Combination Benefits of Short-Time Diversity and Adaptive Satellite Power Control

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***Abstract*—The next generation of satellite will be operated in the higher frequency bands. Rain attenuation will become in front to degrade the satellite signal. In this paper, time diversity method and adaptive satellite power control method are combined in order to mitigate the rain attenuation by using rain radar data over Japan. However, due to the effectiveness of time diversity method and small behaviors of rain in Japan, a short time delays and a few power boost beam are evaluated. The performance of the system presents by the diversity gain, and these two systems are compatible well.**

Keywords—Time diversity; Adaptive satellite power control; Rain radar data.

I. Introduction

Time diversity is one of the most powerful method to mitigate the rain attenuation, especially satellite communication at higher frequency, such as Ka band and above. Since the time diversity has been proposed by Fukuchi [1], [2] and many authors has been researched [3], this technique is never practically used due to it cannot be used in the real time communication. In this decade, the adaptive satellite power control [4] has more studies in order to service in the specific areas hit by rain or the particular cases such as disaster. With the same time, the increase of various contents used in the satellite communication becomes apparent. As this reason, the time diversity method will be the best solution to provide the contents that do not require a real time.

In this paper, we evaluated the performance of time diversity and adaptive satellite power control combined together in order to counteract the rain attenuation for wide areas or specific cases or even to support any services.

II. Simulation Data

This paper used rain radar data over Japan provided by Japan Meteorological Agency. The rain radar data are available every 5 minute and 1 km mesh point. This study considered data from July 2009 to June 2013. For time diversity method, we applied time diversity of 10 and 20 minute delays. For adaptive satellite power control method, we used 2 boost beam numbers and 2 boost beam sizes which are 50 and 100 km. Boost amount is fixed at 10 mm/h or approximated equal to 5 dB evaluated at 22 GHz band. Moreover, we set the boost beam without overlapping each other.

III. Rain Intensity Map Results

In order to derive rain intensity according to the ITU recommendation (ITU) P. 618-11 [5], a cumulative time percentage of 0.1% over Japan was used, and the result is shown in Fig. 1. The value of 0.1% indicates 99.9% service availability each year. The value of 0.1% is a proper value for link calculations designed in the higher frequency bands as the Ka or above. The result show that high rain intensity appeared in the south and along the east coast more than 20 mm/h for cumulative time of 0.1%.

Moreover, a time diversity simulation was conducted in which information was transmitted twice with delay times. Due to the behaviors of rain in Japan is a very small rain rate if compared with other tropical regions. This work collects the time delay of 10 and 20 min in order to evaluate for a short recovery time. After that, we applies the adaptive satellite power control method to increase power margin by using 2 beams with 50 and 100 km of boost beam sizes. The adaptive satellite power control can be used for a specific areas within boost size areas and boost amounts.

Fig. 2 illustrate the rain intensity of 10 minute delay with a cumulative time percentage of 0.1% and it shows decreased rainfall rate clearly which means we can receive more power. As the result, time diversity method shows it is very effective and useful solution to counteract the rain attenuation and so more benefit if the time delay is longer.

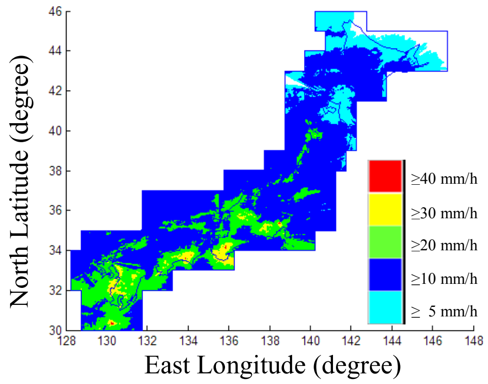

Fig. 1. Rain intensity observed for P = 0.1% of cumulative time with no time delay and no boost beam.

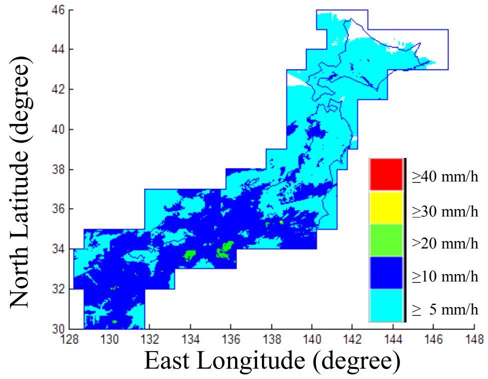

Fig. 2. Rain intensity observed for P = 0.1% of cumulative time with only time delay of 10 minute.

IV. Diversity Gain

The performance of time diversity is expressed by diversity gain as well as the adaptive satellite power control. Fig. 3 illustrates place observation across Japan with a cumulative time percentage of 0.1% by summarized rainfall rate as histogram in scatter plots. A trend of diversity gain of 10 minute delay show significantly increased with a maximum diversity gain (straight line). From our results, a trend of diversity gain will increases proportion to the increased of time delay.

We accumulated from the place observation across Japan to place rate percentage as shown in Fig. 4. This results shows a cumulative plot of 10 and 20 min delays and with boost beam case -11- where –nm- indicates that n in boost beam number and m is boost beam size (1:50 km, 2:100 km). If we considered at 50% of place rate, a 10 min delay is very effective and get the diversity gain of 6.8 mm/h. Then, we applied boost beam case -11- after delay the time, the diversity gain is increased a bit to 7.5 mm/h due to just a specific small areas are boosted. For 20 min delay and with boost beam case -11-, the diversity gain are increased, respectively.

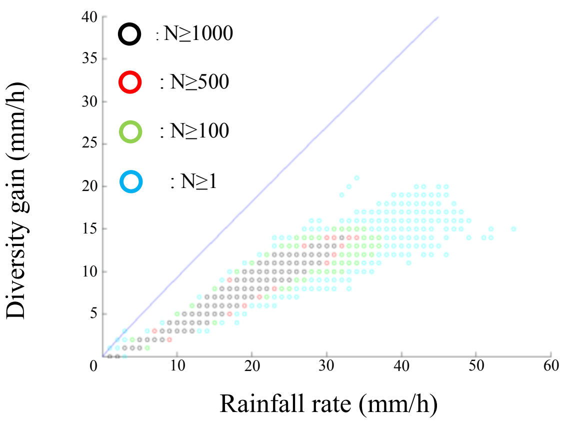

Fig. 3. Place observation for P = 0.1% with only time delay of 10 minute.

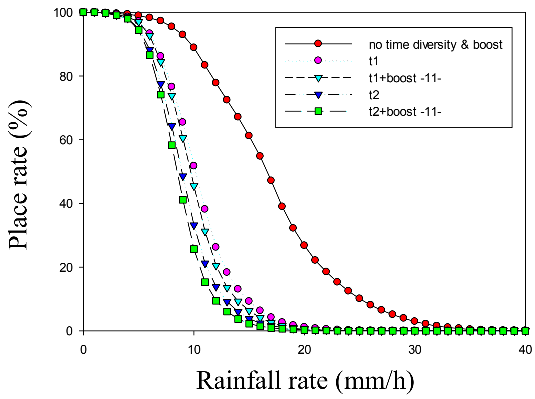

Fig. 4. Cumulative place rate percentage for P = 0.1% of time diversity and adaptive satellite power control.

V. Conclusion

This paper evaluated the performance of time diversity method combined with adaptive satellite power control method from rain radar data over Japan to recover the satellite availability. Just only time diversity method shows a very good results from short to long time delays respectively, but in order to reduce a recovery time, a short time delay is chosen and help by adaptive satellite power control method to increase diversity gain. From this evident, I think the combined techniques will be helpful for the tropical region or the countries where faced a large rain attenuation.

Acknowledgment

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