Cellular Voice/Data Service Onboard Airplanes

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Background

- Seatback phones today generally supported over L-band satellite links
  - Very limited capacity – typically 4 simultaneous calls per plane
  - Monopoly business -> very expensive
  - Customers can only make calls, but cannot receive
- On-board Wi-Fi service was offered by some airlines (e.g., Lufthansa, Singapore Airlines, Quantas,…) on long haul flights in 2005 and 2006 but service has been stopped
  - "Connection by Boeing" decommissioned in Dec 2006
- Key features of new on-board voice/data service
  - Customers can use their own handsets
  - Can be billed by their own service providers (with roaming arrangements)
  - Can be reached on their own cell phone numbers
  - Can use most of their voice and data calling features

Current Industry/Regulatory Status

Europe:

- ❖ Communication authorities in EU have approved the use of cell phones onboard airplanes, with appropriate restrictions
- ❖ Two operators are trying to launch service but going through many technical hurdles
  - ➢ OnAir – Airbus + SITA
  - ➢ Aeromobile – ARINC+Telenor

USA:

- ❖ Conflicting views from two government agencies
  - ➢ FAA has approved use
  - ➢ FCC has concerns about interference with ground-based systems
- ❖ Auctions have been carried out for spectrum
  - ➢ AirCell was the winner for WiFi service, paying $31M for a 3 MHz spectrum in the 800 MHz band
  - ➢ No activity since Dec 2006, when FCC made its decision

Challenge: Spectrum Allocation

Public Opinion and Practical Considerations

- General opposition to voice service except for emergencies. Reachability via voice service is considered desirable
- Data services very well accepted
- FAA has ruled proper shielding to be provided to avoid interference with on-board communication equipment. Certification process in place
- EU instituted the following requirements to avoid interference with terrestrial networks:
  - Service to be available only above 3,000 m (10,000 ft) altitude
  - Forced registration on on-board system
  - On-board noise generator to cancel out signals from/to terrestrial systems
- FCC did not approve fearing interference with ground-based systems, but has kept the door open for future reviews

Key Challenges

Technical:

- System architecture
  - Satellite-based system
  - Ground-based system
- Hand-offs
- Backhaul
- System integration and management

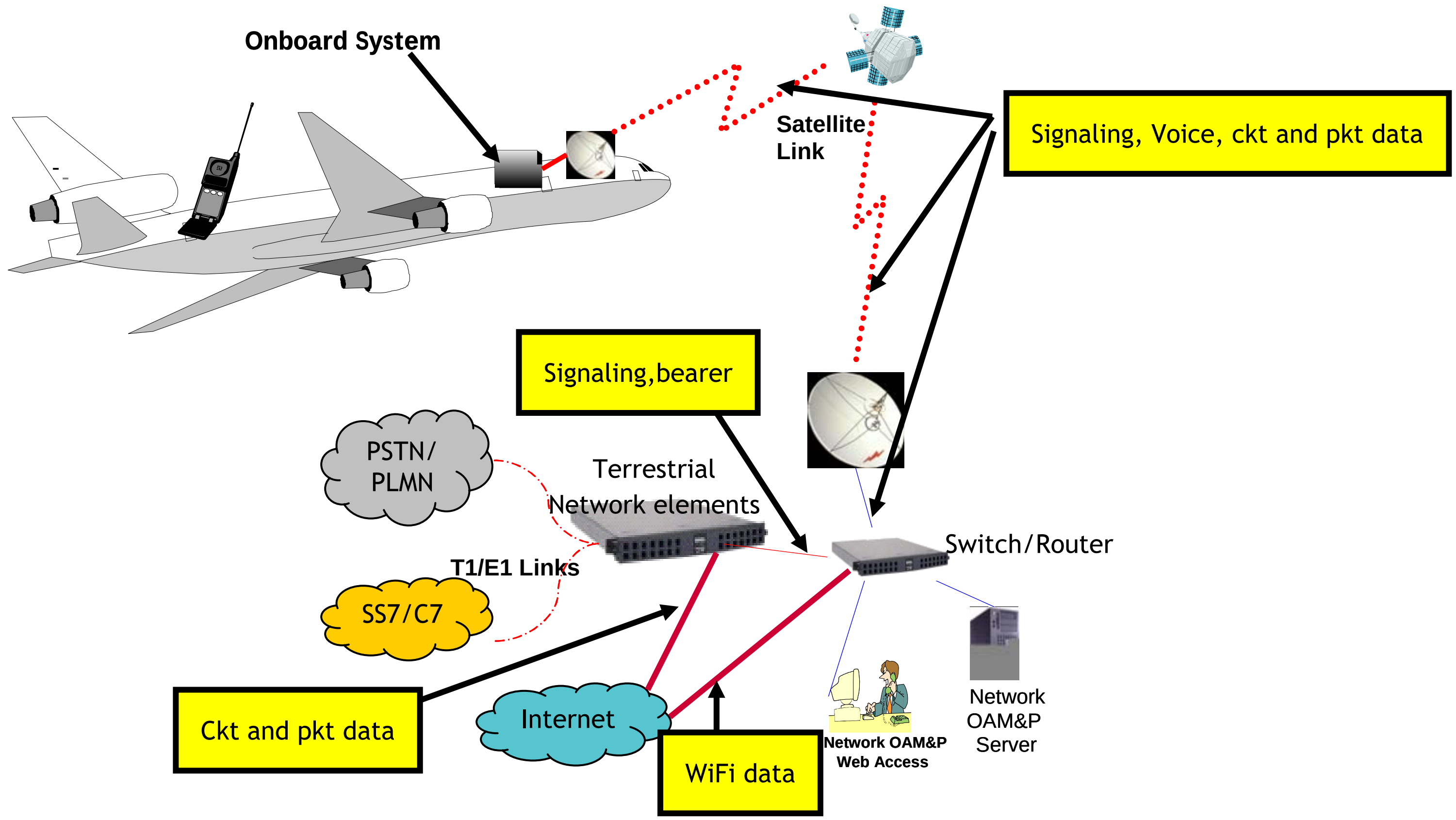
Business:

- Service provider issues
- Roaming agreements

Implementation:

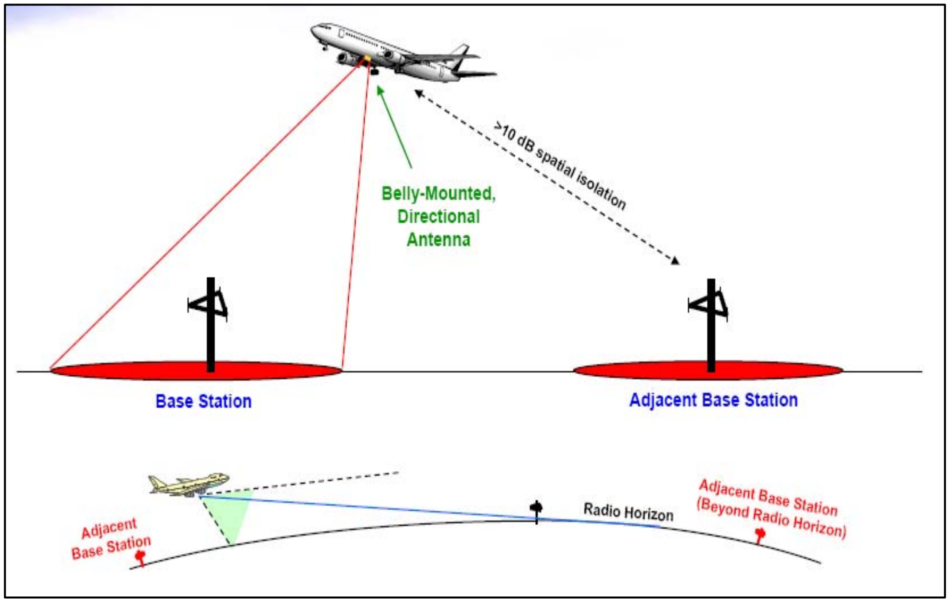
- Multiple wireless technologies for customers
- Size and weight of on-board unit
- Integration with in-flight entertainment system

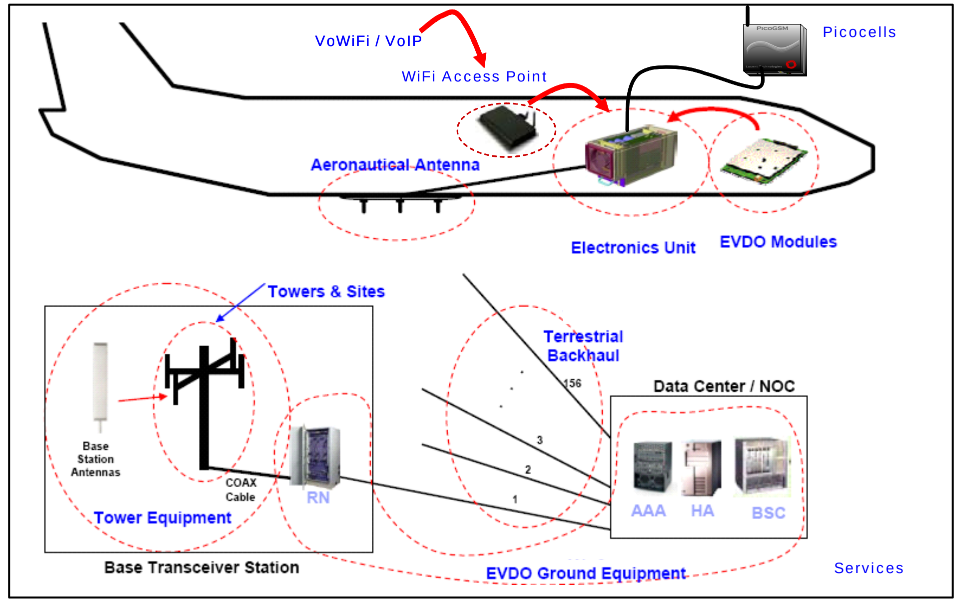
Satellite-based Solution



- On-board equipment behaves like a BTS/BSC
- Satellite backhaul to ground-station
- Core network elements can vary, depending upon technology choice
- Global coverage possible

Ground-based Solution





- **High-speed cellular link to on-board equipment, equipment behaves like a mobile device**
- **Boomer cell radius ~250 km => <100 cells to cover entire US**
- **Directional antennas used to minimize inter-cell interference**
- **Solution developed to address doppler effect**
- **Global coverage not possible**

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Solution Comparison

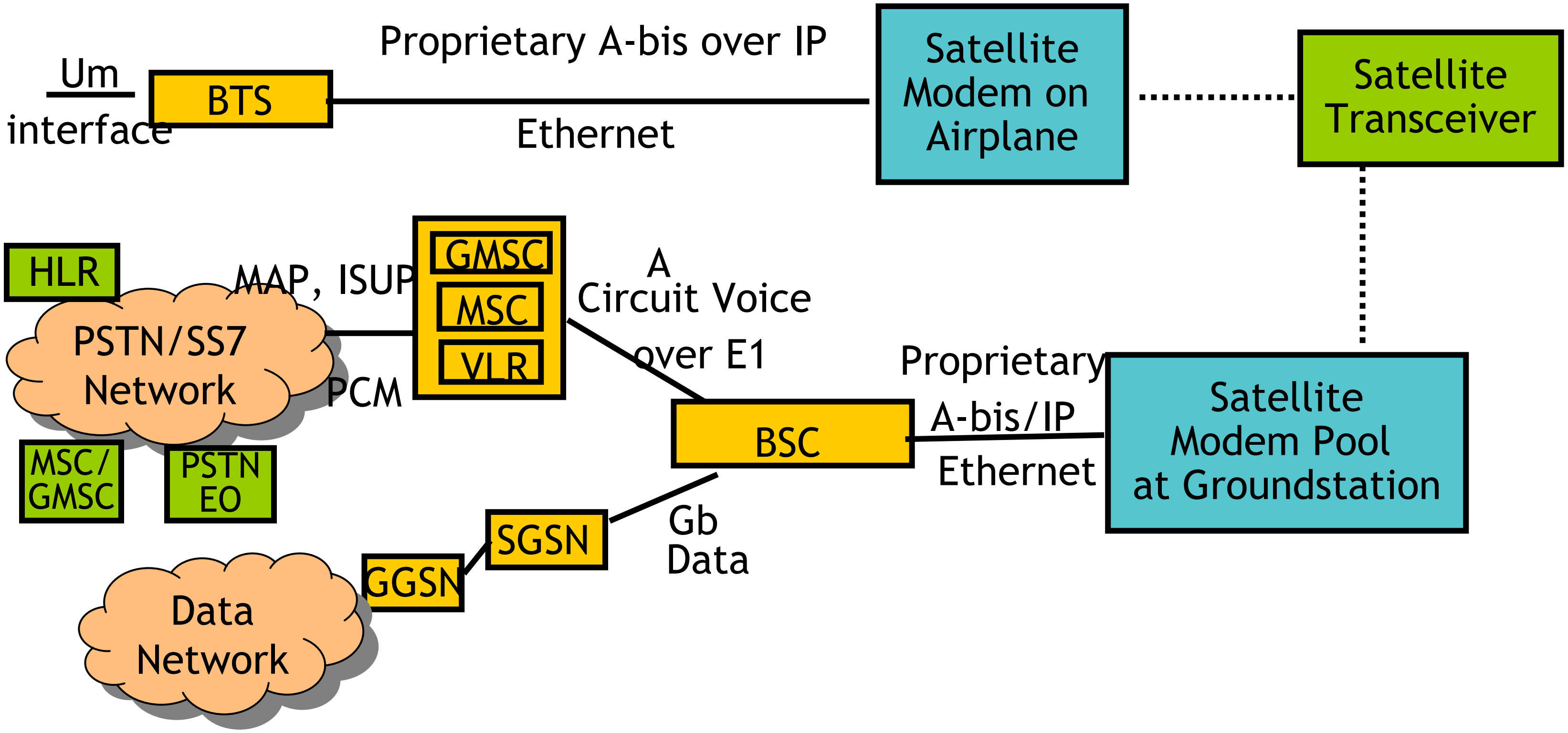
Satellite-based:

- Complicated system, difficult technical solution
- Dependent on satellite service provider, very high OpEx
- Global backhaul to service provider’s facilities
- Global coverage

Ground-based:

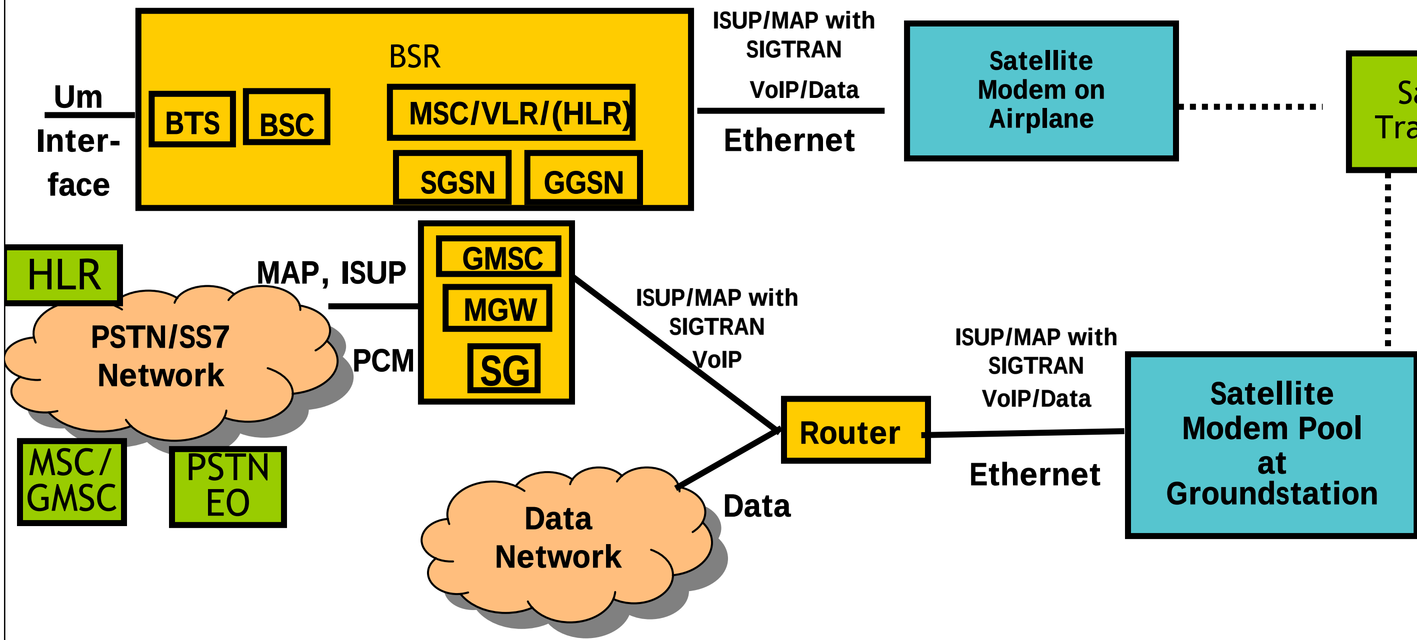
- Relatively simpler system, uses “established” technology
- Lower backhaul OpEx
- Need separate spectrum across coverage area
- Technically feasible only on contiguous body of land

BTS solution Architecture – Option 1



- BTS & BSC connected over satellite backhaul
- BTS has proprietary A-bis interface that terminates at BSC
- BSC supports standard A-interface towards MSC and Gb interface towards SGSN
- BSC can be connected to service provider's existing MSC/SGSN, if there is capacity (following standardized 3GPP interfaces).

BSR Solution Architecture - Option 2



- Logical Interfaces to be supported by PicoBSR (currently not supported):
  - D (MAP) – VLR-HLR
  - C (MAP) – MSC - HLR
  - E (ISUP/MAP) – MSC-GMSC
  - Interface to SCF – CAP

- BSR has most of GSM/GPRS network functionality
- Voice and data sent out over IP interface
- BSR needs to support ISUP/MAP over SIGTRAN to support logical interfaces to HLR & GMSC

Core Network

- Requires a standard GSM GMSC server, MGW and Signaling Gateway – can exist in service provider's GSM network or added separately

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Merits & Demerits

BSR Solution

† Plug-and-play into IP network

† Has been deployed in the field for specialized applications

† Robust interface over satellite link

– Limited product availability

– Needs integration with OSS/BSS

BTS Solution

† Can plug into service provider's existing network based on 3GPP standard interfaces

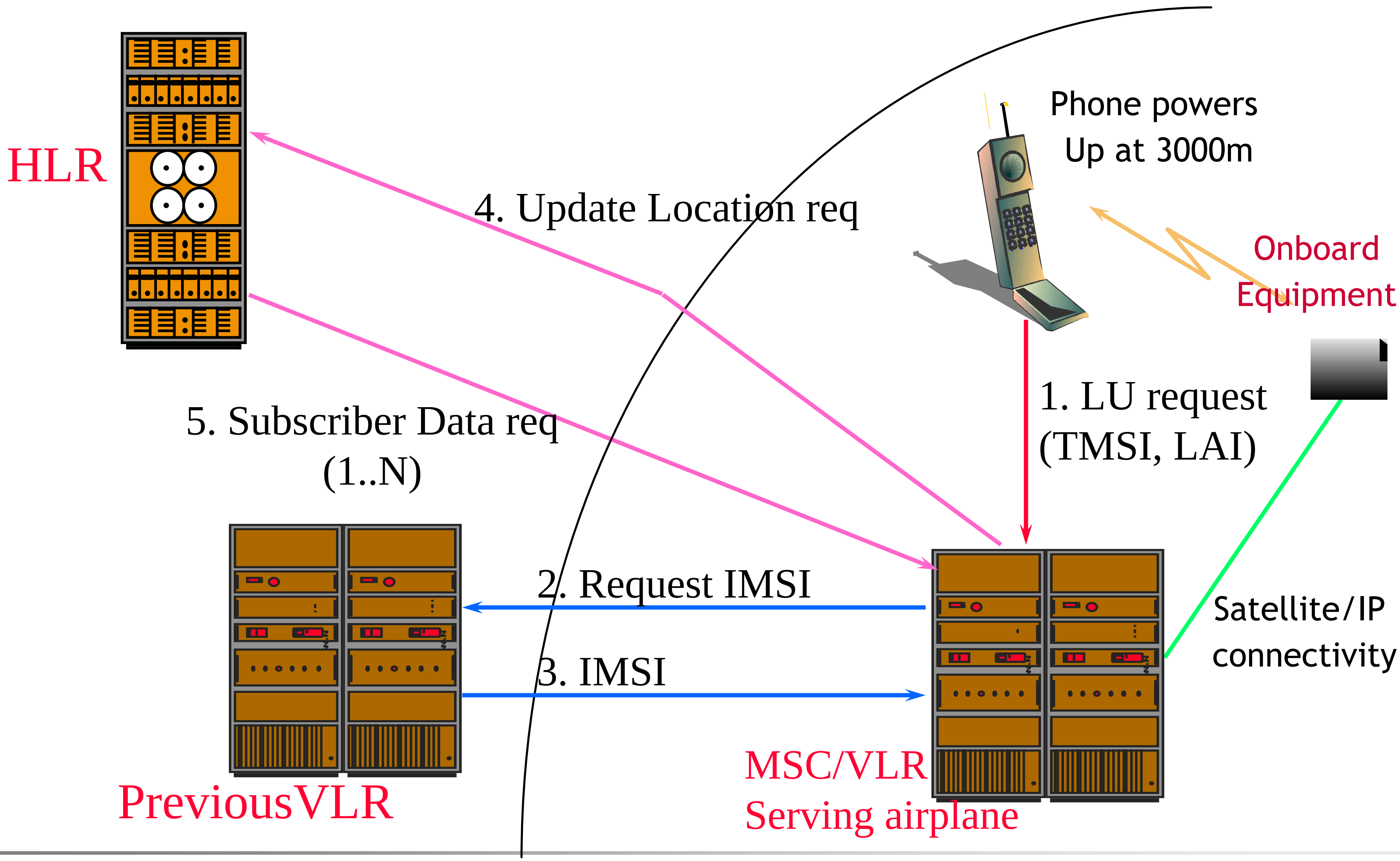
† Well-understood architecture

† Low bandwidth requirement with RTP muxing (~150 kbps per TRX)

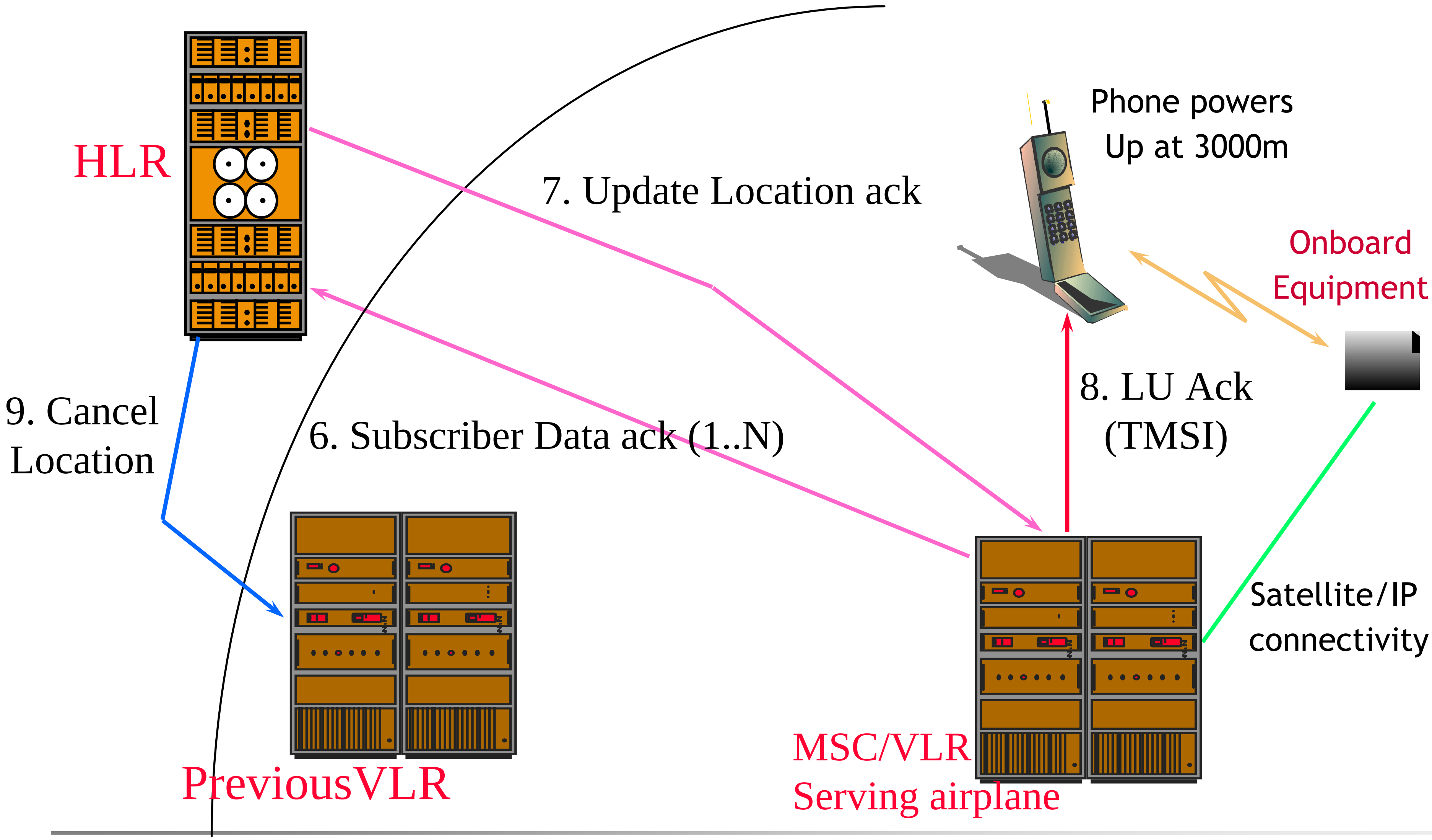
– Proprietary interface over satellite link

– Difficult to support multiple access technologies (GSM/CDMA/UMTS,…)

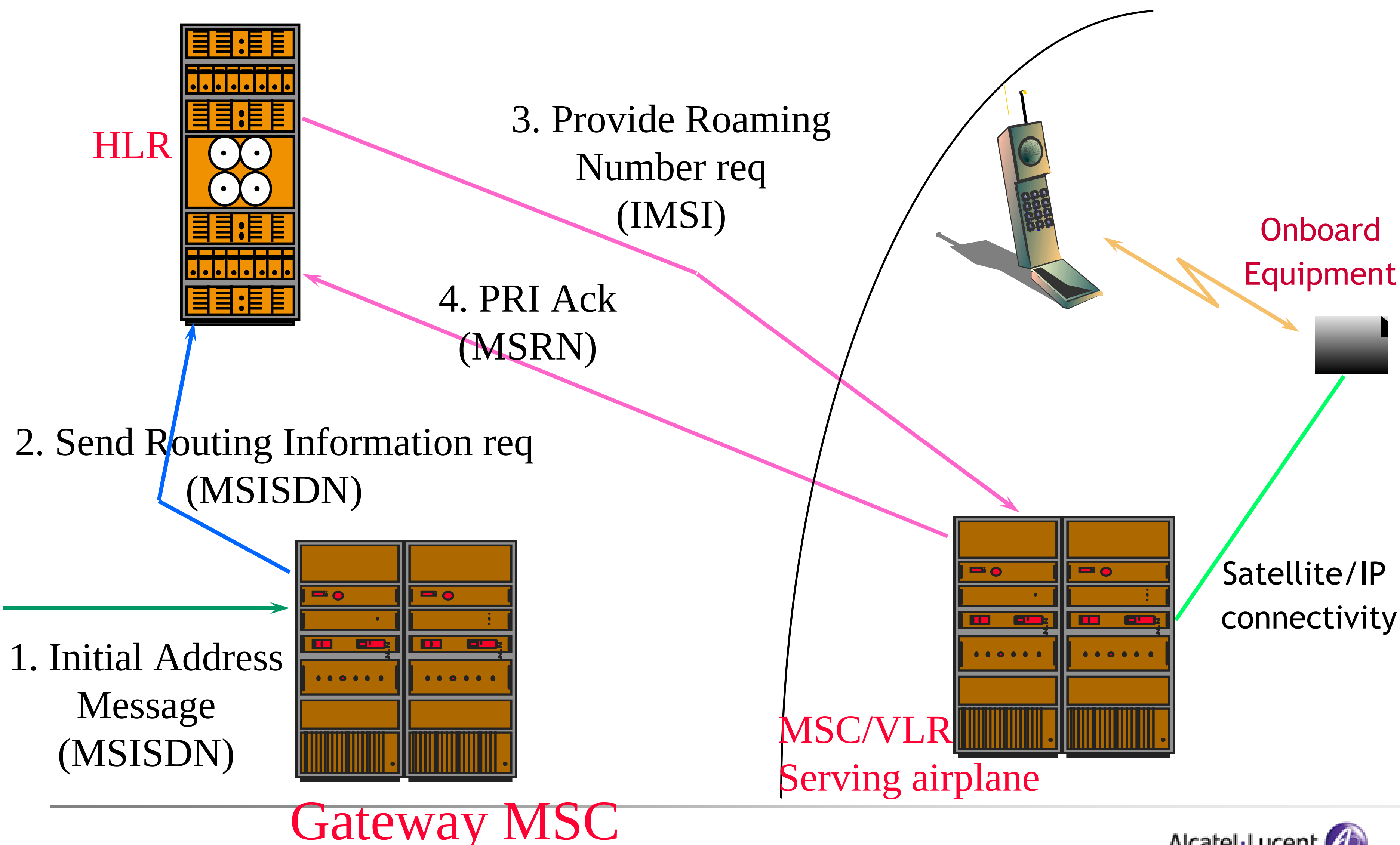
Location Registration (1)



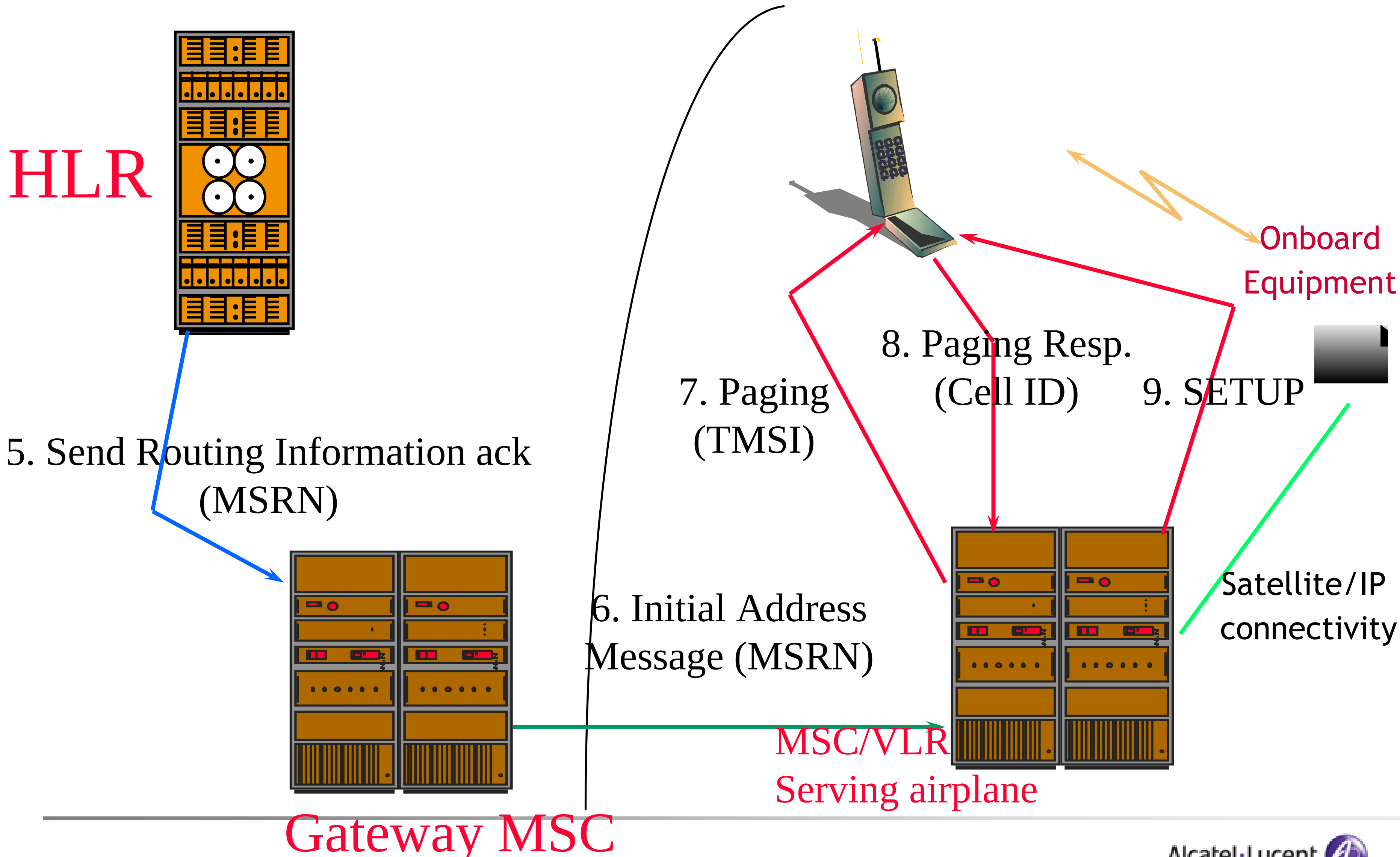
Location Registration (2)



Mobile Terminations (1)



Mobile Terminations (2)



Capacity and Capability

- Capacity
  - Air Interface:
    - Example: For a 300-passenger plane, provides 20 mErlang capacity per passenger but passenger behavior may be different compared to macro networks
    - If used for high speed data services, multiple units may be needed
    - Larger planes (e.g., A380, Boeing 747) may be equipped with multiple units for capacity and coverage purposes
  - IP interface:
    - Voice calls + data traffic+ signaling traffic totals
    - Different voice codecs may need different throughput support
    - Adequate consideration for symmetric data traffic (e.g., VoIP, video telephony,…)
- Capability:
  - Mobile-PSTN, PSTN-Mobile, Mobile-Mobile calls
  - Internet, corporate VPN access
  - Advice of Charge
  - Billing as in typical roaming situations
  - Multiple access technologies

Some Key Performance & Economic considerations

- One-way delay on satellite links 200 – 300 ms => delay between ground station and plane 400 – 600 ms.
  - BSC/RNC may have to be collocated with BTS/NodeB for acceptable radio performance
  - Circuit-based solutions will be difficult to work => consider SS7/SCTP for A-interface signaling
  - Performance enhancing proxies will be needed to improve user experience

- Sample satellite link pricing (for stationary business – not planes)
  - 2 Mbps/512 kbps: Equipment Euro 3,550, Monthly Euro 380(source www.azurebroadband.com)
  - 1.5 Mbps/512 kbps: Equipment $4,999, monthly $499, monthly limit 6GB (source www.net2dish.com)
  - 1.5 Mbps down, 512 kbps up $599 per month, monthly limit 3 GB (US); 2 Mbps down/512 kbps up max 75GB per year, $ 171,342 per year (source www.groundcontrol.com);
  - Satellite links cost 2-10 times higher than terrestrial links (source Technology News)

  Note: These high speed data services are all VSAT based, and probably on Ku/C band

Ku-band systems for airplanes are fairly rare. INMARSAT serves only in L-band

Conclusion

Cell phones on airplanes are things of “not so distant” future:

- Probably see phased introduction in various parts of the world
- Matters of etiquette may dictate use of voice service
- Data usage, including Instant Messaging, e-mail, internet browsing, corporate intranet access etc. will be more common
- QoS issues will dictate popularity of applications
- Usage charges have to be comparable to current roaming charges and far lower than current seatback phone charges
- Alternative approaches (other than cellular) may evolve. Examples are WiFi internet service provided by Live TV (subsidiary of JetBlue Airlines), ROW44, Aircell etc.(Alaska Airlines, American)
- VoIP calls over WiFi with internet access may be possible (unless the airline service provider blocks such calls) but Virgin America is supporting such calls. Voice quality is expected to be very poor in such applications, unless some special arrangements are made.