Master Thesis : Resources notes

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1 A Browser-side View of Starlink Connectivity[1]

Description : This paper compare performances of Starlink user connection with standard connection type mainly on a browser side view by the use of an extension that calculate the Page Transit Time and allow user to make speed test. Other performance test (IPerf, traceroute,...) have been done three users who used a Raspberry Pi connected to the router.
Year : 2022
Utility : 8/10
Notes :

- Web browser extension that calculate the Page Transit Time and Page Load Time
  - PTT : HTTP redirection, resolving domain name, HTTP request and response time
  - PLT : PTT with he time for parsing and rendering the page
- User could decide to share their data (anonymoys) in order to compare them with non-Starlink user
- 28 users used the extension and shared their data, covering 10 cities in UK/EU/USA/AUS
  - 18 are Starlink users and 10 are non-Starlink users
- Three additional volunteers host Rasperry Pi to run basic network performance test (MTR, traceroute)
  - Rune speedtest every 5min to closest Google Data center
  - Remotely accessible with reverse tunneling for further scripts
- Result indicate that Starlink offer the lowest PTT compared with non-Starlink user
- Examine the network-related factors affecting PTT between Google AS and Starlink AS
- Examine how the weather (cloud cover) affect the performance (London) :
  - Lowest median PTT with clear sky
  - Highest PTT under moderate rain
- Comparison with traditional ISPs by doing traceroute from (in UK) Starlink measurement node, major cellular operator and broadband WiFi in a major university to a VM across the Atlantic
- Traceroute observe significant additional delays in hop that traverses **'bent pipe'**
- Performance of Starlink are affected by a number of factors
- Significant geographic variability and performance (Europe overall better than USA)
- Starlink controll the number of subscriber in each region (6 users/sq km)
- Time at wich an iperf3 is made can change the DL
- High packet loss is observed when handover from one satellite to another is made

2 A First Look at Starlink Performance[2]

Description : The paper has a purpose to benchmark the Starlink constellation use in order to compare it to SatCom. It will measure the throughput for QUIC and TCP, the latency and the packet loss. It appears that Starlink delivered its announced performance.
Year : 2022
Utility : 7/10
Notes :

- Three different PC were used :
  - PC-Starlink : connected to Starlink with regular subscritpion
  - PC-Wired : connected to UCL network with 1Gbit/s
  - PC-SatCom : connected to Satcom
- QUIC measurement
  - bolk HTTP/3 transfert
  - light QUIC transfers with regularly sent messages
- Latency
  - Running 3 pings towards the servers and nodes from RIPE Atlas
  - Measure link latency under different network load
  - Latency measured allow high quality voice calls and cloud gaming
  - Traceroute to San Francisco & Singapour : exit nodes is the same as European anchor (one exit in Nl, the other in De) → Inter-Satellite Link not yet enable
  - New satellite added seems to have notable effect on latency
  - RTT increase more when upload is stressed than download, because larger available bandwidth for download
- Packet loss
  - During H3 transfers : 2% of the packets were lost during uploads where 1,5% were lost during downloads
  - Loss events occurring during link loaded is more frequent and affect consecutive packets
  - Packet loss without link pressure occure less but last longer
- Throughput
  - Measure of dl and ul of Starlink with Ookla SpeedTest service.
  - Starlink download ranges from 100 to 250 Mbit/s
  - Starlink upload is much lower with a median of 17 Mbit/s which can vary by about 10% depending on the hours of the day
  - Starlink is more than twice as fast as SatCom. Starlink is also faster than what was the 4G network of a 4 years ago
- Web Browsing
  - Automatic visits of websites BrowserTime) and collect metrics
    - onLoad : time when the browser takes to load everything
      - Starlink : 2.12s
      - SatCom : 10.91s
      - Regular : 1.24s
    - SpeeIndex : time when the page is fully visible

    - Starlink : 1.82s
    - SatCom : 8.19s
    - Regular : 1.00s

- PEPs and middleboxes
  - Two levels of NAT : Starlink access point and carrier-grade NAT node at the exit of satellite
  - Tracebox does not show presence of PEP
- Inter-satellite links are planned to be deployed by the end of 2022

3 Delay is Not an Option: Low Latency Routing in Space[3]

Description : Study the basic Starlink properties, as it was stated when the FCC filings were made by SpaceX. The article also simulate different routing designs on a network architecture such as Starlink.
Year : 2018
Utility : 5/10 because a bit outdated (2018)

4 Distributed On-Demand Routing for LEO Mega-Constellations: A Starlink Case Study[4]

Description : This paper aims to give solution to the problem of routing with Inter-Satellite links. It first starts by giving a mathematical model of the satellite position and then explore two possible routing algorithm. The first one based on hop-minimality while the second is a ”near-optimal” best route approximation but at no cost.
Year : 2022
Utility : 8/10
Notes :

5 Analysis of Inter-Satellite Link Paths for LEO[5]

Description :
Year : 2021
Utility : 8/10
Notes :

6 Security Performance Analysis of LEO Satellite Constellation Networks under DDoS Attack[5]

Description : Analyse and test the effect of DDoS attack on a LEO Satellite Constellation Network
Year : 2022
Utility : /10
Important points :

- Identification of key nodes is the basis of network vulnerability analysis and also for DDoS in LSCNs
- LSCN cannot be model with static graph models, solution → topology snapshot
- Network topology of satellite can be expressed as $G^t = \{V^t, E^t\}$, with V^t all satellite nodes, E^t set of all links.
- Space-time graph model is used instead of topology snapshot to solve connectivity problem
  - Stgm can analyze the topology of a satellite dynamic network and identify the key nodes
- Distributed Denial of Service aim to hijack a large number of normal hosts to make them puppet host and send flood packets. LSCNs could be subject to
  - ICMP Flood : large number of ping
  - TCP SYN Flood : defect the three way handshake
  - UDP Flood : large number of UDP packet
  - HTTP Flood : malformed HTTP packets
- LSCN security performance simulation platform implemented by
  - STK : generate the orbital information and data of LEO
  - NS3 : packet-level simulation
  - Exata : network simulation tool
- basic attack in Exata with a data rate set to 100 pkts/s, with 2047 bits per packets and shortest-path strategy.
- Key nodes are generated with NetworkX and MATLAB, using degree centrality and betweeneness centrality
- Two satellite are selected as key node, three simulate the DDoS from a botnet in one satellite. Three others are launching attack on on of the key node
- With multiple key satellite, LSCN can still communicate by changing its satellite links and number of nodes per path remains the same
- When the number of key node attacked satellite increases, the transmission delay increases proportional to the number of attacked satellites.

7 Laser Inter-Satellite Links in a Starlink Constellation[7]

Description :
Year : 2021
Utility : /10
Important points :

- Free Space Optics (FSO) is used to transmit optical signal from an optical transmitter to an optical receiver in the vacuum space with a clear line of sight.
- Satellite-to-satellite FSO are referred as laser inter-satellite links (LISLs)
- Advantage of LISLs are over radio based links:
  - higher data rates
  - smaller antenna → less weight and volume
  - narrower beams → less interference, more secure
  - lower transmit power → lower beam spread, higher directivity
- LISL could provide lower latency communications than optical fiber network for great distance (< 3.000km)
- Equiped Starlink satellites with four LISLs
  - Two neighbors in the same orbital plane → intra-orbital plane LISL
  - Two neighbors in different orbital plane → inter-orbital plane LISL
    * adjacent OP LISL (AOPL)
    * nearby OP LISL (NOPL)
    * crossing OP LISLS (COPL)
- The duration of LISL can also be a classifier :
  - Permanent LISL
    * instra orbital → easy to establish and maintain
    * AOPL and NOPL as well but harder to establish (velocity)
  - Temporary LISL
- Network with permanent LISL are good mesh network but two separate meshes exist : satellites orbiting northeast and other orbiting southeast

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Description :
Year : 2018
Utility : /10
Important points :

References

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