Architecture for security monitoring in IoT environments

Christos Stergiou
University of Macedonia
Department of Applied Informatics
Thessaloniki, Greece
c.stergiou@ uom.edu.gr

Kostas E. Psannis
University of Macedonia
Department of Applied Informatics
Thessaloniki, Greece
kpsannis@ uom.edu.gr

Andreas P. Plageras
University of Macedonia
Department of Applied Informatics
Thessaloniki, Greece
a.plageras@ uom.edu.gr

Giorgos Kokkonis
University of Macedonia
Department of Applied Informatics
Thessaloniki, Greece
gkokkonis@ uom.gr

Yutaka Ishibashi
Department of Scientific and Engineering Simulation Nagoya, Japan
ishibasi@ nitech.ac.jp

***Abstract*— The focus of this paper is to propose an integration between Internet of Things (IoT) and Video Surveillance, with the aim to satisfy the requirements of the future needs of Video Surveillance, and to accomplish a better use. IoT is a new technology in the sector of telecommunications. It is a network that contains physical objects, items, and devices, which are embedded with sensors and software, thus enabling the objects, and allowing for their data exchange. Video Surveillance systems collect and exchange the data which has been recorded by sensors and cameras and send it through the network. This paper proposes an innovative topology paradigm which could offer a better use of IoT technology in Video Surveillance systems. Furthermore, the contribution of these technologies provided by Internet of Things features in dealing with the basic types of Video Surveillance technology with the aim to improve their use and to have a better transmission of video data through the network. Additionally, there is a comparison between our proposed topology and relevant proposed topologies focusing on the security issue.**

Keywords— Internet of Things; Video Surveillance; IoT; monitoring; network topology; architecture;

I. INTRODUCTION

A number of modern mobile devices, like mobile phones, PDAs, laptops and others, become ubiquitous in recent years and people into the era of pervasive computing [1]. All these devices could be used with the aim to find out useful information when we are on the road and when we are travelling. This procedure can help us to define monitoring. Thus, "Monitoring is the act of listening, carrying out surveillance on, and/or recording the emissions of one's own or allied forces for the purpose of maintaining and improving procedural standards and security, or for reference, as applicable" [2].

Regarding this definition it is proved that monitoring related to surveillance. So, also, we could define surveillance, as a related part of technology in this work. Surveillance is "the close observation of the behaviour, the activities, or other changing information" [3] [4]. Sensors and cameras or other compatible devices are necessary for the surveillance with the aim to do the monitoring. With the use of this technology observation at a distance is possible, using electronic equipment [4] or stealing electronically transmitted information which may include simple, relevant technology methods.

Furthermore, in telecommunication fields there is a new technology called Internet of Things (IoT) [5]. The next major step in the recent technology field is the IoT technology, but however with the major difference that brings enormous changes in business functionality [6] [7]. In order to fully exploit these two technologies, it is mandatory to combine them so as to achieve the optimisation of surveillance technology through the use of the Internet of Things technology [8] [9].

The rest of the paper is organised as follows. In section 2 there is a review of the related research which deals with the monitoring urban areas throw modern networks. Section 3 presents and illustrates the proposal of a contribution of the Internet of Things technology in the function of Video Surveillance with the aim to offer a new topology paradigm. In Section 4 there is a comparison between our proposed topology and other related proposed architectures-topologies. Finally, section 5 provides the conclusions of the current paper and offers new possibilities for the development of future work.

II. RELATED WORKS

For the purpose of this paper we study and analyse previous studies in monitoring urban areas throw modern networks and we examine existing work proposed both in the literature and on the Internet. Below presented the papers we have studied with their main objective.

There are various works for the monitoring urban areas throw modern networks. A large number of several works related to monitoring urban areas throw modern networks the

978-1-5090-1412-5/17/$31.00 ©2017 IEEE

last two years. To begin with, the authors of [10] introduces the Shadow Security Unit, a low-cost device deployed in parallel with a PLC or Remote Terminal Unit (RTU), being able to transparently intercepting its communications control channels and physical process I/O lines with the aim to continuously assess its security and operational status. The device that proposed in [10], regarding the existing control network, does not require considerable changes, in order to be capable of work in standalone or integrated within an ICS protection framework. Also, by the work that has been made in [11], the authors propose an innovative approach for the development of software for modelling of decentralised intelligent systems for security monitoring and control in power systems. The novelty of [11] is to joint use the modern computing environments. Also, the proposed intelligent system was tested on the modified 53-bus IEEE power system. The main aim of [12] is to describe an innovative security system able to localise and classify audio sources in an outdoor environment. The primary intended use of the proposed security system is for security monitoring in serve scenarios, and it has been designed to cope with a large set of heterogeneous objects, including weapons, human speakers, and vehicles. Also, in [12] after the presentation of the details of the system's design, with a particular emphasis on the innovative aspects that are introduced with respect to the state-of-the-art, the authors offer an extensive set of simulations in order to show the effectiveness of the proposed architecture. At the end the authors conclude be describing the current limits of the system, and the projected further developments. The current knowledge in the regard of the use of different tools needed in order to monitoring atmospheric pollution extended in [13]. The chemical response of the lichen Ramalina celastri was evaluated through physiological parameters and sulfur accumulation in relation to the SO_2 and NO_2 concentrations present in the air at the monitoring sites with different emission sources, with the aim to assess the atmospheric pollution in urban environments. Regarding this, it was possible to create different levels of air quality using simultaneous measurements of gaseous pollutants in the air and of parameters for the exposed biomonitor, as well as to determine the relationship between them and their society with the different emission sources present. In addition, in [14] discussed that in regions with a mild climate, pesticides are often used around homes for pest control. Pesticide use in residential areas linked to aquatic toxicity in urban surface water ecosystems, and suggested dust particles on a paved surface as an important source of pesticides by the recent monitoring studies which have been made. With the aim to be tested the hypothesis that dust on hard surfaces is a significant source of pesticides; the authors of [14] evaluated spatial and temporal patterns of current-use insecticides in Southern California, and further explored their distribution as a function of particle sizes.

The [15] reports on the first results of a long-term UFP monitoring network, set up in Amsterdam (NL), Antwerp (BE), Leicester (UK) and London (UK), with the aim to gain a better understanding on the spatiotemporal alteration of ultrafine particles (UFPs) in urban environments. Furthermore, the authors of [15] in order to represent the extreme rainfall-runoff events, the deterministic distributed hydrological modelling is gaining interest both with the increase of the computation facilities and the availability of data especially the topography inputs. Also, in [16] the simulation results of four deterministic hydrological models with different topography resolution (300m, 150m, 75m) for the Var basin, France (2800km2) are analysed with the aim to evaluate the influences on the simulation accuracy. The results of sensitivity analysis indicate the threshold value of the topography resolution on the model simulation with the consideration of both the sufficient accuracy and the reasonable simulation time to cover the extreme rainfall-runoff event in 1994. In [17] the authors introduce a framework for precise vehicle localisation in dense urban environments that are characterised by high rates of dynamic and semi-static objects. The proposed localisation method of [17] is particularly designed for handling the inconsistencies between map material and sensor measurements. The evaluation results of this work show the superior performance of the proposed approach compared to another state-of-the-art localisation algorithm for a challenging urban dataset.

III. Topology Proposal

Concerning our research of the Related Research Review section, we developed the following conclusions as a proposal of IoT's contribution in Video Surveillance. A major issue of the Video Surveillance technology is the transmission of data through the video recorder devices and how those devices should be set up with the aim to have a better use of remote control.

As a solution to this problem, we propose an innovative topology paradigm that combines the advantages of the use of IoT and the characteristics of Surveillance. This proposed topology is a hybrid topology of ring and star topologies. In this topology we could succeed a reliable network in error detecting and troubleshooting, we could scalable the size of the network as in can be increased easily, and additionally, this topology offers flexibility and provides a more effective network.

Furthermore, as a combination of two topologies we can operate this network both as a star-topology-network so as a ring-topology-network, as well as a separate type of networks. By using routers with the aim to have single management network sectors, we can achieve a different type of topology use. Figure 1 presents a paradigm of the proposed topology using two types of video surveillance cameras (simple quality surveillance camera and HD quality surveillance camera). The data transmitted from the cameras to the Cloud Server with the useful help of IoT technology and from the Cloud Server transmitted to another local server, and finally we can have all the transmitted data in the storage system of the network server. As it is shown each router could be able to serve a huge number of network cameras, connected to each other with different ways. Also, in this type of network topology, Local Servers can be used inside the small networks as administrators of network cameras. Cloud Server could provide primarily the important role of the storage system, and afterwards could act as data manager that receives these data with the aim to transmit them to the Network Server. Between the Cloud Server and the Network Server, also could interpolate another Local Server in order to clarify and transmit the data to its final destination, which is the Network Server.

An important improvement in the operation of this topology is analysed and described by the following equation:

$$DS = (TD + VD) - PL \qquad (1)$$

Equation (1) demonstrates Data send (DS) through the network. This data results by the product of the quantity of the Transmitted data (TD) and the quantity of Video data (VD) deducting the quantity of the Packet Loss (PL). By this equation and regarding the number of nodes existing in the network, we can produce the total amount of data which transmitted through the network. Thus, this calculated by (2):

$$TDS = DS_1 + DS_2 + \ldots + DS_n \qquad (2)$$

Moreover, through our research, we detect that another major issue of the Internet of Things and Video Surveillance technology is the event detection problem in noisy environments for a multimedia monitoring application which is solved with the detection of the abnormality in continuous audio recordings of public places [18]. Regarding the combination of the aforementioned technologies, Table 1 lists the characteristics of the technology of Things, with regard to the convenience it provides. It also demonstrates some of the types of Video Surveillance technology which relates more, in our opinion, to the Internet of Things. Table 1 has the purpose to show which of the specific characteristics of the IoT technology pertain to, and improve the particular types of the Video Surveillance. As we can observe, Cameras and RFID devices are the Video Surveillance types which are affected more by the characteristics of the IoT technology. In contrast, the Biometric is the type of Video Surveillance influenced less by the characteristics of IoT technology.

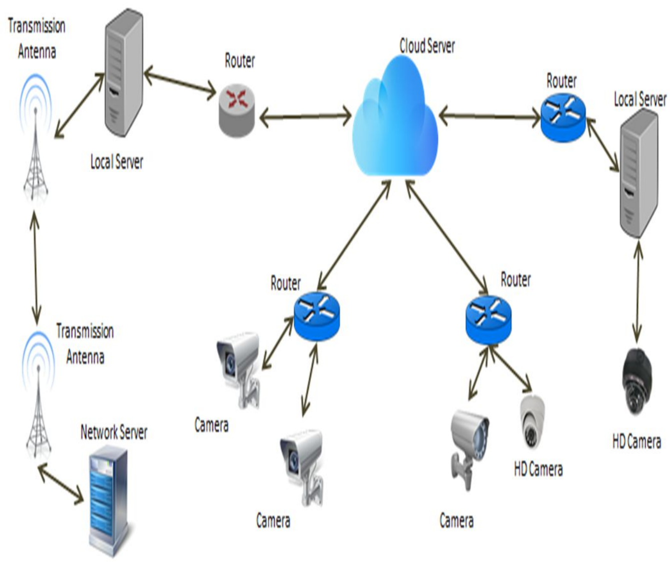

Fig. 1. Proposed topology paradigm.

TABLE I.
Contributions of Internet of Things in Video Surveillance.

Video Surveillance	Computer	Telephones	Cameras	Biometric	Data Mining	RFID
Smart solution in the bucket of transport					X	X
Smart power grids incorporating more renewable	X		X	X		
Remote monitoring of patients	X	X	X	X	X	X
Sensors in homes and airports			X			X
Engine monitoring sensors that detect & predict maintenance issues	X	X	X		X	X

IV. Architecture Comparison

The study of previous works cites us relevant architecture and topology proposals for a Video Surveillance network, which on several occasions supported and combined with other technologies, such as Internet of Things. In this section we will make a comparative study of the proposal made in this work and proposals made by other relevant works.

On the study conducted we singled out six previous architecture-topology proposals relating to Video Surveillance technology. Here, there will be a comparison between the features and the benefits of each proposal. As we can observe from Table 2 most former works deal with the Quality of Communication, and as the second characteristic that deal with is Security. Thus, the main purpose of these works is to provide secure and quality communication architecture. Comparing our proposed topology to the others we can realise that it contributes more security and privacy issues. It has certainly a disadvantage in relation to the others, as regards the Transmission Speed and the Efficiency.

In addition, the proposed topology of this work could mainly be applied in big buildings, in which there are installed systems of surveillance cameras. Buildings such this could also be defined as Smart Buildings instead of the specialised use of the surveillance system in conjunction with the IoT technology. Thus, the proposed topology can be described as an ideal topology for surveillance systems after using a combination of IoT and Cloud Computing technologies.

TABLE II.
Architectures-Topologies Comparison.

Surveillance Architectures	[20]	[21]	[22]	[23]	[12]	[24]	Proposed
Efficiency		X	X	X		X	
Security		X			X	X	X
Easy Installation	X			X		X	X
Transmission Speed	X	X	X	X			
Quality of Communication	X		X	X	X	X	X
Data Privacy					X		X

V. CONCLUSIONS

With regard to the use of the Video Surveillance and the future needs of this technology, there has been a combination of Video Surveillance technology with Internet of Things technology in order to take advantage of the IoT benefits and improve the use of Video Surveillance. The discussion of this contribution proposes an innovative topology paradigm which could offer a better use of IoT technology in Video Surveillance systems. Also, the contribution of these technologies provided by Internet of Things features in dealing with the basic types of Video Surveillance technology is summarised in Table 1. Additionally, there is a comparison between our proposed topology and relevant proposed topologies focusing on the security issue. Finally, as a future research, we suggest a further examination of the types of Video Surveillance which could be improved from the contribution of the technology of Internet of Things with the additional 'help' of the Cloud Computing technology.

REFERENCES

[1] Uichin Lee et al, "MobEyes: Smart mobs for urban monitoring with a vehicular sensor network," IEEE Wireless Communications, pp. 1-15, 1/11/2006.

[2] Dictionary.com, "Dictionary.com", 1/1/2012. [Online]. [Accessed 2/12/2016].

[3] M. Maximino et al, "Journalist's Resourse, Research on today's news topic," 11/2/2014. [Online]. [Accessed 6/3/2016]

[4] J. M. Batalla et al, "Adaptive Video Streaming: Rate and Buffer on the Track of Minimum Rebuffering", IEEE Journal on Selected Areas in Communications, vol. 34, Issue 8, pp. 2154-2167, 1/8/2016.

[5] Christos Stergiou, Kostas E. Psannis, Byung-Gyu Kim, Brij Gupta, "Secure integration of IoT and Cloud Computing", Elsevier, Future Generation Computer Systems, December 2016.

[6] Sandip Roy et al, "A Fog-Based DSS Model for Driving Rule Violation Monitoring Framework on the Internet of Things," International Journal of Advanced Science and Technology, pp. 23-32, 1/3/2015.

[7] Jordi Mongay Batalla and Piotr Krawiec, "Conception of ID layer performance at the network level for Internet of Things," Pers Ubiquit Comput, no. 18, pp. 465–480, 28/4/2013.

[8] George Kokkonis, Kostas E. Psannis, Manos Roumeliotis, and Yutaka Ishibashi, "Efficient algorithm for transferring a real-time HEVC stream with haptic data through the internet", Journal of Real-Time Image Processing, May 2015.

[9] George Kokkonis, Kostas E. Psannis, Manos Roumeliotis and Dan Schonfeld, "Real-time wireless multisensory smart surveillance with 3D-HEVC streams for internet-of-things (IoT)", Journal of Supercompuitng, 2016.

[10] Tiago Cruz et al, "Improving Network Security Monitoring for industrial control systems," σε Integrated Network Management (IM), 2015 IFIP/IEEE International Symposium on, Coimbra, Portugal, 2015.

[11] Daniil Panasetsky et al, "Development of software for modelling decentralized intelligent systems for security monitoring and control in power systems," PowerTech, 2015 IEEE Eindhoven, pp. 1-6, 29/6/2015.

[12] Simone Scardapane et al, "Microphone array based classification for security monitoring in unstructured environments," International Journal of Electronics and Communications (AEÜ), no. 69, pp. 1715-1723, 11/11/2015.

[13] A.C. Mateos & C.M. González, "Physiological response and sulfur accumulation in the biomonitor Ramalina celastri in relation to the concentrations of SO2 and NO2 in urban environments," Microchemical Journal, no. 126, p. 116–123, 1/3/2016.

[14] Jaben Richards et al, "Distribution of pesticides in dust particles in urban environments," Environmental Pollution, no. 214, pp. 290-298, 7/4/2016.

[15] J. Hofman et al, "Ultrafine particles in four European urban environments: Results from a new continuous long-term monitoring network," Atmospheric Environment, no. 136, pp. 68-81, 8/4/2016.

[16] Qiang M.A. et al, "Assessment of High Resolution Topography Impacts on Deterministic Distributed Hydrological Model in Extreme Rainfallrunoff Simulation," in 12th International Conference on Hydroinformatics, HIC 2016, Nice, France, 2016.

[17] Jan Rohde et al, "Precise vehicle localization in dense urban environments," in 19th International IEEE Conference on Intelligent Transportation Systems, Rio de Janeiro, Brazil, 2016.

[18] C. Clavel, T. Ehrette & G. Richard, "Events Detection for an Audio-Based Surveillance System," Multimedia and Expo, 2005. ICME 2005. IEEE International Conference on, pp. 1306-1309, 6/7/2005.

[19] Christos Stergiou & Kostas E. Psannis, "Recent advances delivered by Mobile Cloud Computing and Internet of Things for Big Data applications: a survey," International Journal of Network Management, pp. 1-12, 11/3/2016.

[20] Sola O. Ajiboye et al, "Hierarchical Video Surveillance Architecture - A Chassis for Video Big Data Analytics and Exploration," in Proceedings of SPIE - The International Society for Optical Engineering, Falmer-Brighton, United Kingdom, 2015.

[21] F. Licandro & G. Schembra, "WirelessMesh Networks to Support Video Surveillance: Architecture, Protocol, and Implementation Issues," EURASIP Journal onWireless Communications and Networking, no. 2007, pp. 1-13, 30/1/2007.

[22] S. Dutt & A. Kalra, "A Scalable and Robust Framework for Intelligent Real-time Video Surveillance," Department of Electronics Engineering, Indian Institute Of Technology (BHU), Varanasi, India, 2016.

[23] Henry Detmold et al, "Topology Estimation for Thousand-Camera Surveillance Networks," IEEE, Adelaide, Australia, 2007.

[24] Andreas P. Plageras et al, "IoT-based Surveillance System for Ubiquitous Healthcare," in Industrial Electronics Society , IECON 2016 - 42nd Annual Conference of the IEEE, 22/12/2016.