P2P, DSM, and Other Products
from the Complexity Factory

Willy Zwaenepoel
EPFL
Impact of Research
Impact of Research

Not so great

- Many research ideas 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
- 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

Various other excuses:

- Jetlag, being dean, ...
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
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!
Mirror, mirror on the wall, ...
DSM

- Distributed shared memory
- Parallel computing on clusters
- Make it easier to write programs
- Single shared virtual address space
- Portions cached in physical memory
- Usually by page faulting
- TreadMarks (ParallelTools)
Reality Check

Cluster *hardware* 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
    - True sharing
    - False sharing (can be solved)
Advantages for DSM Research

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

Complexity begets papers ...
Academic experience

- (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

Industrial experience

- Only coarse-grain application
- 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 (!!!)
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)

Many research ideas 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 »
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
- Examples: 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
Thank you