P2P, DSM, and Other Products from the Complexity Factory

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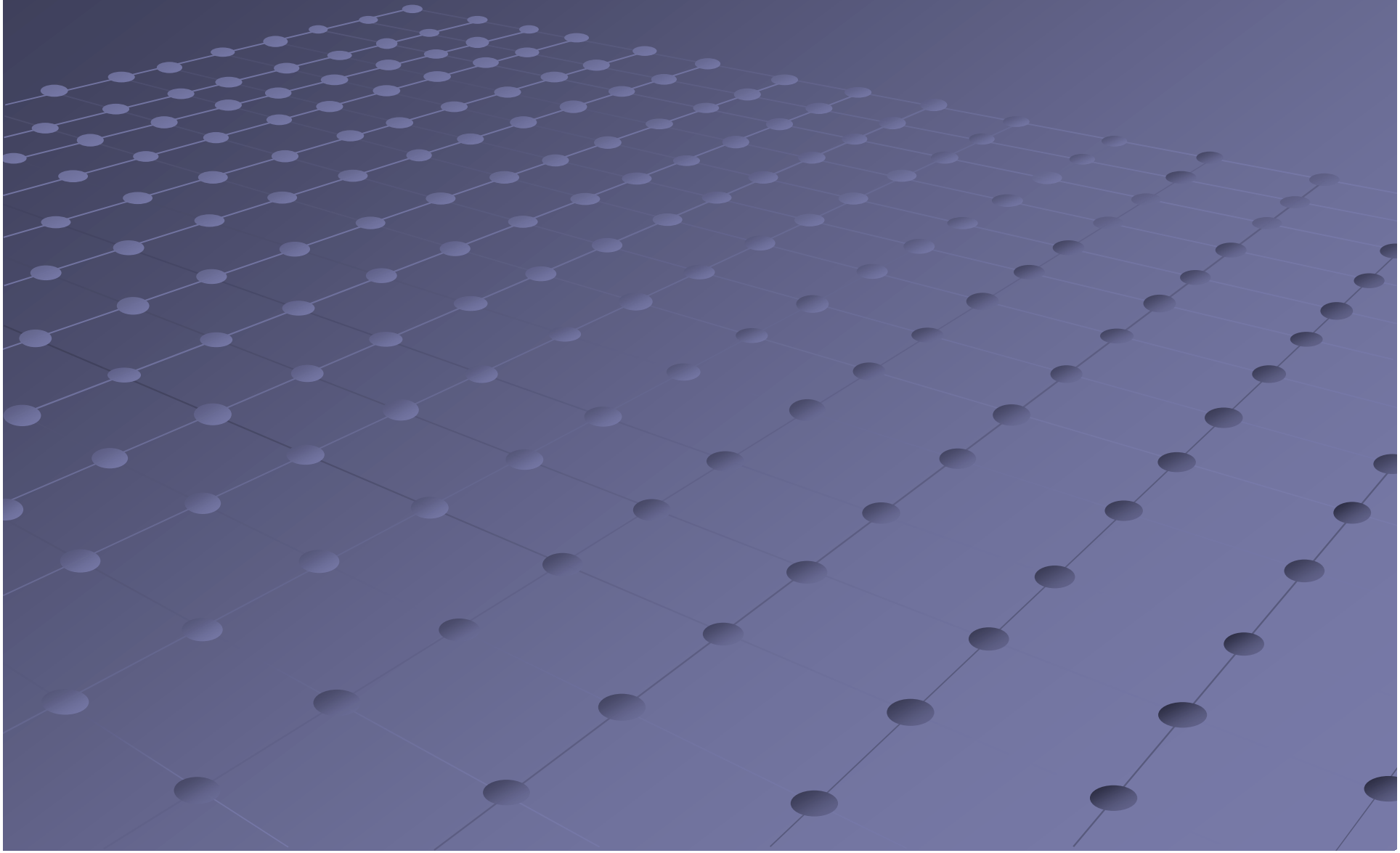
Impact of Research



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- 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, …

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!


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 …

TreadMarks

- 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 »

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
- 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