection and Display PSAP shall display first responder team positions and status information to the emergency control center operators	Operational View
Incident Assignment to First Responder PSAP shall enable assigning incidents to first responder teams and incident information distribution to the first responders by the emergency control center operators	Incident Manager
Public Alert PSAP shall enable sending public alerts regarding incidents and general risk assessments to citizens who have the beAWARE mobile App on their mobile device	Dashboard
Incident Management PSAP shall receive and display incident information, status, and footage from first responders in the field or bystanders (citizen) who will provide the information and footage from their mobile device and FR app	Incident Manager

PSAP System Requirements

TR#	Scenarios	Name	Description
TR_PSAP_01	SCN1_FLOOD	Display Unit Positions	PSAP shall display unit positions on a map.
TR_PSAP_02	SCN1_FLOOD	Display Incident Positions	PSAP shall display incident positions on a map.
TR_PSAP_03	SCN1_FLOOD	Display Report Positions	PSAP shall display positions of reports on a map.
TR_PSAP_04	SCN1_FLOOD	Display Early Warnings	PSAP shall display risk report with risk level
TR_PSAP_07	SCN1_FLOOD	Display incident report attachments	PSAP shall display media attached to incident reports upon user request
TR_PSAP_08	SCN1_FLOOD	Assign FRs to incidents	PSAP shall assign a FR unit to an incident upon user request
TR_PSAP_09	SCN1_FLOOD	Display FR assignment Reports	PSAP shall display reports from FRs on the incidents they are assigned to
TR_PSAP_11	SCN1_FLOOD	Display incident-related metrics and alerts	PSAP shall display incident-related metrics and alerts as part of the incident display
TR_PSAP_13	SCN1_FLOOD	Display assignment completion status	PSAP shall display incident handling assignment completion status based on progress reports from all assigned teams

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 700475

TR_PSAP_17	SCN1_FLOOD	Display multiple indicators in an emergency dashboard	PSAP shall display multiple indicators and metrics in a unified, configurable dashboard, for a common situational picture
TR_PSAP_19	SCN1_FLOOD	Manage Public Alerts List	PSAP shall manage a list of relevant pre-defined public alerts for quick and easy selection by the user
TR_PSAP_20	SCN2_FIRE	Provide incident information to assigned FRs	PSAP shall send incident information to FRs who are assigned to the incident, upon task assignment by user.
TR_PSAP_21	SCN2_FIRE	Support entity indication in incident reports	PSAP shall support incident reports while allowing for clear distinction of entities being reported on
TR_PSAP_22	SCN2_FIRE	Support information layers	PSAP shall let users select information layers for display on the map
TR_PSAP_25	SCN2_FIRE	Store incident status updates	PSAP shall store incident status updates, including assignment information, in a central data store
TR_PSAP_27	SCN3_HEATWAVE	Support incident status update	PSAP shall provide users with the ability to modify incident status and close incidents
TR_PSAP_28	SCN3_HEATWAVE	Manage incidents	PSAP shall provide users with the ability to determine incident relevance, priority, severity, visibility, etc. before and after displaying it on the map
TR_PSAP_29	SCN3_HEATWAVE	Display built-in aggregate metrics in dashboard	PSAP shall display several aggregate metrics in dashboard, including incident count, unit count, average incident duration, average incidents per hour over time (plot), and incident handling assignment duration average
TR_PSAP_30	SCN3_HEATWAVE	Store all metrics in CDR	PSAP shall store all metric data in Central Data Repository
TR_PSAP_32	SCN3_HEATWAVE	Indicate FR team availability	PSAP shall display FR teams in different colors by their availability
TR_PSAP_33	SCN3_HEATWAVE	Display information on web-based map	PSAP shall display all position-based information on a web-based map display

PSAP Interfaces

Logical Interfaces (indirect providers and consumers). Note that the main means of interaction between PSAP and the rest of the beAWARE system is through the message bus.

Component	Supporting Input Providers	Output Consumers
Dashboard	Crisis Classification	Mobile App
Operational View	Mobile App	

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 700475

	Analytic Services – Video, Audio, Text, Image, and Social Media	
Incident Manager	Mobile App Analytic Services – Video, Audio, Text, Image, and Social Media	Mobile App

Physical Interfaces (direct communication channels)

Component	Input Data Senders	Output Data Receivers
Dashboard	Message Bus	Message Bus
Operational View	Message Bus	Message Bus
Incident Manager	Message Bus Central Data Repository	Message Bus

3.3 Internal Services

3.3.1 Communication Bus

The main purpose of this component is to provide generic communication capabilities among different beAWARE components and participants. It can be used to send messages and notification among components or to share information among various entities. The dominant paradigm shall be the publish/ subscribe pattern leading to event-based communication among collaborating partners by registering interest in particular events. Event-based communication is often used in enterprise architectures (SOA) as it decouples any producer and consumer in terms of location and time (asynchronous communication). Using this paradigm producers and consumers do not have to be aware of each other and need only to agree on the topic via which they are going to communicate, and the message format of the agreed upon topic. We will employ open source tools such as Apache Kafka for the Messaging and Communication Framework. The message bus is deployed as a service over BlueMix, IBM's public cloud.

The communication infrastructure is meant to provide group communication and membership services to the entire cluster including all its internal components. That infrastructure can be used internally by components to support their own operations. Moreover, applications running within the platform can make use of these services to communicate between themselves.

Data management notifications can use this mechanism for notification of subscribed events to be dispatched and shared with interested subscribers. The offered services will enable higher layer capabilities, such as fault tolerance and application integration and cooperation.

The communication bus is used as the main integration vehicle between different system components. There are agreed upon topics for different kinds of information that need to be communicated between different beAWARE components at run-time. A typical flow is for a component holding a new piece of information that needs to be processed by another component to store the information to be shared in a temporary raw data store, publish a message on the corresponding message bus topic, providing in it a link to the current location of the information to be processed. The receiving component in turn parses the message, retrieves the information via the supplied link, processes it and in turn may produce a new piece of information that need to be passed to another system component. All further interactions will follow a similar flow.

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 700475

The proposed bus is in charge of notifying interested and registered components when new items which are of interest to them have been received or calculated by another component. In addition, the bus may perform some light transformations on incoming information, upon need.

The communication bus will be configured, upon deployment, with the necessary set of topics as agreed upon between the different components. In addition, the message structure of each message in each topic will be agreed upon and documented by the cooperating components. The communication bus needs to support the number of different topics required for a beAWARE installation, along with the associated aggregated throughput in all topics.

The communication bus is realized by using an instance of a MessageHub service, deployed in IBM's BlueMix cloud. The back-end is based on a Kafka cluster, and the interaction with the service is realized using standard Kafka clients.

3.3.2 Data management

The data management component deals with data ingestion, storage, and potentially some level of processing for shallow analysis. Moreover, data based notifications can be supported by connecting the data pipe to the cloud communication bus which serves as the messaging pipe.

First and foremost, this component oversees ingesting heterogeneous data types into the platform. Based on the requirements of the entity connecting a data source, data flowing into the platform can take several routes. The simple one is for incoming data to be stored for potential use in the future for many purposes, including offline analytics. Offline analytics enables the analysis of offline data of different types. Furthermore, data can be passed through a real-time pipe for performing transformations on the data including filtering, potentially targeting notification, and finally storage of transformed data items.

Of specific interest is data generated from IoT devices. That data will be brought into the platform for enabling the interaction of IoT data with other kinds of data, processes and applications running within the platform.

IoT data poses numerous challenges on traditional data storage and processing systems due to the unique characteristics exhibited by this kind of data, such as scale and heterogeneity. Proper solutions need to address data collection and fusion, in addition to enabling actionable insights out of the data ocean. The Data management component shall address data warehouse as well as real-time aspects.

3.4 External layer

3.4.1 End-users applications

There are two kinds of end-user applications envisioned for mobile devices (smartphones or tablets): one used by the first responders and another used by the general public. These mobile applications will communicate with a backend that will in turn connect to the rest of the beAWARE system.

With these applications, the first responders can communicate with the beAWARE system, send information about the emergency event, receive tasks and report on those assigned tasks. The public will be able to receive information about emergency events and send information about the event to the control center using the communication bus. Both first responders and the public will be able to send text, image, video and audio information.

4 Technological and Engineering detailed view

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 700475

4.1 System development and integration

Due to the distributed approach of the design and implementation of the beAWARE platform, in which different partners develop independently and maintain ownership over different components of the system, combined with the complexity of the platform, which is comprised of many different components, we opted to follow a micro-services approach to make the entire process of design, implementation, and integration more manageable, in a distributed manner.

Using this approach, we maintain the independence of the different components, and the integration focus is on the exposed capabilities of each component. The integration between components is being realized via two main mechanisms, first, inter-communication via the platform communication service bus, and second through exposed REST interfaces of various components, potentially aided by a discovery service.

Micro-services are an architecture form and methodology for breaking up a large and complex system into small units, each fulfilling a unique well-defined task, in an independent manner. Each such micro-service is deployed separately and can interact with its peer micro-services using standard communication protocols. Such an approach eases the task of long term maintenance and evolution of a large system, compared to a monolithic system. In addition, internal changes within a micro-service do not influence any other system component as long as the external contract of the micro-service is adhered to. Moreover, each component can be implemented in a different programming language, using different middleware.

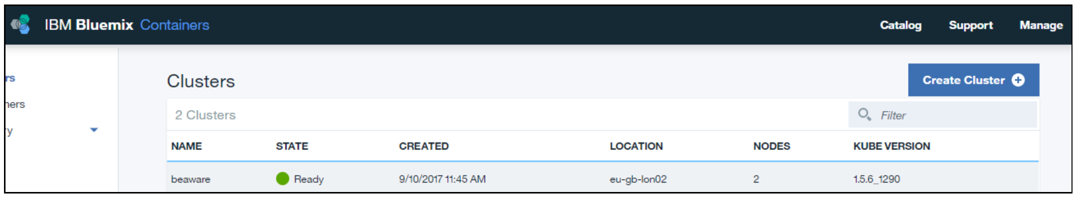
As mentioned earlier, there are two main mechanisms for micro-services to interact, namely, the communication service bus and a REST interface (possibly with the help of a discovery service). For communicating through the communication bus, the components need only to agree on the topic via which they will be interacting, and the format of the messages published on that topic. For communicating via a REST interface, there needs to be a way for one micro-service to find another micro-service it wishes to invoke. For that purpose, a service discovery component may be deployed. Such a component serves as a central registry of available micro-services, responding to queries about the location of a certain micro-service.

Since the platform will be composed of multiple micro-services and aspires to seamlessly deliver services to its users, thus we are encouraged to use the following guidelines provided under the title Twelve-Factor Applications[11]

4.1.1 Technical infrastructure

After having defined the global architecture of the beAWARE platform, focusing on its high-level component design we turn to deployment and hosting issues, focusing on the provisioning and operation of the infrastructure, on which the beAWARE system will run. This includes the internal services, business services, associated repositories and external entities (mobile applications, control centers).

The bulk of the system component will be hosted on a Kubernetes (K8s) cluster managed on BlueMix, IBM's public cloud, as can be seen in Figure 4, Figure 5, and Figure 6.



Clusters

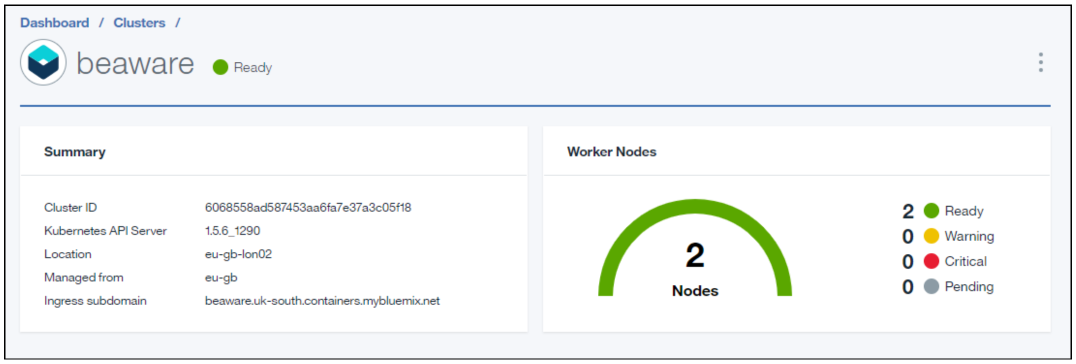
2 Clusters

NAME	STATE	CREATED	LOCATION	NODES	KUBE VERSION
beaware	● Ready	9/10/2017 11:45 AM	eu-gb-lon02	2	1.5.6_1290

Figure 4: beAWARE Kubernetes cluster

[11] https://12factor.net/

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 700475


Dashboard / Clusters /

beaware ● Ready

Summary

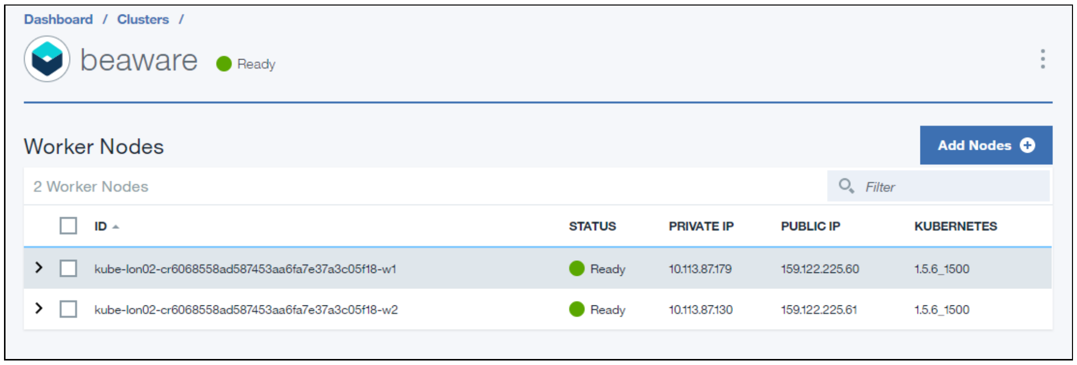
Cluster ID	6068558ad587453aa6fa7e37a3c05f18
Kubernetes API Server	1.5.6_1290
Location	eu-gb-lon02
Managed from	eu-gb
Ingress subdomain	beaware.uk-south.containers.mybluemix.net

Worker Nodes

2 Nodes

2	● Ready
0	● Warning
0	● Critical
0	● Pending

Figure 5: beAWARE cluster overview


Dashboard / Clusters /

beaware ● Ready

Worker Nodes

2 Worker Nodes

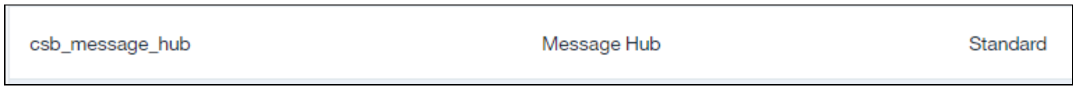
ID	STATUS	PRIVATE IP	PUBLIC IP	KUBERNETES
kube-lon02-cr6068558ad587453aa6fa7e37a3c05f18-w1	● Ready	10.113.87.179	159.122.225.60	1.5.6_1500
kube-lon02-cr6068558ad587453aa6fa7e37a3c05f18-w2	● Ready	10.113.87.130	159.122.225.61	1.5.6_1500

Figure 6: Kubernetes cluster worker nodes

Currently the cluster is composed of two worker nodes, and it may grow based on evolving system needs. The K8s cluster is divided into 3 namespaces:

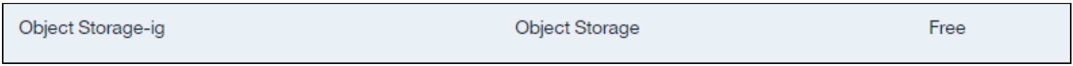
- Default (Jenkins Master)
- Build (Jenkins Slave)
- Prod (Deployed Applications) – residing behind Ingress (a reverse Proxy)

In addition, there are cloud services which are used by beAWARE components, such as the messaging bus (Figure 7) and a central data repository (Figure 8). These services are hosted on IBM's public cloud and offer binding capabilities to all beAWARE components.



csb_message_hub	Message Hub	Standard

Figure 7: MessageHub cloud service



Object Storage-ig	Object Storage	Free

Figure 8: Object Storage cloud service

In addition, there are components that are to be deployed external to the project K8s cluster, namely the PSAP and additional control center capabilities, as well as the end-user applications which will have their front-end deployed on mobile devices, while their backend may still reside within the project cluster.

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 700475

4.1.2 Expected timeline

The system development will be iterative, from an initial dummy prototype to the final version, with the following cycle planned:

1. Integration Prototype: Dummy end-to-end architecture; most service dummies in place, operating on test/mock data. This is expected by the end of the first year of the project as a part of MS2
2. First Prototype: Using real services from WP3-WP6; First Prototype milestone (MS3), expected at M18.
3. Second Prototype: Using real services from WP3-WP6; Second Prototype milestone (MS4), expected at M24.
4. Final System: Complete beAWARE platform; Final System milestone (MS5), expected by the end of the project (M36).

4.2 Integration, deployment, and the Continuous Integration (CI) toolchain

The CI environment is comprised of the following components, as depicted in Figure 9:

1. GitHub repository: all components should have a repository under the beAWARE project (https://github.com/beAWARE-project).
2. Docker - create docker image for each component.
   - Generally, requires a dockerFile for each component
3. Jenkins: build, test, and deploy
   - Requires a JenkinsFile for each component
   - Builds are executed in separate environment in the project's K8s cluster Executing tasks based on Jenkinsfile
     - Pulling code from Github
     - Build artifact
     - Build Docker image
     - Push to DockerHub
     - Deploy on k8s
4. Kubernetes -IBM container services - managed cluster on which all components are deployed
   - Requires Kubernetes config for each component

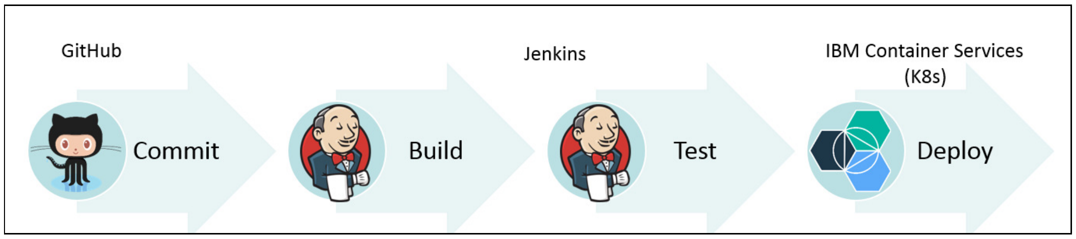


Figure 9: CI workflow

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 700475

The automated workflow kicks in upon a new commit to the master branch in our github repository. Jenkins keeps track of such changes via web hooks, and initiates the procedure as specified in the JenkinsFile. The standard procedure is to build the component using the dockerFile, and if no errors reported, to deploy to the Kubernetes cluster, using the specified K8s configuration. This process happens for every repository for which there's an associated JenkinsFile.

A more elaborated pictorial view of the CI workflow can be seen in Figure 10.

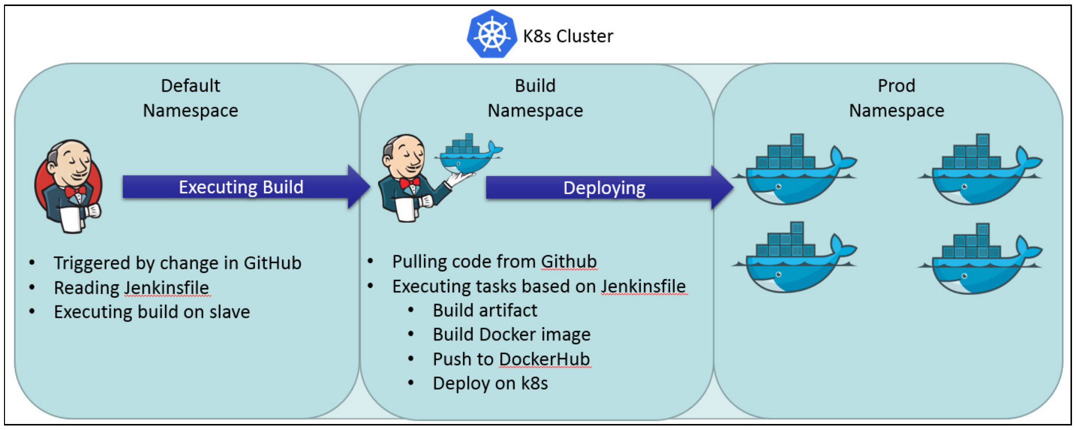


Figure 10: CI detailed

5 Major flows and sequence diagrams

5.1 Data ingestion: text, multimedia, sensors social media

Data of a variety of modalities and formats is ingested into the system from various sources. Even though each piece of data from every source has an independent path throughout the system, there is a unified path to handle the data once it reaches the back-end handling ingested data.

The generic unified flow calls for the incoming data to be temporarily stored in the raw data storage service (typically an instance of an Object Storage service), and a link to it is received by the back-end. The link is inserted into a message that is published through a specific topic based on the kind of data being ingested. Additional beAWARE services which are interested in processing incoming data of a certain kind will subscribe to a specific topic and thus will receive the message in question.

Each component subscribed for the specific topic will parse the incoming message, and will access the raw data it needs as input by following the supplied link. Each component in turn will perform its analysis and further interactions may be initiated in the same manner. Namely, potentially new information can be stored in the raw data storage, and a new message on the relevant topic will make all the interested components aware of the new piece of data to be processed.

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 700475

5.2 Turning data to information

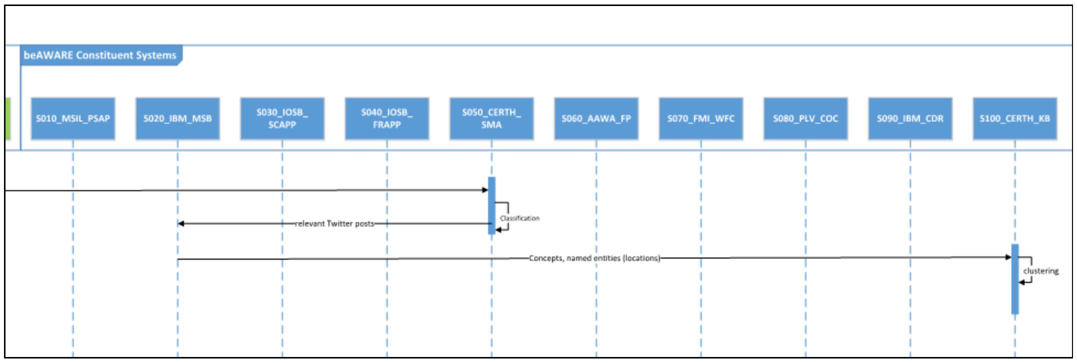


Figure 11: Extracting semantic information

One manifestation of the generic process described in sub-section 5.1 is described herein. In this case tweets are being monitored by the Social Media Analysis Service, which filters incoming tweets based on the ones potentially containing information which is of interest to a beAWARE deployment. Once such a tweet is identified, it is stored in temporary data store (Mongo DB), and the information including the link is published over the message bus. Interested parties subscribe to obtain such messages, and act upon them accordingly. For example, upon such a notification, the Multilingual Text Analyzer accesses and analyses the tweet, extracting information about the mentioned incidences, location, etc. and stores it to the knowledge base for further processing. The KB, in turn, aggregates the newly introduced information with its existing contents/other incoming information, and derives relevant conclusions, e.g. that a warning should be sent to citizens. The accumulated information is stored and made available via the KB.

5.3 Weather data

A special kind of external input into the system consists of weather data. Such data is being gathered and periodically fed into the system. Upon an ingestion of a new set of weather data the corresponding modules (e.g. the Flood Prediction Service AMICO) are made aware of it and grab the information to perform their respective analysis. Conclusions of such analysis is fed into the Knowledge base, and will be assessed by the crisis classification component. If this component reaches the conclusion that a new possible threat is on its way, it shall notify the crisis classification module, which shall determine the next steps to be taken. Otherwise, if the system is in the midst of a declared high alert state, the evolution of the situation is analysed and fed to the decision makers.

5.4 Crisis classification

The beAWARE crisis classification module kicks in upon the arrival and analysis of various kinds of data, such as weather and hydrological forecasts, IoT devices, and images. Thus, the crisis classification module will subscribe to the relevant topic through the message bus. Each such message will carry a link to the new piece of information to be analyzed. Once the analysis of the new data is performed, and a change in state has been determined, the PSAP is made aware of the state either as a new potential upcoming crisis, or an update of the state of the current crisis event.

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 700475

5.5 Early warning

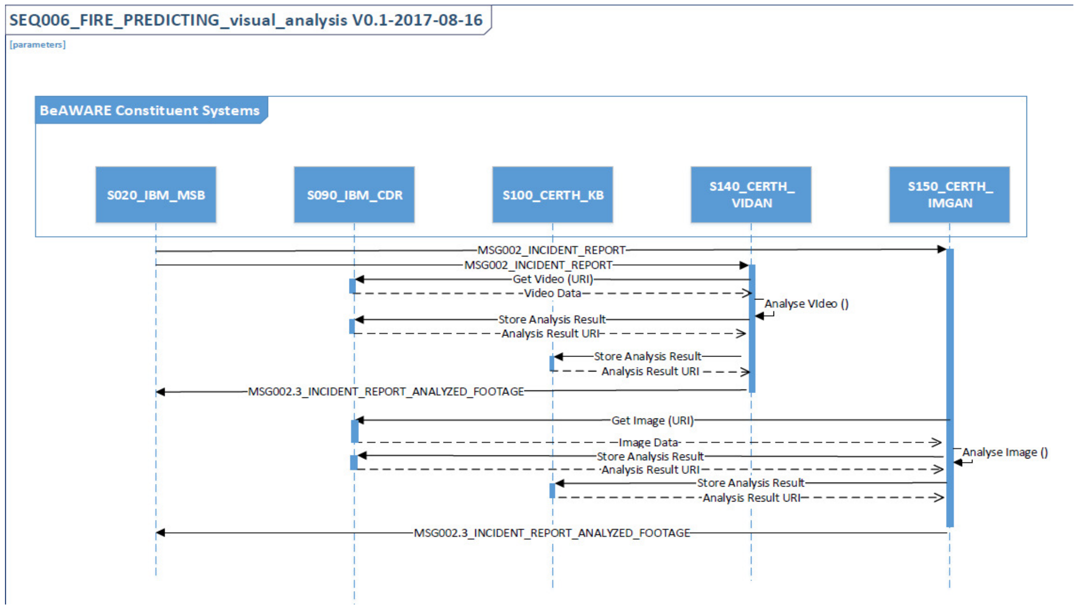


Figure 12. Fire predicting by using visual analysis modules

Early warning algorithms are going to be used to analyse the audio-visual, textual and weather information so as to detect possible incidents that occur in the monitored region and notify the system accordingly. Flood and fire prediction examples can be shown in Figure 12, Figure 13 where a video and an image file are sent to VIDAN and IMGAN modules in order to run DTr, DTstL and ObjD components, find disaster related situations and notify the beAWARE system with an appropriate report.

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 700475

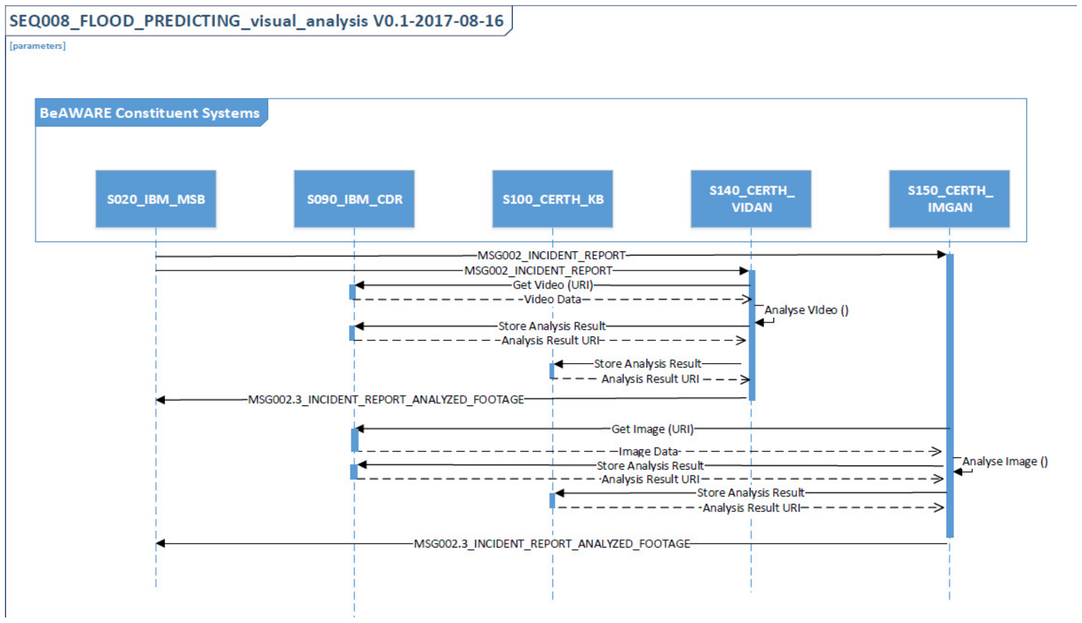


Figure 13. Flood predicting by using visual analysis modules

A similar procedure is going to be followed in the heatwave prediction use case with the difference that only the TLc component is going to be deployed. The proposed sequence diagram for this scenario can be seen in **Figure 14**.

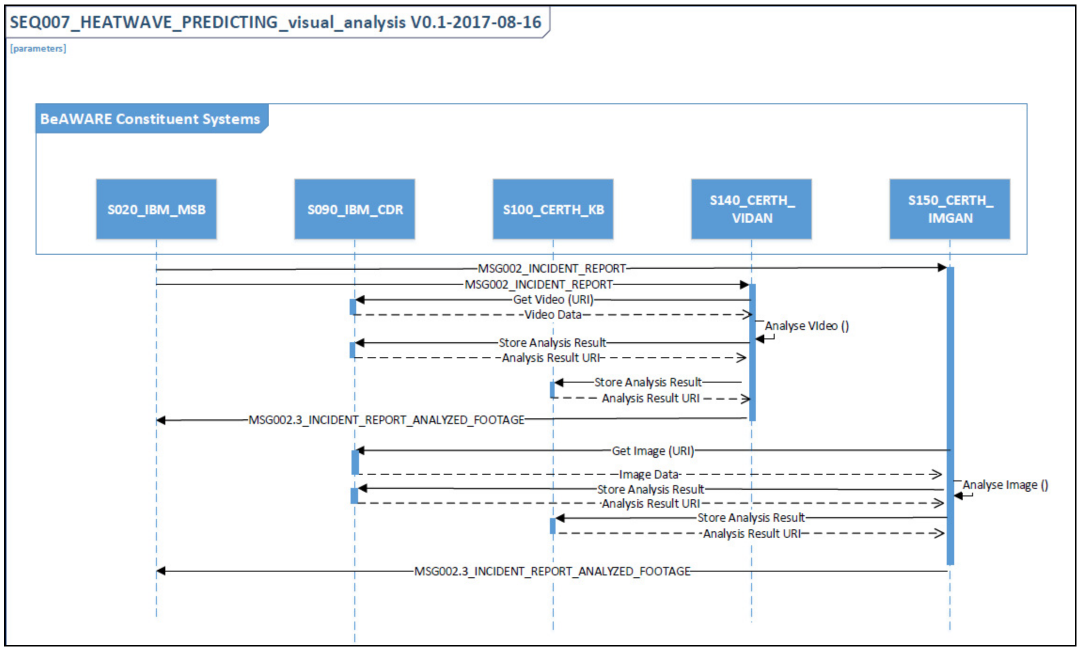


Figure 14. Heatwave predicting by using visual analysis modules

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 700475

5.6 Interaction with the platform - End-user and first responders

The following is an example scenario which demonstrates one of the manners in which end-users interact with the system, while providing another example of the generic sequence of ingesting data into the system as described in sub-section 5.1.

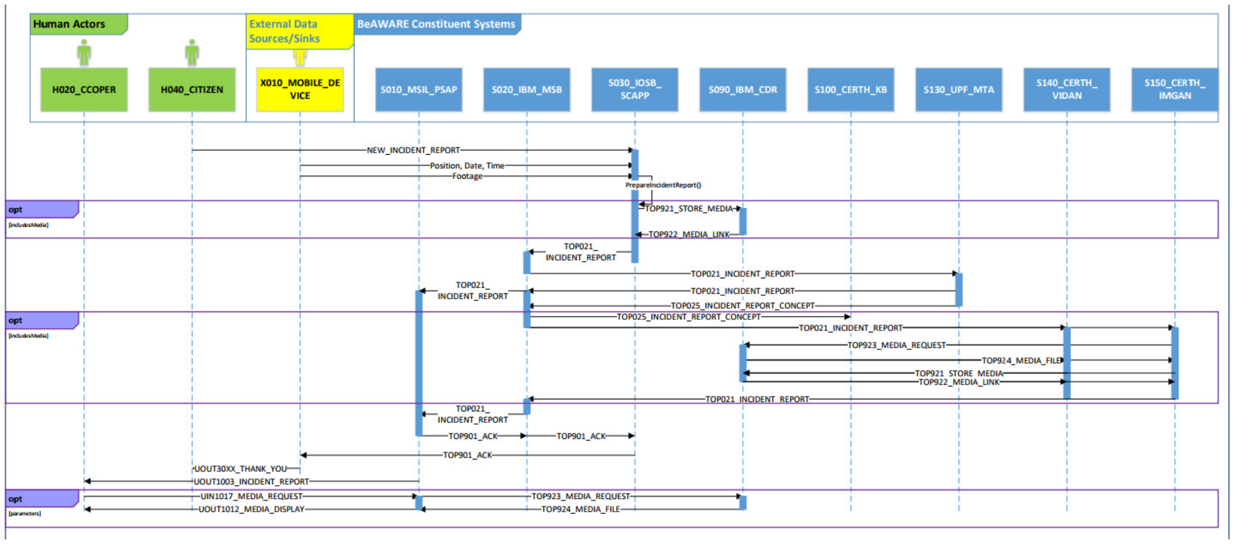


Figure 15: Citizen incident report

In this interaction, a user uses an app on his mobile phone to communicate information to the beAWARE system. The user can send various kinds of information via the app, such as text and video. As the sequence diagram shows the incident report is received by the mobile app back-end, and at first stage is stored in the raw data storage (Object Storage). Once that is done, a message is broadcasted over the message bus to alert all interested components of the newly received incident report.

Based on the kind of information included in the incident report, several components may process it, such as the text analysis, image analysis, and the video analysis. Results of the analysis may in turn be recorded once again in the raw data store, and if required a message targeted to the PSAP or control center will be published.

Reports from first responders may follow a similar path.

The complementary mode of system interaction with external users is for the system to distribute information to registered users.

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 700475

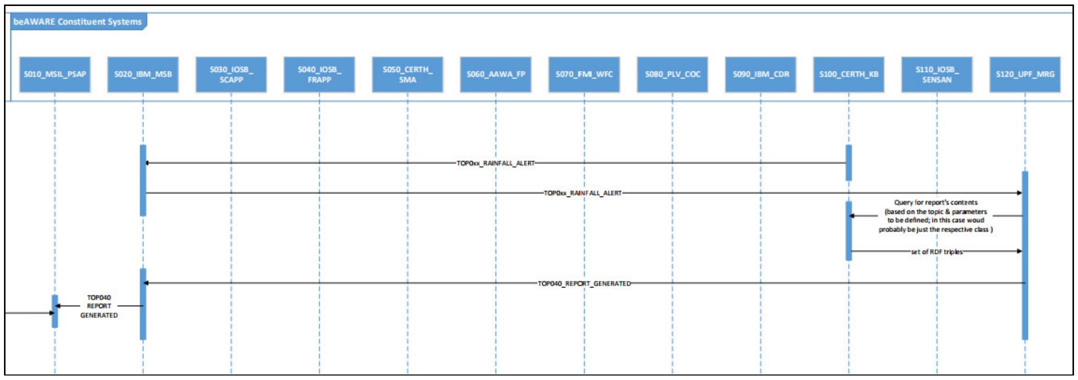


Figure 16: Information dissemination to the public

In this case, as can be seen in Figure 16, the beAWARE system has reached the conclusion that an excessive amount of rainfall is predicted, such that the possibility for floods is increased. That information, which was derived by the Knowledge Base, is being transmitted, via the message bus, to the multilingual report generator. The report generator in turn accesses the knowledge Base to derive the information required to phrase the message to the public appropriately. Once the message is ready it is published on the message bus, and the PSAP can pick it up and further transmit it, or the mobile application back-end may forward the generated message as well.

6 Mapping the use-cases to the architecture

beAWARE is a use case driven project. Use cases remain at the focus of the project throughout the different stages. The initial garnering of requirements focused on the use cases, which helped in turn to devise system requirements out of them. The architecture was conceived to respond to the use cases requirements, and help to enable their real-life deployment and development. At later stages, naturally, the use cases will serve as an important validation points for the deployed platform.

This section further highlights the manner in which the use cases for each Project Pilot utilize the beAWARE core platform in order to deliver the envisioned functionalities. The Pilots consist of several use cases that demonstrate and exercise different platform capabilities. The mapping of the use cases to the beAWARE architecture refers to the identification of the beAWARE core components that are exercised in each use case, and the interaction with various beAWARE components.

6.1 Use Case 1: Flood

The Flood scenario will be set in Vicenza (Italy) and will consist of a simulated flood event; the coordination and operational emergency activities will be carried out, at the municipal level, from the Municipal Operational Centre (COC). Within the COC the Mayor is the highest authority and he has the responsibility to realize risk mitigation strategies. The Municipal Civil Protection, with the Fire Department, manages the rescue operations and all the activities are oriented towards resorting back to normal life conditions. The main end-users in the pilot are therefore:

- The Mayor
- Municipal group of Vicenza Civil Protection;
- National Association of Carabinieri (Italian Army Police);
- National Alpine Trooper Association;

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 700475

- Coordination of Voluntary Associations of Civil Protection, Province of Vicenza;
- Italian Red Cross
- Fire Brigades
- Local Police
- Regional and local authorities
- AAWA

The Vicenza municipality has defined a very clear protocol in response to flooding (the Protocol is described in detail in the official Municipal Civil Protection Plan Document). In particular, three critical levels before the flood expected event were defined:

The first phase is the Ordinary Criticality, in which monitoring activities begin. This state is named "ATTENTION": is declared when the AMICO Flood Forecasting System shows potential risk situations in the next 3 days.

The next phase is the Moderate Criticality. This state is named " PRE - ALARM" (3-5 hours prior to the Maximum forecasted river Level). In this phase the first acoustic alert is activated. At this step, all the programmed prevention measures are taken (closing bulkheads, artificial embankments, preparation of the lamination basins, etc.). Most of these are triggered by observed river levels at the bridge of "Ponte Degli Angeli" with water level varying between 2m to 5.6 meters.

The third level is the High Criticality; this state is named "ALARM": it's activated when the civil protection foresees that a flood will take place within an hour. A second acoustic alert is activated and all the citizens resident in a soon to be flooded zone are instructed to leave their houses. All the rescue resources are activated. When the flood happens, vehicles and men are deployed to give assistance to the population.

The end of the emergency corresponds to the state "END ALARM". A third acoustic alert is activated. After the event the activities are oriented to remove water and mud from buildings and streets. Later a reconnaissance of the damages is necessary.

The purpose of the flood scenario will be to test the beAWARE system by implementing the use cases described in D.2.1:

UC_101: Declaration of the attention status and continuous monitoring of flood forecasting

UC_102: Management of new flood emergencies

UC_103: Monitoring river water level and assignment of tasks to first responders

UC_104: Evaluation of the execution of tasks

UC_105: Monitoring rainfall

UC_106: Monitoring river breaking/overtopping and assignment of relative tasks

UC_107: First responders monitoring

UC_108: Flood forecasting alerts

UC101 and UC102 will be the initial use cases developed in the project.

UC 101

The Flood Forecasting System AMICO will generate a flood prediction based on the most recent available weather forecast provided by FMI. The forecasted river water level will be

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 700475

visualized and analyzed by the SensorThingsAPI. This module will send notifications through the communication bus when any prefixed river level threshold is passed. The KB reasoner will be able to infer implicit knowledge concerning the possible flood impacts by crossing AMICO results with GIS maps (e.g. land cover maps); then, the Crisis Classification component will be activated in order to classify the crisis event and provide early warning and decision support generated by the Multilingual report generation and send to the PSAP. The PSAP shall display a risk report with the indication of the forecasted risk levels and it will allow the decision maker to send Notifications/Warnings to the Public. Public and first responders will receive these notifications in their mobile app. Based on this alert the Mayor will decide to declare the " ATTENTION" status and will convene in a formal way the members of the "COC - Municipal Operative Centre", that will be engaged in monitoring the situation and in the management of the emergency thanks to the Public-safety answering point (PSAP). When the forecasted flood will occur, the crisis classification module will monitor and update the pre-identified crisis event severity level based on the monitored river water levels and on the heterogeneous information coming directly from citizens and first responders as described in the UC102.

UC 102

During a flood event, citizens and first responders will be able to send new emergency reports by using their mobile app. At the same time several tweets related to the flood event in progress will be collected by the Social Media Analysis Tool; all the messages can contain audio and video attachments; real sensors data will be collected and processed by the SensorThingsAPI. All this information will be analyzed by the Multilingual text analysis tool, the Video and Image detection tool and the Automatic Speech Recognition module. The KB reasoner will be able to infer implicit knowledge concerning the current flood impacts; then, the Crisis Classification component will be activated in order to update the crisis event and provide early warning and decision support generated by the Multilingual report generation and send to the PSAP. The PSAP shall display risk reports with the indication of the forecasted risk levels and it will allow the decision maker to send Notifications/Warnings to the Public and to assign specific tasks to first responders team.

6.2 Use Case 2: Fire

This use case refers to a forest fire that takes place in Valencia, specifically in a natural park called La Devesa de L´Albufera (also known as *La Dehesa del Saler*), which has an extension of 850 Hectares. This natural park is located located 8 km. away from the city of Valencia but there are residential areas within it.

The fire scenario will address the beAWARE system by implementing the use cases described in D.2.1:

UC_201: Management of forest fires emergencies

UC_202: Activation of first responders

UC_203: Pre-emergency level 3 activation

UC_204: Evacuation management during an emergency (see Figure 17).

Before a fire starts, the beAWARE platform takes into account the current pre-emergency level. According to weather conditions and other socio-cultural factors (e.g. specific bank holidays), there are three pre-emergency risks of forest fire levels, where the third pre-emergency level corresponds to extreme forest fire risk. In this case, resources are mobilized in order to perform dissuasive surveillance in sensitive areas, as well as from this moment on, the population must be advised so that they take extreme caution.

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 700475

Table 2: Pre-emergency levels

LEVEL 1	LOW-MEDIUM FOREST FIRE RISK
LEVEL 2	HIGH FOREST FIRE RISK
LEVEL 3	EXTREME FOREST FIRE RISK

Thus, once pre-emergency level 3 is declared the beAWARE platform will send warning messages to citizens and first responders through the mobile application.

Apart from the official activation of the pre-emergency level 3 that is declared by regional authorities, beAWARE platform can receive weather specific data of the area that can trigger the warning messages addressed to local citizens in the same way as the activation of the pre-emergency level 3.

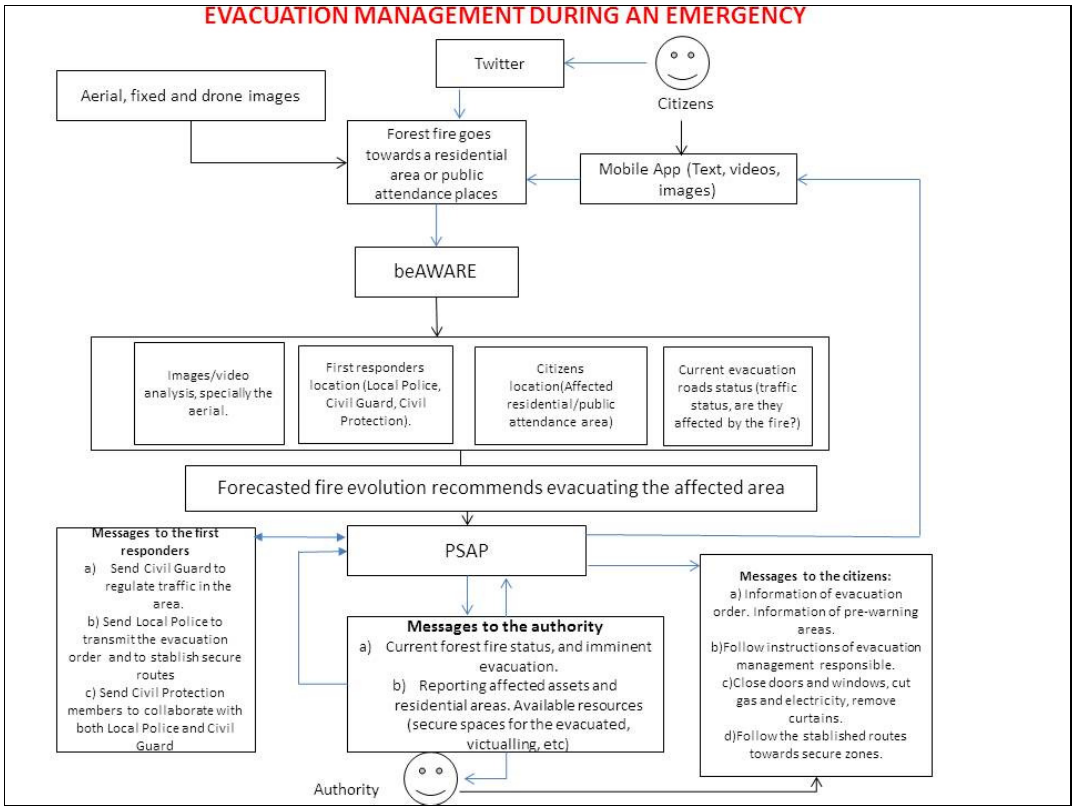

EVACUATION MANAGEMENT DURING AN EMERGENCY
Twitter
Citizens
Aerial, fixed and drone images
Forest fire goes towards a residential area or public attendance places
Mobile App (Text, videos, images)
beAWARE
Images/video analysis, specially the aerial.
First responders location (Local Police, Civil Guard, Civil Protection).
Citizens location(Affected residential/public attendance area)
Current evacuation roads status (traffic status, are they affected by the fire?)
Forecasted fire evolution recommends evacuating the affected area
PSAP
Messages to the first responders
a) Send Civil Guard to regulate traffic in the area.
b) Send Local Police to transmit the evacuation order and to stablish secure routes
c) Send Civil Protection members to collaborate with both Local Police and Civil Guard
Messages to the authority
a) Current forest fire status, and imminent evacuation.
b) Reporting affected assets and residential areas. Available resources (secure spaces for the evacuated, victualling, etc)
Messages to the citizens:
a) Information of evacuation order. Information of pre-warning areas.
b)Follow instructions of evacuation management responsible.
c)Close doors and windows, cut gas and electricity, remove curtains.
d)Follow the stablished routes towards secure zones.
Authority

Figure 17: Evacuation management

Mainly, all these preventive measures (warning messages sent to citizens and first responders through mobile application) involve the use of the ingestion layer regarding the meteorological data, the PSAP component regarding the pre-emergency decision support and the external layer regarding the interaction of the platform with external entities such as citizens and first responders through mobile application.

In case that a fire starts, the beAWARE platform will be able to receive different kind of communications from various actors. Citizens can report the emergency to the platform by sending images, videos, voice, and text through the mobile application. Besides, first responders can communicate with the PSAP through the mobile application. It involves a bidirectional communication with citizens and first responders in which the PSAP component has a relevant role. Moreover, citizens post messages through social media (especially Twitter) that contain

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 700475

images, videos and text related to the emergency. These posts will be detected by the social media monitoring module. Apart from these inputs, the beAWARE platform will receive sensor and weather data.

The management of the emergency will use all the components of the beAWARE platform and especially requires knowledge of the weather forecast, the location of the fire, the location of the first responders and citizens. The beAWARE platform will provide a forecast of the fire development based on the weather data and the characteristics of the fire in order to support crisis classification decisions, assignments to first responders and messages to citizens.

In this regard, an evacuation poses a special episode in the management of a fire. The beAWARE platform will support authorities' decision in order to evacuate citizens from the area in case that they are at risk. In case of evacuation first responders and citizens will get through the mobile application a notification about the necessary evacuation and the way to a secure zone. First responders are given specific tasks in order to facilitate the evacuation and citizens are provided with recommendations.

6.3 Use Case 3: Heat Wave

The main Use Case to be demonstrated in this category is the management of relief places. This use case major requirements form the beAWARE platform:

- UR_301 Real time Weather forecast
- UR_304 Heatwave intensity
- UR_305 Possible location for incidents
- UR_310 City-wide overview of the event
- UR_311 Information Storage
- UR 316 Capacity of places of relief
- UR_322 Information for incident status from Social Media
- UR_323 Information for Hospital Status from Social Media
- UR_325 Suggested places of Relief
- UR_326 visualization

In Figure 18, you can find a sketch of the major flows in the platform for this use case.

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 700475

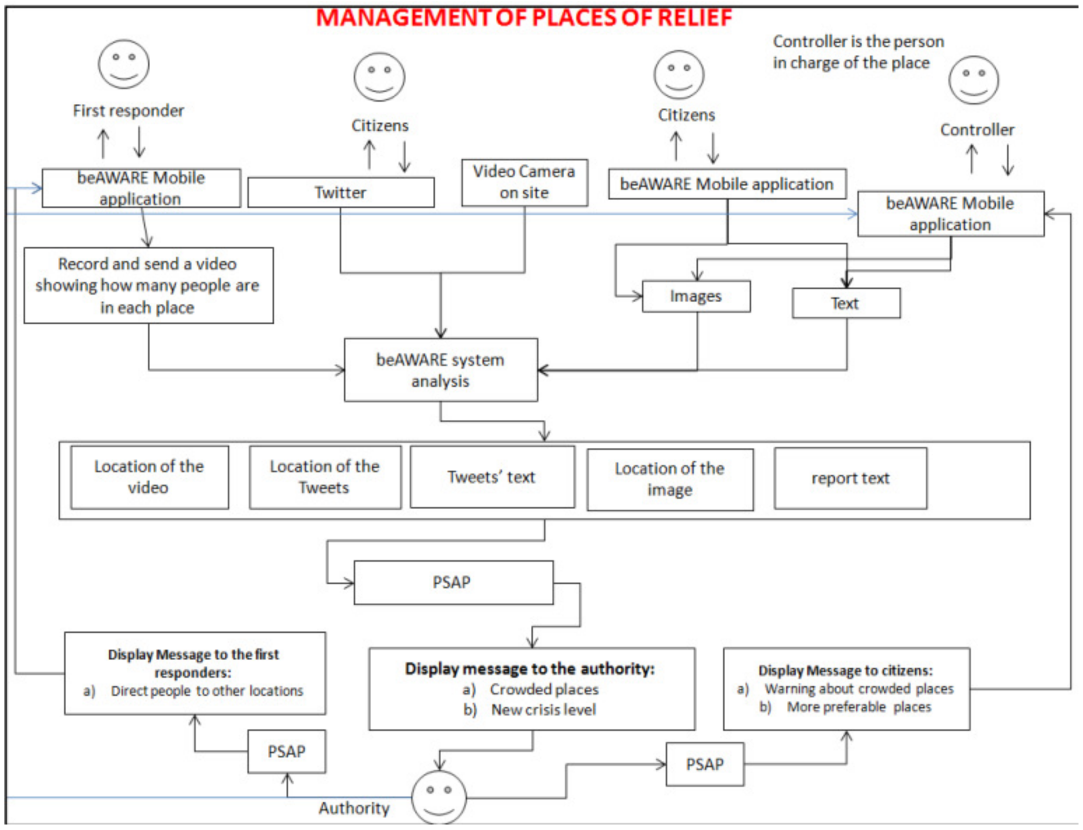

MANAGEMENT OF PLACES OF RELIEF
Controller is the person in charge of the place
First responder
Citizens
Citizens
Controller
beAWARE Mobile application
Twitter
Video Camera on site
beAWARE Mobile application
beAWARE Mobile application
Record and send a video showing how many people are in each place
Images
Text
beAWARE system analysis
Location of the video
Location of the Tweets
Tweets' text
Location of the image
report text
PSAP
Display Message to the first responders:
a) Direct people to other locations
Display message to the authority:
a) Crowded places
b) New crisis level
Display Message to citizens:
a) Warning about crowded places
b) More preferable places
PSAP
PSAP
Authority

Figure 18: Block Diagram of the Heatwave use case

6.3.1 beAWARE Mobile application

The beAWARE mobile application shall be used by the following participant roles:

- First Responders: Will use the app in order to send various kinds of information from the crisis scene (e.g., record and send a video, showing how many people are in each place). The beAWARE system will then calculate the number of people that are in each place and therefore provide information regarding its occupancy.
- Citizens: Will use the app on the one hand as data providers to upload images, text, or voice recordings, and on the other hand as data recipients to receive information or notification from the authorities about the situation or changes that are needed to be known, regarding the occupancy of the places of relief. The mobile phone that will send notifications must be geolocated. In this case, the beAWARE system analyzes the messages and images sent by social media.
- Controller: Will inform about the situation of the relief place with photos, text etc. If a place of relief is crowded, the app shall be used to inform the authorities and the rescuers to manage the situation and direct citizens to other places of relief and also to send notifications to citizens for alternate places of relief. The status of all places will be shown on an online map. The system will provide to the authorities the current state of the available capacity of all relief places provided to the public. The platform will provide the ability to inform in real time, the authorities with the status of the occupancy of the places of relief. Different colours depending on the status of each

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 700475

place's occupancy (e.g. Green means <50% of occupancy, yellow means <70%, orange means <90%, red means >90%).

6.3.2 Twitter – Video Camera on Site

By analyzing Twitter and other Social Media streams, beAWARE should be able to inform authorities and rescuers as to situations that are being reported by citizens. The platform will receive images and messages published on social networks by keywords such as "*#Heatwave / #Καύσωνας*"/ "#Help/ #Βοήθεια""#Δομή…/ #Relief….", and others. These messages and images will be analyzed by the platform. Furthermore, from videos (from a mobile and from a video camera on site), photos and even a text that someone will upload from the place of relief the system can count the number of people who are inside the place.

6.3.3 beAWARE multi-modal analysis

All the information provided by rescuers, citizens and controllers will be gathered by the platform. The analysis will be done to the location of the videos, the tweets and the images, the text of the tweets (and other social media platforms) and the report text of the controller. Finally, the people in the control room will have the ability to see the incoming data and the procedure of the analysis of the platform.

6.3.4 PSAP

All analyzed data and images shall be made available to be observed in the video wall of the PSAP. The different levels of occupancy of places of relief must be categorized in different colors and symbols.

Display message to authorities

The PSAP informs the authorities about the current situation of the heatwave and the situation of the relief places and their capacity. The authority in charge, through the PSAP, informs the controller and the rescuers to direct people to alternate places of relief with mapped and texted directions. Additional messages may be sent to citizens, such as, to inform them about the capacity of the relief places and the ability to use others, with mapped and texted directions.

Message to First Responders

PSAP may inform the First Responders through the app to direct people to other places of relief. Short message will pop-up to the screen of the Rescuers such as "Place of Relief Toumpa is 90% full, direct people to Place of Relief Charilaou". There will be a map depicting the places of relief, with different colors, the proposed one and some guidelines on how to go to this place of relief and ETA.

Message to Citizens

PSAP may inform the Citizens through the app about the capacity of a place of relief which is almost full. Short message will pop-up to the screen of the citizens such as "Place of Relief Toumpa is 90% full, direct people to Place of Relief Charilaou". There will be a map that shows where are the places of relief, with different colors, the proposed one and some guidelines on how to go to this place of relief and ETA.

Type of visualization

All displayed messages, must be in the platform and all information will be visualized, such as mapped, places of relief with associated data, geolocated and mapped videos, photos, tweets and

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 700475

social media texts. Below is an example of the visual information that might be presented to the authorities.

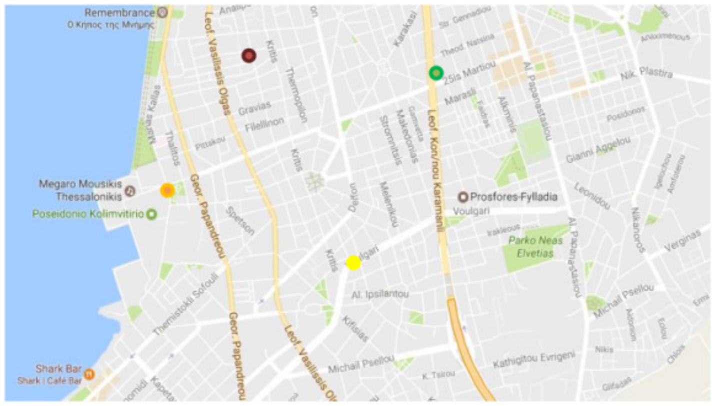


Figure 19: Visualization of the status of places of relief in the city

7 Summary

The quest leading to the current architecture document has started off with the use case requirements document to ensure that the architecture proposed covers the stated requirements and used the pilots as further driving the requirements as well as validation scenarios. System requirements were derived from the use case requirements, which in turn contribute to the specification of the capabilities of the different system components. The bulk of this document provides an overview of the different platform components and highlights the interfaces and dependencies between them.

This architecture document frames the high-level overview of the beAWARE platform, its components, and the main interactions between different components. Consequently, we can break up the large overall beAWARE architecture and assign components to WPs and tasks, to have individual internal low-level design and development of each component.

The resulting platform is targeted mainly towards authorities who wish to be able to handle better crisis events, by obtaining an accurate up-to-date operational picture understanding, along with potential advice as to the actions that may be taken to alleviate the situation.

8 Appendix 1: Detailed technical requirements of different components

Multilingual Report Generation

Name	Description	Specifications & Dependencies	Triggered By
Generate alert messages for authorities	Generate alert messages concerning monitored parameters. These messages may have visual components, such as colour coded points, and	i) language parameter (EN, ES, GR, IT) ii) list of predefined alert	The KB and/or Crisis Classification modules determine

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 700475

Name	Description	Specifications & Dependencies	Triggered By
	accompanying information. In the flood scenario a monitored parameter may be rainfall level or river overtopping. A message content may include information about the exceeded threshold or information about relevant incidences in the reference area	messages iii) list of types of incidences of interest to be included in the alert messages	whether an alert should be issued. In the flood scenario, the water level thresholds are considered.
Generate task status updates for authorities	Generate update reports about the status of the assigned tasks. These messages may have visual components, such as colour coded points, and accompanying information.		Whenever a message about the status of a task is received from a first responder.
Generate situation updates for authorities	Generate updates that describe the current situation based on the aggregated interpretation of the incoming data. The locations of the incidences are expected to be shown on the map.	links to to the original input data need to be preserved and shown upon request	The KB and possibly also upon request of the authorities
Generate summary report	Generate a report that summarises the temporal unfolding of the emergency for after-crisis analysis/reference.		
Generate notification/warning messages for the public	Generate messages with notifications/warning for the general public; some are location-tailored other are generic.	i) language parameter (EN, ES, GR, IT) ii) list of predefined warning messages	The authorities validate the messages the KB service has deduced and that have been generated by the Report Generation (based on standardised actions as described e.g. In the civil protection plan).

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 700475

Name	Description	Specifications & Dependencies	Triggered By
Generate task assignment messages	Generate messages with the corresponding task assignments in the targeted language based on the KB task typology.	i) language parameter (EN, ES, GR, IT)	The authorities validate tasks that the KB service has deduced (based on standardised actions as described e.g. In the civil protection plan) and/or input ones determined on the fly, based on the unfolding situation.

Mobile Application (Public + First Responders)

Name	Description	Triggered By
Add user information	Initial configuration, including i) User group (default: citizen): a) Police b) Fire brigade c) Ambulance d) Volunteer ii) Role of the person: Mayor, … iii) Language iv) URL to Server	First start of the mobile app
User authentication	The user needs to authenticate if accessing a non-public group	First start of the mobile app
Show network status	Display the status of the network connection. E.g. connected, pending messages, last updated	
Offline usage	If no network connection is available the app should be usable as much as possible. At least it should be	

This project has received funding from the European Union’s Horizon 2020 research and innovation program under grant agreement No 700475

Name	Description	Triggered By
	possible to see, create and update warnings, reports and tasks. Use an offline version of the map possible	
Multilingual	The app can be used in different languages. (Static text: e.g. menu, explanation text, e.g. is handled inside app)	
Show warning from authority	Show warnings or evacuation orders and additional information / recommendations to users: i) Depending on the category/type information about the recommended behaviour should be shown ii) Depending on severity a notification should be shown	Based on the technical requirements of the report generation module
Multilingual	Warnings can be shown in different languages. Server is responsible for providing message for given language.	
Create a report	Create a report and sent it to the authority	User of the mobile app
Add position	Add a position to the report. If possible, suggest the current position to the user. If not possible or if another location is affected the user can change the position	Included during report creation
Add media to report	Record or add existing photo/audio/video to message	Included during report creation
Send report	Send message directly if possible or as soon as network connectivity is	Included during report creation

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 700475

Name	Description	Triggered By
	resumed	
Append additional information	The user can append additional information to the report (e.g. some media or comments) after the message is sent.	User of the mobile app
Append report	The user can append existing or newly created report to an existing report	User of the mobile app
Show status of report	The user can see the status of the report. 1) Sent? Pending? 2) Feedback?	Change of status is triggered by: 1) Mobile app 2) PSAP which initiates the actions for this report
Receive a task from the authorities	First responder can receive a task created by the authority.	(i) Multilingual report generator (ii) PSAP
Append additional information	The first responder can append additional information to the task (e.g. some media or comments)	First responder
Send updated task	Send update directly if possible or as soon as network connectivity is resumed	Mobile app
Update report status	Allow first responder (team) to update the status of the tasks assigned to them	First responder
List tasks	User should be able to see in a list his own tasks	First responder
Show tasks on map	User should be able to see on a map his own tasks	First responder
Receive task update	Receive changes in task from authority (e.g. additional information was added or the status changed)	PSAP

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 700475

Name	Description	Triggered By
Notification for assignee	User should be notified if he is assignee of a task	PSAP
Filter reports	The User should be able to filter reports: - Based on time (newer than) - Based on location (in defined location or next to user) - Based on attributes (attribute equals value)	
Track position	Track position	
Sent tracked positions	Send current and non-uploaded historical positions to the central station.	
Display layers on the map	The user should be able to select additional layers for the map. This can be used for: - UR 115: Display flooded areas - UR 116, 125: Display areas to which citizens should not enter - UR 118: Display water level overtopping threshold - UR 122: Display rainfall overtopping threshold - UR 124: Display status of river embankment - UR 130, 131: Display traffic status - UR 206: Display specific weather data - UR 305: Show suggested places - UR 337: Show location of traced position - UR 212: Warning for citizen to avoid interference - UR 336: Traffic	

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 700475

Name	Description	Triggered By
	warnings Each layer can be designated to particular user groups.	
Warning when approaching area	Show warning when user wants to approach area which: - UR 116: is flooded - UR 125: in which there is an ongoing restricted operation	
Display information about fire	Provide first responders information about smoke behaviour, fuel being burned, advancing fire (flame progression, height and length) and aerial images of the smoke and the trajectory flames.	
Communication with authorities	Provide possibility to communicate with authority	

Social Media Analysis

Scenarios	Name	Description
Flood	Social media post visualisation	Demonstrate social media posts which are relevant to a flood event and provide filtering options through searching by query
Flood	Localise Twitter messages concerning a flood event	Localise a flood event and relevant updated information in a two-stage approach: first classify Tweets as relevant or irrelevant and then get locations from relevant posts
Flood, Fire	Detect element at risk, people in danger	Detect element at risk (e.g. people in danger), estimating the level of risk from the latest social media posts

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 700475

Flood	Detect embankment exceeding	Detect if a river embankment is overtopping and/or breaking from Twitter posts
Fire	Notify and warn about fire events	Warn authorities and first responders about Twitter messages concerning a forest fire event through an automatic classification process
Heatwave	Localise Twitter messages concerning possible locations in the city that require rescue team intervention	Localise and display visual information about possible locations in the city (or outside the city) where a situation is more likely to develop that will require rescue team intervention, through clustering extracted concepts (identified as locations) to deliver a message heatmap or to show Twitter reports as points on the map
Heatwave	Hospital status reporting on social media	Localise social media posts which are directly linked to a hospital or places offering air-conditioned rooms and other suggested places for relief, through clustering extracted concepts (identified as locations) to deliver a heatmap of relevant Tweets or to show Twitter reports as points on the map
Heatwave	Estimate traffic conditions from social media	Get Twitter messages relevant to traffic conditions to notify the authorities about existing traffic conditions all over the city grid
Heatwave	Social Media reporting of emergency situations	Collect text and images from social media accounts and classify them as relevant or irrelevant to the target event

Video Analysis

Name	Description	Triggered by
Detect flooded elements from video	Analyse video samples acquired from surveillance and mobile cameras (i.e. CCTV & mobile video) in order to localize flooded objects inside them. Spatio-temporal information is leveraged in order to localize flooded regions inside and throughout video frames. While, object and landscape recognition is applied simultaneously on each video	The module is triggered whenever a new video sample is saved to the server.

	frame in order to detect people, cars and buildings that might exist in the flooded area.	
Detect water depth and velocity	Video frames from static surveillance cameras (CCTV) are monitored and analysed throughout regular and periodic time intervals in order to determine the water's depth and velocity. Historical visual data are analysed so as to build a normal depth and velocity pattern for each time period (i.e. winter/summer) and determine statistically acquired overtopping thresholds. The module raises an alarm whenever these thresholds are surpassed or abnormal patterns are detected.	This is a continuous module that is triggered whenever a new video frame/video sample is saved on the server.
Detect rainfall volume and duration	Analyse static and mobile video samples in order to determine a rainfall's volume and duration.	The module is triggered whenever a video sample is saved on the server.
Detection of people and goods in danger	Video samples from surveillance (CCTV) and mobile cameras are analysed so that fire and objects in danger could be detected. Spatio-temporal analysis of video samples is deployed in conjunction with an object and landscape detector (i.e. people, cars, buildings) in order to determine people and goods in danger.	New video samples for surveillance and static cameras trigger this module.
Smoke behaviour and classification	Video frames from surveillance cameras are analysed so as to detect smoke streams, analyse their behaviour based on stream trajectory and classify them based on the fuel that is burned (i.e. colour/density based discrimination).	The module is triggered whenever a new video sample is saved on the server.
UAV fire analysis	Video samples are going to be used so that a fire management plan could be accomplished. Fire and smoke analysis is going to be deployed so that fire progress could be determined. Evacuation and extinguish plan is going to be returned to the system so that citizens could avoid danger and first-responders tackle the danger.	New UAV video samples would trigger this module.
Management of traffic emergencies	Analyse static camera traffic videos from surveillance cameras so as to detect traffic jam caused by power outage (traffic lights not working) or when many people leaving city for seaside. Vehicle discrimination and traffic density could be determined throughout regular intervals of specific time periods.	The module is triggered whenever new video samples are saved on the server.
Management of	Video analysis of people in places for relief to detect level of occupancy. An object detector is	Triggered whenever a new video sample is

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 700475

places for relief	deployed so that people counting and their behaviour could be measured.	saved on the server.

Image Analysis

Name	Description	Triggered by
Detect flooded elements from image samples	Analyse images acquired from surveillance and mobile cameras (i.e. CCTV, social sites, mobile image) to localize flooded objects inside them. Object and landscape recognition is applied simultaneously on each image sample in order to determine whether the image shows a flooded area and if people, cars and buildings are in danger.	The module is triggered whenever a new image is saved to the server.
Detect water depth from images	Image frames from static surveillance cameras (CCTV) are monitored and analysed throughout regular and periodic time intervals to determine the water depth level. Historical visual data are analysed so as to build a normal depth pattern for each time period (i.e. winter/summer) and determine statistically acquired overtopping thresholds. The module raises an alarm whenever these thresholds are surpassed or abnormal patterns are detected.	This is a continuous module that is triggered whenever a new image is saved on the server.
Detect rainfall volume and duration in images	Analyses static, mobile and crawled images from social sites to determine a rainfall's volume and duration.	The module is triggered whenever a new image is saved on the server
Detection of people and goods in danger from image samples	Images crawled from social sites, surveillance (CCTV) and mobile cameras are analysed so that fire and objects in danger could be detected. Colour based analysis of image samples in conjunction with object and landscape detector (i.e. people, cars, buildings) are deployed in order to determine people and goods in danger.	New image samples from surveillance, social media and mobile cameras trigger this module.
Smoke classification from image samples	Image samples from various camera sources could be analysed so as to detect smoke streams and classify them based on the fuel that is burned (i.e. colour/density based discrimination).	The module is triggered whenever a new image is saved on the server.
UAV fire analysis	Fire detection and people and goods in danger are to be detected.	New UAV images would trigger this module.

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 700475

Management of traffic emergencies from images	Analyse mobile or static camera traffic videos from surveillance cameras so as to detect traffic jams in cities and suburbs. Vehicle discrimination and traffic density based on the vehicle number could be determined throughout regular intervals of specific time periods.	The module is triggered whenever new image is saved on the server.
Management of places for relief from images	Image analysis of people in places for relief could be deployed so as to detect level of occupancy in the surrounding region. An object detector is deployed so as to detect the number of people.	Triggered whenever a new image is saved on the server.

Automatic Speech Recognition

Name	**Description**	**Triggered By**
Visualization of information from voice recordings	Display information to authorities regarding flood events, with information extracted from citizen's and first responder's voice recordings sent through apps. Provide filtering options through search queries.	The analysis of voice recordings and the relevant message prompt to authorities are triggered whenever there is a new audio recording regarding an event (The ASR module is triggered by a message that a new audio file is available). Additionally, Visualization by Query can be prompted after authorities' request.
Detect element at risk and people in danger	Detect element at risk, the degree of emergency, and people in danger with information extracted from citizen's emergency voice recordings sent through apps. and provide relevant information to authorities/first responders	The module will be triggered whenever there is a new audio recording regarding an event (The ASR module is triggered by a message that a new audio file is available). Additional information can be displayed after authorities' request.
Automatic translation from a foreign language	Make easy the communication between people with different languages (citizens, authorities, first responders), by providing the opportunity to record a voice message in one of the supported languages, which can later automatically be translated to the language of the recipient.	Whenever a user doesn't recognize the language of the voice recording will be able to send a translation request.

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 700475

Name	Description	Triggered By
Number of people affected and their location	Provide authorities information regarding people that might be affected from the phenomenon, people that might be trapped (e.g. in an elevator), elderly people in houses without A/C and display their location	The module will be triggered whenever there is a phone call regarding an event (The ASR module is triggered by a message that a new audio file is available). Additional information can be displayed after authorities' request.

Meteorological data

Name	Description	Triggered By
Standard deterministic weather-forecast data	Numerical weather prediction (NWP) outputs from HIRLAM. Key variables at standard heights (e.g. 2 or 10m): temperature, wind direction and speed, humidity, precipitation, pressure. About 7km horizontal resolution. Time resolution probably about an hour. Forecast out to several days ahead.	Potentially the data are always loaded every 6 hours by a script such as wget from the FMI OpenData xml feeds.
Ensemble NWP	GLAMEPS. About 7km horizontal resolution. Time resolution probably about an hour. Forecast out to 2 days ahead.	Probably custom ftp scripts needed to push/pull the data. Data forecasts renewed every 12 hours.
Indices / maps	Forest-fire index, which is compatible with the European Forest Fire Information System (EFFIS)	
Indices / maps	FMI risk maps for heatwaves	
Observational data	Satellite via EUMETSAT	

AMICO flood forecasting model

Name	Description	Triggered by
Supply of flood predictions for the Flood Scenario	The Flood Forecasting System AMICO will generate continuously flood predictions based on the most recent available FMI weather forecasts. AMICO runs in the AAWA server and generates the following outputs (txt files):	A notification of new downloadable weather forecasts from FMI with a link for downloading the data

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 700475

Name	Description	Triggered by
	1) the level of forecasted alarm and timing for each river section (geolocalized points) modelled during the last RUN 2) the timeseries of forecasted levels for each river section. The output of AMICO will be downloadable from the AAWA server by a web service. A notification will be sent by AMICO to the beAWARE system together with a link for downloading the forecast results.	

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 700475