Space Networks

this chapter
1) Internal Spacecraft Communication,
2) Space Networks

Space Wire

During 1990's it was clear needed an interoperable approach

University of Dundee contracted by ESA to do this.

Created Space Wire and later Space Fibre.

Used some exisiting standards as starting point.

SpaceWire in Detail

Electrical signaling

Own protocol stack (Packet, Exchange, Character, Signal + Physical Layer)

High Data Rate → 200 Mbps over 10 meters
→ lower speed for longer distance

Links → Full duplex, bi-directional

Implementation → Can use ASIC technology

Low Gate Count → Can be hardware only, link interface SKLOOK Focus

Scalability → Can add links to augment capacity

Space Use in Detail (continued)

Fault Tolerance → If link fails, remaining links take up load.

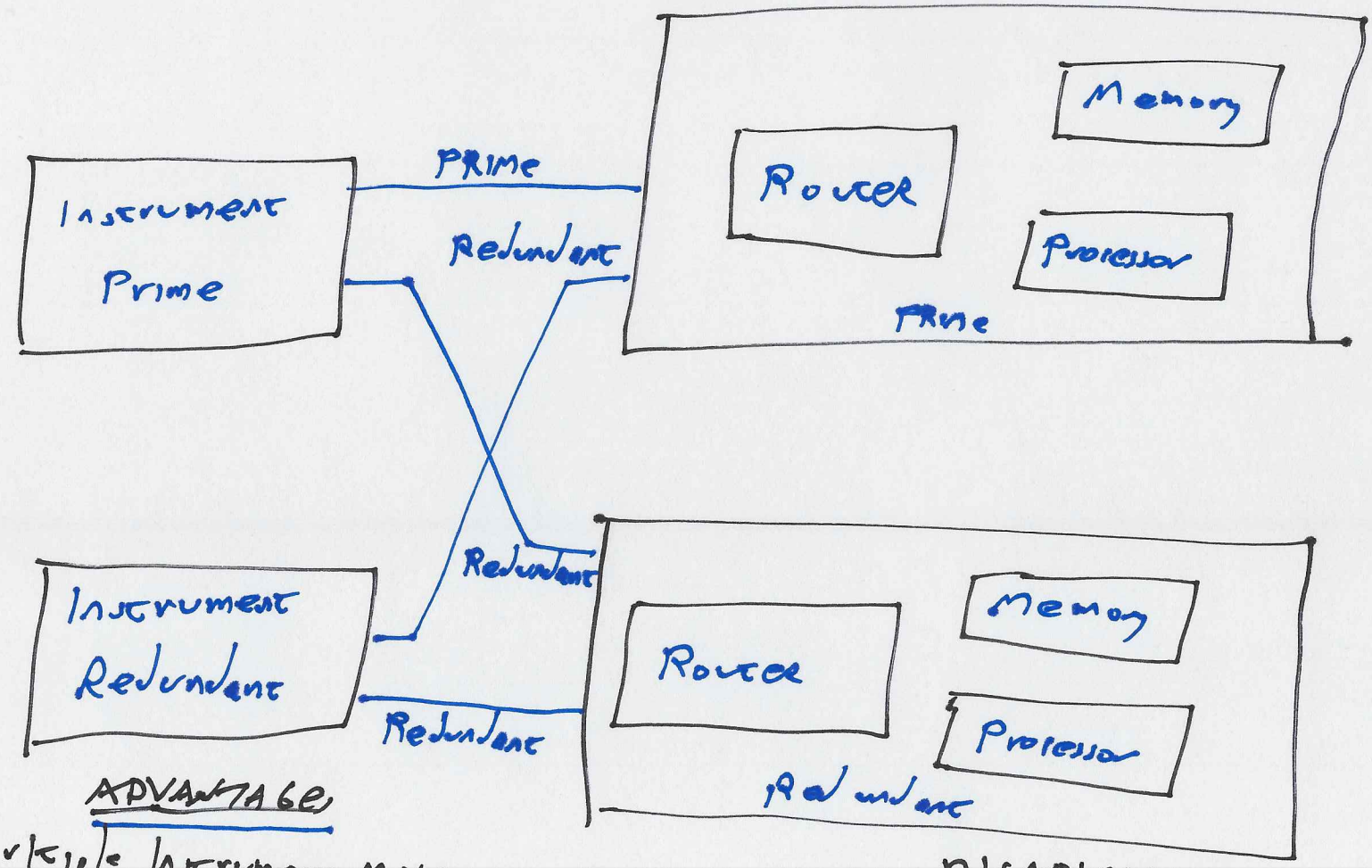
Topological Freedom → No constraint on network topology.
→ Links can be added for more capacity or more fault tolerance.

Sharing BW → Total data rate shared by parallel links between 2 nodes.

Router → Not too different from NOC routers.
→ Worm Hole Routing used

Group Adaptive Routing → "Group" of parallel links sharing load
→ Assures fault tolerance

A Configuration:



ADVANTAGE

- Multiple Instruments MUX
- Support prime+redundant instrument
- No single point of failure

DISADVANTAGE

- Additional router power consumption

Spare Fibre

- Operates at 2.5 Gbps as of 2016.
- For high data rate such as Synthetic Aperture Radar
- Makes possible QoS (Quality of Service) and FDIR (Fault Detection, Isolation and Recovery).

Space Communications

- unique equipment gave way to standardization
- NASA → Near Earth Network (2–8 GHz)
  → Space Network (7 Geosynchronous Satellites + Ground Stations)
  (2 13–15,06 GHz bands)
  → Deep Space Network (S band (2–4) GHz, X band (8–12 GHz)
  bep ~10^{-7}
  availability ~ 95% – 98%
  3 antennas (California, Spain, Australia)

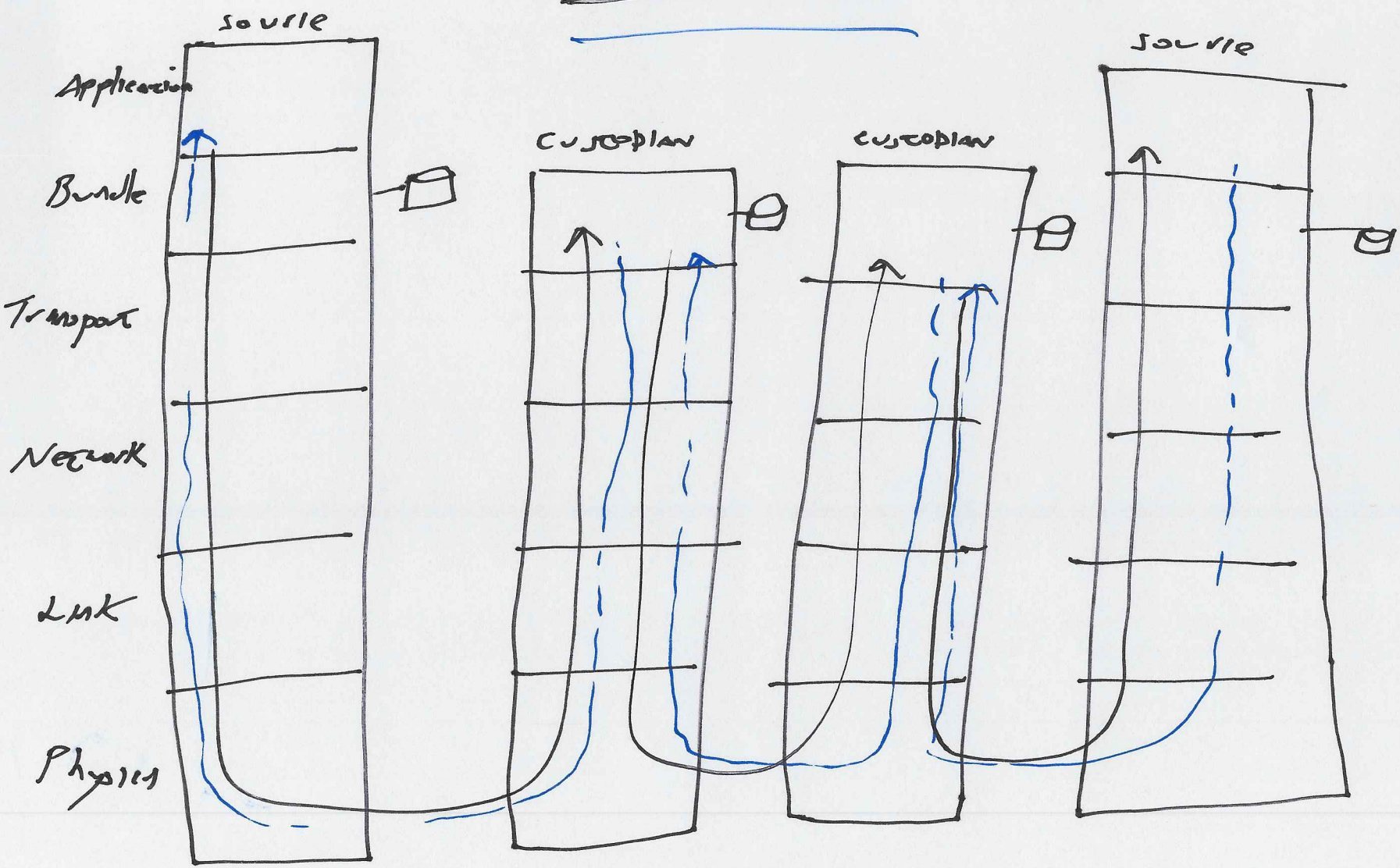
→ European Space Tracking Net for XMM-Newton and MARS Express
→ other countries have more limited networks.

Delay/Disruption Tolerant Networks (DTN)

- 1997 → "Interplanetary Internet" phrase by Vinton Cerf.
- Deep Space → large delays
  → Path blocked by heavenly bodies/orbits.
  → Constraint on how many antennas on spacecraft can be used at once
  → Memory on spacecraft is a constraint.

- Bundle Protocol
  - Bundle layer above Transport layer.
  - One node has "custody" of a bundle of data at one time.

Bundle Protocol



Contact Plan: Schedule of feasible communications creating a path in space.

Many Constraints:
- orbital dynamics
- max xmit rate, xmit power
- attitude of spacecraft
- interference from spacecraft/bodies
- architectural restrictions
- time zones (rules banning communication)

Can use mathematical or heuristic algorithms.