Standardization of the
Spacecraft Onboard Interface (SOIF)
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Joseph F. Smith
NASA Rapporteur to CCSDS Subpanel 1K
JPL/Caltech
818-354-3328
joseph.f.smith@jpl.nasa.gov

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Outline

- Introduction to SOIF, Context, and Scope
- The Use of Standards
- SOIF Reference Model & Layers
- SOIF Services
- Changing the Data Bus
- Advantages of SOIF
- Building a Spacecraft
- Subsystem/Payload Perspective to Interfaces
- Conclusions
- The SOIF Timeline
Introduction

- The Consultative Committee for Space Data Systems (CCSDS) is an organization of national space agencies cooperating in the development of data standards to promote interchange of space related information.
- CCSDS has started a new subpanel (1K) in order to look at what is needed for standardization of Spacecraft Onboard Interfaces (SOIF), starting with data bus (network) standards
- The most important aspect of the work is to determine methods that will allow easier substitution data busses for onboard equipment and applications
  - Will ease effort of moving between different implementations and upgrading to new busses and networks as technology changes
  - Would allow for ordered upgrade in equipment and applications over time
- Also looking at network services, standard communications services, and standard applications interfaces

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End-to-End Communications Context

- SOIF reference model fits in the end-to-end context of the CCSDS model
- SOIF and CCSDS end-to-end protocols are independent
Scope of SOIF

- One standard should be applicable for all mission types, there is no real difference in data bus for spacecraft, however there are some general trends
  - Deep space and commercial communications missions may have a need for longer life missions
  - Human inhabited (manned) missions may have requirements for on-orbit repair, replacement, reconfiguration
  - Earth observation missions may have requirements for high data rate

- Considering that SOIF work will be applicable for all classes of spacecraft devices, payloads, instruments, and subsystems

- Considering three speeds of interface to handle wide range of applications
  - Low-speed sensor and command/control busses: I^2C
  - Medium-speed busses: Mil-Std-1553B and OBDH
  - High-speed busses: IEEE-1394 and SpaceWire
Using Standards Vs. Not Using Standards

- When communications standards are used, then the application can use the services provided by the protocol
- Without communications standards, then the applications either need to supply the service themselves, or do without the service
- Without standards, when the underlying bus changes, then the effects will ripple up into the applications
- The use of layered standards should increase order and clarity, not increase complexity
The SOIF Reference Model

- Application Layer contains user oriented services which are presented to the users
- Transport Layer provides end-to-end transport of messages between users
- Network Layer contains services to control of sub-network operation, & routing of data to location
- Data Link and Physical Layer contain communications services of the low level network, usually a standard
Mapping of the SOIF Layers to OSI Layers

- Provides a mapping of the SOIF layers to the familiar OSI layers
- Presentation Layer services (if any) are included into the Application Layer
- No requirements for Session Layer, so is mapped into the Transport Layer
- Network Layer provides these services
- Data Link and Physical Layers are combined into a single layer
  - This single layer demonstrates how underlying bus interfaces to rest of SOIF Reference Model
  - Can change out bus with change of this layer

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<thead>
<tr>
<th>SOIF Layers</th>
<th>OSI Layers</th>
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<tr>
<td>Application Layer</td>
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<tr>
<td>Presentation Layer</td>
<td>Presentation Layer</td>
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<tr>
<td>Transport Layer</td>
<td>Session Layer</td>
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<td>Network Layer</td>
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<td>Data Link Layer</td>
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<td>Physical Layer</td>
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Mapping of the SOIF Layers to the ISO OSI Layers

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SOIF Services Exposed to Users

- **Application Layer Services**
  - File Transfer for reliable transfer of files
  - Time Distribution for coherent time information to users
  - Command and Data Acquisition service for minimal latency for simple devices

- **Transport Layer Services**
  - Reliable Messaging Service for guaranteed delivery
  - Datagram Service for non-guaranteed delivery
  - Network Management

- **Network Layer Services**
  - Internetworking Service provide connection to other networks
  - Intranetworking for connection to same network (subnet)
Changing the Data Bus or Network

- SOIF also will allow easier changeout from one type of data bus or network to another
- Changes will be confined to the Data Link and Physical Layers (with media) and the two lower sub-layers of the Network Layer
- Elements of the Network Layer that are independent of the underlying bus/network are not changed
  - Routing/Addressing outside of the subnet
- Elements of the Network Layer that are dependent on the underlying bus/network are changed
  - Routing/Addressing within the subnet
- Means that we can change out the underlying bus without effecting the users and upper layers
Advantages of SOIF: Why We Need SOIF

- The SOIF concepts will de-couple the user application (software) from the spacecraft hardware, allowing greater reuse
  - The application software isn’t dependent on the data bus implementation
  - Allows greater use of software drivers for hardware interface, to de-couple the applications from the hardware devices (sensors and actuators)
- Will ease the ability to reuse hardware with different data busses, therefore with different spacecraft
  - Hardware devices, subsystems, instruments, payloads
  - Changing the data bus will only effect the interface, and not the application or the device’s functionality
How We Build Spacecraft

- As spacecraft engineers, we have two (conflicting?) desires
  - To build the best (neatest) spacecraft with the “appropriate” (neatest) technology
  - To build a spacecraft that will do the job and meets schedule and budget
- Program Managers like the engineers to meet the schedule and budget
- Would be nice to use COTS interfaces for spacecraft, but commercial busses usually don’t meet all requirements (usually reliability and/or environment) and carry “extra” functionality
  - Can give us some real savings with larger user base, and test equipment
  - Can modify the bus to meet the requirements, but then it isn’t COTS any more

- A basic assumption to this discussion is that the best way to stay within the budget is to meet the schedule
A Spacecraft Data System Hierarchy

- Spacecraft segment can be modeled with various levels of busses, each with a different level of responsibility for running the spacecraft systems
- Devices interfacing to the busses vary from high speed payloads and the spacecraft executive processor to sensors and effectors
The Subsystem or Payload Perspective

- From the perspective of the instrument or subsystem
  - all external electrical interfaces can be met with the set of standardized interfaces
  - Power standard selected for spacecraft & instrument/subsystem needs
  - Use of high-, medium-, and/or low-speed busses meet all instrument/subsystem needs, using one or more of the three selected busses

- Only standardized interfaces are to be tested during vehicle integration & test, placing all unique I/Fs (if used) inside instrument/subsystem

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Three Cases of the Low Overhead Interface to Simple Devices

Bus Type B

Network Layer

Data Link & Physical Layer
Bus B

Data Link & Physical Layer
Bus A

Existing Bus-to-I/O Conversion

I/O DL & Phy

Bus Type A

Network Layer

Data Link & Physical Layer
Bus B

Data Link & Physical Layer
Bus A

Existing Bus-to-I/O Conversion

I/O DL & Phy

User

Application Layer

Transport Layer

Low Overhead SAP

Network Layer: Highest Sublayer

Convergence Sublayers
Bus A

Data Link & Physical Layer
Bus A

I/O DL & Phy

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Towards Some Conclusions

- What we usually do is to create a number subsystems or instruments/payloads
  - Each subsystem or instrument will be have its own data bus physical domain
  - This domain is good, in that it will wind up integrating subsystems and instruments instead of individual devices
  - This simplifies the interfaces, and puts hard work (systems engineering and integration & test) on the subsystem engineer (minimal schedule theory)
- This is an excellent method for most spacecraft and space vehicles
- But remember, the SOIF architecture is now allowing us nearly transparent access to devices and subsystems anywhere on the vehicle
And Some Conclusions

• Can organize the vehicle avionics by any convenient parameter
  – Can be by subsystem/instrument
  – Can be by physical element
    • Main body
    • Scan Platform
    • Communications package/Antenna
    • Propulsion Module
  – Can be by launch element
  – Can be by most any parameter that we may wish
• Once we learn to build, test, and trust these systems, will give us another level of freedom in spacecraft avionics design
The SOIF Timeline

• Presently SOIF is in a phase where we are working both on Standards Research, and Standards Development

• CCSDS SOIF schedule
  – Presently working of first released draft of White Book, due in November 2001
  – Final late version Red Book (draft) in the second half of 2002
  – Approved final standard (Blue Book) scheduled for late 2003

• If CCSDS Subpanel 1K keeps to this schedule, then will be able to start implementations in 2002, with no expected changes after mid 2003

• Participation is invited