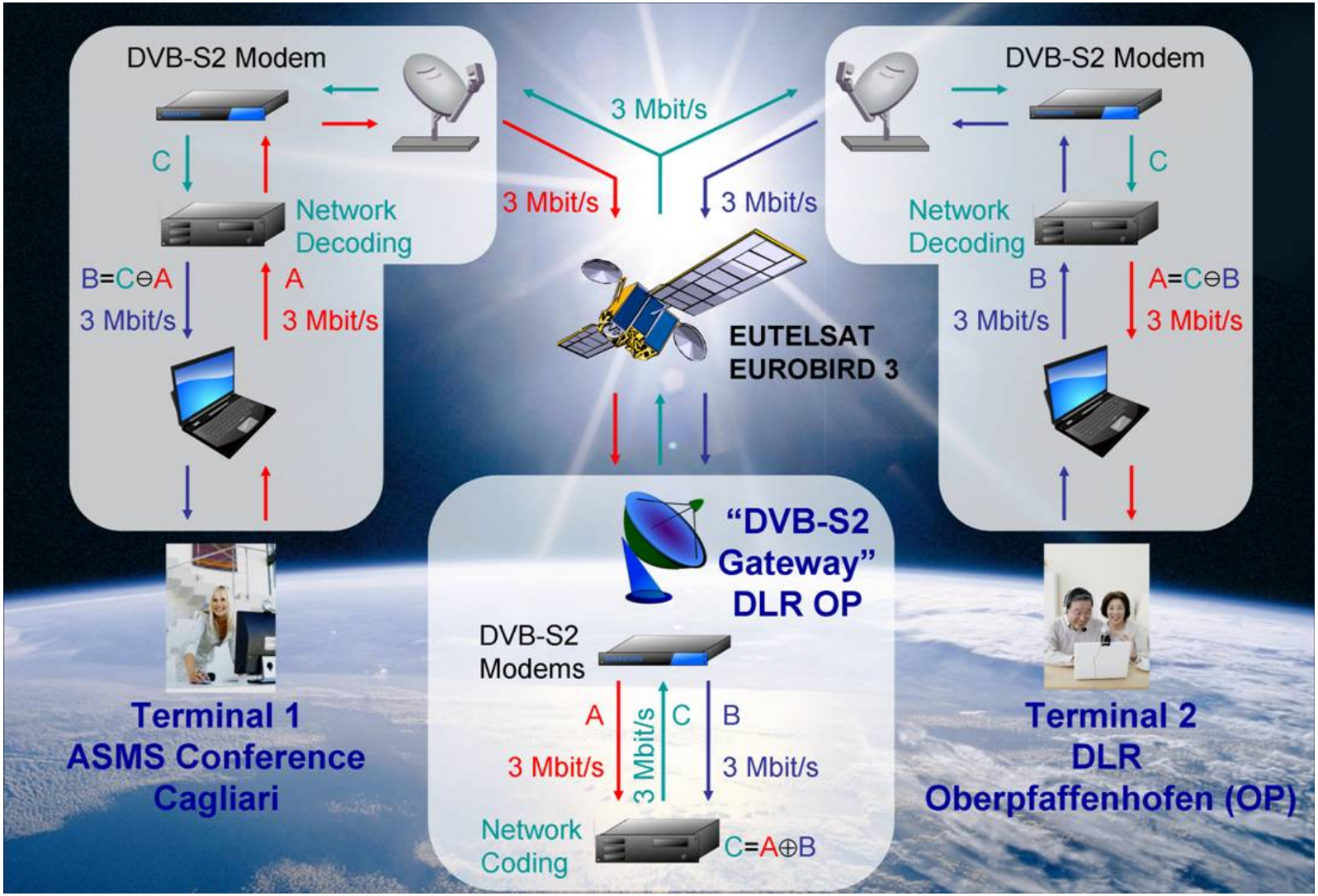
Network coding for bi-directional IP-traffic over transparent satellites

Problem statement

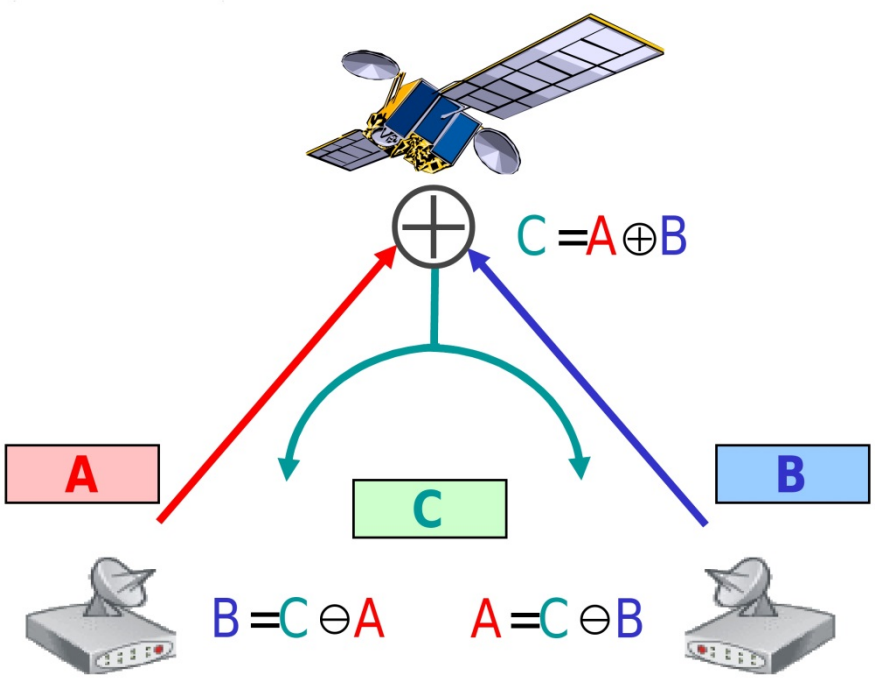
- Satellite transmission is very expensive; both bandwidth and on-board power are scarce resource.
- Especially problematic: terminal-to-terminal transmission over classical hub-based systems with transparent satellites
- Network coding can help if the traffic is bi-directional and point-to-point.
- Uses the broadcast nature of the satellite downlink.

Demonstration ASMS 2010 in Cagliari



Principle of operation

- Each terminal sends unmodified IP datagrams and remembers them.
- The hub XORs the data and broadcasts the result with a new protocol type.
- Each terminal XORs the received data with its own remembered datagrams to produce the other terminal's datagrams.
- CRC-32 over the complete IP datagram is used to match datagrams.



Protocol format (NetCoP)

- `version`: 4 bit
- `flags`: 4 bit – NC_CRC32; NC_DEFPROTO0; NC_DEFPROTO1
- `Defproto0/1`: 16 bit each; default protocol type for each terminal; only of the corresponding `NC_DEFPROTOX` flag is set
- `packet_count0/1`: 8 bit each; number of coded packets from each terminal
- `packet_info`: one info block for each packet:
  - `packet_len`: 16 bit
  - `packet_crc`: 16 or 32 bit
  - `packet_proto`: 16 bit; only if the corresponding `NC_DEFPROTOX` flag is not set
- `header_crc`: 32 bit
- `data`: variable

Protocol operation

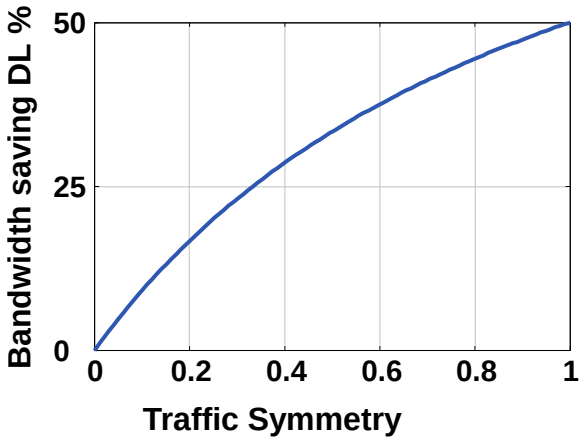
- The sending terminal sends IP packets and buffers each of them together with a CRC over the complete packet.

- Hub buffers some IP packets from both terminals; the amount of buffering is controlled by the maximum output packet size (32kbyte used), a timeout and the maximum number of IP packets for a network-coded packet (256).
- When decision is taken to create new output packet, the smaller buffer is padded with zeros to the size of the larger one.
- Both buffers are XORed – the result forms the data field of the NC packet.
- For each IP packet the CRC is calculated and inserted into the NC header together with packet length and protocol type information.

- The terminal decodes the header, identifies the packets it has sent that are coded in the received NC packet by their CRC and recovers the peers packets by XORing its own buffered packets into the receiver NC packet.

Results

- Savings:
  - Bandwidth or
  - Satellite power or
  - Datarate or
  - a combination of them



- Up to around 45% for full symmetric traffic (bi-directional video); rest is protocol overhead and padding
- Demonstrated at the opening session of the ASMS 2010 transmitting video and audio streams between Oberpfaffenhofen (near Munich) and Cagliari (Sardinia) over and Eutelast satellite