A New Navigation System Based On Spatial Internet Satellites

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Abstract

Low-cost small satellites in low earth orbit are utilized to build spatial internet, which is gradually formed and put into practice. In this paper,a new type of low Earth orbit satellite navigation system is put forward based on the internet satellites. The core of the program lies in the use of GNSS receivers on the internet satellite and inter-satellite links to predict the accuracy orbit information and time synchronization reference, which could be used to generate navigation messages[1]. Through the existed downlink to broadcast signal, the ground users will take the advantage of communications and location information, thus to achieve fast acquisition and precise positioning.

Keywords

Payload, GNSS, Low-orbit Satellite.

1. Introduction

Google plans balloon network to extend internet reach, and then plans to spend more than $1 billion on satellites to offer internet access worldwide from space. SpaceX announce plans to provide Internet access through a global network of about4000 satellites starting within five years.Samsung Electronics discuss a Low Earth Orbit (LEO) satellite system capable of carrying a total at least one Zetabyte/month data traffic by employing thousands of high capacity micro-satellites, each operating at Tb/s or higher data rates.It is foreseeable that low Earth orbit satellite constellation will build the new style Internet, which will create a tremendous impact on the access to network, andsolve the coverage problem.

In this paper, navigation system based on spatial Internet satellites (NSSIS) is proposed. Firstly, the constellation simulation is analyzed, where the coverage and visibility are discussed. Then, the satellite payload are designed where the basic construction is illustrated. At last, the analysis of the ground receiver resources describes the advantages of the ground terminal.

2. System Analysis

The key viewpoint of proposed NSSIS is utilizing the GNSS receivers and inter-sat links in the space Internet satellites to obtain the orbit information and accuracy time, generating the navigation message and broadcasting the related message to the ground terminal. The basic schematic diagram is shown in Fig. 1.

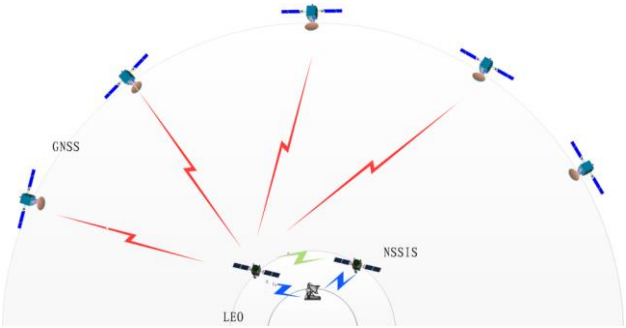


Fig.1 Diagram of NSSIS

According to the presented plans of space Internet satellites, the number of satellites is counted by the thousands. The altitude of orbit is concentrated upon 1000 kilometers. The simulations are based on these constraint conditions. Here the constellation is consisted of 400 satellites distributed in 20 tracks, which is shown in Fig. 2.

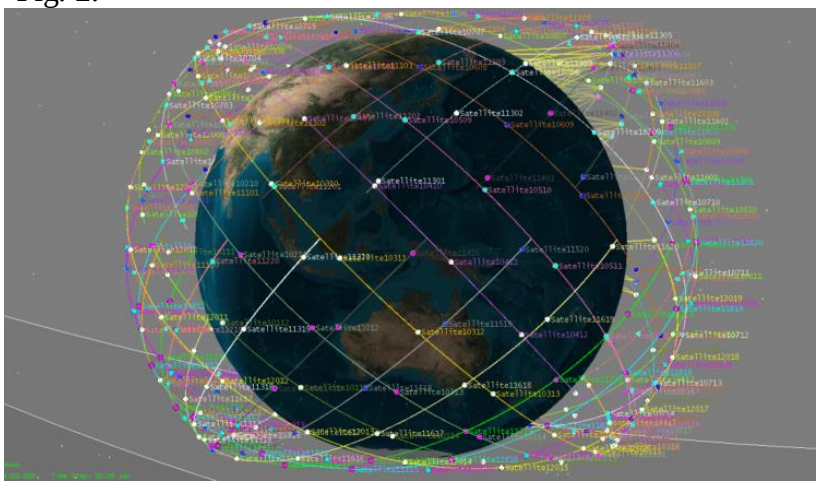
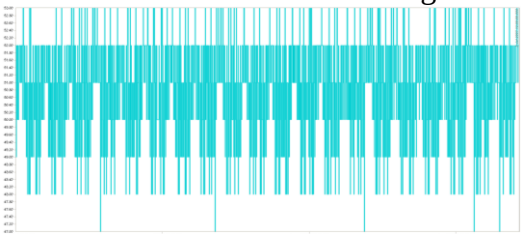
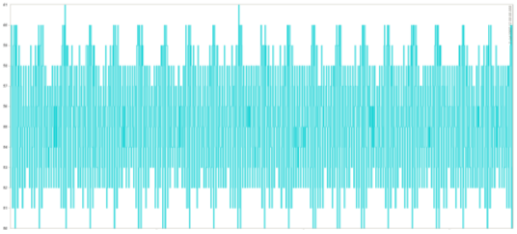


Fig.2 Simulation of NSSIS constellation

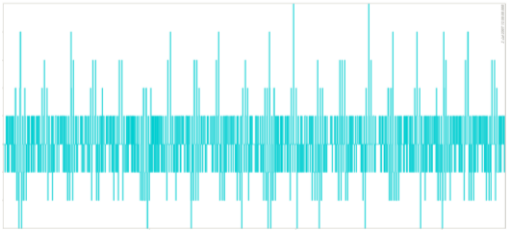
In NSSIS, the downlink is used to broadcast navigation signal. Supposed that the beam rang of downlink antenna in satellite is 0.1 degree, and the beam rang of receiving antenna in ground receiver is 40 degree. In the simulation the ground receivers are respectively located at latitude 0, 10, 20,30, 40, 50, 60 and 70. The visibility simulation between satellites and ground receivers is shown in Fig. 3.



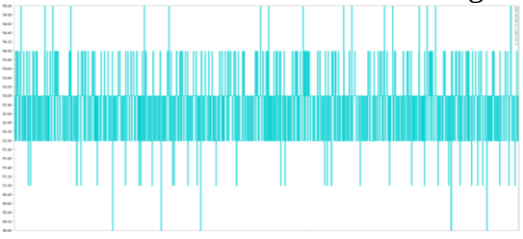
(a) Ground receiver at latitude 0 degree



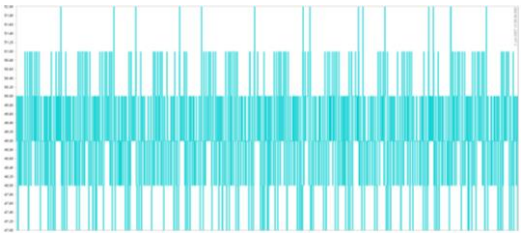
(b) Ground receiver at latitude 10 degree



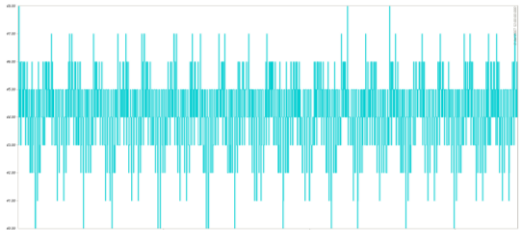
(c) Ground receiver at latitude 20 degree



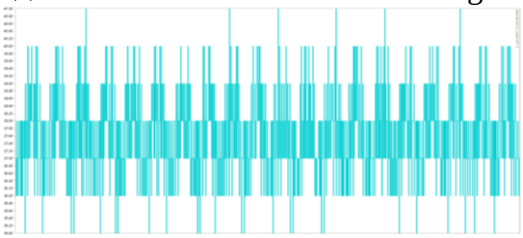
(d) Ground receiver at latitude 30 degree



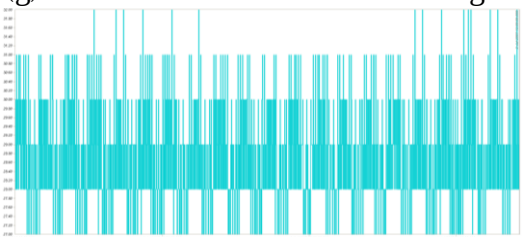
(e) Ground receiver at latitude 40 degree



(f) Ground receiver at latitude 50 degree



(g) Ground receiver at latitude 60 degree



(h) Ground receiver at latitude 70 degree

Fig.3 Visibility simulation between NSSIS satellites and ground receivers

For ground receivers, there are at least dozens of visible satellites, which is better than GPS, GLONASS, Gallieo, Beidou II, even the combination of them.

In addition, the satellite's core function is to meet the requirements of communications, so its signal strength will be higher than GNSS satellites. Taking signal strength into account, ground users will get more accuracy measurements

3. Satellite Equipment

For Internet satellites, the basic payload includes: upward communication link, down communication links, integrated processing unit and inter-satellite communications links. In order to achieve the low-orbit accurate navigation, at least the payload should include GNSS receiving link. The basic composition is shown in Fig. 4.

Diagram description is as follows:

At least 4 GNSS antennas are needed, which will obtain sufficient observations. Utilize Kalman filters to predict precise orbital information.

Use the received GNSS signal to achieve time synchronization and create time reference;

To determine satellite attitude by multiple antennas, here the gyroscopic sensors could be introduced.

The locations of ground users are based on broadcasting signals, which require the satellites should determine the healthy status promptly and give the integrity information in time.

Generate navigation message by observation information and uplink message, and broadcast navigation message by downlink.

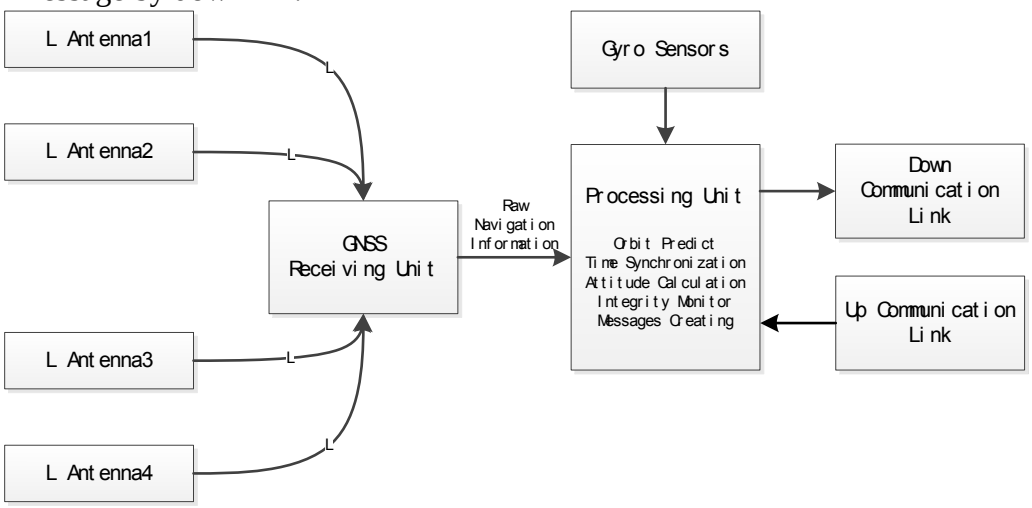


Fig.4 Workflow of payload

4. Ground terminal

From the view of hardware design, terminals of Internet satellites can be directly used for ground navigation. The terminals calculate position results by the pseudo ranges, which is similar to the GNSS receivers. Besides that, the ground terminal of NSSIS will get more information of communications, which will effectively reduce the capture time.

Conclusion

Based on the spatial internet satellites, this paper proposes a new type of low Earth orbit satellite navigation system. The characters of internet satellites constellation is discussed and the integration of navigation is put forward.With the development of the spatial internet, the user network access mode will revolutionize. Meanwhile the combinations of navigation and internet will provide high-level capability of navigation service.

Reference

[1] Khan F. Mobile Internet from the Heavens[J]. arXiv preprint arXiv:1508.02383, 2015.