P2P, DSM, and Other Products from the Complexity Factory

Willy Zwaenepoel

EPFL

Impact of Research

Impact of Research

- Not so great
  - Many research ideas have lost out
  - Many non-research developments won out

Impact of Research

- Not so great
  - Many research ideas have lost out
  - Many non-research developments won out
- Why is that?
  - We make things too complex
  - Note: not: things are too complex

Impact of Research

- Not so great
  - Many research ideas have lost out
  - Many non-research developments won out
- Why is that?
  - We make things too complex
  - 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

Advantages for P2P Research

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

- 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 coarse-grained 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

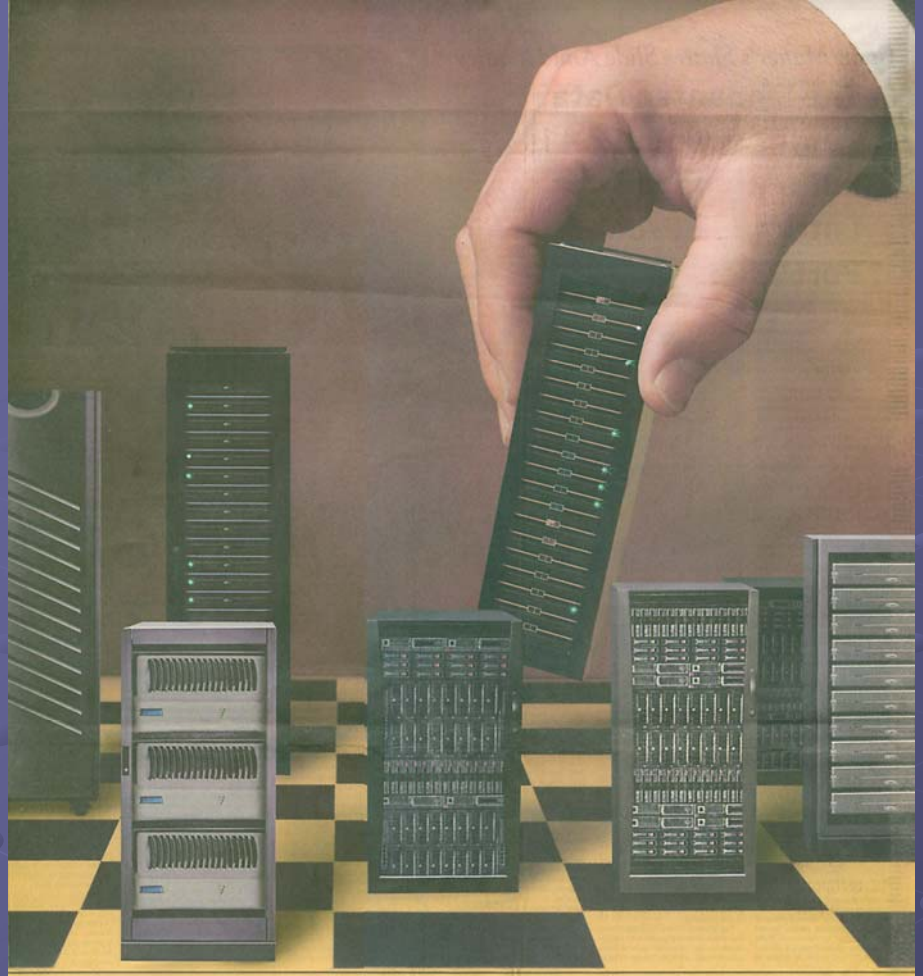
- Lampson: « Keep it simple »
  - True, but somewhat impractical
- Einstein: « Everything should be as simple as possible, but no more than that »
  - Implement functionality at the right interface
  - Keep interfaces stable

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.

Whatever is in your data center, Symantec puts you in control. That's the promise behind the Symantec Data Center Foundation. Thanks to the Veritas cross-platform heritage, this integrated software infrastructure solution supports virtually every major operating system, database, application and storage hardware asset in your data center. It's reduced complexity. It's comprehensive protection. It's the smartest move you can make. Tour the Symantec Data Center Foundation at www.symantec.com/datacenter

symantec.

NYT, June 26, 2006

Thank you