# MULTICAST vs. UNICAST TRANSMISSIONS FOR WIRELESS IP CAMERA SURVEILLANCE SYSTEMS

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**Abstract: This paper presents the results obtained at the installation, configuration and optimization of a wireless IP video surveillance system. Because of the cheap and insufficient hardware resources, the WVC54GC camera permits only a very limited number of HTTP over TCP unicast streams. Multicasting at the data link layer is a more efficient way for sending data to a group of receivers. Some possible solutions for overcoming the above limitation are presented using additional hardware and software. An analysis of their performance is presented using network monitoring tools, together with a discussion. Results have shown that there are several alternatives to efficiently provide a video stream to the end users.**

***Key words:*** *wireless IP camera, unicast, multicast, IEEE 802.11*

## I. INTRODUCTION

An IP-surveillance application creates digitized video streams that are transferred via a wired or wireless IP network, enabling monitoring and video recording as far away as the network reaches, as well as the integration with other systems such as access control or video conferencing.

Multicasting is a more efficient method for supporting group communication than unicasting or broadcasting, as it allows transmission and routing of packets to multiple destinations using fewer network resources. Applications of wireless multicast support group-oriented multimedia conferences, command and control and video streaming of live events.

A network camera can be described as a camera and a computer combined into one unit. It connects directly to the network as any other network device, allowing users to remotely monitor, record and analyse images at long distance, including wireless Internet links. A network camera has its own IP address and built-in computing functions to handle network communication. All the necessary elements needed for viewing images over the network are built into the unit.

In order to fit the bandwidths sharply variety of wireless channel, adaptive MPEG-4 based video compression algorithms are required to encode the high quality video [3].

Not only are wireless technologies much more flexible because of the lack of installation, they are also connected with additional advantages allowing the mobility of someone or something connected to the network. [2]

Low cost IP cameras are capable of streaming only over TCP/HTTP (Transport Control Protocol/Hyper Text Transfer Protocol) allowing only a limited number of unicast streams, while more ambitious products can steam over multicast UDP/RTP (User Datagram Protocol/Real Time Protocol) allowing an unlimited number of clients and a more efficient utilization of the available bandwidth.

In this paper some methods for overcoming the limitations associated with TCP/HTTP unicast only cameras in WLANs (Wireless Local Area Networks) are presented. The performance of the proposed solutions is also analyzed and discussed.

This paper is organized as follows: first, some relevant parameters of the network and of the employed hardware are provided. In section II, we analyze the bandwidth consumption when using end to end TCP. Next, some improvements when using the AP (Access Point) as a proxy are presented. In section IV, the multicast solution is detailed. Concluding remarks are provided in the final section.

## II. NETWORK CONFIGURATION

The 802.11g [11] wireless network used for our experiments was configured in infrastructure mode without any kind of encryption mechanism. Encryption has been disabled because some difficulties arose when capturing encrypted data frames, which have to be decrypted in order to distinguish between different data flows. In production networks authentication and encryption is mandatory. It consists of an Asus WL-500G Premium [4,5] embedded platform acting as a wireless access point, a Linksys WVC54GC [9] compact wireless-g internet video camera, a desktop PC acting as a client, a Fujitsu Siemens N560 [10] PDA (Personal Digital Assistant) acting as another client. Another desktop PC running Wireshark 0.99.6 in monitor mode was used to capture and analyze the traffic on the wireless channel. A monitor on the client station has not been used because the process of saving the received frames on the disk negatively affects the throughput while consuming a large amount of CPU time.

The relevant parameters of the hardware configuration are summarized in Table 1.

| Resource | Relevant parameters |
|---|---|
| WL-500G Premium | CPU: Broadcom 4704 @ 266MHz<br>Wireless NIC: Broadcom 4318 (mini-PCI) IEEE802.11g + WME<br>Flash: 8MB<br>RAM: 32MB<br>Switch: BCM5325 (IEEE 802.3u, IEEE802.1q)<br>USB: 2 x USB 2.0<br>Serial: 2 x RS232<br>OS: Oleg 1.9.2.7-7g [6] |
| WVC54G C | Sensor: CMOS<br>Connectivity: IEEE802.3u, IEEE802.11g<br>Compression algorithm: MPEG-4,<br>Streaming: HTTP overTCP<br>Resolution 320x240, 160x128 |
| N560 | CPU: IntelXScale@624MHz<br>RAM: 64MB<br>Connectivity: IEEE802.11g, Bluetooth<br>OS: Windows Mobile 5 |
| PC1 | CPU: AMD@2600+<br>RAM: 1024MB<br>Conectivity: IEEE802.11g, IEEE802.3u<br>OS: Fedora 6/Windows Server 2003 |
| PC2 | CPU: Intel@900MHz<br>RAM: 512MB<br>Conectivity: IEEE802.11g, IEEE802.3u<br>OS: Fedora Core 5 |

*Table 1. Testbed summary*

The WL-500G Premium embedded platform was equipped with a 512MB USB 2.0 flash drive for installing additional software packages such as VLC 0.8.6c [7]. Linux desktop PCs are equipped with Atheros AR5414 wireless PCI NICs and use the latest version of the MADWiFi wireless drivers [8]. Nonstandard specific vendor features on the wireless card, such as Atheors SuperG or Broadcom AfterBurner have been disabled. All of the tests (including unicast and multicast) are performed using the 802.11g physical maximal transmission rate of 54Mbps, RTS/CTS (Request to Send/Clear to Send) and fragmentation disabled (except the IP camera where it is not possible), MTU (Maximum Transmission Unit) set for Ethernet compatibility (1500 bytes) and the channel number explicitly set (ETSI channel 1, ISM 2.4GHz). Because the IP camera does not support QoS/WMM/WME/802.11e (Quality of Service/Wireless Multimedia Extension/Wi-Fi Multimedia), it has been completely disabled. The employed video compression algorithm at the IP camera was MPEG-4 (Moving Picture Experts Group) configured for best quality at a resolution of 320x240. Using these settings, the required bandwidth is about 1.2Mbps; the camera supports up to 4 simultaneous TCP connections.

## I. SCENARIO I

During the first test scenario, PC1 was used to emulate four clients; PC2 was used to monitor the whole generated traffic (Figure 2). The clients have been emulated by successively starting four *vlc* sessions on PC1 as follows: first, only one session has been started and then, after 50s, the second session was started. After another 50s, the third session has been started and so on. In infrastructure networks (BSS), each link-layer end to end connection requires a double amount of bandwidth because data frames are first transmitted by the sender to the access point which retransmits them at their final destination.

This fact can be observed in Figure 2 (red line), where one connection consumes 2.4Mbps of the available bandwidth. There is a strange behavior after adding a second client. Instead of a doubling of the total bandwidth, each connection's bandwidth drops.

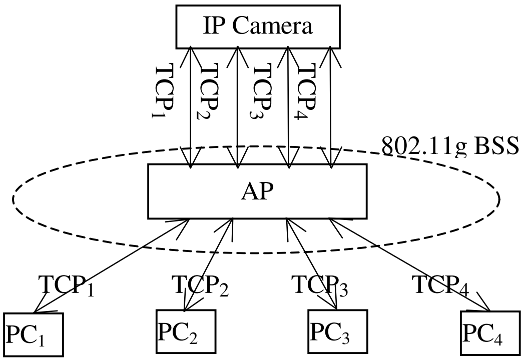


*Fig. 1 End to end TCP over 802.11*

This can be explained by the fact that the WVC54GC wireless network camera does not have sufficient processing power to handle more than one connection at full rate and the TCP flow control mechanism reduces the data rate at about 1.4Mbps for each session. After adding a third client, the bandwidth is further reduced. In the extreme case (four clients), the bandwidth assigned to each client is only 0.8Mbps resulting in a total bandwidth of 3.2Mbps. These successive decreases of the assigned bandwidth per client lead to a decrease of the quality of the transmitted video stream. Having a total number of four clients leads to a bandwidth consumption of 3.6Mbps (Figure 2, black line).

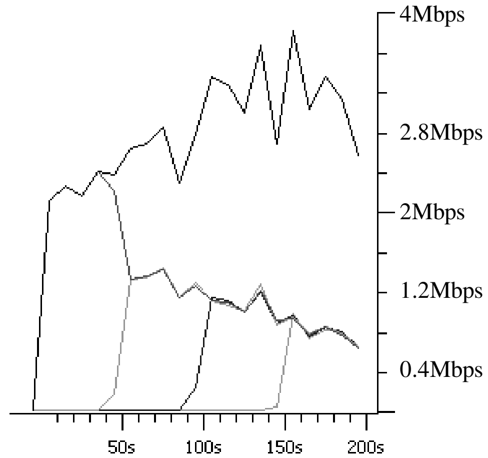


*Figure 2. End to end TCP over 802.11g bandwidth requirements*

## II. SCENARIO II

The difficulties associated with the previous configuration (decrease of the quality by increasing the number of users) can be avoided by using the capabilities of the WL-500G Premium embedded wireless platform. On the router, *vlc* has been started (*vlc http://192.168.2.115/img/video.asf --sout '#standard{access=http,mux=asf,dst=0.0.0.0:10000}'*) which acts as a proxy between the ip wireless camera and the wireless clients (Fifure 4).

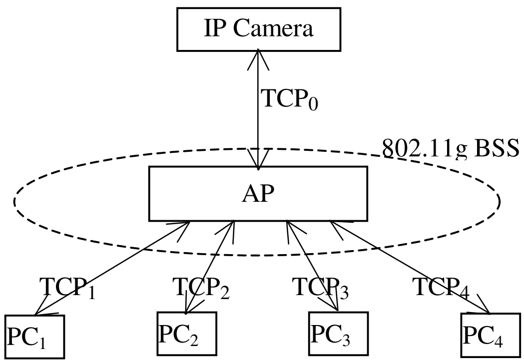


*Figure 3. AP proxy*

In these conditions, only one TCP stream will be necessary between the camera and the AP. For each new client, a new TCP connection will be created but only between the AP and the given client. The required bandwidth will be *1.2Mbps x (number of clients +1)* and the CPU usage at the router 1% for each client. In this case, there will be no decrease of the bandwidth, as in the previous configuration (because the AP has enough processing power) and each client will be provided with a maximum quality video stream. This can be observed in Figure 3 where each client benefits from a bandwidth of 1.2Mbps. The bandwidth between the ip camera and the router is, in this case, 1.4Mbps.

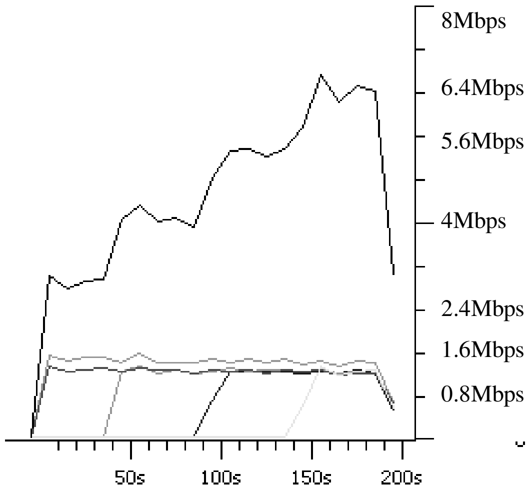


*Figure 4. AP proxy bandwidth requirements*

When having a total number of four emulated wireless clients, the transmissions require a total of 6.4Mbps including IEEE 802.11 management and control frames. This scheme has the advantage that the access point can use different physical data rates for each client based on current channel conditions (adaptive data rate) providing support for user mobility in the WLAN.

## III. SCENARIO III

When the wireless clients are in the same broadcast domain, the scheme from section III can be further improved. To do this, we will renounce using the TCP protocol between the access point and the wireless clients and we will replace it with a single RTP (Real Time Protocol) multicast stream. On the router, *vlc* has been started with the following parameters: *vlc http://192.168.2.115/img/video.asf --sout '#standard{access=rtp, dst=224.0.0.3:10000}'* which receives a unicast stream from the IP camera and redistributes it to a multicast group using RTP. The TCP connection between the IP camera and the access point will be maintained because there are no other possibilities. This approach is depicted in Figure 5.

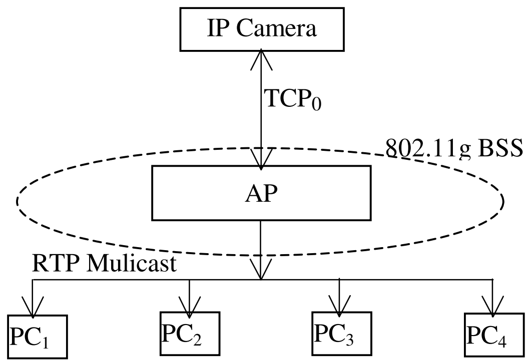


*Figure 5. Multicast over 802.11*

This scheme has the advantage that redundant TCP connections are removed. Good results can be obtained when the signal to noise ratio at each client is high enough to provide a small bit error rate (less than $10^{-6}$) for the employed physical transmission mode. By default, the driver selects the lowest available rate for multicast transmissions to reach as many receivers as possible The bandwidth usage can be further optimized when the conditions for each client are close to one another, by setting a multicast transmission rate at a convenient value.

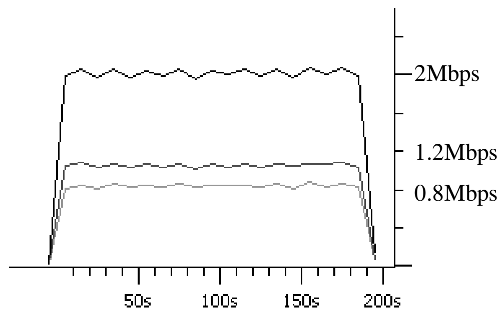


*Figure 6. Multicast bandwidth requirements*

Because there will be no feedback from the wireless clients, the transmission parameters cannot be automatically adjusted. Several solutions have been proposed [1] but until now, there have not been any practical implementations. In these conditions, the above scheme can be used with good results only in fixed topologies.

The amount of bandwidth consumed by the multicast stream is only 0.8Mbps (Figure 6) regardless of the number of wireless clients and the total amount of bandwidth needed in 2Mbps, including IEEE 802.11 management and control frames (beacons, ACK, periodic reassociations, CTS to self etc). Multicast transmissions have been successfully tested on Microsoft Windows (VLC, Real Player) and Linux (VLC), but no Windows Mobile 5 compatible multicast player was found.

## V. CONCLUSION

In this paper, some possible configurations for an IP video surveillance system have been analyzed. Several issues such as available bandwidth, communication protocols, network hardware and end user software have to be addressed before implementing an IP based video surveillance system. Power consumption at mobile devices has to be taken into account.

A possible solution regarding multicast transitions is to select the physical transmit mode that satisfies the worst receiver, ensuring good reception for all receivers. Nevertheless, this can be very resource wasteful if the common bit rate is too low, causing performance anomalies. Any other solution will necessarily cause packets not to be received by all users. A compromise solution can be achieved if the data (MPEG-4 in this case) have a hierarchical structure, but until now, no practical solutions for IEEE 802.11g have been implemented. Except the multicast solution, the TCP scenarios can also be used over the Internet. The multicast scenario can be used on the Internet only if the service provider provides multicast services to the subscribers.

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