FTP for Space

C. Taylor
ESA/ESTEC

The Consultative Committee For Space Data Systems (CCSDS) file delivery protocol (CFDP) offers selectable quality of service, according to mission requirements and transmission capability, ranging from an unacknowledged option to a fully acknowledged option providing error recovery through retransmission. This talk aim to give and introduction to the CFDP protocol with a view on its use cases and the services defined in the standard.

****

Proposed Concepts for File Based Operations

M. Pecchioli
ESA/ESOC

Traditionally ESA missions have been operated using packets in accordance with the ECSS Packet Utilisation Standard. Increasingly however there is a move towards off-line operations concepts and the exchange of large data units between space and ground.

An ESA Working Group has been established with the objective to identify the potential benefits related to the adoption of files as an end-to-end data unit supporting the ground/space interactions and associated operations. The Working Group has recently completed its tasks. This presentation aims at presenting its main findings and promoting a consistent adoption of the basic concepts enabling the full exploitation of File based Operations for future ESA missions.

The presentation addresses all aspects relevant to File based Operations, in particular the identification of possible use cases and associated benefits, the analysis of the main related standards, the definition of standardized solutions supporting the various scenarios, the impact onto the existing ground and space segments roadmaps and relevant recommendations.

****

Euclid Needs for Space and Ground Segments

L. Stagnaro
ESA/ESTEC

Euclid is a mission for the investigation of the role of dark matter and dark energy in the formation and evolution of the universe. Euclid survey a large part of the extra-galactic visible universe and take images and spectra of an immense number of galaxies by tiling the sky with 0.7x0.7 degrees images. This large amount of daily images produce a data volume that precludes the interaction of the operator in providing a reliable transmission of the entire data product. The CFDP protocol will be required to ensure a reliable communication. The presentation provide a prospective from the project on the usage of the protocol and the possible implementation scenario on board the spacecraft."

****

OPS concept for EUCLID

F. Keck
ESA/ESOC

Euclid is an ESA mission selected for launch in 2020 in the Cosmic Vision program. It's main goal is to understand the origin of the accelerating expansion of the Universe. Euclid will have an operational orbit around Sun-Earth-Libration-Point 2 and will generate about 100 GB of science data per day. To transfer these data to ground a high telemetry rate via K-band is required. The weather depending quality of a K-band link requires a failure detecting downlink protocol with automatic retransmissions of corrupted or missing data segments. For this purpose the CCSDS File Delivery Protocol (CFDP) was selected. This presentation will provide an overview about the planned on-board file system and file transfer for Euclid.

****

JUICE mission – Mission overview and communication aspects

C. Erd
ESA/ESTEC

The JUpiter ICy moons Explorer (JUICE) is an ESA L-class mission concept designed to explore Jupiter and its Galilean satellites. The mission plans to perform detailed investigations of Jupiter and its system in all their inter-relations and complexity with particular emphasis on Ganymede as a planetary body and potential habitat. Investigations of Europa and Callisto will complete a comparative picture of the Galilean moons. The JUICE mission will operated by an ESA ground segment consisting of a Mission Operations Centre (MOC) and a Science Operations Centre (SOC), which will be supported by PIs. A single ground station, capable of both X- and K-band operations at the time of the mission, is assumed for the JUICE science operations. File based operations is currently being evaluated as a serious alternative to classical telemetry formatting.

****

Sentinel 2 Mass Memory and Formatting Unit and Future File Based Operations

G. Mandorlo
ESA/ESTEC

This talk will give a brief introduction to the GMES Sentinel 2 mission, looking in particular at the RF communication links and the use of flash technology as storage media for the on-board mass memory. Current use of X-band communication links for high data transfer are reliable towards weather effect such that retransmission of lost data is rarely required. The talk will conclude with a look at the future earth observation requirements which reveals that file based operation and introduction of automated transfer protocols such as CFDP will be required.

****

CFDP – A flight software implementation

A. Bourdoux, P. Parisis
Spacebel

The Consultative Committee for Space Data Systems (CCSDS) has specified the CCSDS File Delivery Protocol (CFDP) in order to answer the increasing need of a protocol suitable for transmission of files to and from data storage mediums over a Ground-Space communication link.

CFDP allows reliable files transfer between spacecraft's or between spacecraft and ground (in both directions). The protocol is specifically designed to cope with a large variety of space mission needs and system constraints and to operate across interplanetary distances, despite extremely long data propagation delays and frequent, lengthy interruptions in connectivity. Additionally, it can also be used on short-haul proximity links.

Spacebel has been carrying out projects aiming at providing the means to validate newly developed protocol units against its specification and to demonstrate its suitability for future missions in specific operational scenarios. Spacebel has also developed a reusable CFDP flight software component intended to be easily integrated in various on board software as an easy configurable and scalable library.

This paper briefly presents the CFDP standard and the characteristics of its implementation by Spacebel as a flight software library. The integration of this library into overall on-board software is then discussed, in particular within missions also complying with the ECSS Packet Utilization Standard (PUS) and with the CCSDS Spacecraft Onboard Interface Services (SOIS). It then concludes on perspectives for future projects and missions drifting towards file based operations.

****

Mass memory trend supporting file based operations

P. Lombardi
Syderal

File based operations and the use of Ka band for downloading payload data require new mechanisms for both ground and space segments. The latter is particularly concerning the mass memory equipment. Syderal past and current experience on mass memories embraces both packet store and file based mass memories. Nevertheless, the implementation of CFDP services together with the demand of challenging performance and use of new technologies require mass memory design changes. Key for an efficient CFDP implementation in terms of performance is an appropriate splitting between hardware and software. As the most of the data flow volume consists of file data PDUs, hardware implementation of the file data PDUs generation and the underlining layers protocol formatting would be necessary for medium to high data rate applications. File directive PDUs generation instead can be implemented in software taking advantages of programming flexibility with minimal impact on performance.

Besides, several open issues on possible combinations of file and packet store services with respect to data acquisition, storage and downloading remain to be defined. At the same time, the interaction between PUS and CFDP services from the mass memory command and control and ground segment operations point of view require decisions. From an end-to-end perspective, file based operations have

considerable advantages in terms of abstraction, flexibility and matching of end user needs. Nevertheless, interactions between different standards make it challenging the integration or replacement of non-file based services. The risk is to increase the overall system complexity.

****

Current and Future Mass Memory Products

M. Staehle, T. Pike
Astrium

For over 30 years now, Astrium has been developing spaceborne mass memory systems with 31 units successfully launched and operating to date. Over this period, the currently available commercial memory component technologies have been evaluated, tested and qualified for use in space. This is the basic approach for every mass memory system to ensure that the best performance is achieved.

The baseline storage technology was and is DRAM (Dynamic Random Access Memory) technology which has continuously evolved, providing continuously improving performance in storage capacity, speed, interfaces and operation. More recently, NAND Flash and DDR3-SDRAM storage technologies enable even higher storage density and data rate solutions. The Sentinel-2 MMFU is the first ESA programme using Nand Flash technology for its mass memory and heritage of this technology in space is being gathered following the launch of the CoReCi unit on Spot-6 in September 2012. This is the first use of NAND Flash in the mass memory of a commercial satellite. Nevertheless interfaces, communication and data processing technologies are continuing to grow further and ESA has initiated a study to investigate solutions for Next Generation Mass Memory Architectures (NGMMA). This study is being performed by Astrium with IDA and UoD and investigates highest performance systems considering current storage technologies, high speed data transmission (SpaceFibre) and emerging communication scenarios (CFDP)

****

Advanced Mass Memory units and outlook on implementing CFDP

M. De Meo, G. Rosani, G. Saldi, T. Campanella
Thales Alenia

The last generation of Solid State Mass Memory Equipment developed by TAS, that are currently in baseline for BepiColombo, Sentinel-1 and Solar Orbiter, have been conceived, for both HW and SW, to implement PUS compliant functionalities. A customised mix of PUS services (mainly S13 and S15) supports the CFDP implementation. The presentation deals with what is available today and what is still to be done according to our vision of the product evolution.

****

Memory Technology Trends and Qualification Aspects

F. Gliem, D. Walter, K. Grürmann, M. Herrmann
IDA Braunschweig

Standard and advanced memory technologies will be reviewed briefly with regard to their suitability for space mass memories of terabit size. TID hardness and power consumption are the most rigid criteria for technology selection. A technology selection diagram will be shown, which allocates the application domains of NAND-Flash and LP DDR SDRAM within the data rate – capacity plane. The chance that Advanced Technologies will becoming competitive for use in Tbit mass memories within the next four years is assessed to be very low. Radiation testing of commercial memory devices is a primary qualification aspect, in particular for missions with a rough radiation environment like JUICE. The TID and SEE characteristics of 16 / 32-Gbit NAND-Flash and 4-Gbit DDR3 SDRAM will be reviewed with the main focus on two rare, but then severe SEFI effects: (i) Device SEFI of DDR SDRAM and (ii) Destructive Failure of NAND-Flash. Finally several test challenges will be addressed such as (i) die thinning in case of DDR SDRAM with BGA package and (ii) the provisions for in situ SEE and TID testing of DDR3 SDRAMs with DLL ON and 660 MHz data transfer rate.

****

ESA Deep sub-micron program ST 65nm

L. Hili
ESA/ESTEC

The next generation of telecom payloads will require ever more digital processing capabilities. DSM 65nm program based on ST technology was launched in 2008 in order to address those future needs and overcome the limitations exhibited by current ASIC technologies. DSM 65nm is an enabling technology for broadband telecom payloads but also for European multi core microprocessor, DSP processor or high density reprogrammable FPGA. ST 65nm Rad Hard technology will offer significant performance improvements giving the possibility to design for the first time applications exceeding 30 Mgates (~ 100 millions transistors) and operating data paths at 300 ... 400 Mhz. Such a tremendous on chip processing capability would be nothing without efficient IO interfaces able to overcome conventional IO bottlenecks and accommodate Gbits/s data rates. The new high speed serial link IP, part of the Rad Hard 65nm offer, will enable serialisation at 6.25 Gbits/s (30 times Spacewire). This presentation will give an overview of the recent achievements regarding Rad Hard library and high speed serial link developments.

****

SpaceFiber

S. Parkes
University of Dundee

SpaceFibre is a proposed very high speed serial data link intended to complement the existing SpaceWire high-speed data link standard. SpaceWire operates at speeds up to 200 Mbits/s in radiation tolerant technology. SpaceFibre is able to operate over fibre optic and copper cable and support data rates of 2.5 Gbit/s and higher in future. The talk will give a brief introduction to the protocol layers of the SpaceFibre standard and then provide some examples of on-board applications of SpFi networks. The status of the current development of a SpaceFibre VHDL IP core will conclude this talk.

****

Improved Memory Module for COTS NAND FLASH devices

F. Bigongiari, W. Errico, D. Iacovelli, V. Nurra, G. Piscopiello, P. Tosi, G. Tuccio
SITAEL S.p.A

In the last years, strong improvements happened in the space memory sub-micron technologies. On board data storage is often implemented using qualified memory, increasing the board complexity, cost and heaviness. A possible alternative to overcome these issues and however increase the amount of memory consists in using COTS memories unfortunately suffering many factors, in particular effects caused by impact of heavy ions, neutrons and protons. These effects can be upset (SEU), functional interrupt (SEFI), latch-up (SEL) and others. In the context of “Digital Latch Up and functional protection for COTS memories in space“ ESA contract activity, SITAEL S.p.A. is producing an IP core based on digital techniques to mitigate SEU and SEFI on commercial NAND Flash memories. This Improved Memory Module (IMM) is a protective VHDL memory wrapper, including BCH ECC, NAND Flash Address Translation Layer, bad block management, wear leveler, and garbage collector. Module is designed to be configurable for different memory sizes and different memory page sizes. At present, IMM architectural and detailed design and Demo Board manufacturing, for incoming IP Core test and validation activity, have been completed.

****

Use of CFDP in NASA/GSFC’s flight SW architecture

J. Wilmot
NASA/GFC

In this talk the NASA/GSFC flight SW architecture is addressed with emphasis on use of CFDP and on-board file use cases. Examples of file types used on-board are e.g. RTEMS files system, VxWorks DOS or POSIX RAMFS which also is applied to solid state recorders. The talk will conclude with lessons learned from use of CFDP on Lunar Reconnaissance Orbiter (LRO) by giving a view the on-board DH architecture as well as ground system perspectives.