Satellite Internet

Nguyễn Như Hiếu—BI9-103
Ngô Ngọc Đức Huy—BI9-119
Ngô Xuân Minh—BI9-167
Nguyễn Gia Phong—BI9-184
Nguyễn Hồng Quang—BI9-194
Trần Minh Vương—BI9-239

University of Science and Technology of Hà Nội

April 9, 2020

Contents

Usage

Popular Use

- Airplane
- Cruise Ship
- Rural Area

Similarity

All three are either in or travel through area with little to no ground station.

Future Usage

Provide Internet for the whole world

Fact

Over 3.7 Billion people are living without being connected to the internet.

Components

- Geostationary satellite (GEO)
- Gateway
- Antenna
- Others:
  - Modem
  - Centralized NOC

Components Interaction

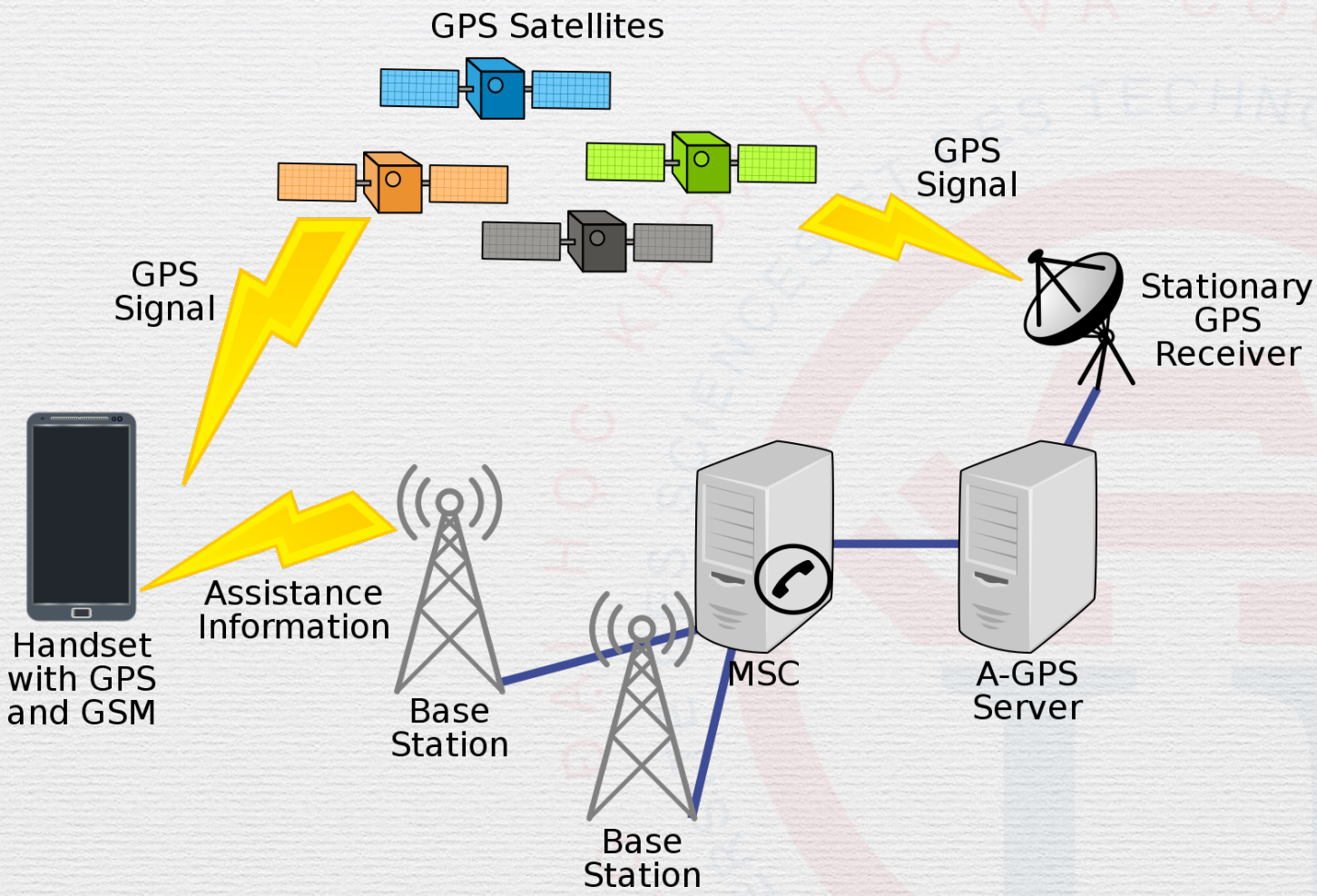
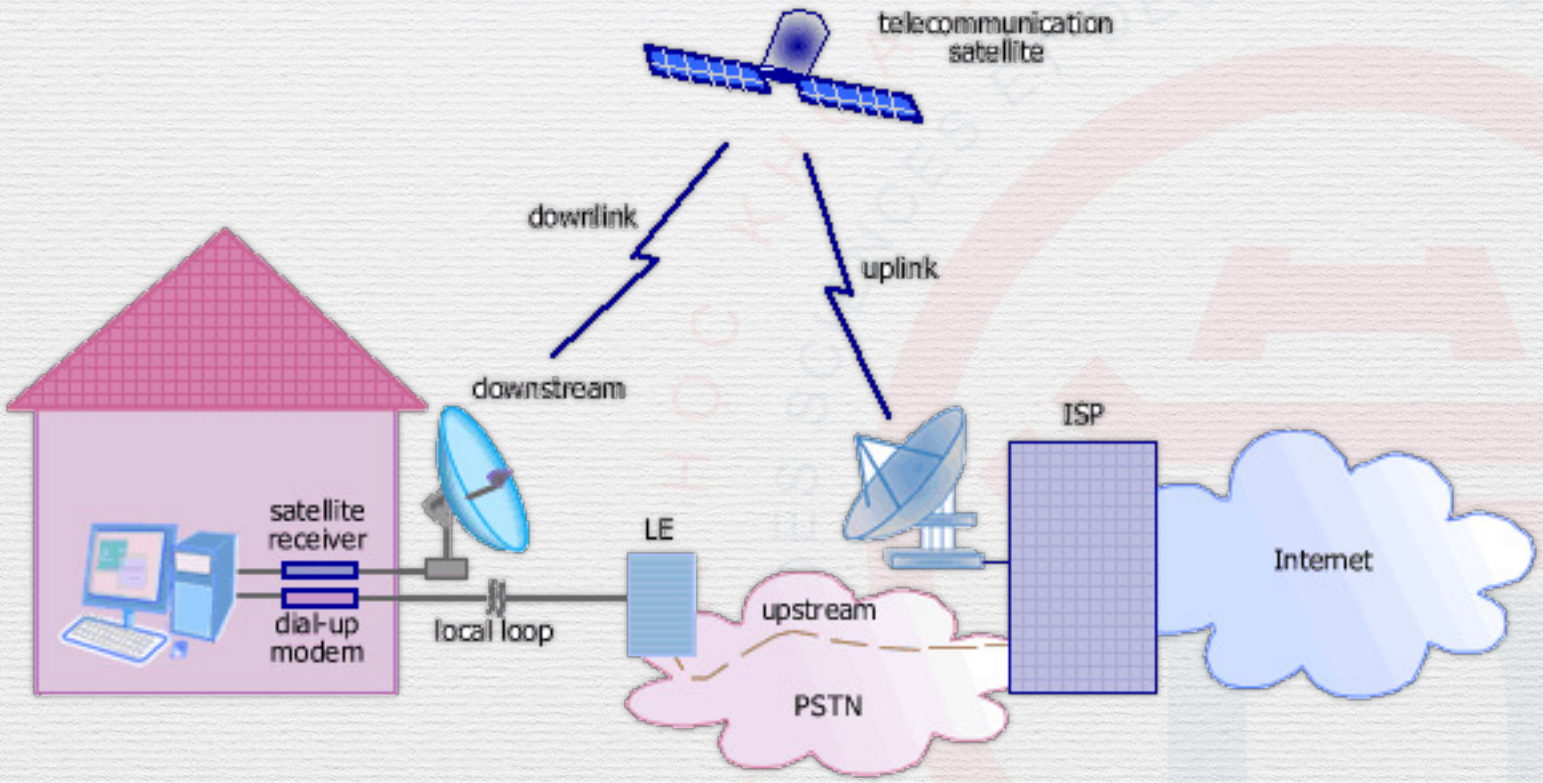


Figure: GPS using A-GPS and GSM network

One-way Satellite Network



Components

- Upstream: Data travelling through telephone modem
- Downstream: Download through satellite

Characteristics

- Upload speed: Same as that of the dial-up internet
- Download speed: Much faster than dial-up internet
- Latency: Still high,much lower than two way satellite internet
- You have to tie up the telephone lie when you use the Internet

One-way to Earth

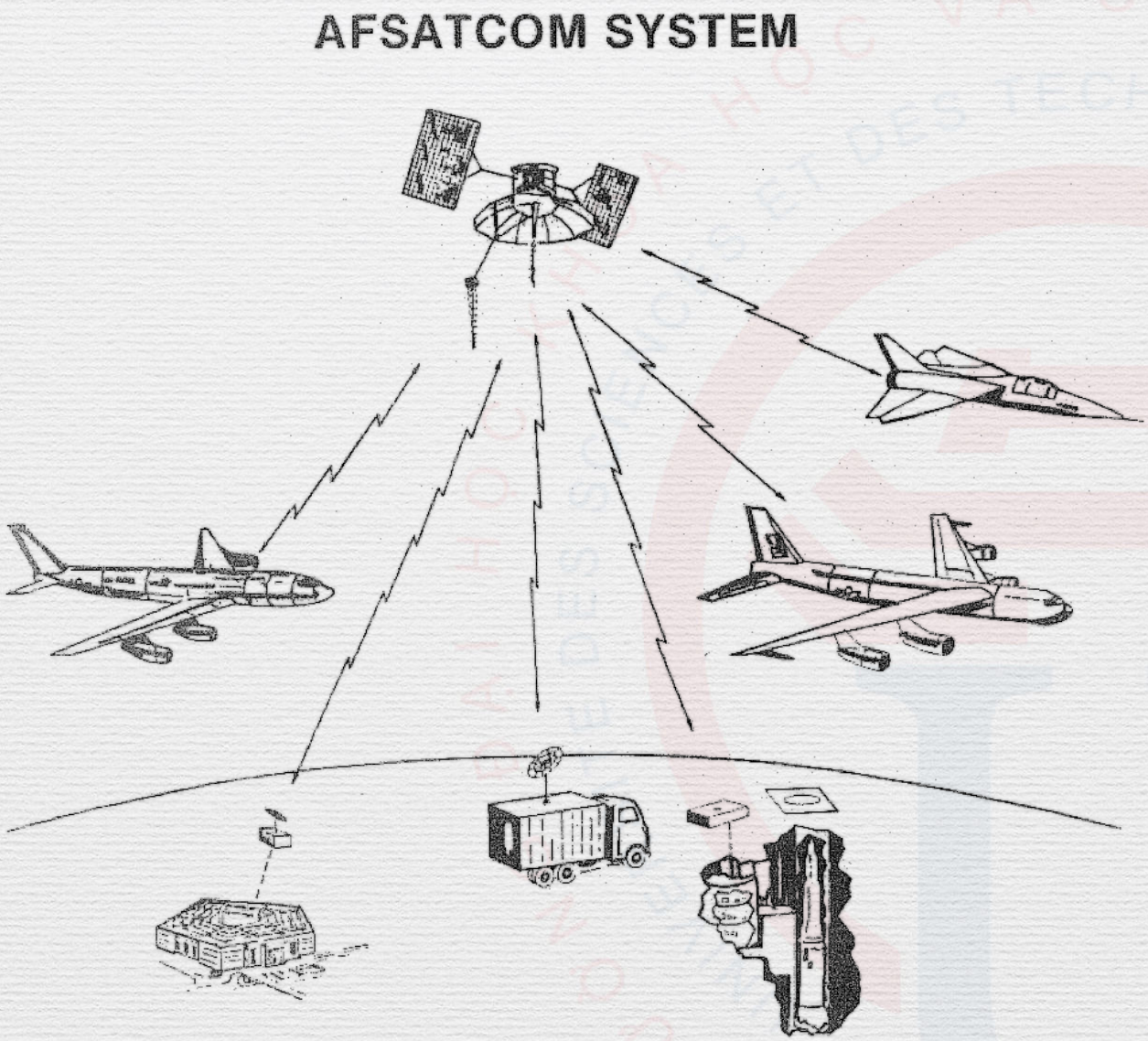
Components

- 1 transmitting hub station (usually very large)
- Multiple receive-only Earth stations

Characteristics

- Usage: IP multicast-based data, audio and video distribution
- Interactivity: Little user interface, similar to TV or radio content

Two-way Satellite Network



Components

- VSAT: Send and receive data
- Telecommunication port: Relay data through Internet

Condition

Satellite dish must be precisely pointed to avoid interference.

Characteristics

- Both TDMA and single channel per carrier
- Mostly Ku-band, but also C-band and Ka-band
- May utilize telephone modem to reduce latency
- Home-user's bandwidth based on payment
- Difficult on moving vehicles

Portable Satellite Internet

Portable

- Use self-contained box pointed in general direction of Satellite
- Expensive

Satellite phone

- Omnidirectional antenna so no alignment needed
- Low bandwidth so slow to browse net,useful for sending email

Heavy rain or Blizzard

- Fading
- Accumulating raindrop or snow
- Wind

Latency

Satellite altitude

- LEO: $< 2000\,\text{km}$
- MEO: 2000–35 786 km
- GEO: $> 35\,786\,\text{km}$

Result

GEO has 12 times higher latency than terrestrial base networks. LEO and MEO have a bit lower delay.

Other Limitations

Economically

Costly: 2 Mb/s costs around $100 a month.

Environmentally

Space junk: Only 2000 out of 5000 launched satellites are still in function.

Fade Mitigation Techniques

Common functions:

- *Monitor* link quality by continuous measurements
- *Predict* short-term behavior and duration of satellite channel's next state
- *Set* parameters based on previous estimation

Effective Isotropic Radiated Power

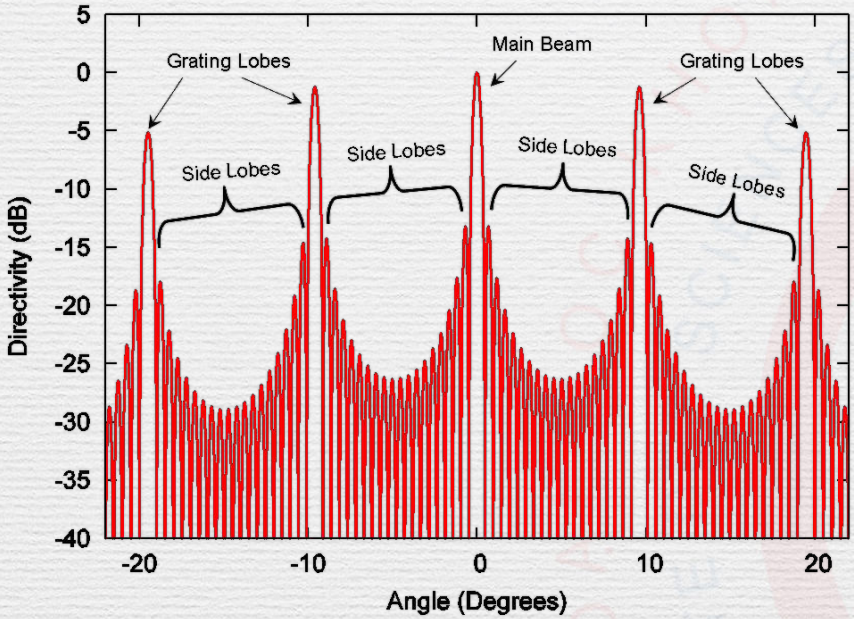
- EIRP = tranmitted power $\times$ antenna gain
- EIRP control = adjusting carrier power or antenna gain to compensate for power losses

Power Control System

1. Open loop: Based on recently received power.
   - Non-reliable
   - Responsive
2. Closed loop: Based on channel power measurements.
   - More comprehensive
   - Large propagation delay

Uplink Power Control

- Vary carrier power at the earth station
- Restoration of side lobes might lead to adjacent *channel* interference



- Increase of earth station transmit power may cause adjacent *satellite* interference*
- Effective and preferred by many satellite operators

*Satellites are separated by 2–3 degrees on the geostationary orbit.

Downlink Power Control

- Vary carrier power on-board the satellite
- Difficult to implement due to satellite size and weight limitations
- Subject to
  1. Adjacent *channel* interference
  2. Inter*modulation* interference
  3. Inter*system* interference (with terrestrial networks)

Spot Beam Shaping

- Adjust antenna gain on-board the satellite for a certain geographical region
- Shape satellite antenna for nearly constant ground receive power, even under rainfall
- Does **not** need expensive calculations for attenuation estimation†
- Technology and research are WIP

†SBS compensates the entire coverage area instead of a single site.

Adaptive Transmission Techniques

- Modify processing/transmission manner of signals
- Resource-shared techniques
- Categories:
  1. Hierarchical coding
  2. Hierarchical modulation
  3. Data rate reduction

Hierarchical Coding

- Add redundancy to the information signal
- Trade-off between bandwidth and error probability
- Different conditions require different coding schemes
- Prioritize users with less efficient coding schemes, i.e. longer bursts (TDMA) or larger bandwidth (FDMA)

Hierarchical Modulation

- Provide lower quality fallback in case of weak signals
- Exchange bandwidth efficiency for power requirements
- Suitable for localized satellite systems, e.g. VSAT
- Users with lower-order modulation get more resources

Data Rate Reduction

- Reduce information data rate for power gain
- Distribute satellite resources equally to every user
- Utilizable where significant information rate reduction is tolerable, e.g. video or data but voice transmission

Diversity Protection Schemes

- Use multiple channels with different characteristics
- Oriented against rain fades and highly efficient
- Performance criteria
  - Diversity gain: difference between site attenuation and joint attenuation, for the same probability level
  - Diversity improvement: ratio of site exceedence probability to the joint one, for the same attenuation value

Diversity Techniques

Diversity	**Setup**	**Efficiency**	**Cost**
Site	Connected earth stations	High	High
Orbital	Earth station may choose between satellites	Low	Low
Frequency	Use lower frequency on higher attenuation	Adaptive	Terrestrial equipments
Time	Repeat faded data	Selective[‡]	N/A

[‡] . . . of fade duration

EIRP Control Techniques

Tech	**Availability**	**Max gain** (dB)	**Cons**
ULPC	0.01–10 %	5 (VSAT) 15 (hubs)	power range
DLPC	0.01–10 %	3 (sat. TWTA)	power range
SBS	0.01–1 %	5 (sat. antenna)	immature research

Table: Comparisons between EIRP control techniques

Adaptive Transmission Techniques

Tech	**Availability**	**Max gain** (dB)	**Cons**
HC/HM	0.01–10 %	10–15 (E_b/N_0 range)	fading in many stations
DDR	0.01–10 %	3–9	low rate intolerant

Table: Comparisons between adaptive transmission techniques

Diversity Protection Schemes

Tech	**Availability**	**Max gain** (dB)	**Cons**
SD	0.001–0.1 %	10–30 (conv. rain)	cost
OD	0.001–1 %	3–10	satellite switch
FD	0.01–10 %	30 (Ka–Ku)	cost

Table: Comparisons between diversity protection schemes

Conclusion

- Have many potentials
- Challenging
- Need more research

References

Athanasios D. Panagopoulos, Pantelis-Daniel M. Arapoglou and Panayotis G. Cottis. "Satellite communications at Ku, Ka, and V bands: Propagation impairments and mitigation techniques". *Communications Surveys & Tutorials*, vol. 6, p. 2–14. IEEE, 2004. doi:10.1109/COMST.2004.5342290.

Satellite Internet access. *Wikipedia*.

Copying