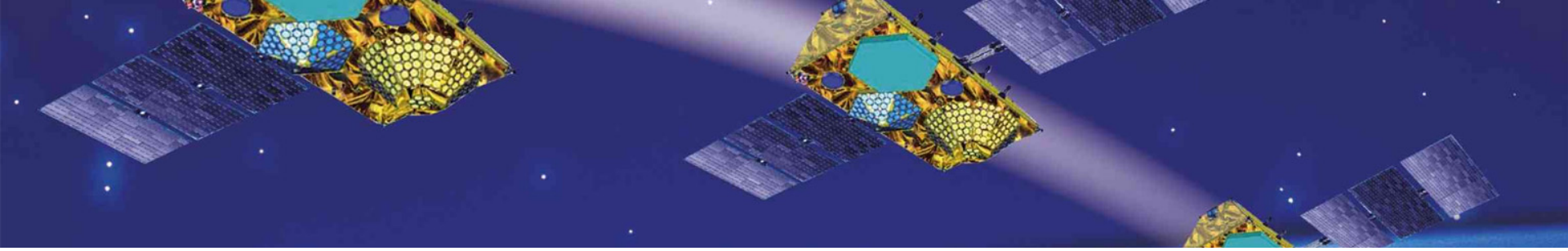

ThalesAlenia Space
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ADCSS 2012
Avionics Data, Control and Software Systems

Round table on mass memories and file based systems

M. De Meo, G. Rosani, G. Saldi (TASI-MI)

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Corporate Communications

Generic User Requirements

Typically the SSMM Users (Payload Instruments, On Board Computer…) provide TM data chunks organised as CCSDS packets (this should become the general rule for the future)

The SSMM files are therefore called “Packet Stores”

From Storage standpoint a PS can be managed as “cyclic” or “non-cyclic”

From Retrieval standpoint each session can be “bounded” or “unbounded”

The **PUS** (ECSS-E-70-41A) specifies a On-board Storage and Retrieval service (PUS Service 15) which allows to selectively store into Packet Stores TM packets that are generated by different application processes, and gives to ground the possibility to retrieve and downlink selectively the stored data.

In case the uplink/downlink chain has some weaknesses (e.g. due to long distance and/or weather conditions) a safe uplink/downlink function/protocol, supporting autonomous retransmission between sender and receiver, is requested.

Therefore in addition to Service 15 the PUS specifies a Large Data Transfer service (Service 13) which allows for the uploading/downloading of large areas of the on-board memory in a controlled manner by means of TC/TM packets with a fixed mission-specific size.

Different operational requirements can apply to the Large Data Transfer, including:

a) the capability to determine when the transfer is complete;

b) the capability to identify and selectively re-transmit those parts of the data which are lost during a transfer;

c) the capability to pass the data parts in order, and without duplication, to the recipient.

CCSDS File Delivery Protocol (CFDP)

A **CFDP** (CCSDS 727.0-B-4) implementation is done through PUS Service 13 and its extension.

In SSMMs where the PUS On-board Storage and Retrieval service (PUS Service 15) is already implemented, the CFDP implementation is adapted to use present S15 functionalities.

File based Mass Memories: the TAS-F User Requirements

System Requirements for File Management in SSMM

The SSMM shall provide the following services for File Management:

- File creation/deletion
- File attributes management (access type, location, …)
- Automatic stored file integrity control (CRC, scrubbing)
- If applicable, scrubbing ON/OFF status and frequency configurable per file type by OBSW
- Directory creation/deletion and attributes management (access type, location, …)
- It shall be possible to operate in read/write mode multiple files in the same bank simultaneously
- It shall be possible to write a file while reading its content (simultaneous write & download shall be possible, providing the download is stopped when reaching the file sector under write)
- The SSMM shall be able to report its current file & directory allocation
- All operations from OBSW to SSMM shall trigger the sending of a report (success, failure, in case of failure: failure type)
- OBSW shall be able to close an opened file in SSMM without losing data
- SSMM shall allow OBSW to suspend/resume all operations requiring a long processing
- (download, upload, integrity check)

System Requirements for File Management in SSMM

File transfer system:

Target: The SSMM shall implement CFDP and (adapted) PUS(13) Large Data Transfer in hardware

- The SSMM shall process autonomously CFDP&PUS proxy requests from Ground (to facilitate the OBSW management of file transfers)
- File reception/sending processing shall be autonomous from OBSW (SSMM to report to OBSW that a file has been received)
    - Includes requests for segment/file repetition processing (CFDP class 2&4, PUS(13) optional services)

Safety:

- An operation on the content of a SSMM shall not disturb the SSMM (file creation/deletion, directory creation/deletion operations) For instance, opening a new file in a directory where another file is already opened shall not result in the dysfunction of the SSMM requiring a warm restart
- The SSMM shall be able to discard autonomously a wrong request and send a failure report (creation failed because a file with same name already exists, …)
- The file & directory allocation shall not be lost in case of OFF/ON cycle and SMU or memory controller reconfiguration/switch-over

File based Mass Memories: the TAS-I experience

Divided into two main typologies:

- **Single User: SAR, Optical – File based**

High data rates (Gbps), files managed as single entities (images),
no need to operate below the file granularity level

- **Multi User – Packet Store based**

Lower data rates (Mbps), files managed as CCSDS packets collections,
need to operate at lower granularity: single stored CCSDS packet

The typologies ask for different implementation of the PUS services.

Single User SSMM: HW needs and PUS services (e.g. Sentinel-1)

HW Must be able to:

- store incoming data as a continuous stream into the specified Packet Store (PS)
- address single memory blocks (sectors) where files are stored (1 - 4 MB)

no need to work at lower granularity (single packets in files), nevertheless packets boundaries are respected.

PUS Services related to file management:

- Service 1 (TC acknowledge): start/stop of file operations
- Service 3 (Periodic Reporting): file system status information
- Service 5 (Event Reporting): anomalies, start/stop of operations
- Service 15 (Data Storage and Retrieval): customised to work at file level as integer number of memory blocks

Multi User SSMM: HW needs and PUS services (BepiColombo, Solar Orbiter)

HW Must be able to:

- check all incoming packets to forward them into PS according to their APID or Logical Address
- address each single packet in memory and find single packets according to Time or APID/SSC.
- Route stored packets both to external (OBC, TFG) and internal (Processor, Input Function) destinations. The latter is the HW support to CFDP implementation.

PUS Services:

- Service 1 (TC acknowledge): start/stop of file operations
- Service 3 (Periodic Reporting): file system status information
- Service 5 (Event Reporting): anomalies
- Service 15 (Data Storage and Retrieval) fully implemented at packet level
- Service 13 (Large Data Transfer), used to supply **CFDP type functionalities** integrated in the PUS environment

Sentinel-1 Service 15 Implementation: PS oriented

- Enable / Disable storage in PS
- PS configuration and reporting
- PS operations: Store / Downlink / Pass_Through / Delete / Read Pointer Management

13 subtypes implemented

BepiColombo/Solar Orbiter Service 15 Implementation: CCSDS packet oriented

- PS Create / Delete / Resize / Rename / Copy
- Enable / Disable storage in PS
- PS configuration (cyclic / non-cyclic, used VC, Priority) and reporting
- PS operations: Storage / Retrieval / Delete
- Single packet management (Find in PS, association to PS by APID)

27 subtypes implemented

BepiColombo/Solar Orbiter Service 13 Implementation

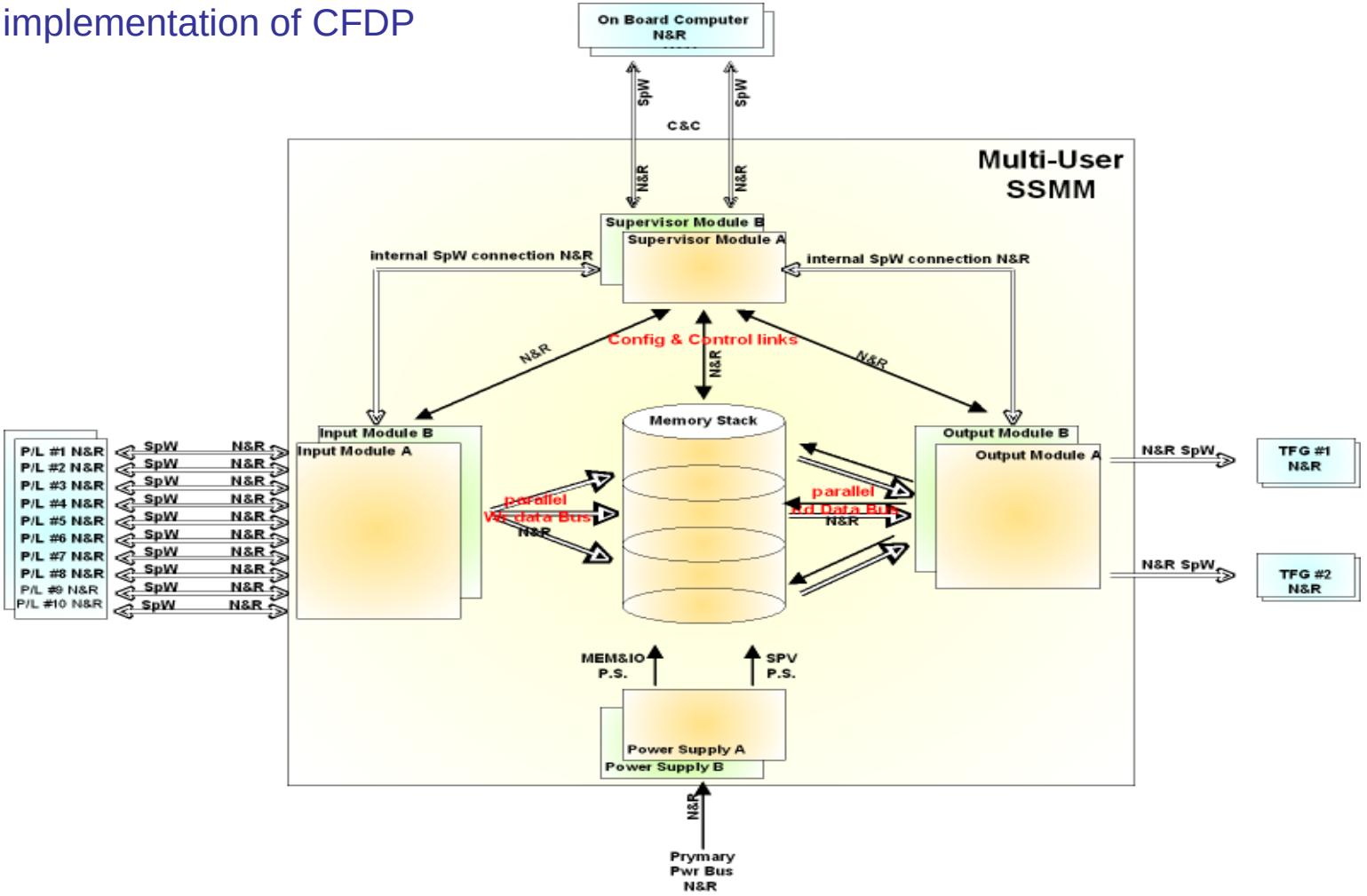
Specifically customised for BC/SOLO

27 subtypes implemented

more

Reference SSMM – HW Architecture
Multi-Users – Low/Medium throughput

The Multi-User SSMM is based on a HW architecture which has been conceived to support a SW implementation of CFDP



Main HW features of Multi-User SSMM and their usage

Unit

- Internal SpW net connecting Input module, Output Module and Processor Module for internal TM routing (PS copy; S13-FDU/CFDP-PDU assembly; Non-Sc PS delivery to OBC)

Input Module

- SpW protocol checks and packets structure checks
- PS vs APID/LA association for PS identification
- Storage of packets into addressed PS

Output Module

- Find single packets in packet stores according to Time or APID/SSC.
- Route stored packets both to external (TFG) and internal (Processor / Input Function) destinations, both in foreground and background
- Data retrieval with priority management for each PS

Main HW features of Multi-User SSMM and their usage:
Unit and SpW network

- Self-Redundant and SPF free architecture
- Internal SpW net, based on SpW router ASICs AT7910E, connecting 3 internal SpW nodes (Memory Node, Processor Module A and Processor Module B) to the external ones (up to 10 P/L Instruments, 2 TFGs, OBC, EGSE)
- Redundant SpW links both inside and outside the SSMM
- Up to 60 packet fluxes simultaneously exchanged among the nodes through the SpW network
- Network topology and Logical Address mapping minimise collisions among different fluxes, guaranteeing min routing latency
- Alternative routing path for each packet flux in case of any failure occurrence
- Automatic SpW timecode distribution for user synchronization
- Direct (wormhole routing) of both TCs from OBC to P/Ls and TM from P/Ls to OBC
- Memory to Memory routing path to support both implemented background services (i.e. copy and S13) and future ones (e.g. advanced PS data delete, ground to space S13)

Multi User SSMM HW (cont.)

Memory Array

- The memory array hosts three 256-Gbit MM guaranteeing a 512/768-Gbit EOL capacity

Input Module

- Handling of concurrent storage into up to 128 PS simultaneously
- Incoming packets checked on: structure, logical address and protocol ID, then stored in PS according to their APID
- Capability to handle up to 12 instruments with a combined input net data rate up to 150Mbps
- timeout on input P/L links to remove stalled packets from the network

Output Module

- Handling of concurrent retrieval from up to 128 PS simultaneously
- Single packet search in PS according to time or APID/SSC
- Data retrieval with priority management for each PS
- Capability to handle up to 7 different destinations with a combined output net data rate up to 150Mbps
- Capability to control the number of retrieved packets/sec towards nodes

Memory node – the MM of the MM array

- SDRAM cubes based – up to 256-Gbit net usable capacity per module
- Provides internal HW redundancy and EDAC protection
- Up to 2,800 Mbps bandwidth shared between I/O and background (refresh + scrubbing)
- Up to 1,600 Mbps sustainable storage rate (reduced to 160 Mbps for Multi User SpW based SSMM)
- Up to 800 Mbps sustainable retrieval rate (reduced to 20 Mbps for SpW based SSMM)
- Direct access byte based (i.e. random access) from Processor Modules A and B for patch and dump of any memory area.
- access time to the internal SDRAM array is always less than the transfer time of the message on the corresponding IO I/F.

For future applications requiring large memory capacity the SDRAM based Memory Module will be replaced with a FLASH based one.

BC/SOLO Multi-User SSMM - S13 Implementation

The Large Data Transfer (PUS Service 13) is customised to allow an autonomous retransmission between sender and receiver (SSMM and ground control centre) of data which were lost in the down link.

The File Transfer Session is a high level function which can be started, suspended, resumed, terminated and aborted on Service level. It controls 12 Low Level File Transfer records and includes the following data:

- a PS Id
- the data volume to be transferred from that file (max 250 MB)
- an enable/disable status flag,

plus attributes common to all records which are:

- the Virtual Channel to be used,
- the maximum number of allowed retransmissions
- the End of File Transfer (EOFT) acknowledge time-out.

In case a retransmission request is received during normal transmission, the transmitting LLFT is stopped and retransmission takes precedence.

BC/SOLO S13: a Space to Ground CFDP

Commonalities between CFDP and BC/SOLO S13 implementation

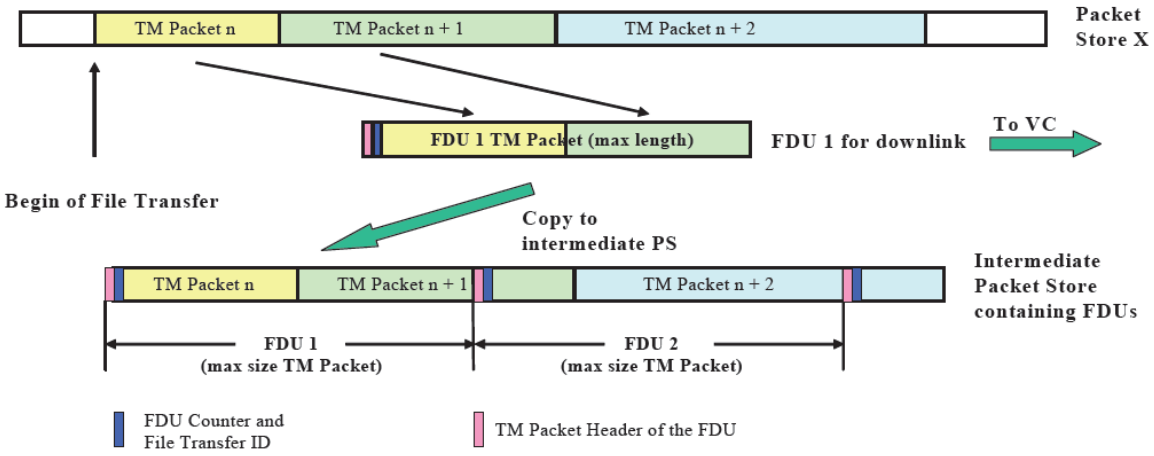
- File DATA PDU => FDU
- File Directive PDU (Metadata) => Cyclic HK and Event TM
- Transaction as transfer of many PDU => LLFT
- Transaction ID => FT_ID
- Acknowledge Mode => EOFT, Repeat Parts or Confirm Reception

The S13 manages File Data Units, defined as max size TM packets (4112 bytes for BC)

FDU are built in a three-stages process:

- A data retrieval from the source PS towards the Memory Controller (and SW)
- FDU formatting by SW
- Data storage from the MC to the FDU intermediate PS, in the memory array

Both data retrieval and data storage are background processes.



BC/SOLO S13: a Space to Ground CFDP

Conclusions:

- Most of Space to Ground CFDP services are already implemented
- The protocol achieves the same functional points of a Deferred NAK Class 2 CFDP

  Deferred NAK release chosen to cope with BC/SOLO mission long GND-Spacecraft communication time.

- **Ground to Space CFDP is already supported by the SSMM HW and can be easily integrated in the existing SSMM SW architecture**

more

Future solid state mass memories:

HW technology trends and challenges

SW architecture trends and challenges

Memory Stack

SDRAM Memory Modules to be replaced with FLASH Memory Modules

- to overcome the SDRAM obsolescence
- to increase the memory size (> 2 Tbit SSMM is not achievable with SDRAMs while up to 8 Tbit are actually requested)
- to guarantee data retention
- to reduce the power consumption

But

- maintaining or increasing the I/O throughput (2,816 Gbps achieved with SDRAM Memory Modules).
- maintaining or increasing the number of Files/Packet Stores that can be simultaneously handled (currently limited by HW to 128 PS that can be simultaneously written in and read from with an overall I/O throughput up to 2,816Gbps)

Communication Links

Internal SSMM communication links doesn't represent a bottleneck for I/O throughput w.r.t. present user requirements (current TASI implementation sustain simultaneously up to 1,920 Gbps input to and 960 Mbps output from each MM).

Internal throughput could be increased:

- adopting internal high speed ser/deser (e.g. WizardLink)
- replacing Memory Controller implemented in RTAX FPGA with Virtex IV/V or ASIC

External SSMM I/O throughput limitation comes from the selected I/F.

Current TASI implementation is limited to:

- 160 Mbps (SpW)
- 2,560 Mbps (WzL)

SW Architecture Trends & Challenges

CORDET REF. ARCH. & BUILDING BLOCKS		SOIS	BEPI SSMM
Central FDIR		*Mission Specific*	Health_Manager
System Mode Management		*Mission Specific*	Mode_Manager
SSMM Management		*Mission Specific*	File_System PS_Operational_Manager
Software Bus		Message transfer service	OS_Interface
On-Board Time		Time access service (TAS)	Timing_Info
Communication Services		Message transfer service	OS_Interface
Context Management		N/A	RTEMS
RTOS & BSP		N/A	RTEMS
Equipment Virtual Devices		Device access service	Memory_Array_Manager IO_Module_Manager HW_Link_Manager
Sub-network Layer		Packet service	SpW_Manager HW_Link_Manager
		Synchronization service	Interrupt_Manager
PUS	Service 1, 3, 4, 5, 12, 13, 17, Custom	N/A	All Implemented
	Service 6	Memory access service	Patch_Dump_Manager
	Service 9	Time access service (tas)	Timing_Info
	Service 15	File & Packet Store service	PS_Manager

The present TAS-I SSMM SW Architecture is already well fitting the architectural concepts elaborated by CORDET/SAVOIR, SOIS.

Limited updating are needed to implement the uplink CFDP and the Directory Management.

M. De Meo, G. Rosani, G. Saldi

Thank You for your attention

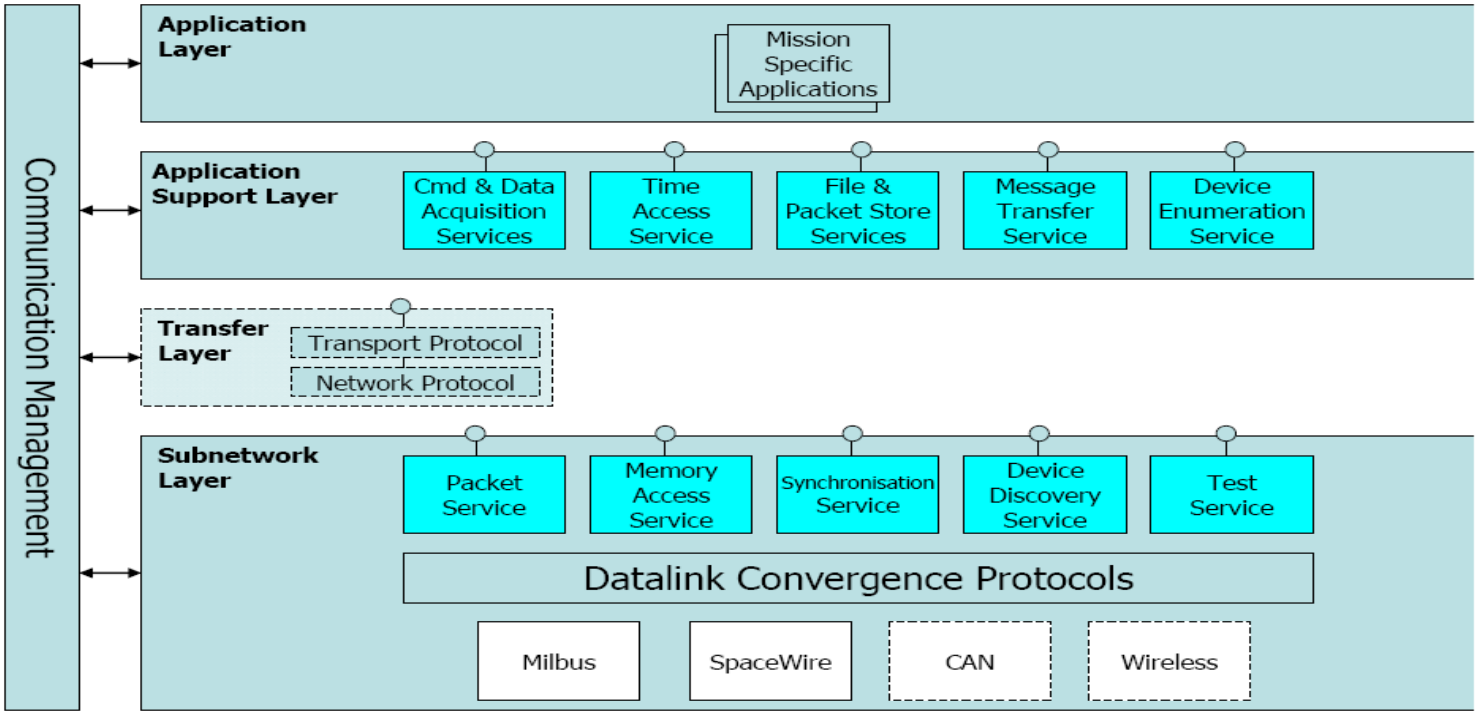
Objective

Description of high level design case studies mapping most of the concepts defined by **SOIS** and **SAVOIR-FAIR** reference architectures.

Reference SSMM – SW Architecture

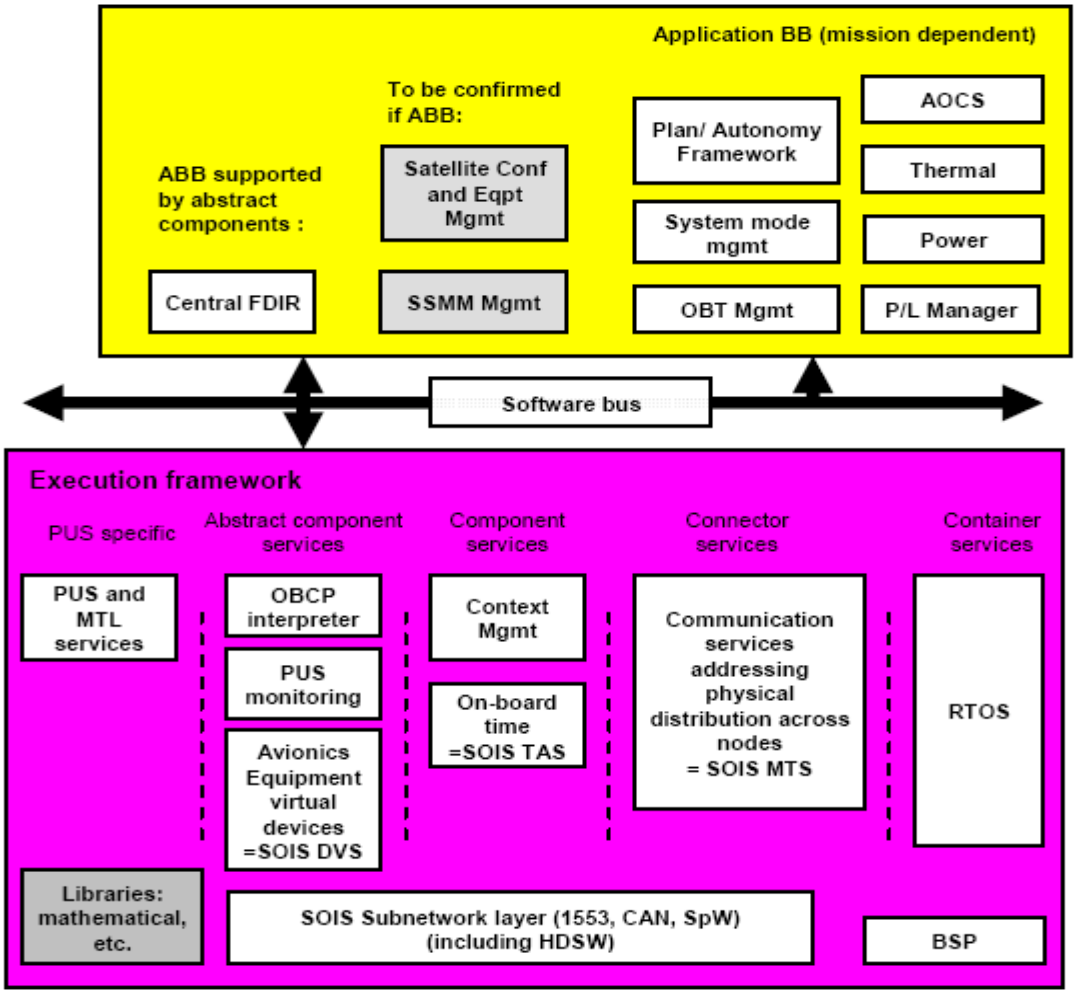
Context - SOIS

SOIS (Spacecraft On-board Interface Services) is an on-going CCSDS interfaces standardisation process between items of spacecraft equipment.

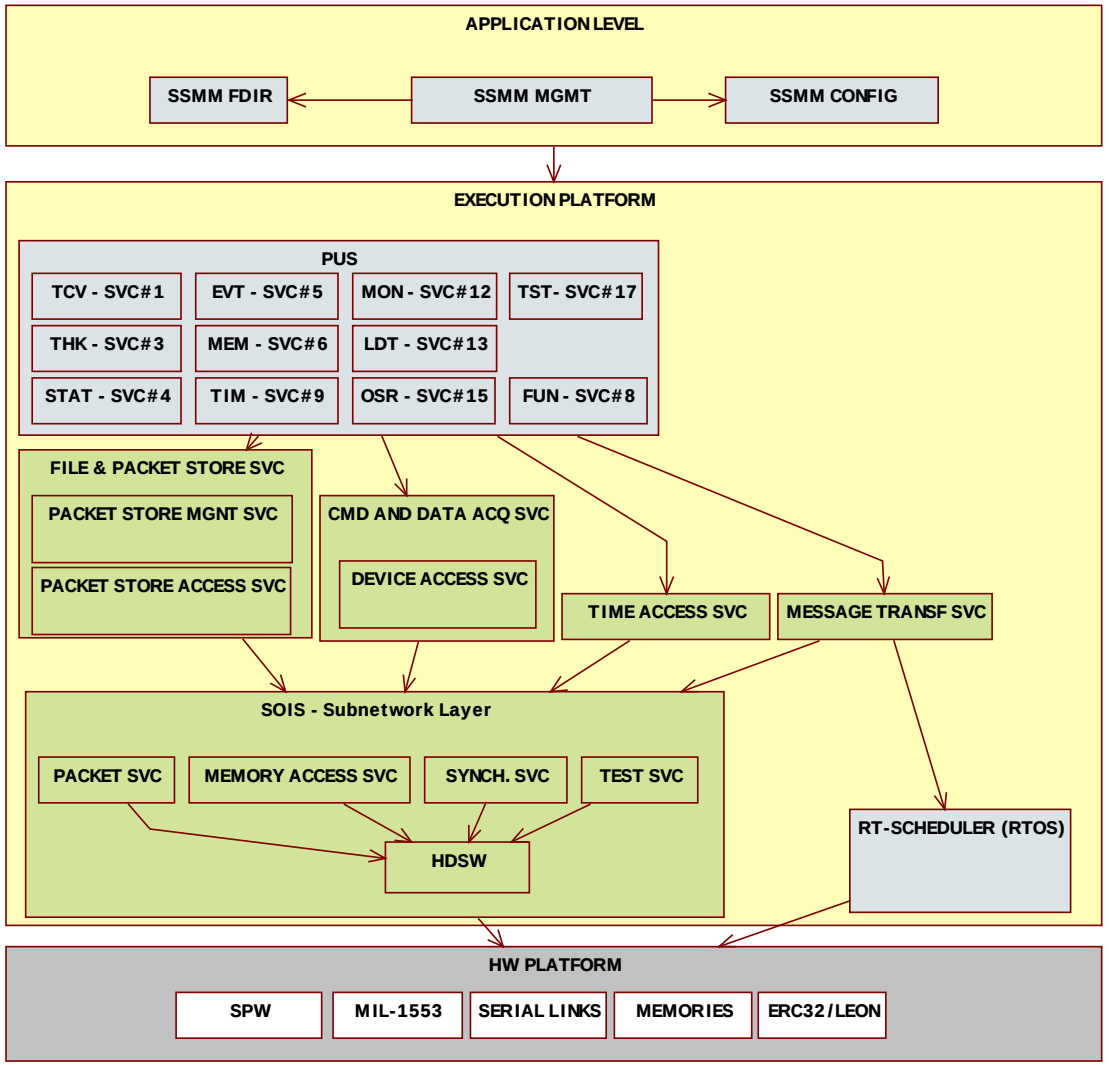


Reference SSMM – SW Architecture

Context – SAVOIR-FAIR - Reference Architecture SW



SSMM ASW SOIS - SAVOIR based reusable architecture



Conclusion

A limited re-engineering of the existing SSMM SW architectures will allow achieving:

- Common and generic architecture applicable to the different programs.
- Compliance to the on-going SW standardisation processes in the European Space Community.

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Thank You for your attention

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Backup Slides

(for further deepening)

SSMM node

- The SSMM node consists of a MM array plus an Input and Output Module interfacing the net.
- Self redundancy → each MM interface IOM A and IOM B
- The Input and Output Module handle storage and retrieval operation both from/to the external nodes and the internal ones (copy, S13, Non-Sc delivery to OBC) on up to 128 PSs simultaneously
- The memory array features three 256-Gbit MMs guaranteeing a 512/768-Gbit EOL capacity (BC / SOLO)

SSMM node – the Input Module

- From SpW routers to MMs
- SpW Log. Addr. and Prot. Id checks plus packets structure checks (length)
- Routing of validated packets towards the PS addressed on APID basis (S15) or SpW Logical Address basis (background data fluxes)
- Capability to handle up to 12 instruments with a combined input net data rate up to 150 Mbps (capability up to 750 Mbps limited to 150 Mbps by the single ended I/F with the MMs)
- Implements timeout on incoming P/L packets to support removal of stalled packets from the network (timeout on outgoing P/L packets implemented by the SpW routers)
- HW-SW interaction limited to new sector assignment and end of storage
- Supports static and dynamic sectors allocation to PS (static for BC)
- Performs packet segmentation before storage

SSMM node – the Output Module

- From MMs to SpW routers
- Search single packets in packet stores according to Time or APID/SSC (S15).
- Route retrieved packets both to external (TFG, OBC) and internal (Processor A, B and Memory for storage) destinations both in foreground and background
- Data retrieval with priority management for each PS
- Capability to handle up to 7 destinations (TFG VCs, OBC, PM, MEM…) with a combined output net data rate up to 150 Mbps (capability up to 750 Mbps limited to 150 Mbps by the single ended I/F with the MMs)
- Capability to control the amount of retrieved packets/sec towards nodes
- HW-SW interaction limited to new sector assignment and end of retrieval
- Support static and dynamic sectors allocation to PS (static for BC)
- Performs packet re-assembly after retrieval of packet segments

SSMM node – the Memory Module of the MM array

- SDRAM cubes based – up to 256-Gbit net usable capacity per module
- Provides internal HW redundancy and EDAC protection
- Up to 2800Mbps bandwidth shared between I/O and background (refresh + scrubbing)
- Up to 1,600 Mbps sustainable storage rate (reduced to 160 Mbps for Multi User SpW based SSMM)
- Up to 800 Mbps sustainable retrieval rate (reduced to 10 Mbps for SpW based SSMM)
- Direct access byte based (i.e. random access) from Processor Modules A and B for patch and dump of any memory area.
- access time to the internal SDRAM array is always less than the transfer time of the message on the corresponding IO I/F.

Annex 1.5 - SSMM HW (further details cont.)

FLASH vs. SDRAM memory Modules – further details

256Gbit net usable is the ultimate size for **SDRAM** based Memory Modules (a SSMM could host 8 of such MMs).

More than **1Tbit** net usable memory per Module is achievable with state-of-the-art **FLASH** devices (so that > 8Tbit SSMM is feasible). Further size increasing is guaranteed by continuous increase of device density.

Annex 1.6 - SSMM HW (further details cont.)
FLASH vs. SDRAM memory Modules – further details

FLASH MM main features:

Error Correction Code (ECC) ➔ Flash Device's datasheet require a small ECC overhead (3 byte per 515 byte typ.) to cope with normal on-ground leakage of NAND FLASH cells. A more effective ECC, causing a 25% overhead, is introduced on FLASH MM to compensate the in-flight SEU and SEFI effects too. The ECC take in account the more demanding requirements coming from new technology step.

Bad Block Management (BBM) ➔In each FLASH device some memory blocks (max 2% of declared size) may be "bad" since the beginning or may became "bad" during the usage → part of memory is reserved for bad block replacing.

Flash Translation Layer (FTL) ➔ Flash device need to be erased before write. The duration of erase operation (2ms) is >> of write operation (200 us). Logical address concept is implemented to avoid delay due to erase.

Wear Levelling ➔ Each FLASH device is guaranteed for a limited number of Program/Erase cycles (100000 typ). An automatic transparent wear levelling strategy is adopted with the aim to distribute the wearing over all blocks of a memory module.

The over provision used by each feature can be configured to fit mission requirements: to increase MM capacity or to improve reliability figure.

Sentinel-1 Service 15 Implementation

TC(15,1) - Enable Storage in PS

TC(15,2) - Disable Storage in PS

TC(15,12) - Report Catalogues for Selected PS

TC(15,226) - Configure PS

TC(15,227) – Store

TC(15,228) – Downlink

TC(15,229) - Pass_Through Mode

TC(15,230) - Perform E2E BITE

TC(15,231) - Perform Memory TEST

TC(15,232) – Abort

TC(15,233) - Set the Nominal Read Pointer in a Packet Store

TC(15,234) - Delete Packet Store Contents up to Read Pointer

TM(15,224) – PS Catalogue Report

BC/SOLO Service 15 Implementation

TC(15,1): Enable Storage in Packet Stores

TC(15,2): Disable Storage in Packet Stores

TC(15,3): Add Packets to Storage Selection Definition

TC(15,4): Remove Packets from Storage Selection Definition

TC(15,5): Report Storage Selection Definition

TC(15,9): Downlink Packet Store Contents for Time Period

TC(15,10): Delete Packet Stores Contents up to Specified Packet

TC(15,11): Delete Packet Stores Contents up to Specified Time

TC(15,12): Report Catalogues for Selected Packet Stores

TC(15,129): Create File

TC(15,130): Resize File

TC(15,131): Delete File

TC(15,132): Rename File

TC(15,133): List Files

TC(15,135): Stop Downlink for Packet Store

TC(15,136): Set File To Cyclic

TC(15,137): Set File To Non-Cyclic

TC(15,138): Change PS Default VC

TC(15,139): Change PS Default Priority

TC(15,140): Find Packet in PS

TC(15,142): Copy File

TC(15,143): Abort Copy

TC(15,144): Reset Copy TC Queue

TM(15,6): Storage Selection Definition Report

TM(15,13): Packet Store Catalogue Report

TM(15,134): List File Report

TM(15,141): Packet Position Report

BC/SOLO Service 13 Implementation

TC(13,129): Start FTS

TC(13,131): Suspend FTS

TC(13,132): Resume FTS

TC(13,133): Terminate FTS

TC(13,134): Abort FTS

TC(13,135): Change FTST Parameters

TC(13,136): Change FTS EOFT Timeout

TC(13,137): Change FTS Down Link VC

TC(13,138): Change FTS Retransmit Limit

TC(13,139): Request FTS Parameters Report

TC(13,141): Enable/Disable LLFT

TC(13,142): Start LLFT

TC(13,143): Suspend LLFT

TC(13,144): Resume LLFT

TC(13,145): Abort LLFT

TC(13,146): Repeat LLFT Parts

TC(13,147): Confirm Correct FDUs Reception

TC(13,148): Request LLFT EOFT Report

TM(13,130): LLFT Start Report

TM(13,140): FTS Parameters Report

TM(13,149): LLFT EOFT Report

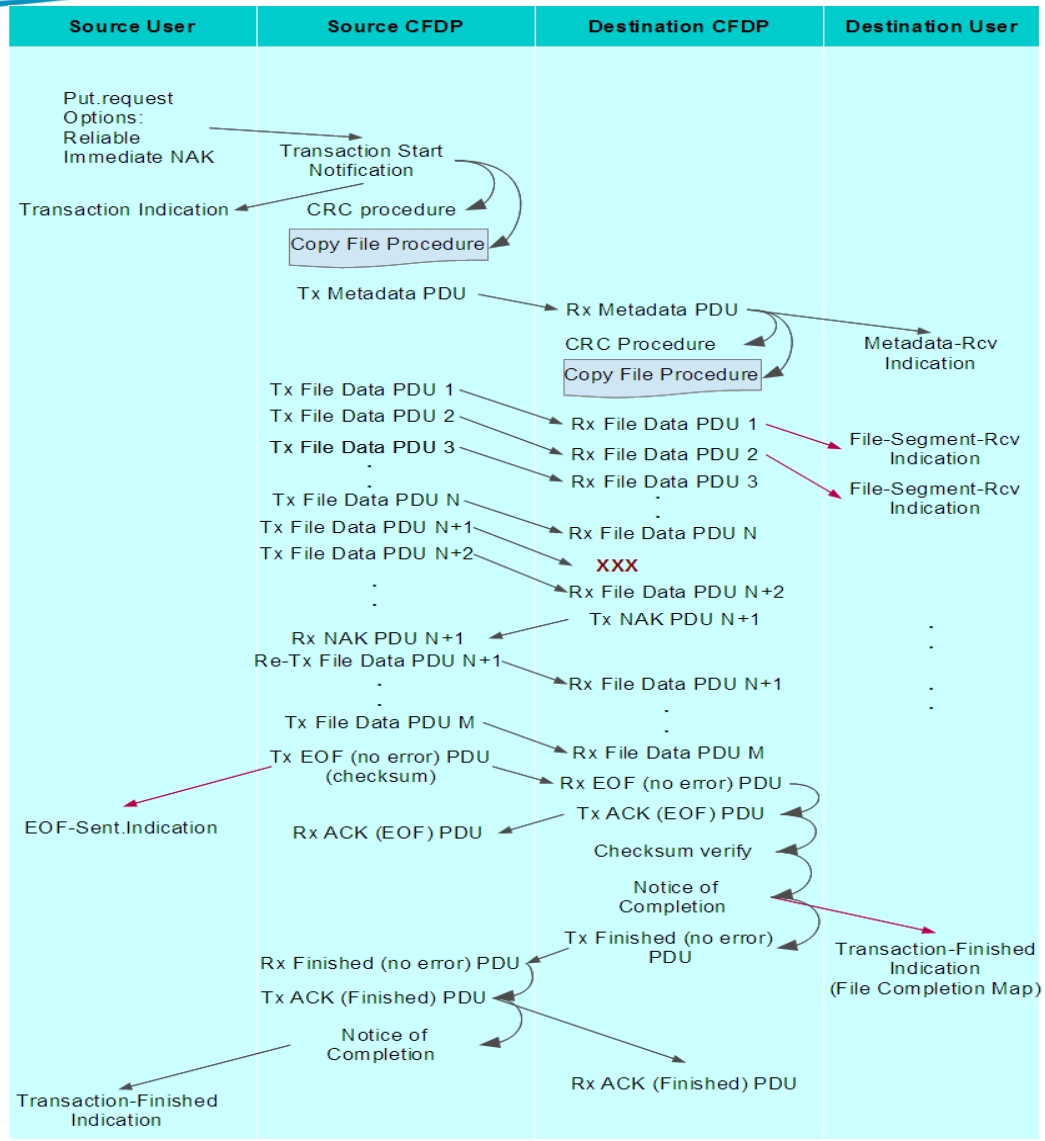
TM(13,150): Retransmission OOL

TM(13,151): EOFT Timeout

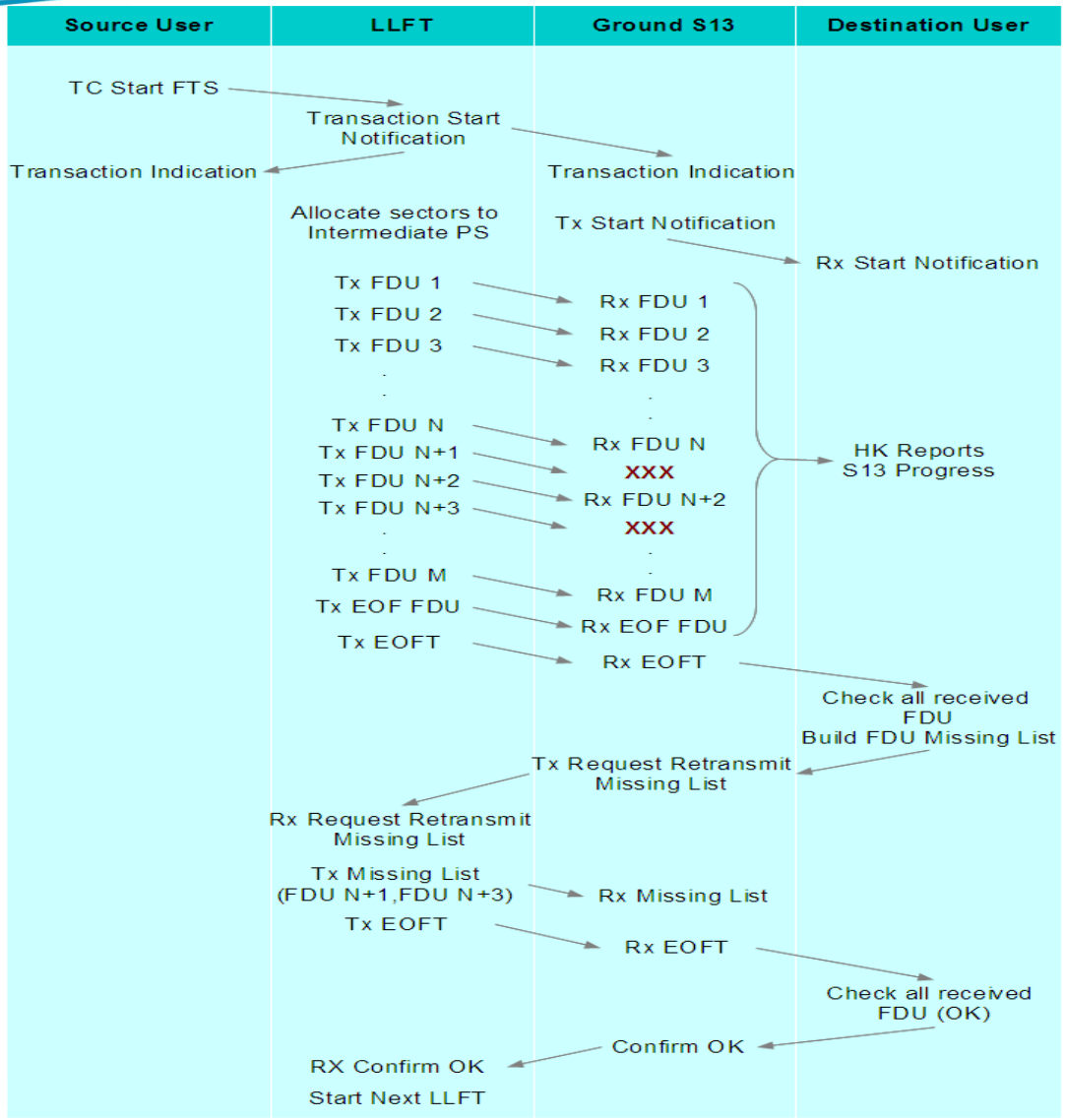
TM(13,152): LLFT Anomaly Abort Report

TM(13,153): FDU Layout

Annex 3.1 - CFDP Event Diagram for CLASS 2



Annex 3.2 - SSMM EVENT DIAGRAM FOR Service 13



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Service 13: Large Data Transfer Service

BEPI Subservices	Description	CFPD Services	CFDP primitives
TC(13,129)	Start FTS	Initiating the transmission of files between filestores	Put.request
TC(13,131)	Suspend FTS	Suspending the transmission of a current transaction	Suspend.request
TC(13,132)	Resume FTS	Resuming the transmission of a current transaction	Resume.request
TC(13,133)	Terminate FTS	Canceling the transmission of a current transaction	Cancel.request
TC(13,134)	Abort FTS	Canceling the transmission of a current transaction	Cancel.request
TC(13,135)	Change FTST Parameters		
TC(13,136)	Change FTS EOFT Timeout		
TC(13,137)	Change FTS Down Link VC		
TC(13,138)	Change FTS Retransmit Limit		
TC(13,139)	Request FTS Parameters Report	requesting status information related to the current transactions	Report.request
TC(13,141)	Enable/Disable LLFT		
TC(13,142)	Start LLFT	Initiating the transmission of files between filestores	Put.request
TC(13,143)	Suspend LLFT	Suspending the transmission of a current transaction	Suspend.request
TC(13,144)	Resume LLFT	Resuming the transmission of a current transaction	Resume.request
TC(13,145)	Abort LLFT	Canceling the transmission of a current transaction	Cancel.request
TC(13,146)	Repeat LLFT Parts		
TC(13,147)	Confirm Correct FDUs Reception		
TC(13,148)	Request LLFT EOFT Report		
TM(13,130)	LLFT Start Report	sending or receiving messages associated with the current transactions	Transaction.indication Metadata-Recv.indication
TM(13,140)	FTS Parameters Report	sending or receiving messages associated with the current transactions	Report.indication
TM(13,149)	LLFT EOFT Report	sending or receiving messages associated with the current transactions	EOF-Sent.indication Transaction-Finished.indication
TM(13,150)	Retransmission OOL		
TM(13,151)	EOFT Timeout		
TM(13,152)	LLFT Anomaly Abort Report	sending or receiving messages associated with the current transactions	
TM(13,153)	FDU Layout		

Service 15: On-Board Storage and Retrieval Service

Subservices	Description	CFPD Services	CFDP primitives
TC(15,1)	Enable Storage in Packet Stores		
TC(15,2)	Disable Storage in Packet Stores		
TC(15,3)	Add Packets to Storage Selection Definition		
TC(15,4)	Remove Packets from Storage Selection Definition		
TC(15,5)	Report Storage Selection Definition		
TC(15,9)	Downlink Packet Store Contents for Time Period		
TC(15,10)	Delete Packet Stores Contents up to Specified Packet		
TC(15,11)	Delete Packet Stores Contents up to Specified Time		
TC(15,12)	Report Catalogues for Selected Packet Stores		
TC(15,129)	Create File	Create file	Put.request(<filestore request> = create file)
TC(15,130)	Resize File		
TC(15,131)	Delete File	Delete File Replace file (Delete+Copy)	Put.request(<filestore request>=delete file) Put.request(<filestore request>= replace file)
TC(15,132)	Rename File	Rename File	Put.request(<filestore request>= rename file)
TC(15,133)	List Files		
TC(15,135)	Stop Downlink for Packet Store		
TC(15,136)	Set File To Cyclic		
TC(15,137)	Set File To Non-Cyclic		
TC(15,138)	Change PS Default VC		
TC(15,139)	Change PS Default Priority		
TC(15,140)	Find Packet in PS		
TC(15,142)	Copy File	Append file Replace file (Delete+Copy)	Put.request(<filestore request>= append file) Put.request(<filestore request>= replace file)
TC(15,143)	Abort Copy		
TC(15,144)	Reset Copy TC Queue		
TM(15,6)	Storage Selection Definition Report		
TM(15,13)	Packet Store Catalogue Report		
TM(15,134)	List File Report		
TM(15,141)	Packet Position Report		

CFDP file manager services not supported by SSMM S15 subservices

Create directory :	Put.request(<filestore request> = create directory)
Remove directory :	Put.request(<filestore request> = remove directory)
“Deny” file :	Put.request(<filestore request> = deny file)
Like “Delete” but it doesn’t fail if File doesn’t exist	
“Deny” directory :	Put.request(<filestore request> = deny directory)
Like “Delete” but it doesn’t fail if Directory doesn’t exist	

Annex 4.5 - SSMM S3 and S5 vs CFDP

Service 3: Housekeeping and Diagnostic Reporting

Subservices	Description	CFPD Services	CFDP primitives
TC(3,5)	Enable HK Parameter Report Generation		
TC(3,6)	Disable HK Parameter Report Generation		
TC(3,129)	Update HK Report Generation Period		
TM(3,25)	HK Parameter Report	sending or receiving messages associated with the current transactions	Transaction.indication Metadata-Recv.indication EOF-Sent.indication Transaction-Finished.indication Report.indication Suspended.Indication Resumed.Indication

Service 5: Event Reporting

Subservices	Description	CFPD Services	CFDP primitives
TM(5,1)	Normal/Progress Report		
TM(5,2)	Error/Anomaly Report – Low Severity	sending or receiving messages associated with the current transactions	Fault.indication Abandoned.indication
TM(5,3)	Error/Anomaly Report – Medium Severity	sending or receiving messages associated with the current transactions	Fault.indication Abandoned.indication
TM(5,4)	Error/Anomaly Report – High Severity	sending or receiving messages associated with the current transactions	Fault.indication Abandoned.indication

Annex 5.1 - SSMM ASW SOIS based reusable architecture

All the building blocks identified follow the approach resulting from the SAVOIR reference architecture.

The building blocks:

- FILE & PACKET STORE SVC
- CMD AND DATA ACQ SVC
- TIME ACCESS SVC
- MESSAGE TRANSF and SOIS - Subnetwork Layer SVC

also follow the current status of the SOIS standard.

Conclusion and Way Forward

Limited adjustment r of the existing SSMM SW architecture will allow achieving:

- Common and generic architecture applicable to the different programs.
- Compliance to the on-going SW standardisation processes in the European Space Community.
- Implementation of a SW product to be applied to the future programs.

Future steps:

- Identification of new functions for Mass Memories of the next years.
- Definition of an HW platform to meet the future requirements.
- Realisation of a SW prototype to be executed on the identified HW platform (possibly simulated) demonstrating SSMM requirements.