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AN INNOVATIVE APPROACH TO INTERFERENCE GEOLOCATION USING RAIN FADE

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Abstract

Satellite communication has solved the communication mystery for many applications. However, the biggest challenge in satellite communication is maintaining the transponders free of interference. The most common method of resolving interference is taking shutdown from the users while observing its effect on interference. But, in case of VSAT users, where hundreds of terminals are spread across a large area, shutdown exercise to analyze the faulty terminal is cumbersome, time taking and impractical. This paper discusses an interesting case of wideband interference and presents a novel approach to solving such interference cases using rain fade analysis.

Index Terms— **Interference, Rain fade, Satellite communication, VSAT, Wideband interference**

1. Introduction

With the increase in popularity of satellite communication, the problem of interference has also increased. Several types of interference and their sources are explained in [1]. Interference in satellite communication is a big challenge and needs to be resolved at the earliest. Most of the interference in satellite communication is unintentional and caused due to faulty terminals or unintentional human errors. Following approaches are most commonly used to solve interference problems:

A. Spectrum Analysis using a spectrum analyzer: This may give an idea of the type of interfering carrier, its modulation type, bandwidth, and nature of interference. Spectrum monitoring may help in categorizing interference into sweeping or fixed, temporary or permanent etc. This method may not always be self-sufficient to resolve interference but is always the first step.

B. A carrier shutdown exercise in coordination with the users along with spectrum monitoring: It is one of the simplest and most popular ways to identify a faulty terminal causing interference. Users of affected transponder and adjacent transponders are asked to bring down the carriers by switching the RF OFF at the HPA for a short time, to ascertain whether the interference is caused by that particular user or not. Carrier shutdown is not always feasible as users running permanent services (for e.g.: TV type services) do not agree to bring down the carriers. Also, in VSAT services, where the control is not centralized, it is quite time-taking to shutdown all terminals one by one.

C. Demodulation of the interfering carrier: If the interfering carrier is modulated, attempt may be made to demodulate the carrier and listen or view its content. This method may be used for interfering carriers with known modulation types. For instance, many a times interference is caused by FM signal picked-up by faulty cable and transmitted to the satellite along with the user carrier. It is helpful in such cases to demodulate and listen to the program on the radio to get the approximate location of transmitter as announced by the radio channel.

D. Geolocation of transmitter using a transmitter locator system or geolocation system: There are many types of geolocation systems available commercially but the most common approach, as described in [2], requires two downlink terminals to receive a reference and the interfering signal from two satellites, i.e., affected satellite and a neighboring satellite. The location of transmitter is found by the intersection of Time difference of arrival (TDOA) and Frequency difference of arrival (FDOA) of the signal from the two satellites. It is the fastest and most accurate method to solve interference problem. However, the method involves complex algorithm. Also, initially setting up the geolocation system requires many tasks, for e.g., arranging a reference signals with known coordinates, finding a suitable adjacent satellite with known ephemeris, arranging more uplinks with known coordinates for ephemeris correction of adjacent satellite, etc. Geolocation of continuous wave, sweeping and hopping type of interfering carriers is difficult. Also, it is extremely difficult to geolocate interference carriers having low signal to noise ratio, especially if the adjacent satellite is fully loaded with traffic.

Considering the difficulties involved in conventional geolocation systems, this paper discusses a new approach to localize the source of interference using rain fade analysis. Microwave signals experience attenuation due to rain. Attenuation due to rain is given by the formula:

$$A_r(dB)=\gamma * L_e$$

where γ is specific attenuation and L_e is the effective path length through rain. The method of calculation of γ and L_e is described in [3].

As the frequency increases, wavelength decreases and wavelength approaches the size of atmospheric particles (like raindrops). Thus, the effect of rain fade is predominant at frequency bands above Ku-Band. The proposed approach of interference localization can be successfully applied to these frequency bands.

2. Background

In one of the interference incidents, wideband noise interference in a satellite was spread across multiple Ku-Band transponders of the same polarization and was causing severe link degradation to many users of the satellite. It was observed that the noise floor level for all these transponders was raised by about 5dB compared to the nominal noise floor. Since, many VSAT terminals were operating in the satellite, shutdown exercise of all the remote terminals was impractical as there were hundreds of terminals operating in the affected bandwidth of the satellite. Shutdown of only the hub carriers was exercised and no correlation was found. Geolocation was also difficult in this scenario as the interference was a wideband noise, having low signal to noise ratio. Also, no suitable adjacent satellite was available near the longitude. Thus, a novel approach based on rain fade was used to resolve this issue.

3. System configuration and tools for analysis

Figure 1 shows block diagram schematic of the interference monitoring setup.

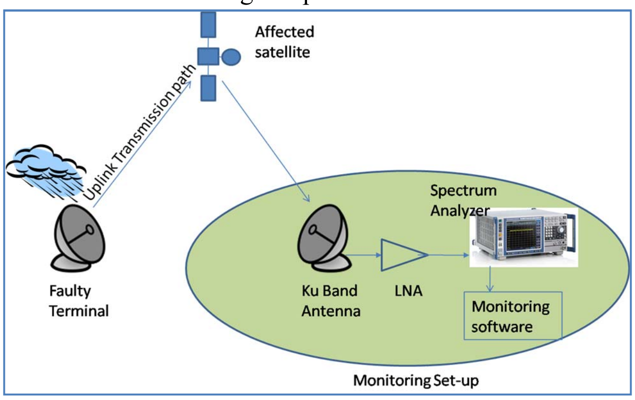

Figure 1: Block diagram schematic of the Interference scenario and analysis setup

A. Monitoring setup

The setup for monitoring included a Ku-Band antenna peaked to the affected satellite, Low Noise Amplifier (LNA), and a spectrum analyzer. The Ku-Band antenna was kept in closed-loop tracking to the satellite, to avoid signal level variations due to antenna mis-pointing.

B. Monitoring software

Through spectrum monitoring and plotting of affected transponders, it was observed that noise floor level became normal at certain times. Some carriers also used to disappear during that time. Monitoring software was used to log the data of the spectrum analyzer. The software logs the marker levels of two frequencies in each of the affected transponders. The frequencies in the software are user configurable. The frequencies were chosen so as to represent a combination of carriers and noise slots. Carriers that disappeared along with normalization of noise floor were chosen. Likewise, data was logged for all the affected channels. The software also allows viewing a line graph (Amplitude vs. Time) of the previously recorded data. Based on analysis of previous day's recorded data, if any dip was observed in the level of noise floor, the time was noted and location of all places in the coverage area of the satellite that recorded rainfall at that time was also noted.

C. Use of weather data explorer application- Real Time Analysis of Products and Information Dissemination (RAPID)

The application enables weather data access using advanced visualization capabilities. It provides access to the previous 7-day satellite data including images and geophysical parameters from Indian satellites in near real time. [4] For the analysis in this case, INSAT-3D satellite was selected and rainfall (HEM) layer of the Geophysical product was chosen. During monitoring, whenever the noise floor dropped in all the channels, the rainfall data from the site for the particular hour was compared to shortlist the possible sites of interfering transmitter.

4. Results

It was observed that noise floor was raised by 2-5dB due to interfering carrier. Figure 2 shows noise floor rise in one of the transponders.

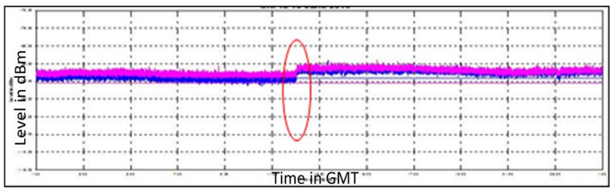

Figure 2: Noise Floor Rise in One of the channels

It was also observed that noise floor dropped at certain times. These were the times of heavy rainfall at the location of the faulty transmitter. Thus, rain fade observation over some time, could be used for identifying area and faulty terminal. Gradual drop and rise in noise floor was noted and correlated with the areas in which heavy rain was reported on the IMD site. Each time, some carriers and some areas were struck off the suspicion list. Thus proceeding, the search narrowed down to the terminals in the vicinity of Delhi and Meerut. Figure 3 shows level stability plot for all transponders during rain at Delhi and Meerut.

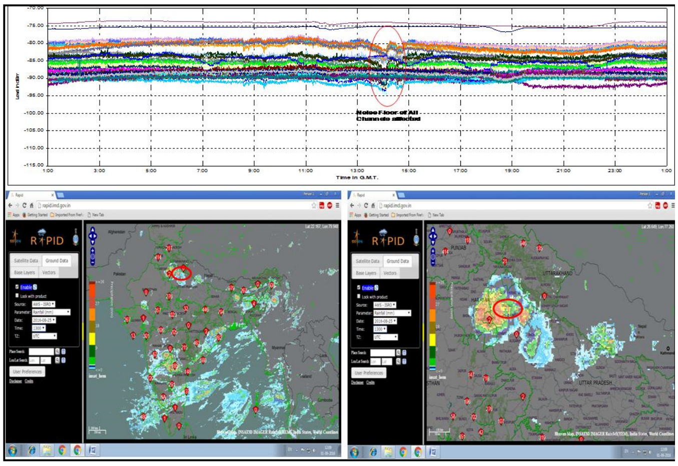

Figure 3: Level stability plot during rain at Delhi and Meerut

On another day, it was observed that level of only the hub carrier which was being uplinked from Delhi went down during rain at Delhi, but noise floor remained constant. Figure 4 shows level stability plot of one of the channels having monitoring point at a carrier uplinked from Delhi and another point at raised noise floor during rain at Delhi only but not at Meerut. Thus, by the rule of exclusion, Meerut was the possible site of uplink transmitter. The result achieved using this analysis was confirmed after coordination with users.

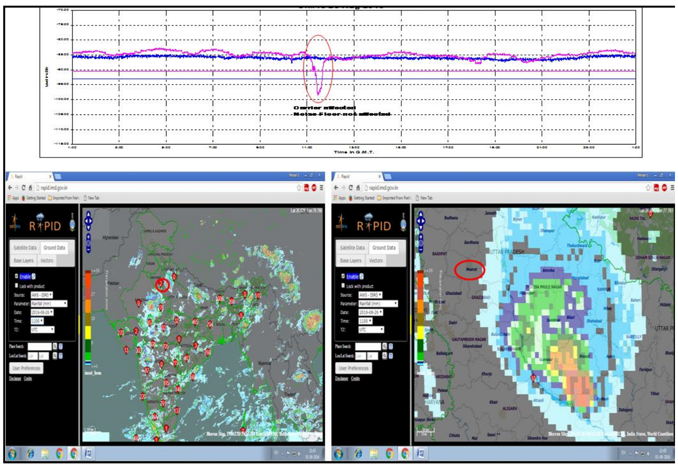

Figure 4: Noise Floor during rain at Delhi, but no rain at Meerut

5. Conclusions

After identification of approximate location of the faulty transmitter, user coordination was done to find out the possible user operating in the affected frequency band from that location. The faulty terminal was identified easily and fault analysis revealed a wideband noise pick-up at the input of TWTA to be the cause of the above interference. The method described in this paper gave successful results with fewer efforts. It does not require complex arithmetic and computation, rather depends mainly on efficient monitoring. The above method of rain fade analysis can also be applied for resolving interference due to modulated carriers and in much easier way. The monitoring for interfering carrier would be limited to the affected bandwidth. Also, depth of rain fade may be correlated with intensity of rain in different regions at that time to easily determine the transmit location of interfering carrier. Following are certain limitations of this method:

A. Even though this method can be used to resolve interference cases with uplink above 1GHz, it works more effectively for frequency bands above Ku-Band since rain attenuation is significant in higher bands.

B. The method has dependency on rain and is more appropriate for tropical climate.

C. Takes a considerably longer time than other geolocation techniques.

According to [7], 39% of all interferences are caused by VSATs, out of which 99% can be avoided if the system is designed well. Adoption of good design strategies and thorough testing before commissioning of a transmitter may go a long way in preventing such incidents in future.

6. References

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