SATELLITE CONSTELLATION LINK TESTING

![iTrinegy logo]

NE-ONE ENTERPRISE ENABLES REALISTIC PRE-LAUNCH SATELLITE LINK TESTING

CompanyX has a vision: To fully bridge the Digital Divide by 2027, making Internet access available and affordable for everyone as, currently half the world has access to a useable internet connection while the other half does not.

To address this inequality CompanyX has embarked on an ambitious multi-billion dollar plan to develop and deploy a constellation of several hundred satellites in LEO (Low Earth Orbit) in order to provide internet access in regions of the world where the infrastructure is not readily available. However, being situated in LEO, the communications links are constantly changing as the satellites move rapidly relative to the ground terminals.

The challenge is to find a way to create a realistic test environment in which to effectively model such a dynamic network and verify that the data links are going to work.

THE REQUIREMENT

Satellites in LEO typically travel at around 17,500 mph (28,000 km/h) which makes for an extremely dynamic network environment with parameters such as bandwidth, latency and error rates changing in fractions of a second. The challenge has been to find a way to create a realistic test environment in which to effectively model such a highly dynamic network and verify that the data links are going to work before the satellites are launched into space.

The task of finding a suitable solution fell to CompanyX Senior Principal Systems Engineer, <Name Protected> who began by exploring the option of using Linux traffic control modules. However, while this initially looked like a promising path to follow, the limitations soon became apparent. <Name Protected> explains, "The problem I encountered with Linux was that there are times in the model when a user terminal is being handed off to a new beam and there are times when a satellite's ground station control is changing as well. This makes for a complex and unique IP performance simulation and while I was really close to getting what I needed with the Linux kernel module, and had even scripted and program-driven it, it just wasn't "real" enough - that's really critical to our testing, so an alternative solution was going to be required."

iTrinegy's NE-ONE Enterprise was able to mimic the links of the highly dynamic LEO satellite network

AUTOMATION

The next step for <Name Protected> was to consider DPDK-based userspace networking which he realized could potentially offer the control and flexibility to address the handover issues. This opened the possibility of using proprietary DPDK-based network emulators. However, a lack of the automation required to drive the necessary parameter changes at the speed needed to accurately simulate the CompanyX network, quickly ruled out a large percentage of products on the market. "I had looked at several network emulators but one of the problems we had with them was the APIs used - they were not dynamically drivable via scripting in the way that we needed - our system is so dynamic it would be impossible for a human to drive it - you have to have automation to drive the impairments dynamically. Other products appeared to offer the required functionality but we quickly ruled them due to their prohibitively high costs", commented <Name Protected>.

THE SOLUTION

A colleague of <Name Protected>'s who had used iTrinegy's NE-ONE Enterprise Network Emulator before, alerted him to its capability and prompted <Name Protected> to take a look, so an online demonstration was arranged. "I recognized it was a "user space app" so I knew that it should offer the flexibility and control that I thought we would need. I was impressed by the architecture that iTrinegy used in the NE-ONE Enterprise and that gave me confidence that its API would succeed where other products had failed me before. Its programmatic control would also enable us to achieve the extremely rapid network parameter changes that our testing required".

Critical to CompanyX, and a feature that iTrinegy specifically engineered into the NE-ONE Enterprise product range, is the ability to simulate the handover capability at the IP level in order to reproduce the timing required in transmission while beams and satellites are being transitioned. <Name Protected> explains, "I use the NE-ONE Enterprise Emulator to pretend I am a user terminal somewhere on Earth with a particular satellite profile which comes with many different impairments including what kind of bandwidth I get under various conditions. The handover capability is a very important impairment in doing this. It is not something I would have expected in a generally available

iTrinegy's NE-ONE Enterprise can simulate "handover" at the IP level and its programmatic control allows extremely rapid LEO network parameter changes

product so I wasn't surprised that some specific software engineering would be required". This unique feature is now a standard component of the INE product range.

The combination of the NE-ONE Enterprise's scalability features, automation and Handover capability provides CompanyX with the required test environment. As a result, <Name Protected> is able to run daily models with many different combinations of latencies, base error rates, signal strengths, power outputs and Signal-to-Noise ratios which will ultimately give particular error rates.

"With satellite communications, there's a very delicate balance between the optimum amount of coverage and the optimum amount of bandwidth we can offer, using the optimum amount of signal quality to achieve an acceptable error rate", explains <Name Protected>. "So basically, what I am modeling is all of those variables, together with all our other impairments in order to see what kind of performance can we get as I program in and out handovers, error rates and retransmission values etc. So the emulated model is helping us find the "sweet spot" - the most efficient way to set up the best environment. We are experimenting with different scenarios ranging from transmitting at maximum data rates with a higher percentage of errors, through to trying out lower overall bandwidth which generates less errors meaning you don't have to pause things for retransmission. As you can see, it's a very "multi-variabled" [sic] equation and with the NE-ONE Enterprise, I can programmatically create and control all these variables at speeds that no human could achieve by pushing buttons manually".

EVERYTHING IN PLACE AND READY FOR LAUNCH

The work <Name Protected> is undertaking is providing CompanyX with visibility of how the satellite constellation is expected to perform. The next stage will be for CompanyX to launch a small number of prototype satellites which should validate the value of the modeling work carried out using the NE-ONE Enterprise network emulator as well as providing real data that will be used to further refine and enhance the modeling process, reduce development costs and increase confidence in subsequent satellite deployments.

<Name Protected> stresses the importance of undertaking realistic pre-deployment testing and the value the NE-ONE Enterprise has made to the process, "CompanyX is not your typical start-up building some web app which, if it fails, you reiterate the next version - this is a multi-billion dollar project involving hundreds of satellites and once you launch satellites into space you don't get to change them later. However, I am confident with the approach we are taking; the NE-ONE Enterprise emulator is proving a great product for our needs and the support iTrinegy has provided has been amazing, I am happy with the way things are going".

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