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Overview, Characteristics and Advantages of IP Camera Video Surveillance Systems Compared to Systems with other Kinds of Camera

Gradimirka Popovic[1], Nebojsa Arsic[1], Branimir Jaksic[1], Boris Gara[2], Mile Petrovic[1]
[1] Faculty of Tehnical Sciences, Kosovska Mitrovica, Serbia,
[2] Ministry of Interior Republic of Serbia, Belgrade, Serbia

Abstract*— This study deals with the basic characteristics of the IP cameras used in video surveillance systems, and it also compares them with the analog ones. The comparison between IP and analog camera characteristics was made when used in operation of one video surveillance system. The IP video surveillance system multiview function mode was also studied. Furthermore, the study dealt with the IP camera power charge principles in the video surveillance systems via Ethernet in cases with and without PoE switch. The overview of the basic characteristics of four kinds of IP cameras: Cube, Dome, Box and Bullet were given.

***Index Terms*— IP camera, multiview, power over ethernet (PoE), video surveillance.**

I. INTRODUCTION

Video surveillance is an integral part of each and every modern security system for protection of facilities, individuals and assets. In large systems, the video surveillance is integrated with other security systems such as anti-theft systems, access control systems, fire detection systems, public address systems. The first video surveillance systems were completely analog. The technological progress has triggered development and appliance of digital technologies in the video surveillance systems. Nowadays, there are practically no more utterly analog systems. There are video surveillance systems which combine analog and digital systems. Beside analog components, such systems also have a digital component (mainly DVR digital video recorder) which performs analog-digital and digital-analog conversion. In digital systems, the signal from camera to the recording location is transferred in digital format.Video surveillance systems are divided into three groups according to the operation technologies used [1]:

A. Completely analog (analog CCTV - Closed-circuit television system using video recorders)

It is completely analog system composed of analog cameras with a composite video signal output connected to VCR (Video Cassette Recording). VCR uses video cassettes identical to the ones used by home video devices. Video material is not compressed, so it is recorded with maximum number of frames, one cassette may record maximum 8 hours. In most systems, quads and multiplexers may be connected between cameras and VCR. It enables archiving from more than one camera, but in smaller number of frames. Analog monitors are used to monitor video pictures [1].

B. Final Stage partly digital (analog CCTV systems using digital video recorders and network video recorders)

These are analog systems with digital archiving. Video tape is replaced by hard disc, which requires digitalized signal to be compressed in order to enable archiving of video material recorded during several days. The first devices had limited hard disc capacity so the length of recording was also limited, or recording with smaller number of frames had to be used. Disc capacity has not been a problem any more due to the production technology development. Most devices have several input channels, usually 4, 9 or 16 meaning that they already have function of quad/multiplex devices. Analog systems using network devices are partly digital systems meaning that they use devices with Ethernet port for network connection. Since the recorded material is digitalized and compressed, it may be transfered via network and viewed at a distant location. Some systems allow viewing of both recorded

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material and live broadcast, whereas other devices enable viewing of only recorded material. Some systems require a special client installantion, whereas some of them use a standard web browser, which makes a distant monitoring more flexible

C. Completely digital (network video systems using video servers and networks, i.e IP cameras)

Network video systems using video servers are composed of video servers, network switch and PC with video surveillance software. Analog cameras are connected to the video server which digitalizes and compresses the video material. Video server is connected via network switch to the network and further to the PC where video data are archived on the hard discs [2]. IP camera may be described as a camera and computer merged into an integral device which digitalizes and compresses video material and has a network connection [2]. Video material is transfered via IP base network, via network switches and is archived on the computer using video surveillance software. Very fast development of network technologies and increase of bandwidth has enables greater application of network CCTV cameras. There cameras use network infrastructure (LAN, Internet, wireless LAN) for signal transfer depending on the TCP/IP protocol. Signal is digitalized in camera itself and in such format sent via network to the surveillance location. Receiving and saving of camera pictures to the system is done by a digital video recorder with network interface or PC computer connected to the network [2], [3].

II. IP CAMERA CHARACTERISTICS

The greatest trend in video surveillance systems is switch from analog cameras to the IP camera. All recordings of the surveillance cameras are digitalized both for viewing and storing at the computers. However, IP cameras digitalize video signals inside the camera, whereas the analog cameras require encoder or DVR video signal digitalization [3].

IP camera is composed of lenses, optical filter, CCD sensor, ARTPEC chip performing controling function and compression chip. CCD sensor (Charge Coupled Device) is a basic element of almost all contemporary cameras. These are photosensitive elements composing of fine network of individual pixels. The monitored picture is focused at through an objective on the surface of an element and an electric signal is generated on it, which is proportional to light intensity falling upon it. Typical number of pixels for CCD elements range between 250,000 and 500,000 pixels. The greater number of pixels, the higher quality of camera [1]. IP camera structure is given on Fig. 1.

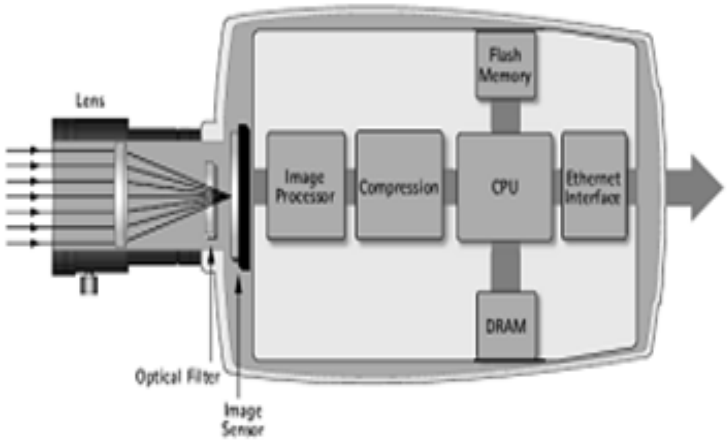

Fig. 1: IP camera structure

IP cameras may be monitored via any web browser, i.e. IP camera signal available on web network. They receive, send and transfer the picture (video signal) directly via IP networks, thus enabling the authorized viewers to see, save and manage the video through standard infrastructure of IP base network.

The advantage of IP camera over other analog cameras is higher resolution of pictures. Access from any computer connected to the network requires DVR. IP camera has its own IP address. It is connected to the network and it has embedded web server, FTP server, FTP client, e-mail client, alarm management, programmability. IP camera does not have to be connected to the PC, since it functions independently, and it may be installed wherever there is an IP

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connection. Beside video, the network also has some other functions and information which may be transferred through the same network connection, for instance, digital inputs and outputs, audio, serial ports for serial data or control pan/tilt/zoom mechanism [4].

IP cameras are easily connected to the existing infrastucture, they have POE ability – power charge through network cable (data and power charge go through one network cable). Furthermore, they have an advantage of SD card- local recording, possess Dual stream – two independent streams, potential application of the former for recording, whereas the latter stream may be used for monitoring via Internet [5].

Shortcomings of IP cameras are those that they have not be designed for analog monitors allowing on-site viewing, as well as that brad width defines speed of video material transfer.

III. Comparison Between IP And Analog Cameras

During recent years, IP camera technology has overtaken analog ones and now they fit to all requirements and specifications. Furthermore, IP performances exceed analog camera performances due to their new functions. Namely, analog camera is a carrier of mono-direction signal ending on the DVR device and level of processing, whereas IP camera is bi-directional and integrates itself with the other parts of a system, up to the high level, in given scalable environment. IP camera communicates simultaneously with several applications in order to perform various tasks, such as moving and sending various video flows [4], [6]. Table 1 gives comparison of characteristics between analog and IP cameras during video surveillance system performance.

TABLE I: Comparison of characteristics between analog and IP cameras during video surveillance system performance.

	Scenario with analog cameras	Scenario with IP cameras
Camera resolution	from 420 to 700 TV lines, 4CIF resolution	from 1 MPixel to 8 MPixel
Cabling (Video and Power)	coaxial to each camera and DVR, additional power cables	Cat 5e, Power over Ethernet (PoE)
The average cable length	100 m/camera (video) 65 m/camera (power)	65 m/camera (Cat5 with PoE)
Power	Power for cameras	PoE
Switches	to all types DVR	PoE switch
Server / memory	Mid-end DVR (H.264 compatible with memory)	PC (standard) with memory
Software	on the DVR (H.264 compatible)	AXIS Camera Station
Monitors	standard high resolution monitors	standard high resolution monitors

IV. IP Camera Multiview Overview

Multiview function is supported by almost all web browsers. IP cameras support possibility to display pictures with sound from great number of cameras simultaneously. Standard version of IP system enables viewing of several cameras (may be of different sizes) in one window of web browser, without problems and without installation of additional software. Multiview function enables several viewers to watch different displays of camera connected to the network from different PCs. Multiview function may integrate both live footage and recordings of events [5].

There are no limitations in number of multiview configurations. Several multiview screens, differently divided between cameras, may be defined in one camera. The user may switch between different displays by a simply click. Number of cameras which may be displayed is limited only by computer performances and screen size. This application supports around 900 fps (frames per second) in CIF picture format on the standard PC (Pentium IV/3.2 GHz). This capacity is sufficient for live broadcast from 30 cameras in 25 fps, including audio. These 30 cameras may be lined up in 6x5 on large TFT screen in CIF format (320x240 pixels) [5]. Example of such control center is given on the Fig. 2. Many systems for video surveillance are able to show one or several cameras alive in 25 fps and Frame Rate decreases fast where there are more than 5 cameras connected. Opposite to that, new applications may easily display live broadcasting from 30 cameras. Furthermore, delay between events and the display on screens is much shorter.

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Fig. 2: Windows application for multiview.

V. POWER OVER ETHERNET

PoE (Power over Ethernet) is a technology integrating power charging into standard WLAN infrastructure. Applying PoE device, the network video products may receive power and data through a single cable. PoE device enables installation of IP cameras on locations without any or difficult power access. PoE enables simple, faster and less expensive installation in comparison to the traditional installation when, in most cases, the new power cables had to be distributed and power switches installed [7].

If PoE device is connected so that it is charged by electric power from UPS, the video surveillance system independent from the public power network will be created, so that the cameras and appropriate software for video management would be operational even in case of power cuts.

There are cameras which support PoE or simple IP cameras which use an adapter. PoE provides power charge to the network device such as IP phone or IP camera using the same cables as the ones for network connection. Fig. 3 provides an overview of IP camera power charge via switch with PoE.

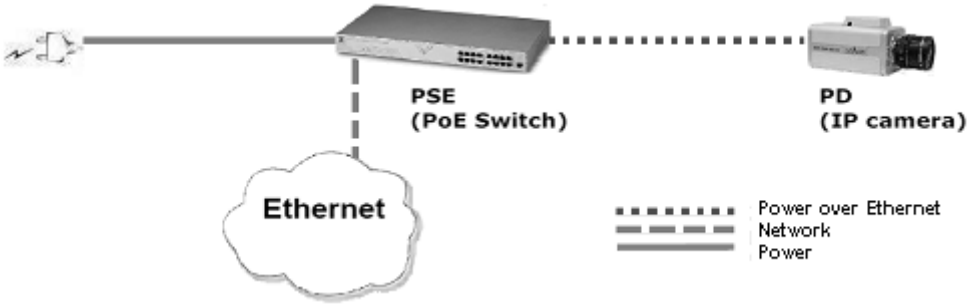

Fig. 3: IP camera power charge via switch with PoE.

PoE switch eliminates a need for charge input on cameras and enables simplified application of continuous charging (UPS) ensuring 24 hour working mode, seven days a week [7].

PoE technology has been defined in standard IEEE 802. af and designed in such a manner so not to degrade performances of network data transfer and not to decrease signal transfer range in the network. Charging provided by LAN infrastructure is automatically activated when compatible terminal has been identified, and it is blocked when the device is not compatible [7], [8].

Nowadays, most producers offer network switches with integrated PoE support. When existing network/switch structure is used, the users may add so-called midspan to the switch in order to make improvements using the same functions, because Midspan provides additional charging to the network cable. PoE midspan are available in 1, 6 and 12 ports (one camera may be connected to each port).

All IP cameras without installed PoE may be integrated into PoE system using an active splitter which separates

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data and power coming through the network cable [7]. Fig. 4 provides a scheme overview of PoE splitter application for the cameras without possibility of direct PoE

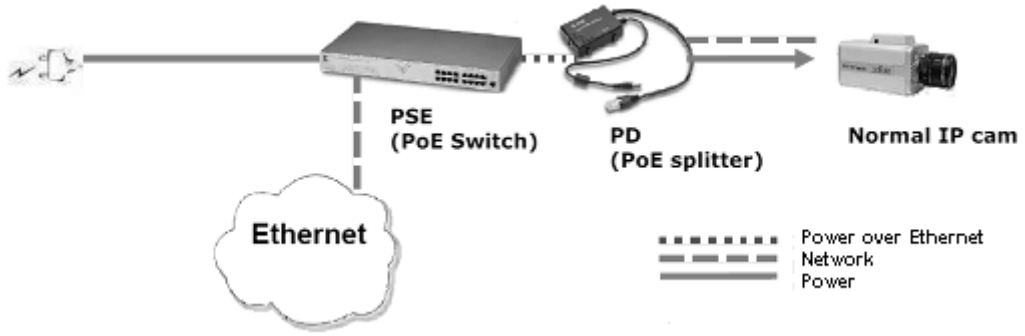

Fig. 4: IP camera power charge via switch without PoE

This characteristic offers a user a possibility to freely and safely combine appropriate cameras and PoE compatible devices on the network. Standard provides up to 15.4 W on the switch or midspan, which transfers maximum power of 12.9 W to the place with a device/camera, ensuring power charging for external cameras as well [8]. Fig. 5 provides a principle of IP camera networking with and without active splitter, using Midspan.

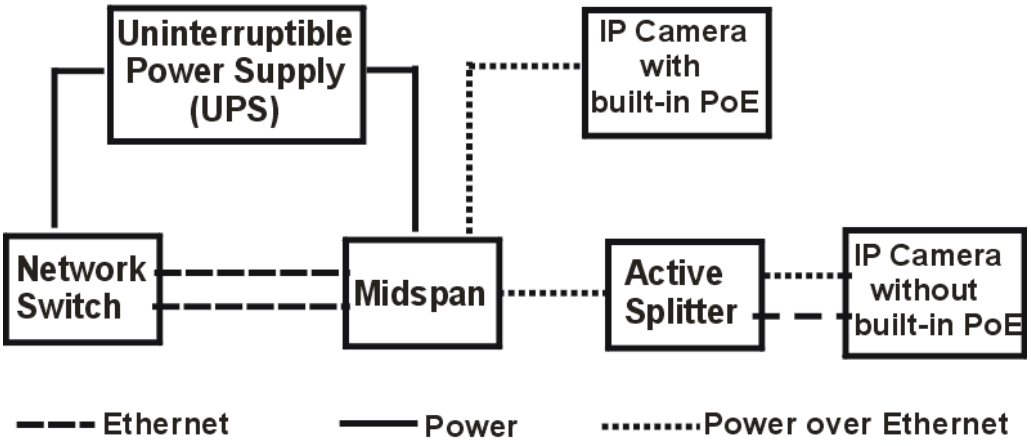

Fig. 5: Principles of connecting IP camera within video surveillance.

Fig. 5 shows how IP camera receives charging through network cable and how it may continue working even in the case of power drops/cuts.

VI. KINDS OF IP CAMERA

A. Cube Camera

With regards to the cube cameras, a number of significant limitations to be taken into consideration is related to the fixed focal lenses, i.e. if there is a need to adjust visual field of cube camera, it has to be physically moved. Some Cube cameras have integrated IR LED diodes in order to improve efficiency in cases of poor light. Cube cameras generally have problems, starting from moderate to significant ones, with background light or changeable light. One more limitation is that only less than 25% of cube cameras have PoE support [9]. On the other hand, some cube cameras offer certain advanced functions, such as integrated wireless networking. Even though it is usually done on short distances, it may be useful due to removal of network cables. Also, wireless technology support is more common for cube cameras than for other kinds. Cube cameras have greater Frame rate, i.e. more than 70% of cube cameras offer 15 fps (frames per second) or more, which is more than sufficient for most applications.

B. Box Camera

Box camera offers flexibility and simplicity for relatively low price. Main reasons why the users choose box cameras is changeable objective. Around 90% of box cameras enable the users to change an objective easily. This is important, especially if they try to see something really distant. Contrary to that, less that 33% of dome camera

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support changeable objectives and those limited by the physical size of the case [10]. If camera should be directed toward some angle, except straight forward, box cameras tend to be easier and offer greater frame rate than dome cameras. The dome cameras, being closed inside a case, may have limited movements (however, it depends on dome camera design). Box cameras may offer supreme esthetics, however, may be complicated for installment.

C. Dome Camera

Dome cameras offer a serial of physical options (advantages) which are not accustomed for the box cameras. Dome cameras may be installed right next to the wall or to the ceiling, making them pretty discrete. Sizes of these cameras may vary, so there are mini dome cameras as well as large cumbersome ones. Mini dome cameras provide the best esthetic solutions. More than 60% of dome cameras are resistant to vandal behavior, whereas it is the case with only 10% of box cameras. Dome cameras are better and have advantage if a camera should be installed outdoors, without additional separate case. In case of dim light/night surveillance, some dome cameras have integrated IR LED. This is an inexpensive way to improve quality of video material when artificial light is not available. On the other hand, distance may be short (less than 20 m). The advantage of dome camera is shorter installation time, since they are mainly installed on platforms, and require less skills and time [11].

D. Bullet Camera

Bullet cameras may be best defined as special forms of box cameras. Bullet cameras usually have some significant advantages not so common for box cameras, such as efficiency in poor light conditions. More than 80% of bullet cameras have integrated IR reflectors [12]. This makes bullet cameras extremely good for situation when there is no light, but only on the short distances (usually 50 m or less). Bullet cameras are easier to be installed outdoors, since there is no need to purchase and install a special case. Fig. 6 provides a physical appearance of IP camera [13], [14], [15], [16].

a) b) c) d)

Fig. 6: Appearance IP camera - a) Cube, b) Dome, c) Box and d) Bullet.

VII. CONCLUSION

Video surveillance concept based on video systems with IP cameras provides great efficiency and decreaces the price of the system, since the existing computer network is used for transfer of audio and video signal within the system of video surveillance with IP cameras. IP video surveillance provides an opportunity to choose a software and hardware for video recording on the base of an open code, great decrease of expenditures for cabling on larger installations (Cat 5e instead of RF-59 coax cable), possibility of using PoE (Power over Ethernet) – charging through computer network. Automatic warning on the camera via e-mail is enabled; data transfer as a response to motion detection; support for newly installed intellegent motion detection with recognision of shapes, posibility to count facilities, people or vehicles. IP systems of video surveillance may be easily integrated with other systems and functions, such as access control, alarm systems, construction management, traffic management.

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AUTHOR BIOGRAPHY

Gradimirka Popovic graduated engineer of electrotechnics, student of master's studies on Faculty of Technical Sciences in Kosovska Mitrovica. She graduated on Faculty of Electro-technical sciences on University in Priština. Participated on numerous expert and scientific conferences. She has written several articles in the field of electronics and telecommunications. She works as a professor of Information and computers in the primary school.

Nebojsa Arsic was born in Serbia in 1960. He received his B.Sc. degree in 1983 in Electrical Engineering from the Faculty of Electrical Engineering, University of Priština, and M.Sc. degree in 1989 from the Faculty of Electrical Engineering, University of Belgrade and Ph.D. degree in 1993 from the Faculty of Electrical Engineering, University of Belgrade. His main research interests include High Voltage equipment and measurements. Currently, he is a Full Professor with the Faculty of Technical Sciences, University of Priština in Kosovska Mitrovica.

Branimir Jaksic is assistant at the Department of Electronics and Telecommunications Engineering, Faculty of Technical Sciences in Kosovska Mitrovica, Serbia. He is PhD candidate in the Faculty of Electronic Engineering (department Telecommunications), University of Nis, Serbia. Areas of research include telecommunications and digital image processing. He has authored over 20 scientific peer-reviewed papers on the above subject.

Boris Gara has completed master's degree in electrical engineering and computer science. His areas of interest include digital image processing and transmission of multimedia signals through telecommunications networks.

Mile Petrovic is full professor at the Department of Electronics and Telecommunications Engineering, Faculty of Technical Sciences in Kosovska Mitrovica, Serbia. Areas of interest include telecommunications - television techniques and digital image processing. He has authored over 50 scientific peer-reviewed papers and a large number of projects and patents. And a member of the technical program committee and reviewer for several international journals and symposia.