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Mobile and Wireless Access in Video Surveillance System

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ABSTRACT

Wireless communication and mobile technologies are already well established in modern surveillance systems. Mobile-based client applications are commonly used to provide the basic access to camera video streams and other system resources. Camera site devices might connect to the system core by wireless links to address/overcome the environmental conditions. Finally, the surveillance systems themselves can be installed in portable environments such as busses or trains, which require wireless access for infrastructure and internet services, etc. However, we observe the growing popularity of mobile and wireless access solutions. The technology itself is evolving rapidly providing efficient transmission technology, feature-rich and powerful mobile and wireless devices. The users expect to have seamless access and tools where the functionality does not depend on access technologies or access devices. The same functionality is demanded from local client application and remote mobile browser. The aim of this paper is to explore access scenario where mobile and wireless access methods are used to provide enhanced client functionality. We analyze these scenarios, discuss the performance factors.

Keywords: mobile, wireless, surveillance.

1 Introduction

The availability of internet access, the development of applications technologies and increasing processing capabilities of different access devices have a big impact on a variety of access methods in surveillance.

Surveillance systems originate from CCTV (Closed Circuit TV) systems. In traditional CCTV the access tools and methods were dependent on user's location, e.g. operating room or administrator premises. The security measures aimed to provide physical security. The performance of the access application was dependent on the particular installed hardware. These systems were difficult to upgrade and were not easily scalable. Therefore surveillance systems have moved from traditional analogue into digital and IP-based technologies. The access applications have been made hardware-independent. The type of access were dependent only on type of the user not his or her physical location. The systems were opened for public domain services such as time synchronization, email and SMS services etc.

Currently another trend is to provide seamless access to the system and use of wireless and mobile technologies. The users expect to have access tools where the functionality does not depend on access technologies and devices. The same functionality is required from the local client application and remote mobile browsers.

Video surveillance systems accommodating wireless or mobile technologies are areas of ongoing research. The key research areas are focused around architectural considerations required to support receivers' mobility [1] [2], and their security and dependability aspects or innovative solutions based on wireless (sensors) and mobile technologies. The researched scenarios are usually presented using small or medium size surveillance systems or other innovative solutions [3].

The subject of transition of complex surveillance into world of wireless, mobile and cloud technologies is relatively unexplored (excluding the security aspects of connectivity).

In case of complex surveillance system the transition towards mobile and wireless solutions is rather continuous than disruptive change of applications, architecture and system design in general. Therefore, it is worth to analyze the existing solutions in context of characteristics and limitations of new technologies.

The article analyses how current access applications are suitable to support mobile and wireless technologies. We describe the architecture of reviewed client solutions. We describe basic functionality of the client

application, based on Teleste VMX system. We analyze the impact of client functions on traffic. Based on expected traffic characteristics we review what access methods could be implemented to provide the expected functionality. Finally, we discuss related performance. In this article we will not address any security related challenges, however the security concerns should not be undermined- security plays the important role in the mobile and wireless access to surveillance.

2 Solutions

The basic access application should be at least capable of displaying the video streams from selected cameras. Additionally, the application can provide PTZ control of a camera and access to recorded content. Enhanced client applications can provide some level of (local) content manipulation, such as, export or modification of material of interest and it should allow the user to react on given system events. Administration client application should enable administrator level of access to the system with the ability to modify the system setup and reacting on all system events and access to all system resources.

The application itself is expected to be device independent, which leads to the application being browser-based and not requiring an installation process.

The client application is typically placed inside the surveillance network. However, the mobile and wireless solutions extended to a variety of available remote locations. In modern surveillance systems the client application should enable access from both private (surveillance system) and public (internet or mobile network) domains. The architecture of surveillance system should adapt to both types of scenarios.

Fig. 1 presents few available scenarios.

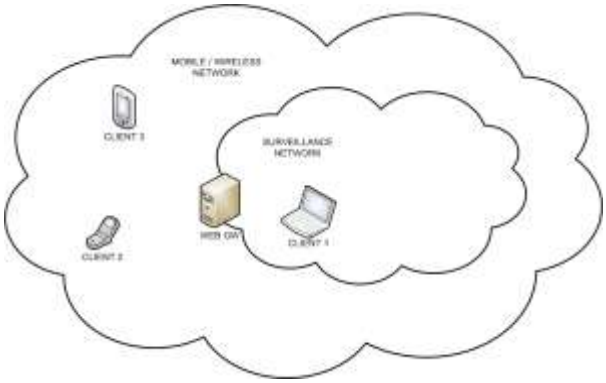

Fig. 1. Client locations

First client is a PC-based application located inside the surveillance system network. The client application is retrieving information and accessing system resources directly from system infrastructure nodes.

The second scenario addresses the devices with limited processing and installation capabilities– this simple application is based on a web browser and requires some level of stream manipulation to be done by system in order to avoid the power- exhaustive video decoding and general application complexity. This solution also provides a good level of security by easy control of stream and resource access. The system modules responsible for stream manipulation are usually also capable to limit the user access to the stream or resource.

The third scenario is represented by more powerful (and increasingly more common) devices. The original streams are directed into the client node (laptop, iPhone, mobile, other) from the system. The device has the capabilities to decode streams as well as being able to host more complex client applications with extended functionality. For security reasons the access might be controlled by gateway-type nodes but the security decisions are based on the system state rather than the content of the streams - therefore the solution tends to be easily scalable. In the next chapter we analyze how well this scenario is supported in terms of client functionality.

3 Analysis

In order to analyze how the client application functionality affects the traffic characteristics we have to first compare traffic characteristics of two types of client installations: PC-installed traditional application and mobile hosted

(browser-based) simple application. The comparison allows us to define the major differences in traffic characteristics between these two application technologies. Additionally, the analysis displays the difference between the second and the third scenario in terms of bandwidth.

Next, we analyze how the traffic characteristics change if enhanced client functions are used. It allows estimating the traffic behavior for a scenario where processing-capable mobile devices are used to access the surveillance resources (see third scenario from chapter above).

Fig. 2 and Fig. 3 present the differences in traffic characteristics for simple client operations. Fig. 2 presents characteristics for traffic from system to browser-based client and Fig.3 from system towards PC-based client -both are examples of Teleste VMX Client applications.

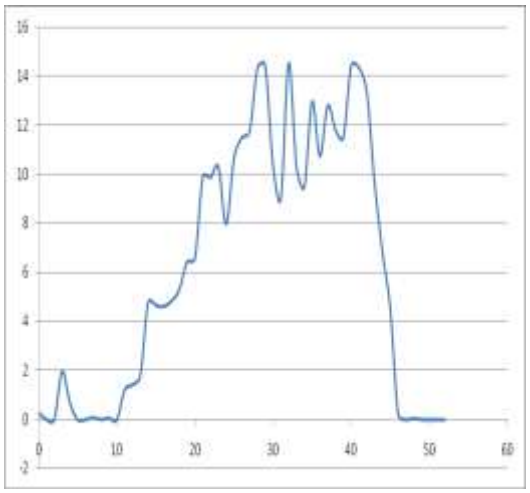

Fig. 2. Traffic statistics for simple browser client-traffic (Mbps) as function of time

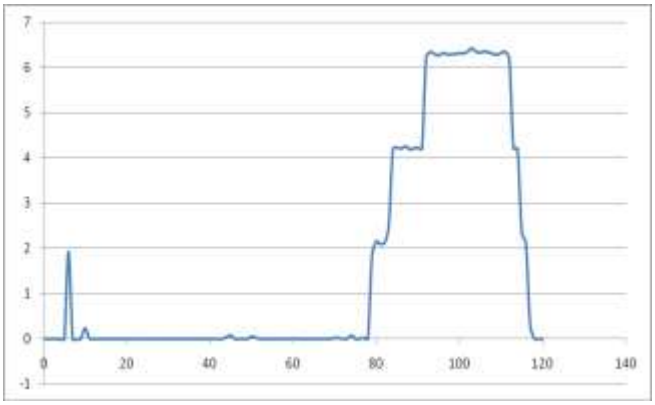

Fig. 3. Traffic statistics for PC hosted client application - traffic (Mbps) as function of time

The operations performed during the time of capture were the same for both types of client applications. The sequence was as follows: logging in, connecting to first camera, connecting to a second camera, connecting a third camera, PTZ operations on first camera, sequential disconnection of three cameras, logging out.

The general shape of the traffic characteristic is similar in both cases. The number of video streams being viewed has the biggest impact on bandwidth occupied by client application traffic. The function of the client application retrieving each of three streams is easy to distinguish.

The bandwidth used by the web browser client for decoding the video transmission is approximately 6Mbps per stream whereas PC-hosted application uses approximately 2Mbps (which is original size of the camera stream in our test bench). The reason for this is the fact that in our test bench the PC-hosted application retrieves the original MPEG-4 stream whereas the browser-based application retrieves JPEG files from the gateway node – in this scenario the gateway transcodes the original video stream to JPEG stream which is easy to decode and display by web browser.

We have also observed that the stream traffic is more variable in case of the browser application, which is expected due to the affects of the http character of transmission. It also indicates that the performance problems of mobile client applications are more likely to be caused by fluctuations of traffic and not by the amount of video traffic in general.

Fig. 4 presents the characteristics for traffic from system towards client tested with advanced operations.

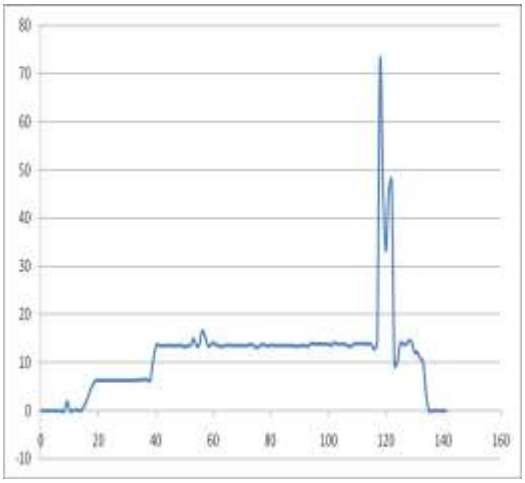

Fig. 4. Traffic statistics for PC hosted client application- full functionality - traffic (Mbps) as function of time

In addition to basic functions (listed earlier) we have added the operations of querying recorded material, playback of recorded material, accessing and modifying system setup, and downloading recorded material. Whereas other functions did not have a substantial impact on traffic characteristics (viewing recorded material has been seen as retrieving another video stream) the function of material download was clearly visible. It indicates that the function of data transmission might have a major impact on the performance of a mobile application. The results is consistent with our expectations- a downloaded stream is perceived by the network as a data transmission file type and might be prioritized as such, this may in turn affect the quality of operation for other client functions.

4 Technology review

The earlier analysis reveals the biggest impact on bandwidth of client connections have the functions of: viewing life or recorded video and downloading of the material. Other operations have minor impact on traffic and can be omitted in analysis.

The number of simultaneously viewed streams is directly dependent on user interface of application. In case of mobile devices where small size of screen limits the number of viewed stream we can assume the maximum number of displays being equal to four (of 4CIF resolution).

The bandwidth occupied by typical stream of this resolution varies from few Mbps for stream of JPEGs, 4Mbps for MPEG-4 compressed stream to 2Mbps and less when H.264 compression is used.

Moreover, we can assume that for solutions where JPEG streams are used (simple applications for devices with limited processing power) it would be also acceptable to limit the number of simultaneously viewed channel to one or two.

In addition, different channel adaptive transmission methods can be used, such as channel-adaptive video transmission method using H.264 scalable video coding proposed by [4].

The above concludes the total bandwidth available for mobile and wireless connection would be: around max 20Mbps for simple applications and up to 10Mbps (typically 3 to 5 Mbps) for remaining types of wireless and mobile client application. The above estimations do not take into consideration the impact of download on the bandwidth. However, it is assumed that if download of the content is required (it is still not commonly used), the application should have capabilities to fix the transmission parameters for download operation. In this case the bandwidth requirements will grow insignificantly and we assume the typical mobile client will be able to use less than 10Mbps.

The bandwidth of 3 to 20 Mbps is available in many technologies.

Popular Wireless Fidelity (Wi-Fi) technology (based on IEEE 802.11 standard) offers WLAN range standard interconnectivity with channel capacity up to 11Mbps for basic 802.11b, up to 54Mbps for 802.11a or 802.11g, and even above 100Mbps for 802.11n. Assuming effective transmission rate being not less than half of standard channel capacity Wi-Fi standards can provide basic wireless interconnectivity within the building with restrictions for simple browser application not being used on 802.11b infrastructure.

WiMAX technology (based on IEEE 802.16 standard) provides wireless access for wide areas (typically several km and up to 50 km) with channel capacity of typically 54Mbps (and up to 100Mbps). It can be used for wide area surveillance networks and provide the access for almost whole range of local system users.

3G mobile technologies do not necessarily guarantee necessary bandwidth but as they are expected to provide the minimum data rate of 2 Mbps for stationary or walking users and 384 kbps in a moving vehicle (refer to [3]). However, also 3G systems bandwidth might be sufficient to

handle client connections if advanced compression standards and channel-adaptation techniques are implemented (see [4]). There are many successful examples of deploying 3G - based surveillance access (see example [1]).

It is worth to underline that the access technologies provide not only the transmission bandwidth but also define available transmission techniques for given environments and infrastructures. IP networks can introduce delays or jittering of transmitter signal. Wireless networks introduce the challenges related to mobility e.g. signal fading and mobile technologies can add the problems with handover.

Typical delays commonly acceptable in surveillance are 300ms for video, 50ms for speech audio and often lip-sync level of synchronization for downloaded content and playback. Whereas the synchronization of playback and downloaded content is independent from network environment and can be done by system itself (based on RTCP protocol). The delays on video and audio transmission affect greatly the quality of client operations and therefore should be considered when deploying wireless access over different technologies.

All proposed access technologies (Wi-Fi, WiMAX and 3G) provide basic QoS mechanisms to address problems of delays in multimedia transmission.

802.11e Wi-Fi standard provide traffic prioritarization for different (real-time) applications by creating different classes of transmission for different types of data transmitted over wireless link. However, delivering multimedia through Wi-Fi might meet additional challenges as Wi-Fi technology was not originally designed as multimedia broadband carrier technology. Article [5] discuss the problem of absence of multicast feedback mechanisms and proposes leader-based mechanism to overcome this problem. Article [6] addresses the problems, such as: multicast transmission using the slowest link-speed, common link adaptation mechanisms for clients, lack of a call admission policy, and irreducible PER even in good channel conditions.

802.16 WiMAX standard has been originally designed to support reliable delivery of broadband multimedia data - it has built in scheduled access and Quality of Service (QoS) mechanisms (refer to [7]).

The topic of WiMAX access for multimedia content has been reviewed by publications, such as: article [8]. We observe the popularity of WiMAX access for surveillance is growing.

5 Conclusions and future prospects

In this paper we provide evidence that secure and good quality access to surveillance systems and data applications and data, using mobile devices and wireless networks is attainable with current technology.

The general trend is to open surveillance networks to modern tools. Despite the fact that the main concerns related to mobile or wireless access-the security of the solution still bring discussions we observe growing need of seamless and mobile access.

It is expected that the future trends bring more openness of the surveillance with enhancement of the security level applied.

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