# Chapter VII
# Pervasive Video Surveillance Systems Over TCP/IP Networks

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## ABSTRACT

*Traditional analog video surveillance systems technology has recently become inadequate to face the massive demand of security systems consisting of hundreds and sometimes thousands of cameras often deployed in hostile environments miles away from the control room. During the last few years, the rapid growth of the digital technology has produced sophisticated cameras which can directly record high-definition digital videos. The packetized video stream can be straightforwardly conveyed to the control room, relaying on common IP network infrastructures. This solution result is extremely flexible as the network infrastructure can be built over a wide variety of heterogeneous network technologies from the traditional Ethernet-based Local Area Networks (LANs) to the recently proposed Wireless Mesh Networks (WMNs). However, the widespread adoption of IP-based solutions for video surveillance poses serious problems in terms of required bandwidth, processing power, network security, and system dependability. In this chapter, we first investigate the advantages of the IP-based video surveillance systems over the traditional analog ones. Then, we describe the technical challenges and the open research issues which still lack an ultimate solution which permits to completely abandon the traditional analog technology. Finally, we propose and verify, by means of a case study, a methodology to address the design of video surveillance systems in real deployment.*

## INTRODUCTION

During the last decades, the world has become on the move. Intelligent transportation and emergency or disaster recovery facilities are more and more often integrated with remote video control. At the same time, urbanization trends combined with socio-economic changes have changed criminal and terrorism-related activities to a globalized phenomenon. As a consequence, the market for security and video surveillance systems has expanded significantly (Welsh & Ferrington, 2002). Security-system installers and integrators face several challenges in designing security and video surveillance systems that must operate in difficult and demanding settings, streaming and recording simultaneously hundreds and often thousands of video flows. In the last few years, the physical and video-security field is experiencing a massive shift from analog transmission over coaxial cables and fiber optic to digital transmission over IP networks (In-stat, 2006). In fact, until the mid-Nineties, recording was mainly performed on tapes using VHS equipments which require analog video streams as input. In the late Nineties, the majority of tape recorders have been substituted by Digital Video Recorders (DVRs) which are embedded systems that integrate hard drives with video encoding hardware. The analog video streams coming from, for example, coaxial cables to the DVR are digitized and compressed using video encoding algorithms. To this end, it is possible to subsequently transmit the video stream as a sequence of independent Joint Photographic Experts Group (JPEG) pictures, so as to realize what is informally called Motion JPEG (M-JPEG), or to utilize techniques such as Moving Pictures Expert Group (MPEG) which exploit interframe prediction; after this step, the stream is recorded on the hard drives.

The major drawback of both VHS- and DVR-based video surveillance systems is that the transmission from the cameras to the recording and viewing locations is kept analog, and therefore video quality is often directly affected by the distance between the control room and the cameras. Additionally, installing analog cameras in rural or even dense residential areas may not be feasible given the impossibility of laying long enough cables to reach the control room. Embracing the digital revolution from the camera to the head-end location and encoding the video stream into TCP/IP-like packets directly in the camera present multiple advantages (Sedky *et al.*, 2005; Cisco, 2006). In fact, the system designer can leverage existing networks and infrastructures irrespective of the specific medium used to convey the video stream (e.g., copper, fiber-optic, radio waves etc.). Furthermore, viewing and recording capabilities can be distributed by enhancing the cameras with integrated reporting and recording systems. However, the IP-based approach requires solving several additional issues in order to meet the requirements, in terms of security and reliability, of a traditional video surveillance system. For instance, the high bandwidth capacity required to transmit hundreds of video streams simultaneously (Koutsakis *et al.*, 2004) and the processing power needed to encode and decode multiple MPEG-4 streams (Ziliani, 2005) are definitely two main problems of IP-based systems which still lack a definitive solution. In this work, we describe the advantages and investigate the research open issues and technical challenges of the IP-based approach with respect the traditional analog systems for video surveillance. Furthermore, we analyze several existing IP-based solutions and develop a viable methodology to deploy efficient and effective video surveillance systems. Finally, we present, as a case study, a video surveillance system installed in a seaport in Europe where the above methodology has been successfully employed at the design stage.

## BACKGROUND

In this section, we describe in detail the components of a video surveillance system. Specifically, we first analyze the video surveillance application