

# A NEW NETWORK CONFIGURATION MANAGEMENT ARCHITECTURE FOR FUTURE AIRCRAFT SYSTEMS

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## Future Trends in Aircraft Systems

Increase in the number of **connected** devices

=> More device connectivity in **cabin**

=> Evolution towards more **integrated** systems

=> New system design paradigms : Distributed Integrated modular Avionics (DIMA) & Flexible Platform (FP) propositions

Increase in devices and ressource sharing aboard aircrafts

## Leads to our Problem: What's Currently in Aircraft System Modularity

Modularity is the top most important aspect for system development

It offers a ressource platform for avionic devices **integration** aboard the aircraft (hardware & communications)

It is for now **only** used for **avionic** devices

Currently used system integration models are reaching their scalability limits

## Problem Statement: Future Aircraft Networks Need for More Modularity

**Problem statement:** Current networks are **reaching their limit** as they were designed using mass over provisioning which led to network **rigidity**

Both **connectivity** and **modularity** ask to look for new solutions

**Objective:** With this work we **investigate** to which extent an **embedded configuration layer** can provide enough **modularity** for networks

How to augment network modularity through configuration management

## A Candidate to Increase Modularity: Software Defined Network

**Software Defined Network (SDN)** is a network paradigm which leverages central controller(s) to administrate network

It offers several advantages for network management including **network wide view** of configurations and **real time monitoring** of the network

It **needs** to be heavily **adapted** to come anywhere near an aircraft

SDN could bring the features needed for the next generation of aircraft networks

Current configuration process

Our proposal

Evaluation

Results

# How do you Create Network Configurations

Creation : Specification + implementation

Validation : Formal methods + simulation

Verification : Functional testing

**Distribution** : Deployment

Configuration management is a multiple step process

## How to Make a Meaningful Proposition: Requirements

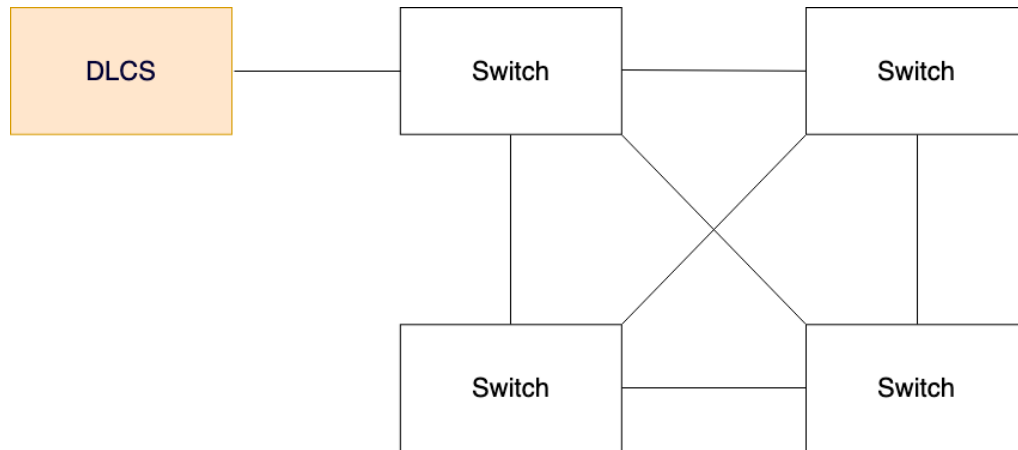
Aircraft system developers are interested in :

Performance	Safety	Security
Determinism Real time	Behavior and worst case insurance	Malicious interaction prevention

Each feature added to a system adds complexity that needs to be mastered



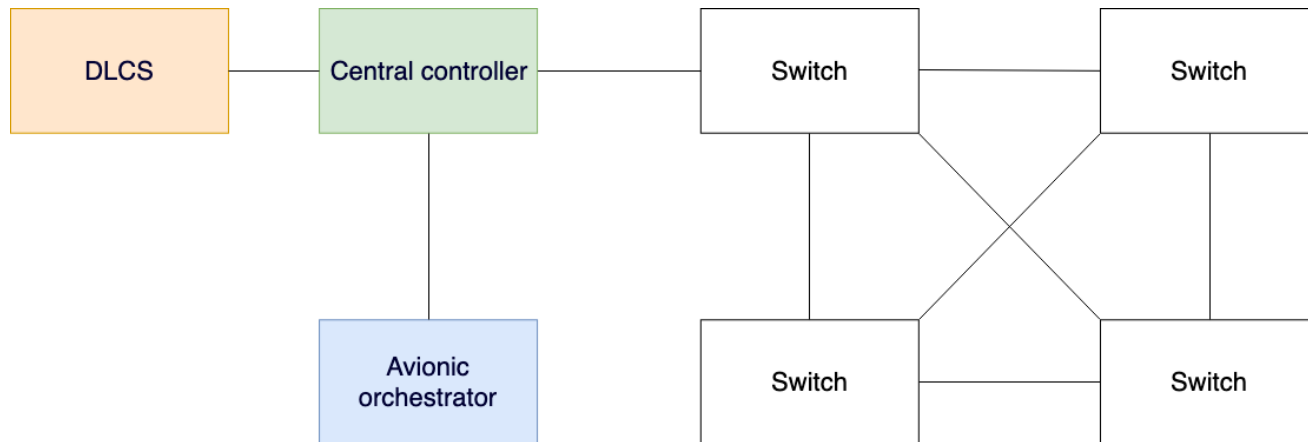
## Current Configuration Architecture for Aircrafts



Data Loader Centralized system (DLCS) is a maintenance device used to download the configurations to the network devices when evolutions happen in the aircraft

## No dedicated controller for networks, limited control for management

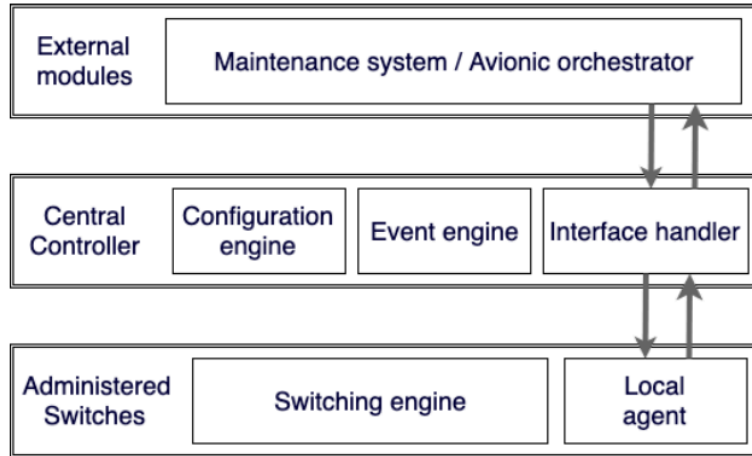
## Proposal: A New Network Configuration Architecture



Selecting an SDN architecture make sense from a functional standpoint  
Designing APIs to implement required behaviors  
System integration processes are to be taken into account for the management

Design philosophy is focused on **adding** new functionalities

## Proposal: A New Network Configuration Architecture II

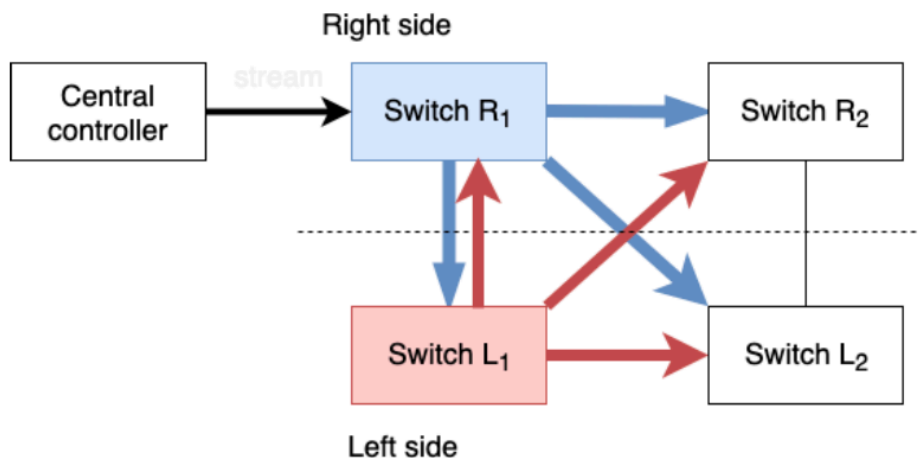


Central controller role is to **interface** the network with the external modules and administrate the Network with interfaces.

This is done by opening **Application Programming Interfaces** (APIs) to and from both external modules and switches

Design philosophy is focused on adding new functionalities

## Proposal: A New Network Configuration Architecture III



The controller talks with the switches through the APIs

The communication on the network is done with a static replication pattern

This communication scheme allows to ensure: configuration **availability** and sound communication **behavior**

**Out of band network** for configuration

Static transmission scheme integrates redundancy and add resiliency to the architecture

## Proposal: A New Network Configuration Architecture IV

Configuration management functions are tied to operational modes in the aircraft

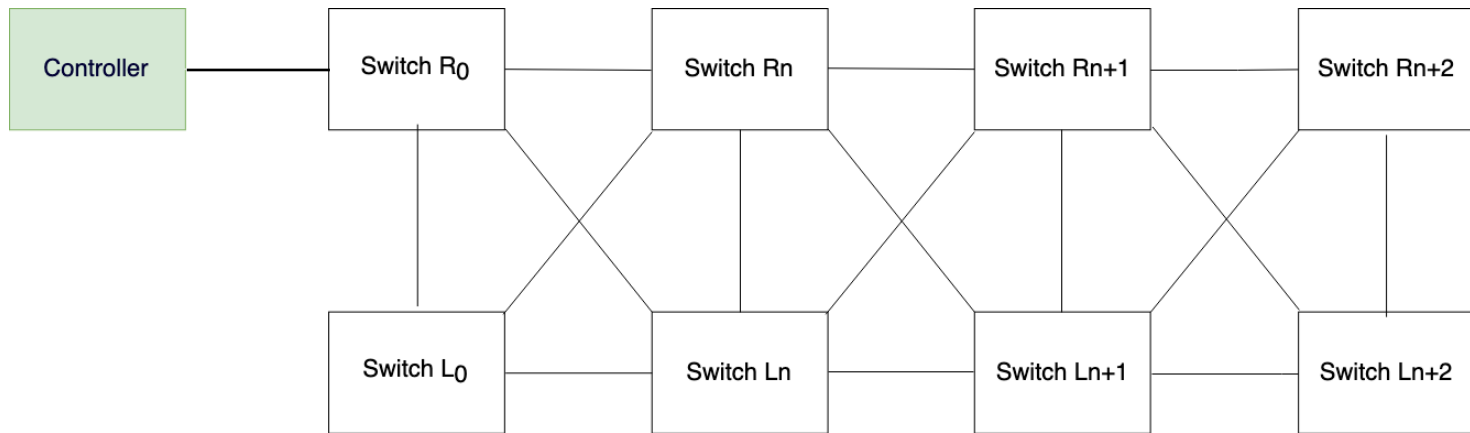
Two sides to the capabilities: **Functions** and **Routines**

**Functions:** The capabilities necessary for the network management to happen,  
In other term (which kind of APIs for the network to work)

**Routines:** In which scenario can these new functions be used

Network management capabilities differ according to the aircraft operational mode

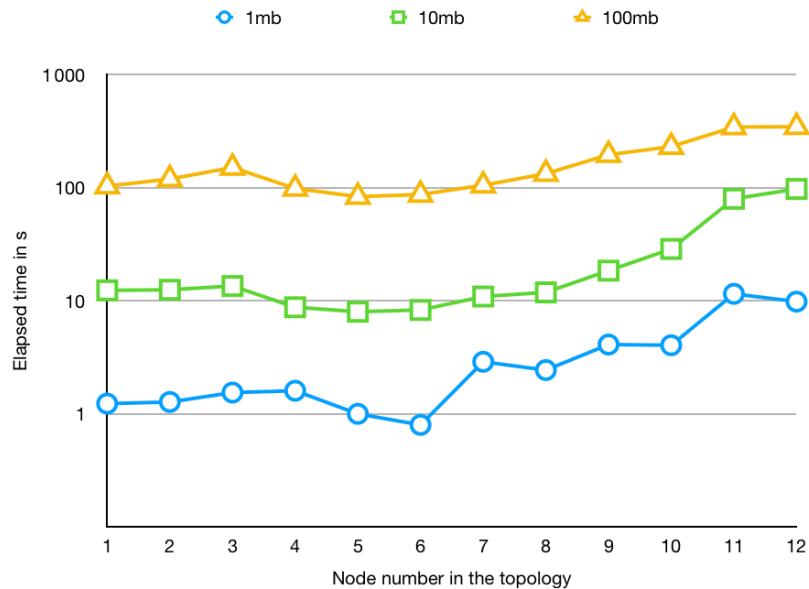
## Emulation: Aircraft Topology and Scenarios



Simulation made using gRPC and Mininet on a virtual machine (2vCPUs, 4Gb of ram)

Aircraft topologies are regular which we can leverage for our transmission scheme

## Evaluation: A new network configuration architecture

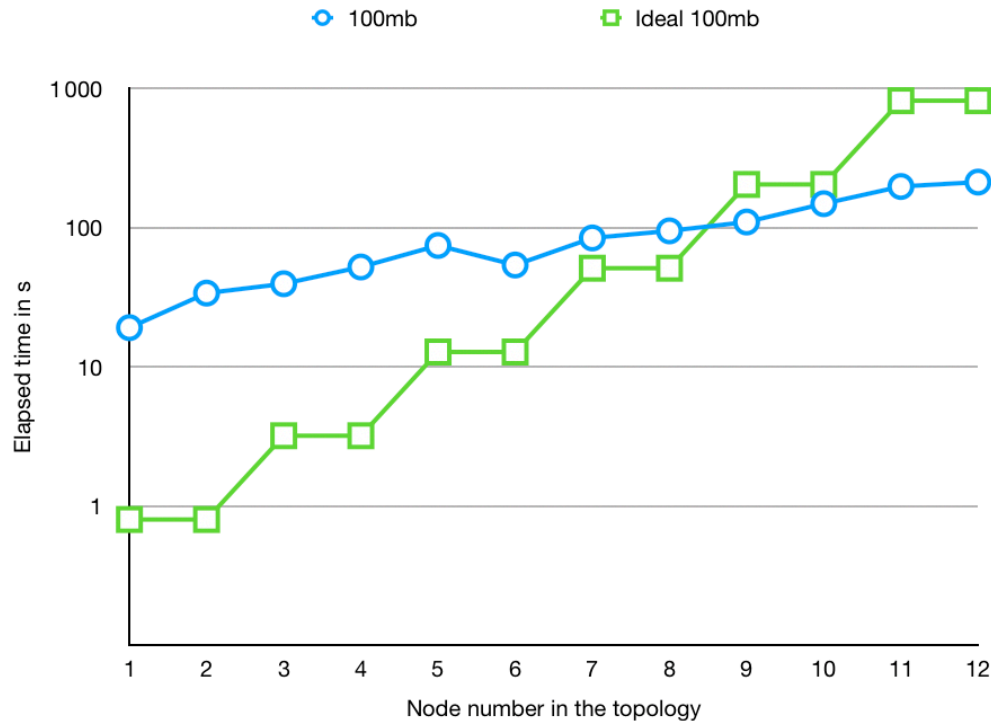


Simulation done on a 12 switch topology

Measured transfer time of configuration files  
For 1mb 10 mb and 100mb file sizes

Transmission scheme was evaluated to understand its limitations

## Evaluation: A new network configuration architecture



Ideal available bandwidth was analytically studied



SDN helps aircraft networks to adapt to new trends

Preliminary results show that this transmission scheme enables to implement new network management features while limiting added complexity

SDN could be an enabler for aircraft system integrator to further improve modularity

Architecture robustness

Advanced scenarios

Transition mechanism

Architecture robustness

Advanced scenarios

Transition mechanism

Thank you. Question time

# ANNEXE

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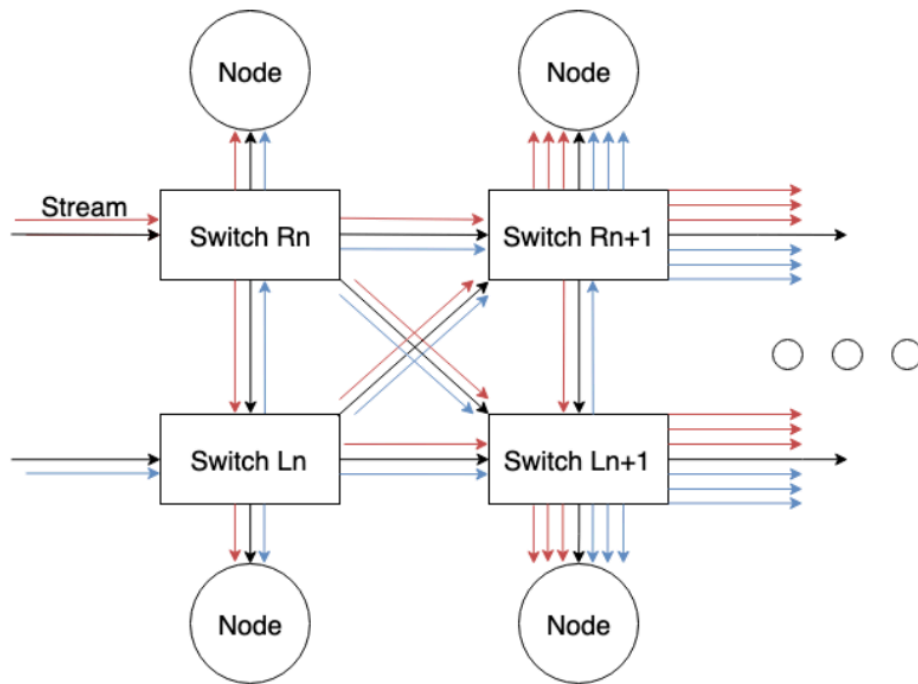


## Necessary Classification

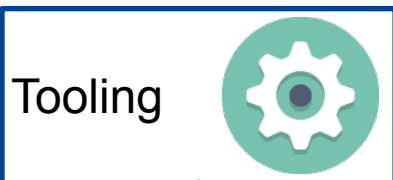
Requirement type	Network related		Safety related		Security related	
Subdomain objectives	Expected latencies	Bandwidth	Reliability objectives	Determinism	Security objectives	Security type
Flight control	< 10 ms	10 mb/s	$10^{-7}$ to $10^{-9}$ h <sup>-1</sup>	Hard	SAL 3	For safety
Avionic	0.5 s	30 mb/s to 300 mb/s	$10^{-7}$ to $10^{-9}$ h <sup>-1</sup>	Hard	SAL 3	For safety
Cabin Core System	10 ms to 100 ms	100 mb/s to 1 gb/s	$10^{-7}$ to $10^{-9}$ h <sup>-1</sup>	Soft	SAL 2	For safety
IFE	10 ms to 100 ms	1gb/s to 10 gb/s	N/A	N/A	SAL 3	For business
Information System	10 ms to 100 ms	1gb/s to 10 gb/s	N/A	N/A	SAL 2	For business

## Effect of Naive Replication

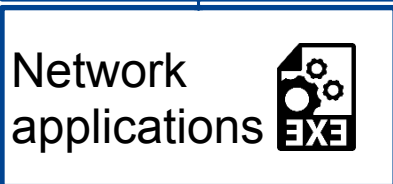
$$NB_S(n) = 4 * NB_S(n - 2) \forall n > 2$$



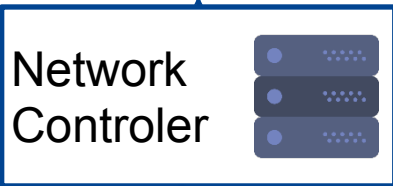
## Where are Modularity Potential in the Network



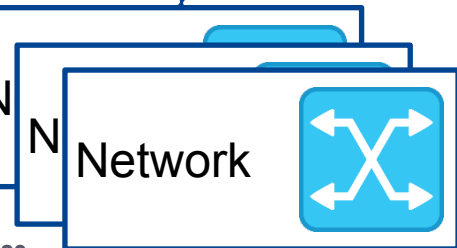
Configuration creation engine optimisation for better ressource reservation (Worst case calculations, synchronized schedules)



Embedded tooling to provide configurations dynamically in the network (Autonomous networks)



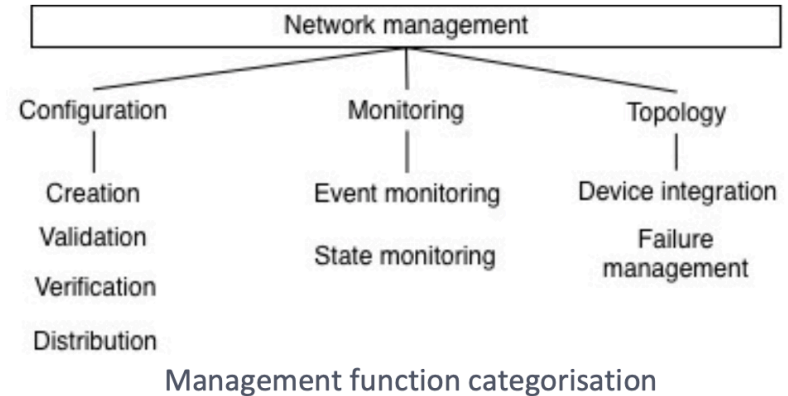
Real time behavior in the network controller (SDN, CNC)



New transport layer for better scheduling (FTT, TSN)

### Exploring real-time requirements for network management:

- Requirements emerge from new architectures and use cases in aircrafts
- Configuration distribution inside the aircraft seems the most anticipated feature
- Each function category can have real-time aspects



Real time applications bring strong requirements for network designs