Achieving Century Availability

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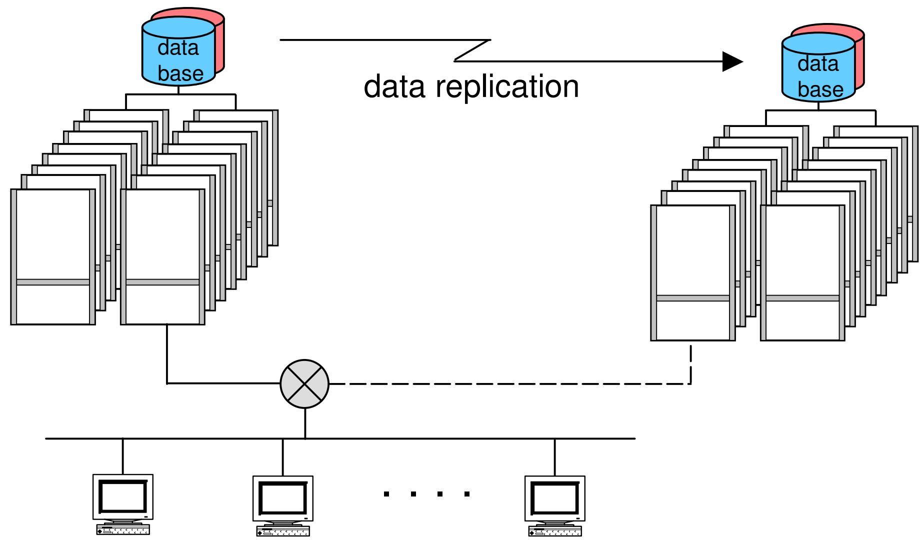
Disaster Tolerance Today

NonStop Active/Passive Architecture



Characteristics:

- Recovery time minutes to hours (RTO)
  - Recover transactions
  - Bring up applications
  - Switch users
- Loss of data in the replication pipeline (RPO)
- All users affected upon failover
- Capacity underutilization

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Question: How can we improve on this?

- Instant recovery time (RTO = 0)
- No data loss (RPO = 0)
- 100% capacity utilization
- Higher availability
- AND all this at less cost

Answer: Active/Active Architectures

(one in which every system carries its share of the load)

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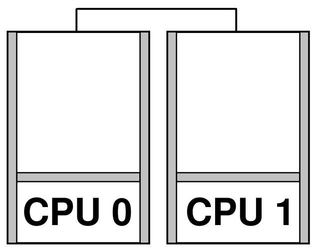
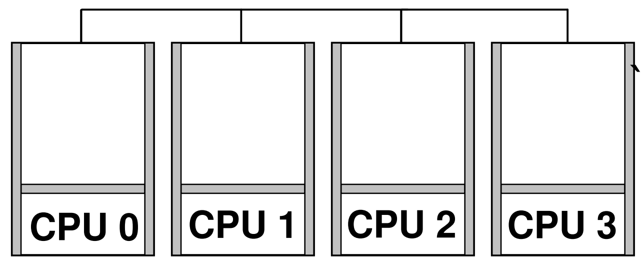
First, some NonStop background:

In a NonStop system, downtime occurs when two subsystems fail, taking down a critical process:





X	X

1 failure mode

Failure 1	X	X		
Failure 2	X		X	
Failure 3	X			X
Failure 4		X	X	
Failure 5		X		X
Failure 6			X	X

6 failure modes

As a system grows larger, failure modes increase, and failures occur more frequently.

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In a NonStop multi-processor system, downtime grows faster than the square of the system size

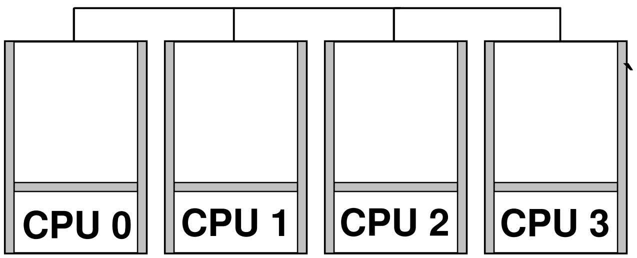
In general, if

n = number of processors in the system

then

failure modes = $\frac{n(n-1)}{2}$

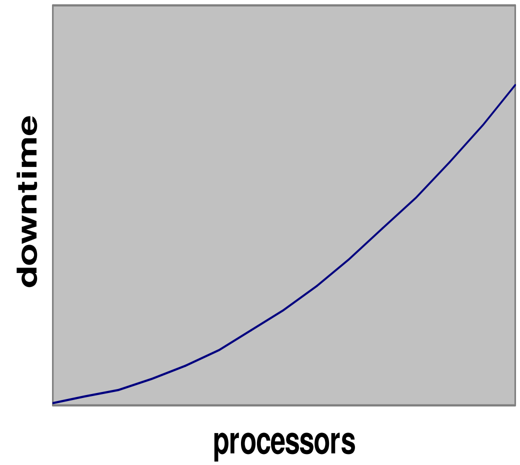
n	failure modes	downtime
2	1	x1
4	6	x6
8	28	x28
16	120	x120



X	X		
X		X	
X			X
	X	X	
	X		X
		X	X

The System Size Rule

As a NonStop system grows, downtime grows even faster.

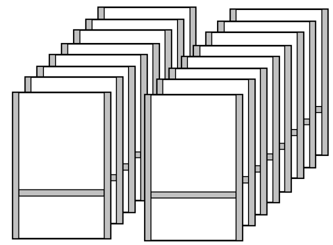


System Splitting

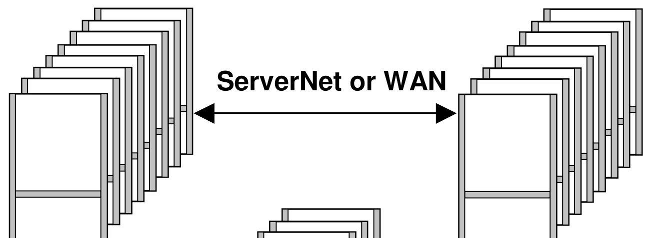
So – Can we gain anything by splitting a big NonStop system into smaller nodes?

	failure modes	downtime reduction
one 16-processor system	120	1
two 8-processor nodes	2x28=56	2.1
four 4-processor nodes	4x6=24	5

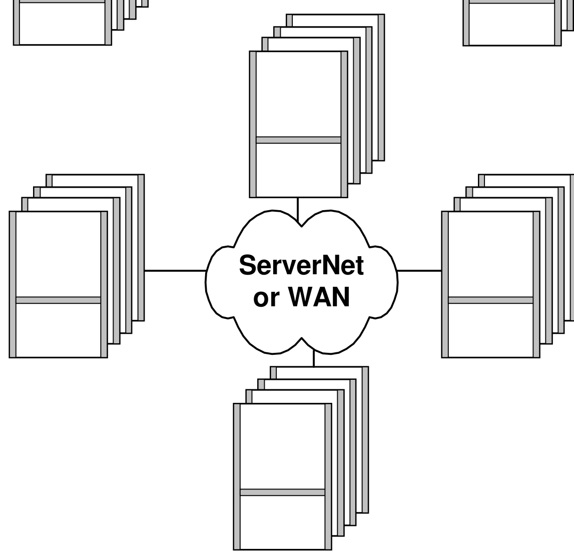
one 16-processor system



two 8-processor nodes



four 4-processor nodes



Yup!

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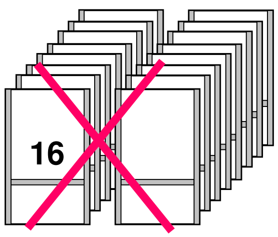
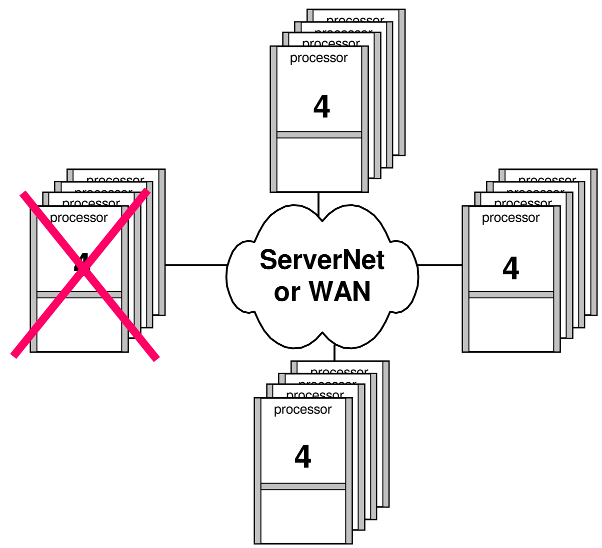
System Splitting

We can improve a single system





Lose 100%
every 5 years

Lose 25%
every 25 years

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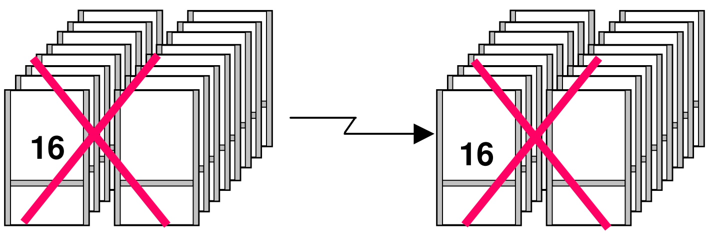
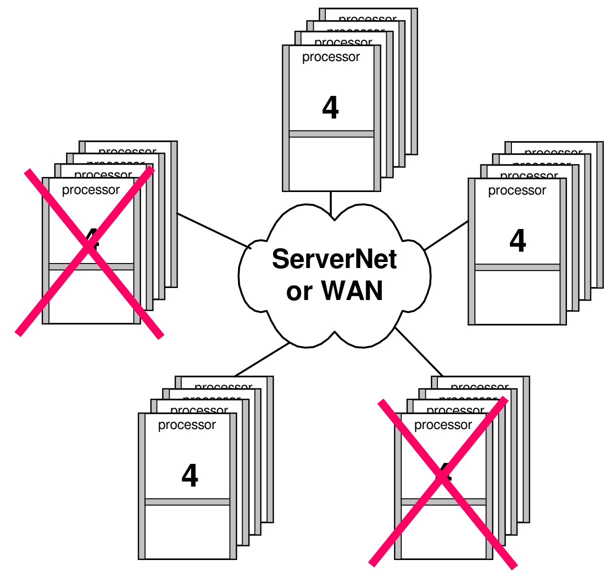
System Splitting

And we can improve an active/passive system





Lose 100%
every 500 centuries

Lose 25%
every 12,500 centuries
… at a fraction of the cost

Can This Be Extended to the UNIX World?

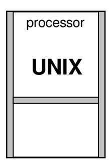
Yes, to a lesser but still effective extent

The 9's Game -

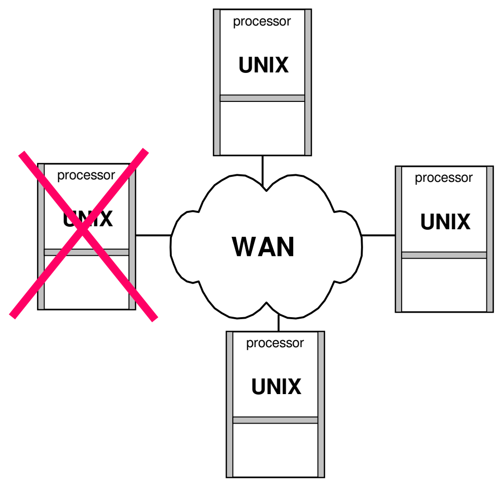
Himalaya	.9999	.8 hours/year
Mainframe	.999	8 hours/year
OpenVMS	.998	16 hours/year
AS400	.998	16 hours/year
HPUX	.996	32 hours/year
Tru64	.996	32 hours/year
Solaris	.995	40 hours/year
NT Cluster	.992 - .995	40 – 64 hours/year

System Splitting in the UNIX World

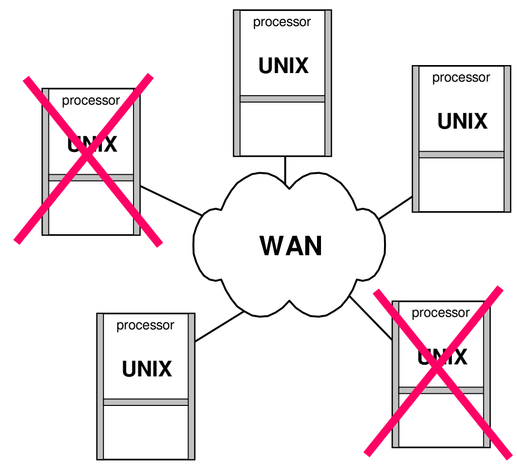
Let's give UNIX systems 3 9s (.999)



Unix: Lose 100% every 6 months (versus every 5 years)



UNIX: Lose 25% every 6 months (versus every 25 years)



UNIX: Lose 25% every 5 centuries (versus every 12,500 centuries)

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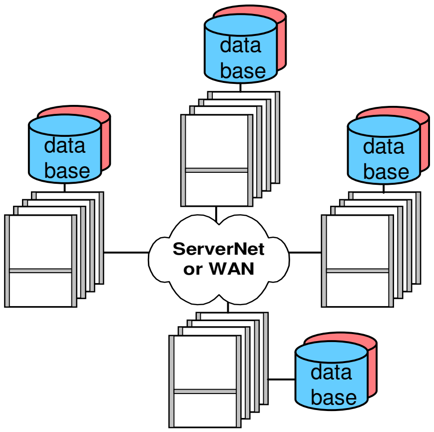
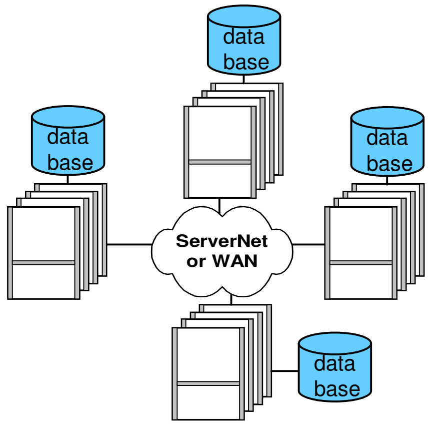
But what about the disk farms?

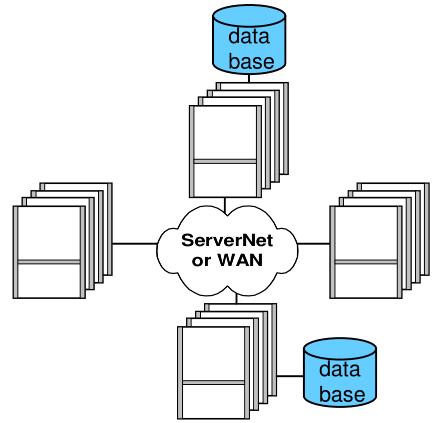
Often the predominant cost



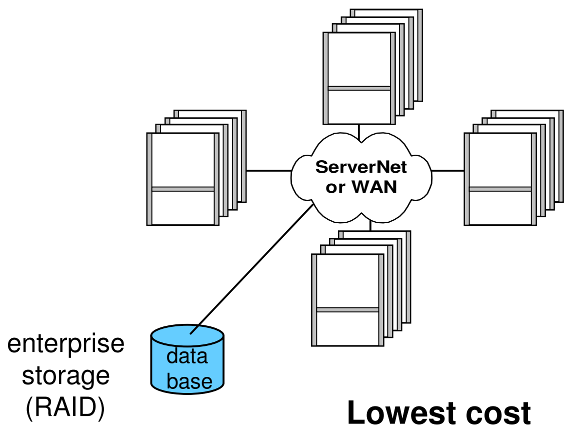
High cost
High performance
Highest availability



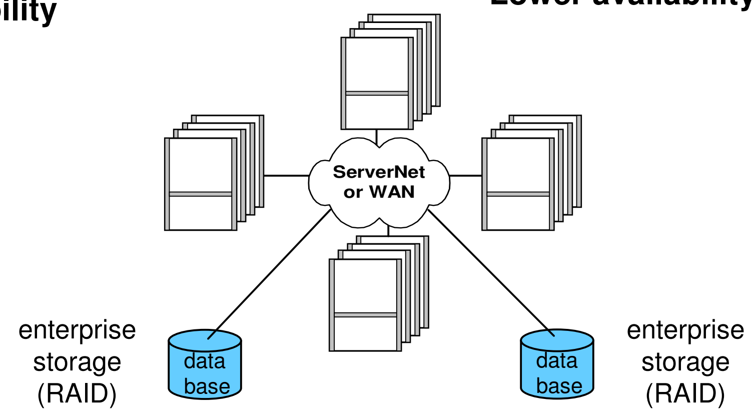
Lower cost
High performance
High availability



Lowest cost
High to Lower performance*
Lower availability



Lowest cost
High to lower performance*
High availability
Not Disaster Tolerant

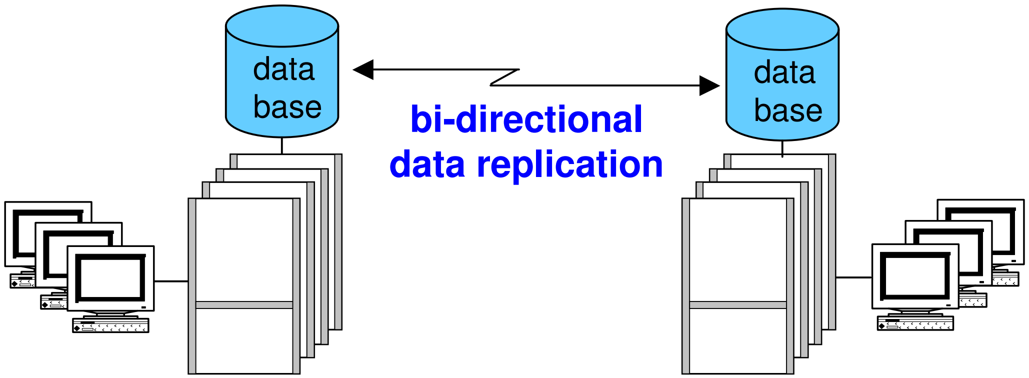


Lower cost
High to lower performance*
High availability
(coming)

***high over ServerNet, lower over WAN**

We've Selected a Disk Configuration

So how do we keep the networked disks in synchronization?



There are some issues with bi-directional data replication:

- RDF won't do it:
  - Can't open standby database for write.
  - Look to third party products.

- Data loss on failover
- Ping-ponging
- Collisions
- Referential integrity must be maintained.

If zero data loss is required, use synchronous replication ➡

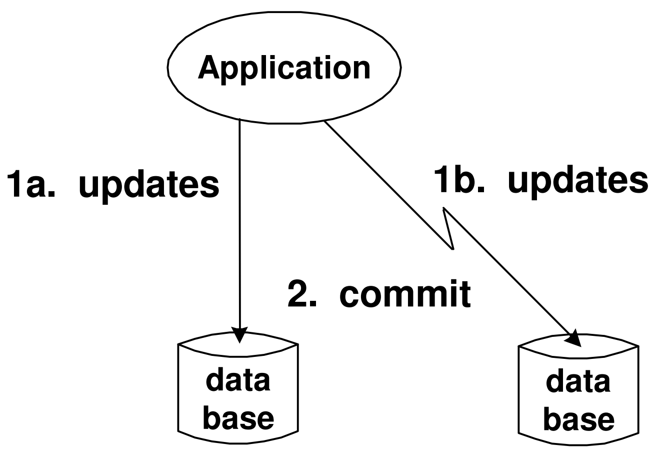
Synchronous Replication

Avoiding Data Loss, Avoiding Data Collisions

Data loss (RPO = 0) and data collisions are avoided by ensuring that all copies of a data item in the network are locked before any are updated.

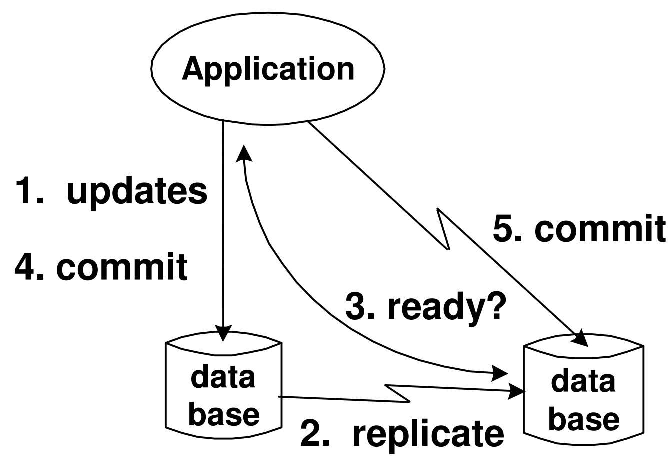
This can be done by making them part of the same transaction:

Single Transaction



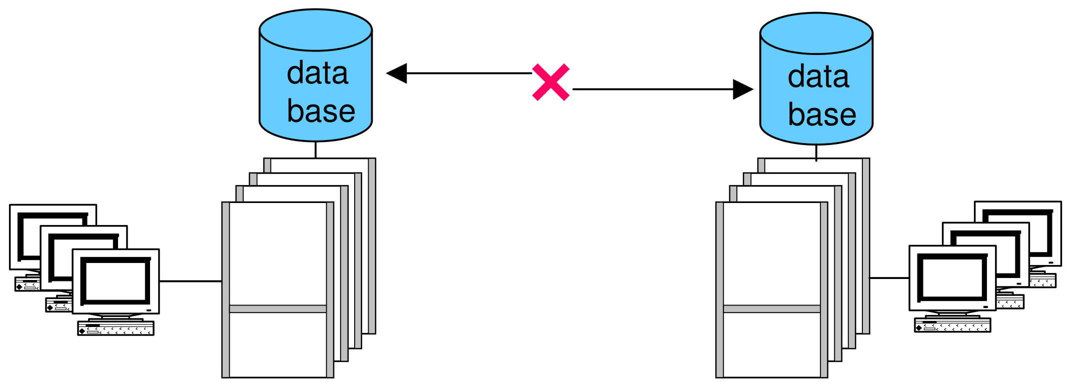
Network TMF

Coordinated Transactions



Coordinated Commits

What if we lose the network?



Option 1:

- Continue in operation at full capacity.
- Systems will get out of sync (split brain)
- On recovery, replication queues will drain, updating the nodes.
- Must resolve collisions

Option 2:

- Switch downed users to a surviving system
- Continue in operation at reduced capacity.
- Shed load if necessary.
- On recovery, replication queues will drain, updating the downed node.
- Switch users back.
- No collisions

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Other issues of which to be aware:

- Rerouting of users (same problem as with active/passive):
  - switches and routers
  - virtual IP (gratuitous ARP)
- Load shedding if additional capacity not provided.
- Licensing
- Network costs
- People costs

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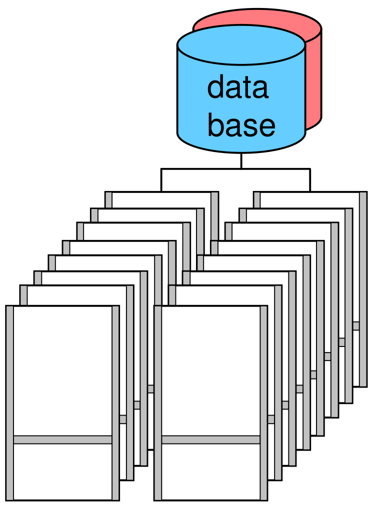
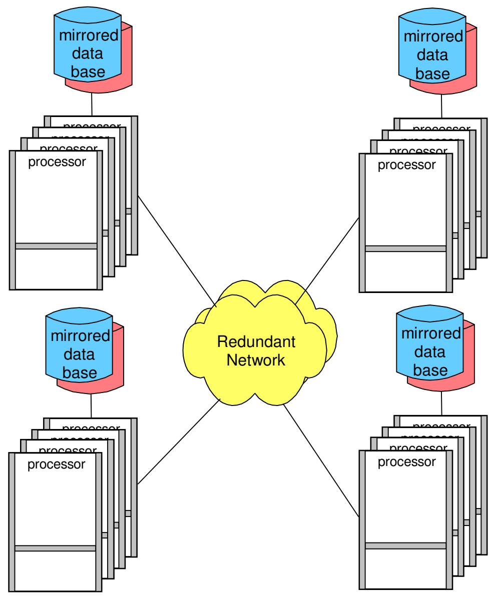
In Conclusion

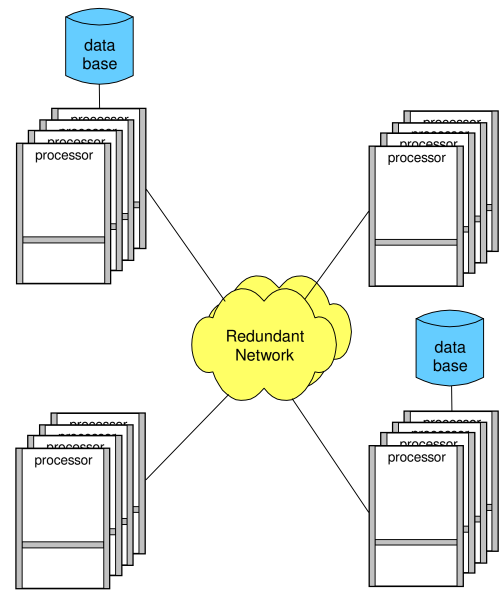
You can optimize availability, performance, and cost. Pick any two.



fast performance, low cost



high availability, fast performance



high availability, low cost

Remember: An unavailable system has zero performance. And its cost may be incalculable.

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In Conclusion

Find details in the 6-part series on Availability published in The Connection starting with the November/December 2002 issue:

Availability Part 1 – The 9s Game
Availability Part 2 – Splitting Systems
Availability Part 3 – Synchronous Replication
Availability Part 4 – The Facts of Life
Availability Part 5 – The Ultimate Architecture
Availability Part 6 – RPO versus RTO

In Conclusion

And even more in our book about active/active systems

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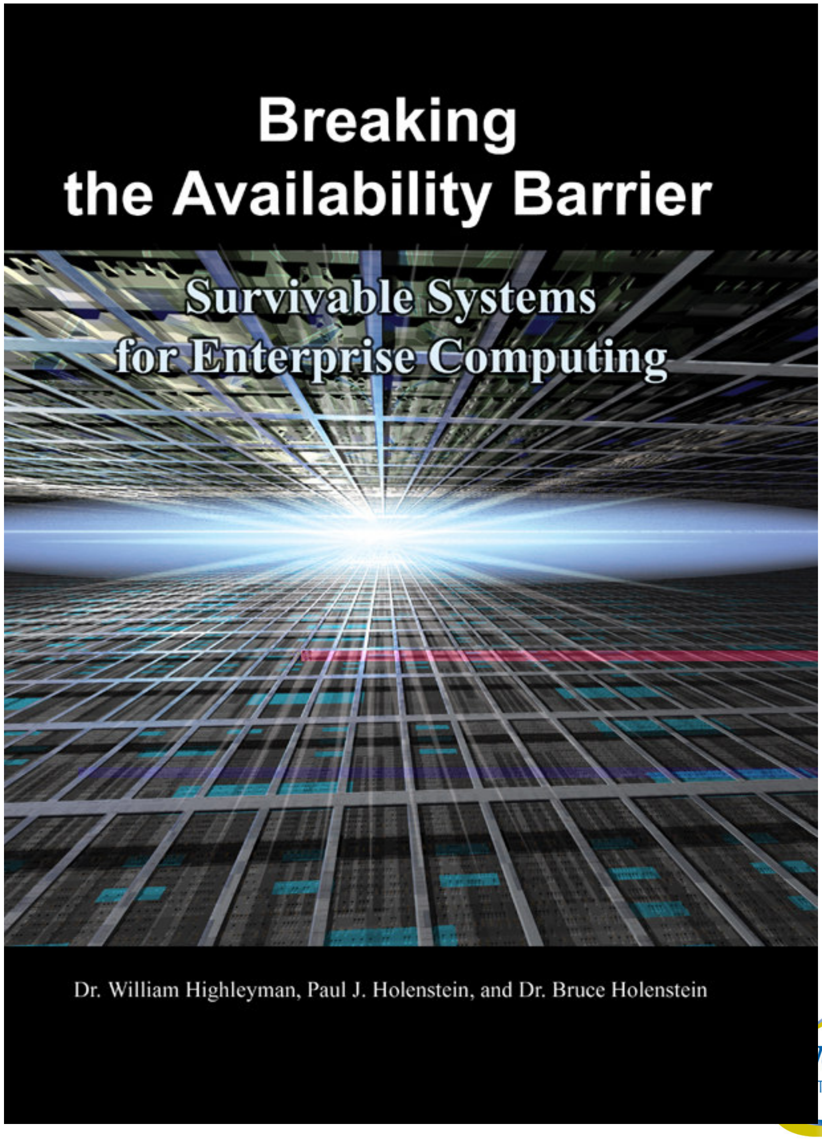

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Addendum

Availability Theory

Following is some mathematical background supporting the conclusions in this presentation.

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Downtime

Failure Modes

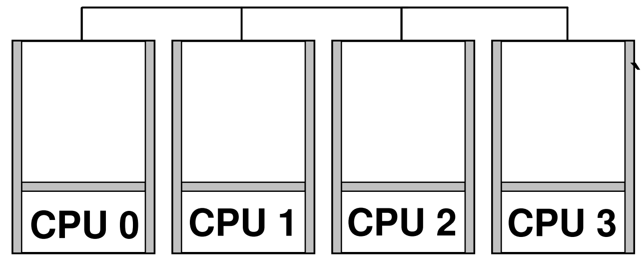
In general, if

n = number of processors in the system

then

$$\text{failure modes} = \frac{n(n-1)}{2}$$

n	failure modes	downtime
2	1	x1
4	6	x6
8	28	x28
16	120	x120



X	X		
X		X	
X			X
	X	X	
	X		X
		X	X

Downtime grows faster than the square of the system size

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System Splitting
Reducing Downtime

If a system of *n* processors is split into *k* nodes, downtime is reduced by more than a factor of *k:*

$$\textit{Downtime reduction} = \frac{\frac{n(n-1)}{2}}{k\frac{n/k(n/k-1)}{2}} = k\frac{n-1}{n-k} > k$$

Example:

16 processors (n = 16)
4 nodes (k = 4)
5 times reduction in downtime (4x15/12)

Note: Outage is defined as failure of just one node.

System Availability

processor availability = a

probability of failure of a processor = (1-a)

probability of a dual processor failure = $(1\text{-}a)^2$

number of failure modes = f

probability of outage = $f(1\text{-}a)^2$

system availability = A = 1 – $f(1\text{-}a)^2$

Availability Example

processor availability = a = .995

probability of failure of a processor = (1-a) = .005

probability of a dual processor failure = $(1\text{-}a)^2$ = .000025

number of failure modes = f = 6 (4 processors)

probability of outage = $f(1\text{-}a)^2$ = .00015

system availability = A = 1 – $f(1\text{-}a)^2$ = .99985 ≈ 4 9s

MTBF

Mean Time Between Failure = MTBF

Mean Time to Repair = MTR

Availability = A = ______________

MTBF = MTR/(1-A)

```
ERROR: rangecheck
OFFENDING COMMAND: .buildcmap

STACK:

-dictionary-
/WinCharSetFFFF-V2TT786613C3t
/CMap
-dictionary-
/WinCharSetFFFF-V2TT786613C3t
```