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An Empirical Performance Study of IRNSS S-band Signals under Wi-Fi Interference

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Abstract

The IRNSS receiver receives dual frequency information on L-band (1164.45 – 1188.45 MHz) and S-band (2483.5-2500MHz) frequencies [1]. Since the license free 2.4GHz S-band is highly populated with various other signals from terrestrial sources using Wi-Fi and Bluetooth, IRNSS S-band signals are therefore more vulnerable to Radio Frequency Interference (RFI) from these sources [2]. This paper investigates IRNSS S-band signal performance in the presence of terrestrial Wi-Fi signals.

1. Introduction

IRNSS is an independent regional navigation satellite system designed, developed and controlled by the Indian Space Research Organization. It is designed to provide two types of services, the Standard Positioning Service and the Restricted Service. IRNSS is a constellation of 7 satellites with three geostationary satellites located at 32.5º E, 83º E and 131.5º E and 4 geosynchronous satellites having their longitude crossings 55º E and 111.75º E (two in each plane) [3][4][5]. The system provides PVT observables under all weather conditions and promises a position accuracy of less than 20 m [6][7][8][9]. The IRNSS transmits dual frequency position information on L5 and S1 frequency bands. The S-band signal of IRNSS uses similar frequencies as that of any terrestrial S-band signal source using Wi-Fi and Bluetooth. Thus they are vulnerable to Radio frequency interference from these sources. In a typical network of devices communicating through Wireless Fidelity (Wi-Fi), some non-network devices, such as microwave ovens, car alarms, cordless phones, or wireless video cameras can interfere with the wireless channels. Most of such devices use the 2.4-GHz frequency. Interference would result in network slowdown. In situations with low capacity data transmission if the interference is intermittent, the slowdown might not be immediately obvious and with retransmissions, packets eventually get through. Therefore, in such cases the retransmissions that take more time, but there is no packet loss. Problems arise when more users log in, increasing the required data capacity and in such cases data loss occurs. Also Voice over IP (VoIP) calls requiring larger bandwidth result is dropped or jittery voice transmission in an interference prone environment. Similar situations would arise when the IRNSS S-band signals are received in the midst of a network of Wi-Fi devices. It is expected that interference would be caused degrading both the IRNSS signal quality as well as the Wi-Fi signal quality. Investigations on degradation of the Wi-Fi signal are not part of the scope of this paper and maybe taken up later. In this work it is proposed to study the performance of IRNSS S-band signals in the presence of Wi-Fi interference.

2. Wi-Fi Interference Generation

It is an already established fact that two devices do not experience any mutual interference either if they are operating near each other, but on very different frequencies, or if they operate on the same frequencies, but out of range from each other [10]. In order to study the IRNSS S-band signal performance in the presence of Wi-Fi interference it was necessary to generate such interference. Artificial simulation of wireless signals near the 2.4 GHz frequency would not be able to present the real picture. Therefore, it was proposed to generate interference using real time Wi-Fi signals from different terrestrial sources.

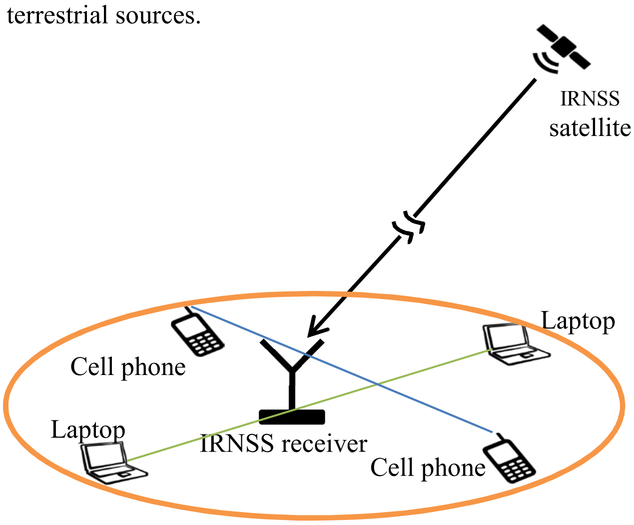

Figure 1. Interference created by terrestrial Wi-Fi signals on IRNSS S-band signals

The more common sources of W-Fi signals in today's world are laptop computers and cellphones. The experimental set-up used to generate interference and study the IRNSS signal behavior is as shown in Fig. 1. Dual frequency IRNSS receivers installed at CBIT, Hyderabad were used for carrying out experiments reported in this work. To ensure minimal interference from the surrounding environment, all the experiments were conducted at an altitude of approximately 20m. The IRNSS receiver antenna receiving open sky signals from IRNSS satellites was placed in the centre of the experimental setup as is shown in Fig.1. In the near vicinity of the antenna (at 0.3m from it) were placed different component sets to generate and receive Wi-Fi signals. Two different component sets or Interference Device Sets (IDS) were used to generate different amount and category of Wi-Fi interference. IDS 1 uses a pair of laptops which communicate using Wi-Fi signal and data is transferred from one laptop to the other in order to generate interference. IDS 2 uses a pair of cellphones which also communicate using Wi-Fi signal and data is transferred from one phone to the other in order to generate interference. Both IDS 1 and 2 use popular data sharing software to communicate using Wi-Fi.

3. Results of Experiments

3.1 Case-I

The IRNSS receiver antenna and the IDS 1 are placed in an outdoor environment ensuring clear visibility of satellites. The IDS are placed at opposite sides of the antenna in the same plane approximately 0.3m away from it (ensuring presence in the near field region). Using this arrangement, the dual frequency C/N measurements for IRNSS 1C on 23 Oct 2017 for the first slot of around 46 minute (2787 seconds) duration are shown in Fig. 2

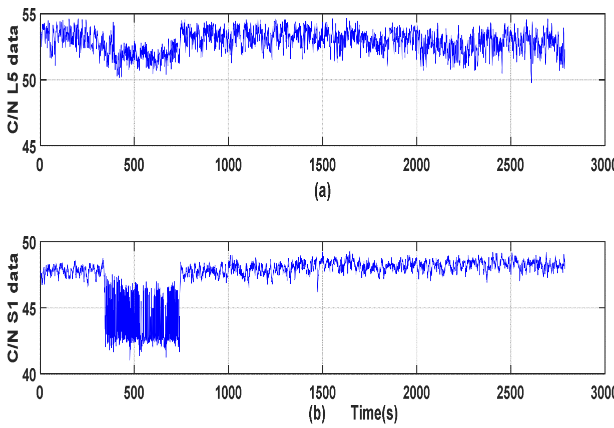

Figure 2. C/N measurementsof Case-I for IRNSS 1C on 23th october 2017 for a) L5 frequency b)S1 frequency

It is observed that the L5 signal strength oscillates between 54 and 51 dB-Hz while the S1 signal strength oscillates between 46 and 48 dB-Hz approximately at the beginning of the experiment. The IDS is introduced between 331 and 746 seconds. There is a sudden change in the trend of the S1 signal strength and the variation is much larger (48.55 to 41.68 dB-Hz) during this period. Beyond this time period, the signal retains its normal trend. It is interesting to note here that the L5 signal too shows a change in trend between 393 to 743 seconds. However, the variation of L5 signal is much lesser (between 50 and 52.8 dB-Hz).

3.2 Case-II

The IRNSS receiver antenna, IDS 1 and IDS 2 are placed in an outdoor environment ensuring clear visibility of satellites. The IDS are placed at opposite sides of the antenna in the same plane approximately 0.3m away from it (ensuring presence in the near field region). Using this arrangement, the dual frequency C/N measurements for IRNSS 1C on 23 Oct 2017 for the second slot of 50 minute duration are shown in Fig. 3. IDS1 was introduced into the experiment at 283 seconds. There is no major change in the trend of L5 signal strength immediately after this but S1 signal strength drops down from 48.78 to 40.75dB-Hz. It oscillates in this range until IDS 2 is introduced (while IDS 1 is still transmitting) at 1891 seconds. At this point the S1 signal drops from 47.83 to 33.57 dB-Hz. Beyond this there are rapid fluctuations in the S1 signal from as high as 47dB-Hz to as low as 32dB-Hz. At 2057 seconds both IDS 1 and IDS 2 are removed and the S1 signal regains its original trend by 2060 seconds. It is also observed that between 1161 and 1352 seconds both L5 and S1 signal show a change in the trend of signal variation. This may be attributed to ambient disturbances external to the experimental setup. The S1 signal regains its trend soon after this phenomenon but L5 signal takes longer to regain its trend.

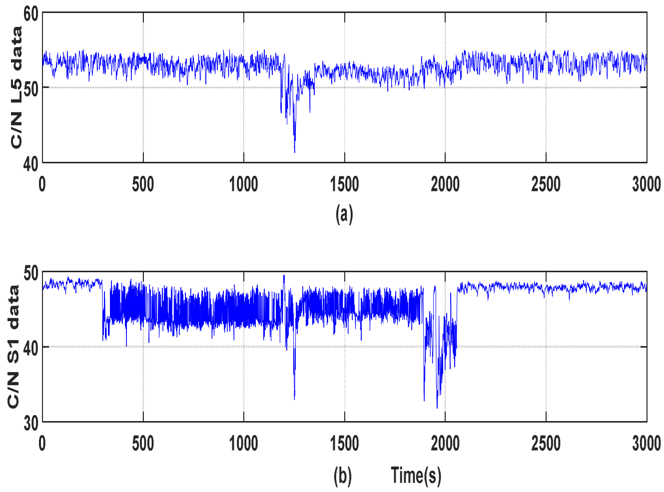

Figure 3. C/N measurements of Case-II for IRNSS 1C on 23rd october 2017 for a) L5 frequency b)S1 frequency

4. Conclusion

It may be concluded that the Wi-Fi signals generated by the IDS 1 and 2 interfered largely with IRNSS S-band signals and the L-band signals were much less affected. The kind of interference was majorly destructive on the S-band signal strength where the level of destruction increased as more number of IDS came into play in the vicinity of the IRNSS antenna. It was also verified that once the IDS were removed the S-band signal gained its original strength. Similar observations were made for other satellites and at different dates. This is very significant since it shows that S-band signal is definitely not as robust as the L5 signal in an interference prone environment. In the fast moving present day world it is very difficult to imagine life without a Wi-Fi network. The experiments in this work definitely prove that in a real time scenario, with laptops and cellphones around the IRNSS antenna, S-band signal would deteriorate and thus degrade the position accuracy of the IRNSS. The interference to S1 frequency signals of IRNSS from terrestrial S-band Wi-Fi signal sources definitely needs to be mitigated. This will form the future scope of this work. The proposed S-band signal reflector in [2] could also significantly attenuate the S1 frequency signal allowing precise position computation using the L5 band signal of IRNSS.

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6. References

1. ISRO (2014) “IRNSS Signal In Space ICD for Standard Positioning Service”, v. 1.0, June 2014, ISRO IRNSS- ICD-SPS-1.0, Indian Space Research Organization, Bangalore.

2. Uttama Ghosh , A.D. Sarma , Mohd Qurram Javeed , N.V. Koteswara Rao, “Selective Suppression of IRNSS S-band Signals for Specific Applications,” IEEE International WIE Conference on Electrical and Computer Engineering (WIECON-ECE) December 2017, pp. 18-20, doi: 10.1109/WIECON-ECE.2017.8468869.

3. S. Shivakumar and Indian delegation, "IRNSS Satellite Navigation Program," Proceedings of the 49th Session of UNCOPUOS-STSC (UN Committee on the Peaceful Uses of Outer Space-Scientific and Technical Subcommittee), Vienna, Austria, Feb. 6-17, 2012, URL: http://www.oosa.unvienna.org/pdf/pres/stsc2012/tech-43E.pdf

4. Anand Dwivedi, "Indian Regional Navigation Satellite System- An Overview," United Nations International Meeting on the Applications of Global Navigation Satellite Systems, Vienna, Austria, December 12-16, 2011,URL:http://www.oosa.unvienna.org/pdf/sap/2011/un-gnss/05.pdf

5. "GAGAN and IRNSS Satellite Navigation Program," Proceedings of the 50th Session of Scientific & Technical Subcommittee of UNCOPUOS, Vienna, Austria, Feb. 11-22,2012,URL:http://www.oosa.unvienna.org/pdf/pres/stsc2012/tech-43E.pdf

6. G Madhavan Nair, "Satellites for Navigation," Press Information Bureau of the Government of India, Aug. 8, 2006, URL: http://www.pibbng.kar.nic.in/feature2.pdf

7. D. Gowrisankar, S. V. Kibe, "India's Satellite Navigation Programme," APRSAF-15 (15th Session of Asia-Pacific Regional Space Agency Forum) Hanoi, Vietnam, Dec. 9-12, 2008, URL: http://www.space.mict.go.th/activity/doc/aprsaf15_17.pdf

8. Surendra Pal, A. S. Ganeshan, K. N. S. Rao, L. Mruthyunjaya, "Indian Regional Navigation Satellite System," Proceedings of the 58th IAC (International Astronautical Congress), International Space Expo, Hyderabad, India, Sept. 24-28, 2007, IAC-07-B2.1.01

9. Parimal Majithiya, Kriti Khatri, J. K. Hota, "Indian Regional Navigation Satellite System," Inside GNSS, January/February 2011, pp. 40-46, URL: http://www.insidegnss.com/auto/IGM_janfeb11-IRNSS.pdf

10. Kevin L. Mills, “Research from the National Institute of Standards and Technology”, Network for pervasive computing-computer networking, NIST special publication 500-259, July 2005