Application Services in Space Information Networks

dr. Anders Fongen, oct 2021
Norwegian Defence University College, Cyber Defence Academy, Lillehammer
email: anders@fongen.no

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Presenter's bio

Anders Fongen

- Associate Professor, Norwegian Defence University College
- Field of research: Distributed Systems, Networking security
- PhD in Distributed Systems, Univ. of Sunderland, UK, 2004
- Career history
    - 4 years in military engineering education
    - 10 years research in defence research (Chief Scientist)
    - 8 years in civilian college (Associate professor)
    - 11 years in oil industry
    - 6 years in electronics industry

Introduction

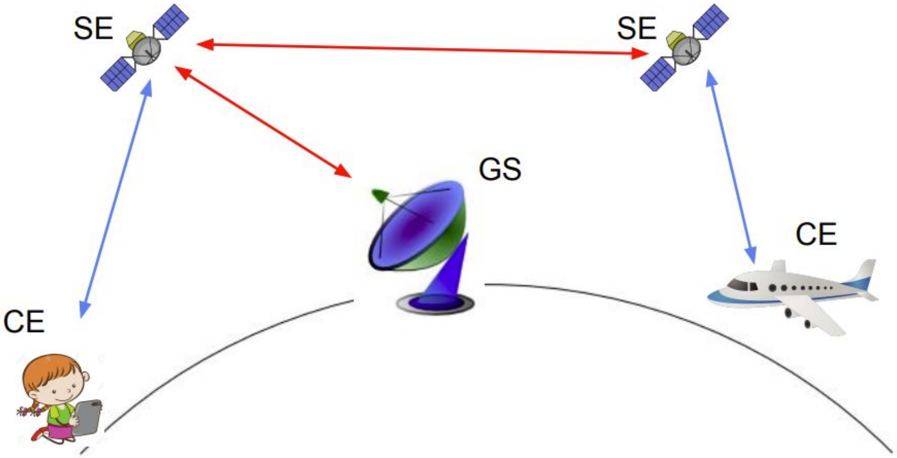
- The future of satellite communication?
  - Application Services ("Cloud Computing in Space")
  - Higher System Complexity - natural evolution
- What are the advantages?
  - Very Low Latency (as low as 2 ms)
  - Global coverage
- Interesting property of a Low Earth Orbit (LEO) system
  - Long idle periods (due to inhabited surface) mixed with traffic peaks
- Viewed as a problem of *Distributed Computing*
  - *having a set of distinct properties*

What is a SIN (Space Information Network)?

- A collection of communicating LEO satellites, called Satellite Endpoints (SE)
- Able to serve terrestrial/airborne client (CE)
  - Communication services (e.g., IP transport, VoIP, Publish-Subscribe comm.)
  - Discovery Services (DNS, Service Brokering...)
  - Storage Services (Content Distribution Network, caching, session states)
  - Application Services (Collaborating editing, Situational awareness ...)
- Resource constrained / disadvantaged
- Predictable workload and link availability
- "Mobile" system: Stationary clients, mobile infrastructure
- Rapid hand-over of client connection and *client state*

Components of a SIN and their relations

- Satellite Endpoints (SE)
  - Any combination of LEO and HEO satellites
- Client Endpoints (CE)
  - Clients to the SIN (but may offer services), on ground or airborne
- Ground Station (GS)
  - Connects the SEs to other endpoints and resources in the Internet



Population distribution

We correlated a LEO orbit with the population density on the surface below.

- Great variations, with high peaks of short duration followed by idle periods. Looks like one peak per orbit.
- Should include these data into the task scheduling in the SE. Introduce *delay tolerant tasks*, e.g., speculative caching

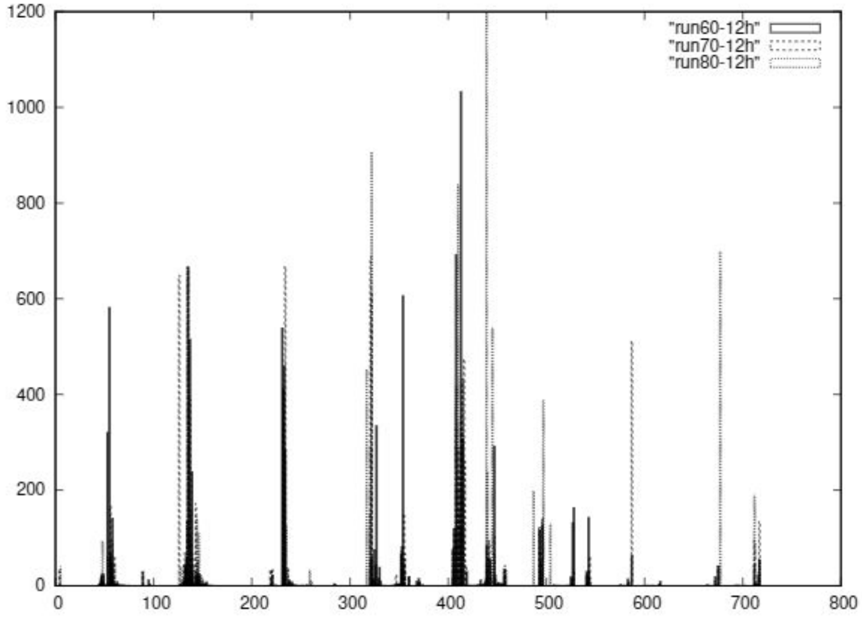
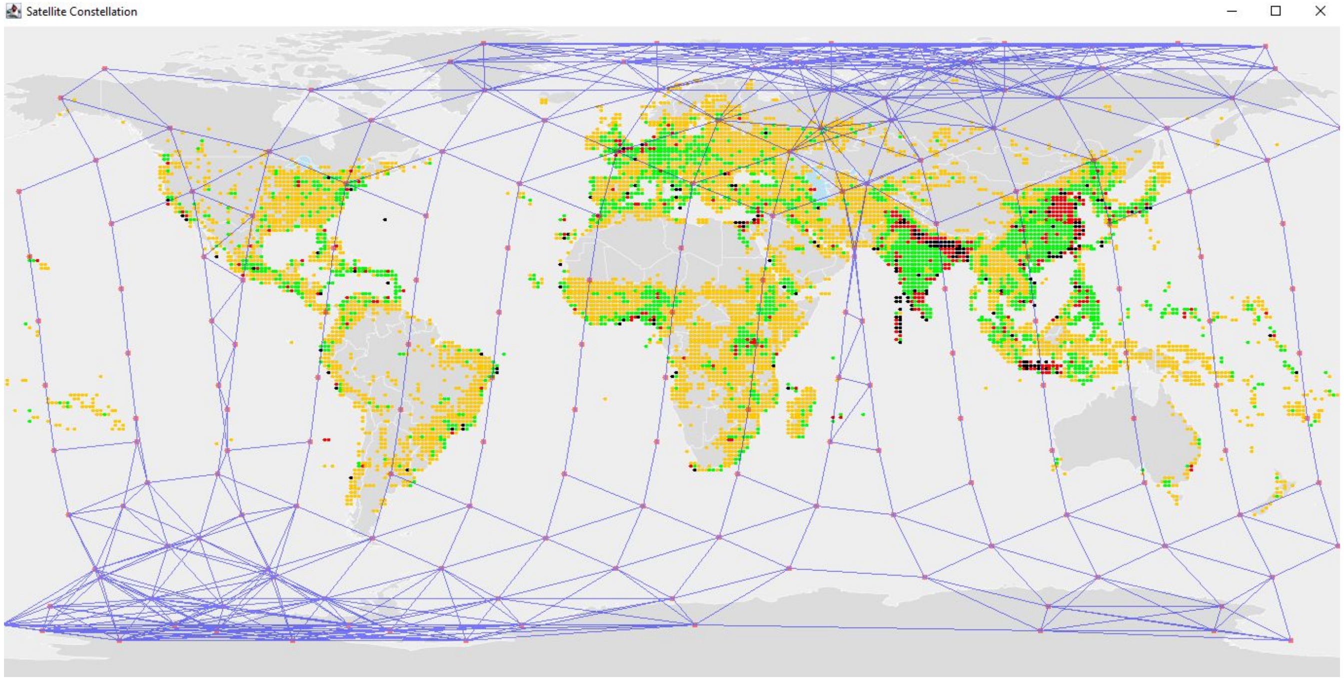


Figure 1. Population density below a satellite during 12 hour orbit

SE constellation vs population density



Example applications served in a SE

Discovery Service - DNS

- Increase hit rate through active replication of DNS entries in the SE (from GS)
  - Selection based on predicted DNS queries. Machine learning?

Conversational Services - VoIP

- Latency sensitive service. Choose forwarding path through less loaded SEs
- SIP service in every SE
- Multi-party conversations should employ IP multicast

Example applications served in a SE

Storage Service - Content Distribution Networks (CDN)

- CDN storage subject to active replication, based on expected queries.
- Do not exploit locality of clients, since infrastructure is not localized
    - Must “localize” SE storage “in flight”

Conclusion

- SIN is a natural and expected evolution for satellite networks
- Lots of unsolved and difficult problems
  - Passing of client state during handover
  - Optimal use of active replication, based on population data
  - Subject to experimentation on machine learning algorithms
- Next paper is on Trust Management in a SIN
  - Involves replacements of the PKI architecture
- Current activities: Experimentation of with a software model
  - Optimization of orbital patterns
  - Caching and replication algorithms, etc.
  - Routing paths established through machine learning