ASPires CATALOGUE

Advanced systems for prevention
& early detection of forest fires

Ref. ECHO/SUB/742906/PREV03
ASPIRES

Advanced systems for prevention & early detection of forest fires

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Technical cooperation projects

European Commission

Directorate-General for European Civil Protection and Humanitarian Aid Operations

ECHO A-Emergency Management

Unit A4-Civil Protection Policy

Project coordinator

Fulda University of Applied Sciences, Germany

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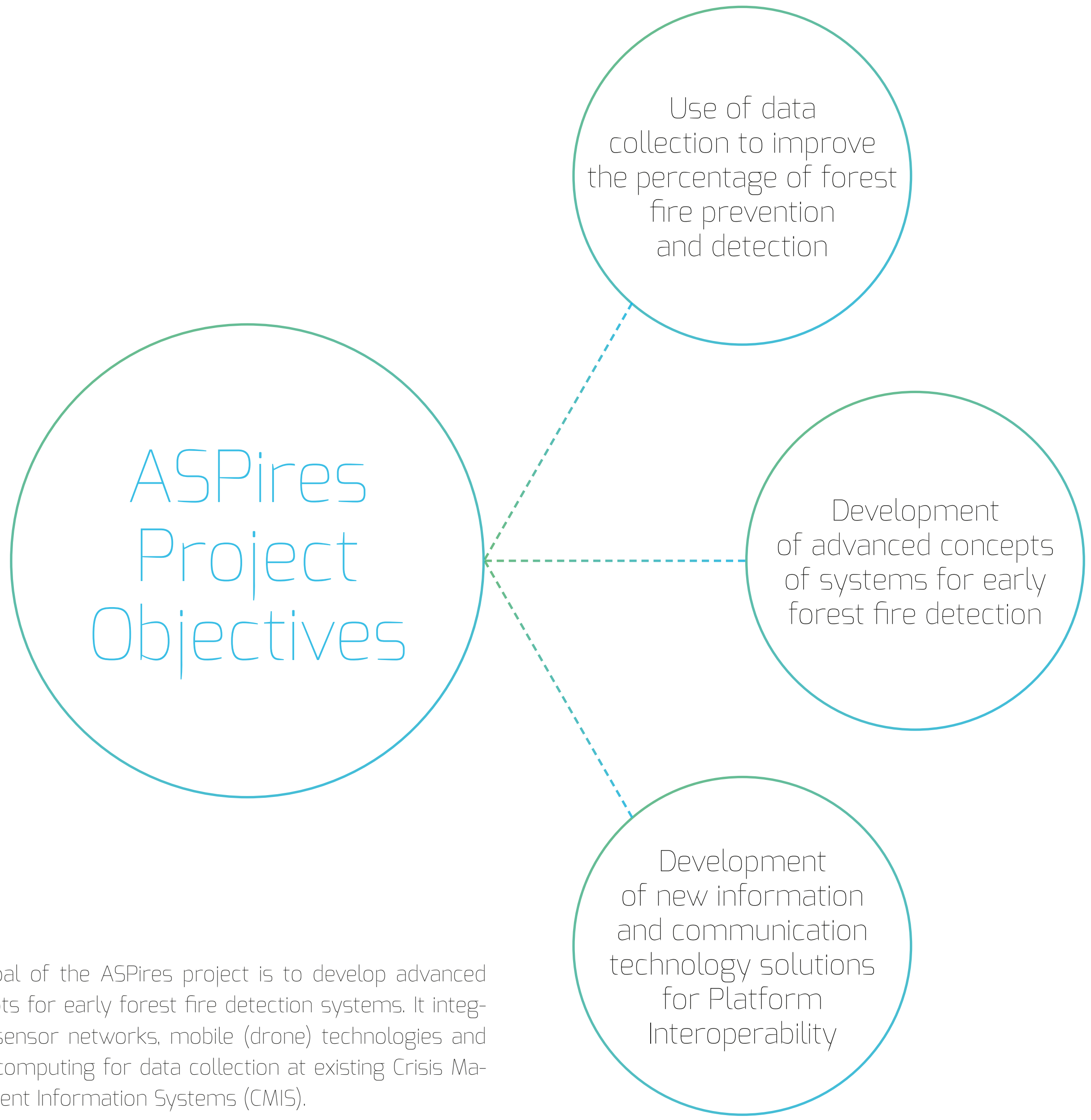
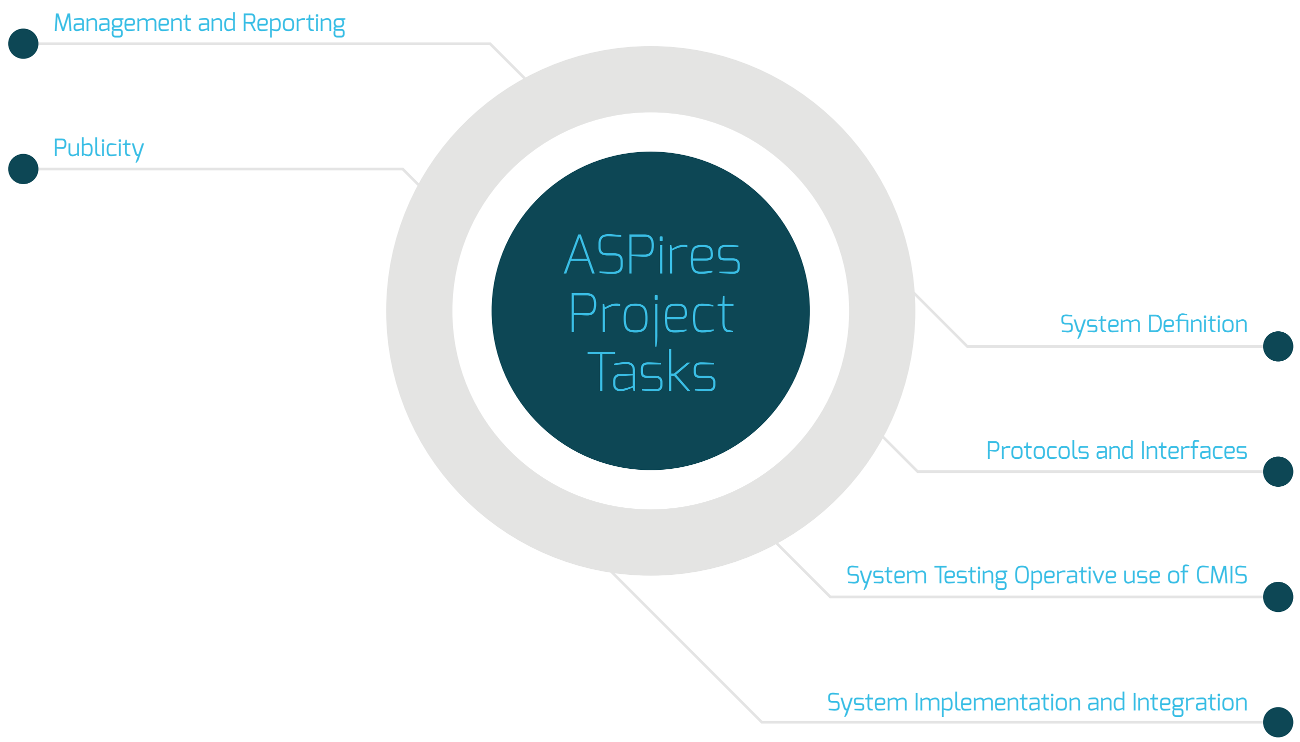


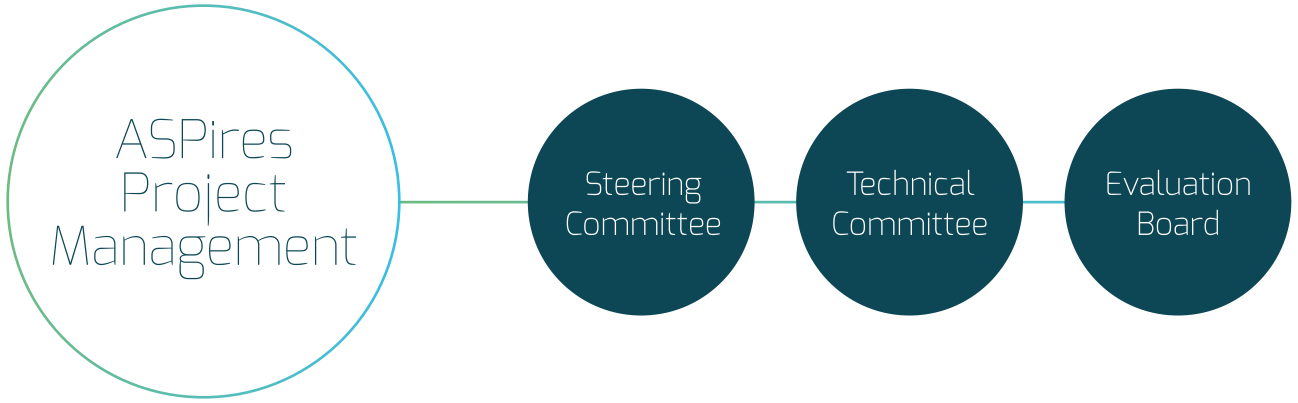
The goal of the ASPires project is to develop advanced concepts for early forest fire detection systems. It integrates sensor networks, mobile (drone) technologies and cloud computing for data collection at existing Crisis Management Information Systems (CMIS).

It will allow CMIS in Europe to develop and implement different methodologies and services for initial stage warning, prevention, localization and organization of the firefighting teams and tactics for disaster suppress.



To achieve the expected results the ASPires project is divided in several tasks, detailed described in ASPires project web site

https://www.aspires.eu/web/guest/deliverables



The coordinator of the ASPires project is Fulda University of Applied Sciences, Hesse, Germany.

The Coordinator is responsible to collect and submit all forms such as deliverables and reports, to the European Commission and represents all project partners in front of the European Commission.

The coordinator is also responsible for the financial and administrative management, which includes preparation of amendments to the grant agreement, final and progress reports and communication of changes regarding the beneficiaries to the European Commission. To ensure the cooperation and proper realisation of complex tasks, a Steering Committee (SC) was established and is headed by the coordinator.

The Steering Committee is composed of one representative from the coordinator and from all partners of the project, who have a mandate to take decisions.

The Steering committee is the body that is finally approving all project documents, deliverables, decisions, reports and the acceptance of every step of the project and guarantees the overall project coordination between tasks.

The Evaluation board takes care of the quality and completeness of the deliverables. The Evaluation board guarantees the integrity of the documents, their readability and style and reports to the Steering Committee.

The Technical committee is the body which makes technical decisions of the project. Participants are representatives from the coordinator and all partners of the project with technical expertise and experience.

Hochschule Fulda
University of Applied Sciences

Fulda University of Applied Sciences

Fulda University of Applied Sciences (www.hs-fulda.de/en/) is a research-oriented University of Applied Sciences in Fulda, Germany

Research is carried out in various areas such as „Nutritional, Food and Consumer Sciences", „Food Technology", „Electrical Engineering and Information Technology and Informatics" and „Applied Computer Science."

This research orientation is also reflected in the right to award doctoral degrees, which Fulda University of Applied Sciences has got since 2016 as the first University of Applied Sciences in Germany.

The University of Applied Sciences in Fulda runs furthermore cooperative doctoral programs and various doctoral research groups in collaboration with other universities.

The wide range of subjects offered by eight departments and several cross-disciplinary research centres and a regional innovation centre provide good conditions for interdisciplinary study, research and innovation activities.

As a university of applied sciences, strong collaboration with enterprises and society is part of the mission of the university.

The Aspires project, which is coordinated by the University of Applied Sciences in Fulda, is a good example of research and development resulting from cooperation between research organisations, companies, end users and further stakeholders.

The Military Academy

The Military Academy, Skopje, Republic of North Macedonia (MA, http://www.ma.edu.mk/?lang=en) was established with the Law on Military Academy, which stipulates that it works in accordance with the Law on Higher Education and the Law on Scientific Research Activity in the Republic of North Macedonia.

The Military Academy is accredited by the Ministry of Education and Science, Republic of North Macedonia in accordance with the European Credit Transfer System (ECTS), as an independent higher education and research institute.

Military Academy attains university studies of first cycle (undergraduate), second cycle (master's and specialization) and third cycle (doctoral studies).

The university diploma for students who complete MA education will be verified in the country, which will enable the cadets and students to have an occupation and opportunity for further education in the educational system of the Republic of North Macedonia and foreign member states of the Bologna Process.

The Military Academy as the only military higher education and scientific institution in the Republic of North Macedonia has the basic task of educating, training and improving staff for the needs of the MoD, the ARM, the Crisis Management System, the Protection and Rescue System and to deal with the NIR for defence needs according to law.

The role of Military Academy Skopje in the ASPires project is to conduct comparative analysis with other models of information systems for detection and monitoring forest fires, develop MOCK-UP for existing MKFFIS, installing a set of cameras detectors and mobile device (like drone) available on the market with a large optical range of monitoring forest fires in areas of importance. He performs research, testing and measurements of the detectors and sensors to analyse the degree of efficiency.

InterConsult Bulgaria

InterConsult Bulgaria (ICB, https://www.icb.bg) has been founded in 1996 with main business focus on software development and business consulting. Today more than 90% of the ICB turnover is generated from companies in the Nordic region, the UK, the USA, Germany and other countries.

During the years ICB has established itself as a leading provider of innovative software solutions in the fields of industrial engineering, maritime, banking and financial services and information technologies. ICB has more than 130 experienced professionals in staff today specialized in the areas of business process modelling, software architecture design, software development, quality assurance and 3D modelling and design.

ICB offers a wide range of professional services in the fields of:

· Development of world-class products and services focused on customer's core business

· Technology lift and modernization of existing software systems and infrastructure

· Business process modelling, optimization and automation

The role of the InterConsult Bulgaria Ltd. in the ASPires project is to develop solution for data management including storing of time series data in the cloud, data modelling and specifying of all data flows necessary for the interoperability of different systems through standard interfaces.

COMICON

COMICON (http://www.comicon.bg) has been established in 1991 as a private company by specialists experienced in the field of industrial automation.

MAIN ACTIVITIES

Turn-key solutions for automated control and monitoring of industrial processes and systems: design by certified designers, production of control panels, assembling, PLC, HMI & SCADA software, warranty and after sell service.

Production of ZigBee, EnOcean, LoRa products for wireless communication, interface converters (RS232, RS485, RS422, current loop), telemetric and embedded controllers, solar controllers, programmable logic controllers (PLC) and remote IO, signal conditioners, transmitters, signal devices.

R&D of hardware, firmware and software for industrial automation.

Energy management and monitoring systems.

Telemetric systems for wireless control and monitoring of remote installations.

Design, delivery and implementation of video wall systems for control rooms and other applications.

In the ASPires project Comicon Ltd., Bulgaria has made a research for wireless sensor networks, has designed and developed a prototype of LoRa based field gateway in fixed and mobile versions, has performed simulations through OMNET++. The aim of the simulation is to prove the vitality of the solution during disasters.

National Cluster for Intelligent Transport and Energy Systems (NCITES)

NATIONAL CLUSTER FOR INTELLIGENT TRANSPORT AND ENERGY SYSTEMS

National Cluster for Intelligent Transport and Energy Systems (NCITES), Sofia, Bulgaria is a voluntary association of legal entities and individuals, established in 2014.

The aim is to achieve a more effective concentration of resources to improve competitiveness and to expand the scope of each participant's resources.

NCITES includes 12 leading companies in the field of education, IT infrastructure, software development, transport and energy control systems.

NCITES organizes the development of scientific and practical projects in the field of intelligent control systems. NCITES collaborates closely with research, training and engineering organizations.

From February 2017, the National Cluster for Intelligent Transport and Energy Systems was successfully categorized by the Ministry of Economy, the SME Agency, Bulgaria in the Cluster "Expansion" category.

The NCITES web site http://www.cluster-ites.org/en/home includes more information about the cluster.

In the ASPires project, NCITES has developed a real model of a fixed early warning system for forest fires based on cameras. The model is used to demonstrate the capabilities of the ASPires platform.

NCITES is also responsible for the creation and management of the ASPires project web site and a creation of a variety of dissemination materials.

End User of the Project

- Ministry of Interior Germany
- Ministry of Interior National emergency Management authority Bulgaria
- Ministry of Environment and Physical Planning Republic of North Macedonia
- Crisis Management Centre Skopje Republic of North Macedonia
- National park Mavrovo Republic of North Macedonia
- National park Pelister Republic of North Macedonia

Comparative analysis of the existing systems for early forest fire detection

Forest fires undoubtedly have come to represent one of the greatest threats to nature's wellbeing and to the world in general. Usually accompanied with the loss of human lives, property damage and loss of homes, loss of forested area, biodiversity changes and climate change, forest fires should not go by being ignored.

As of 2017, in the world there are several systems as well as pilot-projects that have been created to aid the early prevention and detection of forest fires. There are also multiple scientific studies and research papers that cover this issue from different aspects.

The starting point in almost all of them is the great number of forest fires in recent years and the need to act preventively faster, easier and in a simpler manner in order to deal with the threat that forest fires have come to represent.

However, the existing systems differ from one another, and the goal of this project was to specify those differences, identify their strengths and weakness and propose a way to strengthen their reliability in a new system. ASPires combines the positive aspects of each system into a more, if not the most efficient alternative.

Accordingly, much like the leading idea behind the Advanced System for Prevention and Early Detection of Forest Fire Project, we are and we constantly looking for the technologies that would make the development of better forest fire detection systems possible. In this context, the ASPIRES team looked at a couple of ideas that would improve the whole system for fire detection, and they are as follows:

· implementation of LoRa and LoRa WAN as low powered wide area networks in the detection system especially Wireless Sensor N;

· use of drones as part of aerial reconnaissance and early detection of forest fires;

· use of a cloud computing platform for service virtualization at different levels of granularity;

· use of field gateways to map existing or proprietary solutions to the cloud platform;

· define the concepts for systems integration and interoperability at different levels;

· advance measures and image analysis using HD cameras in combination with the weather conditions and drones.

Aerial detection

There are 10 Polar-orbiting satellites (7 meteorological and 3 scientific) which cycles the earth in a sun-synchronous orbit. Some features related to the use of satellites are:

- Places with middle or higher latitude can be seen about 2-4 times a day from the satellite.
- Forest monitoring depends on accessible satellites.
- The use of the satellites is limited by high costs and limited resolution due to the large picture size.
- Satellites cannot detect small fires.

Camera Surveillance

Different types of detection sensors can be used in terrestrial systems:

- a video-camera, sensitive to a visible smoke spectrum, recognizable during the day and a fire recognizable at night;
- infrared (IR) thermal imaging cameras to detect of heat flux of the fire;
- IR spectrometers for identifying the spectral characteristics of smoke.
- systems for detecting and measuring light by measuring light rays reflected by smoke particles.

All these systems are useful for use in towers as tools to improve the quality of surveillance.

Wireless sensor networks (WSN)

WSN has gained worldwide attention, especially with the proliferation of Micro-Electro-Mechanical technology that facilitates the development of intelligent sensors.

For example, deploying a network of sensors with Internet Protocol (IP) cameras can be a great way to detect the fire in the beginning and send an alarm signal to the fire brigade.

Sensors sense physical parameters such as temperature, pressure and humidity, as well as chemical parameters such as carbon monoxide, carbon dioxide and nitrogen.

The camera is used to provide real images from forest fire, thus avoiding false alarms.

These sensor nodes are cheap and small, with limited productivity and computing resources.

They need to be organized to work with other technologies and systems to develop an algorithm for generating fire alarms.

These sensor nodes have limited battery power and limited memory and are usually located in hard-to-reach areas where people cannot go easy.

Some of the advantages of wireless sensing networks for early detection of forest fires are:

- No pre-installed communications network. Nodes require a GSM coverage or Wi-Fi network to work.
- Time-stamp of all measurements made.
- Dual functionality: environment monitoring and early fire detection.
- It is not based on cameras. The acquisition and transmission of video or image are very demanding in terms of bandwidth and power consumption.
- The advantage of sensor networks lies in their low acquisition costs and their easy installation in the forest.

As the area increases, the price advantage decreases as the time-critical fire registration requires a narrow network of separate nodes.

Using drones in forest fires detection systems

Commercialization has brought more unmanned aircraft to the market, making technology more accessible to emergency services. These eyes in the sky can be used in the public security services to identify the heavily affected areas after a natural disaster.

Each drone can be used as an air platform with the potential to carry the same sensors that would otherwise be placed on the ground surveillance pole. Depending on the characteristics of the drones, they can carry one, two or more sensors, a camera, and so on.

Comparison parameters

By comparing the methods and techniques applied in the existing fire detection information systems, it can be concluded that the benefit of the system is best assessed through seven parameters.

The table below gives an assessment of existing technologies.

Evaluation of existing technologies

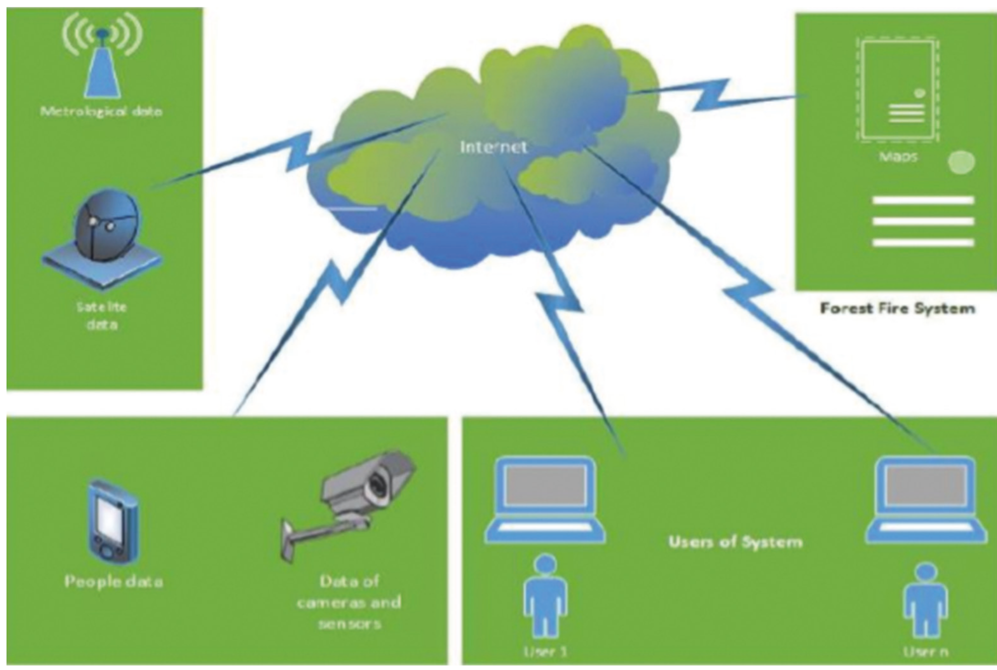
	Human Based Observation (HBO)	Satellite Based Systems (SBS)	Wireless Sensor Networks (WSN)	Camera Based Surveillance (CBS)
Cost (1)	low	very high	medium	high
Efficiency and practicality (2)	low	high	high	medium
Faulty alarm repetition (3)	low	low	medium	medium
Fire localizing accuracy (5)	low	low	high	medium
Detection delay (6)	long	medium	small	long
Behaviour information	-	yes	yes	-
Can be used for other perposes (7)	no	yes	yes	no

General architecture of forest fire prevention and early detection systems

The recommended architecture of a system for prevention of forest fires include:

- A network of automated measuring stations, suitable for obtaining meteorological data on the territory we aim to protect.
- Access to the data from the satellites to calculate the designated parameters.
- Combined set of cameras and sensors, extended with crowd-sourcing modules (such as citizens' smart phones) as needed in the area.

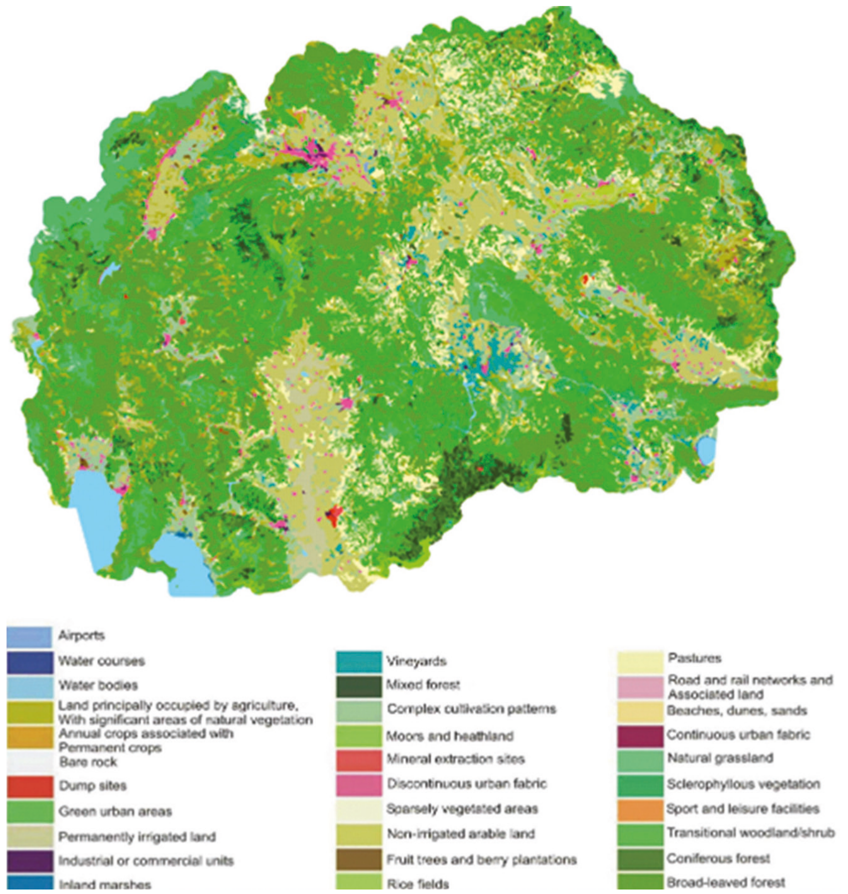
All these real-time data must be associated with static data such as a map of vegetation, demographic maps, orthophoto maps, etc. in an integrated system.



General architecture of a Forest Fire Prevention System

Published comparative analysis of occurred forest fires in Republic of North Macedonia

Forest land in Republic of North Macedonia



A multilayer map of Republic of North Macedonia

The total area of forest land in Republic of North Macedonia is 1.159.600 ha, of which forests cover 947.653 ha. They are characterized by a rich biodiversity and a significant non-timber forest resources: medical plants, mushrooms, forest fruits, game, etc.

The importance of forests is emphasized by the fact that the main part of the territory of the protected areas in this country are under forest.

Protected areas

Republic of North Macedonia recognizes several types of protected areas: national parks, strict animal species outside the natural reserves, and nature areas protected in the category of natural monuments. Officially, there are:

- 3 national parks, with an area of 108.338 ha, or 4.2%;
- 4 strict nature reserves, with an area of 12.855 ha, or 0.50%;
- 3 landscapes with special natural characteristics, with an area of 2.338 ha, or 0.09%;
- 14 areas with distinct plant and animal species outside the natural reserves, with an area of 2.709 ha, or 0.10%;
- 33 nature areas protected in the category of natural monuments, with an area of 61.655 ha, or 2.4%.

Causes of wildfires

The causes for most of the occurred fires are a combination of the overall climate conditions and a human factor. The most severe individual forest fire occurred in 2012 in the pine afforestation near the city of Strumica, when four people were killed and 12 injured (civilians), including seven children. The total damage (burned timber volume plus suppression costs) caused by forest fires in this period has been estimated at around EUR 51.000.000.

The changing climatic conditions have a potential to significantly impact human health, societies and economies, affecting all sectors. It is concluded that the climate characteristics in the period 2001-2005 had reflected well not just in the number of fires but also in the size of burned area. The total amount of economic losses due to forest fires in the period 1999-2005 was 28.298.245.10 €, of which only in the year 2000 the damage was 15.642.775.00 €.

The situation was similar in 2001, but not because of large number of forest fires and climate conditions, but due to improper extinguishing interventions of some of the fires. In the following years, damages from forest fires have seen a drastic decrease mainly because of climate conditions that influenced their appearance and spread.

Forest fires data (1998-2016)

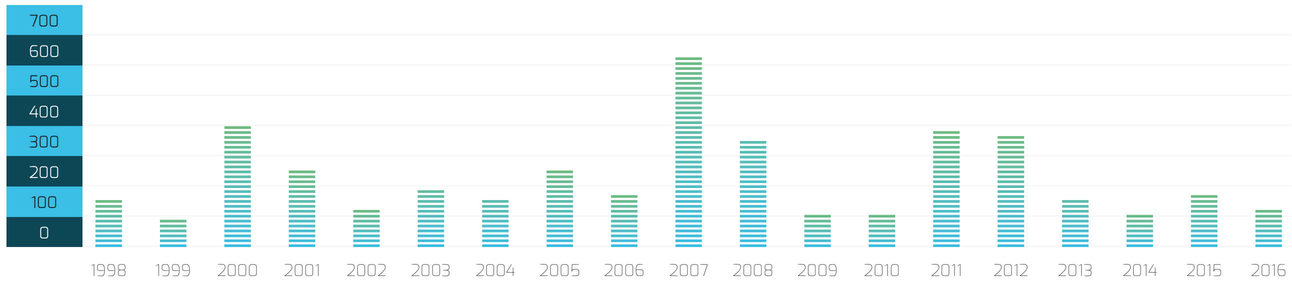
In period from 1998-2007 the highest number of forest fires (620) occurred in summer of 2007, when a state of emergency was declared. One of the contributing factors was the dramatic heat wave and extremely high temperatures that affected the region, along with a prolonged dry period. Related to the monthly data.

The months of July and August are the most intense, due to the high temperatures and drought that is characteristic for the climate at this period. The total number of fires in these months for the period 11998-2007 is 873 (35.7% of all registered wildfires), with 64.328 ha (66.7%) of burned area and 945.719 (82.8%) of burned timber mass.

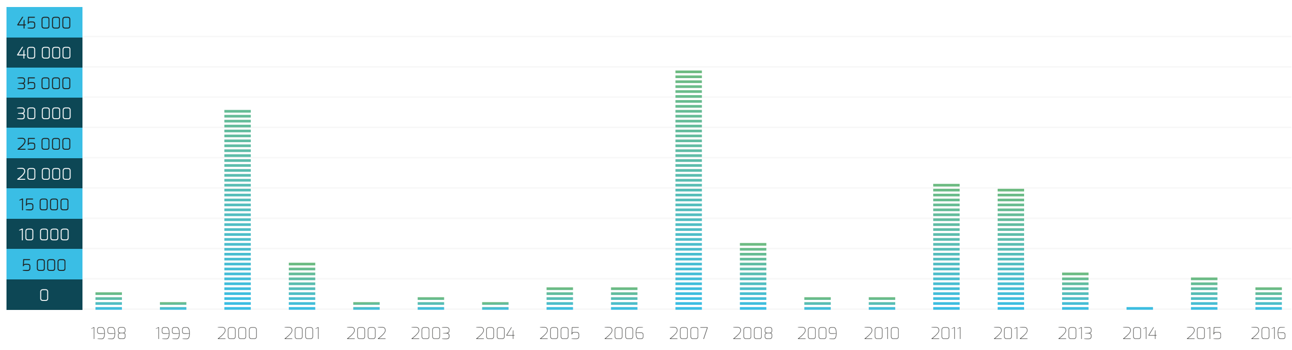
From 2008-2016, the 2008, 2011 and 2012 stand out as years with highest number of occurred wildfires: 339, 390 and 385 respectively. Still, the fires in 2012 were especially destructive, burning 19.967 ha (27.7% of the total burned area from this period) and 155.126 m3 of timber mass (43.6% from the total burned mass).

Monthly data in the period 2008-2016 show an increased number of fires in the months of July (265), August (517) and September (270). In these months, 55.3% of all fires occurred, the burned area amounts to 80.56% of the total, and the burned timber mass is 78.75% of the total.

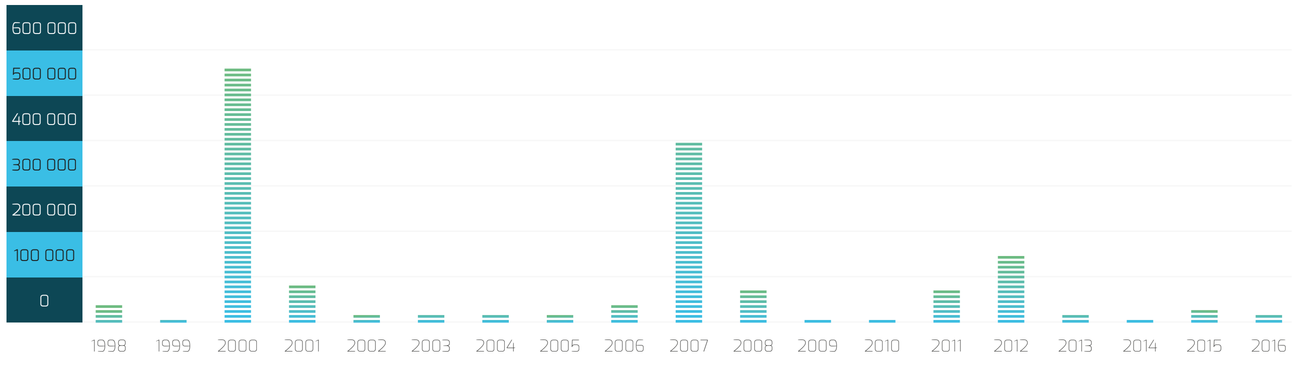
Number of fires for the period 1998-2016



Burned area (in ha) for the period 1998-2016



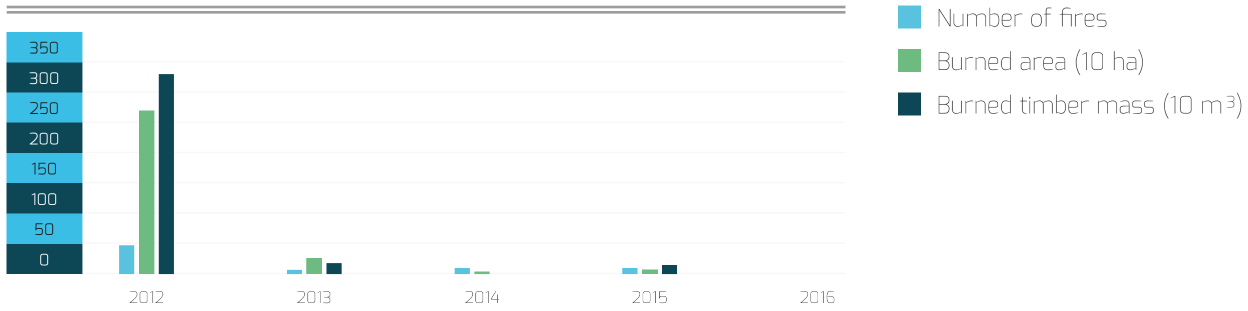
Burned timber mass (m^3)



Data for protected area

Following are the registered data within the three considered categories for the following protected areas: Pelister – Bitola, Galichica – Ohrid, Mavrovo – Mavrovi Anovi, Jasen – Skopje, Smolarski vodopadi – Novo Selo, Parkovi i zelenilo – Skopje, Vodostopanstvo – Kocani, Vodostopanstvo – Bitola and Gradska Shuma – Strumica, given in total for the years 2012-2016.

Categorical data (2012-2016) for the protected area



The most intensive occurrence of wildfires in 2012 was noticed in August (37), most of them have taken place in Parkovi i zelenilo – Skopje.

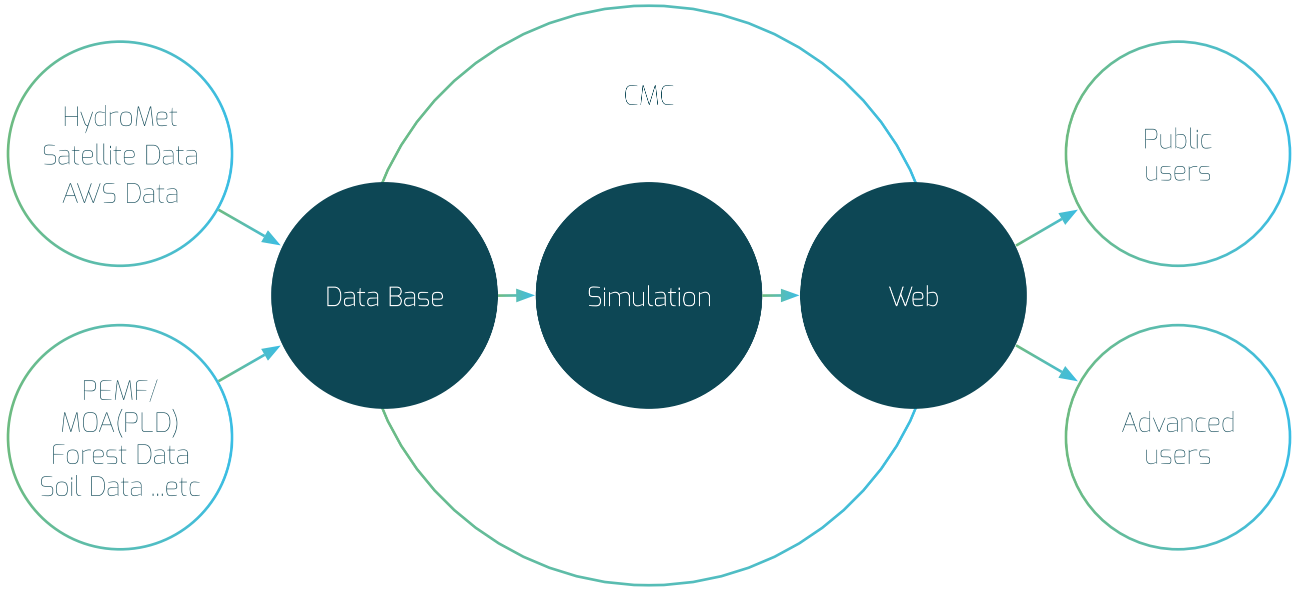
Economic damage

Economic damage is calculated in terms of expenses for fire extinction, damages caused by the fire as well as estimated expenses for rehabilitation and reconstruction of the damaged forest. In the table 2, data obtained from different sources on the total damage (expressed in MKD) caused by wildfire, is presented.

Estimated damage caused by wildfires (in MKD)

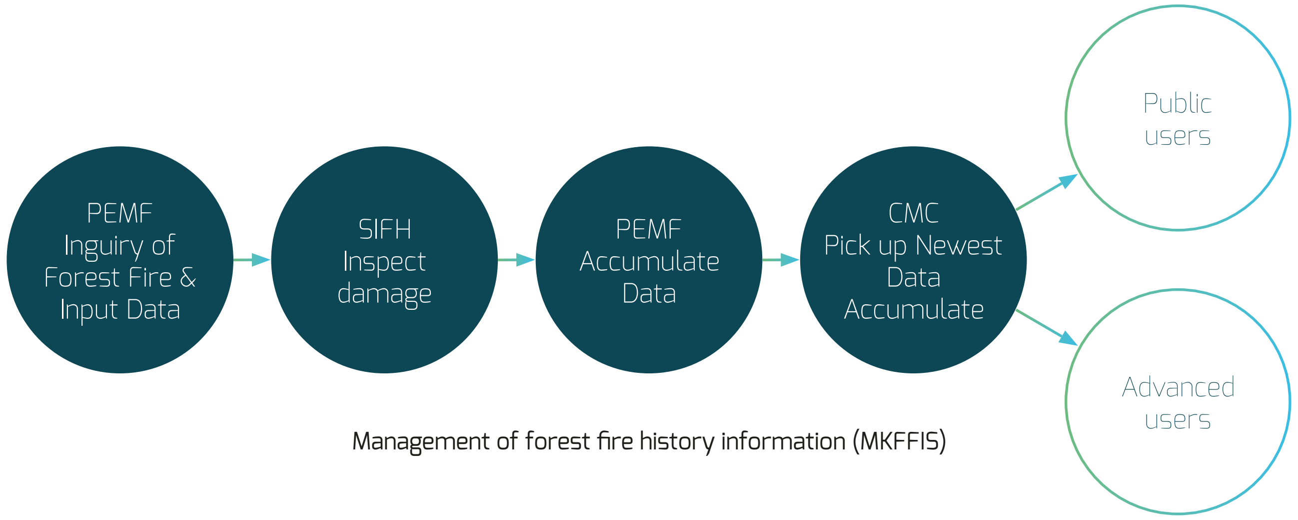
Year	Direct damage caused by fire (1)	Total damage caused by fire (2)	Total damage caused by fire (3)
1998	43.580.628	-	-
1999	9.494.446	105.837.151	23.046.518
2000	938.764.858	969.852.057	966.723.495
2001	140.990.945	610.814.677	609.338.668
2002	15.267.578	18.531.939	18.472.144
2003	25.589.261	15.594.691	15.544.368
2004	25.259.535	91.083.591	90.789.762
2005	12.208.900	25.287.638	25.410.986
2006	39.261.139	148.712.782	150.663.085
2007	655.961.705	1.311.167.721	1.328.372.460
2008	115.892.400	280.083.235	-
2009	5.182.100	29.746.034	-
2010	6.746.936	31.007.401	-
2011	105.725.546	355.053.833	-
2012	257.252.219	181.927.608	-
2013	26.373.484	109.500.306	-
2014	5.878.120	24.655.527	-
2015	40.489.140	1.282.348.110	-
2016	26.384.960	-	-
Total for the reported period	2.496.303.900	5.591.204.301	3.228.361.486

Forest Fire Information System MKFFIS Republic of North Macedonia



Prediction of a forest fire (MKFFIS)

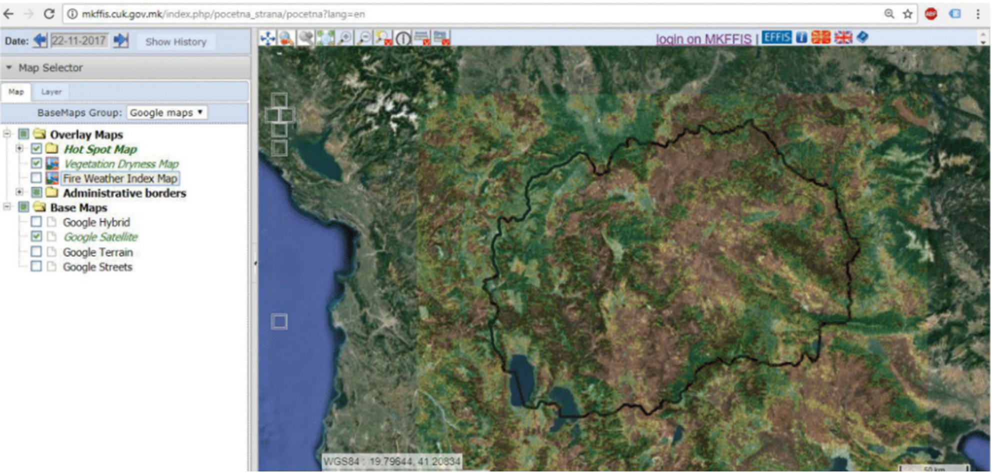
Macedonian Forest Fire Information System (MKFFIS) is an integrated web platform. By establishing MKFFIS, Republic of North Macedonia became the only country in the region that followed the example set by the European Union with the European Forest Fire Information System (EFFIS). MKF-FIS is completely compatible with EFFIS and is responsible to send information on an occurred forest fire as soon as possible.



Management of forest fire history information (MKFFIS)

Using of MKFFIS

- Data creation- entering and maintaining data at various locations (hydro-meteorological, forests, fire-fighting resources and historical data);
- Data acquisition- gathering, integration, and processing at centralized location (calculation of Fire Weather Index and risk assessment);
- Data publication- sharing and dissemination of data and information (via Intra and Internet) to support decision-making, policy-analysis and formulation, planning, monitoring and management at all levels of the national crises management system.



Forest fire history within the MKFFIS platform

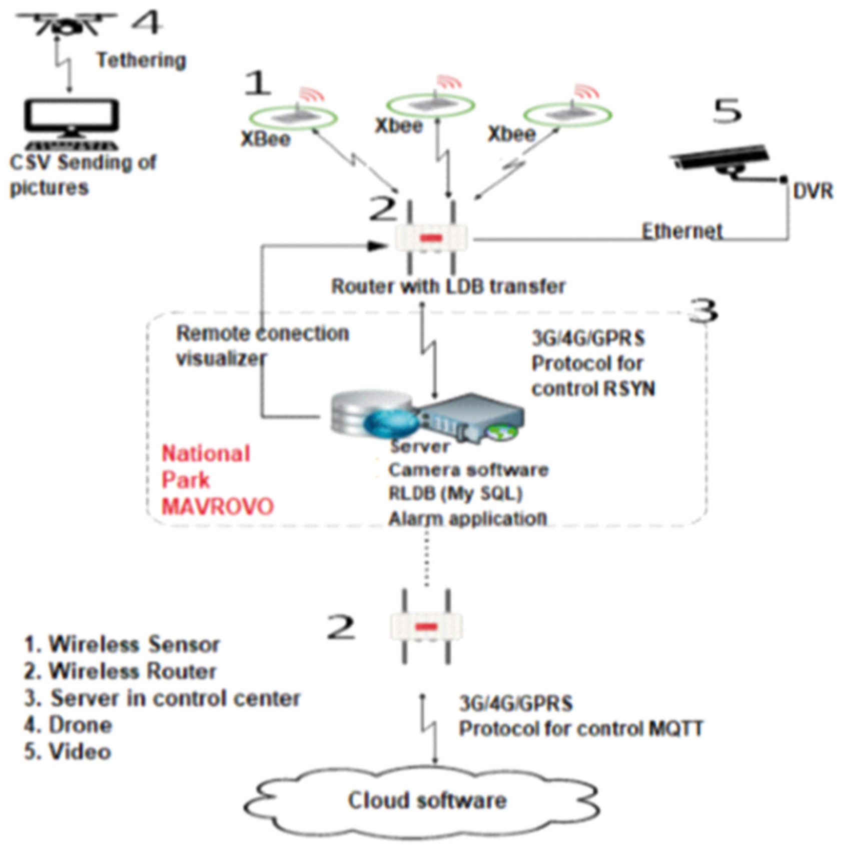
Its two main functions are prediction and management of forest fires. Through its web page, users can have an online access to the Hotspot Map, Fire Weather Index Map, Vegetation Dryness Map (public), while licensed users can access the Forest Vegetation Map and Fire History Map. It has a web feature service which can make fast assessment of burned forest by drawing/simulation of forest fires' boundaries.

As a conclusion, we can emphasis that the biggest benefit from MKFFIS is helping to lower the risk of forest fires and the danger they represent.

MKFFIS'S shortcomings

ASPires project will improve the collection of precise data on the local environmental conditions using sensors. The sensors are only active at specific time intervals for just enough time to gather data and send it to the local station, while the rest of the time they hibernate.

For the improving the data transmission, each bit of data is sent from the sensor to a router. The router can collect data from the sensors and has the option to use different interfaces in case the main interface fails to connect.



WSN design

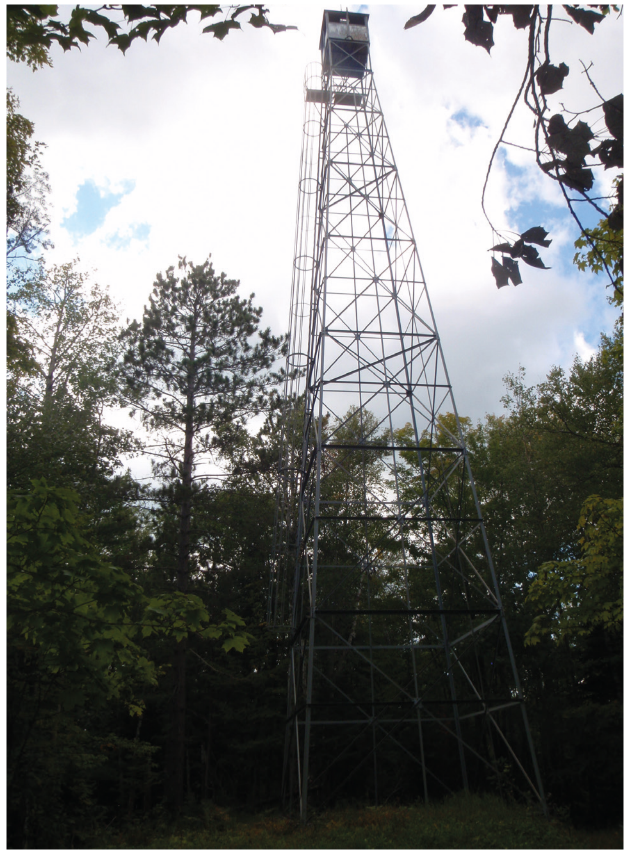
Algorithms for detection of forest fires

Some of the common challenges of the methods for monitoring are to detect and predict forest fires promptly and accurately in order to minimize the loss of forests, wild animals, and people in the forest fire. At the same time these algorithms shall be tolerant to normal environment parameter fluctuations and be immune to false positive alerts that could compromise the reliability and usability of the adopted approaches.

Fire Lookout Towers

The oldest and most common fire prevention and monitoring facilities are the fire observation/lookout towers. Perched high on the mountain top, these manned towers provided an excellent view point for smoke columns and flames. After a fire is spotted, the first objective is to pinpoint the exact geographic location of the fire.

However, these facilities require man to be positioned on site in distant locations and have lost their value with the introduction of newer technologies like cameras.



Fire Lookout Tower

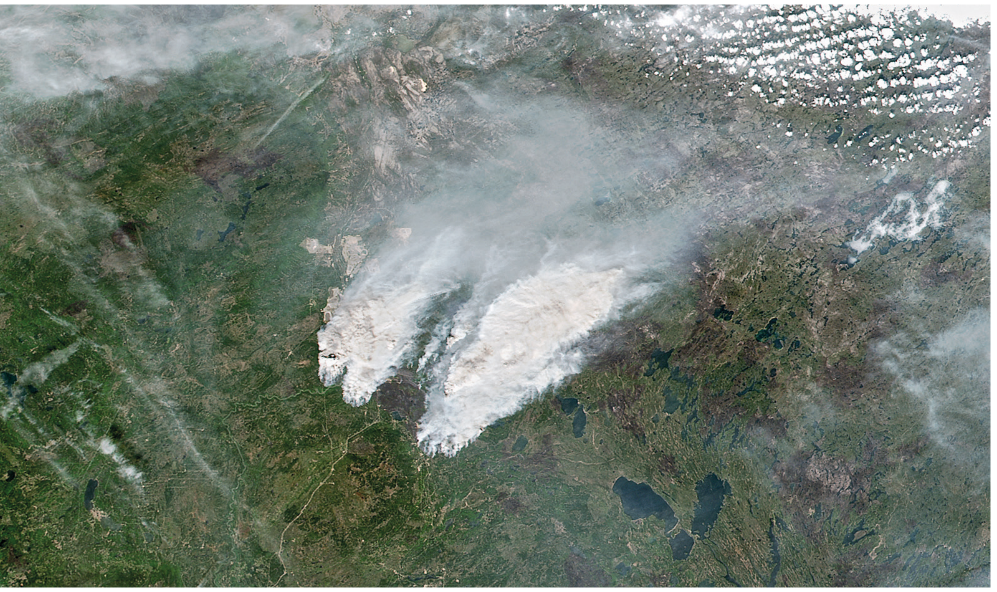
Cameras

Camera surveillance systems were introduced in order to reduce the necessity of man presence on site. Camera solutions have also proved to be ineffective method for fire detection, regards to the need of manual installation of each camera in appropriate position, rather than line of sight images, night images and bad weather images problems.

Satellite

Satellite images have proved more efficient than camera surveillance, where images gathered by two satellites, the Advanced Very High Resolution Radiometer and the Moderate Resolution Imaging Spectroradiometer have been used. Unfortunately, these satellites can provide images of the region s of the earth every two days and that is a long time for fire scanning, besides the quality of satellite images can be affected by the weather condition. This is a long delay for fire scanning, image quality could be affected by the weather conditions and it is practically impossible to deploy satellites to monitor all forests all of the time.

With the development of operational Earth observing satellite platforms useful tools, are provided for continuous surveillance of the Earth.



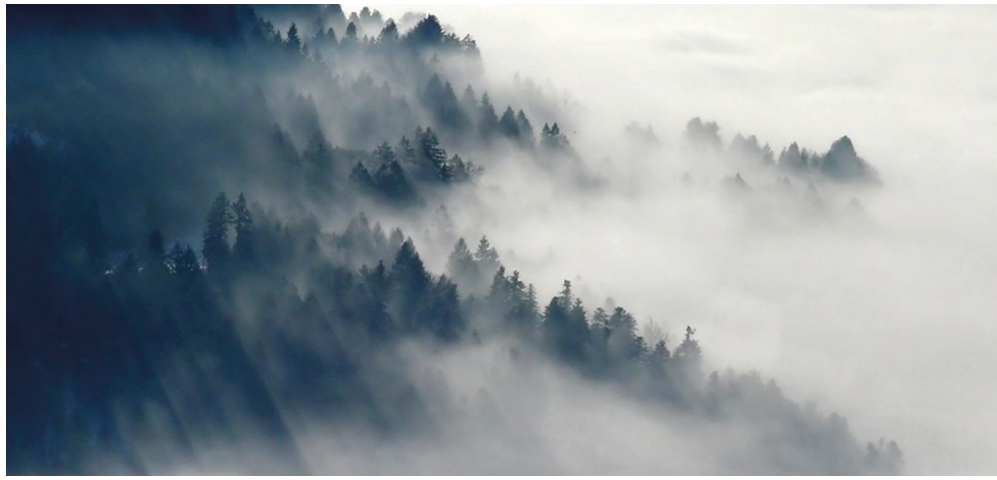
There are many different instruments on board various satellites which are used for different purposes. Sensors in the visible, near Infrared and mid infrared region have been used for observations of the vegetation for quite a while. Combinations of different channels or spectral regions can be used to get information on the state and the health of the vegetation. E.g. the dryness of the vegetation can be observed and included in fire risk analysis or, after larger forest fires this information can then be used to obtain information about the burned area to estimate damages.

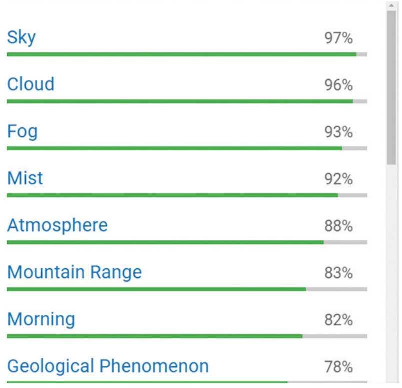
Satellite

Computer Vision as a Service

Cloud-based Computer Vision APIs provides developers with access to advanced algorithms for processing images and returning information. By uploading an image or specifying an image URL, Computer Vision algorithms can analyse visual content in different ways based on inputs and user choices. These are tagging images based on content, categorize images, identify type and quality of images, detect objects and return their coordinates, recognize domain specific content.

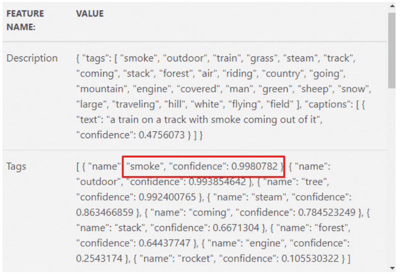
Computer Vision API returns tags based on more than 2000 recognizable objects, living beings, scenery, and actions. When tags are ambiguous or not common knowledge, the API response provides ‚hints' to clarify the meaning of the tag in context of a known setting.





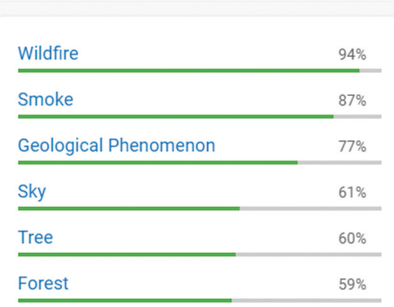
Azure Computer Vision – Tagging with Azure (negative sample) and Google Computer Vision

A test on both positive samples and negative samples (clouds or sunset colours mimic the appearance of a fire) was performed. Each tag is given a corresponding confidence score in the range (0:1) with 1 being the highest degree of certainty for relevance. Smoke – the higher is the rating, the greater is the likelihood for a fire been captured; Clouds, Steam – often fire or smoke could be visually confused with clouds or steam.



FEATURE NAME:	VALUE
Description	{ "tags": ["smoke", "outdoor", "train", "grass", "steam", "track", "coming", "stack", "forest", "air", "riding", "country", "going", "mountain", "engine", "covered", "man", "green", "sheep", "snow", "large", "traveling", "hill", "white", "flying", "field"], "captions": [{ "text": "a train on a track with smoke coming out of it", "confidence": 0.4756073 }] }
Tags	[{ "name": "smoke", "confidence": 0.9980782 }, { "name": "outdoor", "confidence": 0.993854642 }, { "name": "tree", "confidence": 0.992400765 }, { "name": "steam", "confidence": 0.863466859 }, { "name": "coming", "confidence": 0.784523249 }, { "name": "stack", "confidence": 0.6671304 }, { "name": "forest", "confidence": 0.64437747 }, { "name": "engine", "confidence": 0.2543174 }, { "name": "rocket", "confidence": 0.105530322 }]

Azure Computer vision-image description (positive sample)



Google Computer Vision is also capable to detect smoke and wildfire

Computer Vision API's algorithms analyse the content in an image. This analysis forms the foundation for a ‚description' displayed as human-readable language in complete sentences. The description summarizes what is found in the image. Computer Vision API's algorithms generate various descriptions based on the objects identified in the image. A list is then returned ordered from highest confidence score to lowest.

Thermal Cameras & Drones

Thermal imaging cameras (or infrared cameras) are capable to detect full-bodied fires and potential or incipient fires, also known as glow nests. In contrast, a photo imaging camera is capable to detect only full-bodied fires.

Only bodies emit infrared radiation, smoke or air does not. Consequently, strong smoke (smoulder) or smoke, which both block the view of a photo camera, are hardly perceived by infrared cameras. The IR camera has to be in direct line of sight with the heat source.

ASPires project employs a drone equipped with sensor technology to gather data for the monitoring and early detection of forest fires. The drone acts as a gateway that immediately sends all collected data to a central or regional data integration facility - cloud.

The role of the drone for forest fire prevention and detection could be significant in all places where:

- there is no sensor network
- there is no line of sight
- the area is in high risk
- there is a need of alarm confirmation

The combination of WSN with drone having a gateway on board allows fast data collection from the area of importance and could decrease the delay in forest fire detection. The Matrice 600 Pro (M600 Pro) with improved flight performance and better loading capacity is selected.

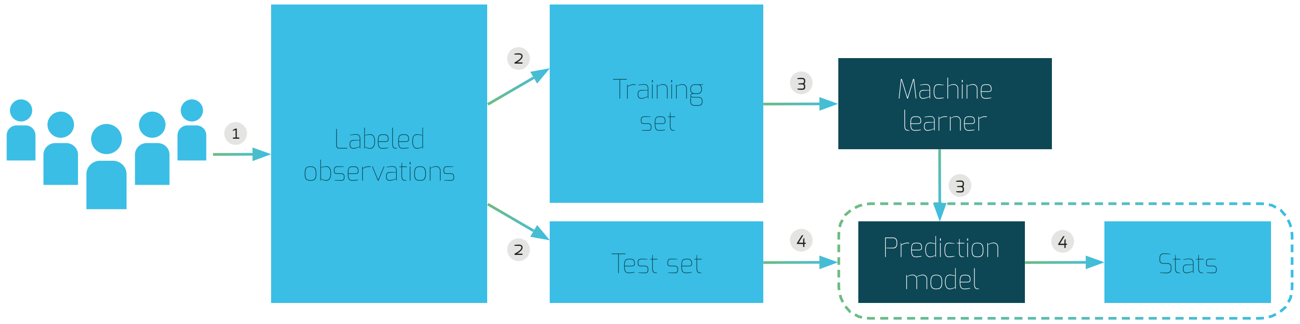
DJi Matrice 600 Pro Drone with Zenmuse Z3 camera

The airframe is equipped with the latest DJI technologies, including the A3 Pro flight controller, Lightbridge 2 HD transmission system, Intelligent Batteries and Battery Management system. All Zenmuse cameras and gimbals are natively compatible and full integration with third party software and hardware make the M600 Pro ideal for professional aerial photography and industrial applications. It can travel and send info and flight control data as far as 5 km, so this drone can monitor area in Radius of 5 km = 80 square km.

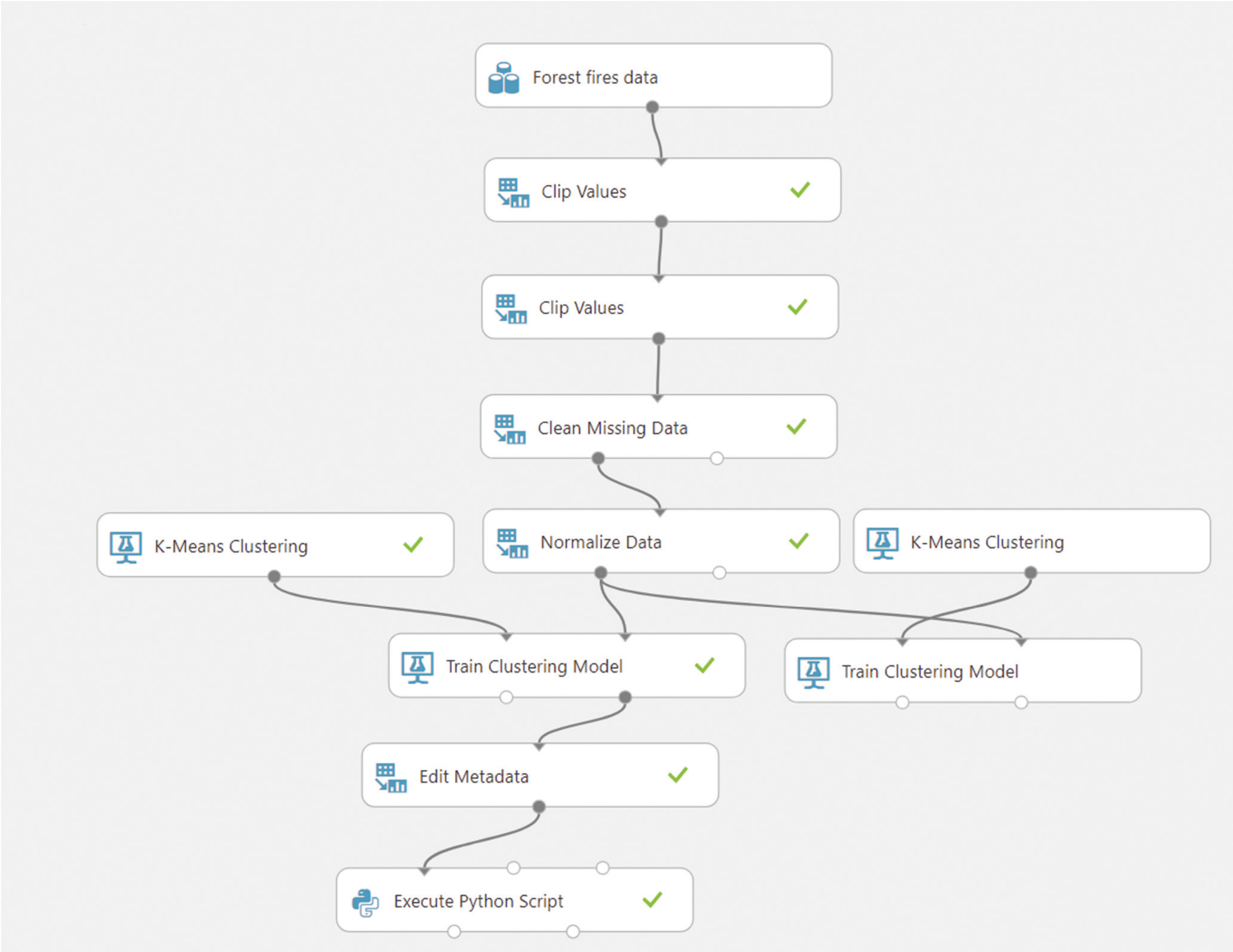
Forest Fire Prediction with Machine Learning

Machine learning predictive experiment was created in addition to computer vision based on test dataset from more than 500 real forest fires. The dataset was normalized, and the experiment was created. Although the result could be considered generally good, it must be pointed out that there is a strong subjective human factor which is involved in a great number of forest fires. However, it is evident that further research is necessary for extending the used set of features and measurements, but this is out of scope of the present.

For fast and efficient machine learning model prototyping and implementation, Azure Machine Learning Studio is used. Azure Machine Learning Studio is a collaborative, drag-and-drop tool you can use to build, test, and deploy predictive analytics solutions on data.



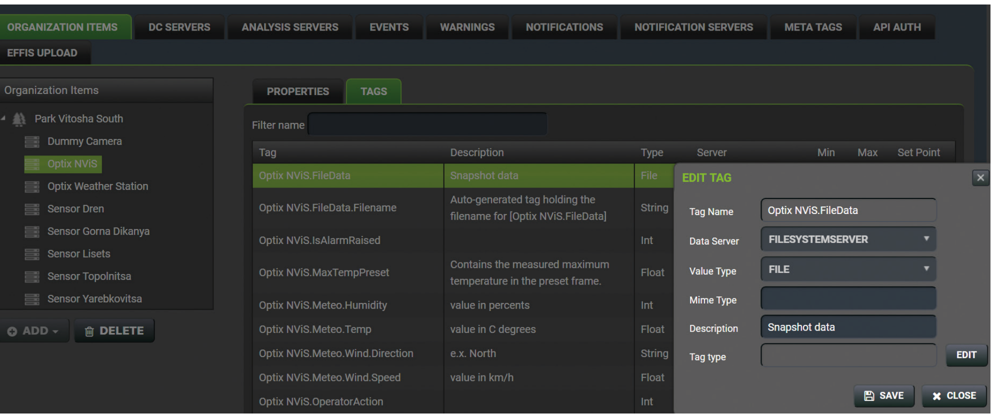
Machine Learning capabilities overview



Sample clustering predictive model for fire detection

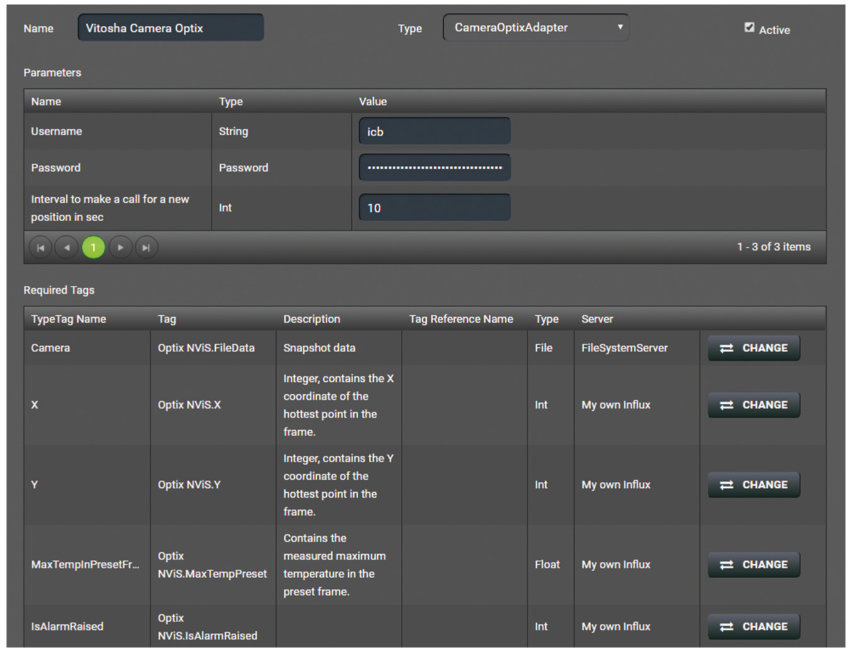
Forest Fire Detection with Image Tagging

ASPires cloud platform allows an abstract description of a sensor in which wildfire monitoring and detection cameras could fit. In the more advanced case of pan-tilt cameras (multiple horizontal and vertical positions), each of the positions is treated as a separate image sensor that delivers files to the central platform.



Camera tags initialization

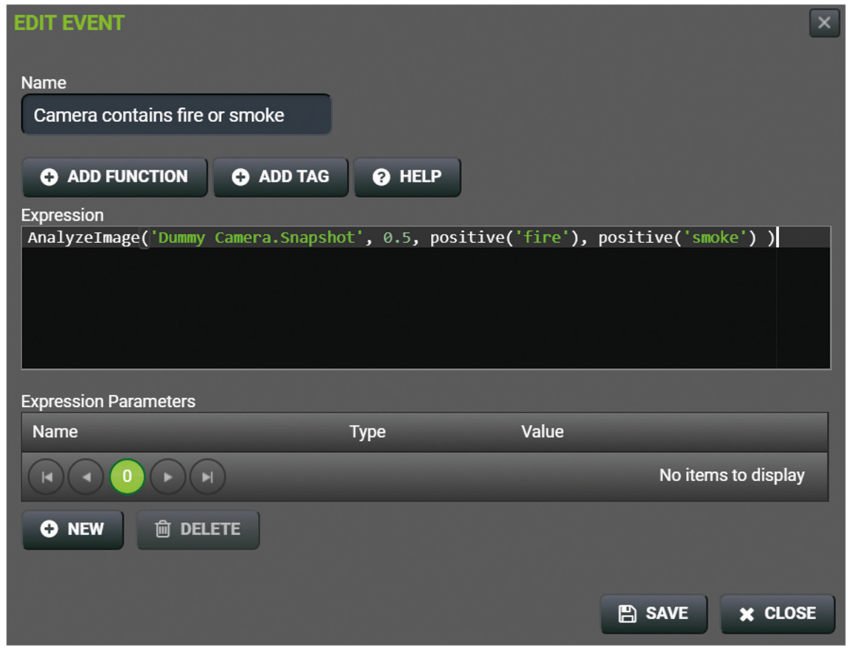
A dedicated analyser is developed to handle the integration with computer vision API. The analyser module takes a single image as an input and receives a response from the APIs in the form of descriptive tags – a procedure also known as feature extraction. The module extracts the named tags from the response and exposes them for further processing by the platform.



Mapping Organization Tags to Camera Adapter

Event is raised if a confidence of at least one positive keyword is above the threshold and there is no negative keyword with higher confidence value.

Warnings and notifications based on camera-based events are described just as any other with the exception that they shall rely on an event described using ProcessImage internal function.



Event definition based on image description tags

Fire Detection Algorithm

The sensors (nodes) that are applied in the WSN measure five physical parameters of the forest environment:

- temperature **Δ (Ti,)**
- humidity **Δ (Hi,)**
- barometric pressure **Δ (Pi,)**
- carbon monoxide **Δ (COi,)**
- carbon dioxide

The measured data are sent directly to the transceiver (gateway) connected to Internet, where an algorithm determines the forest fire occurrence (risk level) according to a defined formula.

In order to enable fire detection at a short time interval after the ignition has started, at each time step, a simple algorithm calculates the mean value for a predefined number of consecutive measuring. Next, the differences of the obtained consecutive mean values are calculated. The fire alarm is triggered by a previously set threshold for the differences's values.

The corresponding threshold values are **Δ (T), Δ (H), Δ (P), Δ (CO) and Δ (CO2).** The leading parameter for identifying fire occurrence is the temperature, **xi = T.** When the value **Δ (Ti,)** at a given sensor **i** is above the threshold value **Δ (Ti)**, it gives a signal a fire occurrence possibility.

Then, a process of verification involving other parameter measurements is launched, that confirm or oppose the results of temperature measurements and discriminate fire and noise sources.

The obtained results can be further applied in a classification of the fire risk level (i.e. HH-high, VH-very high, E-extreme), and a message of warning appears when risk conditions are met. Assigning N to the normal state (no fire), the outcomes of the decision tree process are shown in the Table. All the parameters' data and alarms are stored to a database.

Fire risk (fire alarm types) for combinations of measurements

<table>
<tr><td></td><td colspan="4">Parameter values comparison</td></tr>
<tr><td rowspan="4">Fire risk / alarm type</td><td>Δ(Ti,t) < Δ(T)</td><td colspan="3">Δ(Ti,t) ≥ Δ(T)</td></tr>
<tr><td rowspan="3">N (0)</td><td>Δ(Hi,t) < Δ(H)</td><td colspan="2">Δ(Hi,t) ≥ Δ(H)</td></tr>
<tr><td rowspan="2">HH (1)</td><td>Δ(Pi,t) < Δ(P)</td><td>Δ(Pi,t) ≥ Δ(P)</td></tr>
<tr><td>VH (2)</td><td>E (3)</td></tr>
</table>

N-normal, HH – high, VH – very high and E – extreme

Research for wireless sensor networks (WSN), Comicon Ltd., Bulgaria

ASPires LoRaWAN™ sensors

For the purposes of the ASPires project Comicon Ltd., Bulgaria has implemented LoRa® technology.

Some of the advantages of the wireless networks based on LoRa® technology are:

- It is a new LP WAN advanced technology
- It is able to cover big distances – theoretically up to 15 km
- It is powered by batteries or energy harvesters.

In the ASPires project LoRa® sensors are used to:

- Measure environmental parameters on place like humidity, temperature, CO, CO2, fine particle matters
- Send the measured data to a gateway.

Two types of LoRaWAN™ sensors are used in the project: a radio module with sensor integrated and set of radio module + external transducer.

The sensors used in the project by Comicon Ltd., Bulgaria are described in the table:

Specification of LoRaWAN™ sensors integrated in ASPIRES COMICON GATEWAYS

№	type code	measured parameter	measurement period	period of transmission to the gateway	power supply
1	1	Temperature, Humidity	2 h	6 h	battery up to years
2	2	Temperature, Humidity	10 min	10 min	battery operation up to 5 years
3	4	Temperature, GPS	manual	manual	battery up to 6 months
4	5	Humidity, CO2	10 min	10 min	Radio module - battery up to 6 months; transducer -12VDC
5	6	CO, PM	10 min	10 min	Radio module - battery up to 6 months; transducer -12VDC
6	11	PM	1 s	1s after reaching the alarm level; 30s during alarm level; 5min period otherwise	Radio module - battery up to 9 months; PM controller - 12VDC
7	12	CO	10 min	10 min	Radio module - battery, up to 9 months; transducer - 12VDC
8	21	Soil Moisture	15 min	15 min	220V
9	22	PM2.5, Noise, Temperature, Humidity	2 min	2 min	solar panel
10	23	CO2, Temperature, Humidity	2 min	2 min	220V
11	24	Temperature, Humidity	15 min	15 min	2 x 1.5V AA batteries

Specifications of the integrated sensors

Beyond the planned in the project activities, a suitable particle matter transducer and smart particle matter transducer were developed by Comicon.

PM sensor of Comicon

PM, T, RH, N sensor

CO2, T, RH sensor

CO sensor

Experimental testing of LoRaWAN™ wireless sensors

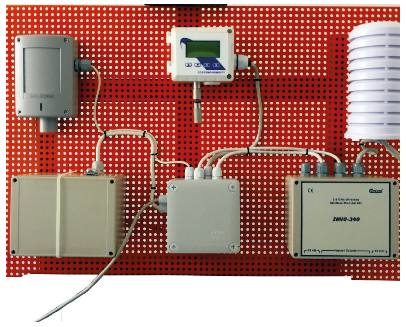
Two types of tests have been performed to study the efficiency and effectiveness of the LoRaWAN™ wireless sensors for detection of forest fire:

- tests of transmitters concerning environmental parameters
- LoRa® wireless sensors tests concerning environmental parameters

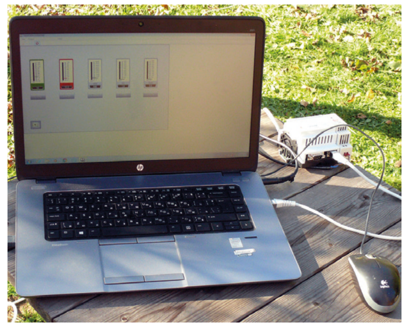
The potential for detection of forest fires by measuring ambient temperature, relative humidity, content of CO, CO2 and PM (particle matters) in the air was investigated.

1. Experiments with transmitters for environmental parameters

Test fire



Measurement panel



Gateway and computer with SCADA SW installed

For the purpose of the tests, a special test stand was developed and manufactured, consisting of a measuring panel, Modbus RTU / Modbus TCP gateway with a power supply unit, a computer with SCADA software installed, with configured screens for visualization (HMI, trend), and a data logger as well.

During the experiments the measurement panel was sequentially positioned at distance of 5, 10, 15, 20, 30 meters from the fire. At each panel position the data received from the transmitters were read and recorded at a time interval of 1 second, via SCADA software. Measured data were visualized continuously - via HMI interface and graphical trends.

Results after the measurement with the transmitters.

Particle matters: The presence of particle matters was recorded at all measuring distances - from 5 to 30 meters. An important condition for registration of particle matters is the direction of the wind. Fine particles transmitter has deviation up to 500ug/m3 - 100% of the measurement scale and response time 1 sec.

CO and CO2 measurements: CO and CO2 measurements have representative value only at distance up to 5 meters. CO transmitter has deviation up to 131ppm - 26% of the measurement scale and response time several seconds. CO2 transmitter - deviation up to 65 ppm - 2% of the measurement scale and response time about 25 minutes.

Temperature and relative humidity measurements: The temperature and the relative humidity are changing only when the measuring devices are located very close to the fire and exposed to its effects for minutes. Compared to PM or CO, the changes of T and RH are negligible.

2. Experiments with LoRa® wireless sensors concerning environmental parameters

For the test purposes a test system has been designed and manufactured, including the following LoRaWAN™ wireless sensors:

- for particle matters - 3 sets
- for measurement of CO2 and RH - 1 set
- for measurement of CO - 1 set
- for temperature and humidity measurement.

The data from the wireless sensors are transmitted to a field gateway, developed by Comicon Ltd., Bulgaria and then to the cloud software, developed by Interconsult Bulgaria.

For the purposes of the experiments a controlled fire was used by piles of straw with dimensions of about 100/50/50 cm.

During the time of the experiments there was a south wind direction, with gusts and maximum wind speed of about 4 km/h. Experiments were made in 3 phases. In each phase the sensors were in different positions/ configurations regarding the fire. The sensors were not in an immediate vicinity of the fire.

The results of the measurements with wireless sensors.

Particle matter measurement: The sensors detected the fire 10 seconds after its burning on at distance 30 meters from it.

CO2 measurement: The CO2 measuring sensor detected the fire after about 20 minutes in a smoke emission area close to the fire.

CO measurement: The CO measuring sensor does not show any deviations during the all experiments.

Temperature and relative humidity measurement: The T and RH measuring sensors also do not show any deviations in all experiment.

3. Conclusion

All wireless sensors used in the experiments can be applied for detection of forest fires. There is a specificity of using of the different types of sensors.

The sensors for particle are important for detection of particles in the smoke distribution area. This makes it possible to detect a fire at long distances from the fire zone, which ensures that the alarms will be sent long before the flame reaches the sensors.
The T, RH measuring sensors need a closer distance to the fire zone to send an alarm.

Wireless sensors for measuring of particle matters are the most efficient.

The efficiency of the fire detection system based on sensors depends on the type of sensors used in correlation with the conditions under which a fire should be detected.

The application of wireless sensors under certain conditions is nearly as efficient as the usage of thermal cameras and even has some advantages such as:

- unpretentious comfortable installation - no tower needed;
- fixed reaction time (1s) vs. variable time (up to 1h) due to camera rotation;
- covering of "invisible" for the thermal camera areas;

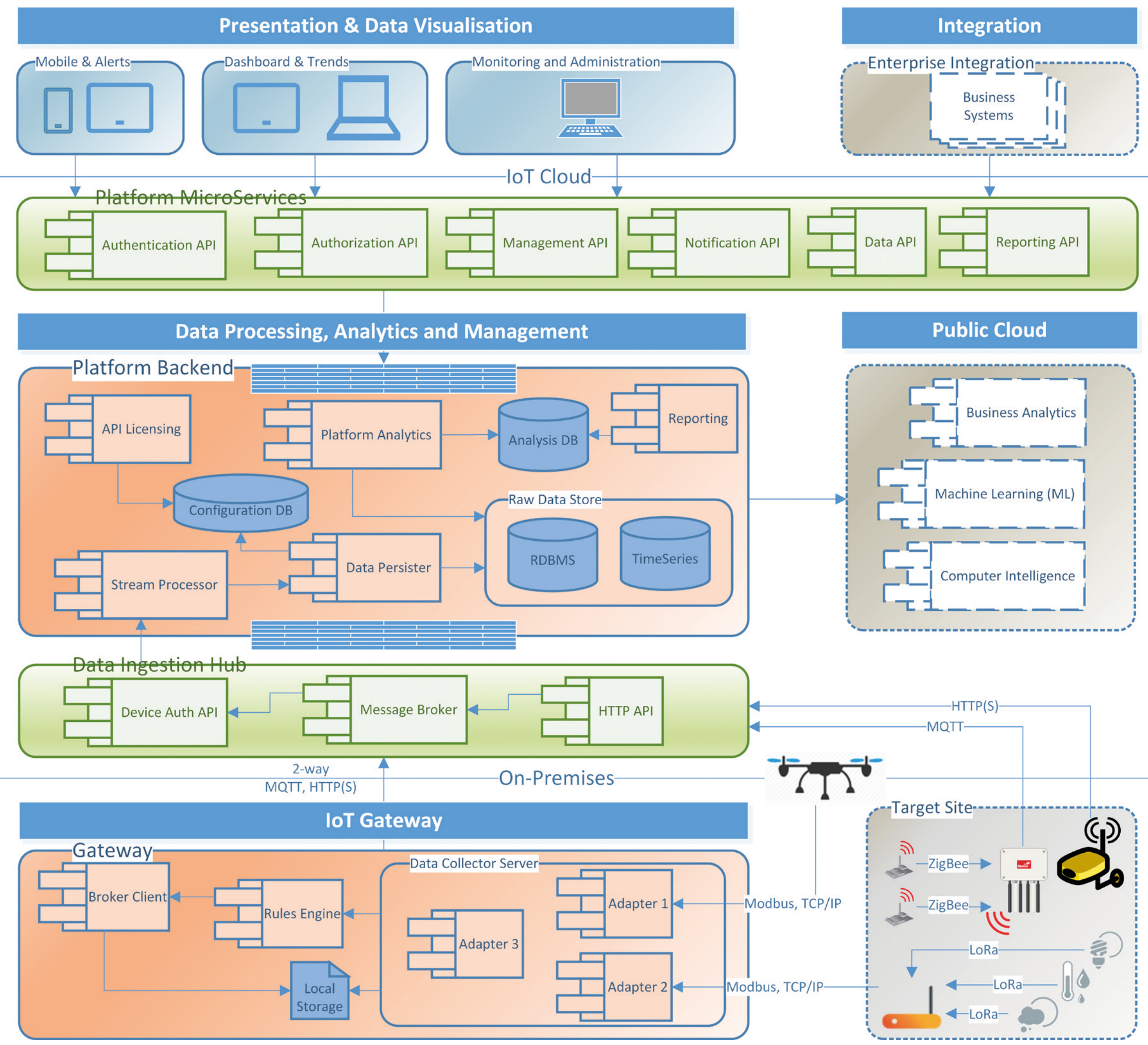
The sensors have a potential for reducing the costs and optimizing the functionality.

ASPires platform Design Description

Forest fires are uncontrolled accidents occurring in wild areas and causing considerable damages to natural and human resources. Unintentional events such as disposed cigarettes, short circuits, explosions and high temperatures can induce fires leading to a disaster. Therefore, early detection, prevention and timely dealing with forest fires becomes essential and drive the need for IoT platform tailored with usage scenarios in mind from which monitoring offices and crisis management centres would benefit.

The primary goal of the architecture is to enable flow of data from intermittent line-of business devices. Video and sensor information from drones, on-site thermal cameras and ambient sensors are just some of the data sources supported by the platform. Once ingested by the cloud-based back-end system, data will be used for performing analysis, control and process automation. Most important, alarms and readings could be transferred from the field in fast and reliable manner and without human intervention.

IoT Platform Architecture



Conceptual architecture at cloud level

ASPires configuration database contains the metadata and settings for the key platform components – adapters, analysers and warnings:

- Adapters to connect new devices and systems as data sources, using large number of protocols.
- Visual instruments to present data in intuitive and easy to manage and perceive form.
- Machine learning models to provide domain knowledge for specific use case.
- Analysers are designated for performing computations from complex raw data from one or more data source and persist the resulting calculations for further use in the platform.
- Event alerting engine is meant to track changes in data streams as well as more complex changes in the relations among parameters measured.
- Notifications could be defined on top of events and allow sending messages to users via predefined set of communication channels, that are described by type and corresponding set of options.

Gateway scope is situated on-premises, physically close and communicating with the data source devices. These could be: intelligent sensors, field gateways that collect data directly from sensors, programmable logic controllers, etc. The main purpose of the on-premises setup is to collect, aggregate, pre-process and buffer raw data on-site and subsequently forward data in a reliable and secure manner to the cloud platform core.

Cloud scope encompasses the core of the platform. It ingests data securely via few protocols over the Internet, stores raw data, analyses and prepares reporting data sets. In addition, the platform core is also responsible for establishing secure communication with the source devices and licensing the usage of the service layer. At the same time, it relies on external services for more advanced functions like computer intelligence, machine learning prediction and business intelligence visualization.

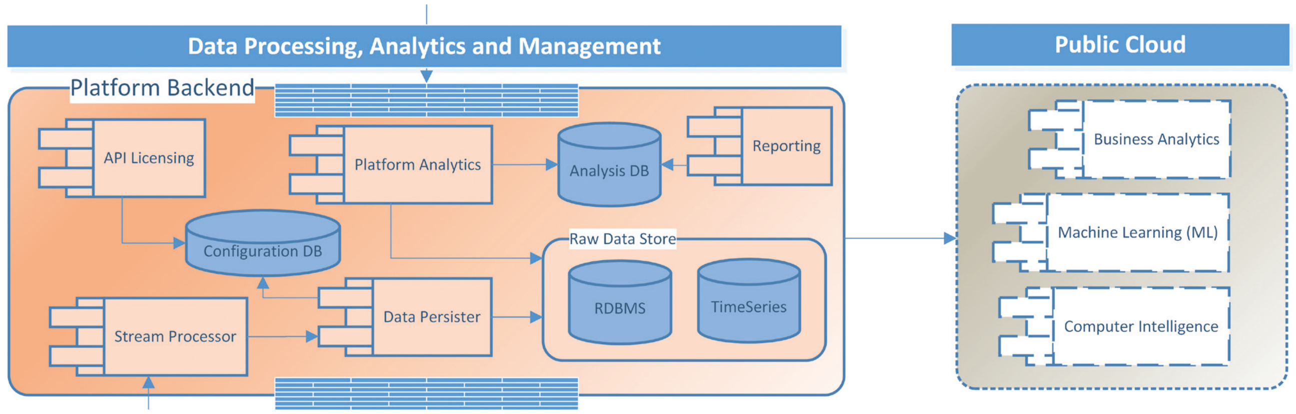
Public services scope refers mainly to advanced services offered by some of the major cloud providers. Development and maintenance of such services typically require vast amount of knowledge and experience and these are to be consumed on Software as a Service basis for specific needs like computer intelligence and business analytics.

Consumer scope is the layer at which end-user applications are. These consume data and perform actions on the cloud platform by using the cloud service layer. These could be mobile applications, dashboard applications for real-time monitoring, configuration application or even 3-rd party systems that would consume raw or processed data. In case a system would supply data to the cloud platform, it would have to be connected via the ingestion hub. The main components of the architecture, their designation and challenges they solve are explained below.

IoT Gateway and Data Ingestion Hub

A field gateway is a specialized device-appliance or general-purpose software that acts as a communication enabler, a local device control system and device data processing hub. It can perform local processing and control functions toward the devices. On the other side, it can filter or aggregate device telemetry and reduce the amount of data transferred to the cloud.

The technology behind the gateway is Azure IoT Edge (previously known as Azure IoT Gateway SDK) which allows building modules that can be composed with great flexibility and serve the needs of the exact scenario. Extension and support could be performed by implementing IoT Edge protocol adapters.



Data Processing, Analytics & Management

Cloud Platform Core

The main responsibilities for the cloud platform core are to collect data in efficient manner and perform pre-processing and analytics.

Stream processor module designation is to perform some basic real-time data analytics after data ingression through the cloud gateway. Stream processor is intended to support multiple data streams concurrent and modify or determine the path of data. Typical analysis tasks in the scope of the stream processor are: detecting threshold limits and anomalies or generating alerts.

Data persister is a data collector service with a built-in message broker client (MQTT) that receives raw data in the form of MQTT messages from the ingestion hub broker. The data collector provides an abstraction on the top of a set of supported database management systems to store and retrieve raw time series data.

Raw data (measurements sourced from devices via the ingestion hub) are stored in either relational DB management system or in a time series database.

Time series data storage and management is one of the most critical elements of every IoT architecture. This task is typically solved by using Time Series (TS) systems that are optimized especially for handling such data types.

Analysers are a key element of the cloud platform flexibility and extensibility. Platform analytics are implemented in the scope of analysis service. The service allows analyser implementations to be plugged in a flexible manner only by configuration. Analysers are also intended to communicate with external services to enrich the platform with business intelligence capabilities, cognitive computing algorithm processing and machine learning for prediction.

During prototyping phase Cortana Suite with Cognitive Services and Azure Machine Learning have been evaluated with very promising results.

Public Cloud

A set of services are intended to be used from public cloud vendors under SaaS. The motivation behind is mainly towards algorithms that require vast amount of knowledge and experience in science branches that are not in scope of the present platform.

Machine learning (ML) originates from pattern recognition and from the theory that computers can learn without being programmed to perform specific tasks and that this learning could happen only based on data.
For the predictive analytics nature of the cloud platform, an algorithm from the binary classification family shall be considered.

Business analytics solution building blocks are: datasets, dashboards and reports. Datasets are imported or connected and are the basis for subsequent interaction and presentation. Reports could be either predefined or presented by self-service capabilities.

Service level consists of multiple individually scalable micro- services instead of one monolithic and general service. The designation of these is to present data to the presentation layer of applications where mobile applications, dashboards and management portals could be developed. The service layer, on the other side, is also used to provide data to 3rd party systems that are interested in the data collected, managed and analysed by the IoT cloud platform like regional, national, international crisis management centres and agencies.

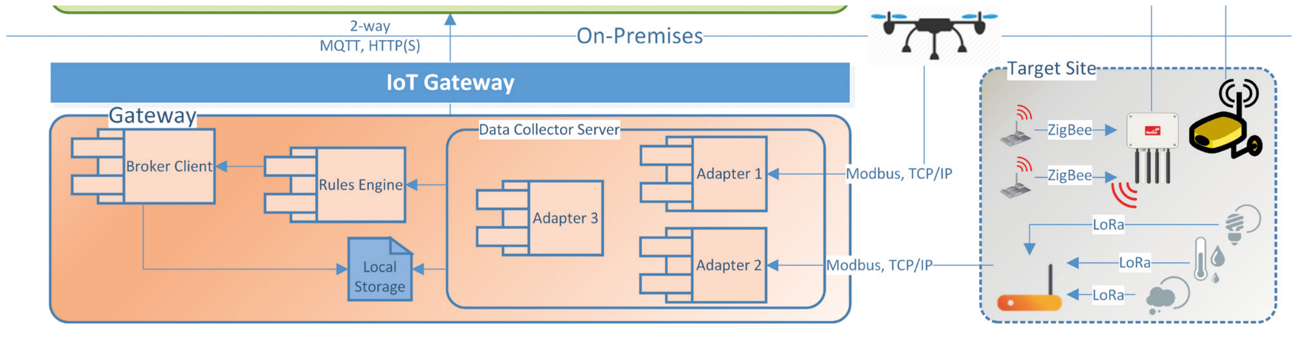
MQTT broker, being the heart of the data ingestion layer, was benchmarked using an open source MQTT stress tool. Scalability of the test setup was evaluated by incrementally increasing the number of publishers with the goal to reach maximum number of publishers, rather than message throughput. During the stress test the broker was easily capable to ingest the target requests from 30'000 publishers simultaneously.

It was also identified that transmission latency appears somewhere above 10'000 messages. The broker behaviour was modified to authenticate requests coming from devices, using JWT tokens, issued by the platform identity server.

Ingestion Hub

The platform data ingestion hub takes the main role in connecting IoT devices directly or via the cloud gateway to the platform core. The hub is capable to connect hundreds of thousands of devices, provide 2-way communication for receiving telemetry and sending back commands to be executed on the edge. It also includes a built-in device identity store that stores a registry of device identities and manages security credentials.

The ingestion hub was designed to provide and serve bi-directional communication with edge gateways or devices over MQTT and HTTP protocols.



Cloud platform ingestion hub

Edge Gateway

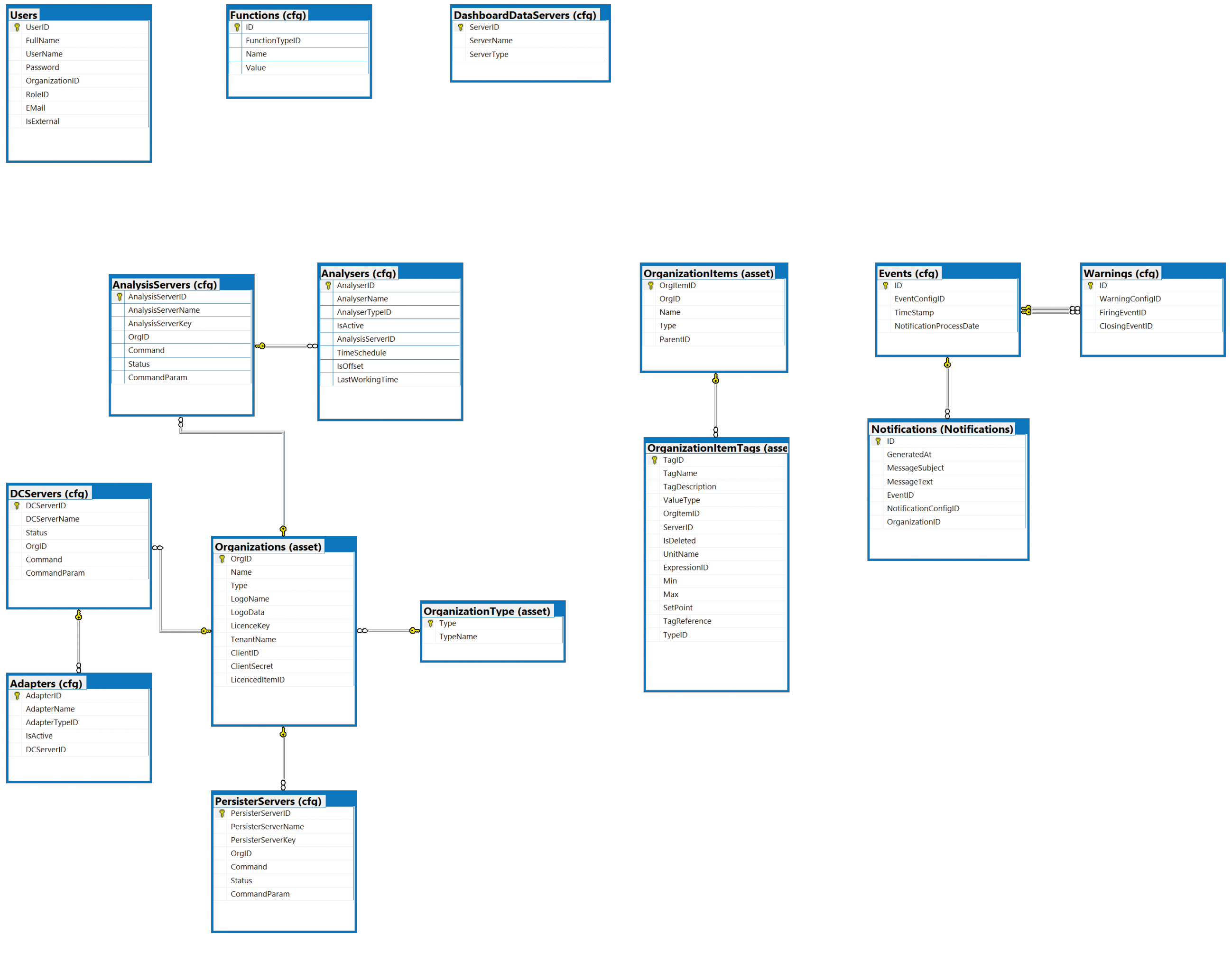
The edge gateway is a form of cloud gateway that enables remote communication to- and from- devices in the field. It is capable to reach the cloud ingestion hub over the Internet or if necessary, even over a private VPN connection. The underlying technology is open source and perfectly fits to ASPires concept for openness.

The edge gateway communicated with the ingestion hub over a secure MQTT protocol connection and is capable to cache data locally if the Internet connection to the cloud is unstable.

End-points

The ASPires cloud platform presents a layer of individually scalable micro services which designation is to serve data to the end-user application layer – these being web applications, mobile applications or integration with other software systems.

Some of the third-party systems that are interested in the data collected, managed and analysed by the cloud platform could be regional or national crisis management centres. An overview of the concept is available in the figure.

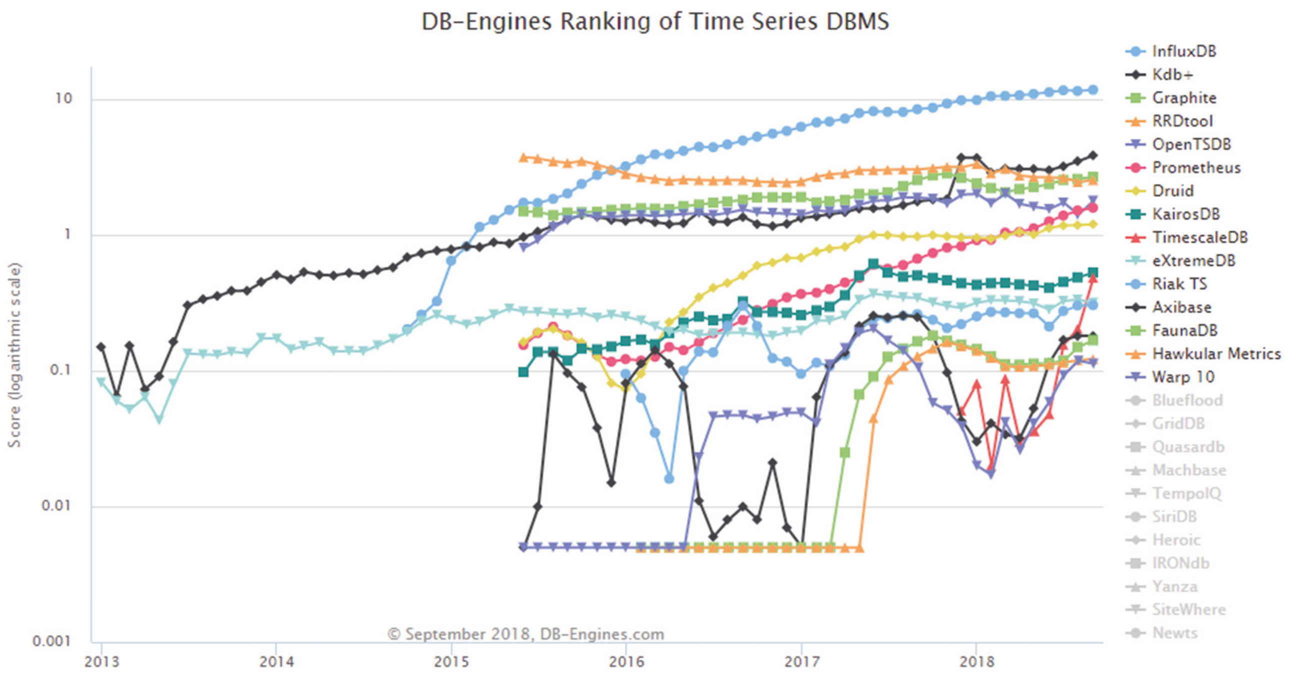


Simplified Database Architecture

Time series Data storage

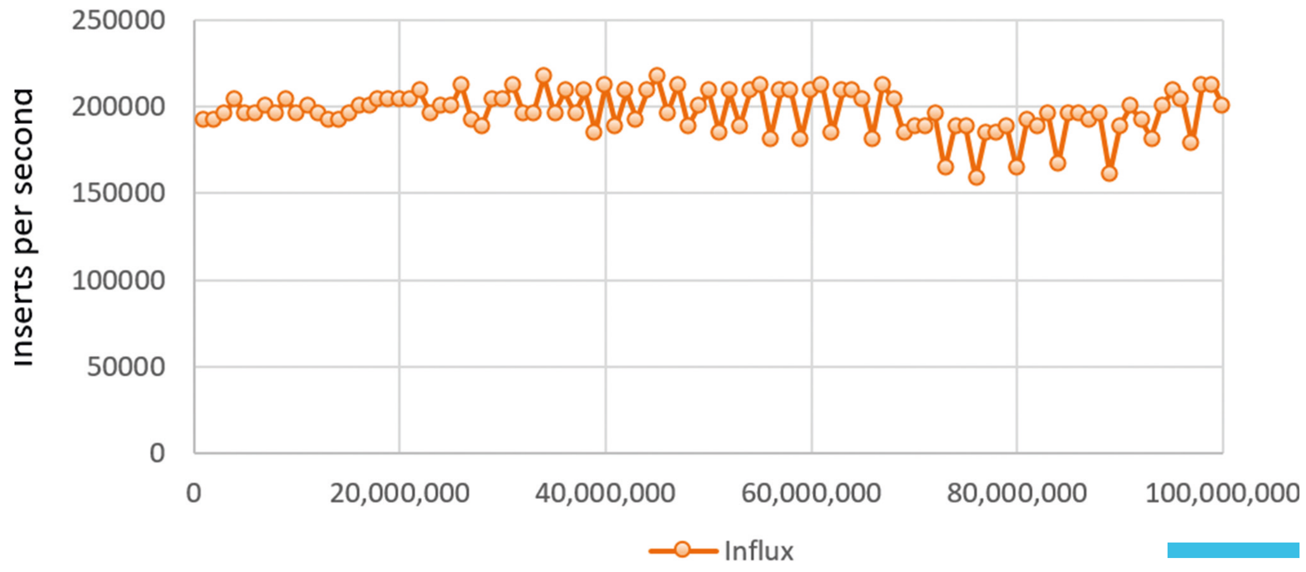
Time series data storage and management is realized by using of InfluxDB.

InfluxDB is maintained by a single commercial company following the open-core model, offering premium features. InfluxDB is the top-most ranked time series DB as of the score of DB-engines initiative with a visualization of the rating. A detailed comparison, together with description of the popularity evaluation method are available at https://db-engines.com.

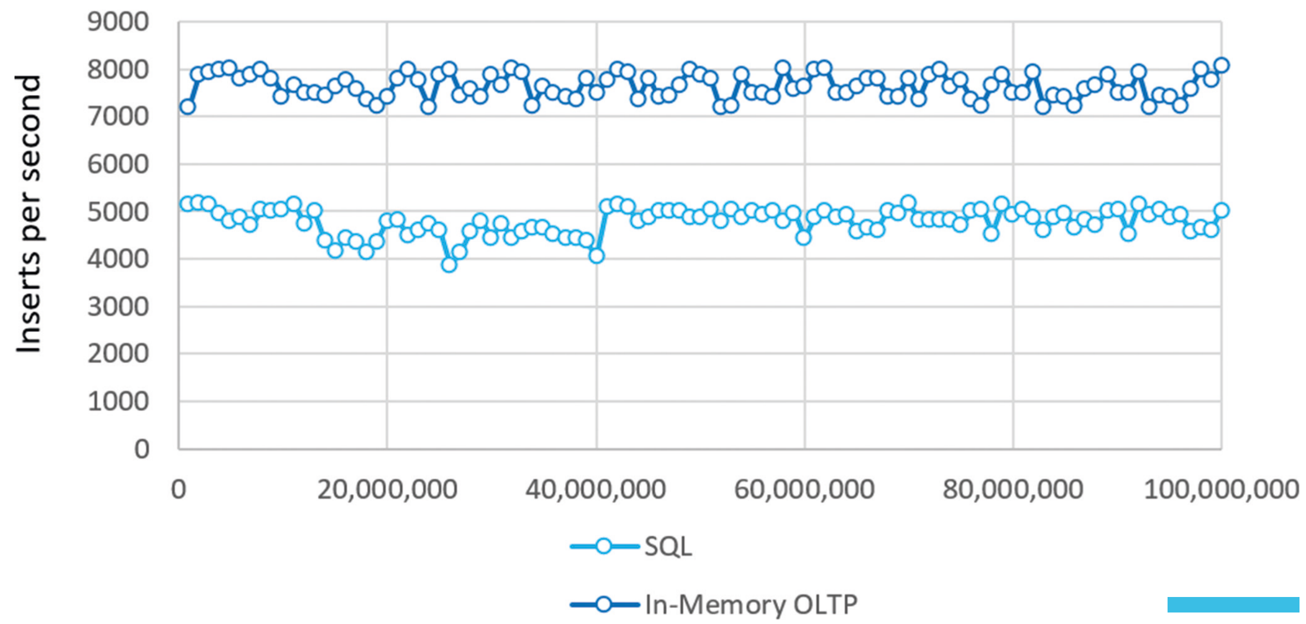


Top ranking time series DBs

Big-data are IoT data and IoT data are time series data. This task is typically solved by using Time Series (TS) systems that are optimized especially for handling such data and ingest, process and make use of them in practical use cases. Database benchmarking started with SQL server. As illustrated, Influx DB over-performs 40 times SQL Server 2016 with it being able to operate at about 200'000 writes per second and SQL Server at just about 5'000. SQL Server 2016 implements in-memory OLTP technology that significantly improves transaction processing and data ingestions. Enabling it with delayed write to disk improves speed with 45% to about 7'800 writes/sec but this still leaves SQL Server far behind.

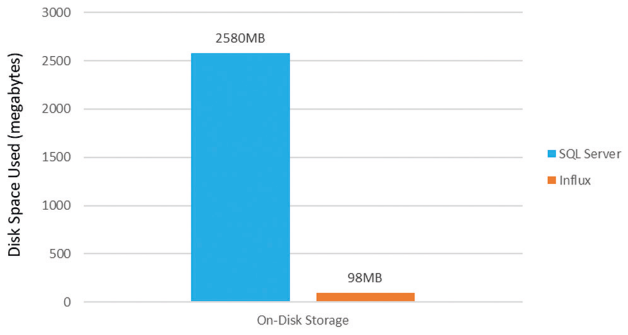


Influx DB write performance

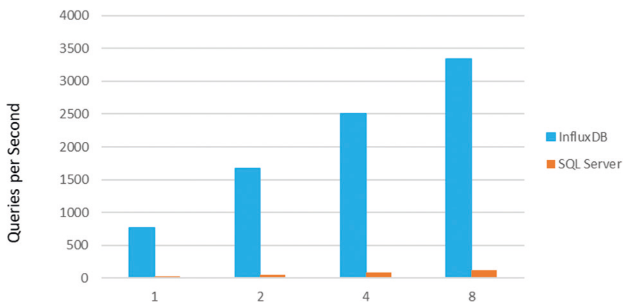


SQL Server 2016 write performance

Storage space required is another important parameter that illustrates the data compression capabilities and determine the number of required disk I/O operations. The test was performed by using a subset of 38 million points which proved to be enough to provide credibility of the overall tendency. As identified during benchmarking, Influx DB is capable to achieve 26 times better compression (98 MB vs 2580 MB) for the scenario.



On-Disk Storage



SQL Server 2016 write performance

Another major characteristic of database engine is the capability to respond to queries. To benchmark this a query that aggregates data chunks of 10000 points was used with the result averaged over 1000 executions. The test was also executed in parallel from 2, 4 and 8 threads to measure the abilities for parallel processing. The overall conclusion is that SQL Server mean query response time is 78 ms (nearly 13 queries/sec), while Influx DB can achieve 60 times better throughput of 769 queries/sec and response time of 1.3 ms.

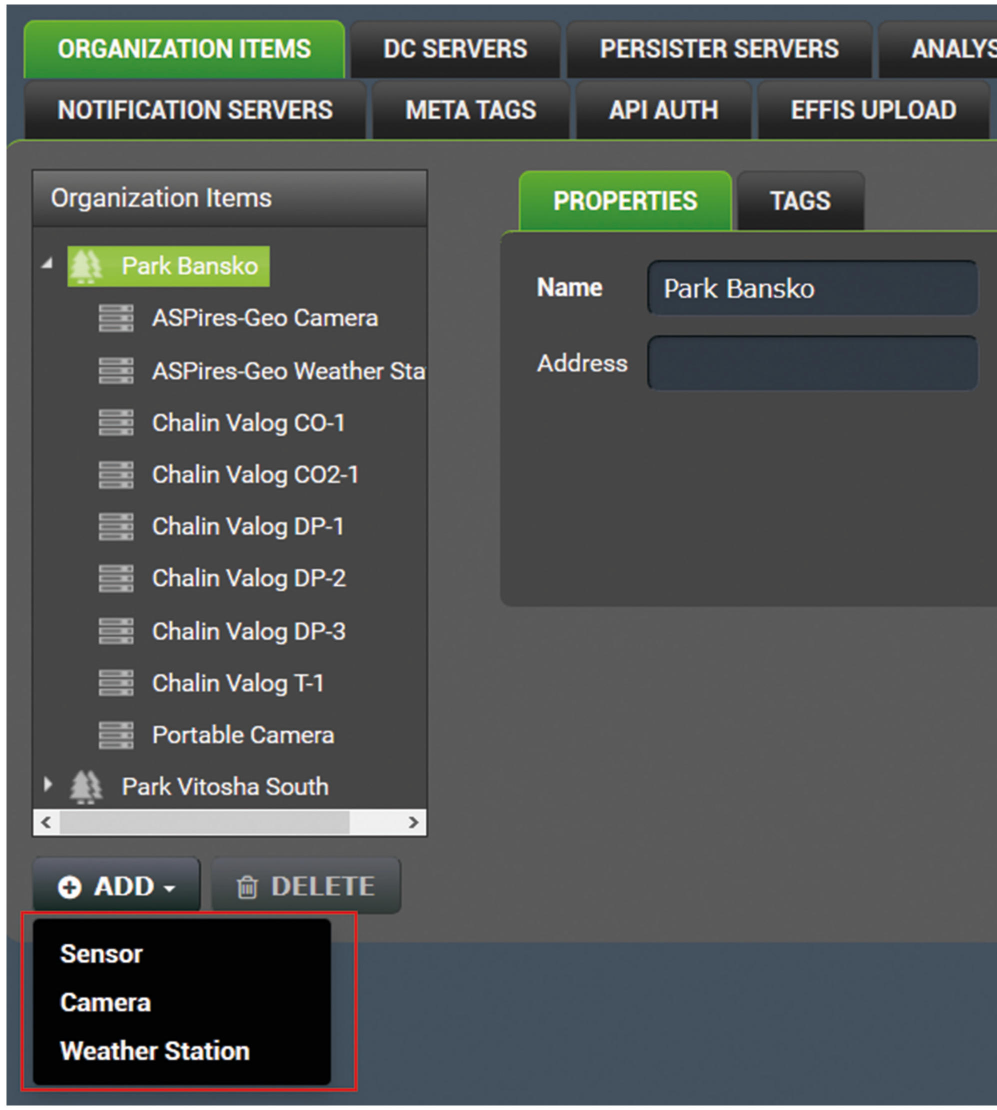
Organization Hierarchy Configuration

Asset management is broadly defined as a system that is used to monitor and maintain valuable entities of any group.

Assets are grouped below organization elements that eases management by making possible to delegate different access privileges for system users to the various hierarchy elements.

Each organization element could have individual license that is used to control the number of users, devices and access to the platform.

Cloud Gateways and sensors are maybe the most important entities in the configuration. They are defined as regular organization hierarchy level nodes of type "Gateway" and "Sensor" respectively. Other types could be "Country", "Region", "District" or other.

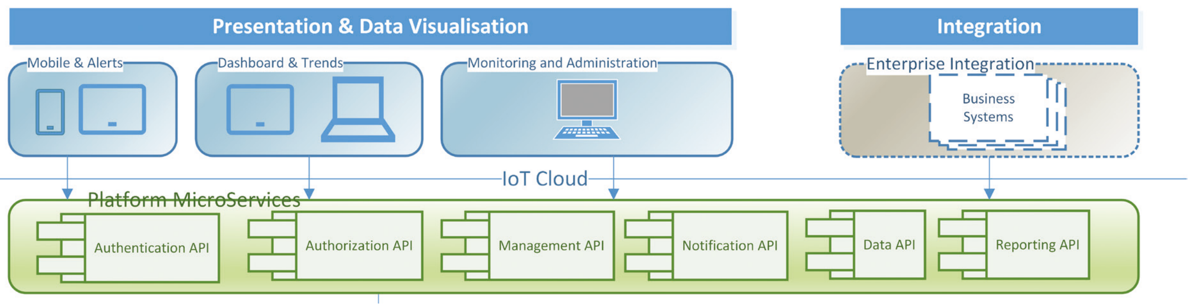


Organization hierarchy level nodes

ASPires Outbound Interfaces

The service layer consists of multiple individually scalable micro- services instead of one monolithic and general service. The designation of these services is to present data to the presentation layer of applications where mobile applications, dashboards and management portals could be developed. The service layer, on the other side, is also used to provide data to 3rd party systems that are interested in the data collected, managed and analysed by the IoT cloud platform.

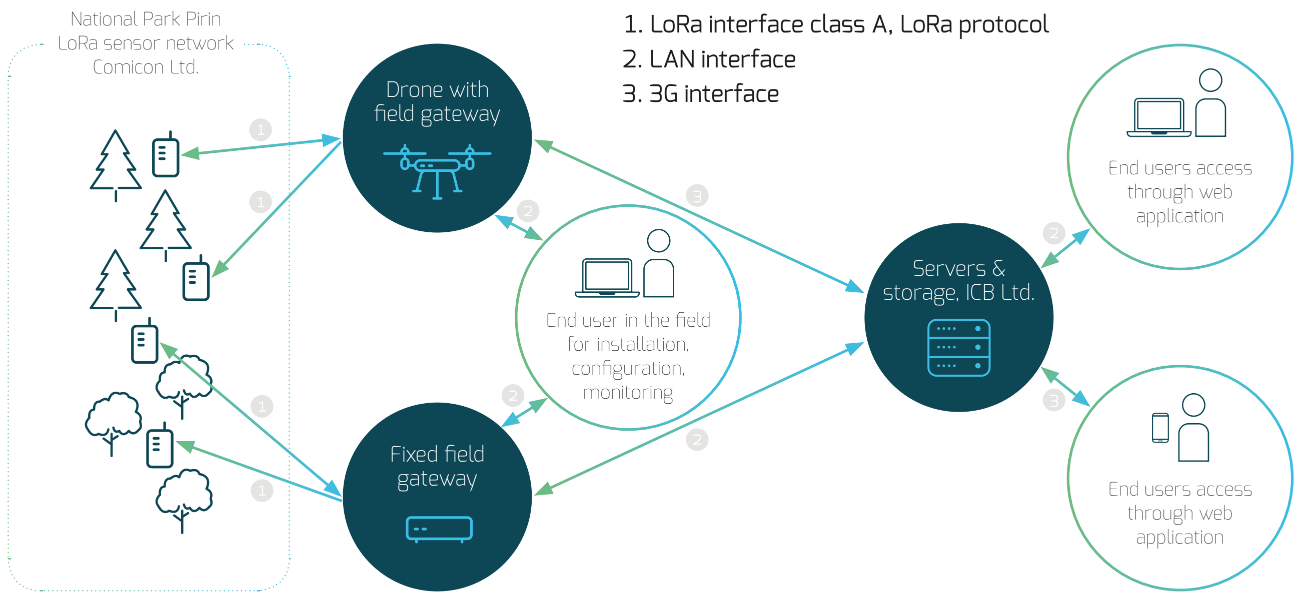
The Micro-services platform represents the multitude of small services responsible of sustaining a good and scalable end user experience with the UI of ASPires. Micro-services provide all user authentication, licensing, data management, configuration, reports and integration endpoints in order to make platform data accessible to the end users.



Aspires-Output Service Layer

Communication protocol used to transfer data from sensors to field gateway

The protocols and interfaces used in the experiments in Bulgaria are related to the LoRa sensor networks, fixed and mobile (on drone) field gateways and connectivity to the ASPires cloud. In the Figure the interfaces are marked with red lines and numbers while the legend is explaining their nature.



LoRa sensor network to ASPires cloud interfaces and protocols

Communication Protocols to Support Sensor Network Solution

In the communication between the test environments in Bulgaria was successfully experimented with two protocol types – Modbus TCP and MQTT.

Modbus TCP

Modbus TCP is a Modbus variant used for communications over TCP/IP networks. Modbus itself is a serial communications protocol, intended for use of programmable logic controllers (PLCs). The main benefits of the protocol are that it is developed with industrial applications in mind, open and royalty-free.

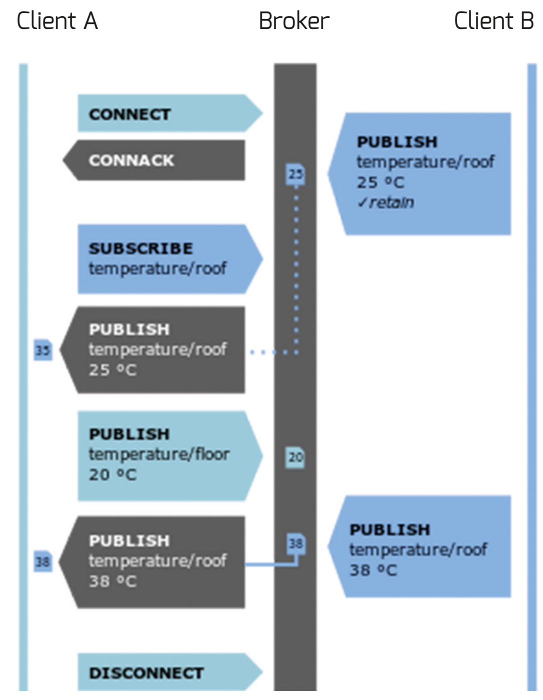
However, a major downside of the protocol was the complete lack of security features which made it inappropriate for public IoT solution like ASPires. The project evaluated the options to implement own custom signature to be attached to each Modbus frame. The signature was designed to be put at the end of every Modbus frame, just like the signature in JWT tokens and guarantee both the origin of data and the fact that they have not been tampered after being submitted by the device gateway.

Although Modbus communication passed tests successfully, it for the following major reasons it was decided that ASPires would not use that communication protocol for production purposes.

MQTT

MQTT is publish-subscribe messaging protocol specially designed for constrained low-bandwidth, high-latency or unreliable networks.

After in-depth comparison of capabilities and requirements, the platform description suggests Mosquitto MQTT as among the most suitable. Mosquitto MQTT is an open source software message broker, offered under Eclipse Public License (EPL).



MQTT Broker Communication

Communication Protocols for Thermal Camera Solution

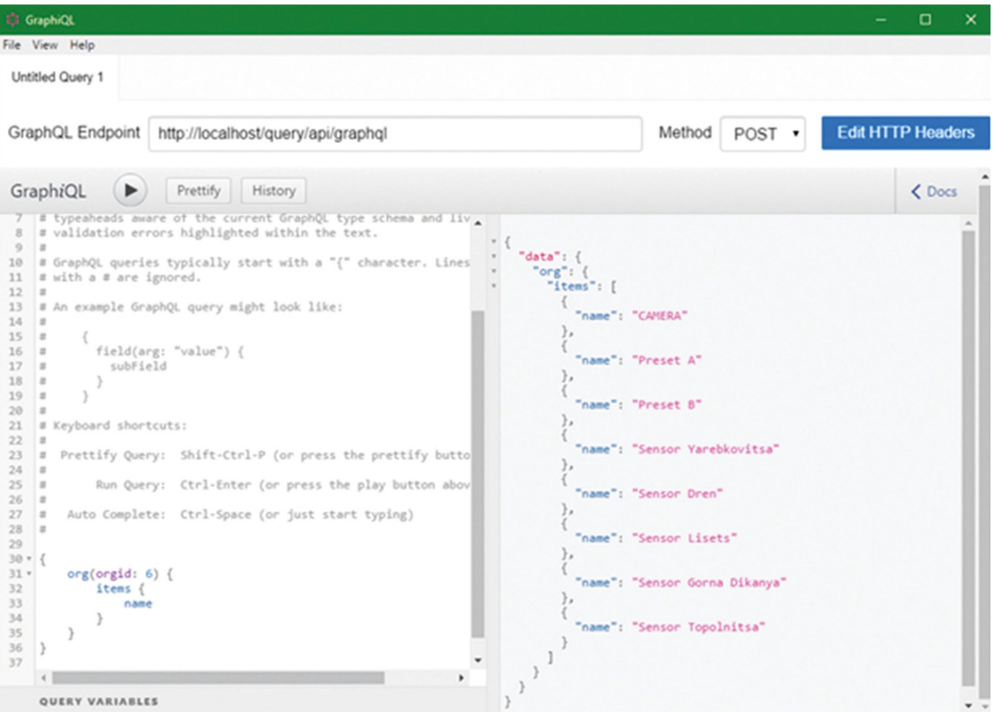
The main objective of ASPires-GEO is to build a real model of a stationed monitoring system for early warning of forest fires that is capable to be integrated in a cloud platform and source valuable data, based on which advanced computer algorithms for forest fire detection could be deployed.

The pan tilt device on which the cameras are attached is controllable remotely. This allows the pre-definition of points of the forest area for scanning. Each preset point is bound to an area depending on the distance of the camera to the object. The intelligent software then defines the warmest object within each preset and raises an alarm if the warmest element has a temperature higher than a configurable threshold. Hence, a single ASPires-Geo node with cameras could be considered as a gateway with multiple sensors which are namely the camera presets.

Another interface for weather station is also supported with the ASPires-GEO experimenting with a module produced by Reinhardt GmbH, Germany. The weather station provides all data for current measurements in the form of XML.

GraphQL Protocol Service Endpoint

GraphQL is a query language for APIs, and a server-side runtime for executing queries by using a type system, defined for the data. The graph refers to virtual graph data structures where nodes are defined as objects and the vertices are the relationships.



GraphQL Query

GraphQL was chosen for the ASPires service layer as it allows both more elegant methodology and improved experience for data retrieval. It eliminates ad-hoc endpoints and roundtrip object retrievals.

One of the most important benefits of GraphQL is that, it is a specification and standard which results in low overhead of adoption-it is a wrapper that could be defined and the developers will not have to replace the existing REST system.

ASPires APIs

ASPires warnings API is an important part of the GraphQL API which deserves being emphasized in a separate section. Its designation is to provide access to warnings generated in the cloud platform based on events. It is important to point out that events are always configured for tags, hence the relation between tags and warnings.

Another REST API is available that returns information on files or images captured in the cloud platform. Most file data are currently pushed by the drone solution developed by Fulda University and the camera solution deployed by NCITES. These images are processed in the cloud platform for automated fire detection using cognitive algorithms such as computer vision and could also be provided on demand by the platform.

ASPires Interoperability

The asset database has the necessary capabilities for configuration of flexible custom rules on sensor data for implementing conditions for raising alerts. These alerts could then be used for triggering notifications to predefined list of users on common notification channels (i.e. email or SMS).

For the purpose of building custom GUI on the top of the ASPires platform, the service layer provides data services that allow reading and in some limited manipulation of the sensor data received from gateways of a particular organization.

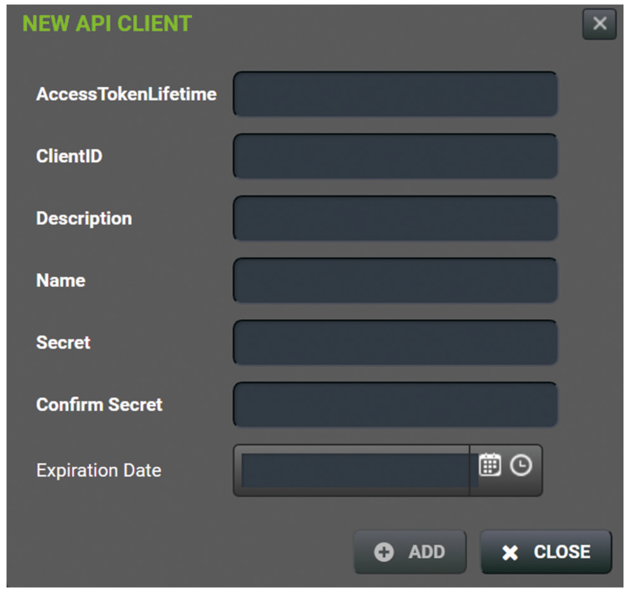
Collecting of no personal or sensitive data is foreseen for end users and actions to comply with GDPR, such as data encryption, are out of scope.

The administration portal of ASPires cloud provides access to general settings of the environment. It is accessed either by platform administrators who belong to the organization responsible for the platform maintenance, or by organization administrators - i.e. a crisis management centres or national parks.

Platform Data Services

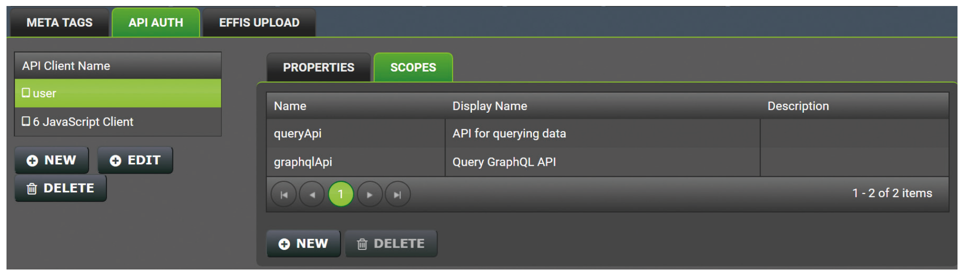
ASPires cloud platform presents a service layer which is aimed to aid to the openness by providing raw and analysed data to a presentation layer where mobile applications, dashboards and management portals could be developed by independent software vendors.

The ASPires platform follows the "who generates the data, owns the data" rule to secure that unauthorized parties would not receive access to sensor data. Each organization could use services from different vendors for application development, for analysis and reporting, auditing or other purposes.



Organization data API authorization configuration

For each API client there could be defined scopes (ASPires service APIs) to which the third party would have access. Scopes are identifiers for resources that a client wants to access.



ASPires API scope access

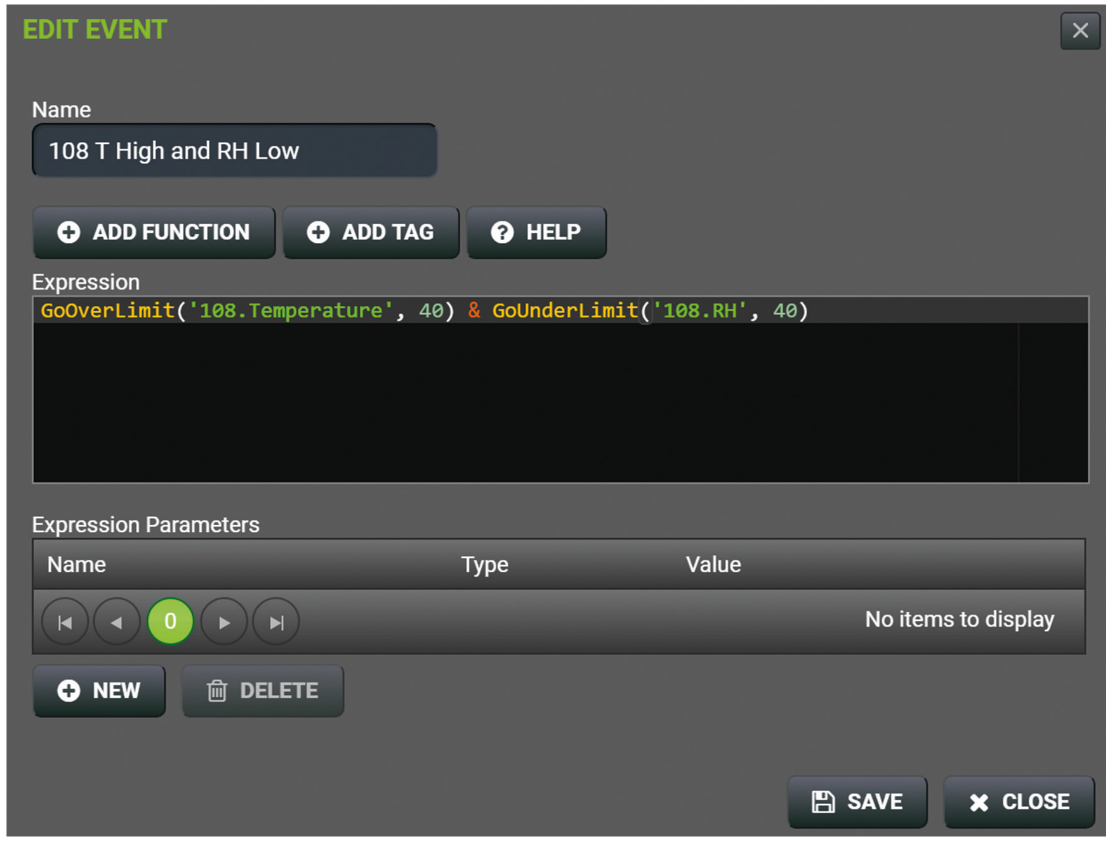
These identifiers are sent to the identity management server of ASPires during authentication or token request. In the example below, credentials have been granted to the GraphQL API for access to data and the Query API which serves the files stored in the platform.

ASPires Events, Warnings and Notifications

In ASPires platform it is possible to define events at organization level. These are actions or occurrences that are recognized by the software platform, could be handled and have value for the end user.

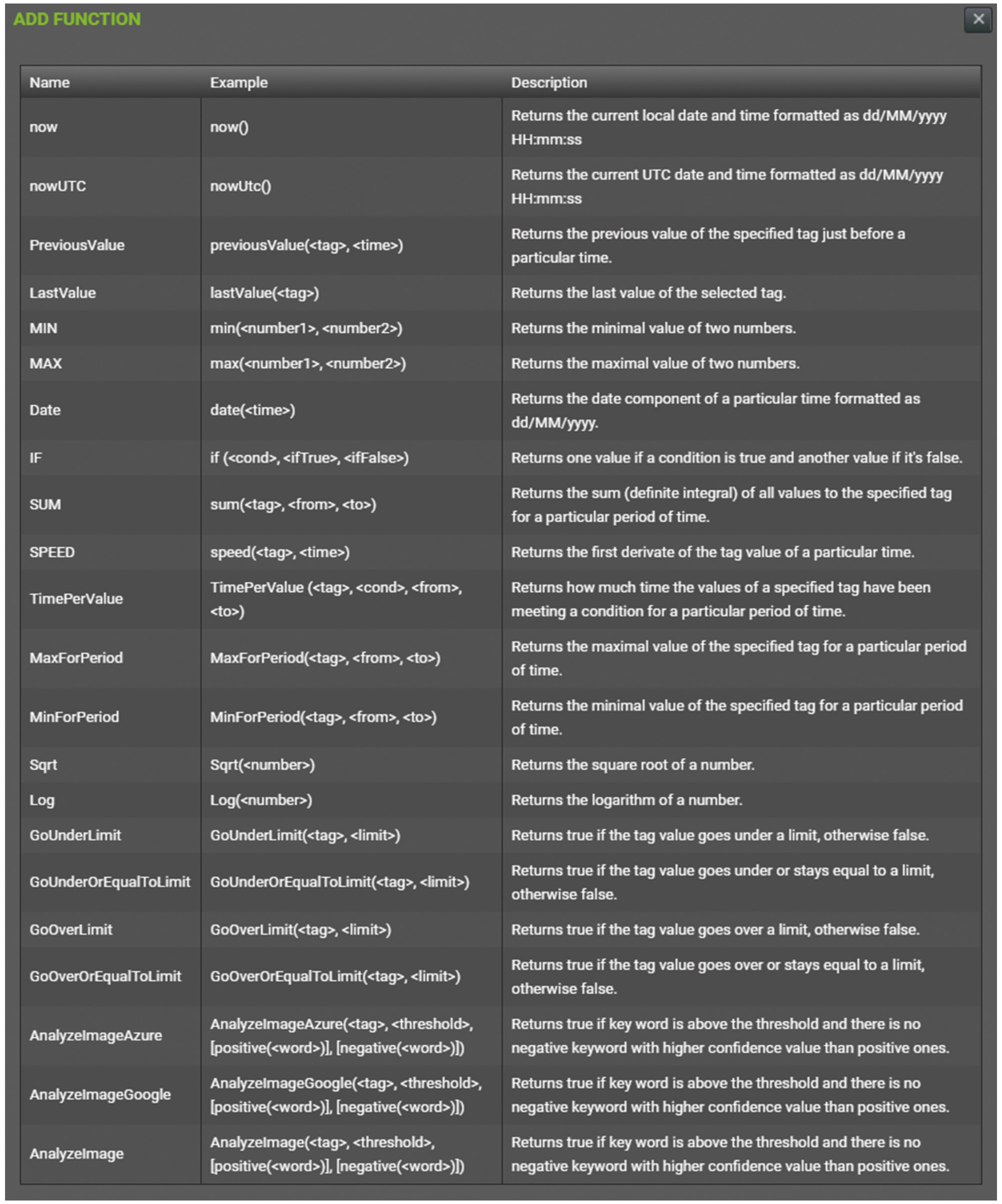
Events are described using extensible expression syntax and after the condition is checked the ASPires events engine decides whether the event has to be raised or not.

The source of events are the data ingested by the platform and evaluation takes place as soon as a data point arrives.



Organization data API authorization configuration

Built-in functions and operators are used in constructing the expressions that are used to configure Events.



ADD FUNCTION

Name	Example	Description
now	now()	Returns the current local date and time formatted as dd/MM/yyyy HH:mm:ss
nowUTC	nowUtc()	Returns the current UTC date and time formatted as dd/MM/yyyy HH:mm:ss
PreviousValue	previousValue(<tag>, <time>)	Returns the previous value of the specified tag just before a particular time.
LastValue	lastValue(<tag>)	Returns the last value of the selected tag.
MIN	min(<number1>, <number2>)	Returns the minimal value of two numbers.
MAX	max(<number1>, <number2>)	Returns the maximal value of two numbers.
Date	date(<time>)	Returns the date component of a particular time formatted as dd/MM/yyyy.
IF	if (<cond>, <ifTrue>, <ifFalse>)	Returns one value if a condition is true and another value if it's false.
SUM	sum(<tag>, <from>, <to>)	Returns the sum (definite integral) of all values to the specified tag for a particular period of time.
SPEED	speed(<tag>, <time>)	Returns the first derivate of the tag value of a particular time.
TimePerValue	TimePerValue (<tag>, <cond>, <from>, <to>)	Returns how much time the values of a specified tag have been meeting a condition for a particular period of time.
MaxForPeriod	MaxForPeriod(<tag>, <from>, <to>)	Returns the maximal value of the specified tag for a particular period of time.
MinForPeriod	MinForPeriod(<tag>, <from>, <to>)	Returns the minimal value of the specified tag for a particular period of time.
Sqrt	Sqrt(<number>)	Returns the square root of a number.
Log	Log(<number>)	Returns the logarithm of a number.
GoUnderLimit	GoUnderLimit(<tag>, <limit>)	Returns true if the tag value goes under a limit, otherwise false.
GoUnderOrEqualToLimit	GoUnderOrEqualToLimit(<tag>, <limit>)	Returns true if the tag value goes under or stays equal to a limit, otherwise false.
GoOverLimit	GoOverLimit(<tag>, <limit>)	Returns true if the tag value goes over a limit, otherwise false.
GoOverOrEqualToLimit	GoOverOrEqualToLimit(<tag>, <limit>)	Returns true if the tag value goes over or stays equal to a limit, otherwise false.
AnalyzeImageAzure	AnalyzeImageAzure(<tag>, <threshold>, [positive(<word>)], [negative(<word>)])	Returns true if key word is above the threshold and there is no negative keyword with higher confidence value than positive ones.
AnalyzeImageGoogle	AnalyzeImageGoogle(<tag>, <threshold>, [positive(<word>)], [negative(<word>)])	Returns true if key word is above the threshold and there is no negative keyword with higher confidence value than positive ones.
AnalyzeImage	AnalyzeImage(<tag>, <threshold>, [positive(<word>)], [negative(<word>)])	Returns true if key word is above the threshold and there is no negative keyword with higher confidence value than positive ones.

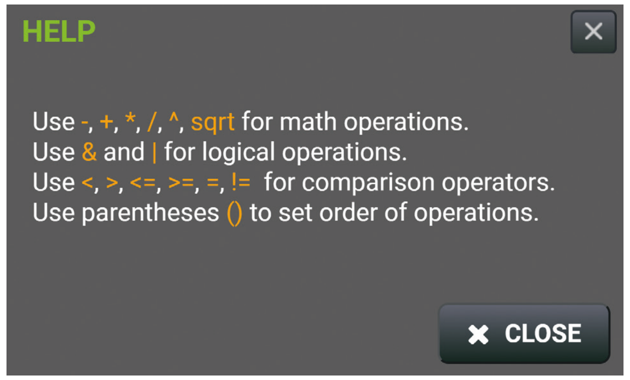
ASPires built-in functions

Start and stop events to Min tag limit and to Max tag limit are created automatically when a tag with min-max limits is created.

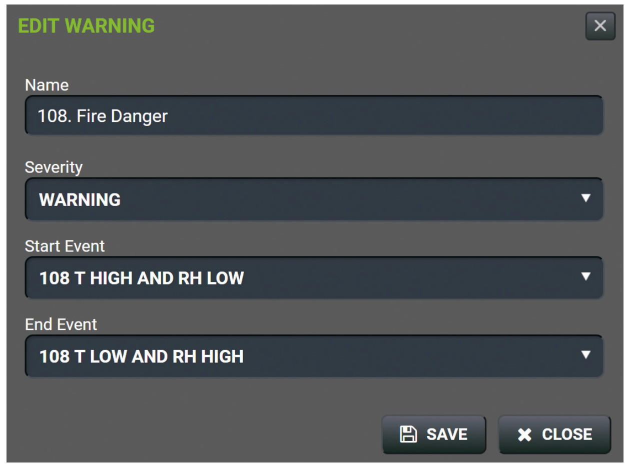
Another important capability of ASPires platform is the definition of warnings. Warnings are available under the warnings tab and are based on events. Start and end events define the time interval in which the warning shall be valid, and severity is flagged by the system operator and shall allow different warnings to be distinguished and sorted as informative, warning or alarm.

Warnings are exposed for external applications via the platform micro services layer and for applications that provide valid access tokens.

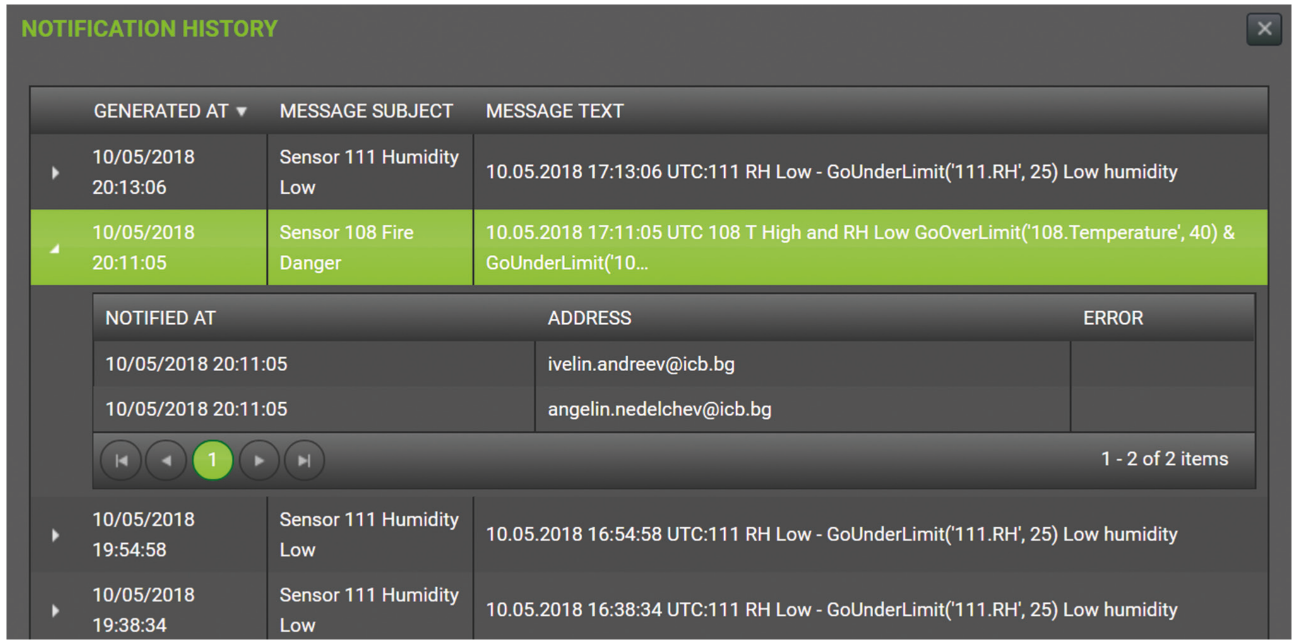
ASPires platform has its own capabilities to send notifications based on events. For every notification the user has to specify name, firing event, recipients list and media (e-mail). The system is monitoring the events and as soon as event that fires a notification appears, the system generates and sends the configured notifications.



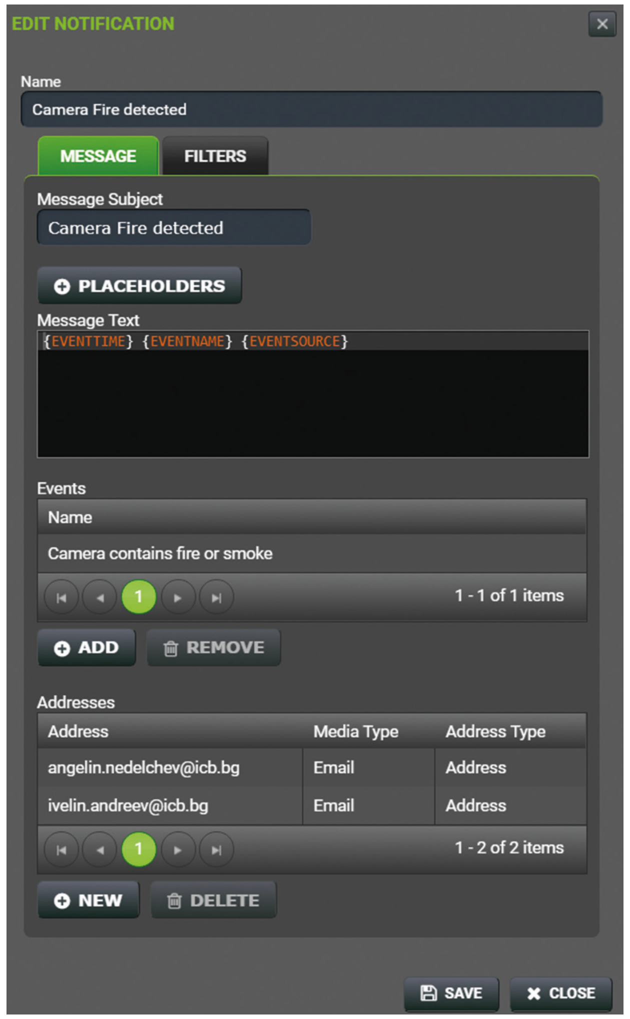
Valid operations in ASPires event definition



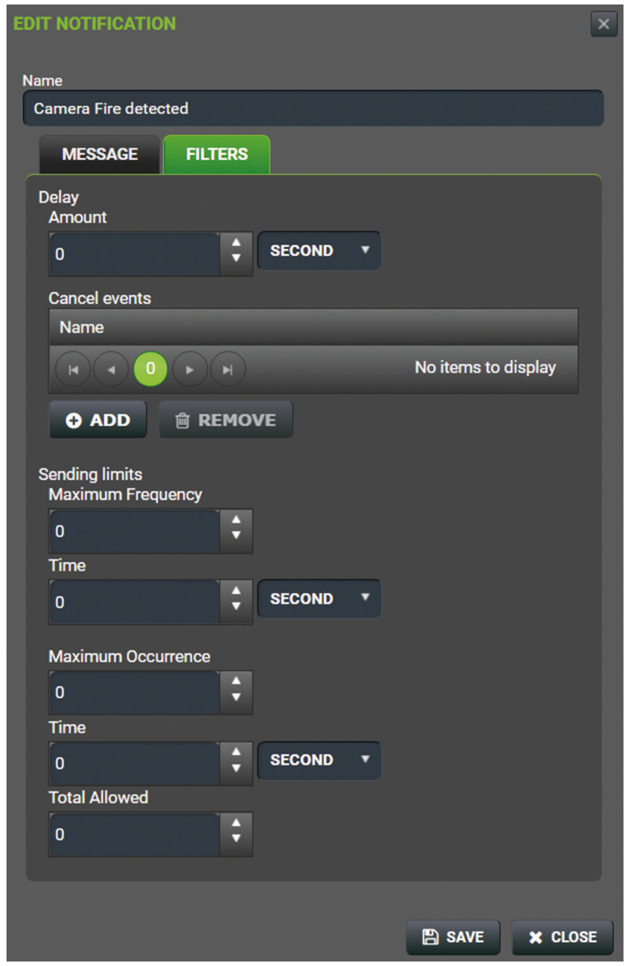
ASPires warning configuration



ASPires notification history



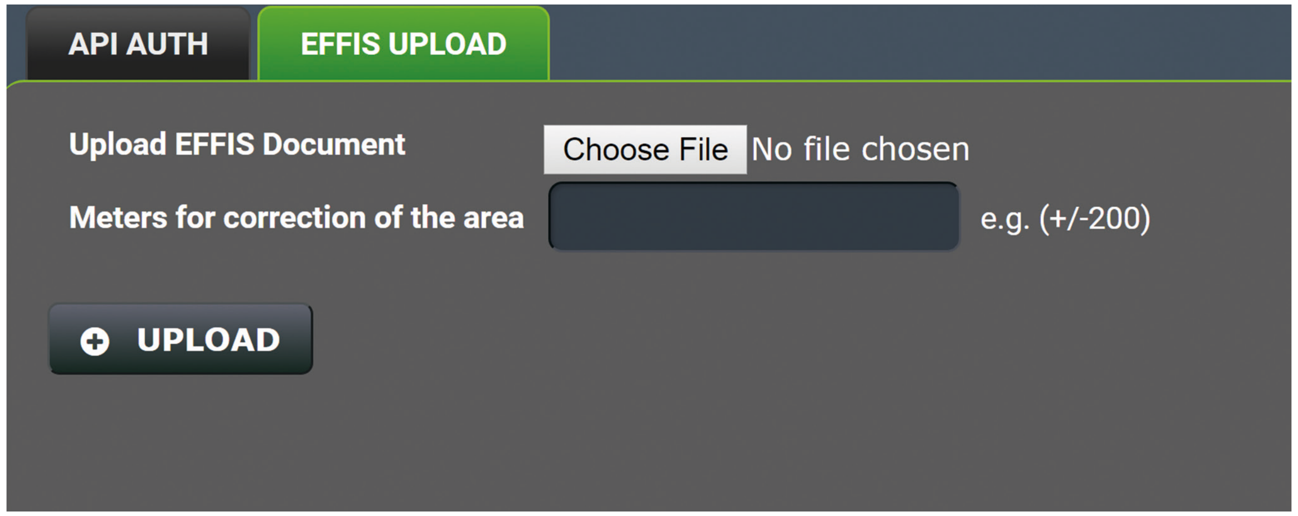
ASPires notification definition



ASPires notification filters definition

Reporting Forest Fires into EFFIS

For creating and using ML models for classification (fire or not fire) it is important that the system has knowledge about fire occurrences. In conformity with the overall project concepts, this is done through importing files in the format used by EFFIS, thus allowing already existing and verified information to be reused to the best possible extent.



Reporting Forest Fires through EFFIS File Upload

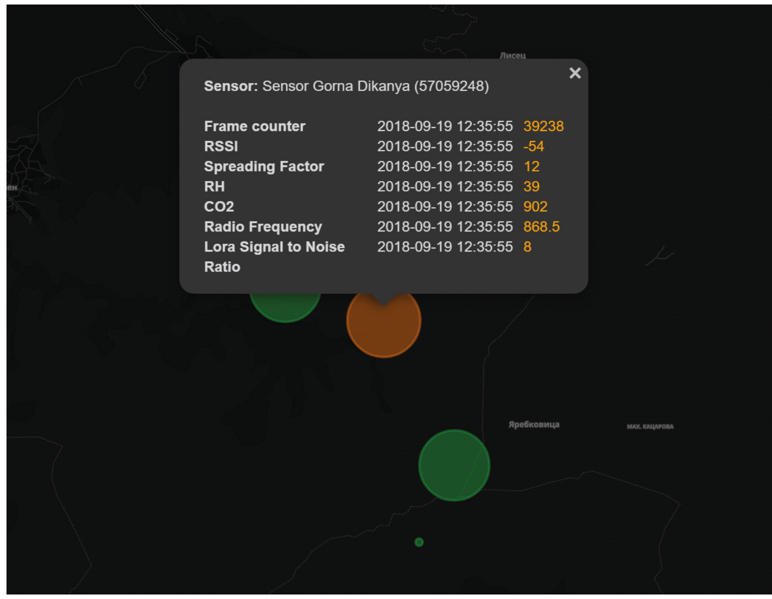
Dashboards and Alerts

With the flexibility and openness that ASPires platform provides, it appears logical to create a GUI dash boarding solution using an open source tool like Grafana.

Grafana is an open-source, feature-rich, general purpose dashboard and graph composer, which runs as a web application. It allows users to foster a data-driven culture by querying, visualizing, alerting on and understanding metrics no matter where they are stored.

Grafana supports multiple organizations for the purpose of fitting in a wide variety of deployment models, including using a single Grafana instance to provide service to multiple potentially untrusted Organizations. Each Organization can have one or more Data Sources under each of which there sits a single database.

The Sensor Map dashboard uses a modified version of the World map Panel – a tile map of the world that can be overlaid with circles representing data points from a query and can be used with time series metrics. The plugin was modified to show details pop-up with the latest data available when a circle denoting a sensor is hovered.

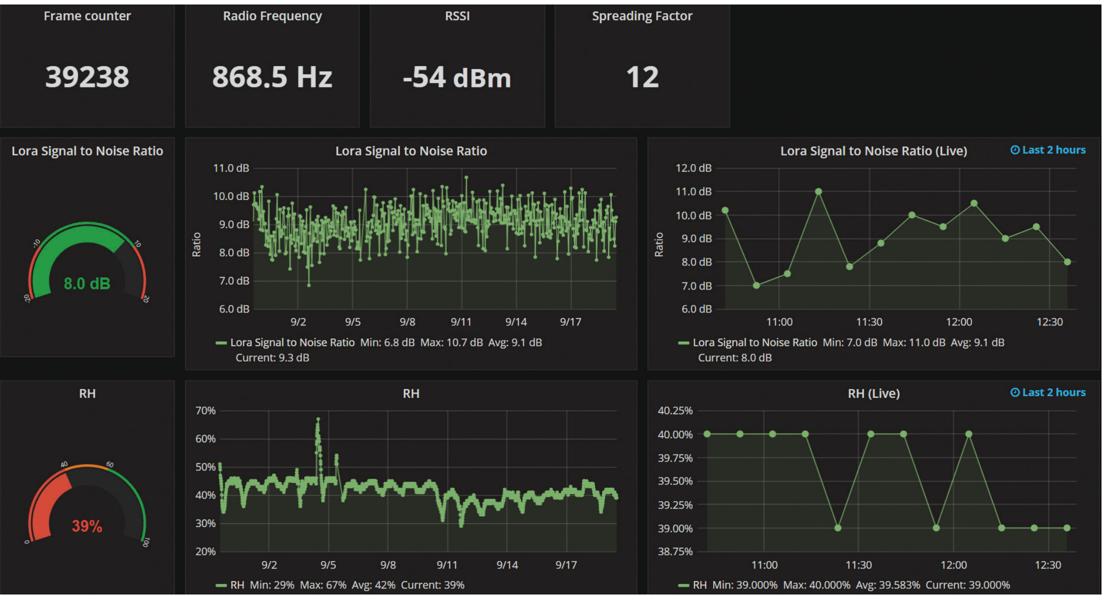


ASPires Grafana sensor map dashboard

Sensor Dashboard

Another major modification of the World map panel is the use of the ASPires GraphQL API to retrieve sensor point locations and present points according to sensor type and values.

When the user performs a drill-down by clicking on a sensor from the main dashboard, he is redirected to a specialized view, customized for the sensor type.



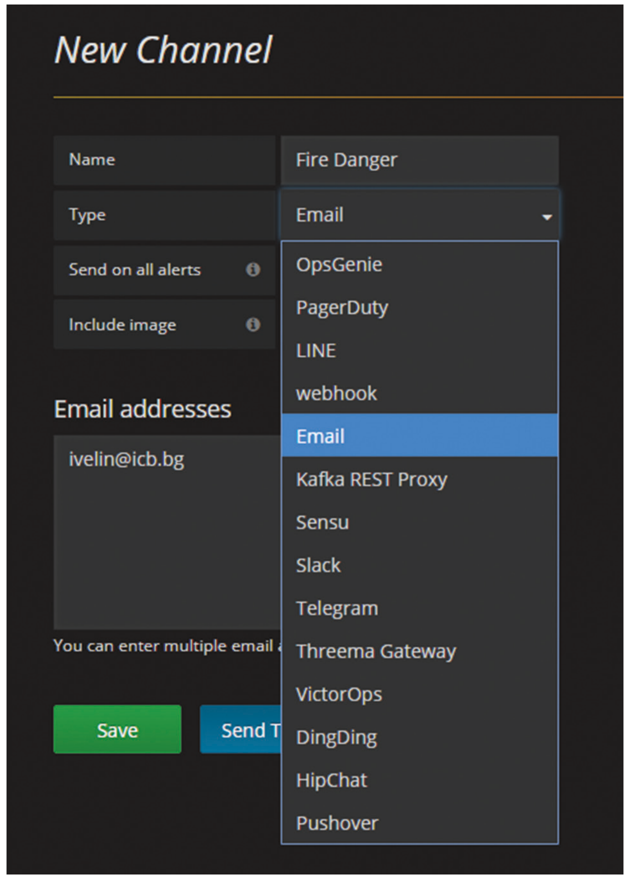
At its top the sensor dashboard displays sensor metadata (i.e. frame counter, radio frequency, signal strength – RSSI, spreading factor, battery voltage).

This is gauge charts that display how the current value is positioned in a customizable range of values for the sensor type, together with colour identification that denotes whether a parameter is critically low or high.

ASPires Grafana sensor details dashboard

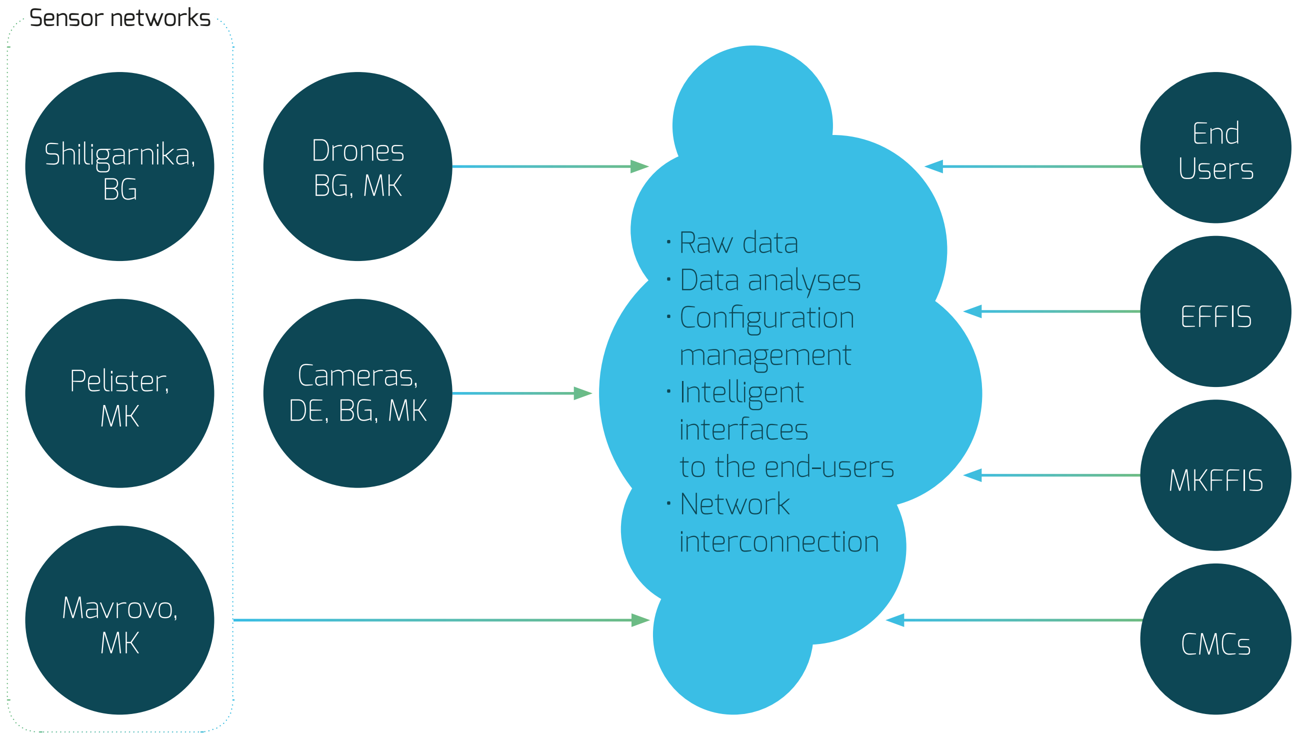
Configuration of alerts

Grafana alerts are similar, although less flexible than the alerts and events definition by ASPires platform.



ASPires Grafana Alert Configuration

Integration & Interoperability



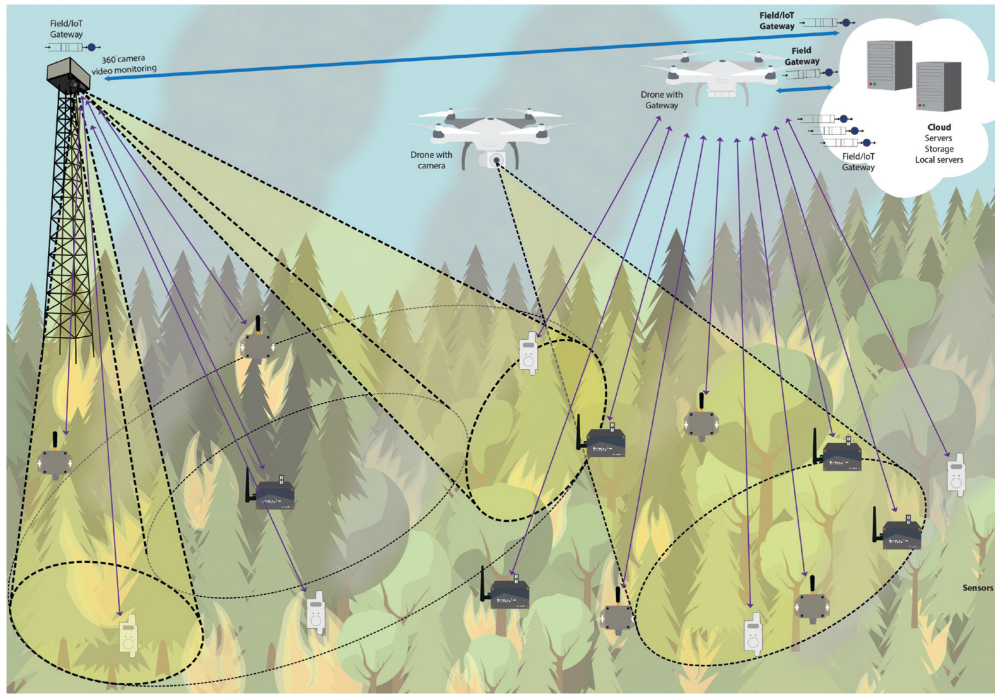
The ASPires platform aims to be a global solution integrating multiple local and regional fire prevention and detection platforms at cloud computing level. Three networking levels are distinguished, i.e. access, edge and core parts.

They correspond to the sensors/end-devices, end-user's devices and area of work, regional area of work and long distance or national/international level of work. Raw data is collected at access network, harmonised at access and edge network and processed at core network.

Field and cloud gateways are used for connections to the servers and network configuration. Field gateways could fly on a drone, i.e. being mobile and transmitting in real time via 3G/4G network. Edge or software gateways could be installed on field or at the entrance of the cloud.

At computing level, it is possible to distinguish smart dust computing level based on gateways, dew computing level based on local servers and data bases, fog computing level based on regional and national level servers and storages, cloud level computing based on national and international servers and storages.

The ASPires platform could be connected to EFFIS and MKFFIS, where EFFIS stands for European Forest Fire Information System and MKFFIS stands for Macedonian FFIS. The connection to Crisis Management Centre (CMC) is defined at conceptual level and experimented with Macedonian partner.



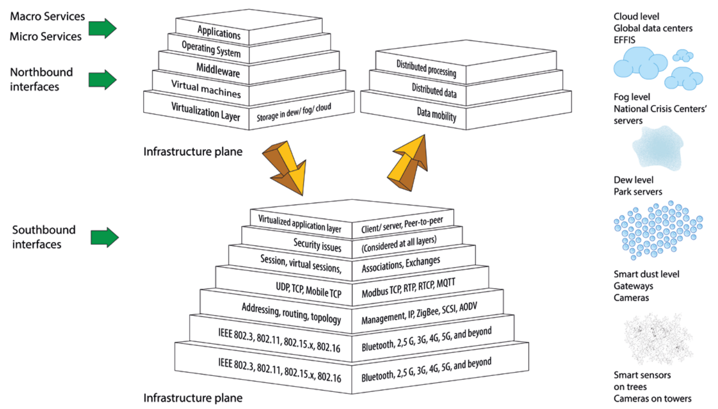
The ASPires platform

The ASPires platform architecture reference model has an open design. The cloud gateway works at application layer while the field gateways are working at channel, network, transport and application layers according to Open System Interconnection Reference Model (OSI RM). LoRa sensor network is part of the channel and network layers. Power management is flexible and depends on the type of equipment, i.e. batteries, solar panels, and main sources.

The field gateway could be mobile or fixed whereas the cloud/edge gateway could be installed locally or remotely and is usually fixed. All communication scenarios aim at data collection and network configuration through the cloud.

There is also the possibility to support the services only locally as in the case of national park Mavrovo, where all the alarms and data analysis are performed locally, and the data is replicated to the cloud in near-real-time as a backup service. Camera surveillance in Bulgaria also performs alarm detection locally and reports all alarm conditions to the cloud in near-real-time.

Different implementations within the scope of ASPires project aim to demonstrate the applicability of the solutions in variety of use-cases.
Integration and interoperability with existing and new platforms could be done at all possible layers of the platform. The two main possibilities are through southbound and northbound interfaces. Whereas the southbound interface requires usually a gateway the northbound interface supports interoperability via APIs.



Infrastructure plane

Existing solutions using proprietary technology could send and receive data to ASPires platform via a gateway. It needs to support the proprietary protocols at one side and standard protocols of ASPires platform from the other side.

New platforms that use standard interfaces will flourish the development of the standard gateways on the market aiming to have a scalable and flexible solutions at reasonable cost. This is the aim of the European Commission while speaking on Digital Single Market possibilities.

New trends in dew/ fog computing aim to distribute the services regionally and allow further service customisation.

Efficiency analysis has been calculated at all levels of the ASPires platform. Special attention is paid to the sensor part that is deployed in the forest. It was determined that at current level of responsiveness, there is no need to take measurements in time intervals smaller than one to five minutes.

The experiments carried out at ASPires-GEO show that the ASPires platform operates according to the project. Loss of data depends on the performance and the protocol supported by the sensor module.

The experiment with using machine learning for detection of forest fires based on sensor data proved to be a valid approach for creation of new methods for other than threshold-based mechanisms and algorithms. The approach could be researched even more, especially with the fact that the current dataset is considerably more balanced than expected in real life. However, an accuracy of 98% is enough to stimulate further work in that direction.

The proposed real-time WSN fire detection system mixes sensors with IP cameras in a wireless communication environment, to detect and verify fire forest areas. The measurements of the sensor/ controller are sent through the wireless network to a central server, where it is stored in a database. Then, an algorithm for determining the risk of a fire presence is applied. Upon viewing the results, the operator decides if the video surveillance component needs to be activated, i.e. if the drone must be sent to the reported location of the event.

The camera helps in corroborating the existence of a fire and thus avoiding false alarms.

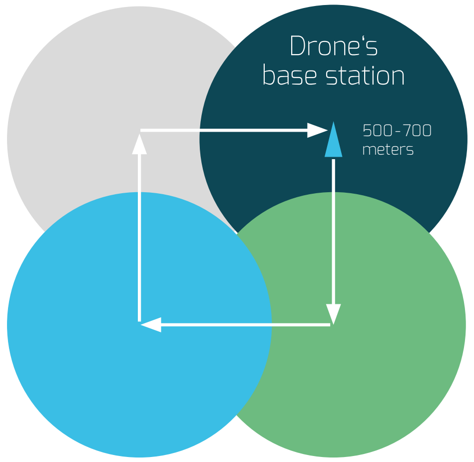
Sensors give a perspective for decreasing the costs and optimizing the functionality. They can be selectively installed in areas with flammable vegetation available. Performance and scalability analysis have been done with OMNET++ simulator for all parts of the network. Network clusters of 2, 5, 10, 100, 200, 500, 1000 sensors have been simulated as well as the connectivity to the gateways and the cloud.

Thanks to the use of drones the coverage of the area of difficult proximity and deployment is increased significantly. The work through the cloud allow continuous data analysis and service definitions in few seconds, i.e. almost in real-time. This decreases significantly the time of the fire detection.

Sensors need to be grouped in clusters to decrease the contention for the transmission channel. Special attention is needed to all European regulations on the sensitivity, transmission power, bandwidth used.

The testing of the drone and the cameras in fire detection has been successful, which is documented by both video and photo captures.

The experiment with using machine learning for detection of forest fires based on sensor data proved to be a valid approach for creation of new methods for other that threshold-based mechanisms and algorithms. The approach could be researched even more, especially when the fact the current dataset is considerably more balanced than expected in real life. However, an accuracy of 98% is enough to stimulate further work in that direction.



ASPires developments

Comicon Field Gateway

The field gateways, developed by Comicon Ltd., Bulgaria, are part of the sensor network.

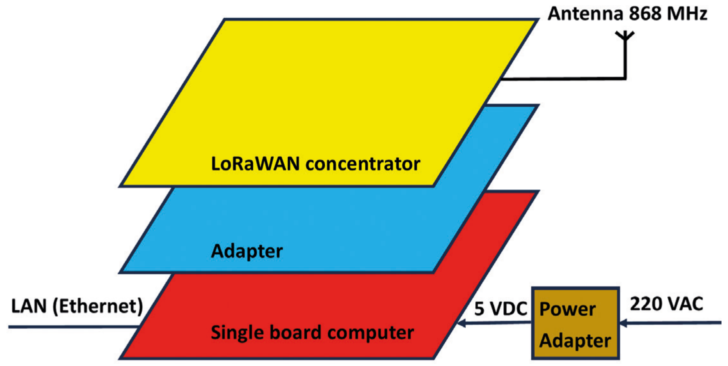
The tasks executed by the field Gateway:

- Connecting LoRa® wireless sensors to supervision and control equipment.
- Collecting data from predefined set LoRaWAN™ Class A sensors.
- Sending data to MQTT broker.
- Sending data to registers of a targeted Modbus TCP server.
- Supporting Modbus TCP client functionality

The field gateways were developed in 2 versions:

- fixed - based on Ethernet, powered by main power supply;
- mobile - based on 3G cellular network, powered by batteries, for use on a mobile vehicles incl. drones.

The structure of the fixed field gateway is presented on the figure on the right. It includes a LoRaWAN™ concentrator for the sensor data acquisition and aggregation, adapter, Raspberry Pi for LAN connectivity and firmware running, power supply. The power supply of the forest fire detection tower and its Ethernet connectivity are used. The adapter includes Real Time Clock (RTC) which allows the gateway to keep correct time in cases of Ethernet and/or power loss.

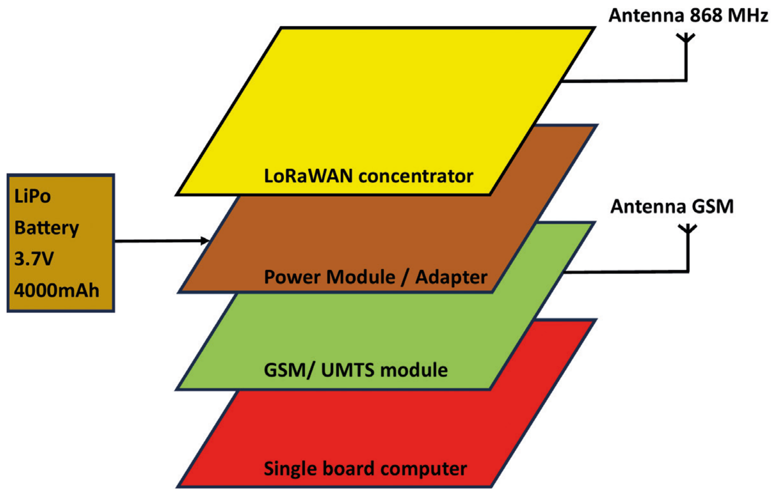


Hardware structure of LoRa® fixed field gateway

The mobile field gateway structure is presented on the picture below. The main parts are the same as of the fixed field gateway, but also it has in addition battery and GSM/UMTS/LTE module. The weight of the mobile field gateway is an important parameter.

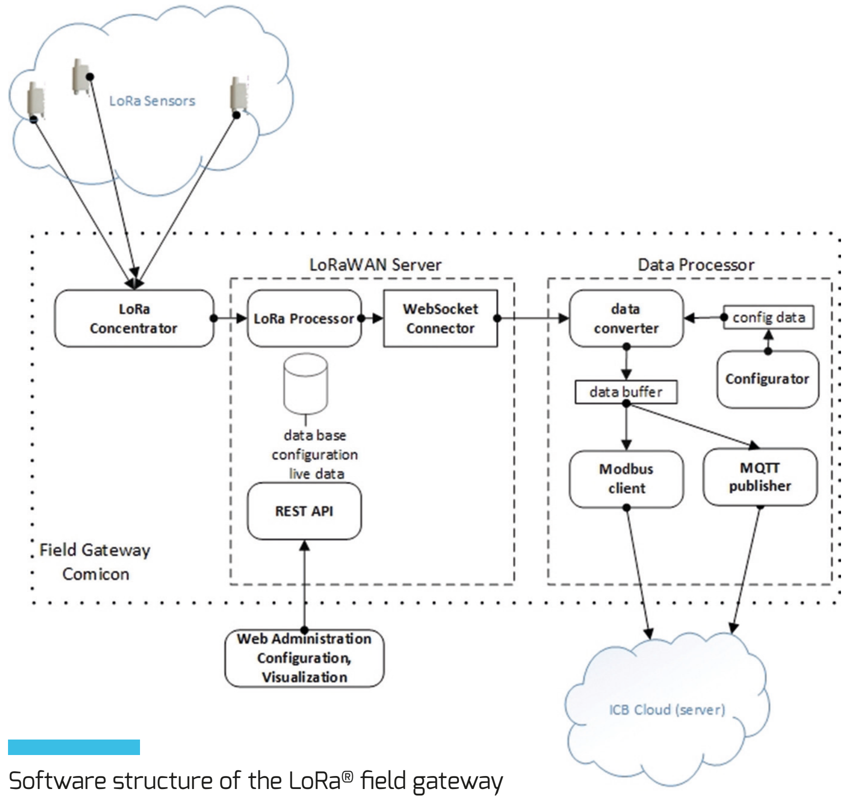
The software modules of the gateway are shown in the picture. Starting from LoRa® technology on one side while reaching the Modbus TCP or MQTT on the other side the modules are:

- LoRa® concentrator taking the data from every sensor and transferring data to the local LoRaWAN™ Server.
- LoRaWAN™ Server that is responsible for the network. LoRaWAN™ Server knows about active node sessions and when a new node sends join request, the server checks whether the node is allowed in configured private network and what are the settings to use for this node. When a new message arrives from any sensor in the configured network, the LoRaWAN™ Server decrypts sensor's payload, saves it to the local database and then sends the payload to the Data Processor module through / via a Web Socket Connector. Configuration and monitoring of the network is available through a Webpage of the LoRaWAN™ server.

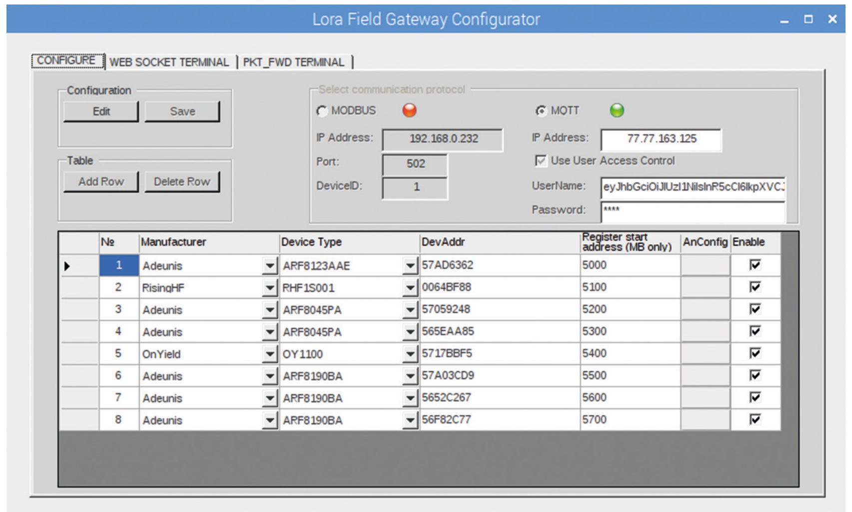


Hardware structure of the LoRa® mobile field gateway

- Data Processor module includes the configurator, configuration table, data buffer, data converter, Modbus client, MQTT publisher.
- Configurator that serves the configuration of all sensor types, type of end communication to be used (Modbus or MQTT) and addresses of the cloud server.
- Configuration data table stores configuration made by the Configurator submodule.



Software structure of the LoRa® field gateway



LoRa® field gateway configurator

ASPires mobile field gateway on a drone

The mobile gateway can be mounted on any kind of mobile device. For the ASPires project was used a drone.

The gateway is configured to collect the data from the sensors in its area of fly. In this way a fleet of drones could cover quite big area of importance with difficult terrain for fixed installations and access. The flight could be predefined as a regular service or being made on demand in case of alarm or high risk.

ASPires fixed gateway

The drone, flying with the mobile gateway on board, is of great significance for forest fire prevention and detection:

- If there is no fixed sensor network gateway or it is damaged or if communication obstacle is present, the mobile gateway can collect the data.
- In case of lack of a cellular communications coverage (3G, 4G).
- In case there is no line of sight for a fixed thermal camera.
- The combination of a wireless sensor network and a drone with a gateway on board allows fast data collection from the area of importance and decreases the delay in forest fire detection.
- The drone with a gateway on board is a useful instrument for fast forest fire detection.

ASPires-GEO

ASPires-GEO is a model, that includes standard high-tech equipment located on stationary towers in forest areas and used for early detection of forest fires.

The purpose of this model is to demonstrate the working ability of the ASPires platform. The main goal of the ASPires platform is to collect online data from different types of sensors, organize them in the Cloud database and create correlations for these data. Conformity will provide an opportunity to accurately determine the situations: forest fires and wildfires.

ASPires-GEO is installed in Sofia, Bulgaria at the foot of Vitosha Mountain. It is directed to Vitosha Mountain and ten predefined positions are scanned.

ASPires-GEO consists of a thermographic camera with video surveillance features, a daily HD camera, a positioning device, a server with intelligent fire detection software installed.

ASPires-GEO located in Sofia, Bulgaria

ASPires-GEO scans the forest terrain according to a predetermined route. The route consists of predefined positions (Presets).

Within each preset, the hottest point (pixel) is determined. The temperature at this point reflects the energy that reaches the camera. This energy depends on the weather conditions, the distance of the scanned position and the visibility.

A weather station is installed at the point where the cameras are mounted, which provides data on weather conditions in XML format on HTTP protocol upon request. This data gives precise information about the weather conditions of the cameras.

The Equipment Manufacturer OPTIX, Bulgaria defines the following fire detection ranges:

Fire detection ranges

Area	Distance
1m x 1m	0.8 km
2m x 2m	1.6 km
3m x 3m	2.3 km
6m x 6m	4.7 km
24m x 24m	19 km
40m x 40m	40 km

Fire detection ranges

The measured data are received from two sources:

· From the infrared camera, once data is processed by intelligent software, developed by OPTIX, Bulgaria. The following data are available: The name of the system, Data and Time, the name of the preset. The temperature of the hottest pixel inside the preset and the X and Y ordinates, Alarm indicator, URL link to the Pictures (makes by the cameras and related video clips, if the alarm indicator is on).
· From the weather station, produced by Reinhardt System- und Mess electronic GmbH, Germany. The following data are available: Temperature, Humidity, Air pressure, Barometer, Dew-point, Wind speed, Wind average, Wind direction, Main wind direction, Windchill.

The Data is provided on-demand in real time. The request is made by the ASPires platform Gateway. The received data are transferred to the ASPires cloud platform.

The experiments carried out prove, that the concept on which the platform is created, is correct and is as expected. There is no data loss. The data collection layer allows the development and expansion of early forest fire prevention systems.

The live demonstration is published on the ASPires project WEB Site https://www.aspires.eu/web/guest/aspires-geo/pontech-ugis.

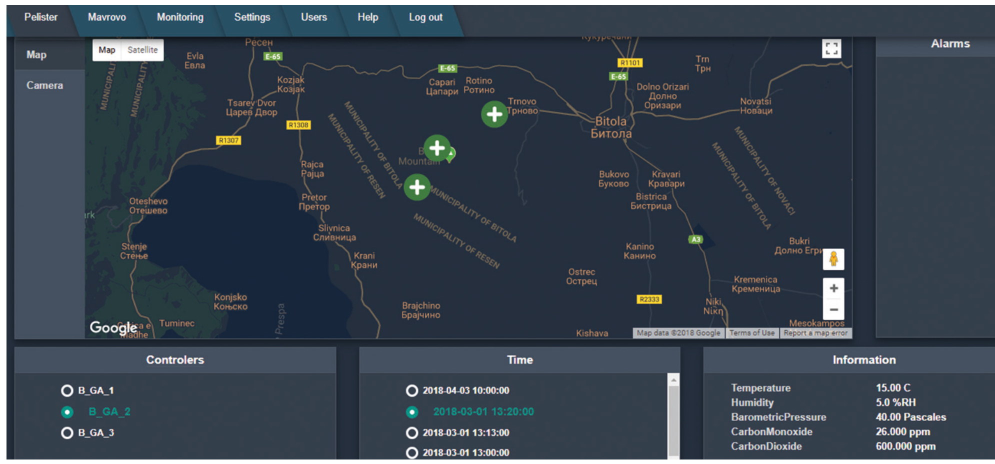
End User Application by Military Academy, Skopje

To process the data and respond accordingly to any risk situation, operators trained in forest fire detection and monitoring will rely exclusively on ASPires and its web and mobile-web application.

While the desktop web application includes a wider range of data management tools integrated within its interface, the mobile web application primarily looks to reduce the reaction time in case of a fire by alarming the appropriate decision capable personnel of the crisis management system.

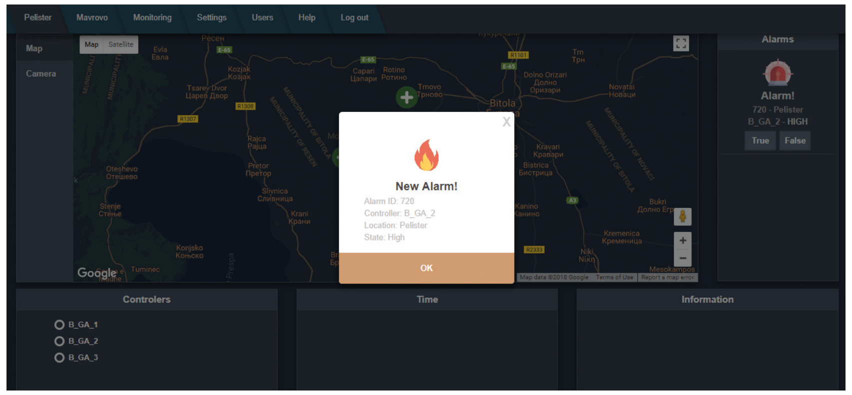
Home/Main Monitoring Page

Upon logging in, the Home/Main Monitoring Page opens to an interactive map, with a lot more vivid and expressive colors, and text (names of geographical objects) that stand out. Sensor Controllers are marked with multicolored (green- Normal, yellow – High, orange – Very High and red – Extremely High) pins based on the state of alertness and possibility of a fire occurrence.



Sensor Controllers

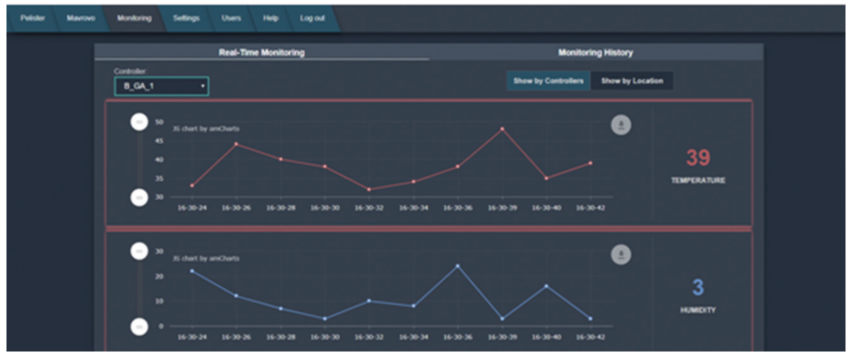
When the sensor values are different than Normal, an Alarm pops up and the operator/user who monitors the state of the National Park should click on the button "OK" and check with the Camera or Drone if there is an actual fire in place, while the Alarms are shown in the background (to the right of the map).



Alarm

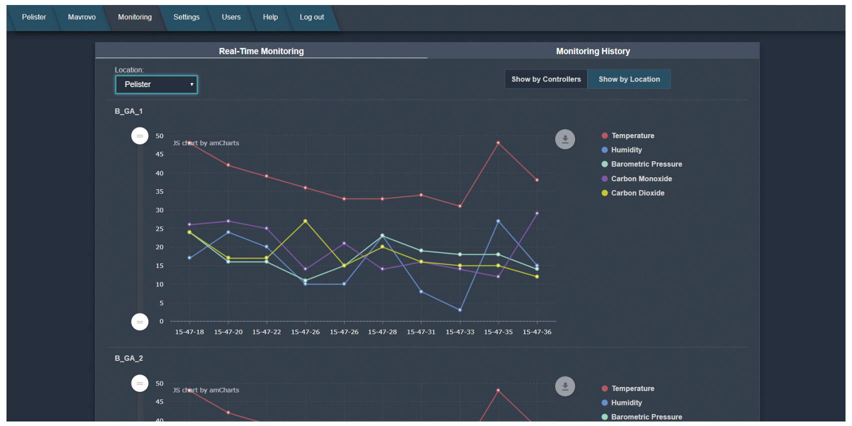
In the Monitoring Page each of the sensor values are shown as graph visualizations.

The „Location" button displays information about all the sensors mounted on this location. (Mavrovo, Pelister).



Graph visualizations

On the Monitoring History page there is a drop-down menu, where for the selected controller can be picked the time interval for which the graphs should be displayed.



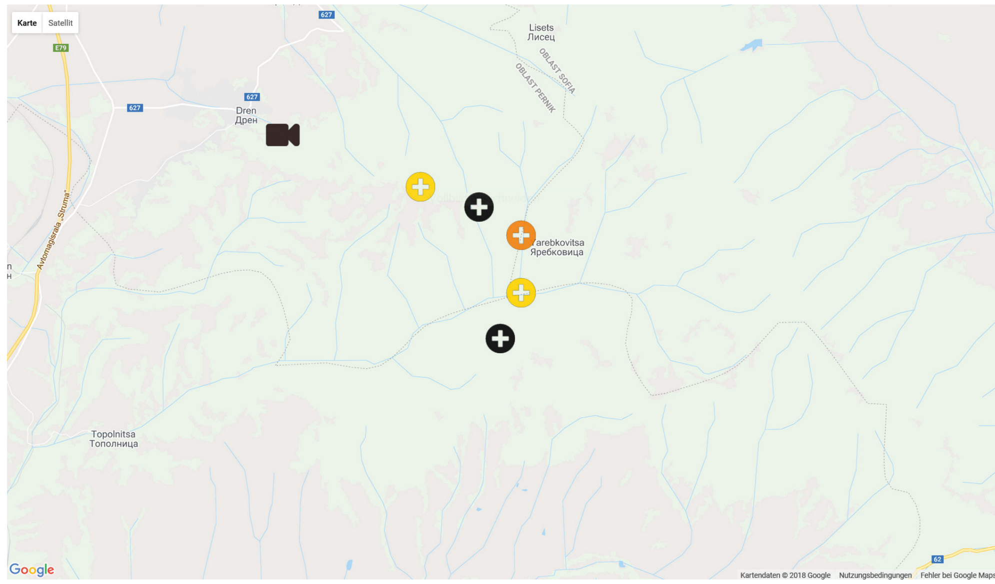
Graph visualizations

UFulda Web application for End-Users

The University Fulda, Germany has developed a Web application that does require data to be available in real-time, which means sub-second or even lower delay from the time of capture and time of delivery by the northbound cloud interface. The screenshots shown here of taken from the operational application. Actual data values (sensors, pictures, etc.) are obtained by invoking the proper services of the northbound ASPires cloud interface.

The functionality and information available to end-users is structured into the following subjects:

- Administration (including user and profile management)
- ASPires region page (map-based information)
- Sensor information (including statistics)
- Camera information
- Alarms

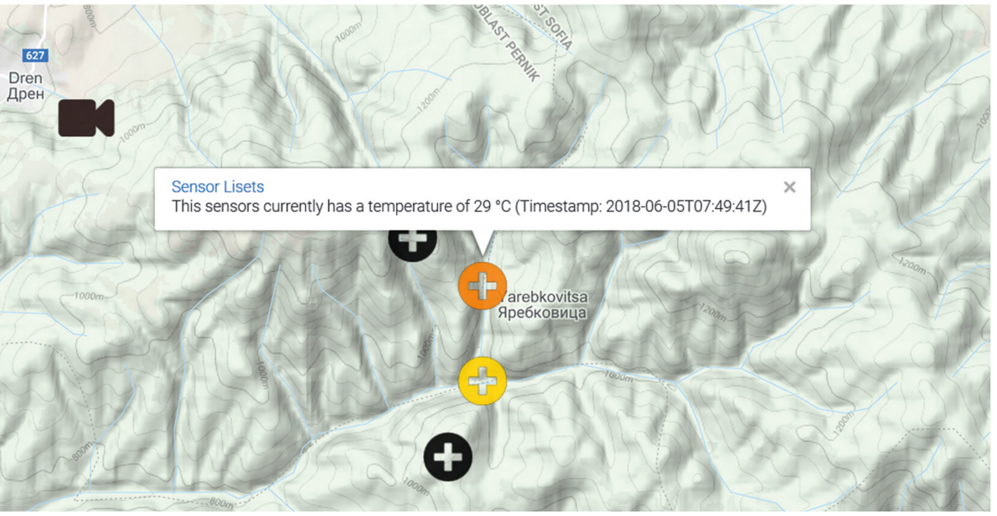


Geographical representation of the ASPires region

The security is role based. As end-users from several ASPires regions in different countries may work with the Web application, some profile management functions, such as multi-lingual support and the specification of a default ASPires region are provided. A help function is available, too. When a user logs into the system for the first time, he or she will be directed to the system default region.

After successful login, the end user is given a geographical representation of the ASPires region. All Information available to the end-user can easily be reached by clicking on icons or menus on this pivotal Web page. The map itself may be enlarged (zoomed in), scaled down (zoomed out) or re-centred thanks to the built-in functionality of Google maps.

Each circle shaped icon points to a sensor site. The colours indicate the temperature by default. The default may be altered by changing the settings in the and-user's profile. The colour black signals that a sensor currently does not deliver any (temperature) data. Colours, in general, are associated with a range of values. Regarding temperature, the colour scheme ranges from green (low) to red (extremely high, potentially a real fire). The colour scheme is variable (configurable).

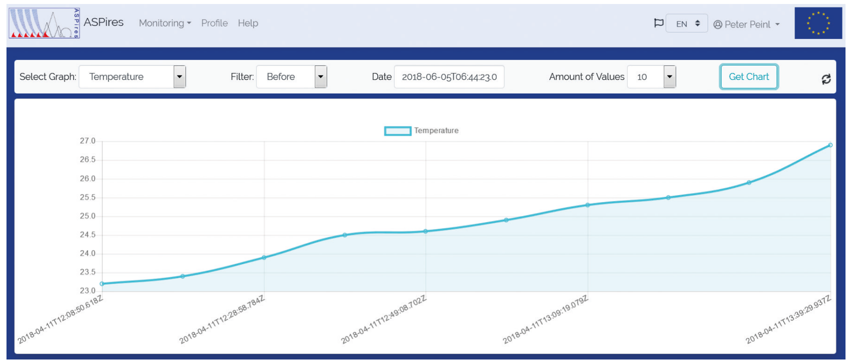


Sensor Lisets

A region might be very large or densely populated with sensors and cameras. In this case, the UFulda Web application can produce the complete list of all available devices.

Actual data from individual sensors may be obtained by a click on the sensor icon on the map.
The UFulda Web application is also able to display all time-series data available via the northbound ASPires cloud interface. There are two alternatives, either simple list or preferably graphs.

The graphics package used by the UFulda implementation automatically smooths the curves. Images taken by cameras constitute a very powerful type of "sensor" data that is made available by the ASPires project. Those cameras are either mounted on watch towers in the forests or carried by drones (UAV). Drones add a flexible, mobile and low-latency component to the data capturing side of ASPires.



Graphics package

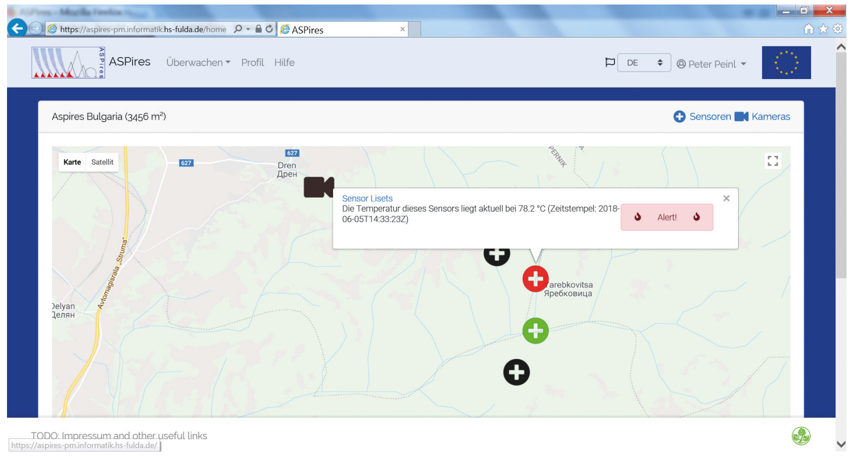
Images, when available, are extremely helpful in verifying automatically generated alarms. Human experts may check the validity of alarms by analysing images of the location of a purported fire or unusual sensor readings.

The last, but extremely important new feature that ASPires will give the CMCs, is automatic generation of alarms based on the information gathered by the sensor infrastructure (dust level of the cloud).

The entire Web application of UFulda has been implemented based on the concept of a Virtual Machine (VM). Virtualizing software has been employed to create a VM for the UFulda application. The UNIX operating system1 has been installed within the VM. The VM software technology allows to create clones of a VM that may be shipped to other computers and installed there with relative ease, provided that the virtualization software is available on those computers.

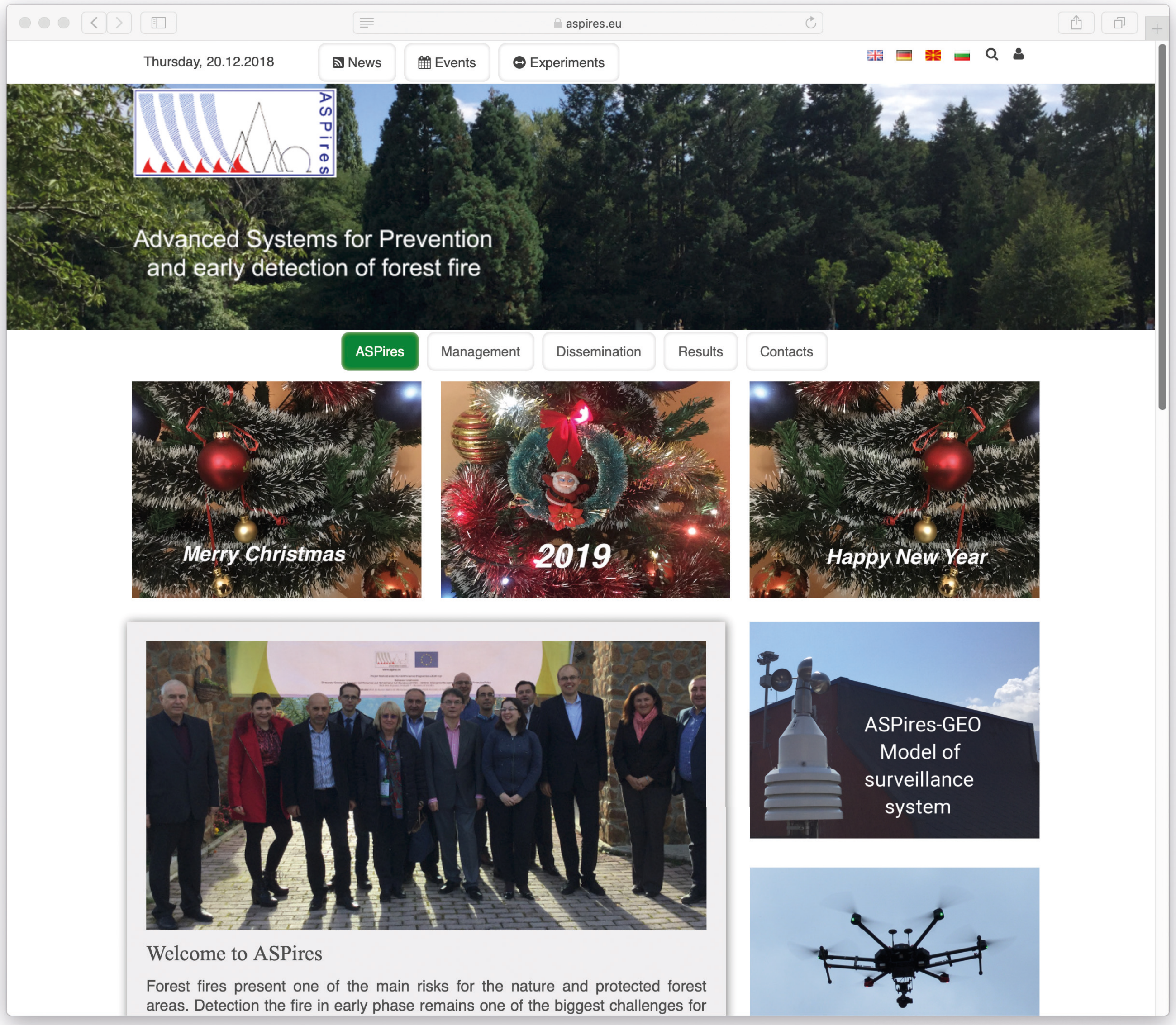
This feature would allow to move the application to other organizations and make it operational after some rather limited customization. In that way each organization might have and administer its "own" version of the UFulda application.

However, the platform is intended and capable to work with data from multiple locations. The UFulda Web application receives the data through the ASPires northbound cloud interface, which contains information about the organization of origin of those data.

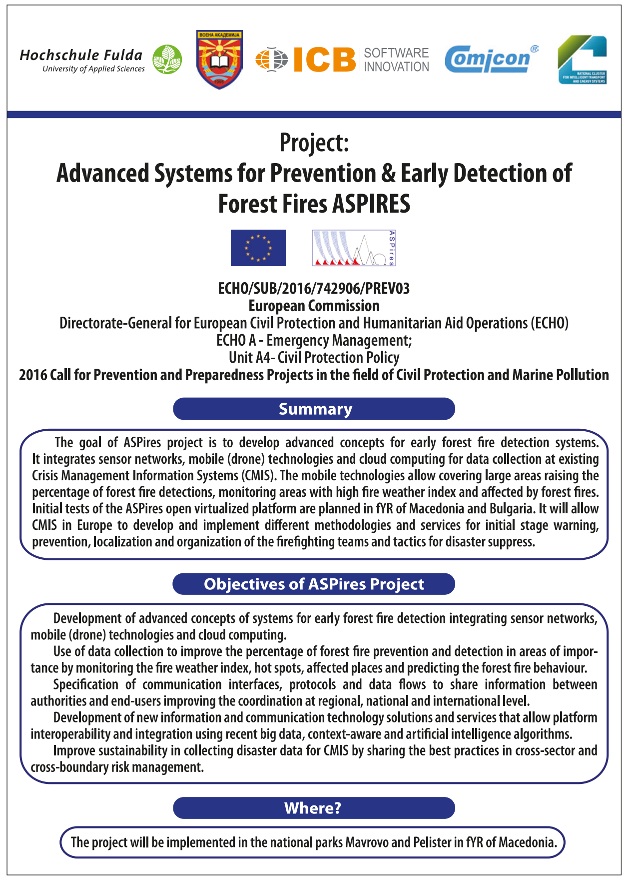


Web application

The ASPires team shared the objectives, tasks and results of the ASPires project through a variety of communication channels



The ASPires project web site is located at
https://www.aspires.eu



Hochschule Fulda University of Applied Sciences
ВОЕНА АКАДЕМИЈА
ICB SOFTWARE INNOVATION
Comicon

Project:
Advanced Systems for Prevention & Early Detection of Forest Fires ASPIRES

ASPires

ECHO/SUB/2016/742906/PREV03
European Commission
Directorate-General for European Civil Protection and Humanitarian Aid Operations (ECHO)
ECHO A - Emergency Management;
Unit A4- Civil Protection Policy
2016 Call for Prevention and Preparedness Projects in the field of Civil Protection and Marine Pollution

Summary

The goal of ASPires project is to develop advanced concepts for early forest fire detection systems. It integrates sensor networks, mobile (drone) technologies and cloud computing for data collection at existing Crisis Management Information Systems (CMIS). The mobile technologies allow covering large areas raising the percentage of forest fire detections, monitoring areas with high fire weather index and affected by forest fires. Initial tests of the ASPires open virtualized platform are planned in fYR of Macedonia and Bulgaria. It will allow CMIS in Europe to develop and implement different methodologies and services for initial stage warning, prevention, localization and organization of the firefighting teams and tactics for disaster suppress.

Objectives of ASPires Project

Development of advanced concepts of systems for early forest fire detection integrating sensor networks, mobile (drone) technologies and cloud computing.

Use of data collection to improve the percentage of forest fire prevention and detection in areas of importance by monitoring the fire weather index, hot spots, affected places and predicting the forest fire behaviour.

Specification of communication interfaces, protocols and data flows to share information between authorities and end-users improving the coordination at regional, national and international level.

Development of new information and communication technology solutions and services that allow platform interoperability and integration using recent big data, context-aware and artificial intelligence algorithms.

Improve sustainability in collecting disaster data for CMIS by sharing the best practices in cross-sector and cross-boundary risk management.

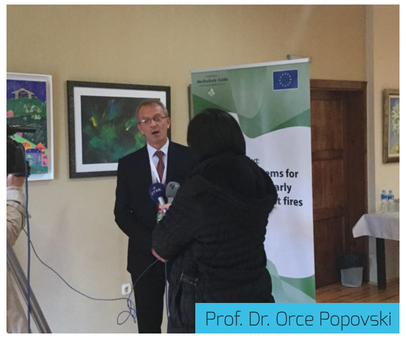
Where?

The project will be implemented in the national parks Mavrovo and Pelister in fYR of Macedonia.

The ASPires project flyers, posters and brochures are ready for download at https://www.aspires.eu/web/guest/aspires-project-flyer-and-poster

The first workshop in ASPires Project was held on the 8th of November 2017 in Berovo, Republic of North Macedonia.


Workshop in Berovo


Prof. Dr. Orce Popovski

The workshop was held in Berovo, a small town near Maleshevo. The seminar was attended by all members of the ASPires project development team and the end users of the project.

On the seminar have been presented the main objectives of the project and the results achieved so far. Some of the important themes and questions, that was discuses, are:

- Prevention and early detection of forest fires
- Special technologies
- What should be done so that false forest fire alarms decrease by over 90%?

The seminar was attended by the ASPires project end users:

- Crisis Management Centre, represented by Dragan Balas
- Ministry of Agriculture, Forestry and Water Management in Republic of North Macedonia, represented by Boris Peshevski
- Ministry of Environment and Physical Planning in Republic of North Macedonia, represented by Alexander Nastov
- Ministry of the Interior, Bulgaria, represented by Alexandro Iliev
- National Park Mavrovo, represented by Dragan Blazevski
- National Park Pelister, represented by Pece Cvetanovski


Prof. Dr. Peter Peinl

The end users of the project presented interesting presentations on the organization of crisis management systems.

Presentations and videos are available at https://www.aspires.eu/aspires-workshop-in-berovo

The workshop in Fulda, Germany was held during the RETTmobil exhibition on the 17th of May 2018.

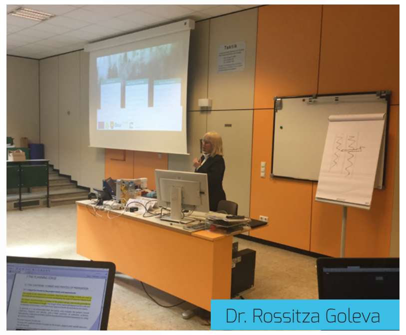

Prof. Dr. Peter Peinl

Stakeholders and visitors was briefed about and actively involved in the ASPires project, including demonstrations prepared by the ASPires Fulda team and the project partners.

The workshop participants had the opportunity to learn more about the ASPires project. The topics of sensor, drone and platform applications for fighting and preventing forest fires were presented.

Prof. Dr. Peinl presented the ASPires project, dealing with fighting and preventing forest fires. He presented the current results of the ASPires project.

The participants included representatives of the fire brigade of the city and the district of Fulda, representatives from the interior ministries of Hesse, Lower Saxony and Bavaria, representatives of the Hessian Fire Brigade School and participants from industry.


Dr. Rossitza Goleva


Exhibition RETTmobil, Fulda, Germany

The workshop was attended by students from the University of Applied Sciences, Fulda.


Dr. Jugoslav Achkoski

Presentations and videos are available at https://www.aspires.eu/aspires-project-at-rettmobil

Workshop in Bansko, Bulgaria

On the 9th of November 2018 in the town of Bansko, Bulgaria was held the third specialized seminar for the end users of the project ASPires.

The purpose of the seminar was to disclose the results achieved by the project.

This workshop demonstrated the work of the ASPires platform live. Live demonstrations were organized with the invaluable assistance of the Bulgarian National Emergency Management Authority, the Fire Safety and Civil Protection Chief Directorate, the Ministry of Interior of Bulgaria.

In the area "Chalin Valog" near the town of Bansko on the part of COMICON special sensors were installed, related to the early detection of signs of forest fire.

The ASPires-GEO module, designed for the early detection of forest fires by using an infrared camera and additional hardware and software equipment, was installed on the part of NCITES.

On the part of the fire command, a forest fire was simulated by firing ball of straw. Within a few seconds the fire was recognized by the installed equipment.

The alarms that were triggered were automatically sent via SMS to the mobile phone numbers provided by the attendees. The experiments show that the basic concepts underlying the ASPires platform are correct.

Live demonstration of the ASPires platform

Experiments in Republic of North Macedonia

A series of experiments including different sets of parameters and varying conditions were conducted by the Military Academy ASPires team with the support of 10 employees from the Armed Forces on the 5th and 17th of October 2018 in the Military Academy, Skopje, Republic of North Macedonia.

By simulation of fire during different time periods in the day, under different weather conditions and other accompanying parameters, facilitated and secured by firefighting mechanisms provided by Armed Forces employees, the Military Academy, Skopje team has been able to generate significant body of data relevant for the successful implementation of the ASPires project.

The experiments have resulted with sets of data that are currently being processed and used for theoretical and practical assessment of the hypotheses made earlier by the research team, leading up to invaluable conclusions and guidelines for the on-site functionality of the ASPires system on the territory of the Republic of North Macedonia, the partners in the ASPires project and beyond. Further testing and experiments have also been envisioned upon the installation of the equipment to reflect the actual environment of the national parks where the equipment will be used. These experiments will facilitate factoring in all relevant elements, such as vegetation typical for the area, different physical obstacles, weather conditions, etc.
In the experiments conducted by the Military Academy, Skopje, software and hardware tools were used to demonstrate the functionality of the ASPires platform.

The used sensors and the corresponding network equipment are Controller Waspmote Plug & Sense SE-PRO 868, Carbon Dioxide (CO_2) Gas Sensor (Calibrated), Temperature, Humidity and Pressure Sensor Probe, Drone Matrice 600 PRO, Carbon Monoxide (CO) Gas sensor probe for high concentrations (calibrated), Meshlium 4G AP 868 EU type M4G -868-EU, Camera for drone Zenmuse X5.

Experiments with Drone

Conclusion

The concepts and architectures developed within the framework of the ASPires project allow the creation of a single European, National or Regional system for early detection of forest fires. This system is the basis for the development of new forest fire detection algorithms, early warning of disaster prevention and emergency services. The project is an important contribution to protecting the environment and forests through which we exist.

The great interest to the ASPires project shows the degree of importance of the problem being developed.

ASPires
CATALOGUE