Use Cases of SpaceWire connection from the satellite-construction field: in case of ISAS/JAXA spacecrafts

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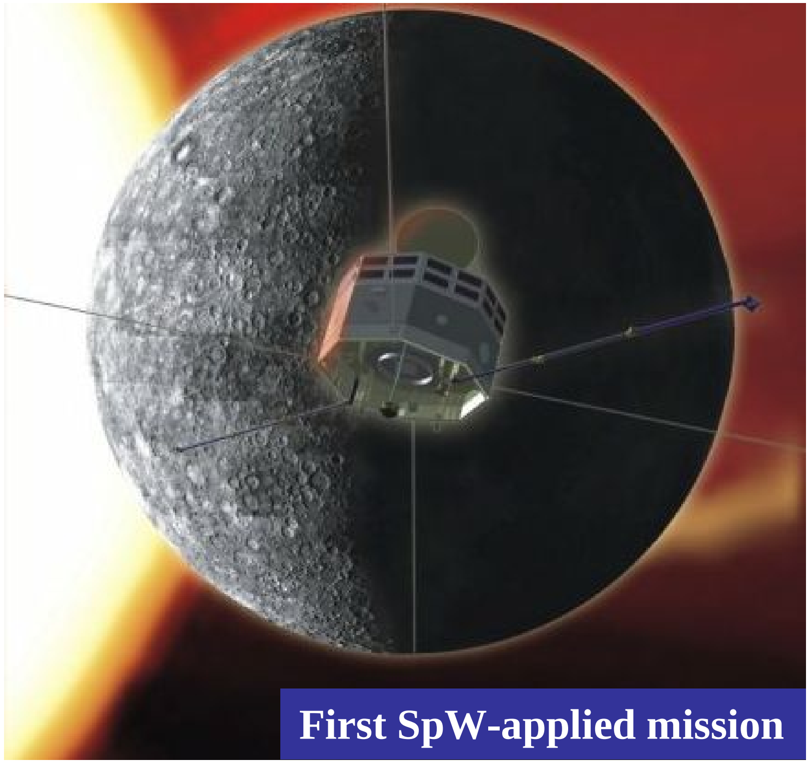
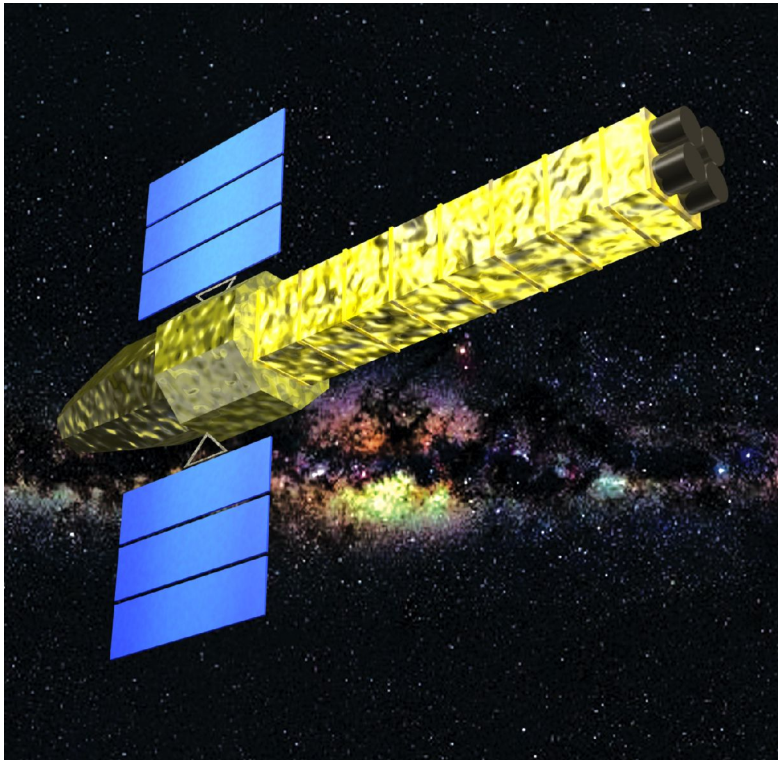




I/F problem

- Too much cost for I/F!
  - Time and man power in design and test stages.
  - Mass and power consumption.
- Requirements?
  - Standard intelligent I/F of small resources, flexibility and reliability.
  - Plug-and-play testing at the satellite construction stage.
- We need a high-speed serial I/F that can be tested automatically. SpW?

Target Spacecrafts

Light weight and low power consumption

- BepiColombo MMO (introduced by Kasaba)
  - Low data rate, highly-autonomous control.
  - Distributed (Japan & Europe) development, including performance verification.
- NeXT: X-ray observatory on Low Earth Orbit
  - High data rate, highly-independent subsystems.

(and other future missions...)

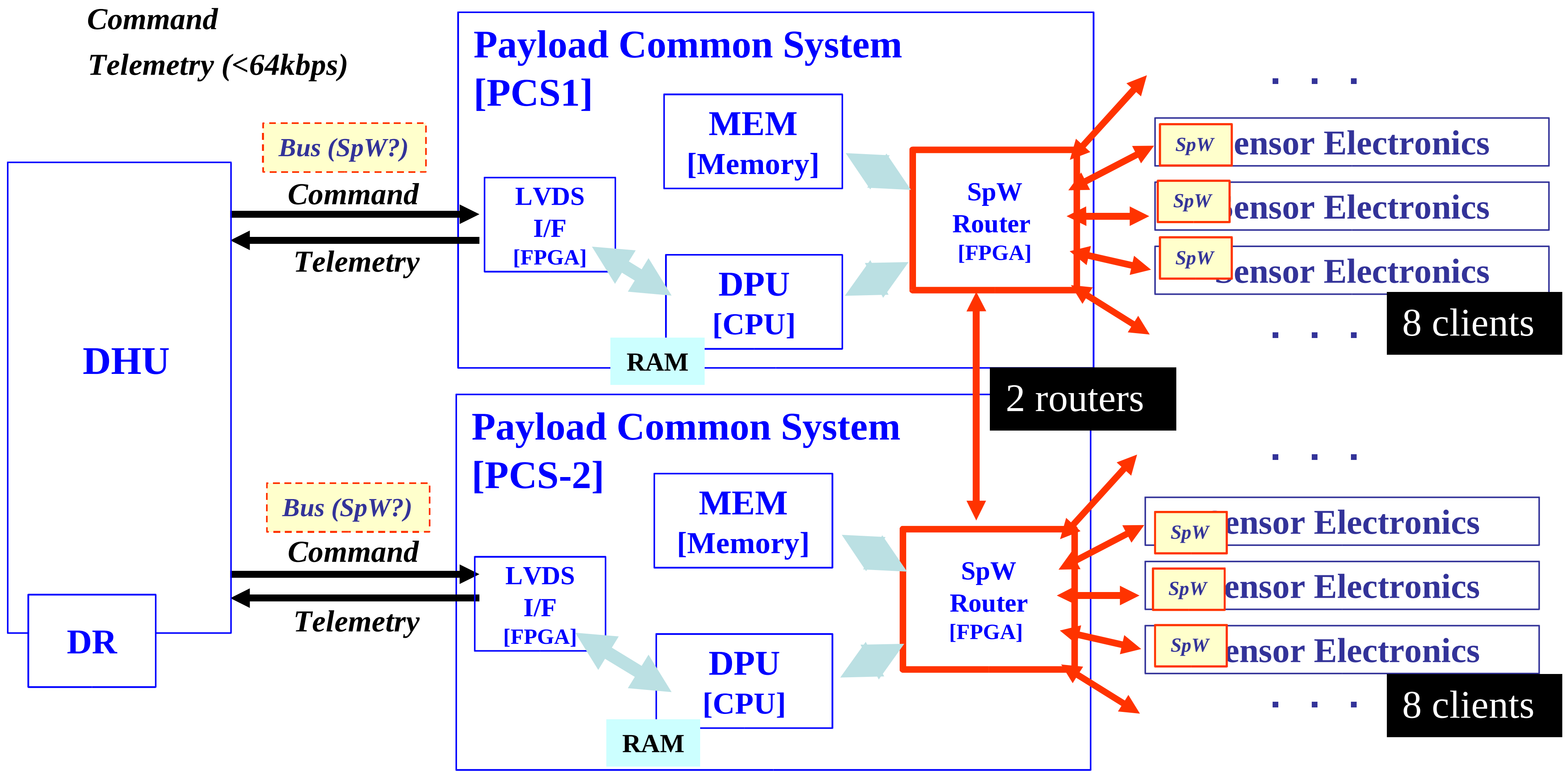
Use Case 1: MMO (1)

- Data collection from thin sensors
  - Sensor output:
    - Waveform or event list with time tag of ~0.1ms resolution synchronized with external pulse (orbiter's spin phase).
    - Congestion can occur unless some flow control.
  - Very low power and light weight sensors.
    - Typically 1-FPGA (+ I/F chip?) digital part, no memory chip, no additional OSC, but standalone.

Use Case 1: MMO (2)

- Data flow topology:
  - Grouped into two; each is treated by corresponding collector (PCS).
    - In case of a PCS failure, the other one is expected to take care of the failure-side sensors.

Use Case 1: MMO (3)

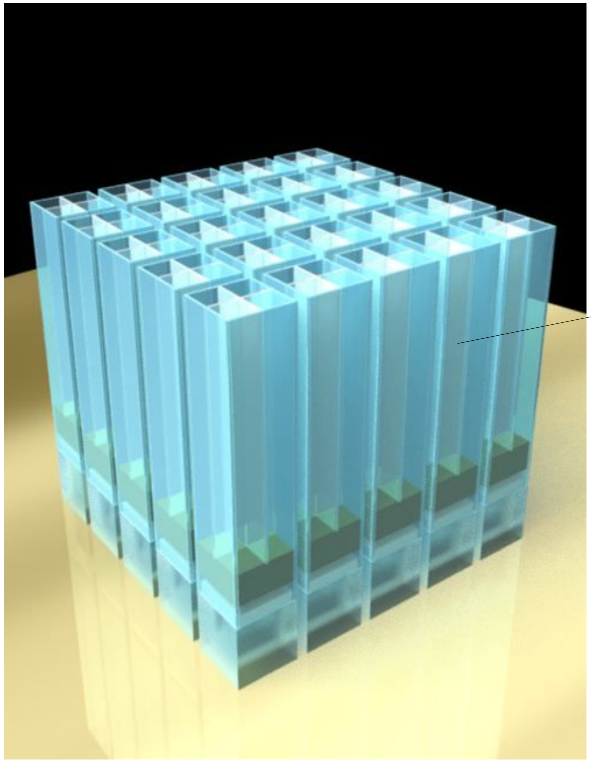


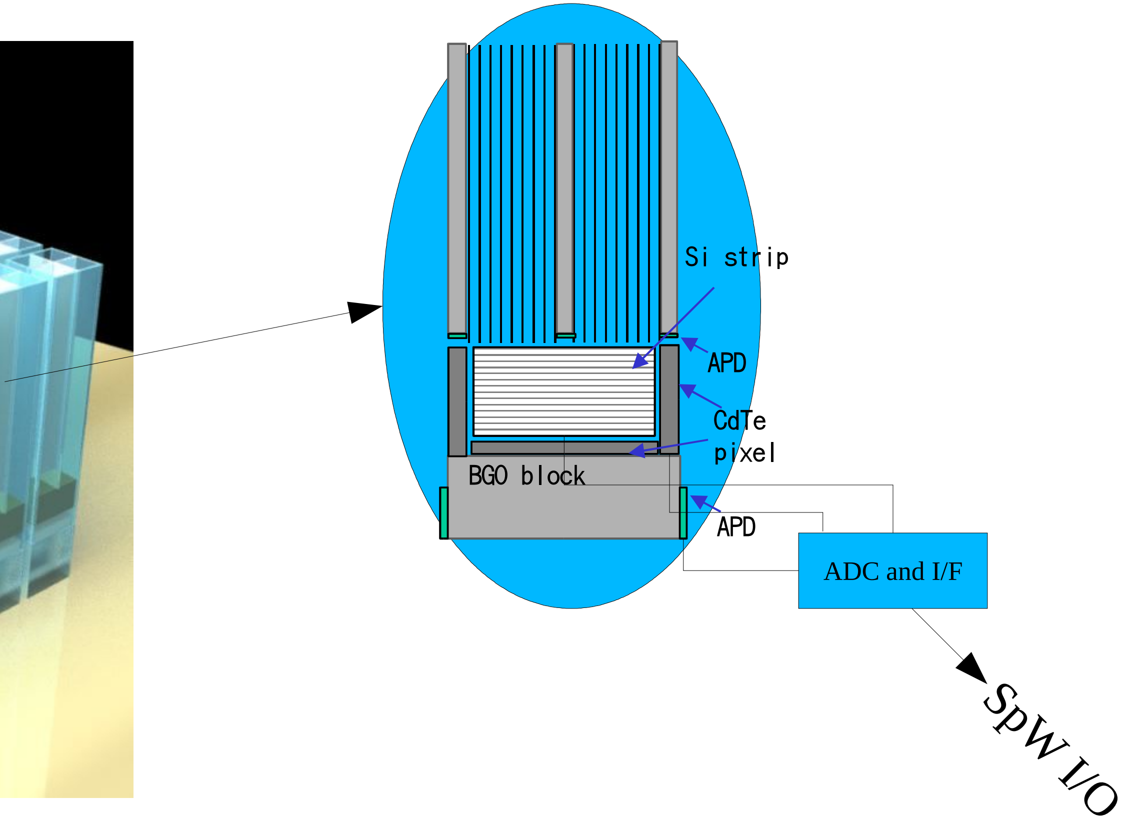
Use Case 2: NeXT (1)

- Telemetry and command link among intelligent subsystems (sensors).
  - 4 different sensors with the capability of CCSDS packet handling.
    - Each can decode commands from the ground base directly and output CCSDS packets with data rate controll.
  - No central data collector or command interpreter.
  - Longer TI counter (16-32 bits?) with 1/4096s precision
    - 32 bits for Astro-E2

Use Case 2: NeXT (2)

Link between the core and end sensors can also be SpWed.





Use Case 2: NeXT (3)

- Link between the core and end sensors can also be SpWed.
  - Digitized-output rejection by anti-coincidence method.
  - Synchronization among the sensors is essential.
    - Timing accuracy and precision should be ~10μs.

Use Case 3: satellite bus (1)

- Migration from legacy I/F (called PIM: next page)
  - Want to use legacy (i.e. well-tested) central nervous system of the spacecraft with minimum modification.
    - For cost reduction.
    - For steady development by step-by-step approach.
  - Bridging between SpW and PIM?
  - Pseud-PIM channel on SpW protocol?

Use Case 3: satellite bus (2)

- PIM: I/O channel between the central data handler (DHU) and subsystems
  - Hardware specs:
    - data channel redundancy, low noise/interference
  - DHU side:
    - command, data collection by memory-mapped I/O, 24bit time distribution (LSB: 1/8sec)
  - Subsystem side:
    - event notification to DHU (i.e. interrupt)
    - command receiving even in case of very high I/O load

Conclusion

- We are studying SpW system for future ISAS spacecrafts' infrastructure.
  - Light-weight (I/F and wire harnesses) and automated-testability is very important.
  - Realtime channel is essential.
    - Time distribution and interrupt.
  - Application range:
    - Links between sensors and subsystem controllers.
    - Links between subsystems and central hub.
    - Replacement of legacy central nervous system.