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Interference Detection & Mitigation in Satellite Communication: Case Studies

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Satellite communication systems operating in the C-band spectrum face significant challenges from various sources of interference, compromising their reliability and performance. This paper examines multiple interference incidents encountered by the SATCOM division of ISTRAC, highlighting the diverse nature of these challenges and the methodologies employed for detection and mitigation. One prominent interference source investigated is from a WiMax base station operating in overlapping frequencies with satellite communication links operated by ISTRAC. This terrestrial interference caused continuous demodulator unlocks necessitating detailed spectrum analysis using specialized tools like spectrum analyzers to identify and characterize WiMax signals. Direction finding techniques were also deployed to pinpoint the exact location of interfering base stations. Naval surveillance radar activities near the Andaman Islands emerged as another critical interference source affecting the ISTRAC mission links, particularly at specific times during the night. Monitoring tools deployed in the station could identify periodic outages correlating with radar transmissions, prompting the integration of bandpass filters to attenuate radar signals. The advent of 5G technology introduced new challenges, with broadband noise from 5G networks penetrating satellite receive chains. Detailed downlink spectrum analysis was crucial in understanding 5G interference patterns, leading to the implementation of precise bandpass filtering solutions to mitigate these disturbances effectively. The success of these mitigation strategies restored stability to communication links, proven by improved signal-to-noise ratios and reduced error rates. FM radio interference incidents highlighted vulnerabilities in ground station equipment, where unintended uplinks of FM signals to satellite. Through appropriate demodulation techniques and coordination with regulatory bodies, identified the causing earth station and corrective measures were implemented. Additionally, emissions from VSAT BUCs posed challenges to radio astronomical observations at sensitive installations like the GMRT campus at Pune. Employing spectrum analysis and shielding solutions, emissions were effectively mitigated, preserving the integrity of astronomical data collection without compromising satellite communication operations. Throughout these case studies, continuous monitoring emerged as a fundamental practice for early interference detection and immediate implementation of mitigation strategies. Towards this, automatic interference detection using ML based techniques employing historical anomaly-free spectrum data is being explored for future implementation. Deployment of advanced bandpass filters and shielding technologies, proved crucial in mitigating interference from various terrestrial sources. Further, geo-location techniques to locate the interference transmitter through FDOA and TDOA based approaches are studied.