POLITÉCNICA

STRAST

SpaceWire network

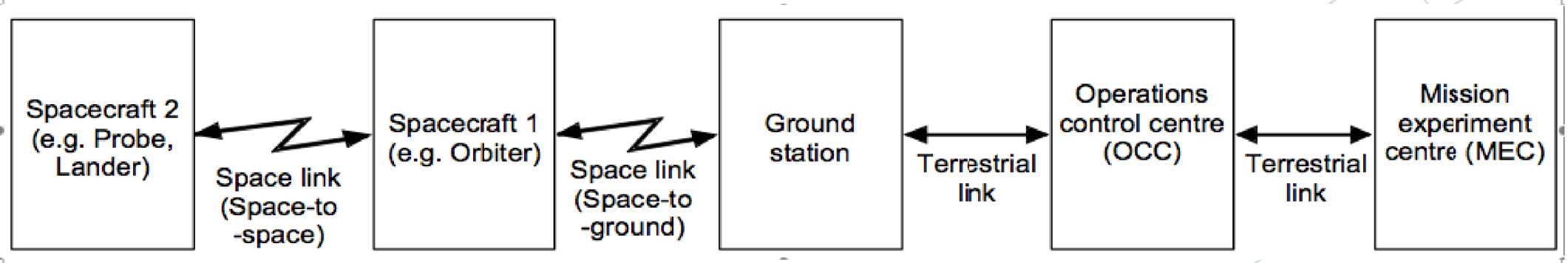
Juan Zamorano
Real-Time Systems Group
Universidad Politécnica de Madrid

dit UPM

datsi

Space communications

STRAST

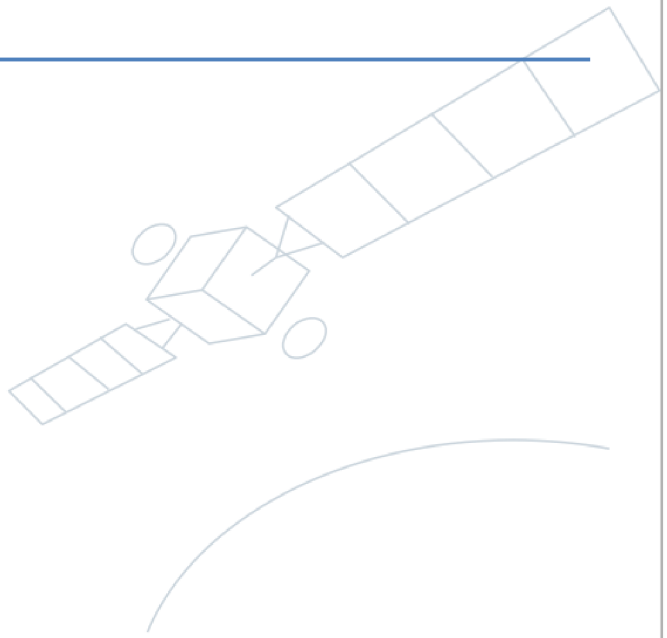


- SpaceWire is intended to be used as space link
- To comunicate
  - Systems inside a spacecraft
  - Spacecrafts in flight formation fleets

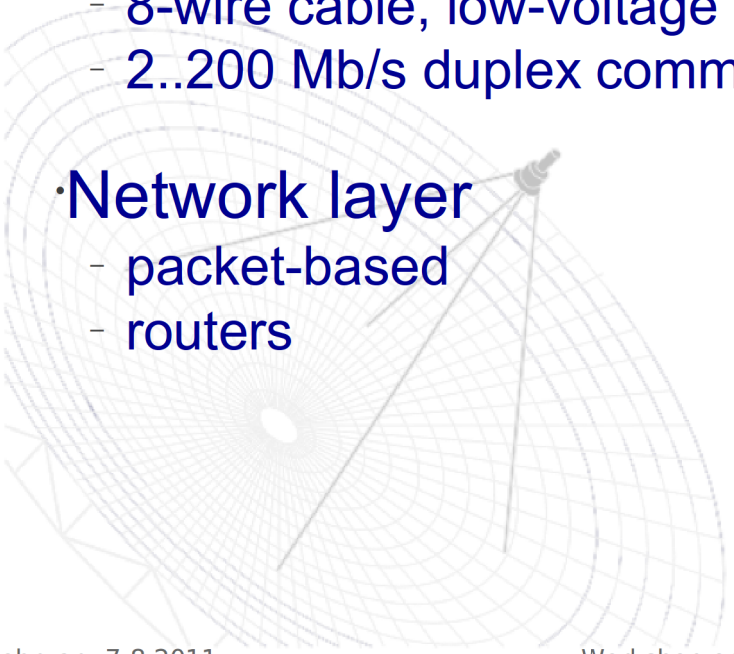
On-board data link technology

STRAST

- Milbus (MIL-STD- 1553B / ECSS-E-ST-50-13)
  - serial data bus, 1 Mb/s half duplex transfer rate
  - TDMA master-slave: controller and remote terminals.
  - the higher priority, the more frequent polled
- SpaceWire (ECSS-E-ST-50-12C)
  - serial link, 2..200 Mb/s full duplex data rate
  - point-to-point: nodes and routers
  - group routing
  - dynamic routing (fault tolerance)
  - priority based dispaching with tables (no header modifications)
  - clock synchronization
- Spacecraft discrete interfaces (ECSS-E-ST-50-14)
  - analogue, digital, serial point-to-point
  - links between OBC and simple devices



- High-speed, point-to-point network
  - complex networks built with routers
- Physical layer
  - 8-wire cable, low-voltage differential signals LVDS
  - 2..200 Mb/s duplex communication
- Network layer
  - packet-based
  - routers

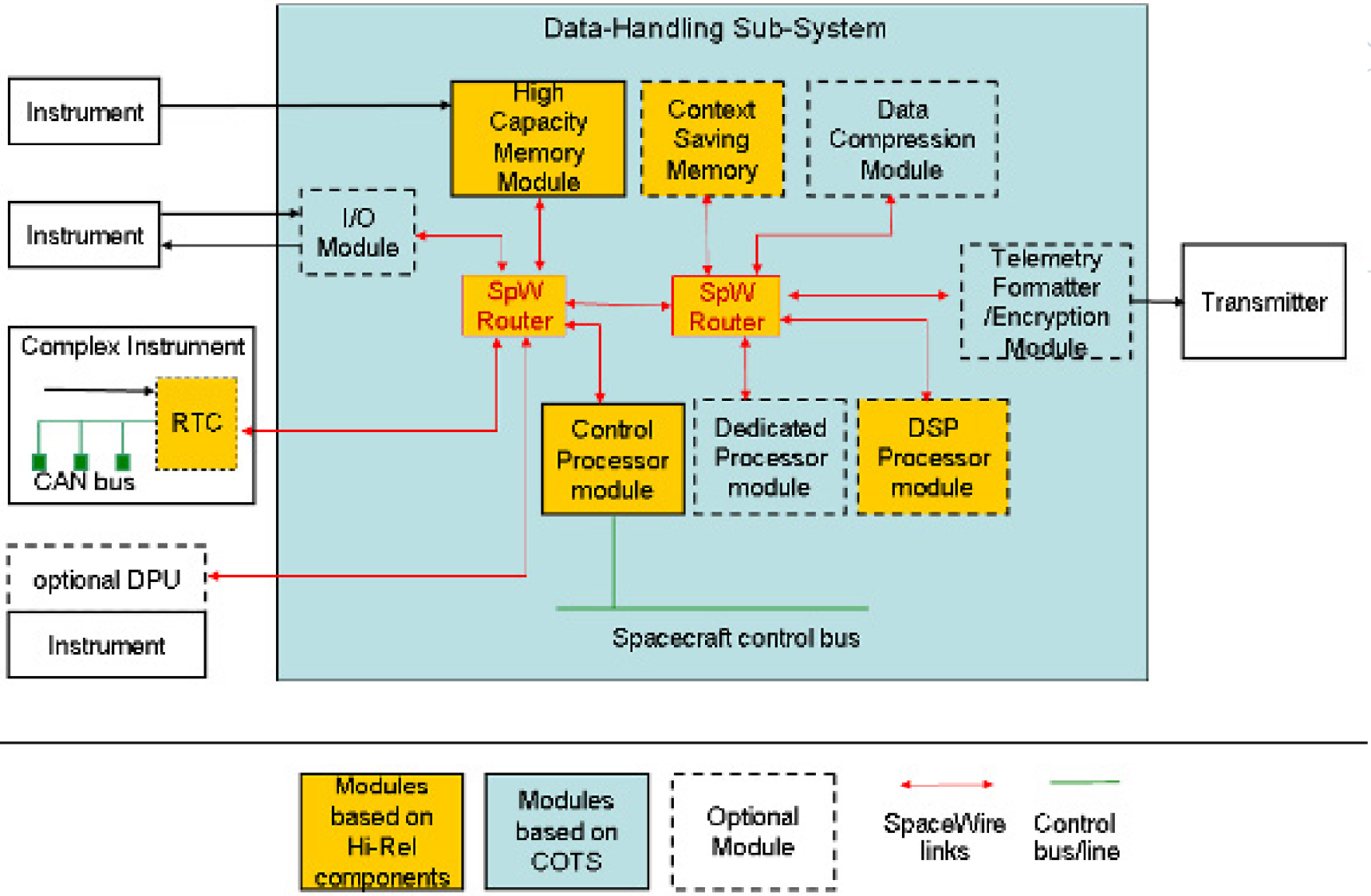


On-board networks

GR-RASTA - LEON2/3/4 spacecraft avionics development platform. Source: Aeroflex Gaisler .

- Direct connection between nodes can be used to interconnect a limited number of nodes (e.g. 3 nodes).
- A routing switch can usually connect more nodes.
- Several switches can be cascaded to form large networks.

Sample on-board network



Internals

- Standard spacewire chips and IP cores use receive and transmision buffer rings (similar to LANCE chips).
- Direct Memory Access is used to minimize interrupt overhead.
- Interrupts can be delivery when packets are received or transmited.
  - It is also possible to use polling tasks
- In bare-board kernels is not usually needed to copy “cargo” (the data to deliver) but just to put the access in the corresponding transmision descriptor and then the spacewire chip “shall DMA” them to the transmision mechanism.

Protocol

- Packet composition:
  - <destination address> <cargo> < end_of_packet >EOP/EEP
  - <destination address> = <dest_id1> <dest_id2> 0 <dest_idN>
- Nothing is said about packet length in the standard.
  - It can be agreed at system level and define buffer size accordingly.
- Uses flow control to “xon/xoff” the transmision of next 8 N-Chars (Normal Characters)
  - Therefore contention can occur at switches or sending nodes depending of switch flow control policy and buffer availability.
  - Allows directly sending the input packet to the output port in routers (Wormhole routing).

Addressing

Address range	Function	Header deletion
0	Internal configuration port	YES
1-31 (01-1F hex)	Physical output ports	YES
32-254 (20-FE hex)	Logical addresses, which are mapped on to the physical output ports.	Optional on each output port. Header deleted if the physical output port is a gateway between distinct regions. Header can also be deleted on final link to a node.
255 (FF hex)	Reserved logical address, which is mapped on to physical output port. Treated in the same way as any other logical address (refer to 10.3.3 o.), but is reserved for future use (refer to 10.3.3 n.).	Optional on each output port. Header deleted if the physical output port is a gateway between distinct regions. Header can also be deleted on final link to a node.

Group adaptative routing

- Links that connect to the same destination (node or routing switch) are called a group.
- Links physically connect output ports with input ports.
- Physical sockets are called ports in SpaceWire jergon.
- GAR is a means of routing packets to a requested destination over alternative paths through a network.
- If the requested output port is busy, the packet can be routed throught an equivalent (same target) output port.
- GAR can be implemented relying on the configuration registers to hold information about equivalent output ports.

Arbitration

- Is needed when two or more input ports are waiting to send data out of the same output port:
  - SpaceWire routing switch means of arbitrating between input ports requesting the same output port can be:
    - Priority based, round-robin or random arbitration schemes.
  - Arbitration is performed when the output port becomes free.
  - Input port priority must be set.
- Group adaptive routing:
  - The same arbitration policy shall apply to all output ports within a group.

Non-preemptive fixed priority scheduling among input ports can be used.

Clock synchronization support

- SpaceWire devices have a 6-bits counter that is incremented with a TICK_IN signal.
- The counter is sent by the time master interface every TICK_IN tick: Time-Code.
- Receivers update their counters and resend Time-Code incremented by 1.
- Routers propagate Time-Code to all their outputs.
  - Received Time-Codes equal to local counter are ignored:
    - Backward flows are supressed.
- Support application level clock synchronization protocols.
  - Time accuracy up to 10 μs.

Conclusions

- Packet length can be agreed at system level and thus blocking time can be bounded.
- Non-preemptive fixed priority scheduling can be used to arbitrate among ports.
- Packet priority can be changed by traversing routers.
  - Fixed priority for packets can be obtained by properly setting up the network.
- The SpaceWire network configuration is versatile enough for covering different scenarios.
  - For instance: mixing fixed priority with round-robin arbitrated packets.