CSECS 2017, pp. 000 - 000

The 13th Annual International Conference on

Computer Science and Education in Computer Science,

30 June – 3 July 2017, Albena, Bulgaria

CLOUD, FOG, DEW AND SMART DUST PLATFORM FOR ENVIRONMENTAL ANALYSIS

Rossitza GOLEVA[1], Aleksandar SAVOV[2], Ivelin ANDREEV[3], Rumen STAINOV[4], Jugoslav ACHKOSKI[5], Nikola KLETNIKOV[5], Igorche KARAFILOVSKI[6]

[1]Technical University of Sofia, Department of Communication Networks Bulgaria

[2]Comicon Ltd., Bulgaria

[3]Interconsult Bulgaria

[4]University of Applied Sciences, Fulda, Germany

[5]Ss. Cyril and Methodius University, Faculty of Computer Science, and Engineering, Military Academy „General Mihailo Apostolski "Skopje, Department for Security, Crisis, Protection and Requeue, Republic of Macedonia

[6]Crisis Management Center, Department of IT, TC and Support of the alarming system and E-112, Skopje, Republic of Macedonia

***Abstract**: This work presents a cloud-based platform for forest fire and environmental monitoring and analysis. The platform is distributed, open for interconnection and fully virtualized. The smart dust, dew, fog and cloud levels are defined and applied for the forest monitoring, fire detection and prevention. The necessary data is collected through high variety of* *interfaces and sources and is not limited technologically. The virtual level allows implementation of the artificial intelligence algorithms regardless of the sensor level of the system. The solutions could be mobile or fixed. As a further research plans we aim to simulate specific use-cases of the platform and show performance analysis.*

***Keywords**: cloud computing, fog computing, dew computing, smart dust computing, sensor networks, forest fire prevention, fire detection.*

***ACM Classification Keywords**: C.4 Performance of Systems; D.2.8 Metrics; D.4.8 Performance; I.4.7 Feature Measurement; I.5.3 Clustering*

Introduction

The virtualization of Information and Communication Technologies (ICT), services, their broad implementation in different areas of life, easy and cheap access to the data storage and communication capacity, enormous enhancement of the artificial intelligence algorithms are a ground basis for this work that aims to demonstrate the applicability of the ICT for forest fire detection and prevention. This is possible also thanks to the new and scalable cloud computing technologies named fog, dew and smart dust computing. On the other side, the work of the fire prevention and detection algorithms is impossible without gathering and analysis of the raw data for temperature, humidity, smoke, CO, CO2 etc. This data is obtained through sensors that could be very smart like high definition video cameras, thermal cameras, smartphones, smart field and IoT gateways, smart controllers, robots and equipped drones [Batalla et al., 2017; Goleva at al., 2017a].

In order to obtain data concerning the status of the forest one needs to collect data regularly. The existing technology uses towers equipped by high definition and thermal cameras. The images collected during the day and the night are analyzed manually, automatically or semi-automatically. Then, alarms are raised in case of fire. The main problem with camera detection is the accuracy of the solution when the fire is behind a hill or within a valley.

Another way to detect a fire is using satellite pictures. They have a good accuracy but have a problem of lack of real-time processing and good ground infrastructure and procedures for reaction [Sabri et al., 2013].

In this paper, we propose the use of sensors that collect data in addition to the cameras and satellite detection. The data is combined by whether index to get knowledge of the fire spreading. Every bit of information is transferred to the local server, regional server, national server or to the global fire information center. Data centers are equipped with processing algorithms that are capable to predict the fire event with certain accuracy. As a result, alarm will be raised to the authorized people for reaction. There is a risk to have a false alarm. The aim of the platform is to improve the existing systems for fire detection by at least 5% concerning fire detection and even more while fire prediction and prevention. The use of information and communication technologies in the process of fire detection and prevention allows fast and complicated calculation of the risk and data collected almost in real-time. This could improve the working procedures of the civil prevention authorities. The solution is heterogeneous, i.e. fixed and mobile allowing the use of mobile devices, drones, cars as well as towers.

We also aim as a future research plan a simulation of the collection of data and detection of the fires.

This paper starts with a section presenting stare of the art, a section showing the reference model and architecture of the platform. A general idea of the developed field gateway for the platform as well as applicable protocols are presented in the following section. Possible scenarios are explained too. The paper concludes with comments on applicability of the platform and future work plan.

State of the Art

The present fire detection and fire prevention systems worldwide are different and depend on the environment, economy level, local law and customs. Fire detection in south countries is considered more seriously due to the weather conditions and big number of fires annually [Malaga, 2017]. Fire detection in north countries has more monitoring and preventive character [Mathematics, 2017].

The information gathered by different countries is accumulated off line by EFFIS where it is possible to be analyzed in non-real-time [EFFIS, 2017], [Landsat, 2017]. The data is useful for analysis but is only part of a fire prevention technologies.

While speaking for fire detection the time is becoming critical in order to prevent people, their property and the environment. Fast reaction to the fire could help to limit the losses and also resources necessary to extinguishing.

Countries with limited resources are not capable to cover completely their territories. For example, the national parks in Republic of Macedonia in the mountains are difficult to be preserved in real-time. Only 20% of the territory if Republic of Bulgaria is covered by fire detection towers. Civil prevention authorities in Greece and Cyprus use partially drones with cameras in all places of high risk and rough surface. Spain and Italy are well equipped by towers with cameras too. Spain applies sensor technology for raw data collection.

On the other hand, collection of the data concerning fires to EFFIS is performed off line, i.e. in non-real-time. This prevents the international authorities to react on time after detection of the fire especially when the fire is on the borderline or has a range beyond capacities of the local authorities.

The aim of the proposed system is to speed up the process of fire detection at local, regional, national and international level as well as to support the better coordination between authorities [Cruz et al., 2016].

Platform Architecture Reference Model

The reference model of the fire detection platform proposed in this section has been probed with different implementations recent years [Goleva at al., 2017b]. The structure of the platform and its main elements are similar to the already seen in different areas systems [Goleva at al., 2017a]. We improve the solution taking into account the specific requirements of the forest fire detection and prevention task as well as environment to be monitored. The reference model is prepared using well known Open System Interconnection Reference Model (OSI RM) and is presented in Figure 1. The infrastructure plane of the model could be compared against the network structure starting with sensors, other type of devices supporting different protocols and interfaces and ending with smart application.

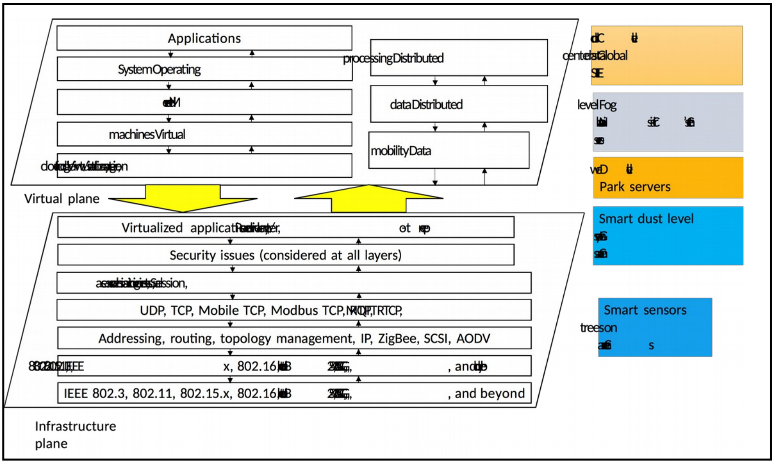


Figure 1. Platform Architecture Reference Model

The system is distributed by nature and fully virtualized at application level. It is well developed towards technologies for virtualization like middleware, virtual machines, data mobility, distributed processing and storing, context analysis, data migration. The relation to the cloud computing is shown on the right side of the figure. While sensors in the forest, equipment of the drones, cars, towers, cameras, field gateways could be considered 'smart dust', i.e. nodes in the network with limited intelligence, the local servers in national parks could be considered 'smart dew' computing nodes. They obtain more capacity to analyze data and trigger alarms at local level and remotely.

Regional servers and storages are presented as 'smart fog computing' nodes. They may allocate more processing time and resource computing algorithms for data mining allowing more precise analysis. Also, the connection to other systems and sharing of the data at this level between platforms is essential. All configurations, legislation limits, rules, procedures could be defined and coordinated at this level. 'Cloud computing' level is generic and could be organized at national or international level. It will allow not only easy system interconnection but also sharing of the expertise worldwide, accumulation of the resources for civil prevention in the points of need.

In Figure 2 we present part of the possible implementation scenarios. It starts with sensors that are energy harvesters and are part of the equipment deployed in the forest. Multiple sensor technologies could be in use and the main difference between them is the coverage distance they could support in a reliable way. Speaking of sensor technology, the distance is considered the most important parameter. Part of the sensors could be fixed and be installed on the trees and towers. Another part of the sensors or field gateways could be mobile, i.e. being installed in a car, drone, being carried in hands. Sensor network configuration could be done during sensor deployment. It also could be automated through the local or remote server. Sensors, cameras, drones, other equipment on the towers and cars are considered smart dust.

Local servers are working at dew level, regional and possibly national servers and storages are working at fog level. The cloud level is able to interconnect other platforms, to perform data mining, data analysis, data acquisition, network configuration and many other artificial intelligence level tasks.

In Figure 3 we presented partially the possible protocols supported by the field gateway for network interconnection that maps the sensor technologies and other protocols like Message Queue Telemetry Transport (MQTT), industrial standard MODBUS TCP, standard HTTP and many others. The field gateway could be developed and implemented in many different configurations.

Platform Architecture Reference Model

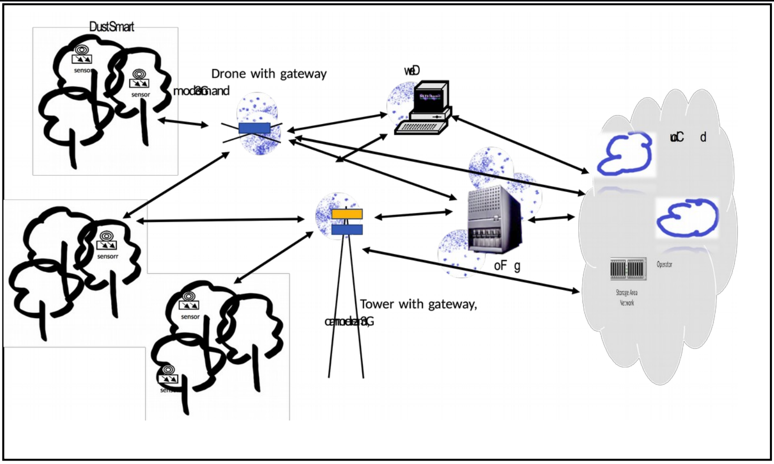


Figure 2. Platform architecture scenario

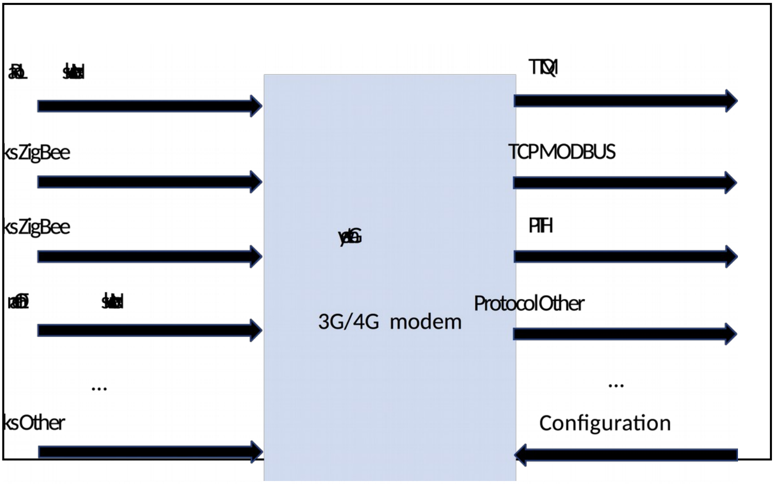


Figure 3. Field gateway

Sensor network dynamic configuration will allow the use of the field gateway and sensor data transfer through the drone in almost real-time.

Conclusion

This work presents an open architecture of the virtualized platform for fire prevention and detection that is based on sensor networks, cameras and smart dust, dew, fog, cloud computing technologies. The complexity of the platform and its heterogeneity requires definition of different options and possibility for platform interconnection. The use of artificial intelligence algorithms at dew, fog and cloud level allows the implementation of improved algorithms regardless of the sensor network. The use of the sensor networks through gateways allow development of the platform with new technologies regardless of the computing levels.

Our future work plans are related to platform prototyping and partial implementation as well as simulation.

Acknowledgement

Our thanks to ICT COST Action IC1303: Algorithms, Architectures and Platforms for Enhanced Living Environments (AAPELE), ICT COST Action IC1406: High-Performance Modelling and Simulation for Big Data Applications (cHiPSet), TD COST Action TD1405: European Network for the Joint Evaluation of Connected Health Technologies (ENJECT), and H2020 project on Advanced systems for prevention & early detection of forest fires 2016/PREV/03 (ASPIRES).

Bibliography

[Batalla et al., 2017] Jordi Mongay Batalla, George Mastorakis, Constandinos X. Mavromoustakis. Special issue on management of the Internet of things and big data. Int. Journal of Network Management 27(3) (2017).

[Cruz et al., 2016] Cruz H, Eckert M, Meneses J, Martínez J-F. Efficient Forest Fire Detection Index for Application in Unmanned Aerial Systems (UASs). Willms I, ed. Sensors (Basel, Switzerland). 2016;16(6):893. doi:10.3390/s16060893.

[EFFIS, 2017] European Forest Fire Information System (EFFIS). Available online: http://forest.jrc.ec.europa.eu/effis/reports/ (accessed on 28 May 2015).

[Goleva at al., 2017a] Rossitza Goleva, Rumen Stainov, Nikola Kletnikov, Jugoslav Achkoski, Seferin Mirtchev, Ivan Ganchev, Aleksandar Savov, Performance Analysis of End-to-End Sensor-to-Cloud Personal Living Platform, International Workshop on IoT and M2M in Healthcare (IMH 2017), Lund, Sweden, 18-20 Sept. 2017 (accepted paper).

[Goleva at al., 2017b] Rossitza Goleva, Mara Pudane, Sintija Petrovica, Egons Lavendelis, Karl Kreiner, Mario Drobics, Ivan Ganchev, Nuno Garcia, Rumen Stainov, Ciprian Dobre, Constandinos Mavromoustakis, Ivan Chorbev, Vladimir Trajkovik, Eftim Zdravevski, George Mastorakis, AALaaS and ELEaaS Platforms, in Rossitza Goleva, Ivan Ganchev, Ciprian Dobre, Nuno Garcia & Carlos Valderrama, (Editors), Enhanced Living Environments: From Models to Technologies, Publisher: The Institution of Engineering and Technology, 2017 (on publishing).

[landsat, 2017] https://landsat.gsfc.nasa.gov/fire-prevention-in-spain/ (accessed June 2017).

[Malaga, 2017] https://eastofmalaga.net/2014/07/04/wildfires-in-spain-what-you-should-do/ (accessed June 2017)

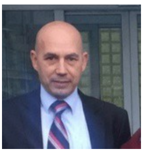
[Mathematics, 2017] http://www.imnovation.com/society/mathematics-and-technology-service-fire-prevention/ (accessed June 2017).

[Sabri et al., 2013] Y. Sabri, N.El Kamoun, V. Gramoli, R. Guerraoui, Rachid. Forest Fire Detection and Localization with Wireless Sensor Networks. In Networked Systems: First International Conference, NETYS 2013, Marrakech, Morocco, May 2-4, 2013, Springer Berlin Heidelberg, Berlin, Heidelberg, pp. 321—325.

Authors' Information

Rossitza Goleva, Ph. D., Assistant-Professor, Department of Communication Networks Technical University of Sofia

Major Fields of Scientific Research: *Distributed Networks and Cloud Computing Communication Networks*

	***Aleksandar Savov, MSc in Computer Science, General Manager of Comicon Ltd., Bulgaria*** ***Major Fields of Scientific Research:*** *Sensor Technologies, Distributed Networks, Automation*
	***Ivelin Andreev, MSc in Informatics is with Interconsult Bulgaria last 10 years.*** ***Major Fields of Scientific Research: Cloud computing, data mining, application design***
	***Rumen Stainov, Ph. D., Associate Professor of Computer Science (Boston University, USA); Professor of Computer Science (Hochschule Fulda, Germany)*** ***Major Fields of Scientific Research:*** *Information Technology, Computer Science*
	***Jugoslav Achkoski, PhD Assistant Professor, Military Academy „General Mihailo Apostolski "Skopje, jugoslav.ackoski@ugd.edu.mk.*** ***Major Fields of Scientific Research:*** *Information Technology, Computer Science*
	***Nikola Kletnikov, MsC, Military Academy „General Mihailo Apostolski "Skopje, nikola.kletnikov@ugd.edu.mk.*** ***Major Fields of Scientific Research****: Crisis management, Operation Planning*

Igorce Karafilovski, MsC, Crisis Management Center "Skopje, igorce.karafilovski@cuk.gov.mk.mk.

Major Fields of Scientific Research: *Information Technology, Computer Science*