

ONBOARD HIGH RATE DATA PROCESSING USING CANOPEN PROTOCOL

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01: Introduction

Introduction

- Use case
- ROS Benchmark
- Klepsydra Space
- The product
- The company
- Conclusions



Embedded systems today

Embedded autonomous systems is a fast growing market with as fast growing challenges:

- Increasing demand in complexity:
 - Large data processing on-board (sensor data, communications with other systems, etc)
 - Heavy algorithms: filtering, FDIR, optimal control, vision navigation, etc.
- Hardware has improved substantially:
 - Better on-board computers
 - Improved sensors (more and faster data)





Software fo embedded systems

Software challenges:

- Lower priority.
- Lack of modern techniques.
- Lack of highly skilled software engineering
- This translate into:
 - Error prompt software
 - Limited functionality
 - Delays in delivery
 - Suboptimal resource utilisation





Parallel data processing





The majority of embedded software problems are related to data processing.
The financial sector has known this for a long time! This is where Klepsydra come into place





Innovation

High Frequency Trading

- Thousands of transactions per second.
- Require access to real time data.
- Delays in processing might result in millions in loses.

Jse case

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Use case: windmill inspections

Client Requirements

- •Onboard capture, video-stream, process and record high resolution images at 20 frames per second(FPS).
- Fly as fast and close as possible to the blades of the windmill and do it very robustly.
- ·Vision-based navigation.

Situation before Klepsydra

- •Only low resolution images and **low FPS**.
- Error prone and slow and inaccurate navigation.





Two main architectural approaches





1 Camera, 3 real-time uses

- One big producer of data.
 Usually large data (image, point cloud, etc)
- Several independent consumers.
- Each can have different rates.



Use case: the solution





High CPU Consumption

Without Klepsydra: Low resolution camera



With Klepsydra: High resolution camera







Two main architectural approaches





Conclusion

Now Alerion, offers the most advanced autonomous drones for windmill inspections. They produce the highest resolution images and closest captured in the market.

This extremely complex application was much easier with Klepsydra solutions.

They are now the official inspection provider for Siemens-Gamesa. Second biggest windmill manufacturer in the world with 15'000 windmills worldwide.



03: ROS Benchmark

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The Robot Operating System

EROS



- Benchmarking for ROS and ROS with Klepsydra
- Test for high rate sensor data as per expected in the vision based navigation.
- ROS is an asynchronous middleware.





EROS

- Used by Universities for simulation of Space scenarios and applications
- Used by companies and organisation to simulate space robotics scenarios





Parallel data processing solutions





Benchmarking





Processing Rate Comparison



Pure ROS starts
 loosing data at 1KHz.

 Klepsydra does not loose any data and remains close to ideal curve.



Conclusion

H = H = H

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Space systems today

In Space applications there is a growing need of high rate data processing:

- Constellations for:
 - Fast communications (LeoSat),
 - Internet providers (OneWeb), or
 - IoT (LaserLight/Xenesis)

1000's requests per second from Earth, plus routing and position coordination. etc.

• <u>Space robotics, GNC, rendezvous, planetary</u> <u>landing.</u>

These systems need to process data as fast as possible in order to perform the mission correctly.







Sources of data events





Benchmarking



- Combination of: **SDO**, **PDO** and **SDO block** communications.
- Two implementations:
 Klepsydra and
 traditional Multi thread
- Variable 5-20 parallel processes
 - Tested in the **Zedboard.**



OpenMCT Performance Monitoring



- Telemetry monitoring tool developed by NASA.
- Used in real missions.
- Web-based,
 lightweight.
- Klepsydra uses for performance monitoring



Benchmarking



• At 3KHz, Klepsydra is at the ideal point

• Traditional methods degrades 15%

 Klepsydra has negligible variability, while traditional approach does not.



CPU Usage Comparison



• Better CPU usage from the beginning.

 For the same rate of data processing, the gain is much bigger (15-20%)



Data Processing Rate Comparison



 At 700Hz the difference become noticeable

• Klepsydra remains close to the ideal processing curve.



Variability of processing



 Klepsydra's std dev in processing is constant

 Means predictable system, which in turn means more reliability.



Conclusion

- Negligible latency
- 'Absorbs' parallel processing complexity and therefore, <u>makes</u>
 <u>software development</u>
 <u>much easier</u>
- Predictable, <u>faster</u> and reliable behaviour

No data losses!!!





Conclusion

Processing faster and more data on-board has the following benefits:

- <u>Constellations</u>
 - Process more requests from Earth (= \$\$\$)
 - Process more constellation position/coordination data (= larger constellations, and longer service life)
 - Low latency processing (= faster Earth-to-Earth communications)
- Space robotics, GNC, rendezvous, planetary landing.
 - Low latency processing (faster response to sensor data)
 - Process more sensor data (higher accuracy of GNC)
 - Predictability (increase reliability in any conditions)

Increase economical benefit and chances of mission success!!



Our Vision

ESA OBDP Workshop 2019. Talk by Cornelius J. Dennehy from NASA about GN&C software:

"There is a critical need to modernise on-board computing capabilities to support higher levels of GN&C Autonomy. In our view improved spaceflight computing means not only enhanced computational performance, energy efficiency, fault tolerance, but also **ease of programming, affordability, reconfigurability and availability**"

This is exactly in line with out vision and philosophy!!!

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Technical description







Development tools

MATLAB/Simulink



Direct programming



- Efficient and reliable autocoding code without manual modifications.
- Accelerate development with our enhanced processor-in-the-loop simulations.

Run it in most Linux and RTOS distributions. Integrate our product with add-ons for CAN and FPGA boards.

Adoption and integration into existing applications with very small effort.

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- Dr. Pablo Ghiglino. Founder and CEO.
- · Isabel del Castillo. Admin management
- Dr. Mandar Harshe. Senior C++ developer.
- Franco Bugnano. Part-time software developer (space)
- **Dr. Francisco Sanchez**. Part-time C++ developer (core and aerospace)
- Javier Aldazabal. Part-time C++ developer (aerospace)
- Hervé Flutto. Business development Europe.



Awards



Finalist in the NASA iTech Colorado Spring 2019

> Finalist in the Digital Energy Forum, Munich. 2017

Selected by ESA to be one of the top space startups to present at IAC 2018.



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- High performance
- Sensor fusion
- Agile development
- Competitors
- The company





- We are currently doing projects with companies in the 'NewSpace' sector and Universities.
- Klepsydra Space is available for trial:
 - Klepsydra + CANOpen add-on.
 - MATLAB add-on for beta testing.





Thanks

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