Software-Defined Satellite Networking: Motivations and Challenges

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Agenda

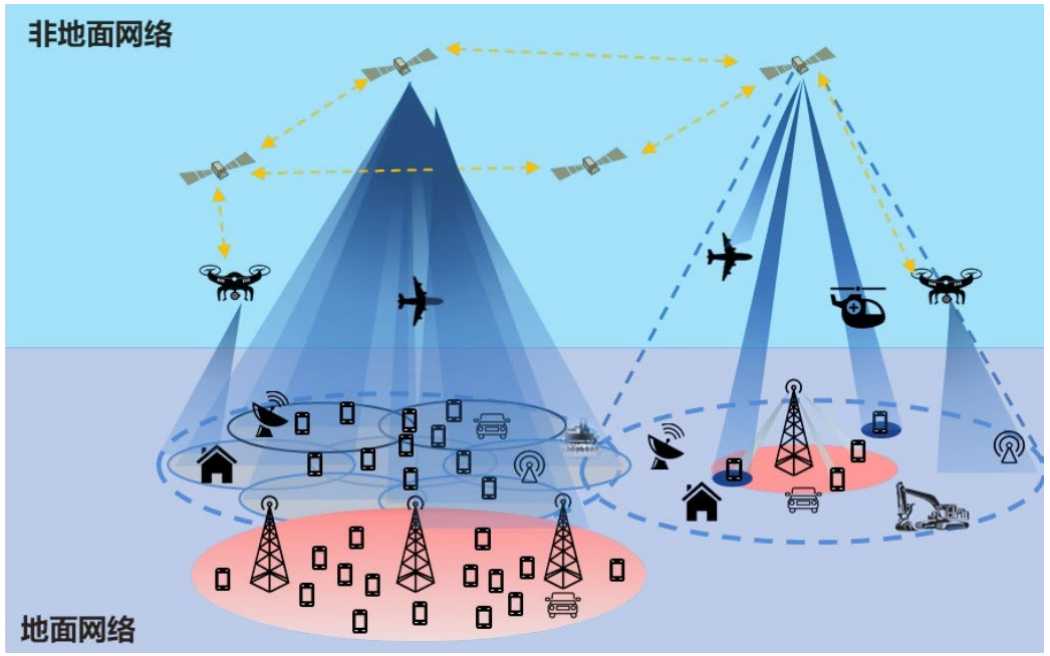
- Motivations
- Challenges
- Practice
- Conclusion

PART ONE

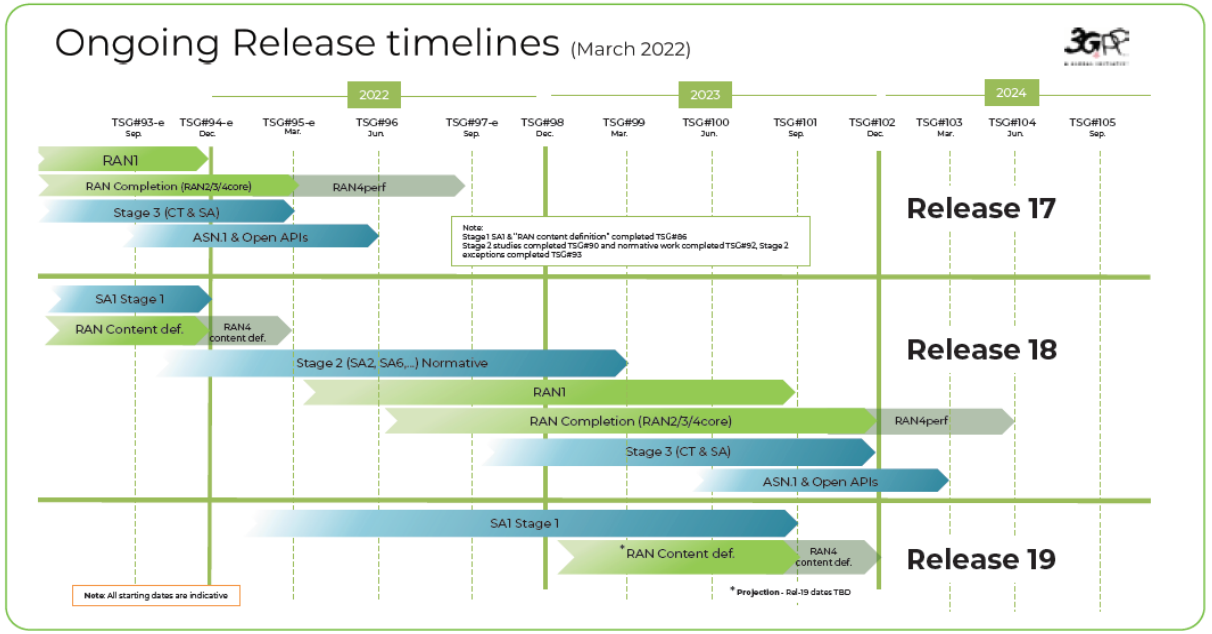
Motivations

Scope of 6G

- eMBB, uRLLC, mMTC promised by 5G, global seamless coverage still unavailable
- 6G promises to integrate terrestrial, aerial, space infrastructure to achieve global coverage



IMT-2030（6G）Space-Terrestrial Integrated Network (STIN) work group.



3GPP:R15-R18. TR and TS on satellite, UAV, NTN, and space network.

The low-orbit satellite network will be an important infrastructure that 6G can utilize

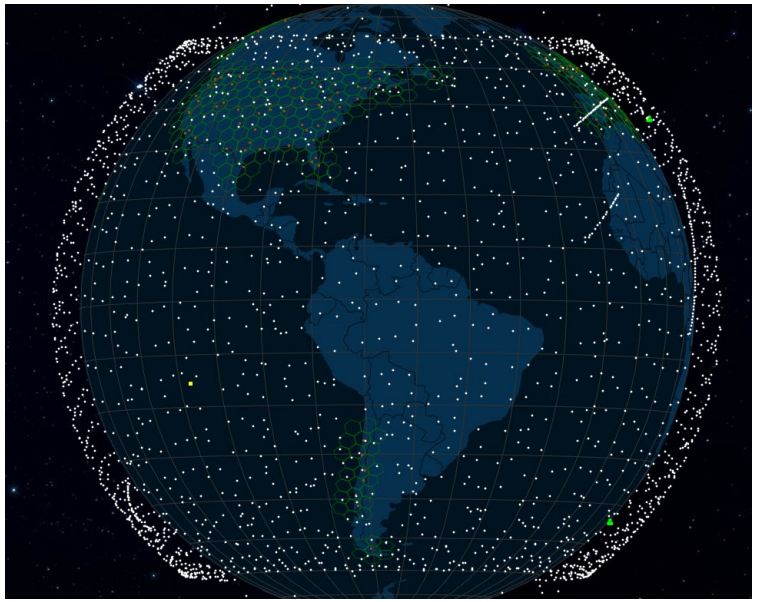
Low Earth Orbit Satellite

Features

Wide coverage, lower latency, higher bandwidth; Less influenced by landforms

Progress

Over 4K satellites launched by Starlink; Over 5 hundred launched by OneWeb.



42,000 satellites planned by Starlink

Via recyclable rockets, the manufacturing and launch expenses are 500,000 US dollars. Per satellite

Service provided in over 40 countries and region, subscribed by over 1 million users, and peak rate at 100Mbps

LEO is almost the hottest satellite direction at present

Diversified Service Requirement

- **Coverage:**
  From big city to countryside

Big City

Aerial Comm.

Ocean Comm.

- **Service category:**
  From communication to computation

Virtual Reality

Robot Control

Remote Sensing

- **QoS Requirement:**
  From best efforts to deterministic

Internet of Industry

Automatic Driving

UAV control

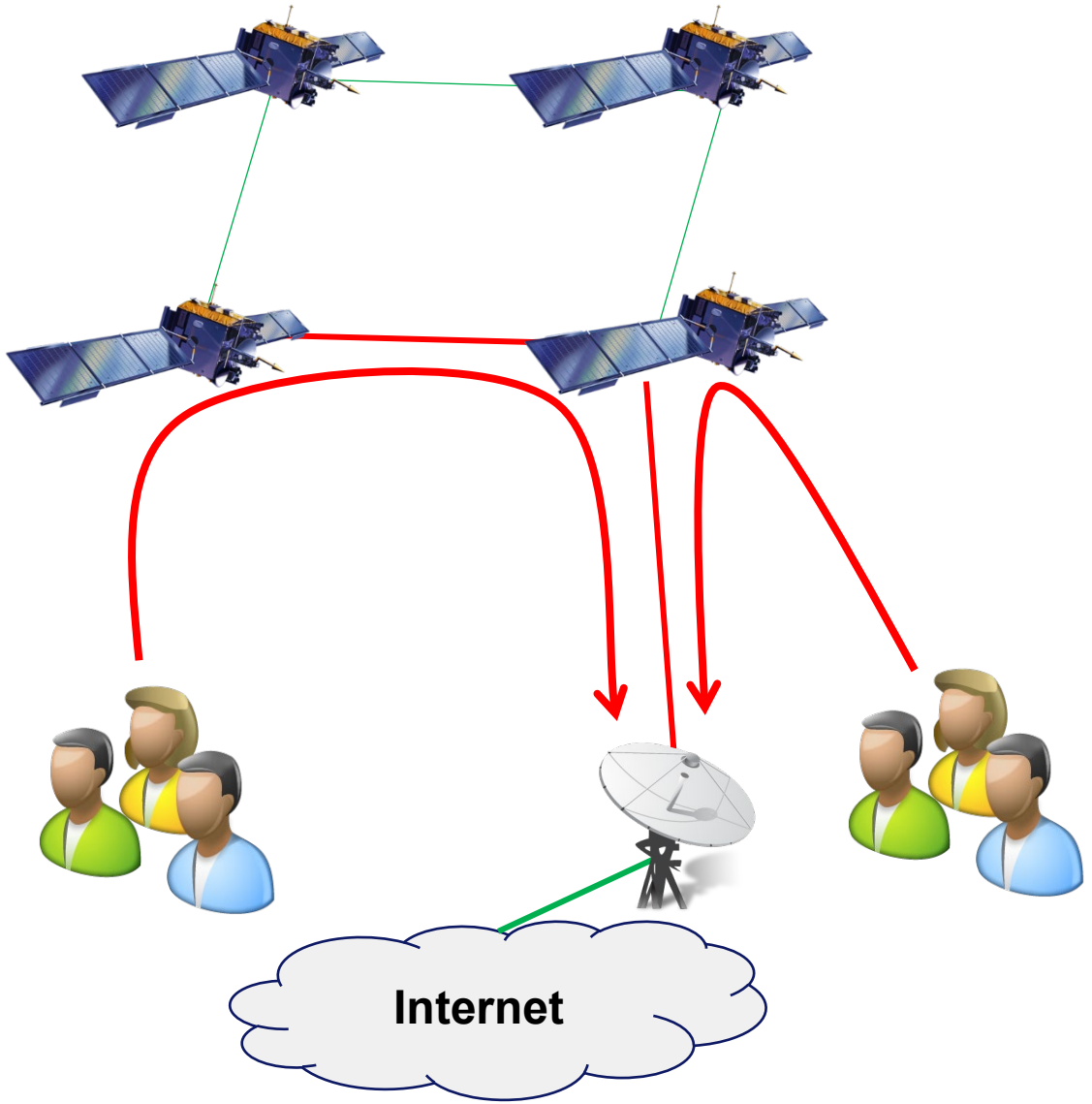
LEO networking challenges

New Constraints:

- high dynamics
- low computing power
- complex weather influence

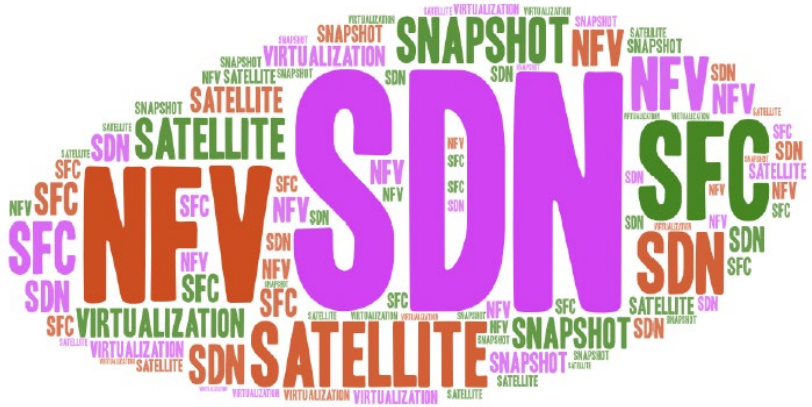
New networking requirements

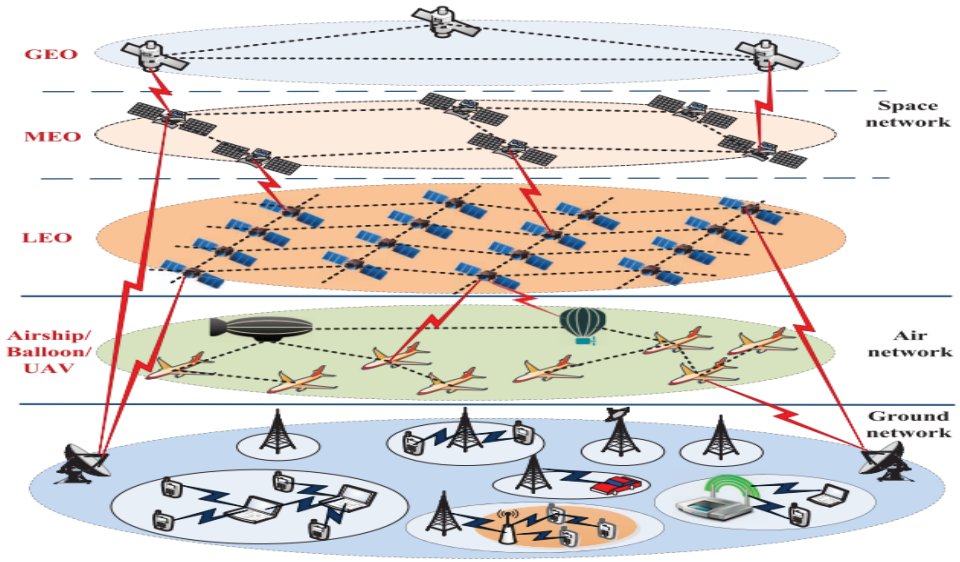
- Flexible Routing
- Efficient traffic engineering



Software Defined Satellite Networking

- The logical centralized control pattern of SDN consists with the constellation control, which can leverage the predictable topology information.
- The control and forward separation pattern reduces the requirement of on-board computing
- The programmability promises flexible control over the entire network.





PART TWO

Challenges

Challenges faced by SDSN

Features

- High Dynamics: Topology keeps changing
- Large space scale: Long interaction delay
- QoS diversity: Diversified service at one constellation
- Attributes such as delay keeps changing: Flapping end to end performance

Challenges

- Routes converging frequently
- Control response slow
- Control granularity is mixed
- QoS scheduling frequently

Factors to take account for SDSN

Factors	Service Requirement
Connection Oriented & Connectionless	• Connectionless: Routing for arbitrary nodes and service data • Connection-Oriented: Scheduled for special users, usually with QoS guarantee
Predictable & Unpredictable	• Predictable: The satellite orbit and motion is predictable, and thus topology is mostly predictable. But sometimes the prediction is not that accurate. • Unpredictable: Perturbation, vibration, and solar radiating are usually not predictable, and cause unpredictable link outage, thus topology changes
Centralized & Distributed	• Centralized： The global view is easier to achieve better global optimization • Distributed: Resilient to destruction, but the optimization is usually limited

PART THREE

Practice

Hierarchical Routing Architecture

1. **Connectionless Underlay Routing：**

- Use distributed routing to achieve basic end-to-end reachability

2. **Connection-Oriented Overlay Routing：**

- Source routing to guarantees connection while keeping stateless on intermedia nods

Emulation Platform

How to evaluate and validate the design?——Docker based emulation

- Topology generation
- Protocol loading
- Application Data Generation
- Functions

- Convergence analysis, QoS verification, scalability test, robustness test, …

PART FOUR

Conclusion

Conclusion

Satellite networking faces new challenges. SDN and other related technologies should be fully utilized. We hope to contribute to SDN-related satellite networking standardization work.


THANK YOU