

The Use of Carrier Grade Linux in Space

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Agenda

- ✦ What is Carrier Grade Linux?
 - ➔ Carrier Grade
 - ➔ Standards
 - ➔ Evolution
 - ➔ Services
- ✦ Applicability to Spacecraft
- ✦ A usage scenario
- ✦ Conclusion

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What is Carrier Grade?

- ✖ From the Telecommunications Industry
- ✖ Carrier Grade refers to product availability
 - ➔ Typically 5 nines or better (99.999%)
 - ➔ Less than 5 minutes downtime per year

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Challenges faced in Telecom

- ✦ Demanding Environment
 - ➔ Quality of Service
 - ➔ High Availability
- ✦ Custom hardware
- ✦ Custom / Proprietary OS
- ✦ Upgrades and Implementation of New Services and Features
 - ➔ Tied to proprietary vendor
 - ➔ Long Lead times to implement / limited development support
 - ➔ Very expensive



Challenges for Flight Software

Harsh environment

- Radiation
- Limited Resources

Custom Hardware

- Long Lead times
- Very expensive
- Limited development support

Technology Gap

- Moore's Law



Solution: Carrier Grade Standards

✦ Hardware Standards: ATCA

- ➔ Enables development of portable software applications
- ➔ One board may be swapped for another

✦ Software Standards: Middleware

- ➔ Move the autonomy requirements from the application into middleware
- ➔ Requires standardized middleware interfaces

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What is Carrier Grade Linux?

Linux Flight Heritage



Photo Courtesy NRL



Illustration Courtesy AirForce

Linux OS

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What is Carrier Grade Linux?

Promoting and Maintaining Standards

**SERVICE
AVAILABILITY
FORUM™**

 **SCOPE**
*Promoting Open Carrier Grade
Base Platforms*



HA Middleware
Linux OS



What is Carrier Grade Linux

- ✦ Increased Mission Availability
- ✦ Tools, Technologies, and APIs
- ✦ Use of COTS processors and boards for space applications



CGL Middleware Services

Service Name	Feature
Availability Management Framework	Fault detection, fault recovery, cluster coordination
Cluster Membership Service	Infrastructure, Publish-Subscribe - Node joins cluster, node leaves cluster
Checkpoint	Assists with fault recovery - reduce downtime
Event	Infrastructure, Publish-Subscribe state changes
Lock	Infrastructure, Shared resource control
Messaging	Infrastructure, inter-node, intra-node messaging
Information Model Management Service	Standard model of cluster entities
Logging	Storage of data for system administrators
Notification	Failure notifications



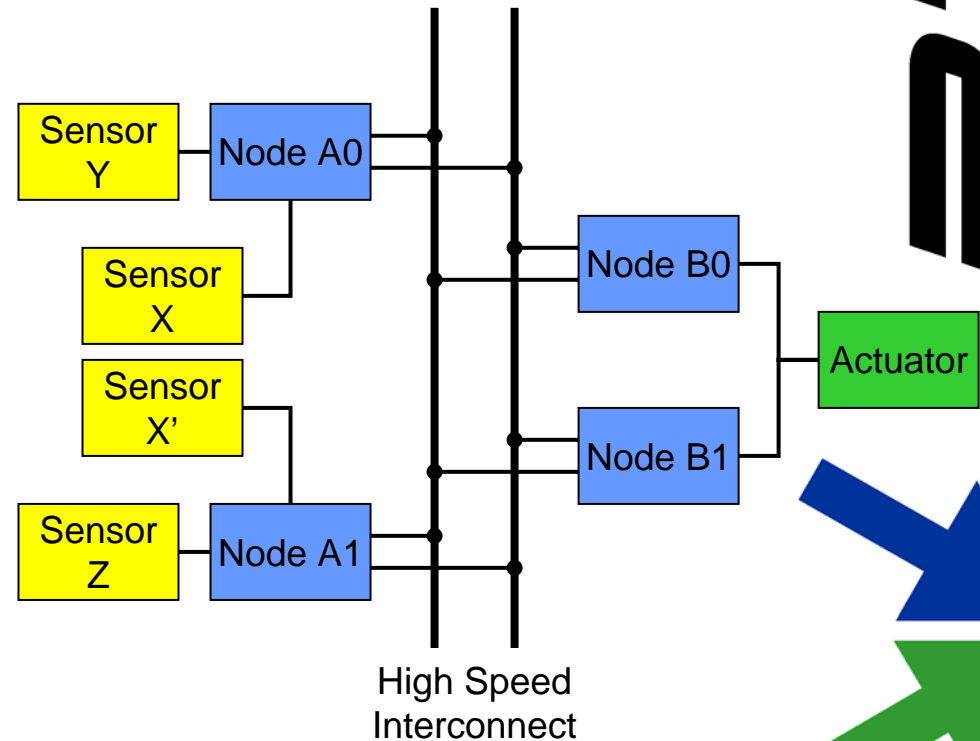
A CGL Bus Design...

* Hardware components

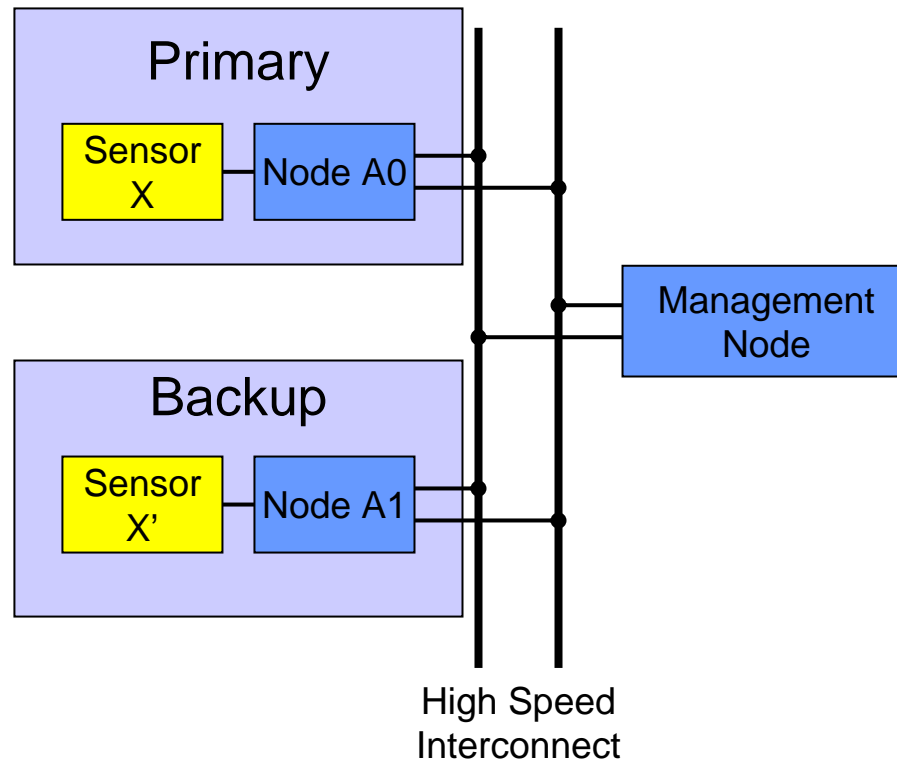
- Processors, Redundant Interconnects, Sensors, Actuators

* Software responsibilities

- Command and Data Handling
- Sensor data manipulation and processing
 - Actuator control
 - Inter-processor communication

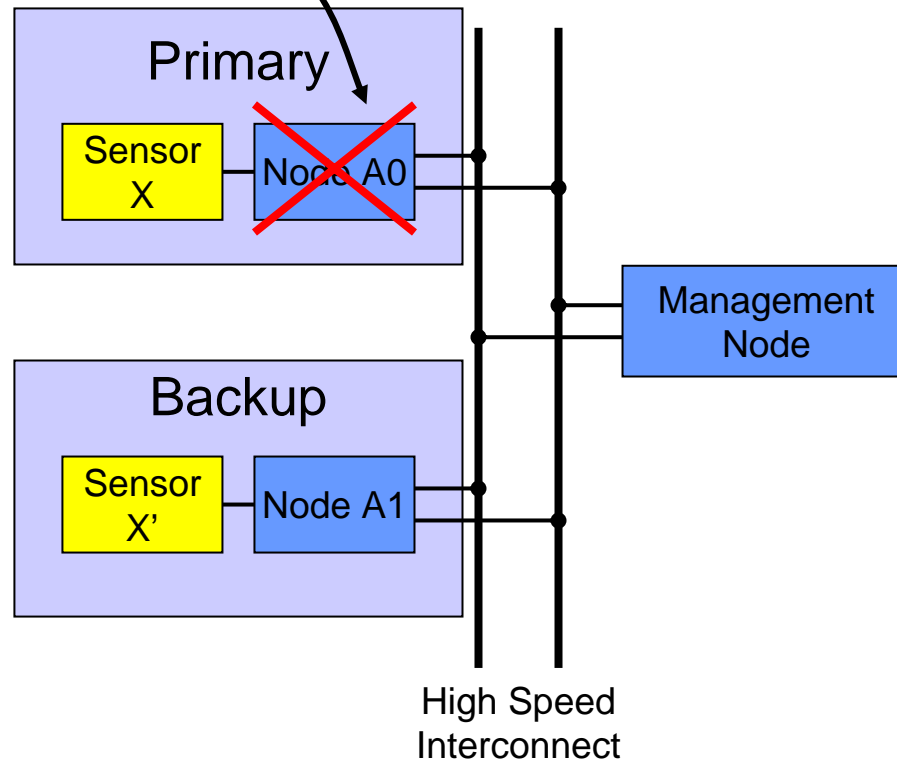


Failover Scenario

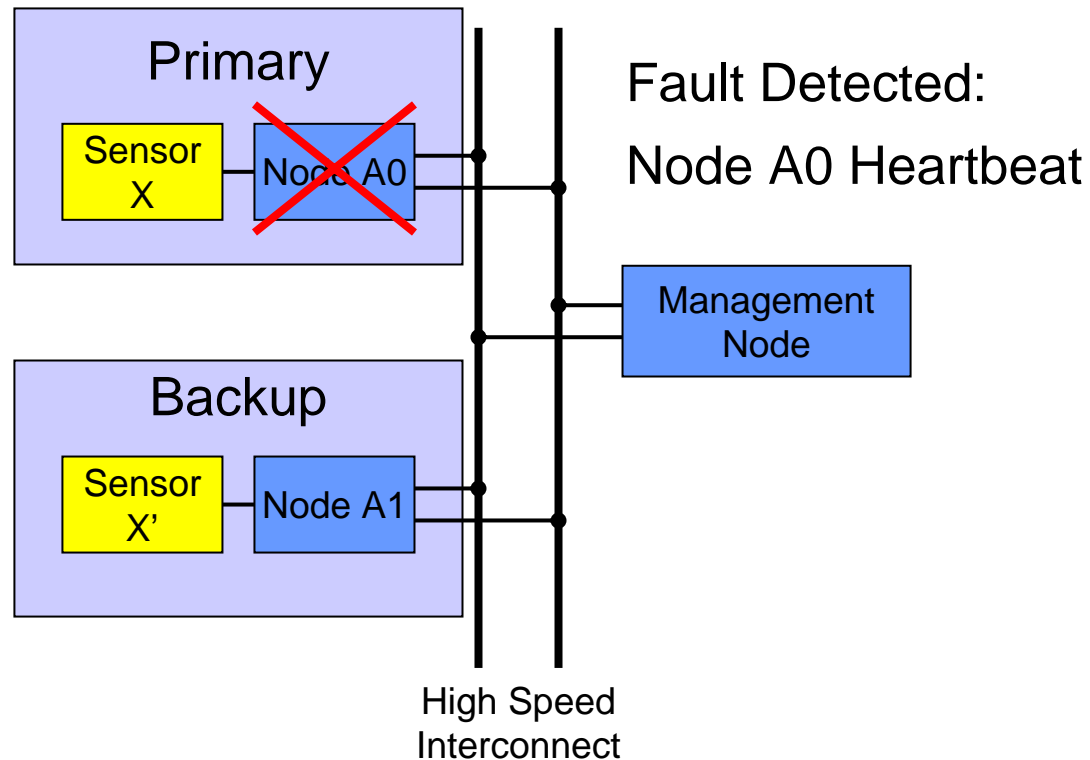


Fault Occurs

Primary Node Fails



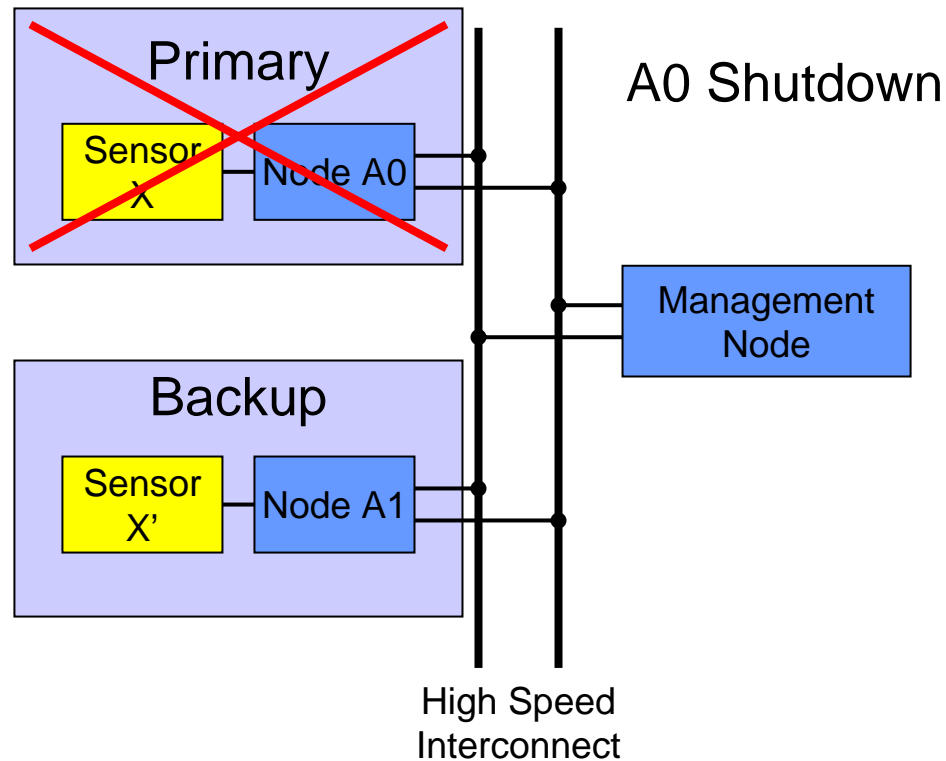
Fault Detection



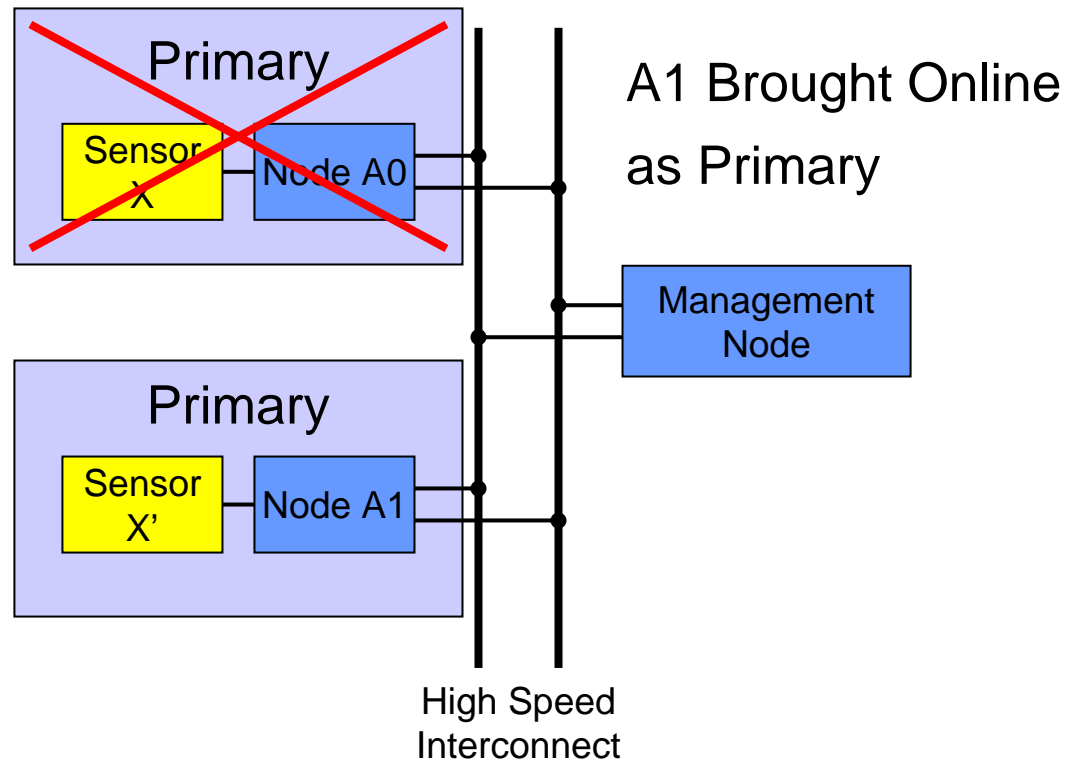
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Fault Recovery



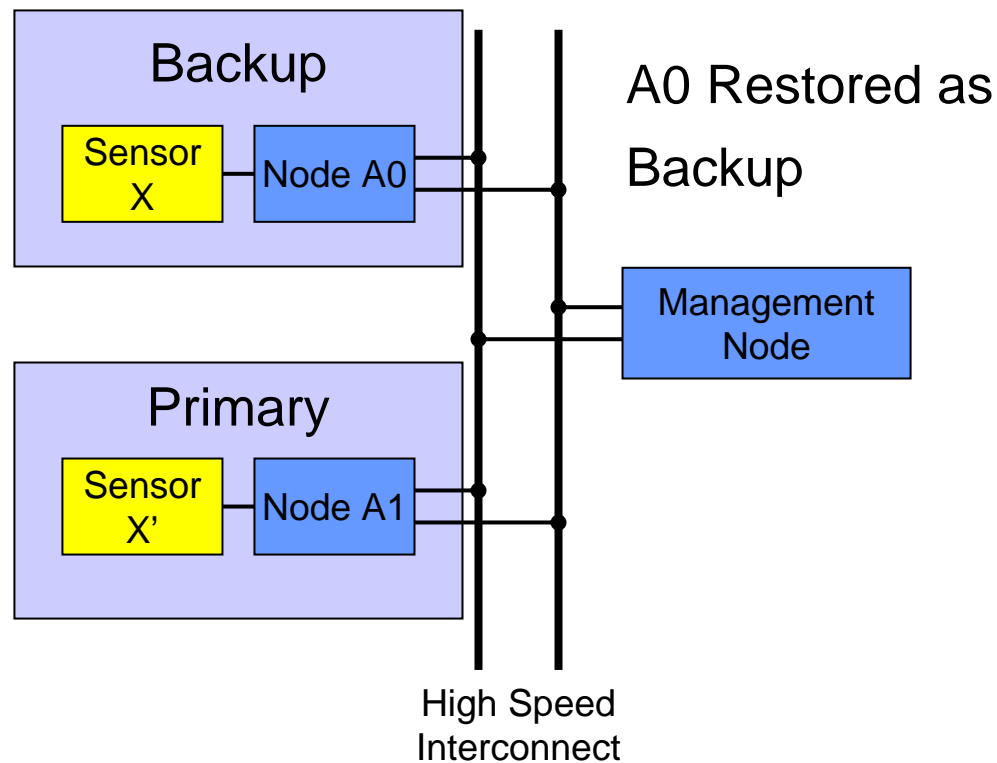
Mission Restored



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Redundancy Restored



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Conclusion

- ✦ Carrier Grade Linux is an enabler for high availability space applications
 - ➔ Low Cost - significant functionality is available out of the box
 - ➔ Portable - CGL is an implementation of a standard
 - ➔ Reduces the development lead time

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For More Information...

Carrier Grade Linux

➔ <http://www.linux-foundation.org>

Service Availability Forum

➔ <http://www.saforum.org>

SCOPE Alliance

➔ <http://www.scope-alliance.org>

FlightLinux

➔ <http://www.openflightlinux.org>

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