

Big Data SW framework for EGSE products

Project overview

teletel space

ThalesAlenia
a Thales / Leonardo company **Space**

Final Presentation Days, ESA/ESTEC, 03-04 December 2019

Project Information

- **Project Title: Big Data SW Framework for EGSE Products**
- **ESTEC Contract No. 4000121348/17/NL/CBI**
- **ESA Technical Officer: Mr Peter van der Plas**

- **Actual Duration: 21 months**
- **Budget: 250KEuro**

- **Prime Contractor: TELETEL Space Srl**
- **Sub-Contractor: Thales Alenia Space - France (Cannes)**

- **Funded by the Romanian Industry Incentive Scheme**

About TELETEL

- SME, established in Greece (Athens) in 1995, subsidiary in Romania (Bucharest) in 2016
- Supplier of EGSE for flight equipment
 - **Recent References:** Euclid ADPME EGSE, Microcarb Instrument EGSE, IASI-NG MDE EGSE
- Specialization in on-board data handling technologies, with special emphasis in the validation of satellite/spacecraft on-board data networks
 - **iSAFT product Line:** Network Interface Cards, SW, Simulator/Recorders for SpaceWire, SpaceFibre, MIL-STD-1553, CAN, Time-Triggered Ethernet etc.
- OBSW development
 - **Recent References:** JUICE on-board (and ground) CFDP development, EUCLID ASW development

The problem

- **Electrical Ground Support Equipment (EGSE) is essential at all levels of pre-launching testing of satellite and spacecraft, namely AIT / AIV.**
- **Systems under test are continuously evolving and becoming more complex, using communication networks with significantly higher data rates (e.g. AFDX in Airbus or SpaceWire in the space domain) and also employ significantly more interfaces (e.g. I/O analog/digital discrete interfaces) connecting the different sub-systems, with increased sampling rates.**
- **This trend imposes also a major challenge in the design of the EGSEs, since they need to store, process and analyze a continuously increasing volume of test-data, usually in very accurate time-series format, in real-time or in near real-time in order to satisfy the demanding requirements of air/space-craft AIT activities.**
- **The main problem with the current EGSE SW architectures is that they do not scale well with the increased volume of test-data. The data volume imposes a major bottleneck, even with the use of modern multi-processing PC systems, fast SSD disks and advanced RDBMS systems.**

The challenge

- **Big Data processing has gained particular attention in the ICT domain due to the significant challenges it imposes and it has increased the demand of information management architectures and specialists.**
- **Big Data uses exceptional technologies to efficiently process large quantities of data within tolerable elapsed times and several frameworks are currently available (Apache Hadoop and related projects).**
- **The required flexibility in Test Benches in order to fulfil the AIT requirements can be provided by spinning-in existing Big Data technologies and architectures to the EGSE domain.**
- **Currently in the market, there is no Big Data solution adapted for the EGSE domain available, although Big Data related products are already a stated requirement of the Space Industry.**

Objective of the study

- **The main vision: Spinning-in existing Big Data technologies and architectures into the EGSE domain.**

- **The objective of the activity is to design, develop and validate a proof-of-concept prototype of a Big Data SW framework for EGSEs, with particular focus on high data rate DFEs based on SpaceWire interfaces.**

- **The overall activity includes the following main work elements:**
 - Big Data SW framework tuning and optimisation for EGSEs.
 - Big Data models design, definition and development.
 - Use of test Consoles, retrieval and analysis tools .
 - Integration with of the Big Data SW framework with DFE interfaces supporting SpaceWire.
 - Validation of the developed the Big Data SW framework at a representative testbed in order to reach TRL5.

Participants and main roles

- **TELETEL Space Srl (Romania) as prime-contractor, bringing its experience in EGSEs and SpaceWire technology, through its mother company TELETEL SA, and having incorporated Big Data among the main strategic components in its business plan. Its main role includes:**
 - Requirements consolidation and system top-level partitioning.
 - Fine-tuning and optimization of Big Data SW framework.
 - Design and development of the required Big Data SW sub-systems, services and tools.
 - Integration and verification of the Big Data SW Framework.
 - Design and development of the test cases for the demonstrator.
- **Thales Alenia Space France (Cannes), as sub-contractor, provided requirements to TELETEL Space Srl and also validated the project results in a representative EGSE demonstrator. Its main role includes:**
 - Provision of system and validation requirements for a Big Data SW framework for EGSEs.
 - Validation of the integrated Big Data SW Framework with the iSAFT DFE in a representative demonstrator.

Main Work Areas

- **WP1 - Requirements definition and validation plan**
- **WP2 - Design and development of the Big Data SW framework for EGSEs**
- **WP3 - Integration and verification of the Big Data SW Framework**
- **WP4 - Validation and demonstration of the Big Data SW Framework in TAS-F facilities**

Big Data SW framework components

- The selection of the Big Data SW framework components was based on state of the art technologies, the requirements provided by TAS and by taking into consideration the technologies used with the current EGS-CC version, having as a target to provide a modular, scalable and future-proof system architecture.
- The following key components were selected:
 - Apache KAFKA as distributed streaming platform
 - Apache SPARK for stream real time processing
 - InfluxDB as TM TC parameters database
 - Elasticsearch as TM TC packets database, and for logs, SDB definitions and documents storage
 - Hadoop and HDFS distributed file system (required by Cloudera CDH distribution)

Integration with DFEs – iSAFT SpaceWire Simulator/Recorder

- The iSAFT SpaceWire Simulator / Recorder is an advanced EGSE platform with traffic generation capabilities that simulates SpaceWire devices or instruments, enabling S/C integration tests before the availability of Flight Models.

- Site Rackmount System (3U) HW platform.
- Octal SpaceWire PCIe NIC.
- SpW simulation/recording support for eight (8) ports.
- iSAFT client API (C++ or Python) for interfacing/integration with 3rd party SW.
- Configuration & Control Application (GUI for complete local operation).

■ Activities

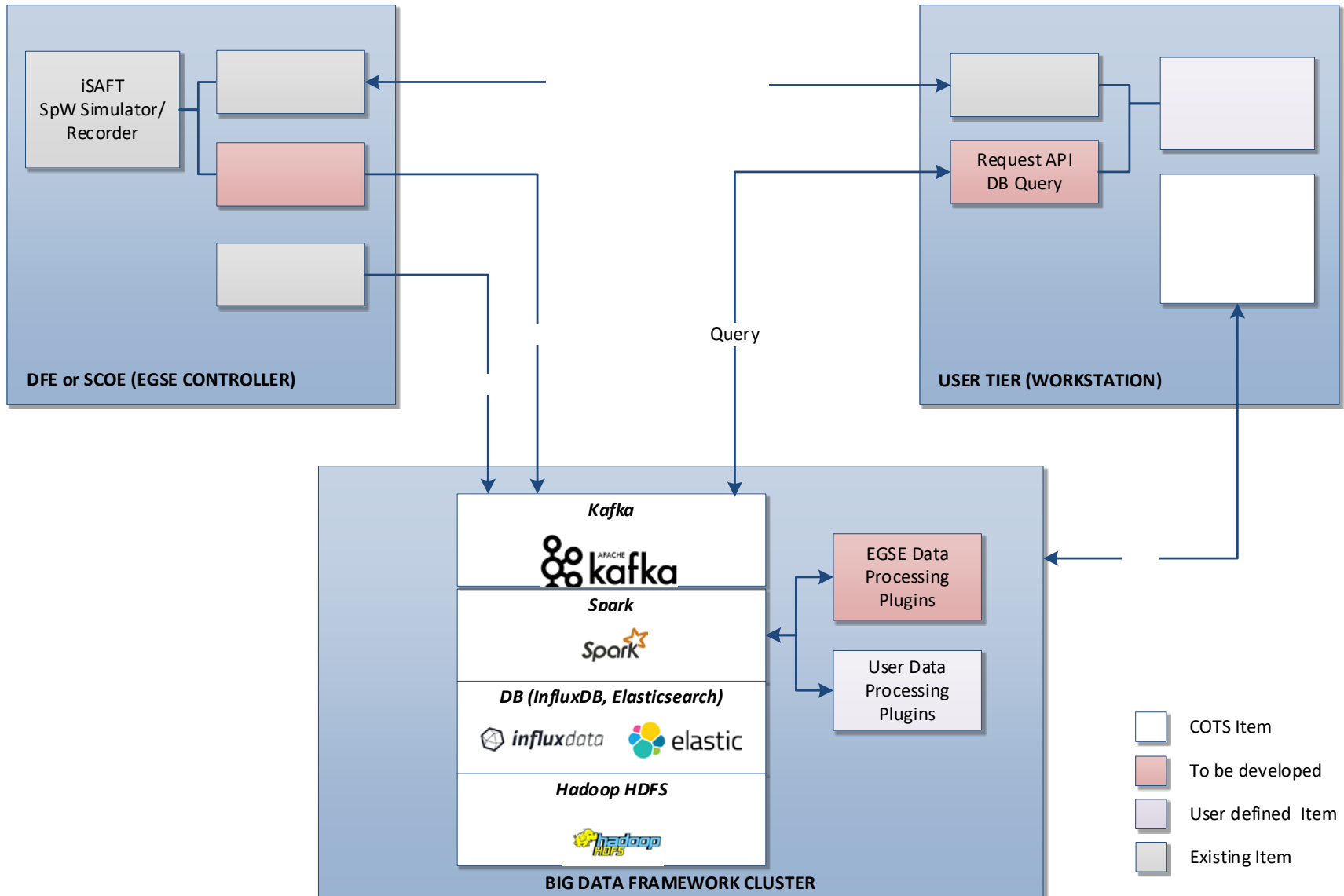
- Provision of the iSAFT SpaceWire Simulator / Recorder SW API .
- Design and development of the DFE API abstraction layer.
- Integration with the Big Data SW framework. (TM/TC packets pipeline via Kafka)



iSAFT SpaceWire Simulator / Recorder by TELETEL SA

- Support for transmission triggers, filters for the captured data and statistics.
- Time synchronisation with other components in a testbed through IRIG.
- Protection of flight equipment against internal failures (FMEA).
- Interfaces with EGSE Central Checkout Systems (C&C CCSDS or EDEN).

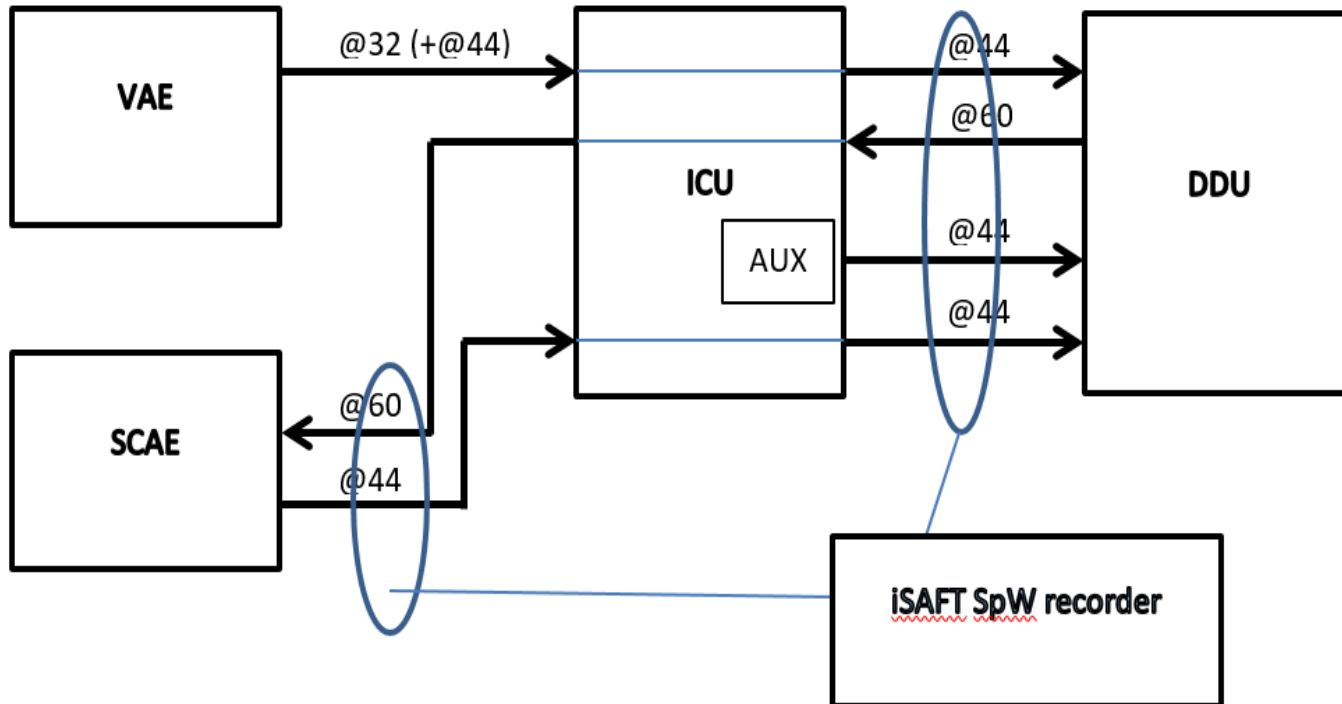
Big Data SW framework system top level partitioning



Validation testing in a representative AIT Test Bench

- **Validation was performed in accordance with a defined Test Plan for the Big Data SW framework integrated with the iSAFT DFE.**
- **A set of functional and performance tests were executed in representative spacecraft AIT Test Bench at TAS-F premises in Cannes (MTG-FCI testbed).**
 - Connection tests
 - Real-time data analysis tests
 - Post analysis visualisation tests

MTG-FCI test setup



SpW links and connection to iSAFT DFE

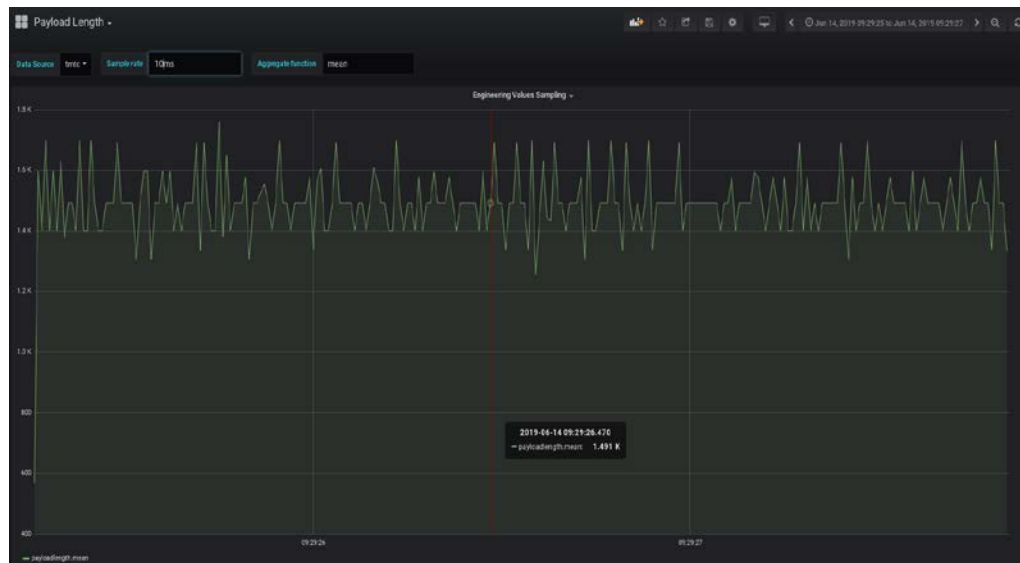
BDF workstation and iSAFT SpaceWire recorder connected to the TAS MTG-FCI testbed



iSAFT DFE

Grafana

The screenshot shows the iSAFT DFE software interface. The top part features a dashboard with several status indicators for different components, including 'Default Station' and 'Default Station'. Below this, there is a detailed log window showing a list of entries with columns for 'Time', 'Event', 'Event Length', 'Logcode', 'AFD', 'Type', 'Subtype', and 'Segno'. The log entries show various events occurring over time, such as '2019-09-18 16:11:49 INFO DATA records 2684 Instant-rate 7647,579 batch-rate 2455,497 total-packets 1151635 total-params 2301902'.



Spark

Kibana

The screenshot shows a terminal window with a series of INFO log messages. The messages are formatted as follows: '2019-09-18 16:11:49 INFO DATA records 2684 Instant-rate 7647,579 batch-rate 2455,497 total-packets 1151635 total-params 2301902'. The logs show a sequence of events related to data processing, including 'influxdb.write_points', 'influxdb.write_points', and 'DATA records'. The terminal output shows a consistent pattern of these log messages over time.

The screenshot shows the Kibana interface. The top part features a navigation bar with 'Discover - Kibana' and 'Discover - Kibana - Mozilla Firefox'. Below this, there is a search bar and a 'Discover' button. The main area displays a bar chart with a y-axis labeled 'Count' and an x-axis labeled 'Time'. The chart shows a series of bars representing data points over time. Below the chart, there is a list of log entries with columns for 'Time' and '_source'. The log entries show various events, including '2019-09-18 16:11:49 INFO DATA records 2684 Instant-rate 7647,579 batch-rate 2455,497 total-packets 1151635 total-params 2301902'.

Results

- All tests have been successfully executed.
- The system is robust enough and can store and analyse millions of packets and parameters (at the end of each test session **more than 13 million packets** and **43 million parameters** (were stored in Elasticsearch and InfluxDB) providing an insight and data analysis capabilities, in real time, that are not possible from current EGSE systems.
- During the execution of the test and monitoring of 2 links at MTG-FCI testbed an aggregate data rate of 64Mbps of traffic was captured and analyzed in real-time.
- The performance of the BDF was adequate for such scenarios. Response time to complex queries (for packets and parameters) was **less than 1 seconds**.
- **Feedback by TAS:** The Big Data Framework node and the iSAFT SpW Simulator / Recorder are very easy to set up, configure and use. They were proved to be a valuable tool for monitoring, analysis and visualization of data in SpaceWire networks with high rates and high volumes of data. It offers a complete suite of SpW monitoring, storage, visualization and analysis in real time very easy to set up, configure and use.

Foreseen follow-up activities

- Addressing additional DFE technologies and interfaces (such as MIL-STD-1553, CAN, TTEthernet, SpaceFibre etc.), provided by various suppliers.
- Integration with SCOE components addressing various I/O analog/digital discrete interfaces including HPC, BSM, ASM, RSA, TSM etc., provided by various suppliers.
- Use Time Synchronisation equipment for accurate time stamping across EGSE components, enabling timely accurate analysis of Big Datasets in EGSEs, using IRIG and NTP.
- Extend the Big Data SW framework for EGSE products by introducing Artificial Intelligence (AI) as complement to the standard engineering processes.
- Performance assessment of the system with respect to programming environment (Python vs Java) and scaling number of nodes.
- Enable additional de-commutation capabilities for different traffic data types (telemetry, science data etc.)
- Product qualification in integrated EGSEs and Primes' Test Benches.

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The logo for teletel space, with 'teletel' in blue and 'space' in red, both in a lowercase, italicized sans-serif font.

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The logo for ThalesAlenia Space, featuring 'ThalesAlenia' in black and 'Space' in blue, with a blue swoosh above 'Space'. Below 'ThalesAlenia' is the text 'a Thales / Leonardo company' in a smaller font.