Joint Engineering Team (JET) Meeting Minutes

National Coordination Office for Networking and Information Technology R&D (NCO/NITRD)
490 L'Enfant Plaza SW, Suite 8001, Washington, DC 20024
April 19, 2022, 12:00-2:00 p.m. ET
This meeting was held virtually

Participants

Francine Alkisswani, NTIA
Jeff Bartig, Internet2
Jeff Conklin, NCO/NITRD
Basil Decina, NRL
Martin Doczkat, FCC
Ann Keane, NOAA
Bill Fink, NASA/GSFC
Mallory Hinks, NCO/NITRD
Sridhar Kowdley, DHS
Kevin Kranacs, NASA/EOS
Padma Krishnaswamy, FCC
Michael Lambert, PSC/3ROX
Ann Von Lehmen, NSF
Paul Love, NCO/NITRD
Joe Mambretti, StarLight/MREN
Gabriel Martinez, DHS
Joseph Maurer, SNL
Linden Mercer, NRL
Aruna Muppalla, NASA/GSFC
Nils Pachler de la Osa, MIT
Glenn Ricart, US Ignite
Pat Smith, NSF
Kevin Thompson, NSF
David Wells, DOE

Proceeding: This meeting was chaired by Kevin Thompson (NSF).

I. **Action Items**:

- Final updates from Internet2 and ESnet on their respective new networks.

II. **Review of the Minutes of the March 2022 meeting:** The review was delayed and will be done via email due to the draft minutes not being available before this meeting.
Note: The minutes were circulated, corrections received, and the corrected minutes have now been posted to the JET's web site.

III. **A brief comparison on the next generation of satellite communications – Nils Pachler de la Osa**

The slides for this talk are posted on the JET's web page:
https://www.nitrd.gov/coordination-areas/lsn/jet/jet-meetings-2022/

A. This brief is based on:
An Updated Comparison of Four Low Earth Orbit Satellite Constellation Systems to Provide Global Broadband (Nils Pachler, Inigo del Portillo, Edward F. Crawley, Bruce G. Cameron), presented at the IEEE International Workshop on Satellite Communications in the 6G Era, 2021.

B. The four LEO constellations with announced plans for more than 1,000 satellites will be discussed and compared: Amazon, OneWeb, Starlink (SpaceX), and Telesat.
C. The analysis looks at each company's initial deployment and their planned final configuration. Among other choices it also looks at a company's plans to cover the polar areas, if they plan to use inter-satellite [communication] links (ISL), what altitude their satellites will be at, what is the minimum elevation angle (MEA) at which a ground site can communicate with a satellite and if their satellites can communicate with one or more than one gateway (ground) station concurrently. (Gateway station antennas are what a satellite uses to transmit data between all the users it is supporting and the ground segment of the system vs .the satellite's antennas that communicate with individual users on the ground.) With this information predictions can be made on how much traffic each company can support. As a note, lower MEA means a satellite can cover a larger portion of the earth's surface but because of the longer path through the atmosphere steps need to be taken to deal with the increase in signal attenuation. These might include increased power, improved antennas, improved modulation, and coding schemes.
D. Telesat and OneWeb will both be at a similar altitude (1,000-1,200 km). Both will have polar orbits.
    a. Telesat will start with ~300 satellites and grow to 1671. It will use inter-satellite communication, has a very low MEA of 10^{o} and each satellite can communicate with two gateway stations giving an average forwarding data rate of 25.9 Mbps per satellite with a maximum of 34.4.
    b. OneWeb plans 716 for its initial deployment growing to over 6,000, and no ISL initially and hasn't said what their long term ISL plan is. Its MEA is 25^{o} and each satellite can communicate with a single gateway station. Its initial average data rate is 8.8Mbps with a maximum of 10. In OneWeb's finale configuration these rates are 17.0 and 19.7
E. Amazon and SpaceX will use a much lower altitude (~500-600 km).
    a. SpaceX starts with ~1600 satellites growing to over 4,000. SpaceX plans for ISL but initial satellites don't have it. It will have polar orbits, a MEA of 25^{o}, and each satellite can communicate with a single gateway station. Average and maximum data rate per satellite are 13.7 and 19.7Mbps.
    b. Amazon initially will have 578 satellites and end up with 3236. Amazon hasn't said what they plan on doing for ISL. Its MEA is 35^{o} with no polar orbits planned. Its satellites can communicate with two gateway stations and use a higher bandwidth than any of the other three companies. Together these give the largest data rate of the four with an average data rate per satellite of 48.1Mbps and a maximum of 50.8.
F. Steps to analyzing each system
    a. Known: Location of the satellites and their orbital dynamics.
    b. Unknown: Demand and the ground segment of each system
        i. Demand/person was estimated. Demand was only considered from the populated portions of the Earth.

        ii. Based on prior work 200 gateways stations sites from around the world were selected. Then a sub-selection from that list was made that best fit each of the four constellations.
        iii. The final estimates were for the communications' link budgets and, from an ITU model, the atmospheric effects.
    c. Simulations were then run to generate estimates of total throughput, etc.

G. Results for each of initial configurations (with thanks to Nile, see posted slides for related graphs):
    a. Telesat achieves 7.52 Tbps (25 Gbps/sat.) maximum throughput when using 20 Gbps ISL, thanks to the dual feeder connection and low minimum elevation angle.
    b. OneWeb only achieves 1.44 Tbps (2.3 Gbps/sat.) due to less flexibility in their satellite design.
    c. Despite using around 1,600 satellites (5x Telesat's number) SpaceX only achieves 10.3 Tbps (6.5 Gbps/sat.) maximum throughput due to the non-usage of ISL.
    d. Amazon achieves the highest throughput when using 20 Gbps ISL (12.5 Tbps, 22 Gbps/sat.), but obtains significantly less capacity (8.97 Tbps) when not using it.

H. Results for final configurations (with thanks to Nile, see posted slides for related graphs):
    a. Telesat achieves 25.4 Tbps maximum throughput when using 20 Gbps ISL, which they can achieve with about 2500 gateway antennas.
    b. Thanks to a more flexible satellite design and a larger network, OneWeb manages to increase their throughput to 30.3 Tbps.
    c. SpaceX improves previous results by 4 Tbps thanks to the combination of lower altitude and lower minimum elevation angle.
    d. Despite being second-to-last in number of satellites, Amazon achieves the highest throughput at 53.4 Tbps when using 20 Gbps ISL. However, they suffer a 25% loss (to 41.4 Tbps) when not using it.

I. Conclusions (with thanks to Nils):
    a. Telesat achieves a high throughput and high satellite utilization thanks to three factors: dual gateway antenna, low minimum elevation angle, and usage of ISL.
    b. Despite OneWeb achieving the lowest throughput in the initial constellation, the combination of an improved satellite design and a larger network allows OneWeb to achieve higher throughput than Telesat and SpaceX in their final architecture.
    c. SpaceX improves [over its] prior [initial] results thanks to the combination of lower minimum elevation angle and lower altitude [from their initial configuration].
    d. Amazon's throughput is the highest of the four systems. However, they also need the largest ground segment with more than 4,000 gateway antennas. [The other systems plan to have between 3,000 and 3,500 ground stations.]
    e. Both OneWeb and Amazon experience significantly lower throughput if they choose not to use ISL. They could achieve 13% and 25% increase in capacity by using 20 Gbps ISL.

J. Q&A:
   a. Are all ISLs laser based?
      Ans: From what information is available most, if not all, will be laser based. Inter-satellite communications are believed to be unregulated while satellite to ground is regulated by the FCC.
      Related: SpaceX may be looking at laser for ground station links. Laser for ground would require satellites to be at higher MEAs and have a more accurate tracking system. But would have very little to no interference with other users.
   b. Given the very large number of satellites being planned, what is the strategy for when they reach end-of-life?
      Ans: Burnup upon reentry with the operator launching replacements. The replacements may be the same model satellite or enhanced models.
   c. What about First Responders (& others) who want to communicate with other users who are all using the same satellite. Who is responsible for linking them as efficiently as possible?
      Ans: It's the operators of the ground portion of the network. This might be the service operator, or it might flow to the internet before returning.

IV. **Discussion of the JET's tasking on tools to help with inter-domain issues – Joe Breen (via email)**

This is a community project to collect shared data from all who are willing to share.
The related, live map is at: https://www.globalresearchmap.org/

- We have been making slow progress but progress. We are waiting on data from several entities. For TENET, we now have the data, but Dan is trying to sort through the topology for the main backbone interfaces.
- On a related topic, my students have been able to adapt some tooling to use the new ESnet Stardust API.

V. **Operational network security roundtable:** No updates were received.

VI. **Network roundtable**

A. Internet2 (Jeff Bartig): Internet2's (I2) main focuses are on wrapping up the decommissioning of its old network gear. I2 is now running completely on its NGI network. The teams are just going through and doing a lot of cleanup work which has been going on for the last month or two.
B. NASA EOS (Kevin Kranacs) No updates this month.
C. NASA/GSFC (Bill Fink): Continuing to work with Linden Mercer (NRL) and Joe Mambretti (StarLight) on getting ready for SC22 in Dallas.
D. NOAA (Ann Keene): Lots going on but nothing to report this month.
E. NRL (Linden Mercer): Prepping for SC22 with Bill Fink & Joe Mambretti. NRL sees good opportunities and big challenges. Great to be able to start as early as is now possible. If you are interested in collaborating for demos at SC, please get in touch.

F. NSF Polar Programs (Pat Smith): NSF is still preceding with the desktop study of an undersea cable from McMurdo Station, Antarctica, to either New Zealand or Australia. It is anticipated that the draft will be ready for government review in May.
G. PSC/3ROC/XSEDE (Michael Lambert): No updates this month.
H. US Ignite (Glenn Ricart): No report today.

VII. **Exchange Points Round Table**

A. StarLight (Joe Mambretti):
   a. StarLight (SL) is working with NRL and GSFC and the SCinet WAN team to plan for Dallas. SL has requested a ring of 1.2Tb for SL<>Joint Big Data Tasking (JBDT) facility in McLean, VA<>SC22 in Dallas, TX<>SL. The goal is that the segments be comprised of 400G or 800G circuits to push the technology. Requests for unusual WAN requirements need to be submitted by April 29 (though late requests usually are accepted). Full details at:
   https://sc22.supercomputing.org/scinet/network-research-exhibition/
   b. SL is working with Singapore to bring up a SDX based on AutoGOLE and Open NSI.
   c. A companion project is working with Alex Moura and Kevin Sales of KAUST establishing an AutoGOLE open exchange at KAUST. It will take advantage of the 2x100G circuits that KAUST has to both Singapore and to the Netherlands and connect the KAUST open exchange with the AutoGOLE fabric.
   With the existing connections from Singapore to KISTI and then to SL and NetherLight there will be an AutoGOLE global ring.
   d. Harvey Newman from Caltech has also started his conference calls with the SCinet WAN team for November. He's asking for 400G circuits. Harvey would also like to keep using 2x100G circuits to SL that were left up after last year's SC and are still being used.
   e. A lot of Network Research Exhibits are coming together; P4, AI dynamic networking, Name Data networking, etc.

Meetings of Interest 2022

Note: Meetings whose format has changed have been updated.

Apr 24-27	ARIN 49, Nashville, TN
Jun 6-8	NANOG 85, Montréal, QC, Canada, hybrid
Jun 13-17	TNC22, Trieste, Italy, primarily in-person with a basic remote option
Jul 10-14	PEARC22, Boston, MA
Jul 23-29	IETF 114, Philadelphia, PA
Aug 22-26	APAN54, Jinan, China, primarily virtual with possibly limited local attendance
Sep 20-22	The Quilt Fall Meeting, South Minneapolis, MN
Oct 10-11	Global Research Platform Workshop, Salt Lake City, UT
Oct 17-19	NANOG 86, Hollywood, CA
Oct 20-21	ARIN 50, Hollywood, CA
Nov 5-11	IETF 115, London, UK

Nov 13-18	SC22, Dallas, TX
Dec 5-8	Internet2 Technology Exchange, Denver, CO

Next JET meetings

Note: It is anticipated that JET meetings will remain virtual for the foreseeable future

May 17, 2022	12-2 p.m. ET
Jun 21, 2022	12-2 p.m. ET
Jul 19, 2022	12-2 p.m. ET