Defining avionics system architecture for multiple use cases with stringent requirements using system modelling

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Title - Defining Avionics System Architecture For Multiple Use Cases With Stringent Requirements Using System Modelling

- Challenge in avionics
  - Ensuring safety and reliability of communication, navigation, and flight control systems
- New challenges to security and data management
  - Increased use of software
  - Integration of wireless communication and internet of things (IoT)
- System modeling is the solution to test, identify and patch the safety and security
  - Hard to create scenarios in lab can easily be recreated in a simulation platform.
- Use cases
  - Power generator failure triggers backup sources and leads to load shedding
  - Glitch in processing unit clock signal skips current branch instruction and takes incorrect path
  - Performance of critical applications like activation of de-icer and hatch alarms
- Complement experimental and physical analysis to improve existing architecture.

Transition

- Prior generation of avionics sub-systems were built with a single use-case
  - Vendor reference boards used to stress test and validate
- New avionics systems
  - Integrates multiple application on a single electronic system
  - Supports multiple use-cases
  - Higher speed interfaces
- Integrated Modular Architecture (IMA) with redundant nodes handles all the use-cases within the performance, power and safety requirements

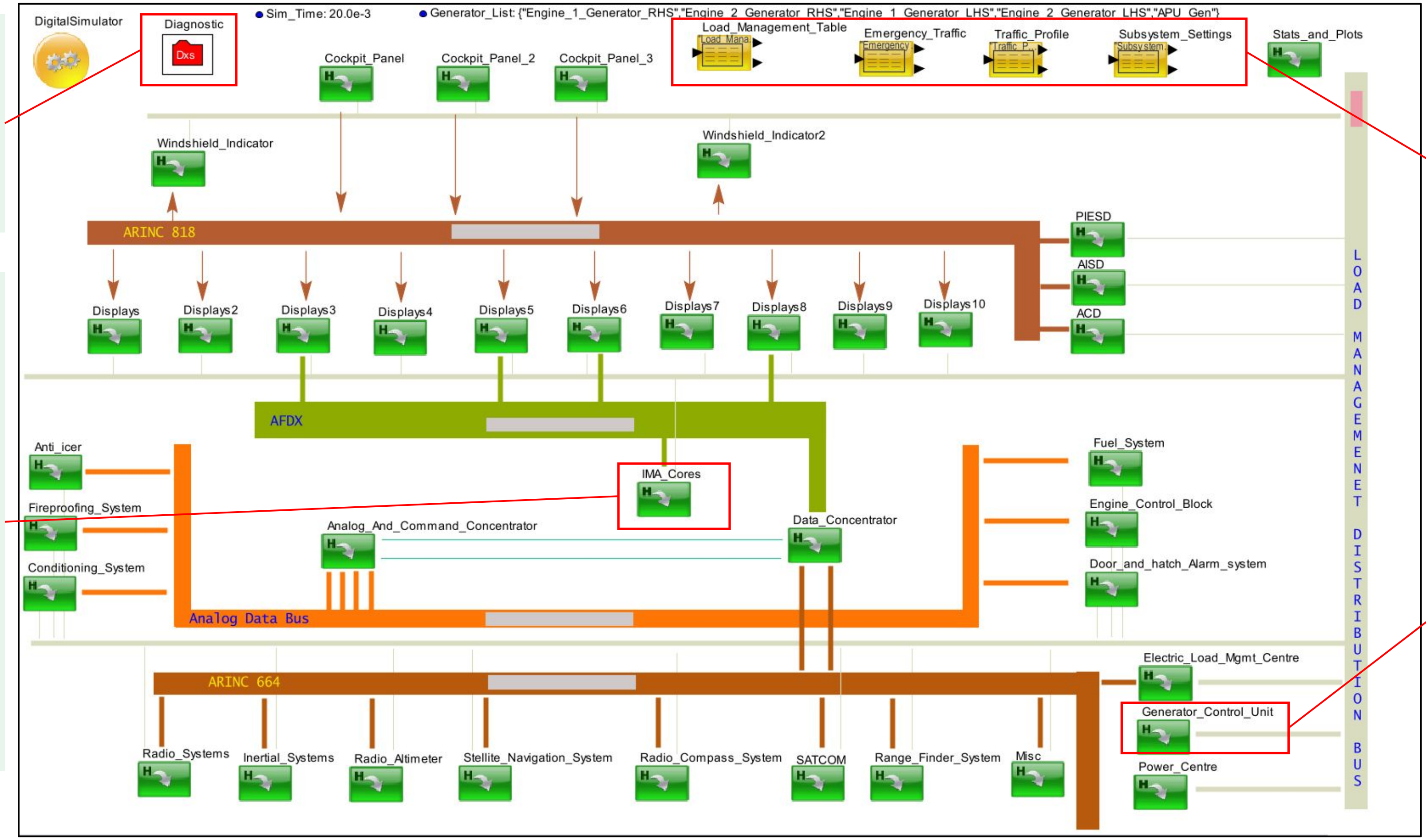
Proposed Solution - Architecture System Model

- Selected VisualSim Architect from Mirabilis Design as simulation platform:
  - GUI based environment
  - System-level modeling IP and saved considerable time and resources
- Created Digital Twin of the flight avionics
  - All sub-systems and variations are modeled
  - Different level of abstraction for each sub-system depending on the analysis
- Simulate use-cases
  - Optimize and validate system design to meet requirements

Breakdown of the Avionics System Model

Requirement Database:
- Latency
- Temperature
- Power
- Utilization

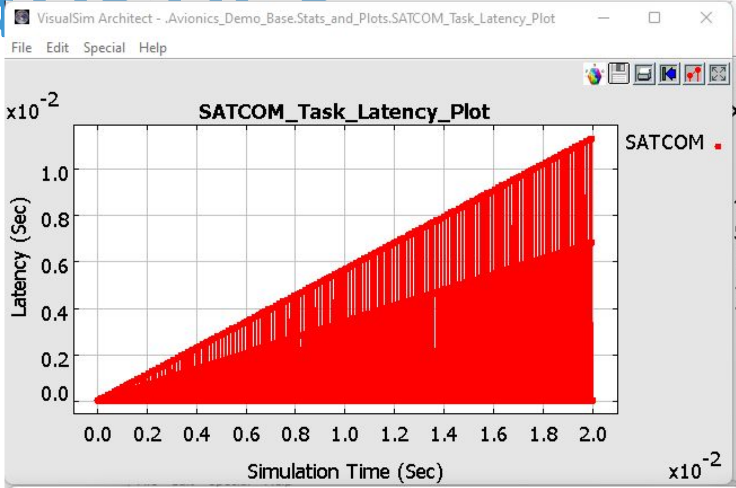
- Provides a set of shared resources for processing various sensor signals and make decisions
- Supports Dual and Triple redundancy
- Fault is injected to evaluate the application performance under core failure

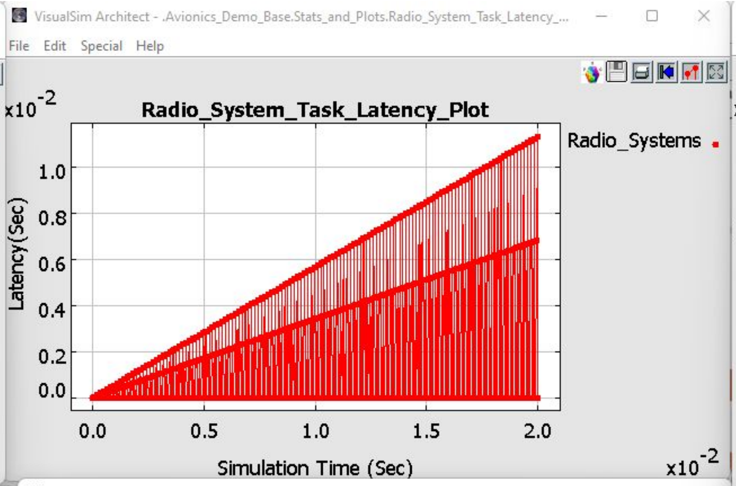


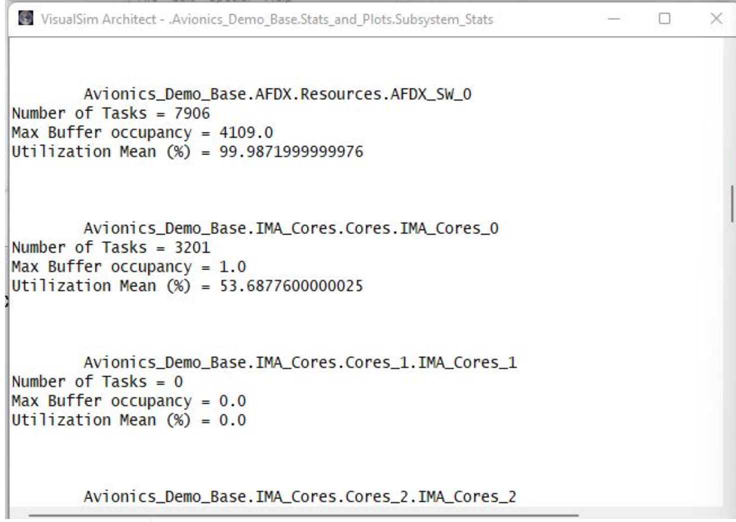
System settings and traffic profiles – normal and Emergency sequences are defined using databases

- Provide power supply to all subsystems
- Fault is injected to evaluate system performance under limited power supply

Avionics Systems- Decision-making Statistics

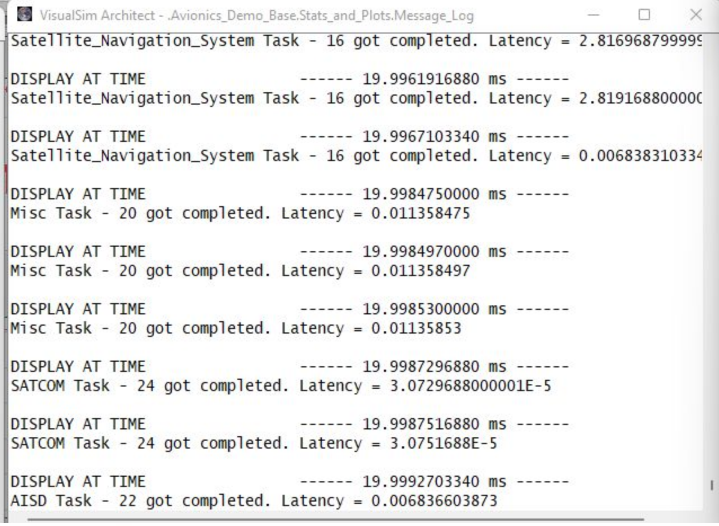






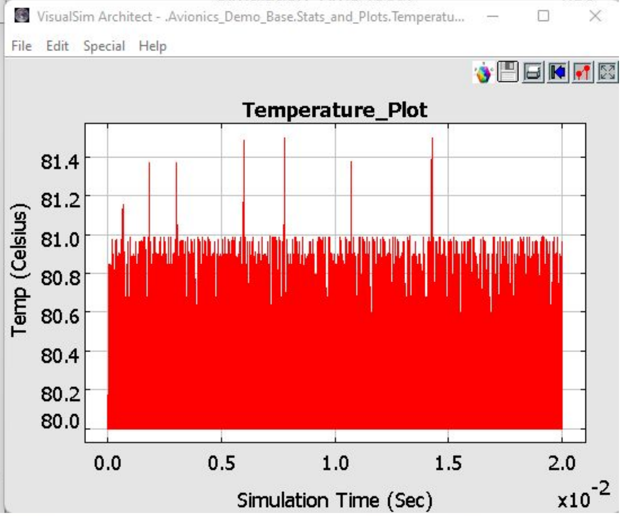
VisualSim Architect - .Avionics_Demo_Base.Stats_and_Plots.Subsystem_Stats

```
        Avionics_Demo_Base.AFDX.Resources.AFDX_SW_0
Number of Tasks = 7906
Max Buffer occupancy = 4109.0
Utilization Mean (%) = 99.9871999999976

        Avionics_Demo_Base.IMA_Cores.Cores.IMA_Cores_0
Number of Tasks = 3201
Max Buffer occupancy = 1.0
Utilization Mean (%) = 53.6877600000025

        Avionics_Demo_Base.IMA_Cores.Cores_1.IMA_Cores_1
Number of Tasks = 0
Max Buffer occupancy = 0.0
Utilization Mean (%) = 0.0

        Avionics_Demo_Base.IMA_Cores.Cores_2.IMA_Cores_2
```



VisualSim Architect - .Avionics_Demo_Base.Stats_and_Plots.Message_Log

```
Satellite_Navigation_System Task - 16 got completed. Latency = 2.816968799999

DISPLAY AT TIME             ------ 19.9961916880 ms ------
Satellite_Navigation_System Task - 16 got completed. Latency = 2.819168800000

DISPLAY AT TIME             ------ 19.9967103340 ms ------
Satellite_Navigation_System Task - 16 got completed. Latency = 0.006838310334

DISPLAY AT TIME             ------ 19.9984750000 ms ------
Misc Task - 20 got completed. Latency = 0.011358475

DISPLAY AT TIME             ------ 19.9984970000 ms ------
Misc Task - 20 got completed. Latency = 0.011358497

DISPLAY AT TIME             ------ 19.9985300000 ms ------
Misc Task - 20 got completed. Latency = 0.01135853

DISPLAY AT TIME             ------ 19.9987296880 ms ------
SATCOM Task - 24 got completed. Latency = 3.0729688000001E-5

DISPLAY AT TIME             ------ 19.9987516880 ms ------
SATCOM Task - 24 got completed. Latency = 3.0751688E-5

DISPLAY AT TIME             ------ 19.9992703340 ms ------
AISD Task - 22 got completed. Latency = 0.006836603873
```



Use Case Results and Findings

No:	Use case scenario	Max Application latency	IMA Core utilization	Bus utilization (AFDX)	Remarks
1	Base model –Existing system architecture	11.3 msec	53.6%	99.98%	For the new requirements and applications Very high and increasing application latency AFDX bus has high utilization at 100 Mbps
2	AFDX bandwidth increased to 1 Gbps	35.2 usec	66.3%	18.29%	Bottleneck was correctly identified Achieved acceptable application latency
3	Reduced IMA Core from 4 to 2	3.52 msec	99.99%	16.63%	Number of IMA cores are insufficient to meet processing requirements.
4	Fault injected at IMA Cores resulting in its failure	70.0 usec	67.9%	18.29%	Spikes in application latency Performance requirements met for single core failure Redundant core provided the required processing

Summary

- We successfully used system modeling to define architecture specification
- We identified bottlenecks correctly and resolved them efficiently
- Analysed response to failures for different use cases to ensure compliance with safety standards
- Integration company reused the system model as the specification to select the components and assemble the system

WHERE **INNOVATION** BEGINS

DESIGN AUTOMATION CONFERENCE

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MOSCONE WEST CENTER
SAN FRANCISCO, CA, USA