The Future of the Mainframe

Prof. Dr.-Ing. Wilhelm G. Spruth
Dept. of Computer Science, Leipzig University
Dept. of Computer Science, Tuebingen University

spruth@informatik.uni-leipzig.de
spruth@informatik.uni-tuebingen.de
The Death of the Mainframe

A fairly well accepted notion in computing is that the mainframe is going the way of the dinosaur.
   Forbes, March 20, 1989

The mainframe computer is rapidly being turned into a technological Dinosaur...
   New York Times, April 4, 1989

On March 15, 1996, an InfoWorld Reader will unplug the last mainframe.
   Stewart Alsop, InfoWorld 1991

...the mainframe seems to be hurtling toward extinction.
   New York Times, Feb. 9, 1993

Its the end of the end for the mainframes
   George Colony, Forrester Research,
   Business Week, Jan. 10, 1994
Good morning!
Today is 16. Juli 2036.
your /370 Computer
Three Reasons that speak for the Future of the Mainframes

1. Investment in existing applications
2. Leading edge technology
3. Attractive business for both IBM and its customers

One Reason that speaks against the Future of Mainframes

1. Low volume development and manufacturing

Looking into the future
Three Reasons that speak for the Future of the Mainframes

1. Investment in existing applications
2. Leading edge technology
3. Attractive business for both IBM and its customers

One Reason that speaks against the Future of Mainframes

1. Low volume development and manufacturing
   Looking into the future
The worldwide number of CICS transactions executed each second is in the same ballpark as the number of hits on the WWW net.

In 2001 worldwide approx. 15 000 enterprises used CICS. Of the 2000 largest companies more than 90 % use CICS.

There are 30 Mill. active CICS Terminals worldwide.

For comparison: in March 2001 there were 379 Mill. Internet connections worldwide, most of them in private homes.

Average CICS Terminal use: 4 - 6 hours/day.

Average internet connection use: estimated 10 hours/month.

The Significance of COBOL

Cobol remains the most widely deployed programming language in big business, accounting for 75% of all computer transactions. Cobol is pervasive in the financial sector (accounting for 90% of all financial transactions), in defence, as well as within established manufacturing and insurance sectors. We estimate that there are over 200 billion lines of Cobol in production today, and this number continues to grow by between three and five percent a year.

http://store.ovum.com/Product.asp?tnpid=&tnid=&pid=33702&cid=0
The Significance of COBOL

75% of all business data is processed in COBOL. - Gartner Group

There are between 180 billion and 200 billion lines of COBOL code in use worldwide. Existing legacy systems are predominantly written in COBOL. - Gartner Group

Replacement costs for COBOL systems, estimated at $25 per line, are in the hundreds of billions of dollars. - Tactical Strategy Group

15% of all new applications (5 billion lines) through 2005 will be in COBOL. - Gartner Group. CICS transaction volume (such as COBOL-based ATM transactions) grew from 20 billion per day in 1998 to 30 billion per day in 2002. - The Cobol Report.

http://www.cobolwebler.com/cobolfacts.htm
http://www.eweek.com/article2/0,3959,25993,00.asp
Example: Credit Suisse (Zürich)  
2006

12 Mill. lines of code in PL/1  
6 Mill. lines of code in Java

PL/1 source code has 78 000 Elements

Main programms (24 000)  
Copy Books  
Subroutines  
On-Line programs

1 000 GUI Services with 15 Mill. Calls/day

30 Mill. $ Investment to restructure existing Code
“Rip and Rewrite”
is a high-risk, low-reward proposition

ovum report, Oktober 2005
Three Reasons that speak for the Future of the Mainframes

1. Investment in existing applications
2. Leading edge technology
3. Attractive business for both IBM and its customers

One Reason that speaks against the Future of Mainframes

1. Low volume development and manufacturing
Looking into the future
<table>
<thead>
<tr>
<th></th>
<th>Compaq Proliant W2000</th>
<th>SUN Exxxx Solaris</th>
<th>HP HP9000 HPUX</th>
<th>IBM S/390 OS/390</th>
</tr>
</thead>
<tbody>
<tr>
<td>Processor Technology</td>
<td>7</td>
<td>6</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Systems Performance</td>
<td>30</td>
<td>50</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>Clustering Performance</td>
<td>2</td>
<td>4</td>
<td>4</td>
<td>10</td>
</tr>
<tr>
<td>Single Systems Availability</td>
<td>20</td>
<td>30</td>
<td>30</td>
<td>50</td>
</tr>
<tr>
<td>Multiple Syst. Availability</td>
<td>20</td>
<td>24</td>
<td>32</td>
<td>40</td>
</tr>
<tr>
<td>Workload Management</td>
<td>5</td>
<td>20</td>
<td>30</td>
<td>50</td>
</tr>
<tr>
<td>Partitioning</td>
<td>4</td>
<td>28</td>
<td>16</td>
<td>40</td>
</tr>
<tr>
<td>Systems Management</td>
<td>28</td>
<td>24</td>
<td>28</td>
<td>40</td>
</tr>
<tr>
<td>Totals</td>
<td>116</td>
<td>186</td>
<td>200</td>
<td>290</td>
</tr>
</tbody>
</table>

Application Server Evaluation Model, Technology Comparison
Gartner Group, February 2001
High Numbers are better
zSeries, S/390, z/OS, OS/390
Leading Edge Technology

Unique zSeries and z/OS Facilities:

- Architecture, e.g. Hardware Protection prevents Buffer overflows
- Compatibility 1964 - 2007
- Hardware-Technology, e.g. TCM Multi-Chip Module, common L2 Cache
- Input/Output Architecture (see publication)
- Symmetric Multiprocessing
- Scalability, using the Coupling Facility (see publication)
- Partitioning and PR/SM LPAR Mode (see publication)
- Hipersockets (z/OS – zLinux Integration)
- Goal-oriented Workload Manager
- CICS-Transactionmanager
- WebSphere Web Application Server
- Persistent Reusable Java Virtual Machine (see publication)

http://www-ti.informatik.uni-tuebingen.de/~spruth/publish.html
/360 Architecture

April 7, 1964

- 8 Bit Byte
- Main Store Byte Adressing
- General Purpose Register
- Supervisor/Problem State (Kernel/User State)
- I/O Channel
- **Extended Lifetime** – strictly upwards and downwards compatibility over a line of models
What has happened since 1964?

Many efforts to come up with a better computer architecture

- B5000
- VAX
- HP Precision
- MIPS
- Itanium
- many others

Given today's knowledge: What should Amdahl, Blaauw and Brooks have done differently in 1964?
Storage Protection

Key Store

1 key (4 Bit) for each 4096 Byte Block (plus Control Bits, e.g., Reference Bit R and Change Bit C)

compare

yes

access ok

no

Program Interrupt
Main Store, partitioned into 4 KByte Blocks (page frames) using different protection keys

Buffer Overflow into adjacent 4 KByte Block

Buffer Overflow Prevention
z9 Multichip Module
Pentium Pro
387 Pin Multi Layer Ceramic (MLC) Multi Chip Carrier (MCM) Module
zSeries Cache Structure

Central L2 Switch, permits concurrent access by all processors
CICS, DB2 and IMS Lock Management, significant performance Improvement
Contrary to other Systems, I/O devices communicate with the L2 cache and not with main store. zSeries engineers were able to solve the resulting cache coherence problems.
zSeries
large system configuration

128 000 disks (devices)
2 Channel Subsyst.

Logical Volumes

10 - 1000 TeraByte disk space
Symmetric Multiprocessor, SMP. Single z/OS Instance

Relative Performance

z/OS up to 32 CPUs

other Platforms approx. ½ for Transaction- and Database applications

Number of CPUs
Coupling Facility

SMP SMP SMP SMP SMP SMP 32 max.

200 MByte/s Sysplex FICON / Fibrechannel Timer Protocol (ESCON)

Switch / FICON other I/O

Glasfibre CU CU CU CU Control Units

Sysplex with Coupling Facility
You cannot scale a transaction processing system, if you do not solve the locking problem.

Jim Gray, Andreas Reuter, 1993

Separate System for the SAP Lock management
25 000 MIPS at 95% Utilization sustained 15 947 Transactions/s with subsecond response time
Contrary to all other platforms, LPARs use real storage.

Dynamic LPAR Storage management.

IRD
Goal oriented Work Load Manager
Policy driven Work Load Mgmt.

Classification
Rules
Response Time
80% trx complete with 0.5 seconds – (24x7)
(Claims Trx Class)

Average Response Time
All trx must complete within 4 seconds – (18x5)
(Policy Browser)

Average Response Time
All trx must complete within 2 seconds
Loc: MA, NY, PA USA

Service
Class
Claims
Policy
Browser

A. Discretionary Response Time between 7:00 – 16:00
B. Response Time percentile
50% trx complete within 3 mins between 16:00 – 7:00

Response Time (8 x 5)
A. South East = 0.8 Secs
B. South West = 1.5 Secs.
C. North West = 2.5 Seconds
D. NORTH EAST = 2.5 Seconds
Use of Java Threads

The existing application isolation mechanisms, such as class loaders, do not guarantee that two arbitrary applications executing in the same instance of the JVM will not interfere with one another. Such interference can occur in many places. For instance, mutable parts of classes can leak object references and can allow one application to prevent the others from invoking certain methods. The internalized strings introduce shared, easy to capture monitors. Sharing event and finalization queues and their associated handling threads can block or hinder the execution of some application. Monopolizing of computational resources, such as heap memory, by one application can starve the others.

Grzegorz Czajkowski, Laurent Daynès:
Multitasking without Compromise: a Virtual Machine Evolution.

Java gives the virtuoso thread programmer considerable freedom, but it also presents many pitfalls for less experienced programmers, who can create complex programs that fail in baffling ways.


http://www-ti.informatik.uni-tuebingen.de/~spruth/DiplArb/jmueller.pdf
Persistent Reusable Java Virtual Machine (PRJVM) Technology.

The PRJVM is a regular JVM with some additional functions.

Multiple PRJVMs within the CICS address space.

The first PRJVM plays the role of the Master PRJVM and manages the JVM Set.
Three Reasons that speak for the Future of the Mainframes

1. Investment in existing applications
2. Leading edge technology
3. Attractive business for both IBM and its customers

One Reason that speaks against the Future of Mainframes

1. Low volume development and manufacturing
Looking into the future
Declining cost per user due to mainframe scalability versus Unix server scalability.

Average yearly Transaction Cost/User

Distributed Unix

Centralized Unix

Mainframe

100 – 249
250 – 499
500 – 999
1000 + simultaneous users

IDC, 2/1999
IBM Mainframe Revenue and Profit Growth

IDC reported today that IBM continues to hold the number one position in worldwide server revenue share with 32.8 percent revenue share for 2006.

IBM’s leadership position in global server revenue in 2006 was augmented by noteworthy revenue growth in its System z mainframe business.

IDC Worldwide Quarterly Server Tracker, 4Q06, issued on February 26, 2007

The iQDIO Interface provides a high speed IP-Datacommunications between the LPARs of a zSeries system. Works like an IP-LAN interchange; data exchange via main storage Hipersockets.
19 separate SAP production-systems and 20 SAP test-systems
3,700 users, 2,500 simultaneously
35 subsidiaries, 71 locations, 0.5 seconds avg. response time for SAP applications
<table>
<thead>
<tr>
<th></th>
<th>Servers</th>
<th>Reliability</th>
<th>Utilization</th>
<th>Staff</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>First move:</strong></td>
<td>Implemented distributed computing architecture that became too difficult to monitor, maintain, upgrade and scale</td>
<td>30+ Sun Solaris servers, 560+ Intel servers</td>
<td>Un-acceptable</td>
<td>12%</td>
</tr>
<tr>
<td><strong>Next move:</strong></td>
<td>Consolidated back on the mainframe</td>
<td>z990</td>
<td>Much improved</td>
<td>84% with additional reserve capacity on-demand</td>
</tr>
</tbody>
</table>

Seven times better utilization on mainframe hardware.
Three Reasons that speak for the Future of the Mainframes

1. Investment in existing applications
2. Leading edge technology
3. Attractive business for both IBM and its customers

One Reason that speaks against the Future of Mainframes

1. Low volume development and manufacturing

Looking into the future
Looking into the Future

In the future we will see 4 different platform-types:

1. **Embedded Systems** Handy, Palmtop, RFID, refrigerator IP address, Computer embedded into the human body (pacemaker)

2. **Personal Computer** Office, Home Computer for Mail, correspondence and photographic processing, extension into Blades

3. **Game Computer** X-Box, Sony, Nintendo, High Performance computer with Blades

4. **Mainframe** offers functions not available on other Platforms: Performance impact, availability, I/O, additional cost and development effort.....
Cell Processor Chip

- ~250M transistors
- ~235mm²
- Top frequency >4GHz
- 9 cores, 10 threads
- > 256 GFlops (SP) @4GHz
- > 26 GFlops (DP) @4GHz
- Up to 25.6GB/s memory B/W
- Up to 75 GB/s I/O B/W
- Large design investment (time & money)
Cell Applications

- Home Computer Entertainment
  - Game consoles, home servers, media boxes, ...

- Medical imaging, radar imaging, ...

- Simulation

- High performance computing
  - Life sciences, seismic, and a few others fit well; broader Cell-based HPC needs Research

- Video surveillance

- Online gaming
  - Backend servers

- Digital media – content mgmt & delivery
  - Backend servers for content providers

- Digital media – production
  - Render farms, ...
Mainframe Properties

Mainframes have hardware and software functions, that require additional development effort and manufacturing cost. This will not change in the future.

These functions are needed. The resulting expense is not justified in other platforms.
zSeries Fibre Channel, based on the Common I/O Card
Software Implementation for different Platforms

Separate Implementations for z/OS and all other Platforms

CICS
DB2

and for WebSphere?

common Code Basis, but special z/OS features.
A z/OS WebSphere Server has a Controller and multiple Servants, which do the actual work. The Controller manages Servants using the z/OS Goal oriented Work Load Manager.
Ovum report believes PC technology will catch up with mainframes

Yes, e.g. a coupling facility integrated in each PC
But, 1 Billion $ investment in next generation Mainframe

Remember PC introduction in 1980 ?

No cache, virtual storage, virtualisation, disk I/O,
PC-DOS vs. OS/370, .......

By the time PC technology catches up, mainframes will be much further advanced.

System integration issues and Service Oriented Architecture (SOA) favour mainframes
**Future SOA Configuration – Network in a Box**

The iQDIO Interface provides a high speed IP-Datacommunications between the LPARs of a zSeries system. Works like an IP-LAN interchange; data exchange via main storage Hipersockets.

VM – (emulated) Virtual Machine, z/OS test system, Apple, Solaris
Willkommen auf jedi.informatik.uni-leipzig.de

Uni Leipzig z/OS Web Application Server


Auf dieser Web-Seite werden die Bemühungen am Institut für Informatik der Universität Leipzig, den interessierten Studenten und Absolventen grundlegende Kenntnisse in der Hard- und Software-Architektur der IBM z/390-Computer einschließlich modernster Internet-Technologien zu vermitteln, vorgestellt.
Good morning!
Today is 16. Juli 2036.
your /370
Computer
Good morning!
Today is 23. May 2057
Your z/OS computer