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  - Not: things are too complex
- Why?
  - Publishing/reviewing pushes us to complexity

### Apologies, Caveats and Excuses

- Talk is rather polemic in nature... things are said a little crassly
- Now a dean intellectual life prohibited
  - "There was once a dean who was so dumb, that other deans actually started noticing it"

#### P2P

- Peer-to-peer
- No (central) server
- Easier to operate, maintain, scale, make more reliable ....
- Started as an application
- Proposed as an infrastructure for a large number of applications

### Research on P2P

- Concentrated largely on DHTs
- Log(n) access
- Chord, Pastry, ...
- Applications: backup, streaming, ...

### The Problem with P2P

Very little application other than illegal file sharing

### Reality Check

 If we have learned anything about distributed computing over the last 25 years, it is that anything distributed is harder than anything centralized

#### Reasons for Distribution

- You cannot handle it in one place
  - Performance controlled replication
  - Availability controlled replication
- Geographical distribution
  - Google!
- Illegality P2P
  - From Napster to Gnutella, Kazaa, ...
  - "Raw" traffic numbers are high
  - Much of it static
  - Could be handled by conventional replication (?)

### Difficulties for P2P

- Hard to find anything
- Hard to make anything secure
  - Open invitation to attack
  - Actively used by RIAA (pollution attacks)
- Hard to write anything

### Advantages for P2P Research

- Complex to find anything
- Complex to make anything secure
- Complex to write anything

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- Complexity begets papers
- P2P = Paper-to-Paper

### There are Applications

- Large file multicast
- Can be handled by very simple techniques
  - BitTorrent
- It should worry us that these come from non-research corners of the world!

#### DSM

- Distributed shared memory
- Parallel computing on clusters
- Distributed memories abstracted as a single shared memory
- Easier to write programs
- Usually by page faulting
- TreadMarks (ParallelTools)

# Reality Check

- Clusters are only suitable for coarsegrained parallel computation
- A fortiori true for DSM

### Problems with Fine-Grained DSM

- Expensive synchronization
- Expensive fine-grained data sharing
  - Smaller than a page
    - False sharing (can be solved)
    - True sharing

## Advantages for DSM Research

- Complex fine-grain synchronization
- Complex fine-grain data sharing
  - Compiler, language, runtime, ...
- Complexity begets papers ....

#### TreadMarks

- (Almost) every paper or grant for research on fine-grain DSM was accepted
- (Almost) every paper or grant for research on coarse-grained DSM was rejected
- It turns out that for real applications a page is not large enough!

## Coarse-grain Applications

- Large (independent) units of computation
- Large chunks of data
  - 1 page = 4k
  - Not very large at all
  - Page faulting brings in one page at a time
  - Message passing brings in whole data segment at a time (> page)
- Can be and was done with DSM
  - Increase page size (!!)
  - Compiler support

# Competition is Message Passing

- MPI (Message Passing Interface)
- Low abstraction
- No room for complexity fabrication
- As a result more successful
- It should worry us that MPI did not come from distributed systems research but from linear algebra!

#### Server Performance

- At the beginning of the Internet boom, server performance was badly lagging
- Multithreaded or multiprocess servers
  - Context switching
  - Locking
- Two types of solutions
  - Exokernel
  - Event-driven servers

### **Event-Driven Servers**

- Events
  - Incoming request, i/o completion, ...
- Single thread, event loop
- Event handler per event
  - Straight code (no blocking)
  - At end:
    - nonblocking or asynchronous i/o
    - create (hand-made) continuation

### Advantages

- No multithreading
  - No context switching
  - No locking (at least on uniprocessor)
- Control over order of event handling
  - Not bound by OS scheduler

#### Flash

- Most popular event-driven Web server
- Combined multithreaded / event-driven
- Many follow-ons
- iMimic Networking

# Reality Check

- It's too complex
- Maybe Ph.D.s can figure it out
- Your average industry programmer cannot
- Actually, most Ph.D.s can't either
- Many (expensive) bugs

### How the Problem was Solved

- Linux O(1) thread scheduler
- Linux futex
  - User-level locking
  - No overhead if no contention
- Benefits of event-driven remain
- But too small to warrant complexity

### How the Problem was Solved

- The main servers are all process-based or thread-based (Apache, MySQL)
- It should worry us that these servers did not come out of research!

# Painful Observations (1)

- Most of the strong research trends have not found much application
- Non-research designs have won out
- Has to do with this fabricated complexity

# Painful Observations (2)

- Has to do with publishing/reviewing
  - Simple papers tend to get rejected
  - Complex papers tend to get in

# Your Average Review Form

- Novelty
- Excitement
- Writing
- Confidence

### Some Questions to Add?

- Does the added functionality justify the increase in complexity?
- Does the performance improvement justify the increase in complexity?
- Could this system be maintained by an above-average programmer in industry?
- Does this paper simplify a known solution to a worthwhile problem?

# Some Likely Review Comments

- « Incremental »
- « Engineering »
- « Nothing new »
- « Boring »

### It IS Possible

- Virtual machines
- Provide simple solutions to real problems
  - Server consolidation
  - Migration

### Virtual Machines

- Virtual machine monitor
- VMM provides a number of VMs
  - IBM VM
  - VMWare
  - Xen
    - Open-source
    - Paravirtualization (VM ~ machine)

#### Provenance

- DISCO: a very complex OS for SMPs
- VMWare:
  - Simplified to Linux/Windows on one machine
  - Precise virtualization on x86 very complex
- Xen
  - Paravirtualization to improve performance and decrease complexity
    - VMM less complex
    - Guest OS (slightly) more complex
    - Performance better (?)

# The Way of All Technology

- All technology
  - Becomes more complex on the inside
  - Becomes less complex on the outside
- Example: car, Windows (?!)
- Not sure it fully applies to software
  - Most complex systems ever built
  - Rare example of discrete complex system
  - Maybe we are over the limit already

### Nonetheless

- Success = interfaces defined early?
- Very successful systems
  - Apache, MySQL, MPI, VMWare, Xen
  - Interfaces stable (few iterations)
  - Internal complexity grew
- Less successful systems
  - DSM, event-driven
  - Interfaces unstable, complexified

# Standardization (!?)

- I am afraid some of it is necessary
- Find a way through publishing system

### Other People's Advice

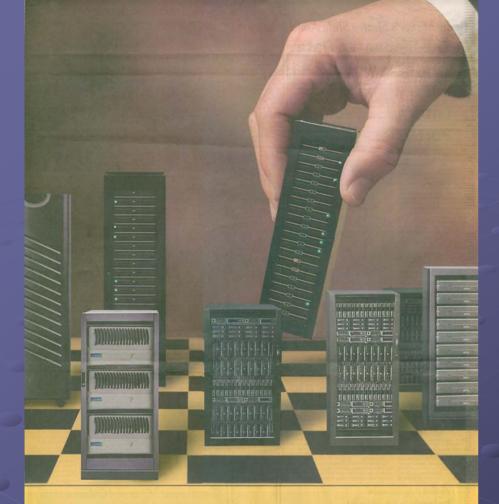
- Lampson: « Keep it simple »
  - True, but somewhat impractical
- Einstein: « Everything should be as simple as possible, but no more than that »
  - Implement functionality at the right interface
  - Keep interfaces stable

#### Lessons

- Brute force often (not always) works
- Our publishing and reviewing system pushes us in the opposite direction

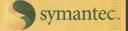
### More Lessons

- It is the interface, stupid
- The implementation can be complex
- The interface has to be simple and stable



### Master complexity.

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# Thank you