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Scalable Video Coding of H.264/AVC Video Streaming with QoS-based Active Dropping in 802.16e networks

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***Abstract*—Multimedia applications over mobile wireless network are becoming popular in recent years. High video quality depends on the wide bandwidth but the wide bandwidth restricts the number of users in the network system. Effective bandwidth utilization is the major problem in wireless network because the bandwidth resource in wireless environment is limited and precious. For this reason, we propose an active dropping mechanism to deal with the effective bandwidth utilization problem. In the proposed mechanism, if the network loading exceeds the threshold, the dropping mechanism starts to drop the enhancement layer data for low level user and the dropping probability is varying with the different network loading. For the multimedia application, we use the characteristic of the Scalable Video Coding (SVC) extension of H.264/AVC standard to provide different video quality for different level user. By the dropping mechanism, base station increases the system capability and users can obtain better quality of service when the system is under heavy loading. In this paper, we study the network platform of the 802.16e standard and add the QoS-based Active Dropping mechanism to the MAC layer. In the simulation results, the system capability that releases bandwidth by dropping mechanism and service quality of users are observed.**
***Keywords*: WiMAX , IEEE 802.16e , H.264/AVC, Scalable Video Coding (SVC)**

I. Introduction

In recent years, the wireless broadband network technology is developed and the demand of wireless network is increased[1-3]. The wireless network is used from the personal wireless network IEEE802.11 system or the latest 3G telecommunication network. Application of wireless network system is not only used in data or voice transmission but also in video streaming. For the video streaming, we need wide bandwidth network as IEEE 802.16 Metropolitan Area Network (Wireless MAN)

WiMAX is short for Worldwide Interoperability for Microwave Access and conformed to the 802.16 standard. In the 802.16e-2005 standard, the system provides user to access network with mobility like cell phone. WiMAX can provide different service flow according to the request of user. In this way, the bandwidth is used flexible and effective. This advantage makes WiMAX to popular wireless broadband network system.

Video streaming needs wide bandwidth to transmit the video data but the bandwidth is limited in the wireless environment in early stage. For this reason, The Joint Video Team (JVT) formed by the ISO/IEC MPEG and ITU-T develops the extension of H.264/AVC scalable video coding (SVC) which provides different video quality according to the data is received. The research[4] uses the rate control algorithm to control the transmission rate and reduce the client buffer size. The research[5] uses the Adaptive Media Playout (AMP) buffer control the mitigate the risks of buffer outage. The research[6] focus on congestion control and use the buffer management to control loss of less important data. This research[7] uses the priority dropping mechanism to increase the PSNR of video quality. These researches don't provide the different video quality for different level of users. The network system consumes lots of bandwidth when the video server provides user with the best video quality but not all users need better video quality. To satisfy the requirement with each user, we propose a QoS-based Active Dropping mechanism in this paper. In this mechanism, network system drops the enhancement layer data which is for low level user according to the user level when the network loading is exceeding the threshold. By using the dropping mechanism, the 802.16e network system not only provides different video quality for each level user but also reduces the waste of bandwidth and satisfies more users to access this network system that means the capability of 802.16e networks is improved. The proposed mechanism is also available in 3G system.

The rest of the paper is organized as follows. The basic medium access control layer of IEEE 802.16e is introduced in Section Ⅱ. The Scalable extension standard of H.264/AVC is introduced in SectionⅢ. The proposed Active Drooping mechanism model and simulation results are in Section Ⅳ. Finally, the conclusion is in SectionⅤ.

II. Overview of IEEE 802.16e

The IEEE 802.16 Metropolitan Area Network[8-9] is developed in two structures. The first structure is a fixed Broadband Wireless Access(BWA) system called IEEE 802.16-2004. In 802.16-2004 system, the modulation technique in PHY layer is Orthogonal Frequency-Division Multiplexing (OFDM). Using the OFDM technique, 802.16-2004 system can support broadband access and long

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transmission distance but the range restriction of each base station (BS) must be line-of sight (SOL). The 802.16-2004 system is used to deal with the Last Mile problem and it can build up quickly with cheap cost. The second structure is a mobile Broadband Wireless Access system called the IEEE 802.16e-2005. The IEEE 802.16e-2005 standard is extended from the 802.16-2004 standard and provides mobility support in cellular deployments. In this standard, the modulation technique is Orthogonal frequency-division multiple access (OFDMA). The 802.16e system can provide stable service for user because of the OFDMA modulation in PHY layer and Medium Access control(MAC) layer. The range restriction in this system is non-line-of-sight (NSOL) and the advantage of NSOL is the signal with no serious fading when the signal is obstructed by buildings. In this reason, the 802.16e system can provide the users moving freely in the cities. In this advantage, the IEEE 802.16e-2005 system is suitable to use in Metropolis because the better quality of service depends on better signal quality.

IEEE 802.16e provides different service flow according to different requirement and characteristic of service. The first is Unsolicited Grant Service (UGS). The UGS is designed to support real-time service flows that will generate fixed-size data packets periodically. The UGS will be granted periodically without polling-request procedure. The second is Real Time-Variable Rate service (RT-VR). The RT-VR is designed to support real-time service flows, which will generate variable-size data packets on a periodic basis. The service needs more request and latency than UGS, but it can support variable grant sizes. The third is Extend Real Time-Variable Rate service (ERT-VR). The ERT-VR is designed to support real-time service flows that generate variable size packets on a periodic basis. ERT-VR has the service characteristic with the UGS and RT-VR. The fourth is Non-Real Time-Variable Rate service (NRT-VR). The NRT-VR is designed to support delay tolerant data streams that consists of variable sized data packets. The last is Best Effort service (BE). The BE is designed to support data streams that has no minimum transmission delay. Each service flow has unique service parameter and this parameter is used to scheduling and the transmission priority. In IEEE 802.16e, the MAC layer protocol is shown as Figure.1[10].

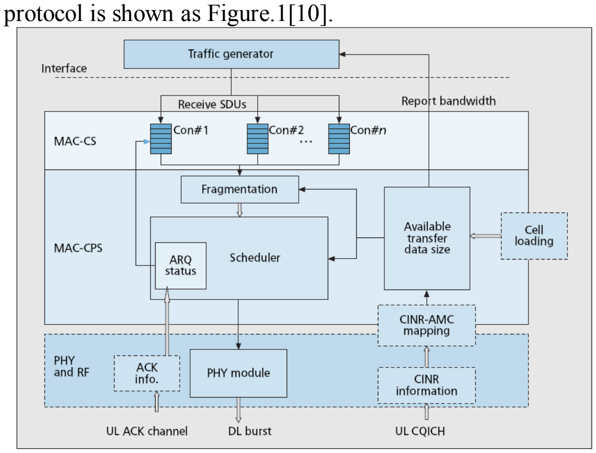

Fig 1. IEEE 802.16e MAC layer

Each service is mapped to one or multiple connections. Each connection is identified by a 16-bit connection identifier (CID). The convergence sublayer(CS) classifies the service data units (SDUs) to a proper connection with specific QoS parameters. The common part sublayer controls most functionalities as fragmentation, packing, scheduling and retransmission, etc. By these service flows, IEEE 802.16e-2005 can provide suitable service flow for different application and system which have better service quality. For the video streaming service, network system should provide real-time service and large variable-size data packets on a periodic basis. The UGS has less latency than RT-VR but the UGS only provide a fixed data rate. Therefore the RT-VR service flow is suitable for video streaming application.

The IEEE 802.16e provides wireless broadband access but the bandwidth resource in wireless networks is limited. The network system should need a mechanism to drop the packet which is less important or delay from the transmitting queue. By this mechanism, the network system can avoid unnecessary transmission and enhance the bandwidth utilization [11].

III. SCALABLE VIDEO CODING

Video streaming is a popular application in the wireless network systems. In the video processing, video encoder needs more effective compressing rate to reduce the streaming bit rate. The lower video bit rate can provide more users to access the same wireless network system. Scalable Video Coding (SVC)[12] can improve the video streaming adaptation on unstable network environment. The network system can maintain video streaming quality with the low bit rate when the network is in congestion. Scalable Video Coding has three dimensions in spatial scalable, temporal scalable and quality scalable. Video server encodes video by three dimensions to several layers. These layers consists of one base layer and one or several enhancement layers. The base layer provides basic video quality with low bit rate for user. Enhancement layer is used to refine the base layer video quality. User receives more enhancement layer data can decode the video in better quality. The base layer only provides basic video quality with low bit rate. Maintaining the video streaming is important to users because users feel uncomfortable when video is observed in delay. Basic video quality with low delay is acceptable for user and more enhancement layer data can help the video quality better.

Non-scalable video coding only has a single bit rate streaming but not all users adapt to the bit rate in their position. In the 802.16e network system, different positions of user influence the signal modulation and each modulation technology provides different size of bandwidth. For this reason, single bit rate streaming can't satisfy the requirement of each user. Comparing with non-scalable video coding, SVC can provides different bit rate streaming for user who is in different network environment. SVC uses the layered structure to assign importance for each layer. For the important layer, the unequal erasure protection (UEP) can be used to protect the important data. In these advantages, the SVC is more suitable transmitting technology in wireless network system than non-scalable video coding system.

The Scalable Video Coding extension of H.264/AVC standard is developed by The Joint Video Team of the ITU-T Video Coding Experts Group (VCEG) and the ISO/IEC Moving Picture Experts Group (MPEG) [13-14]. In this standard，three dimension is used including Temporal scalability (frame rate), Spatial scalability (picture resolution) and SNR scalability (quality). Figure 2 shows the H.264/ AVC Scalable Video Coding structure [16].

For supporting the temporal scalability, the concept of hierarchical prediction structure is used. Each set of temporal layers can be decoded independently and the enhancement layer is coded as B pictures. The group of picture(GOP) is separated into several layers. For supporting the spatial scalable coding, the Multi-layer structure with inter-layer prediction is used. The inter-layer prediction is including the motion prediction, residual prediction and intra prediction.

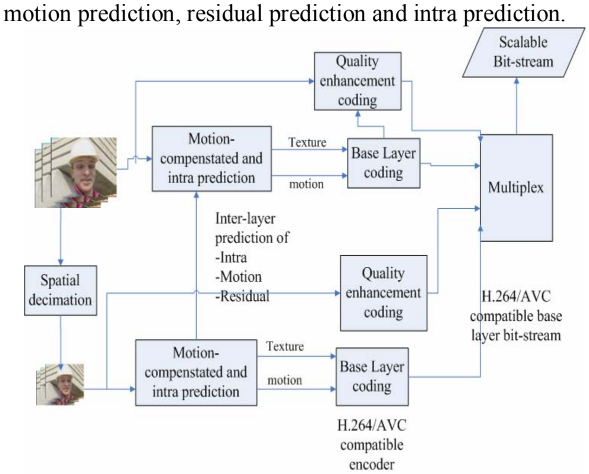

Fig.2 The scalable extension of H.264/AVC structure

The video is decomposed into several layers and each spatial layer can get prediction from lower spatial layer. Quality scalability is the special case of spatial scalability with the same picture size for base and enhancement layer. Each spatial layer is referred to as coarse-grain quality scalable coding(CGS) or medium-grain quality(MGS).When quality scalability is using CGS, switching between different CGS layers must be at the defined point but the quality scalability is using MGS, switching different MGS layer can be in any access unit. With the MGS concept, any enhancement layer NAL unit can be discarded from a quality scalable bit stream. For the first Quality layer is restricted to CGS, and enhancement layer is consist of Fine Grain scalability (FGS).

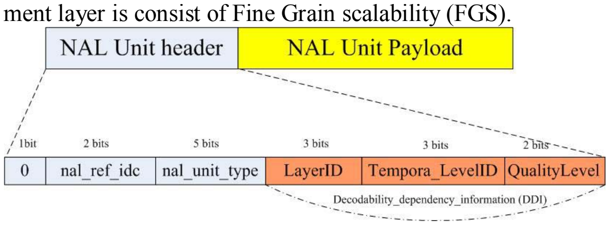

Fig.3 The NAL header of scalable H.264/AVC

The header information of H.264/AVC is depicted as Figure 3. The first byte is used in basic video which is encoded by H.264AVC standard. For supporting the H.264/ AVC scalable video, a byte extension of the NAL header is used. In this byte, the first three bits stand for different spatial resolution. The next three bits stand for a temporal resolution while the last two bits stand for a quality level. The quality level for the base layer is zero and it is increased by one for each FGS enhancement layer.

In this paper, we propose an active dropping mechanism which is dropping packet according to the network loading presently and different user level. If the network loading exceeds the threshold, the dropping mechanism starts to drop the enhancement layer data for low level user and the dropping probability is varying with the different network loading.

IV. SIMULATION

A. Simulation model

Figure 4 depicts the 802.16e point to multi-point system that is simulated in this study. The system consists of a multimedia server, one Base Station (BS) and several Mobile stations (MS). The connection between video server and BS is an IP-base network. Users (MS) receive the video stream form the video server through the connection between BS and MS. For video transmission, we chose the RT-VR service flow between the base station and mobile station.

Table 1. The average bit sates of the SVC bit stream at different spatial-temporal –quality layer.

Format	Bit rates (kbit/sec)				
QCIF 15Hz	96	112	128	160	192
CIF 7.5 Hz	192	224	256	320	384
CIF 15 Hz	256	320	384	448	512
CIF 30Hz	384	448	512	640	768

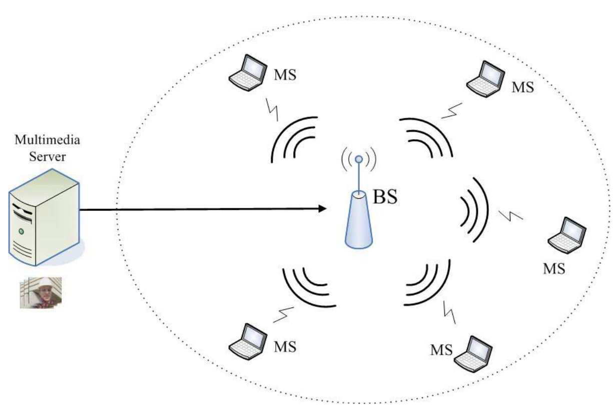

Figure 4. the point to multi-point system.

The video streaming is encoded by scalable extension of H.264/AVC in this study. For the video server, we provide several spatial and temporal resolutions. In those resolutions, the Quality layer consists of three layers which is one base layer and two enhancement layers. In the study[15] , the scalable bit-streams are generated by scalable H.264 / MPEG-4 AVC extension with the SVC coding structure. Table 1 shows the average bit rates in each spatial-temporal resolution.

In the simulation, the 802.16e-2005 OFDMA-TDD mode is used. The bandwidth is 5 MHz and the FFT size is2048. From the standard [13] we can calculate the OFDMA parameters. The results of calculated parameters are shown in Table 2.

Table 2 The parameters of 802.16e PHY layer

Parameters	Value
Channel Bandwidth	5M (Hz)
Used of sub-channels	60
Size of FFT	2048
Symbol time (Tb)	358.4μs
Guard time (Tg)	44.8μs
OFDMA symbol time (Ts=Tb + Tg)	403.2μs

In the base station, the base station will drop enhancement layer information from the queue when the network loading over the threshold. As the followed, we set two conditions which represent the two stage network loading threshold.
When the network loading exceed this thresholds, the active dropping mechanism will be used. The first stage threshold is setting with network loading in ***p*** percent and the second threshold is ***q*** percent. The active dropping mechanism is shown in this equation.

$$\text{Dropped data} = \sum_{i=1}^{3} Pi * quality\_i \qquad \text{equation(1)}$$

where quality_i represents the video stream Quality layer. The base layer is assigned to quality_1 and others quality_i is standing for its enhancement layer. In this study, the video server encodes the video to one base layer and two enhancement layers. The *P*i is the probability which representing the data should be dropped or not. $P1$ is equal to zero before the network loading exceeding 95% because we guarantee the basic video quality for user. The network and video quality become unstable when the system loading is exceeding 95%. The first level enhancement data is dropped by the probability of P2 when the network loading is exceeding the first level threshold.

$$P2 = \begin{cases} 0 \quad , & 0 \le x \le p\% \\ 0 < \dfrac{x-p}{q-p} < 1 \, , & p\% < x \le q\% \\ 1 \quad , & x \ge q\% \end{cases} \qquad \text{where}$$

The value of x is representing for the network loading. The second level enhancement data is dropped by the probability of P3. The dropping probability of second level enhancement is large than the probability of first level because the second level enhancement data is less important than the first level enhancement data.

$$P3 = \begin{cases} 0 < \dfrac{x}{p} < 1 \, , & 0 \le x \le p\% \\ 0 < \dfrac{x - p}{q - p} < 1 \, , & p\% < x \le q\% \\ 1 \quad , & x \ge q\% \end{cases}$$

By using these equations, we can calculate the dropping probability of each layer data by the network loading presently.

B. Simulation results

In the simulation, we assign three level of user priority the each user and set the value of ***p*** equal 50 and ***q*** equal 75. The highest priority users can obtain the whole video stream data include one base layer and two enhancement layers in any network loading condition. The medium and low priority users can receive the whole video data when the network loading is under the first stage threshold. When the network loading is exceeding in the first stage threshold, the medium priority users receive only one base layer and one enhancement layer data and low priority users receive only base layer data. The users(MS) accessing the video server increase by one per second and user priority is random assigned to each user. The bandwidth loading with users by priority dropping mechanism is shown as Figure 5. The normal scheme (no active dropping) can be observed that the network loading increasing with the number of users. In this case, the system of providing service for users(MS) restricts to fixed number of users because all the users receive the whole video data include the base layer and enhancement layers. In the priority scheme, the system drops the level two enhancement layer data from the buffer by the P3 probability value in equation (1) in any network loading. The level one enhancement layer data si dropped by the P2 probability value in equation (1) when the network loading exceeding in 50%.

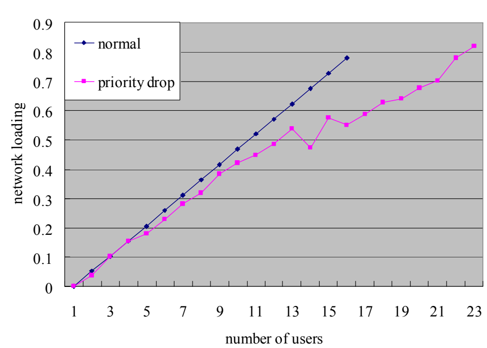

Fig5. Network loading with priority drop mechanism

Fig 6 is the simulation result by using the QoS-based active dropping mechanism. We can observe the network loading fluctuation because the active dropping mechanism is working. At the proposed system, all users can obtain better video quality when the system loading is low. The video quality for high level user is guaranteed even in the network high loading and low level users can obtain the basic video quality when the network high loading. We can use the same bandwidth to provide more users accessing the base station(BS) which means the base station has more effective system capability.

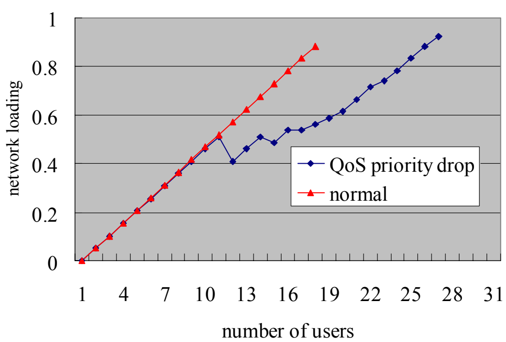

Fig 6. Network loading fluctuation with user QoS-priority drop mechanism

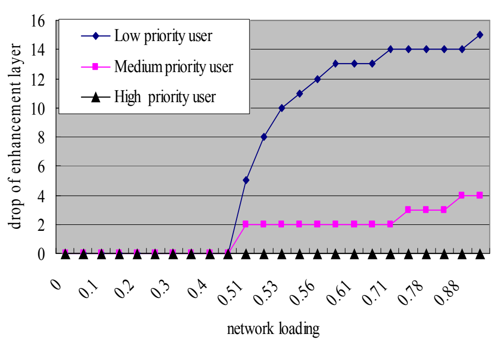

Fig 7. Drop of enhancement data with different network loading

The dropped data in different network loading as shown as figure 7. We observe the low priority and medium priority users can't receive the enhancement layer data when the network loading is exceeding the threshold, the base station releases the bandwidth which is transmitting the dropped data before.

V. CONCLUSION

The major problem in video streaming over wireless network is effective bandwidth utilization because the video quality and bandwidth utilization can not to be complete in both respects. In this paper, we study the Scalable Video Coding extension of H.264/AVC standard and video streaming in 802.16e network. A novel QoS-based active dropping mechanism is proposed and deals with the bandwidth utilization by the active dropping mechanism. The user priority is used to assign different level for each user and the priority level influence the user how many enhancement layer data can be received. The dropping mechanism works when the base station loading is exceeding the bandwidth threshold. We choose the threshold value to balance between the bandwidth utilization and video quality. By the dropping mechanism, network system can release bandwidth which is used to transmit the dropped data before and base station can support more users to access this network system. In the simulation results, we not only improve the effective bandwidth utilization and the network capability by the proposed mechanism but also satisfy the requirement of video quality for different level of user.

VI. ACKNOWLEDGEMENT

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REFERENCE

[1] Wireless LAN Medium Access Control (MAC) and Physical Layer(PHY) specifications. ANSI/IEEE Std 802.11: 1999 (E) Part 11,ISO/IEC 8802-11, 1999

[2] Amendment 8, Medium Access Control (MAC) Quality of Service(QoS) Enhancements, IEEE Std. 802.11e, July 2005

[3] IEEE Standard for Information technology— Telecommunications and information exchange between systems— Local and metropolitan area networks—Specific requirements Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications

[4] Zhang, Yuanhai; Huangfu, Wei; Xu, Jin; Li, Kaihui; Xu, Changqiao, "Integrated Rate Control and Buffer Management for Scalable Video Streaming, "IEEE International Conference on Multimedia and Expo, 2007

[5] Hsiao-Chiang Chuang; Ching Yao Huang; Tihao Chiang, "On the buffer dynamics of scalable video streaming over wireless network

[6] Bajic, I.V.; Tickoo, O.; Balan, A.; Kalyanaraman, S.; Woods, J.W.," Integrated end-to-end buffer management and congestion control for scalable video communications," ICIP 2003, Proceedings. 2003 International Conference on Image Processing Volume 3,2003, pp.257-260.

[7] Athina Markopoulou and Sangeun Han, "Transmitting Scalable Video over a DiffServ Network 2001. http://www.stanford.edu/class/ee368c/Projects/project06/index.html

[8] IEEE 802.16-2004, "IEEE Standard for Local and metropolitan area networks Part 16: Air Interface for Fixed Broadband Wireless Access Systems," June, 2004

[9] IEEE 802.16e-2005, "IEEE Standard for Local and metropolitan area networks Part 16: Air Interface for Fixed and Mobile Broadband Wireless Access Systems, Amendment 2: Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1," February, 2005

[10] Ching Yao Huang; Hung-Hui Juan; Meng-Shiang Lin; Chung-Jun Chang "Radio resource management of heterogeneous services in mobile WiMAX systems" Wireless Communications, IEEE [see also IEEE Personal Communications] Feb 2007

[11] James She, Fen Hou, Pin-Han HoAn "Application-Driven MAC-layer Buffer Management with Active Dropping for Real-time Video Streaming in 802.16 Networks IEEE International Conference on Advanced Networking and Applications(AINA'07)

[12] T.Wiegand, G. Sullivan, J. Reichel, H. Schwarz, M. Wien (Editors) "Joint draft 9 of SVC amendment (revision 2)," Document JVTV201 Marrakech, Morocco, January 13-19, 2007

[13] "Joint Scalable Video Model JSVM-5," ITU-T and ISO/IEC JTC1 JVT-R202, Jan. 2006

[14] "Joint Draft 5: Scalable Video Coding," ITU-T and ISO/IEC JTC1, JVT-R201, Jan. 2006

[15] Heiko Schwarz, Detlev Marpe, and Thomas Wiegand:Overview of the Scalable Video Coding Standard," *IEEE Transactions on Circuits and Systems for Video Technology*, scheduled March 2007

[16] Thomas Schierl, Cornelius Hellge, Shpend Mirta, Karsten Grüneberg, and Thomas Wiegand "Using H.264/AVC-based Scalable Video Coding (SVC) for Real Time Streaming in Wireless IP Networks", 2007