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Various layer techniques to improve video transmission on 20 GHz radio link in a rainy environment

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Abstract. The transmission rate via radio increases to transmitting frequency increment. The higher frequency the higher transmission rate. Video traffics require radio with large bandwidth. This requirement may be fulfilled by the use of millimetre radio transmission on 20 GHz. However, radio signal on millimetre band decreases significantly in presence of rain mainly caused by link attenuation. This paper evaluates the performance of video transmission on 20 GHz in presence of rain on tropical environment. As various layers techniques are available, some techniques such as APA, Java Servlet Alias (JSPA), Digital Subtraction Angiography (DSA) and mac-application layer scheduling are implemented to help radio dealing with rain attenuation. The evaluation results through designed simulations proves that the video quality degrades significantly to rain. The combined technique is able to increase video quality, namely; physical technique up to 0.395 dB, MAC scheduler up to 6.5dB and upper layer technique achieves 1.17 dB.

Keyword : APA, Java Servlet Alias (JSPA), Digital Subtraction Angiography (DSA), mac-application layer scheduling

1. Introduction

Millimetre band on frequency range of 20-40 GHz offers high data rate transmission [1]. Potential high data rate on non-licence frequency spectrum may be useful for terrestrial video transmission link either for public services or commercial video transmission. Video transmission for remote monitoring [2], for instance, observation of eruption of Mount Sinabung as well as traffic surveillance require unshared frequency spectrum so that high definition video can be transported.

The biggest challenge in using radio working on frequency from 20 GHz is the rain that significantly degrades the radio signal. Rain causes fading where the received signal is under receiver threshold. The received video may not be able to be decoded at this fading presence.

The matter becomes emergency as Indonesia has tropical weather where rain fall is very intense. Rain attenuation achieves 80dB for 5.7 km link on frequency 29 GHz [3]. Some techniques have been proposed [1, 3, 4, 7] to deal with rain attenuation, including the use of orthogonal multiplexing that narrowing the orthogonal carriers, by using dynamic channel allocation, power control and upper layer solutions. This paper will examine the rain impact to the video transmission on 20GHz frequency through the measurement of peak signal to noise ratio (PSNR).

2. Methodology

The intensity of the rain were measured by using Hellman measurement unit [3] which is in millimeter per hour (mm/h) and conducted in several regions that were located in Medan,Indonesia. The rain attenuation was modelled by using Equation 1, where ITU-R Rec.P.530-10 was employed for the validation [3].

$$A = \int_{o}^{L} aR(x)^{b} dx \tag{1}$$

The radio was assumed to use orthogonal frequency division multiplexing (OFDM) as it is currently the most effective technique. The slotted model of the radio frame was shown in Figure 1 [7]. Uplink and downlink frames were assumed at the same length, which bandwidth request of piggybacking mechanism was assumed to be allocated in a specific channel.
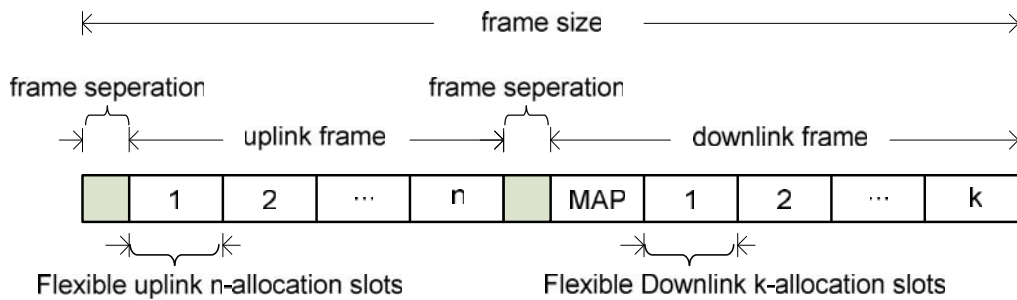

Figure 1. OFDM model

The evaluated video traffics were generated by using Akiyo cif video traces [8] with various starting point in every simulation iteration. The peak signal to noise ratio (PSNR) was used to measure the video quality [10]. The PSNR calculation was modelled by using Equation 2 approximation, $\varphi_{i,m}$ is the received bytes of the mth I-frame, $T_{i,m}$ is the transmitted bytes and Max_I is the maximum PSNR.

$$PSNR = \frac{\sum_{m}(\frac{\varphi_{i,m}}{T_{i,m}} Max\_I) + \sum_{n}(\frac{\varphi_{p,n}}{T_{p,n}} Max\_P)}{m+n} \tag{2}$$
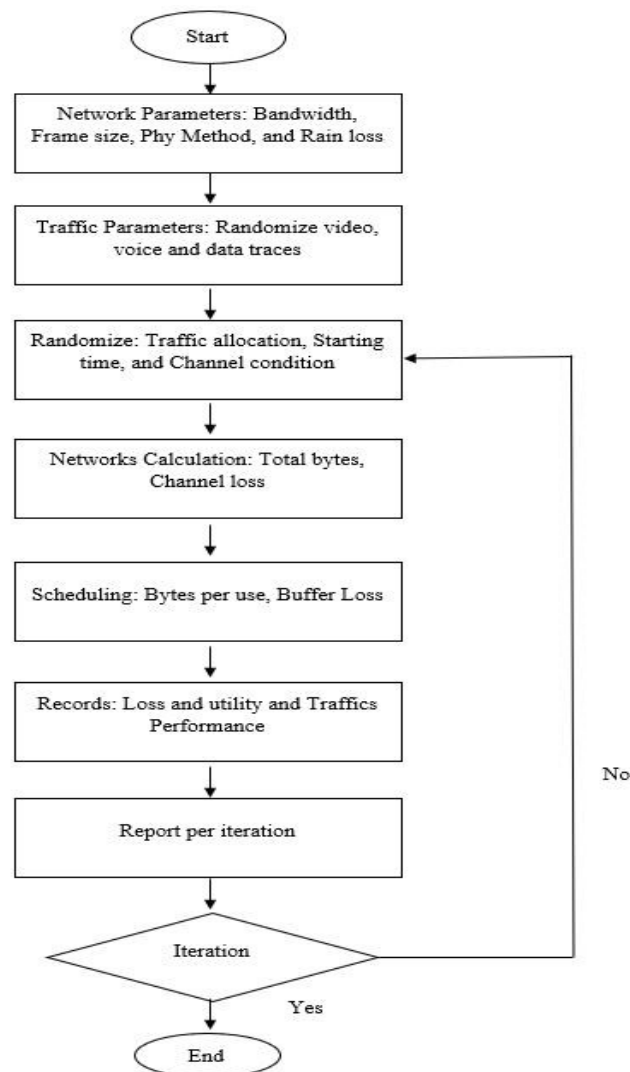
Figure 2. The simulation design flow diagram

Figure 2 shows the simulation flow. Radio transmission time was divided into some transmission slots. The rain loss and the possible available bandwidth are approximated by hundreds iterations. In each iteration every node has random starting video. Nodes transmit the bytes according to the allocated bandwidth. Channel introduces link loss, base station introduces buffer loss. Both losses recorded, the total of successfully received bytes within the same allocation frame were calculated. Network utility and total loss were then determined. Number of mobile users and the total bandwidth were randomly chosen based on the fact that the generated traffics are low bit-rates. Mobile users were set from 5 to 35 and bandwidth 1 MHz which results maximum 10 Mbps in clear sky.

3. Results and discussion
Simulations run for a-thousand iterations, record the successful bytes and calculate the PSNR. It was found that the rain degrades the radio signal, hence, will resulting the video quality decreased by 0.73 dB in average. The APA, DSA and JSPA techniques [3] are then applied and the improvements of the video quality about 0.19dB, 0.4 dB, and 0.39 dB were observed subsequently. The upper layer

scheduling techniques such as round robin (RR), first in first out (FIFO), minimum signal to noise ratio (mSNR), PF and BABS scheduling [5] are then used to prioritize frame transmission when the link is better. Figure 3 below shows the overall PSNR improvements. The DSA combination to these scheduling resulting various achievements where the FIFO technique increase the quality about 0.08 dB, mSNR technique improved about 8.3 dB, and both of PF and BABS techniques enhance about 2.75 dB and 8.32dB.
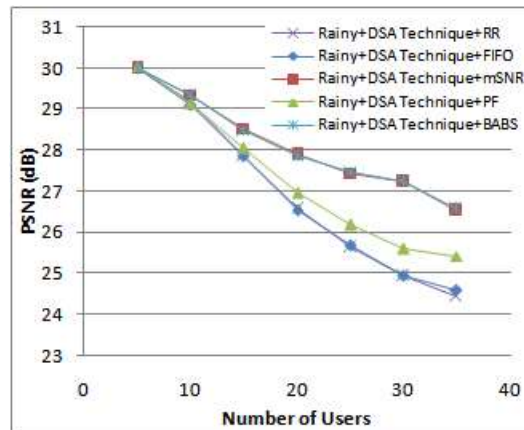

Figure 3. Various techniques impacts

4. Conclusion

This paper has assessed video quality degradation to rain presence in 20 GHz video transmission. The PHY and MAC techniques such as APA, JSA and DSA increase quality at most 0.4 dB.by prioritizing frames (application layer) using mac scheduler which means mac-application layer technique, increasing video quality significantly. The mSNR and BABS frame scheduling's produce up to 8.3dB improvement.

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