Tiretracks nouveau
- the network systems slice

David E. Culler
University of California, Berkeley
July 23, 2012
Clusters, Internet Services, Cloud ...
NOW — Scalable Internet Service Cluster Design
NOW – Scalable Internet Service Cluster Design

- TMC CM5
- IBM SP1
- No nodes
NOW – Scalable High Performance Clusters

Yet Another Workstation Network
Ed Lazowska
University of Washington

STONE SOUP
AN OLD TALE

“This commodity parts multiprocessor is great. But y’know, it’d be even better if only it had ...”
NOW — Scalable High Performance Clusters
Inktomi – Fast Massive Web Search
Fiat Lux - High Dynamic Range Imaging

Paul Gauthier

NOW Project Timeline


ATM, fidi Start of Funding Myrinet VIA G-Ether

NOW II Nowhop II PHD NOWhop II 2nd PHD

npaci Many PhDs

CS267, Spring 1995: Final Projects

- Fast Parallel Iterative Matrix Diagonalization
- Ptolemy C Code Generation and Scheduling for the Network of Workstations (NOW)
- Parallel Raytracing using a Network of Workstations for Rendering Spline Surface Animation
- Parallel Monte Carlo Simulation
- Berkeley Search Engine
- Porting and Characterization of GATOR, an Atmospheric Chemical Tracer Model
- A Distributed Memory Concurrent B-tree Implementation
- Design, Implementation, and Performance Evaluation of a Portable Distributed Task Queue
- Porting The BLACS From MPI To GAMS On The SP-1
- Implementation of a Parallel Preconditioned Conjugate Gradient (PCG) Solver in Finite Element
- Parallelizing Impulse, a dynamic simulation system
- Model of LPARX multigrid performance on the CM5

Lycos
infoseek

Paul Debevec
inktomi.berkeley.edu
Large Ultra/Myrinet NOW
Massive Cheap Storage

Serving Fine Art at http://www.thinker.org/imagebase/
NOW performs ‘96
Google.com

No $’s in Search
Big $’s in caches

Yahoo moves from inktomi to Google
Cluster of SMPs (CLUMPS)
Expeditions to the 21st Century
Service Based Applications

- Application provides services to clients
- Grows/Shrinks according to demand, availability, and faults
Ninja Internet Service Architecture

Opportunity: infrastructure services

- Prehistoric: DNS, IP route tables, ...
- Historic: crawl, index, search,
- Emerging: compose and manipulate data and services

And client diversity has just begun!

Java Grande
Startup of the Week …

Example: Ninja Jukebox 98

- **.au/.mp3 player**
- **WWW Browser** with song playlists
- **HTTPd service**
- **Music Directory service**
- **Collaborative Community**: anyone can add content
  - mp3.com, real jukebox, napster
- **Authentication and authorization was built-in**
- **Jukebox 99: Music similarity query engine**
  - mongomusic.com, ...
- **CD “ripper” service**
- **CDDB service**
- **Fetches track/title & artist information from an online DB.**

Ninja iSpace

Java Grande

6/4/2001
... and ...

Santio: universal instant messaging

AOL client

ICQ client

AOL worker

english to spanish

ICQ worker

profile DDS

sanctio service (cluster)
Existing Applications

- **Ninja "NOW Jukebox"**
  - Harnesses Berkeley Network of Workstations
  - Plays real-time MPEG-3 audio served from 110+ CD’s worth of music

- **Voice-enabled room control**
  - Speech-to-text Operators control room services (camera, lights, microphone)
  - Eventual integration with GSM cell phones and PDA-based UI

- **Stock Trading Service**
  - Accesses real-time stock data from Internet
  - Programmatic interface to buy/sell/trade stocks through online brokerage

- **NinjaFAX**
  - Programmable remotely-accessed FAX machine service
  - Send/receive FAXes; authentication used for access control

- **Keiretsu: The Ninja Pager Service**
  - Provides instant messaging service via Web, 1/2-way pagers, WorkPads, etc.
Composable, Secure Proxy Architecture for Post-PC devices

S. Ross, J. Hill

Diverse Clients

Internet Services

Personal Appl

Embedded Untrusted Client

Trusted Client

Transient Store

Identity Service

Filter and Control Modifier

Format Transcoders

Security Adapters

S A

F T

S A

F T

DATEK (Trust Contract)

https

Java Grande

6/4/20
A ‘Structured Architecture’ Approach

- Bases (1M’s)
  - scalable, highly available
  - persistent state
  - databases, agents
  - "home" base per user
  - service programming environment

- Active Proxies (100M’s)
  - not packet routers
  - bootstrap thin devices into infrastructure
  - soft-state and well-connected

- Units (1B’s)
  - sensors / actuators
  - PDAs / smartphones / PCs
  - heterogeneous
  - Minimal functionality: “Smart Clients”
Delayed Gratification

Webos: Operating System Services For Wide Area Applications, HPDC 98

HPDC Best in 20 years, April 2012
99.9 Club

NOW Project Timeline

ATM, fddi
NOW 0
CS 252
NOW I
CS 258
CS 257
NOW II
Intra
1st PhD
NOW Workshop II
NOW II
2nd PhD
NPACI
NOW I
NOW Final
NOW Finale
VIA
G-Ether
NOW Final
Many
PhDs
10th ANNIVERSARY REUNION 2008
Network of Workstations (NOW): 1993-98

NOW Team 2008: L-R, front row: Prof. Tom Anderson†‡ (Washington), Prof. Rich Martin† (Rutgers), Prof. David Culler†‡ (Berkeley), Prof. David Patterson† (Berkeley).
Middle row: Eric Anderson (HP Labs), Prof. Mike Dahlin†‡ (Texas), Prof. Armando Fox† (Berkeley), Drew Roselli (Microsoft), Prof. Andrea Arpaci-Dusseau† (Wisconsin), Lok Liu, Joe Hsu.
Last row: Prof. Matt Welsh† (Harvard/Google), Eric Fraser, Chad Yoshikawa, Prof. Eric Brewer†‡ (Berkeley), Prof. Jeanna Neefe Matthews (Clarkson), Prof. Amin Vahdat† (UCSD), Prof. Remzi Arpaci-Dusseau (Wisconsin), Prof. Steve Lumetta (Illinois).

*3 NAE members  †4 ACM fellows  ‡9 NSF CAREER Awards
Monitizing the internet ...

Costis Daskalakis

Research as “Time Travel”

- **Imagine** a technologically plausible future
- **Create** an approximation of that vision using technology that exists.
- Discover what is **True** in that world
  - Empirical experience
    - Bashing your head, stubbing your toe, reaching epiphany
  - Quantitative measurement and analysis
  - Analytics and Foundations
- Courage to ‘break trail’ and discipline to do the hard science