



**Fibre Channel**

**Testing For  
Avionics**

**Applications**



# Overview

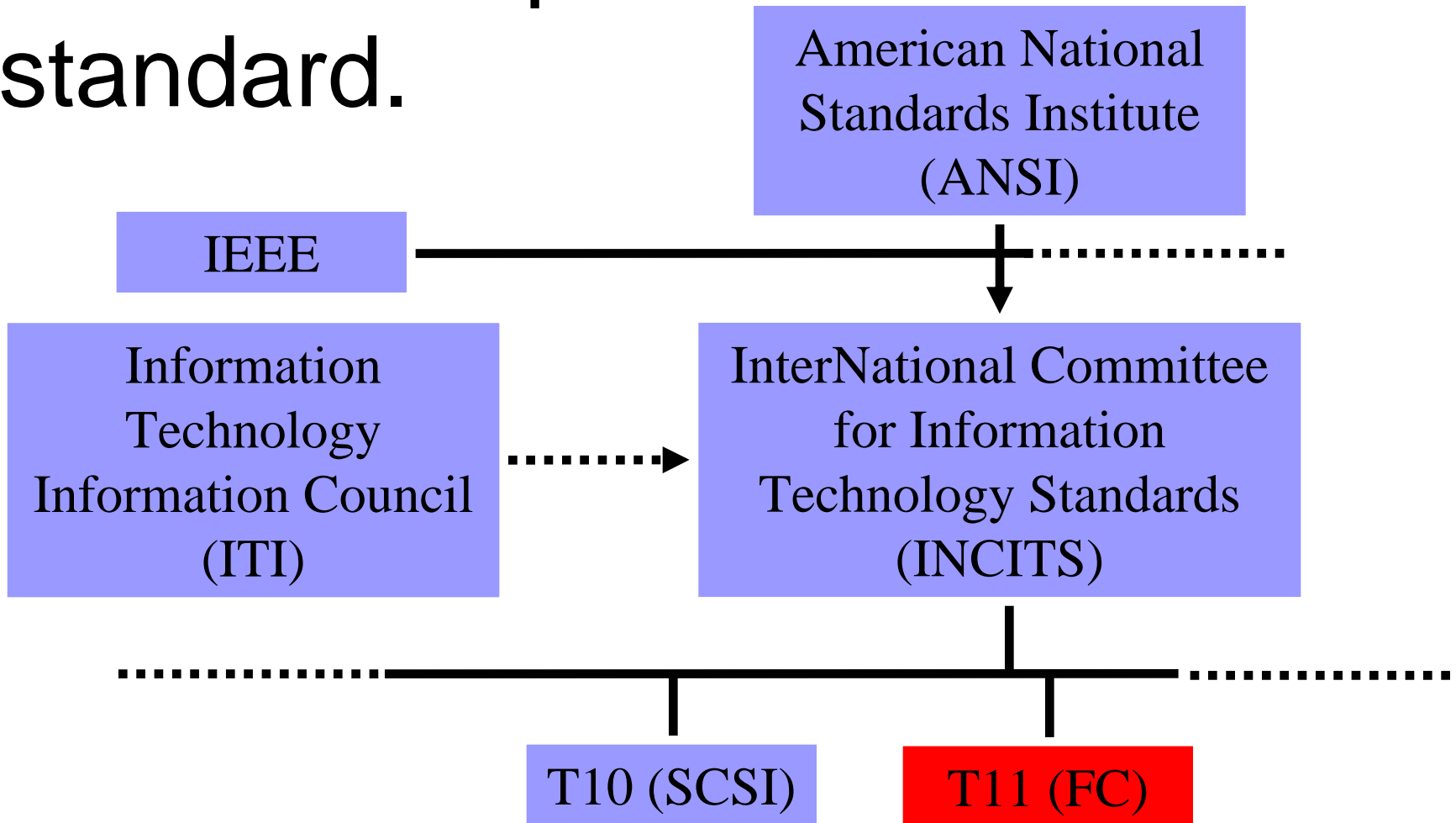
- A Brief Introduction to Fibre Channel
  - Fibre Channel Basics
  - Characteristics of a Real-Time Network
- An Overview of a Fibre Channel Avionics Network
  - Topology Use
  - Fault Tolerant Designs
- Some Popular Avionics Protocols
  - 1553
  - ASM
  - RDMA
- Testing Challenges
- Testing Strategies



# A Brief Introduction To Fibre Channel

# What is Fibre Channel?

It is an accepted international standard.



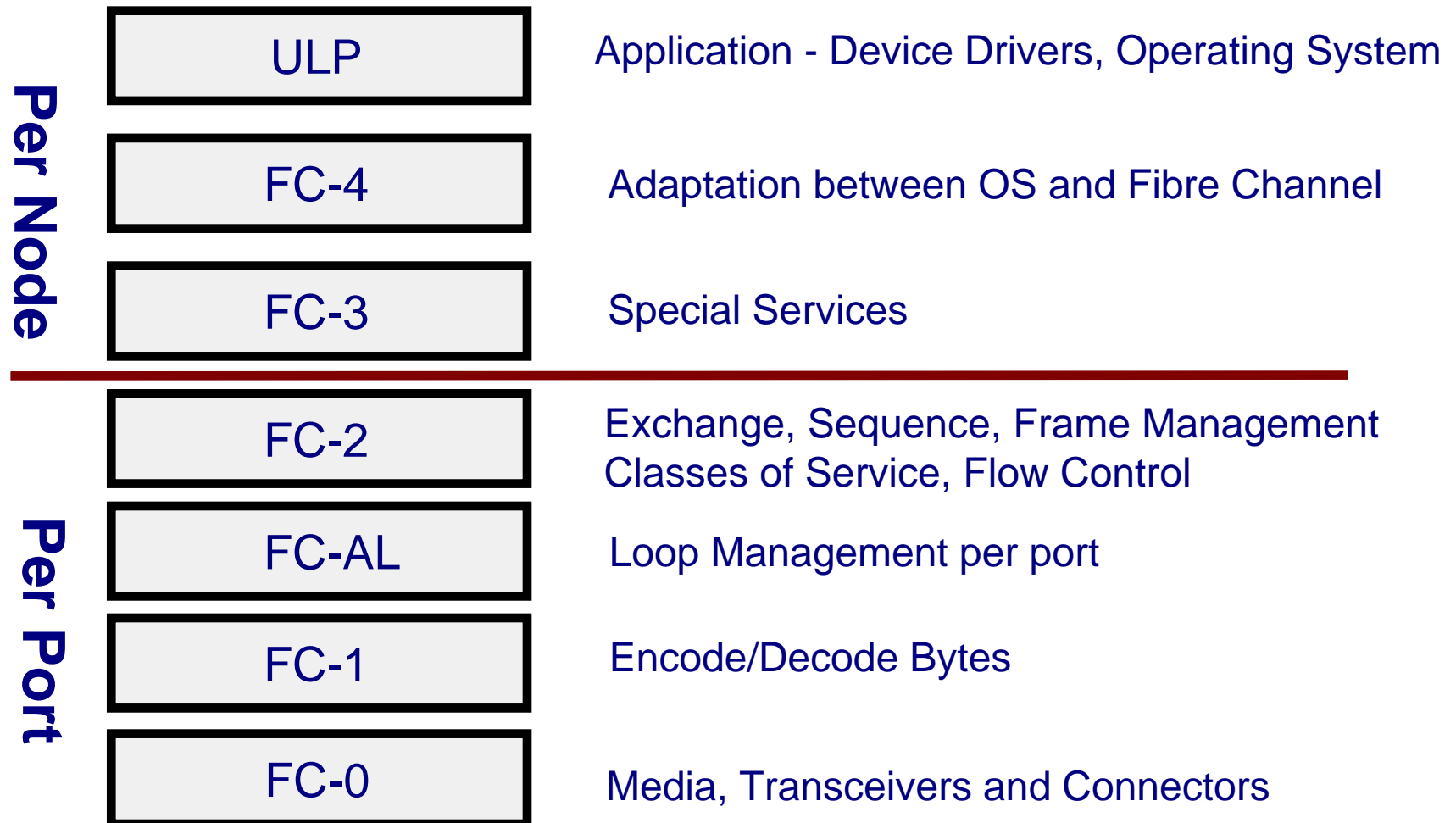


# What is Fibre Channel?

**Fibre Channel is a communication protocol between host processors and secondary storage elements.**

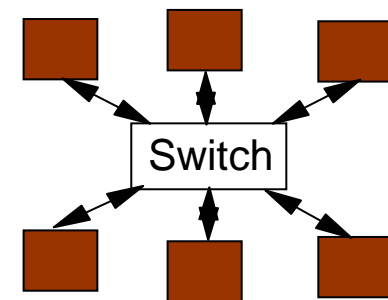
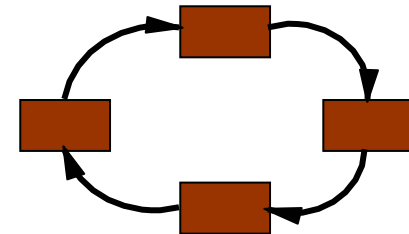
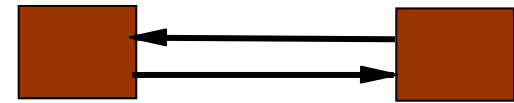
- Fibre Channel has been designed by combining the best characteristics of I/O subsystems and networks.
- Fibre Channel has been designed to be a universal carrier of data protocols.

# Architectural Levels – Simple Node

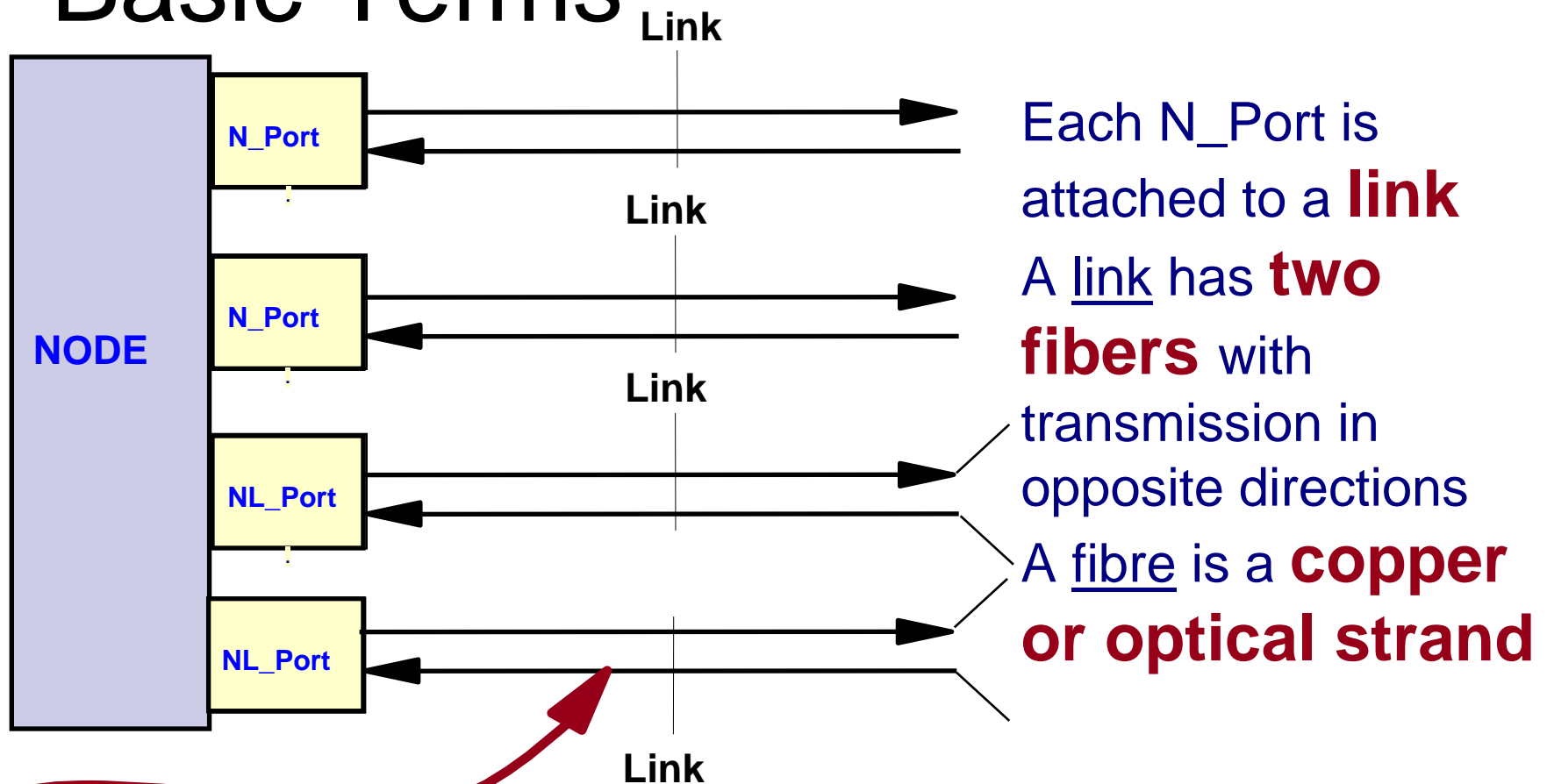


# Fibre Channel Basics; Topology Terms

- Point-to-Point
  - Exactly two N\_Ports connected together
  - No Switch (routing function) present
- Arbitrated Loop topology
  - Low cost attachment of 1-126 ports
  - Two NL\_Ports is a practical minimum
  - Switch (routing function) distributed into each NL\_Port
  - Can use Loop and Switch topologies together
- Switch topology
  - Up to 14 million ports connected together
  - 2 million reserved for special functions
  - Generic centralized switch (routing) environment
  - Well-Known Services usually required



# Basic Terms



Each N\_Port is attached to a **link**

A link has **two fibers** with

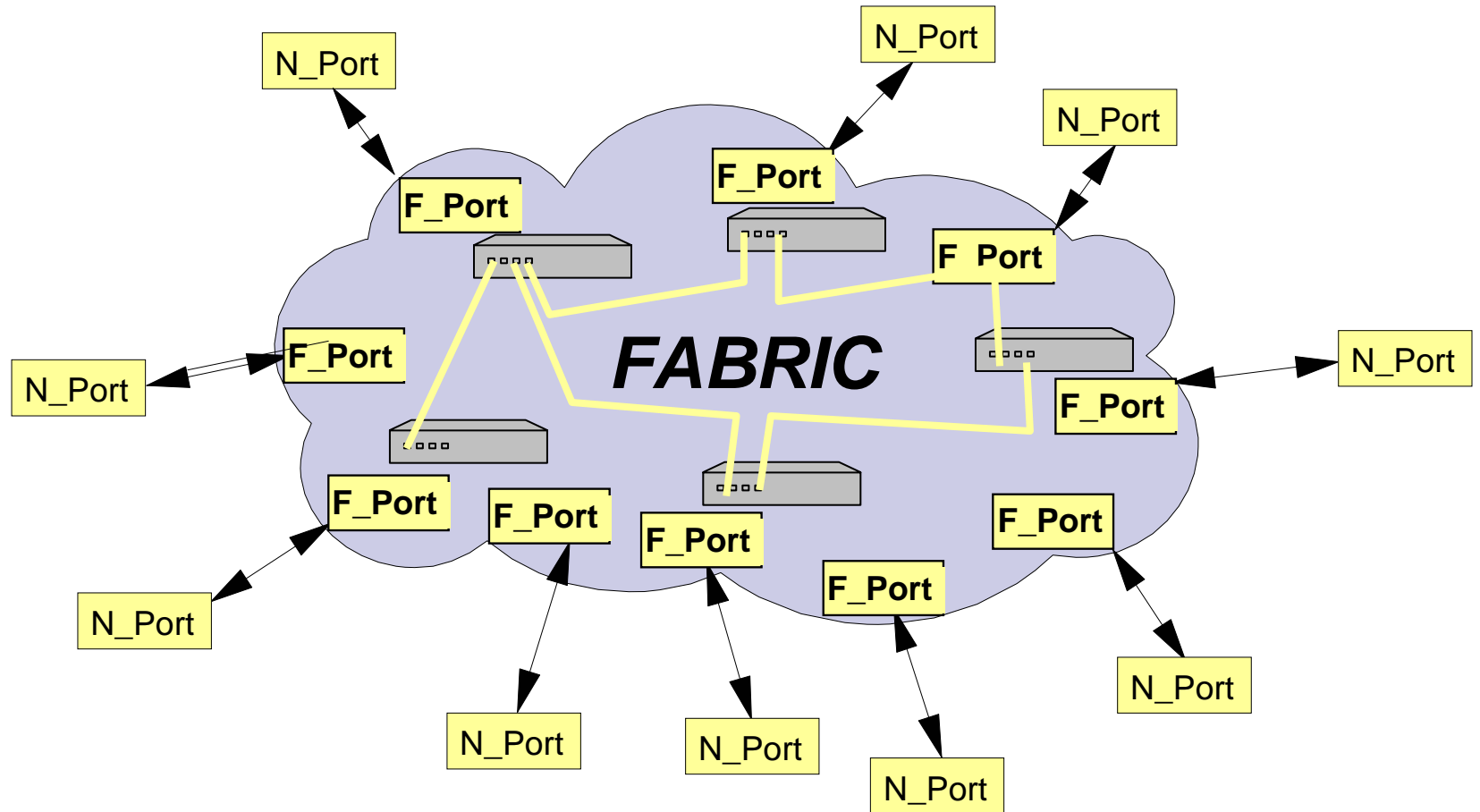
transmission in opposite directions

A fibre is a **copper or optical strand**

A Node attached to an arbitrated loop has at least one **NL\_Port** (Node Port with additional Loop functions)

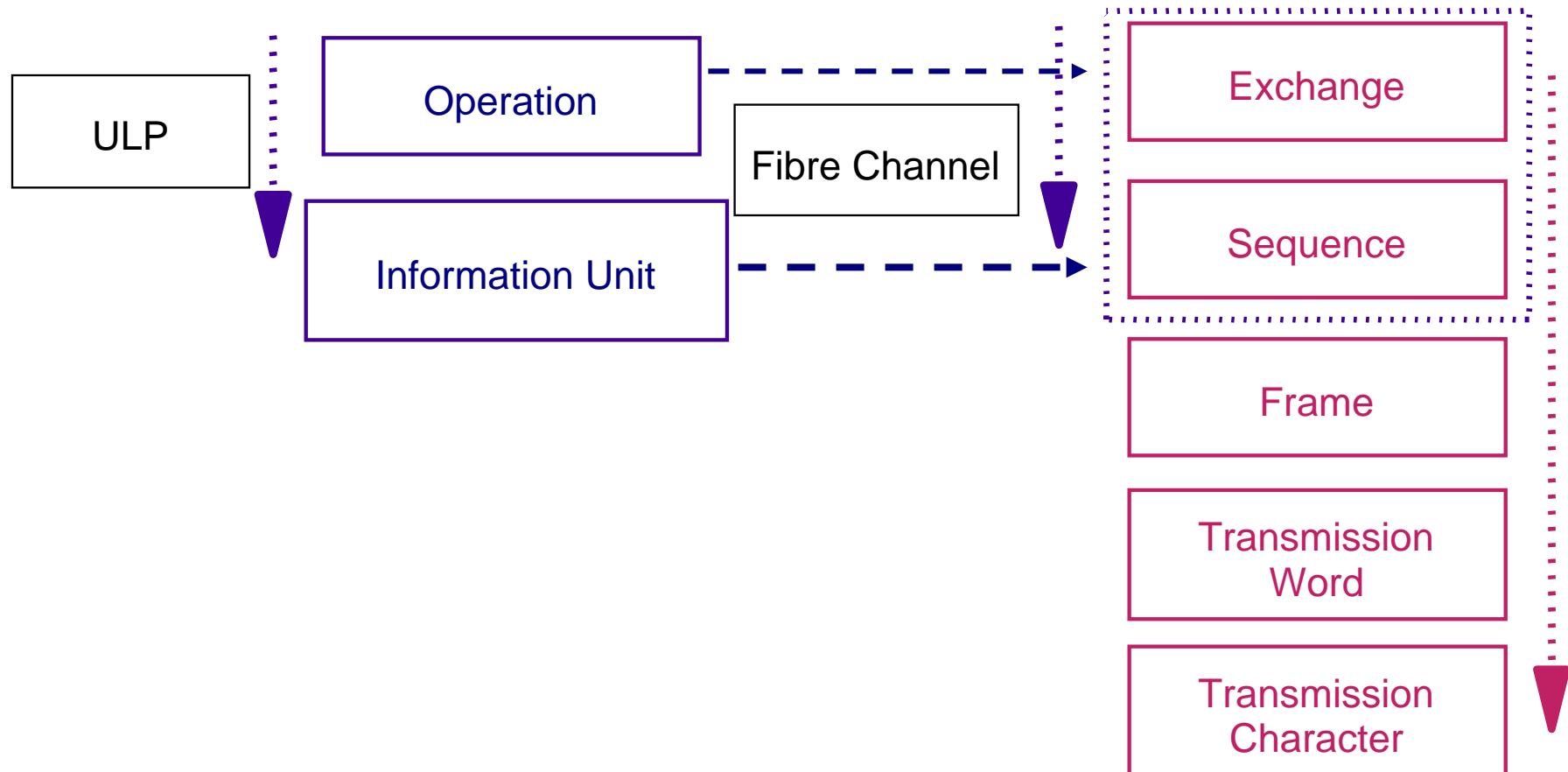
The fibers in the link are logically, if not physically split to form a loop.

# Topology Examples



Each link from an **N\_Port** is attached to an **F\_Port**

# Data Organization Hierarchy





# Classes of Service

- Class of Service - Style of information transfer
  - Connection-Oriented (e.g., phone system)
  - Connectionless (e.g., mail system)
- There are two user classes of services commonly used in Avionics Fibre Channel
  - Class 2
    - Acknowledged Packet-Switched Service
    - Buffer-to-Buffer and End-to-End Flow Control
  - Class 3
    - Unacknowledged (Datagram) Packet-Switched Service
    - Buffer-to-Buffer flow control



# Where Can I Get more Fibre Channel Information?

## Where to get the Standard's Documents

### ■ Completed Standards

#### □ Techstreet

1327 Jones Dr.

Ann Arbor, MI 48105 USA

Phone: (734) 302-7801

Fax: (734) 302-7811

E-mail: [service@techstreet.com](mailto:service@techstreet.com)

### ■ T11 Web Site at [www.t11.org](http://www.t11.org)

□ May get drafts in PDF format, many of which are completed

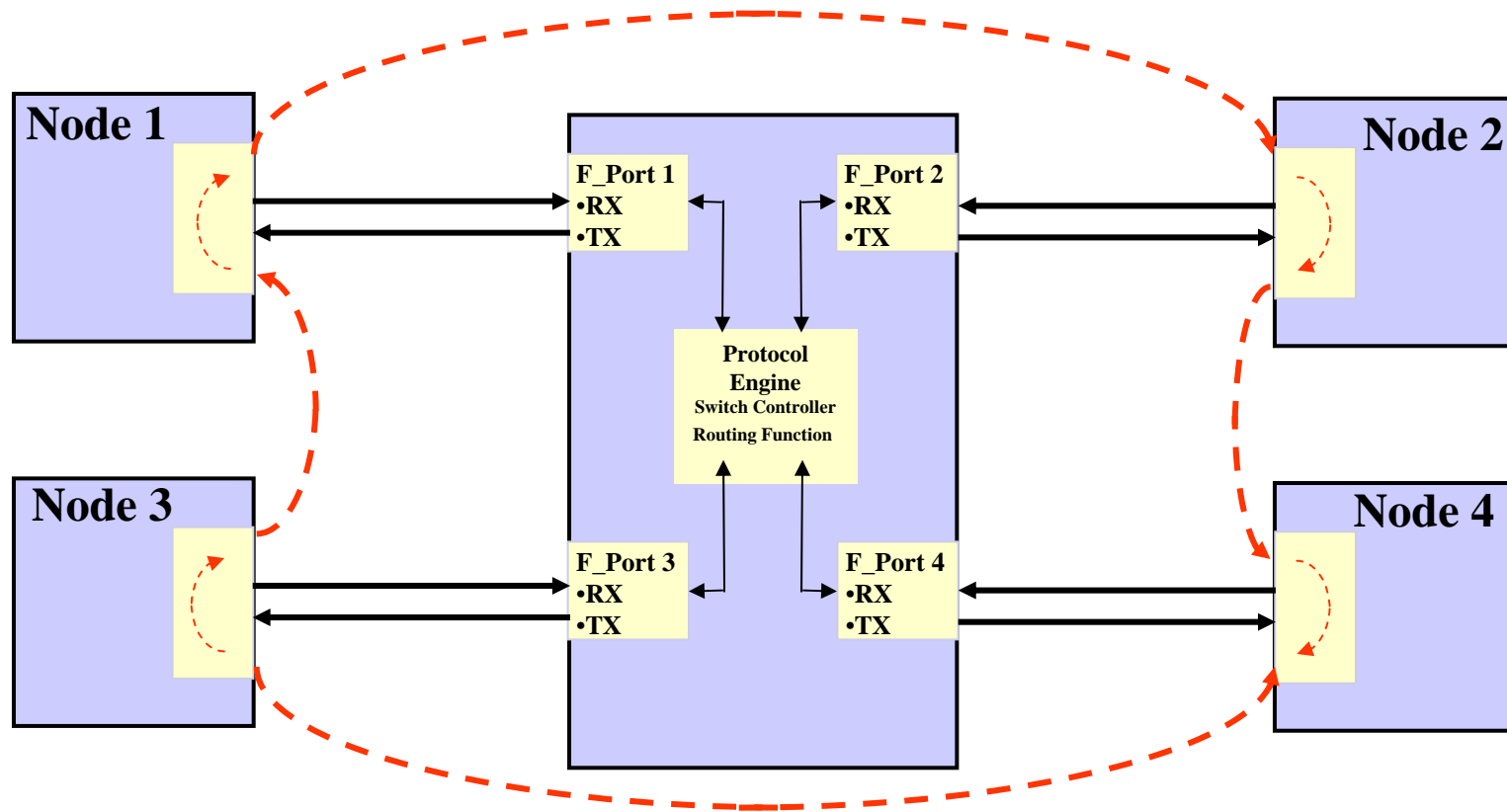
### ■ Your Internal Corporate Library



# An Overview of a Fibre Channel Avionics Network

# Topology Development

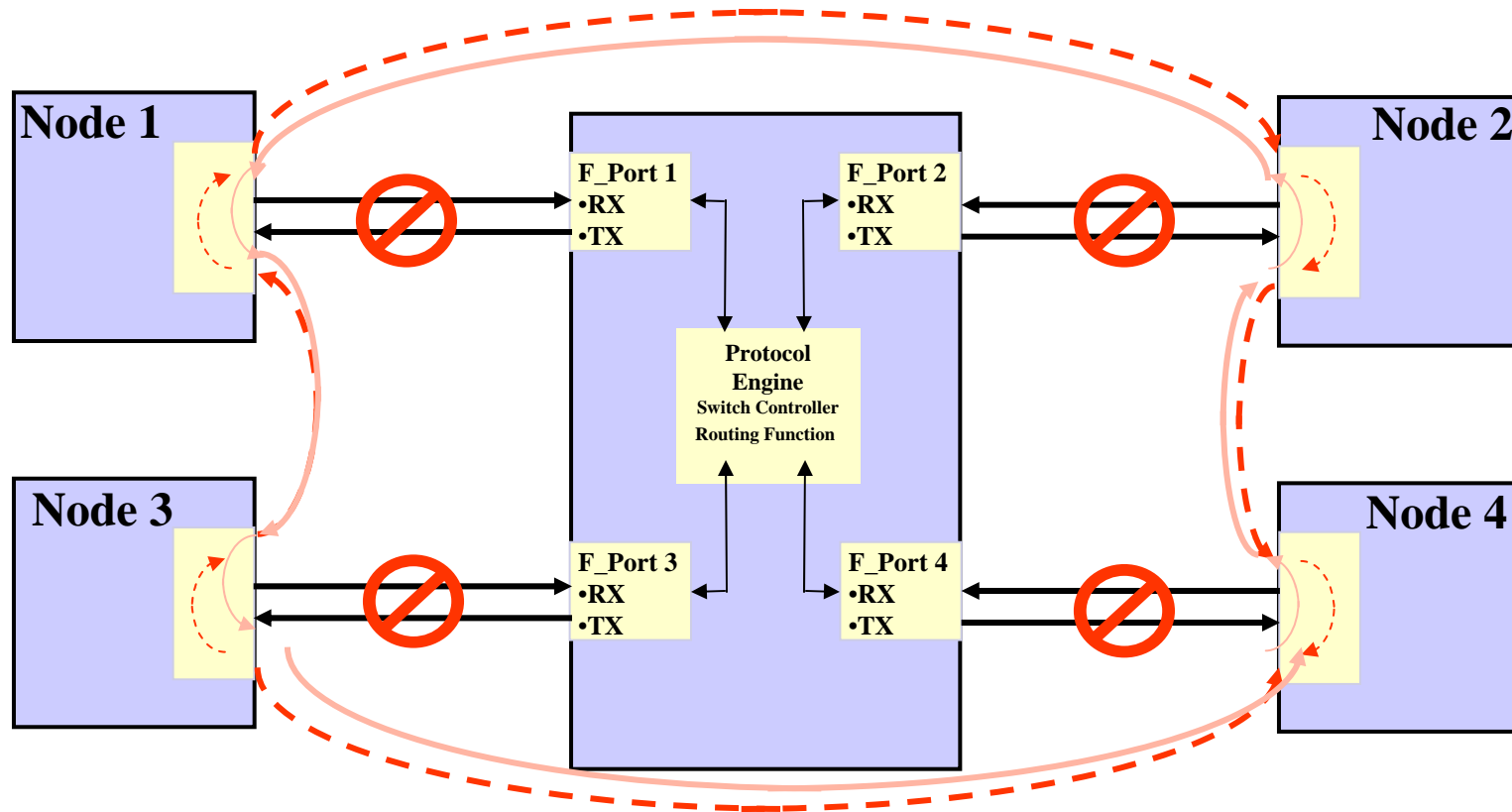
## Switched And/Or Arbitrated Loop Topologies



**The Switched Network Is The Primary Communications Path**

# Topology Development

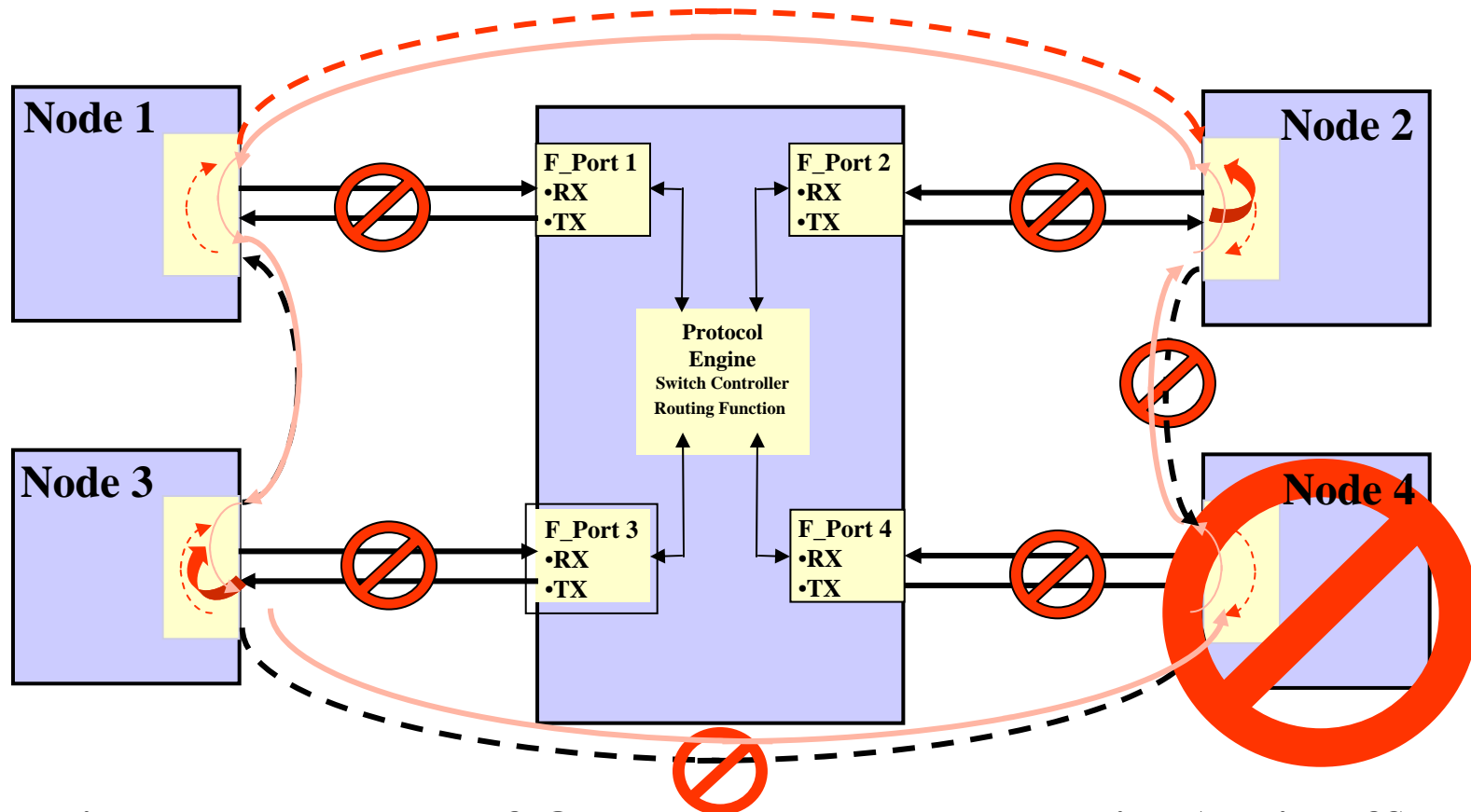
## Arbitrated Loop Robustness - Or Lack Thereof



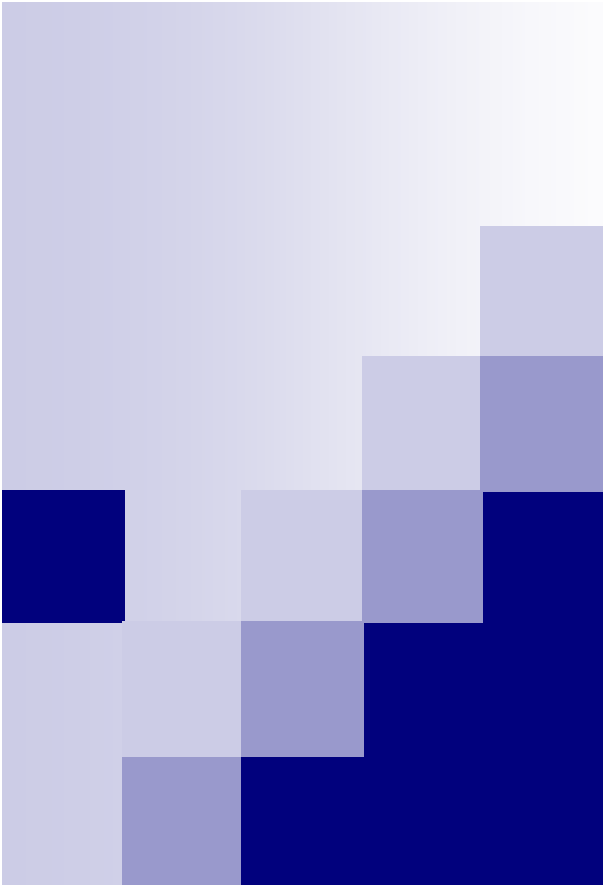
- **To Avoid A Failure, Two Loops Are Used**
  - **Loops Look Redundant When The Loops Are Operating Normally**
  - **In Reality, One Loop Carries Data, The Other Is Idle**

# Topology Development

## Failed Node Loop Back Operation



**With Two Loops, If One or more Nodes Fails (or is off),  
A Loop Can Still Be Maintained with a Loopback circuit**




# Some Popular Avionics Protocols



# Avionics Protocols

Remember Fibre Channel separates the command set from the means of the transport

- ASM
- RDMA
- 1553



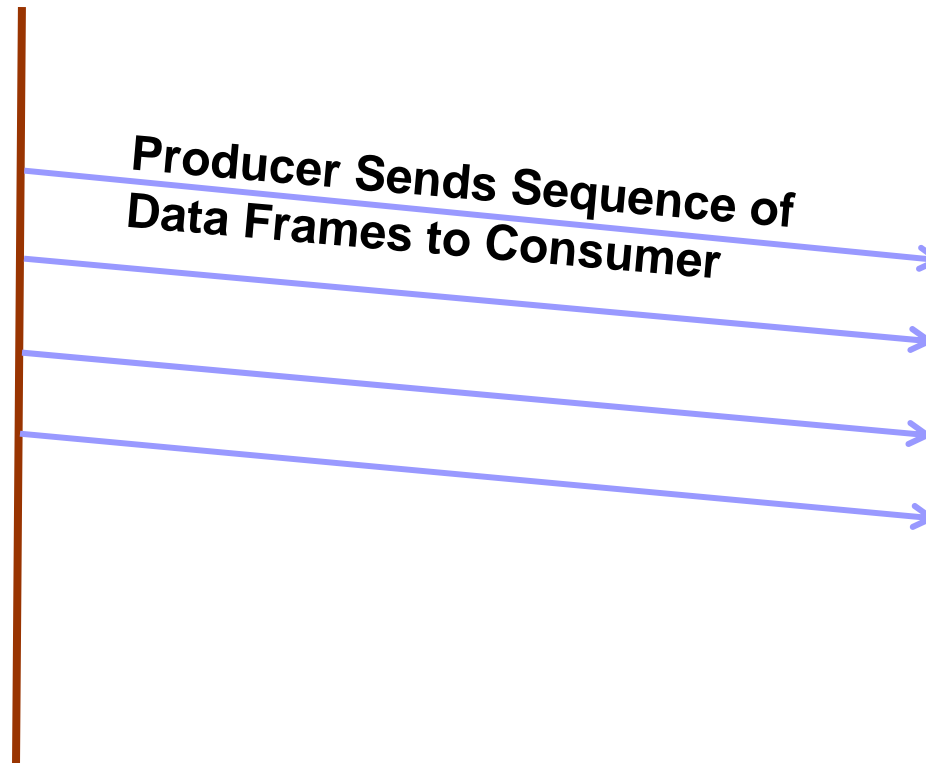
# Fault tolerance and Determinism for Avionics Fibre Channel applications

- Fault tolerance and Determinism are derived from a combination of architecture, topology utilization, physical transport protocol, and application protocol

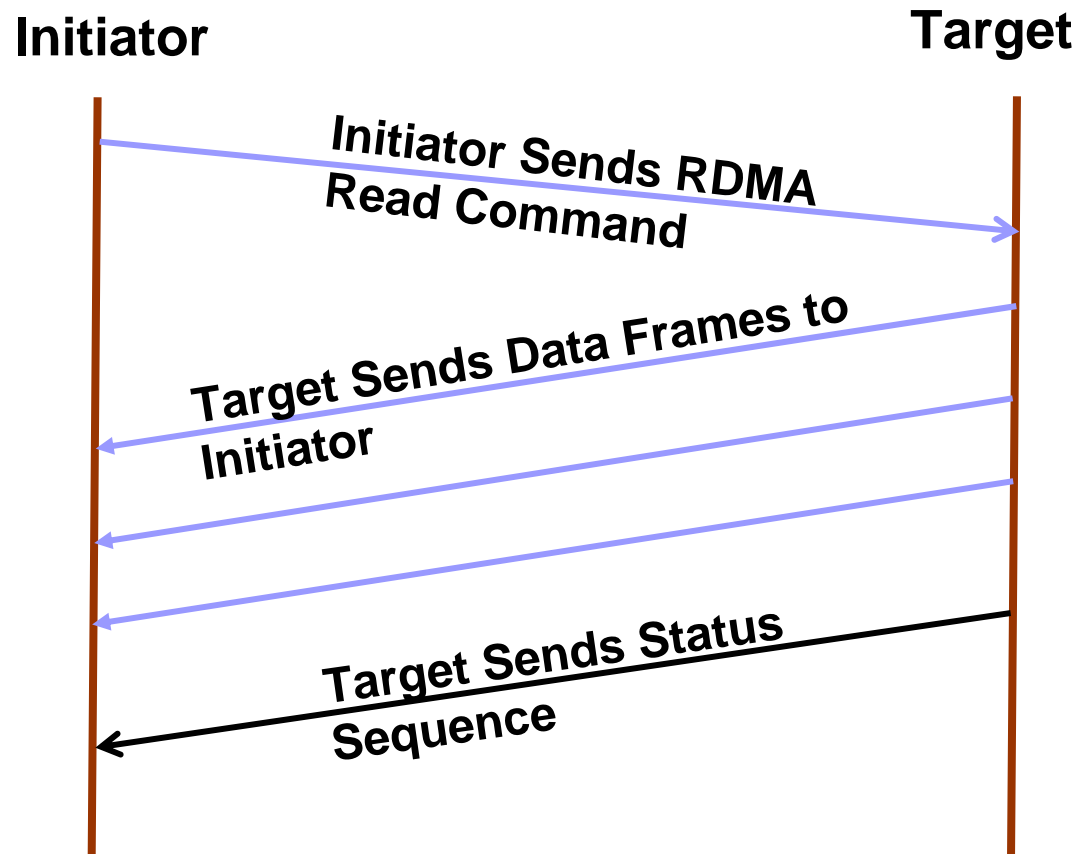
# Example ASM Exchange

Data Producer

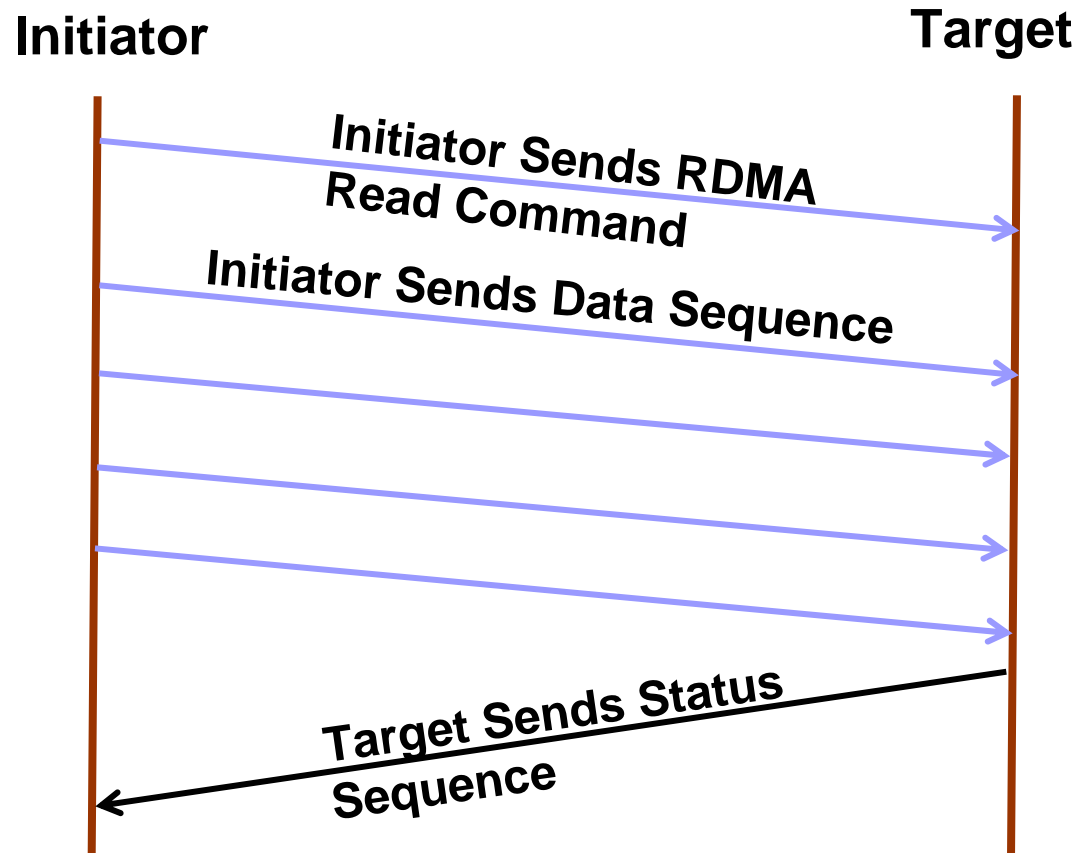
Data Consumer



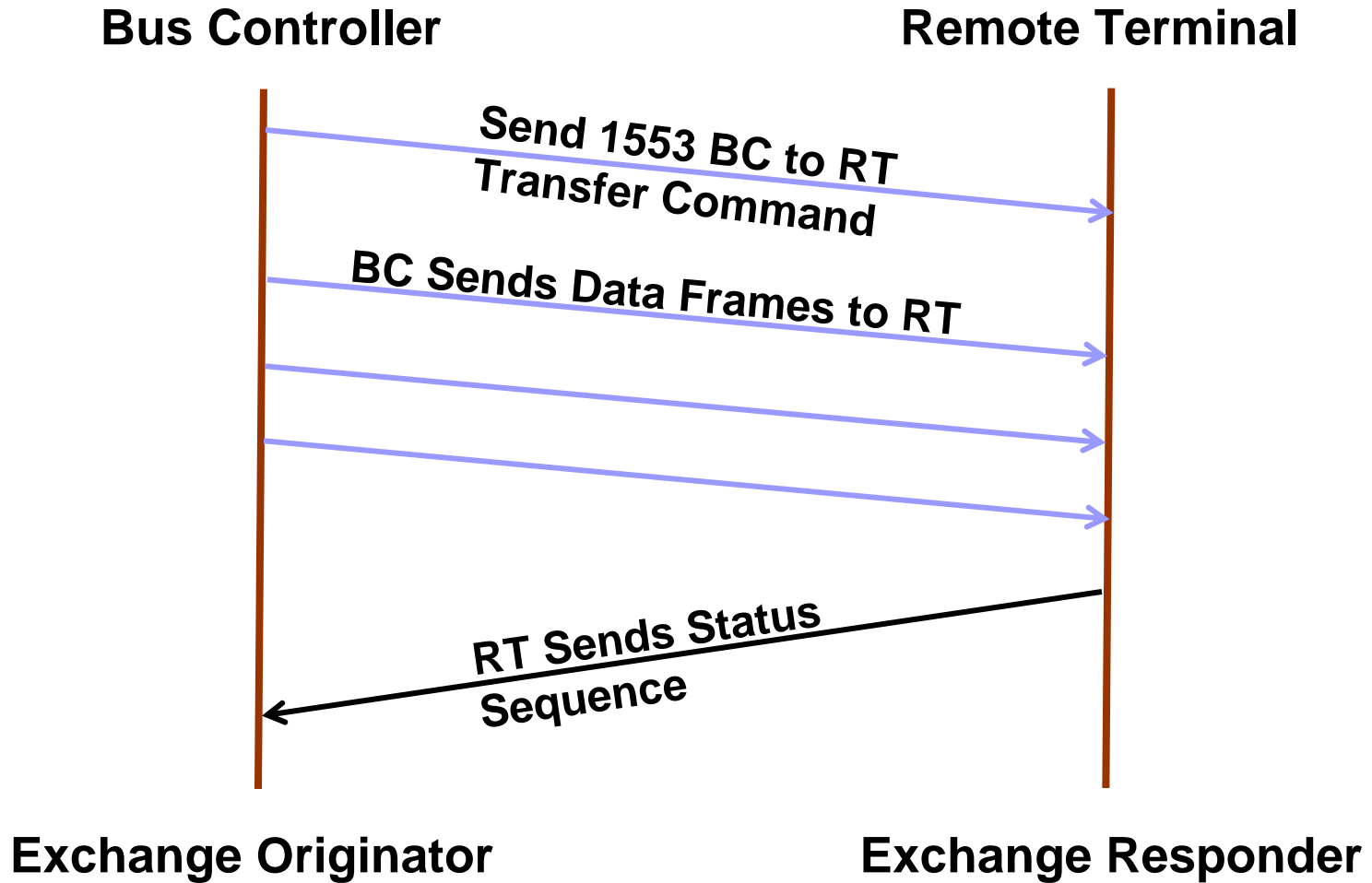
# Example RDMA Read Operation



# Example RDMA Write Operation



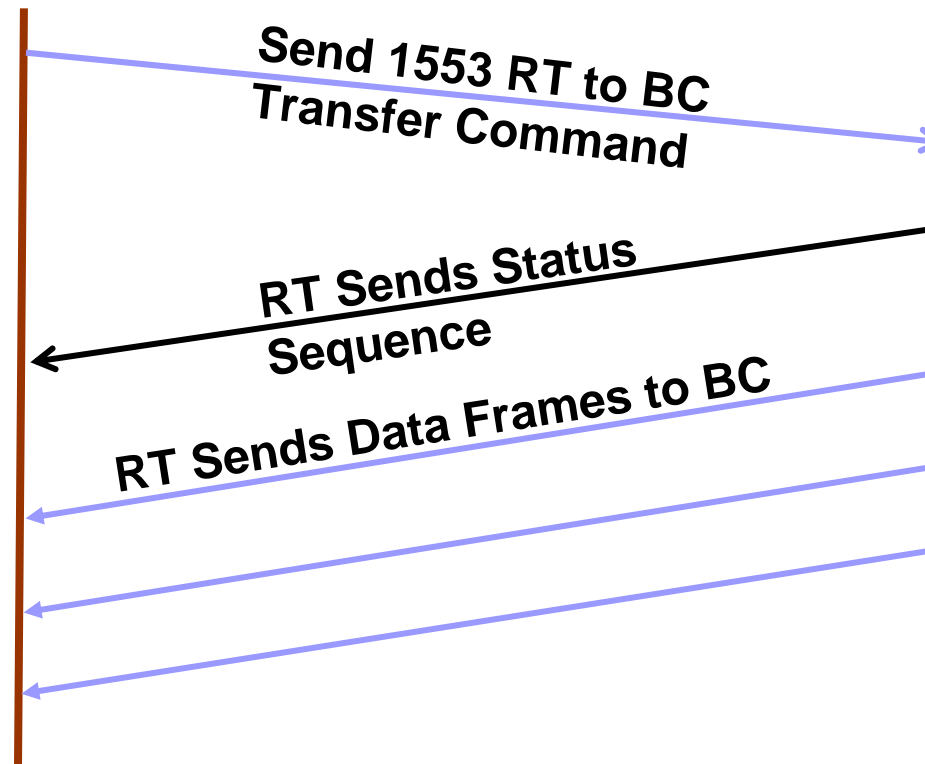
# Example 1553 BC-RT Operation



# Example 1553 RT-BC Operation

Bus Controller

Remote Terminal





# Testing Challenges



# Testing Challenges

- The sheer volume of the bandwidth
- Except for the point-to-point topology there is no single place to tap where all the traffic may be monitored
- Since the topology is not a bus there is no completely unobtrusive way to tap a link
- Fault tolerance and Determinism are derived from a combination of architecture, topology utilization, physical transport protocol, and application protocol



# Testing Strategies



# Testing Strategies

- Protocol Analyzers
- Data Generators
- Emulators



# Protocol Analyzer

- Flow Control

- Are there any delays being caused by the network?

- Determinism

- Are Exchanges occurring in timely manner?

- Are Sequences and frames being received in a timely manner?

- Data Integrity

- Is the contents of frame data correct?

# Protocol Analyzer

**Chronological Monitor**

FC2 FC4 FC4ASM FC1 RAW

Trigger Delta	ddd:hh:mm	ss:mm...	Port	Count	Port 0	Port 1
+00000002	026:14:21	42:885....	1	3D...		IDLE
+00000002	026:14:21	42:885....	0	3D...	IDLE	
+00000003	026:14:21	42:894....	1	63		ARB(x), DA
+00000003	026:14:21	42:894....	0	65	ARB(x), DA	
+00000004	026:14:21	42:894....	1	1		OPN(yx), E8,E8
+00000005	026:14:21	42:894....	1	65		ARB(x), FO
+00000004	026:14:21	42:894....	0	1	ARB(x), FO	
+00000005	026:14:21	42:894....	0	1	R_RDY	
+00000006	026:14:21	42:894....	0	2	ARB(x), FO	
+00000007	026:14:21	42:894....	0	1	R_RDY	
+00000008	026:14:21	42:894....	0	2	ARB(x), FO	
+00000009	026:14:21	42:894....	0	1	R_RDY	
+0000000A	026:14:21	42:894....	0	5D	ARB(x), FO	
+00000006	026:14:21	42:894....	1	5		IDLE
+00000008	026:14:21	42:894....	1	1		SOFI3
+00000009	026:14:21	42:894....	1	1		06 00 00 E8
+0000000A	026:14:21	42:894....	1	1		00 00 00 DA
+0000000B	026:14:21	42:894....	1	1		08 29 00 00
+0000000C	026:14:21	42:894....	1	1		3B 00 00 00
+0000000D	026:14:21	42:894....	1	1		05 10 FF FF

Previous to Current      Mark to Current      Mark to Previous



# Data Generators

- Flow Control
  - What does it take to overwhelm network or node?
- Determinism
  - Place time tag in Frame payload and measure networks effective transmission rates
- Data Integrity
  - FC-4 Protocol errors
  - Introduce Application Data errors

# Data Generators

**Build PTX Send File**

Preset Primitives: IDLE Counter (Dec): 10 Add Primitive

Frames

Sof: SOF3 Title: EOF Add Frame

HW1	06	000055	R_CTL DID
HW2	00	000074	CS_CTL SID
HW3	08	290000	TYPE F_CTL
HW4	2A	00 0000	SEQ DF SEQ_CNT
HW5	2A2A	FFFF	OX_ID RX_ID
HW6	00000000		Parameter

Payload 0 - 528 (Long Words)  
Payload Size: 128

Generate CRC and Disparity  
CRC: FFFFFFFF  
Eof: EOF

Send List

```

IDLE
IDLE
IDLE
Frame 1
Frame 2
EOF
IDLE
IDLE
IDLE
    
```

Raw Data

	HEADER	DATA
Frame 1	22000001	BCB55656
HDW_1	00000001	06000055
HDW_2	00000001	00000074
HDW_3	00000001	08290000
HDW_4	00000001	2A000000
HDW_5	00000001	2A2AFFFF
HDW_6	00000001	00000000
PYLD_7	00000001	00000000
PYLD_8	00000001	00000000
PYLD_9	00000001	00000000
PYLD_10	00000001	00000000
PYLD_11	00000001	00000000
PYLD_12	00000001	00000000
PYLD_13	00000001	00000000
PYLD_14	00000001	00000000
PYLD_15	00000001	00000000
PYLD_16	00000001	00000000
PYLD_17	00000001	00000000

Modify Header and Data Words

Function: HDR WORD Modify

Header: 00000001 Commit

Data: 00000000

Offset: 0

Entries: 1

Save as Exit



# Emulator

- Simulate device/network traffic
- Change data frames on-the-fly
  - Also known as “data corruption”



# Summary

- Fault tolerance and Determinism are derived from a combination of architecture, topology utilization, physical transport protocol, and application protocol
- 3 types of Testing
  - Protocol Analyzer
  - Data Generator
  - Emulator