# Bipolar Disorder in Cluster Networking

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# Overview

- Definition
- The Five Step Program
- The problem
- Possible fixes
- Conclusions

# Bipolar Disorder in Cluster Networking

- We think about cluster interconnect two ways
- Reliable but slow
- Unreliable but fast
- Hence the bipolar disorder
- Of course you might think otherwise but
  - That means you haven’t done the 5 step program

# The Five Step Program for Recovering NIC Designers

- Idealism: This hardware eliminates all errors
- Optimism: This hardware eliminates all errors
  - you might encounter
- Disappointment: We have found that
  - On certain machines
  - On certain days
  - In certain circumstances
  - No data for you!
- Hope: V++ (hardwarelsoftware) will fix it

Realism: Software checksum and ARQ is really neat, huh?

# Some examples ...

- Type Ether ATM H800 Myrinet Quadrics

Idealism 1981 1988 1994 1994 199?

Optimism 1982 1990 199? 199? 199?

Disappointment 1986 1991 1998 1999 2001

Realism 1988 1995 1999 1999 2001

- Hope is always with us

# Ethernet

- Idealism: we can run memory ops over this memory-bandwidth network
- Optimism: Who needs UDP checksums for NFS?
- Disappointment: Can’t edit/ftp certain files
- Hope: Find and fix the hardware problems
- Realism: Edit kernel binary to turn on UDP checksums

# ATM

- Switched, End-to-end CRC, flow control, QOS
- Idealism: Who needs IP?
- Optimism: Run IP but you'll never really use it
- Disappointment: It runs HOW SLOWLY?
- Hope: perpetual
- Realism: Who needs ATM?
  - TCP over SONET
  - Cells in Frame

# HIPPI 800

- Switched, end-end CRC
- Idealism: Errors "can’t happen"
- Optimism: Errors "won’t happen to you"
- Disappointment: 1200 interfaces, 48 machines, 15 minutes
  - Every 864000000000000 bits or so, something BAD happens
  - Actual failure is not clear since undetected errors are undetected
- Hope: H800++ (GSN) will fix it!
- Realism: Build software reliability into user library
  - ULM

# Myrinet (LANAI 7)

- Switched, flow-controlled, end-end CRC
- Idealism: Just pump data through, it will work
- Disappointment: 128 interfaces, run full bore, NAS FFT won’t finish
  - Data is getting corrupted and not detected
  - Actual failure is not clear since undetected errors are undetected
- Hope: Software fix will do it!
- Realism: We’re porting reliable messaging to Myrinet

# 128 node ES45 cluster, Quadrics

- Switched, Flow Control, end-end CRC, built-in ARQ
- Idealism: Just pump data through, it will work
- Disappointment: 128 interfaces, run full bore, undetected errors
  - Main symptom is unexplained hangs (packet loss?)
  - Actual failure is not clear since undetected errors are ...
- Hope: The Elan 4 will be better
- Realism: We’re porting reliable messaging to Quadrics

# What’s going on?

- In the ideal case the interfaces provide:
  - Flow Control
  - End-End CRCxx (CRC32 for Myrinet, CRC16 for Quadrics)
  - ARQ (request-resend) in hardware
- How can this not work?
- It DOES work
- Unless it fails
- And if it fails, how would you know?
  - You won’t
  - Unless the applications writers tell you

# Applications-based error checking

- Typical scenario:
- App fails
- Vendor says
  - "Can’t be us. We’re reliable"
    - Because your software doesn’t detect errors
  - "Our Diags run to completion with no errors detected!"
    - Diags only find trivial errors
  - "You’re doing something wrong"
    - But it’s your own demo code!
  - "We haven’t seen this"
    - Of course not, you don’t even HAVE a cluster

# How do you know? (cont)

- Programmer works hard and sooner or later finds ....
  - It’s the network
- Programmer moves to TCP/IP
  - "It may be slow, but it’s reliable"
  - This happened on our Rockhopper cluster
  - Many commercial Myrinet users run IP over Myrinet
- Programmer recreates IP reliability in user mode
  - This happened to us on our 48x128 CPU SGI cluster
  - This also happened on our Rockhopper cluster
  - It is happening on our ES45 cluster

# Wait a minute!

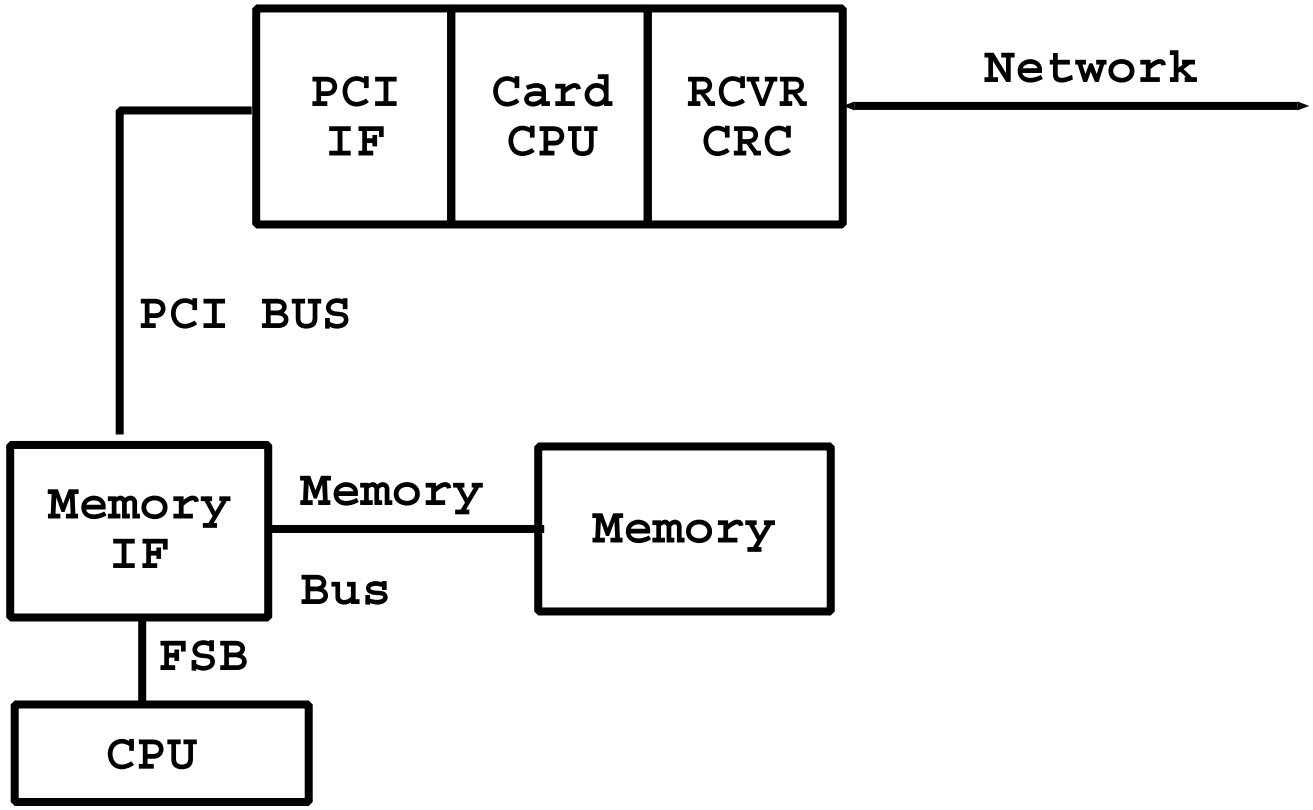
- The card-card checking is high-quality CRC
- Some cards have end-to-end flow control
- Some cards even have automatic request-resend
- Some cards have error counters to detect packet errors
- Again: how can these cards not work given built-in end-to-end protocols?

# How can the cards not work?

- They can "not work" if the protocol is not end-to-end
- And it’s not ... it’s card to card!

# Card-to-card Protocol

- CPU runs complex software
  - In fact the memory footprint is larger than V6 Unix
- Result: for these cards, think of PCI bus as a network
  - Unreliable packet network, in fact
- Protocol is hence NOT end to end



# Failure modes

- Most frequently observed failure is not corruption
- It is a NIC failure that causes loss of data
  - Blocks of Zeros
  - Missing Word (PCI Abort bug)
  - Lost packets (even on cards with ARQ)
- Caused by
  - Resource exhaustion on the NIC
  - Race conditions
  - NIC vs. CPU  "Version Skew"
  - Programming errors
  - PCI problems
- All these are "Can’t happen" errors
  - No need to detect "Can’t happen"
  - So undetected errors are undetected

# What do we do?

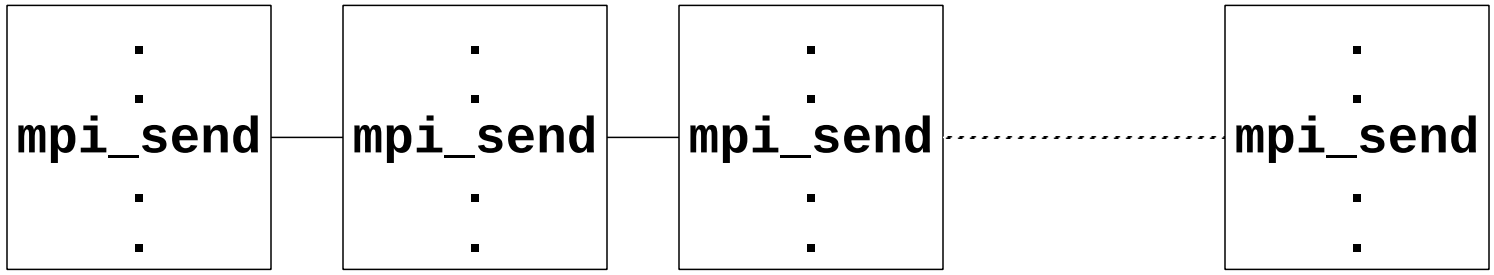
- Run TCP/IP for everything
  - A frequently-used solution
- Recreate TCP in user mode?
  - Frequently used in HPC

# Why do we use these interfaces?

- We need bandwidth
  - And will need more
  - Problem data sets only grow larger as time goes by
  - IPC increases as problem sizes grow
- We need low latency
  - Or do we?

# Do we really need low latency?

- Is it inherent to applications
- Or is it an artifact of MPP programming style?
- Lock step SPMD
- Requires low latency, scheduling tricks
- Doesn’t tolerate node outage at all



# What if we could relax the latency requirement?

- Asynchronous rather than synchronous communication
  - Allow latency to go back up to ~50 microseconds
  - Find ways to use "Task bags" for traditional applications
  - Paul Woodward is experimenting with weather model
    - Can tolerate very high latency (milliseconds) for tasks
- What if we go to a hierarchical latency model?
  - Low latency "in group"
  - Higher latency "between groups"
  - Analogous to using "Fat SMPs" with fast interconnect

# If we can relax the global latency constrain

- We could focus on bandwidth and worry less about latency
- Could try using TCP-like protocols optimized for small area
  - e.g. Plan 9 IL
- Once we remove global latency requirements
  - We can use kernel-level protocols for fast, reliable comms
  - We can eliminate unreliable, bug-prone user-level "TCP"
  - We can build simple, reliable, high quality NICs

# Conclusion

- I only promised questions and a challenge
- The quest for low latency is producing
  - complex
  - high cost
  - unreliable
  - low quality
- NICS
- Need to develop latency-tolerant programming models for clusters
  - Also requires new kernel interfaces (a la CLIC)
- Result: we can use simpler, commodity NICS