Accuracy improvement of Spatio-Temporal information with GPS scintillation

IS-01Accuracy improvement of Spatio-Temporal information with GPS scintillation

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1. Introduction

GPS (Global Positioning System) has been received much attention as means for acquiring accurate position and time information. Information obtained from GPS is already widely employed for communication control field and the range of its application is also expected to expand rapidly in the future. However, the accuracy of position and time information acquired by GPS has a potential to be inherently deteriorated due to GPS scintillation problem. As a result, the accuracy of communication control will be also likely to be affected severely.

Therefore, in this study, we investigate the correlation between the huge amount of GPS information (i.e., big data) and the ionosphere environment, and then propose a new criterion enabling to predict its impact in advance.

2. GPS scintillation

Unstable electron density region of the ionosphere inherently increases the propagation delay, which is widely referred to as the GPS scintillation. As a result, not only the accuracy of time synchronization but also the calculated location information get worse.

The unstable ionosphere is roughly caused by two main factors. The first one is solar flares (activation of solar activity), while the second one is the increase of galactic cosmic rays (declining solar activity). We should note that the GPS scintillation of unprecedented magnitude may occur in the minimum period corresponding to the Maunder minimum period of about 200 years ago, as shown in Fig. 1.

3. Simulation

In simulation, we assumed an environment where a handover is handled based on GPS location information as an example. The simulation model is shown in Fig. 2.

The STA5 moves from the location just under the AP1 to AP2. At this time, if an error occurs in the position information, STA5 could not execute a handover at an appropriate position and connects to an inappropriate AP. Therefore, we examined how the error of position information due to GPS scintillation of the moving STA5 affects the communication quality of all STAs.

4. Simulation result

As shown in Fig. 3, although the throughput of STA5 (moving STA) is deteriorated due to the GPS location error, other STAs (not moving STA, e.g., STA1 and STA2) also suffer from the degradation of throughput performance. This indicates the occurrence of a phenomenon called a performance anomaly (PA) problem.

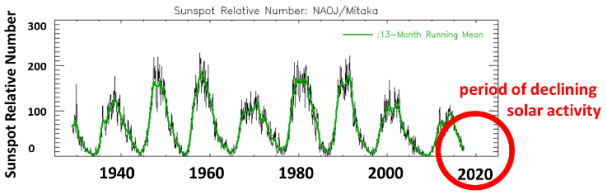

Fig. 1:Solar activity repeating at about 11 years cycle[1]

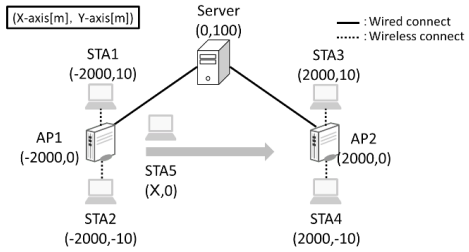

Fig. 2:Simulation model

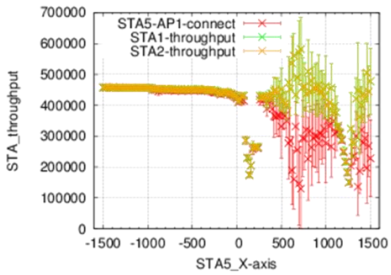

Fig. 3:Simulation result

5. conclusion

In this paper, we investigated that GPS scintillation affects not only the STA with location error but also all of other STAs belonging to the same network in the environment.

However, the existing studies focusing on GPS scintillation is limited to the long-term measurement at the fixed points. That is, time correlation can be verified, but spatial correlation can't be verified.

Therefore, we plan to utilize big data collected from the huge amount of GPS devices and the detailed ionospheric data obtained from the LEO Environments Observation Satellite to be launched next year.

Finally, we will investigate the correlation between the GPS big data and the ionosphere observation data, and then will propose a new indicator that can precisely estimate the GPS location even with the severe scintillation.

5. Reference

[1] Solar Science Observatory, NAOJ Mitaka Facilities
http://solarwww.mtk.nao.ac.jp/jp/database.html, (2018/8/6)