Mainframe Reliability on Industry-Standard Servers :

How Intel® Itanium®-based Servers are Changing the

Economics of Mission-Critical Computing

Michael EISA

Intel Strategic Initiatives Manager
Europe, Middle East & Africa

HP EMEA TSG

16th October, 2008

Business Challenges

Mainframe Environment Costs

- **Lack of agility** incurs cost in lost opportunity and business responsiveness
- High cost levels for **maintenance and support**
- Poor **price/performance**
- Poor choice of software, **high proprietary licensing cost**
- Lack of Open Systems severely **restricts options**
- **Limited skills availability** with an ever shrinking pool of talent
- Big server footprint with **high power and cooling costs**

CIO Agenda 2008

silicon.com

Recession fears hit IT budgets*
CIO Agenda 2008: The challenges for the year ahead...

"The state of the economy and its potential **impact on IT budgets** will be the key challenge for IT chiefs this year along with the **ongoing war for tech talent**, according to silicon.com's exclusive CIO Agenda 2008 survey"

*http://www.silicon.com/research/specialreports/cio-agenda-2008/0,3800014530,39182131,00.htm

(intel)

Mainframe customers are moving to Itanium®

HP Announces Over 50 Mainframe Customers Successfully Complete Migration to Integrity Systems : April 2008*

The End of One Era

IBM Mainframe declines 31% in Q3 and 15% in Q4 2007

The Start of Another

HP Integrity Itanium® increases 71% in Q3 and 59% in Q4 2007

(intel®)

Intel: A Better Alternative

Intel® Itanium® Processors

9000 Sequence

Mainframe-class server

For Your Most Critical Data Center Requirements

Designed for Enterprise

Agenda

- **Reliability and Security**
  - **Mainframe Class Reliability**
- **Performance and Scalability**
  - **Mission Critical Performance**
- **Cost Savings through Choice**
  - **Cutting TCO in half**
- **Investment Protection**
  - **Intel Advantages**

Reliability and Security

Delivering Mainframe-Class Reliability

Reliability Feature	IT Benefit	Intel® Itanium®	Typical Mainframe
Bad Data Containment	High System Availability	☑	☑
Cache Reliability	Data Error Protection	☑ Intel® Cache Safe Technology	☑
Advanced Machine Check Architecture	Data Integrity	☑ Soft Error Checking	☑
Memory Mirroring & Hot Swap	Data Protection & On-line Repair	☑	☑
Processor Lockstep	Computational Accuracy	☑ Core Level Lockstep	☑
Memory Compartmentalization	Information Security	☑	☑

Depend on Itanium® Reliability When it Matters Most

(intel)

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Intel® Itanium® Core Level Lockstep

Socket

L3 — Core 0

Core 1 — L3

Arbiter

Duplicate ECC Data
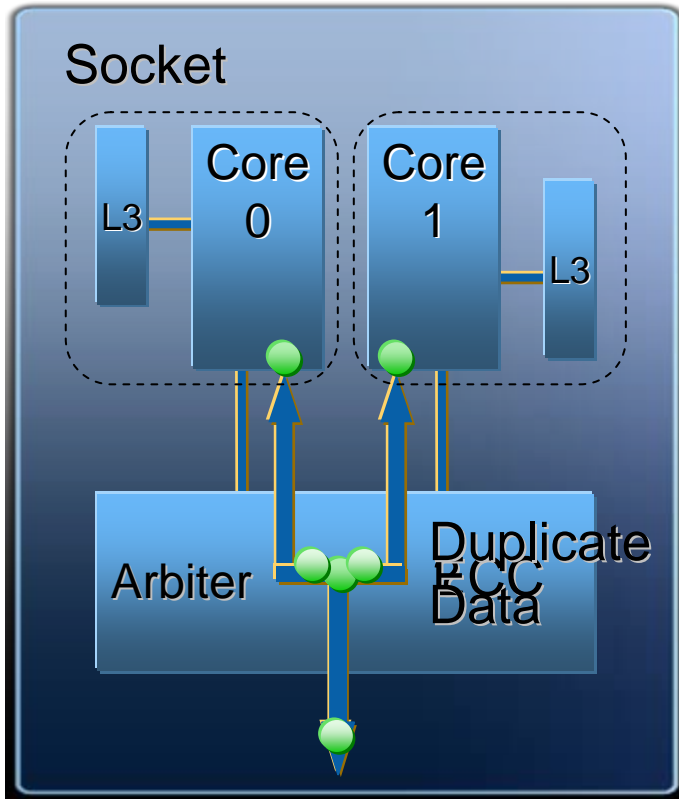
- Two Lock-stepped Cores Act As One Logical CPU Core

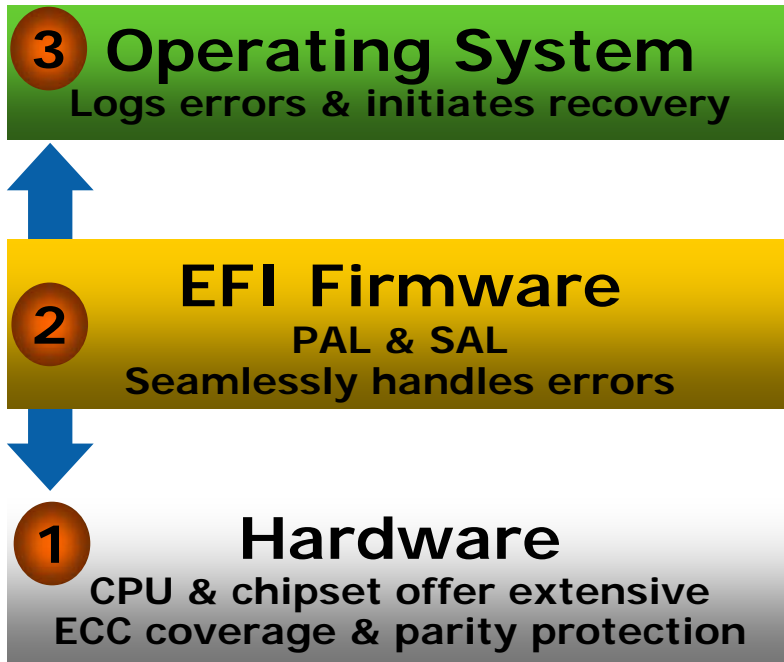- Checking Function To Ensure Data Integrity Throughout The Cores

Enabling Mainframe Reliability at non proprietary prices

Intel® Itanium® Advanced Reliability Partnership

ORACLE®

3 Operating System
Logs errors & initiates recovery

2 EFI Firmware
PAL & SAL
Seamlessly handles errors

1 Hardware
CPU & chipset offer extensive
ECC coverage & parity protection

1 Extensive hardware error detection and correction. Cache Safe Technology. Processor Lockstep Support.

2 Well-defined flow for smooth platform error handling

3 HP-UX, Windows and Linux operating systems interacts with firmware to correct and recover from complex platform errors protecting the integrity of Oracle data

Itanium® 2–based platforms deliver Mainframe-class RAS—up to 99.99999 Uptime*

Intel® Itanium® Advanced Error Handling Capability

Increasing Error Severity →

Error Handling	Itanium	RISC & x86
System reset: 2-bit error in kernel	**Non-recoverable**	**Non-recoverable**
OS recoverable: 2-bit error in application	**Execution Continues (Recoverable)**	
OS corrected: Translation errors		
Firmware corrected: 1-bit error in write through cache Hard error in L3 cache with Intel® Cache Safe Technology[1]	**Execution Continues (Corrected)**	
Hardware corrected: Most 1-bit errors		**Execution Continues (Corrected[2])**

Maximizes uptime and lowers service costs

1. Supported starting with Montecito processor.
2. Intel Xeon Architecture implements Cache Safe Technology in Hardware

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Added Security built into Intel® Itanium® Architecture
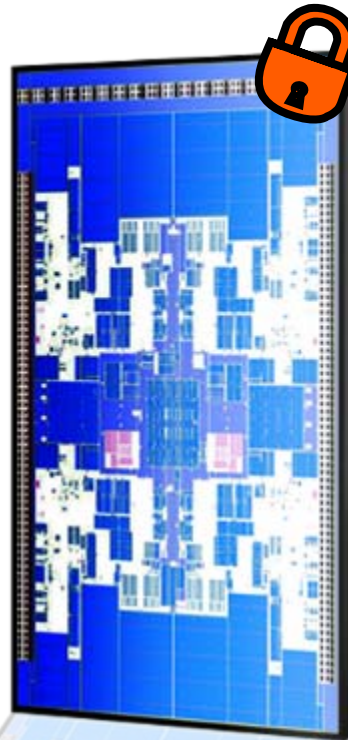
Register Store Engine[1]

Protects against buffer overflow attacks

Hardware Access Rights

R/W/X virtual memory access control. Protects memory contents, prevents insertion of code into a running system

Hardware Protection Keys[1]

Locks memory pages with encrypted keys. Helps protect against unauthorized memory access by applications or malware

Root Trust[2]

At system boot, Itanium computes and authenticates a cryptographically strong digital signature over initial FW image

Assures that system boots with correct and complete code and data image

Fast Data Encryption

Enabled by architecture-level parallelism. Helps protect confidential information throughout the system

Stronger Protection For Mission Critical Operating Systems And Applications
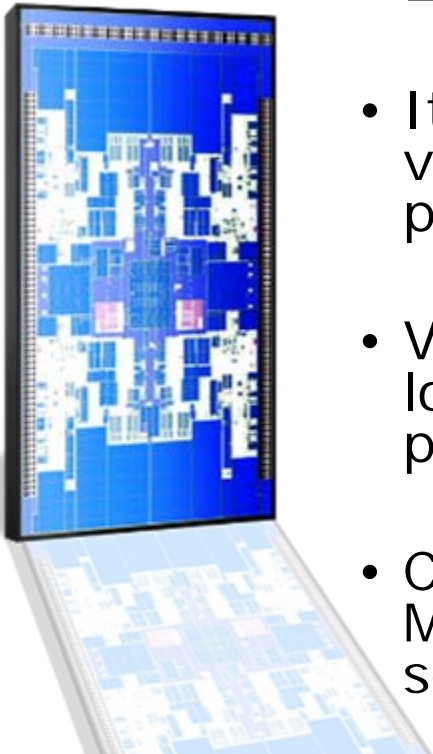
(2) Requires enabled chipset and TPM

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Virtualization on Intel® Itanium® Architecture

- IDC White Paper : Virtualization on Itanium: Intel Enables Choice and Flexibility for Customers

- Itanium-based servers with their extensive virtualization partitioning features are the premier platform for mainframe migration

- Virtualization on Itanium-based servers is ideal looking beyond static consolidation today, toward policy-based resource allocation

- Consolidate multiple instances of HP-UX*, Microsoft Windows* and Linux* on the same server.

Intel VT-i Virtualization Technology enables consolidation and efficiency gains
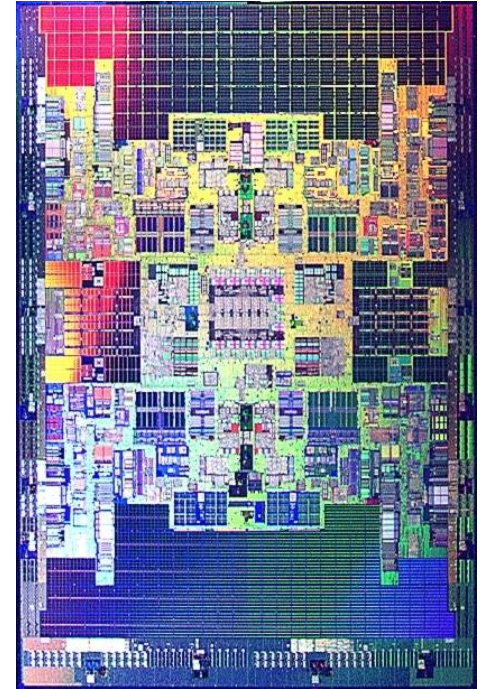
On Track with Tukwila for 2008

Enhanced Mainframe-level RAS features

– New interconnect reliability features

– Double Device Data Correction (memory RAS)

New platform design for innovation

– Virtualization enhancements

– Common chipset with future Intel® Xeon® platforms

Tukwila RAS example – DDDC Double Device Data Correction

Memory

Today: systems can fix memory errors when a DRAM device fails on a DIMM due to a hard-error...

However, cannot fix when 2 sequential DRAM devices fail which could result in memory loss and a fatal-system crash
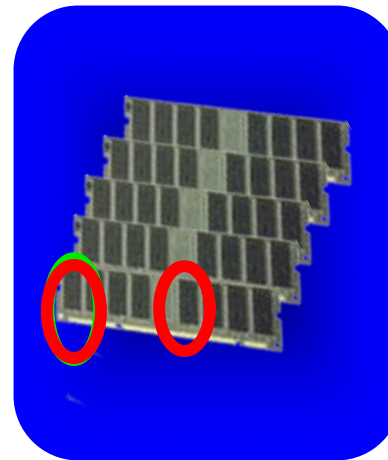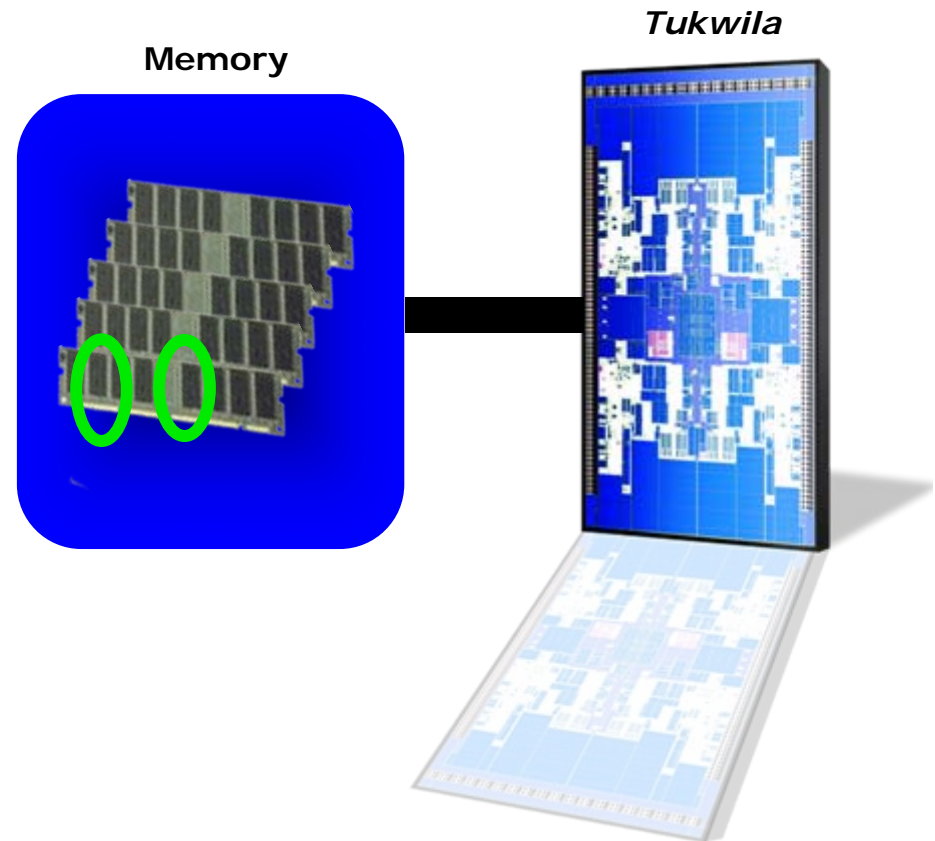
Most high-end server processors

Tukwila RAS example – DDDC Double Device Data Correction

- Tukwila DDDC can fix both single and double memory hard-errors
- Tukwila DDDC can improve system uptime and reduce DIMM replacement rates lowering overall service costs
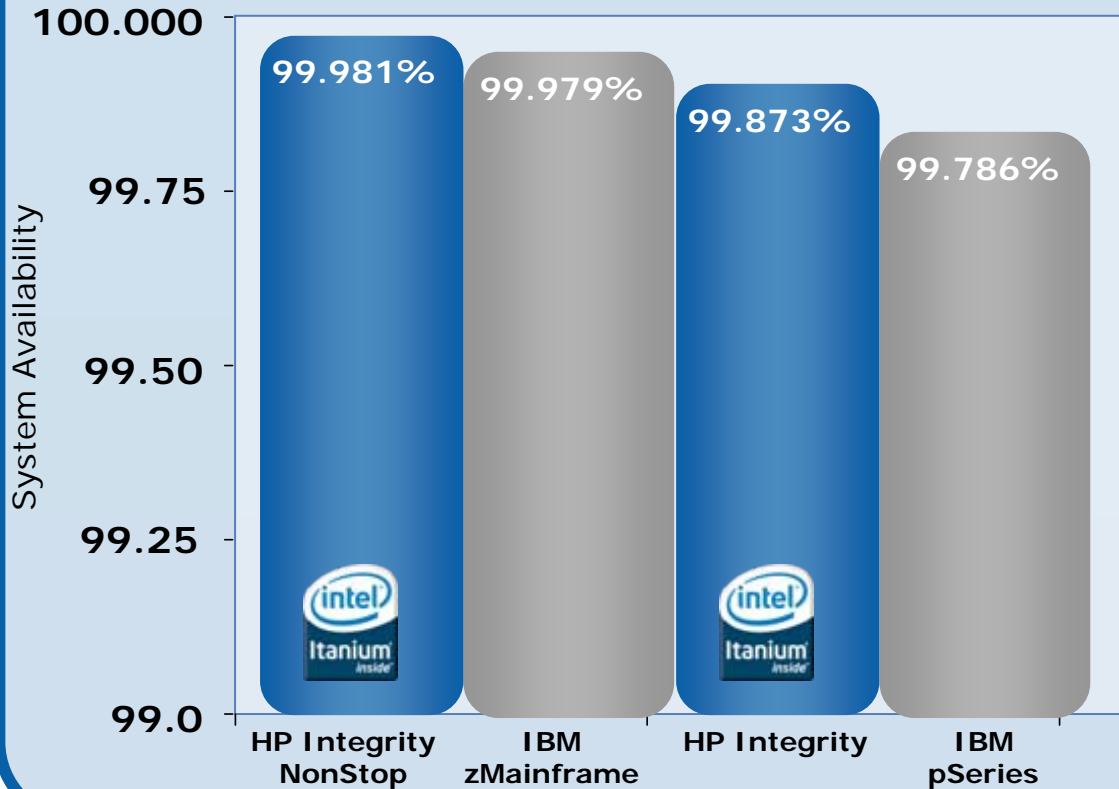
Memory

Tukwila

Intel® Itanium® Superior Availability

System Availability

Chart: System Availability (y-axis from 99.0 to 100.000)

- HP Integrity NonStop: 99.981%
- IBM zMainframe: 99.979%
- HP Integrity: 99.873%
- IBM pSeries: 99.786%

Independent consultant analysis by the Standish Group shows that HP's Integrity NonStop systems are the most reliable in the world, superior to IBM's System z mainframes*

*The above chart shows selected system availability by percent of yearly uptime. The data was collected monthly, from January 2006 to January 2007, with almost 50,000 entries. Source: Standish Group Special Report

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Performance and Scalability

(intel)

Intel® Itanium® processor 9000/9100 series Mission Critical Server Performance

World Record Performance

Workload	Results	Benchmark
OLTP	4,092,799 tpmC @$2.93/tpmC	ORACLE® TPC Benchmark* C
Data Warehouse	150,960QphH @$46.69/QphH	ORACLE® TPC Benchmark* H @30,000GB
ERP Solutions	3,000 users w/ 0.453sec avg. response	ORACLE® Oracle* E-Business Suite 11i (11.5.10) Benchmark with Oracle* 10gR2
Java Server	5,180,451 bops	SPECjbb*2005
Floating-Point Throughput	3,507 Score	SPECfp*_rate2006
Integer Throughput	3,354 Score	SPECint*_rate2006
Application Server	10,519 jops	ORACLE® SPECjAppServer*2004

= 9100 series ("Montvale")

Performance Summary

Vs. Itanium® 2 Processor 1.60GHz	Relative Scaling
SPECjbb*2005	Up to **2.8x**[1]
Vs. Competition 128C (64P/128C Itanium® Processors vs. Sun* SPARC* VI 2.4 GHz)	Relative Scaling
SPECfp*_rate2006 vs. Fujitsu/Sun* SPARC* Enterprise M9000	Up to **1.6x**[2]
Top OS-based result *Itanium®-based Servers offer choice to customers*	Best-in-Class Results
TPC - C **Red Hat* LINUX** ORACLE®	**2,196,268** tpmC (rank #4)

1 Performance comparison of 128P Intel® Itanium® 9150 vs. Itanium 2 processor 1.60GHz on SPECjbb*2005. Source: SGI* submitted results and http://www.spec.org/osg/jbb2005/results/res2006q2/jbb2005-20060327-00097.html as of Oct 07.
2 Performance comparison of 128C Intel® Itanium® 9150 (1950) vs.128c Fujitsu/Sun SPARC* Enterprise M9000 (1294). Source: SGI* submitted results and http://www.spec.org/cpu2006/results/res2007q2/cpu2006-20070416-00835.html as of 30 Oct 07.
Itanium® 2 9000 series: Dual Core Intel® Itanium® 2 Processor "Montecito", Itanium 9100 series: Dual-Core Intel® Itanium® Processor "Montvale"

Itanium®-based servers deliver world-class, scalable performance

Itanium® Architecture® Advancements

More than GHz:

- Parallel Execution
- Massive Resources
- Scalability
- Performance
- Compiler Control

EPIC (Explicitly Parallel Instruction Set Computing) Features:

- **Instruction Level Parallelism**
  - *2 bundles (6 instructions) per clock*
- **Massive On-chip Resources**
  - *Allows compiler to exploit parallelism*
- **Register Save Engine**
  - *Reduces procedural overhead*
- **Static/Dynamic branch predication**
  - *Branches executed simultaneously*

- **Control & Data Speculation**
  - *Reduces memory latencies*
- **Software Pipelining**
  - *Generates compact code for loops*
- **Floating-point Architecture**
  - *Improves computational performance*
- **Memory Support**
  - *64-bit addressing, 3 levels of cache*
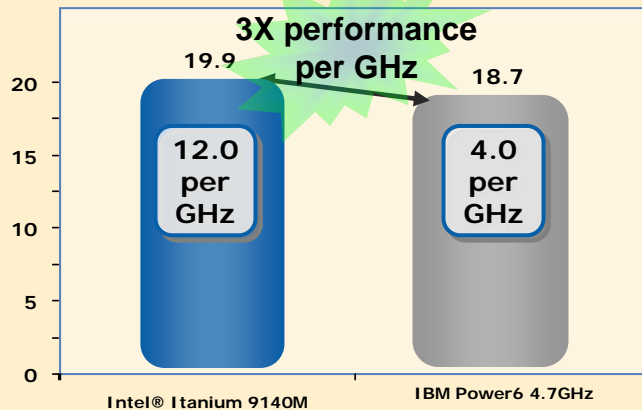
Optimized for business critical computing

Efficient Performance

SPECcpu2006 benchmarks show that Intel® Itanium® Processors do more work per clock cycle

Intel® Itanium® 1.66GHz
IBM Power6 4.7GHz
SPEC CFP2006*
single core performance

3X performance per GHz

19.9   18.7

20

15

10

5

0

12.0 per GHz

4.0 per GHz

Intel® Itanium 9140M   IBM Power6 4.7GHz

Leading Performance/core

"A lower frequency approach for Itanium means less heat, more headroom for the future"*

ideas International

"Leveraging the fast clock rate design point of POWER6, IBM highlights that the quad-core z10 chip runs at 4.4 GHz, more than 2.5 times faster than the 1.7 GHz of the z9 predecessor. Of course, to achieve such clock rates, less "work" is accomplished per clock cycle. The result is that z10 processors offer about a 50% performance boost over z9"*

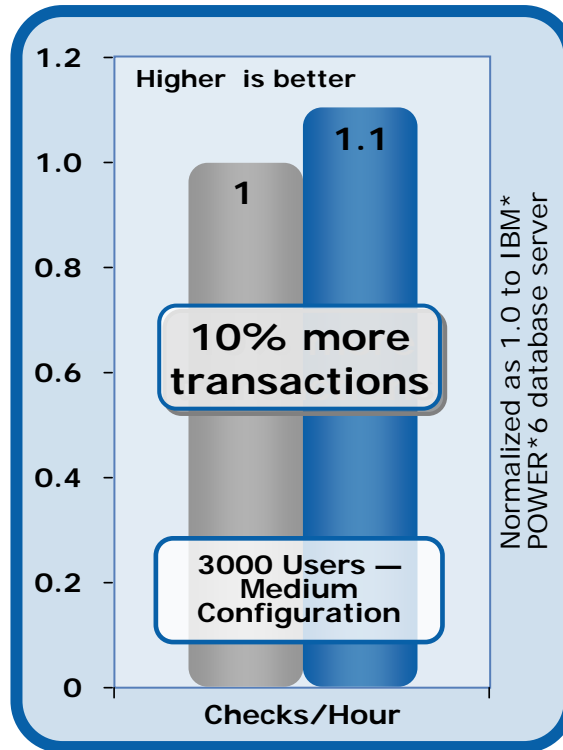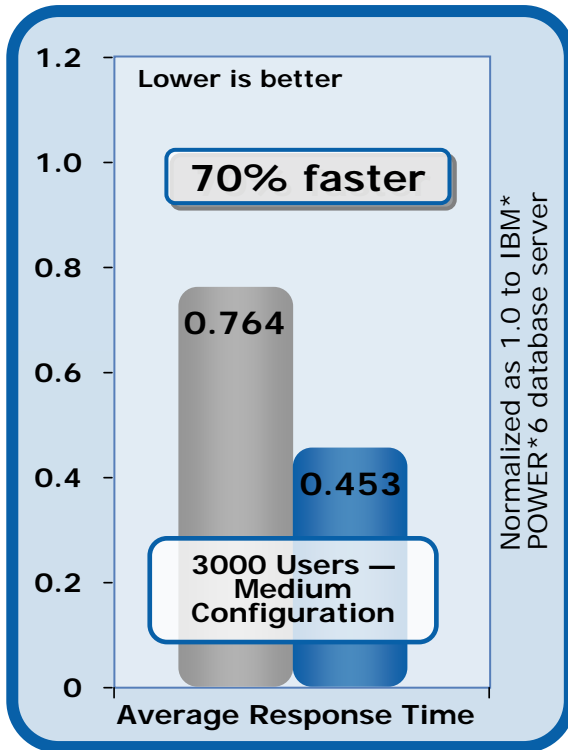*http://ideasint.blogs.com/ideasinsights/2008/02/ibm-teaches-its.html

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Performance Versus IBM*

Oracle E-Business Suite 11i (11.5.10) Benchmark

Intel® Itanium® 9000 Sequence running

Oracle E-Business Suite

70% Quicker

10% More Transactions

Average Response Time
Lower is better

70% faster

- IBM p570: 0.764
- Itanium: 0.453

3000 Users — Medium Configuration

Normalized as 1.0 to IBM* POWER*6 database server

Checks/Hour
Higher is better

- IBM p570: 1
- Itanium: 1.1

10% more transactions

3000 Users — Medium Configuration

Normalized as 1.0 to IBM* POWER*6 database server

■ IBM* p570 Server Dual-core POWER*6 (4.70 GHz)
■ Dual-core Intel® Itanium® Processor 9150M (1.66GHz)

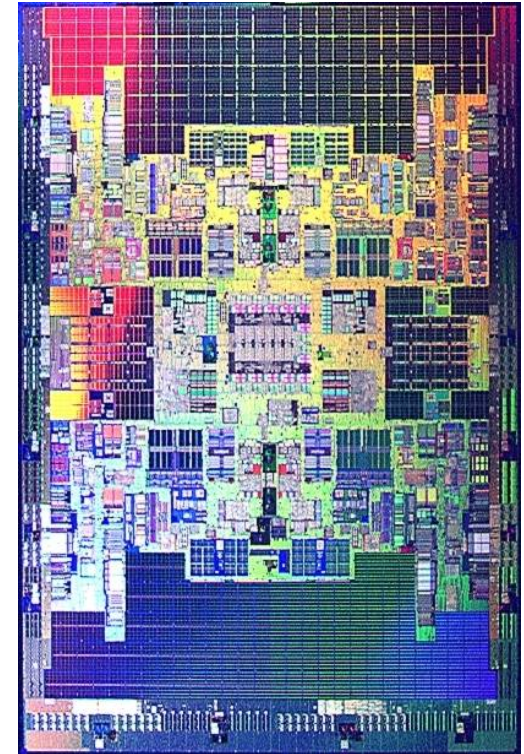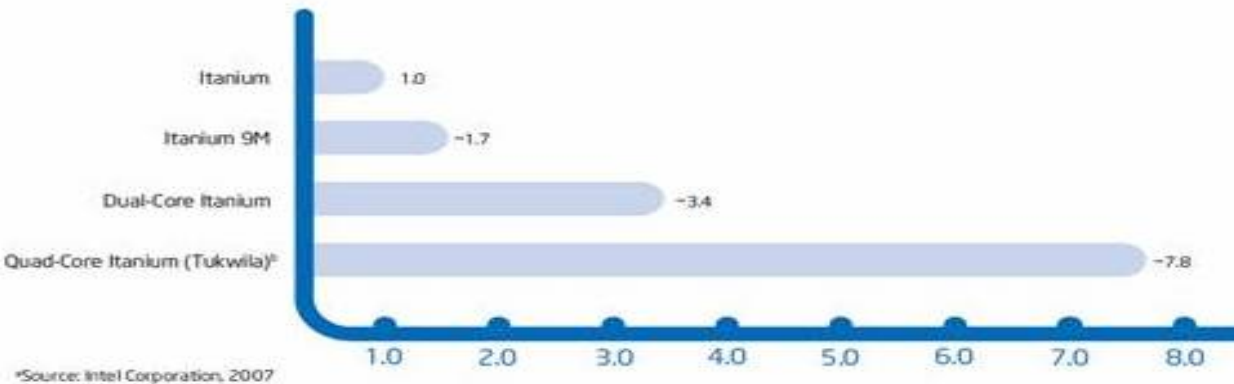For notes and disclaimers, see legal information slide at end of this presentation.

On Track with Tukwila for 2008

Up to 2x performance[1] of Itanium® today

Ongoing Performance Ramping for Intel® Itanium® Processors
45 Online Transaction Processing (OLTP)ª

Itanium	1.0
Itanium 9M	~1.7
Dual-Core Itanium	~3.4
Quad-Core Itanium (Tukwila)ᵇ	~7.8

1.0   2.0   3.0   4.0   5.0   6.0   7.0   8.0

ªSource: Intel Corporation, 2007

- Quad-core with large on-die caches
- Hyper-Threading Technology
- Integrated memory controller
- New high-speed interconnect

Performance Example
Arabian Automobiles is Transformed

Migration Strategy

- **Migrated from IBM**
- **Deployed Oracle database on Intel® Itanium® processors**

Result

2X Productivity

".. Linux on Itanium® Servers provided the high level of stable performance required for mission critical applications in an open, standards-based platform"

Cost Savings Through Choice

(intel)

TCO Case Study

ALINEAN

Mainframe Migration Case Studies: A Total Cost of Ownership Comparison
Lowering Cost and Improving Flexibility by Migrating to Open Systems
Financial Services Case Study : Introduction

Business Goals

a large financial services company was interested in **reengineering their core banking applications** to **increase application flexibility** and quickly offer new customer services by deploying modular applications **leveraging Service Oriented Architecture (SOA).**

Business Benefits

1. Increase agility to drive competitive advantage, expected **revenue gains of the new application offerings**
2. **Tangible IT cost reductions** by migrating to an open systems solution

(intel)

TCO Case Study

Mainframe Migration Case Studies: A Total Cost of Ownership Comparison
Lowering Cost and Improving Flexibility by Migrating to Open Systems
Financial Services Case Study : Original Mainframe Environment and Open Systems Solution

58%
Lower Cost

Mainframe Solution

Core banking applications 40% processing capacity on zSeries 2094 model 740
Annual hardware costs over $4,200,000

Open Systems Solution

Oracle Database Two HP Integrity rx8640 servers with 12 dual core Itanium processors.
Application Two HP Integrity rx8620 servers with 8 dual core Itanium processors
Front end user interface Four HP ProLiant DL580s with 4 dual core Xeon processors

Reduced total annual Mainframe costs by $2,450,000

TCO Case Study

Mainframe Migration Case Studies: A Total Cost of Ownership Comparison
Lowering Cost and Improving Flexibility by Migrating to Open Systems
Financial Services Case Study : ROI

Four Year Investment and Savings Summary for Financial Services Case

Four Year ROI Analysis	Open Systems Investment	Total Savings Over 4 Years
Server Hardware Costs	$2,682,000	$6,125,000
Server Software Costs	$3,831,552	$11,287,500
Server Administration and Operations Labor Costs		$2,900,000
Facilities Costs		$5,000
Migration / Project Change Costs	$2,850,000	
Total	**$9,363,552**	**$20,317,500**

ROI of 117%

TCO Case Study

Mainframe Migration Case Studies: A Total Cost of Ownership Comparison
Lowering Cost and Improving Flexibility by Migrating to Open Systems
Financial Services Case Study : TCO

Four Year TCO Comparison	Mainframe Server	Open Systems Solution	Total Savings	Difference
Server Hardware Costs	$9,800,000	$2,682,000	$7,118,000	72.6%
Server Software Costs	$18,060,000	$3,831,552	$14,228,448	78.8%
Server Administration and Operations Labor Costs	$21,984,000	$17,344,000	$4,640,000	21.1%
Facilities Costs	$232,000	$140,000	$92,000	39.7%
Migration / Project Change Costs	$0	$2,850,000	($2,850,000)	
Total	**$50,076,000**	**$26,847,552**	**$23,228,448**	**46.4%**

TCO difference of 46%

intel

Linux on Mainframe

Linux on Mainframe and Linux on Industry Standard Itanium® cost

Bar chart — Thousand US$:
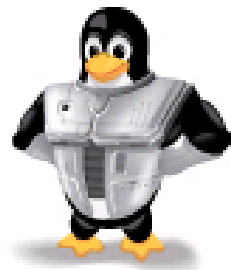- Mainframe z9BC Model z04 8 processors: $690,060
- HP rx7640 8 cores 8MB RAM: $97,150
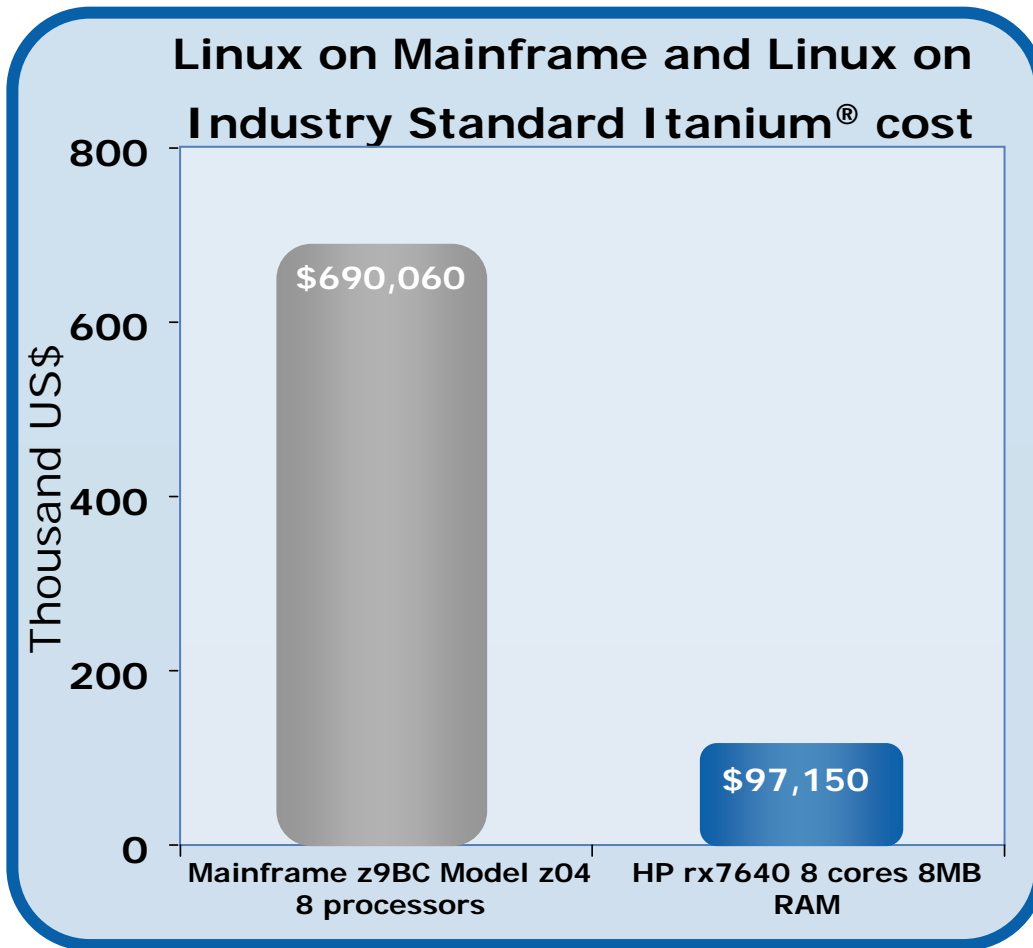
Cost of Linux on a new HP rx7640 (8 cores) is 1/7th the cost of adding 4 Linux processors to an existing mainframe

Software Choice

Oracle to Support Itanium Platform

By Robert Mullins, IDG News Service, CIO Tech Informer, www.CIO.com, September 26, 2006

"Oracle is committed to delivering its industry-leading infrastructure software products for the Itanium platform,"

"Oracle plans to certify the next major releases of Oracle Database and Oracle Fusion Middleware across a range of operating systems for Itanium, with proven Oracle performance, availability, and security."

Prem Kumar, vice president, Server Technologies, Oracle.

Oracle Unbreakable Linux: Enterprise-Class Support

Scope of Support
The Oracle Unbreakable Linux program offers operating system support for the Red Hat Enterprise Linux distribution. Oracle provides the following for Linux server deployments:

• Linux x86 and x86-64:
• Linux Itanium

Enterprise Linux Premier Support
Annual price per system with unlimited physical CPUs **$1,999**

Intel® Itanium® #1 for Oracle Database and Clustered Database Performance on UNIX, Linux and Windows*

Power and Cooling Costs

Worldwide IT Spending on Servers, Power and Cooling, and Management/Administration
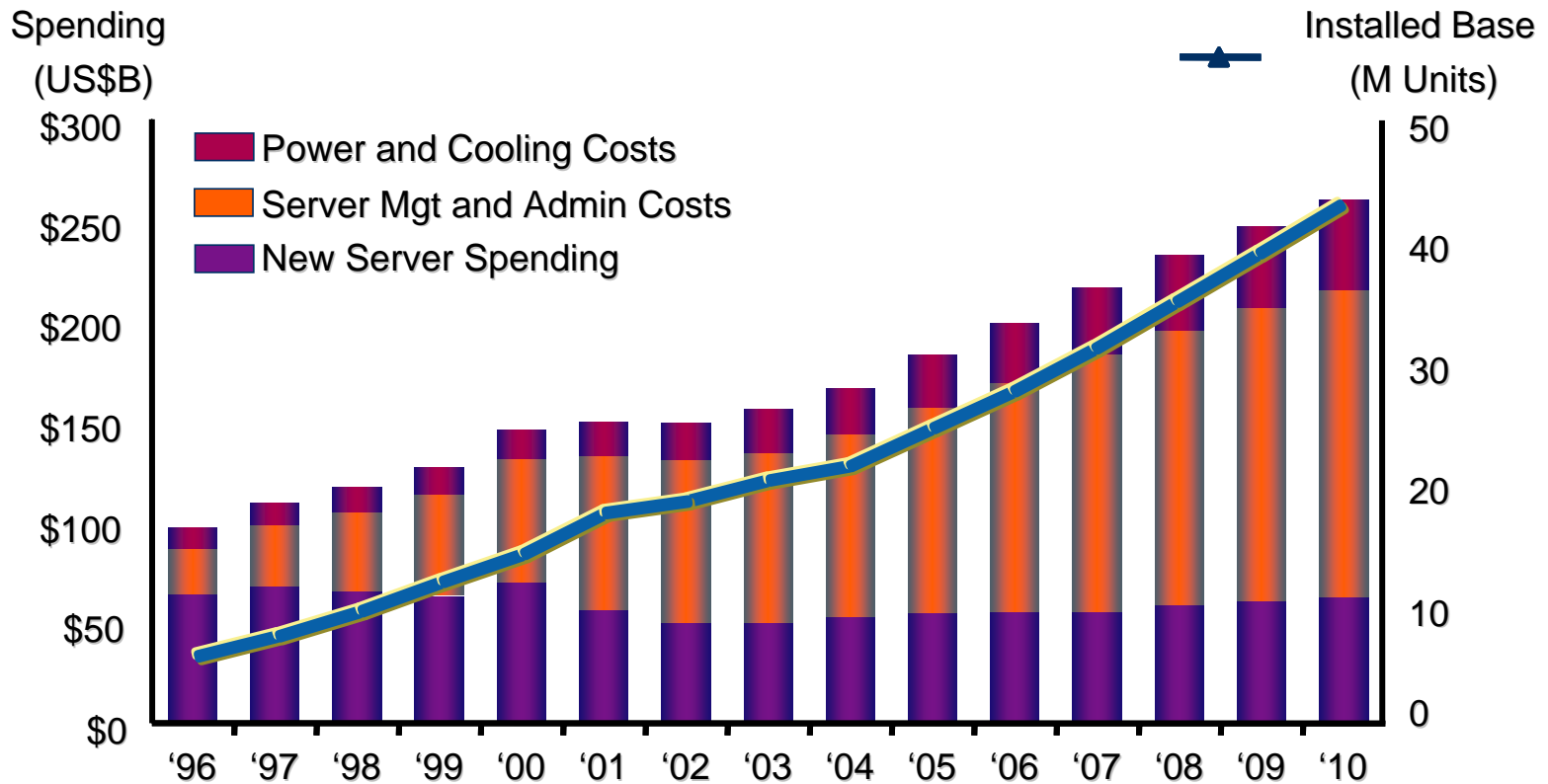
Reducing Power and Cooling

- Demand Based Switching

  – Dynamically reduce processor power consumption during low utilization periods

  – Works in conjunction with the OS

  – Helps end-users save on power & cooling costs

- 1/2 the Power and 1/2 the heat per processor of the IBM Mainframe z9 S94*

Increasing Processor Power Efficiency

Investment Protection
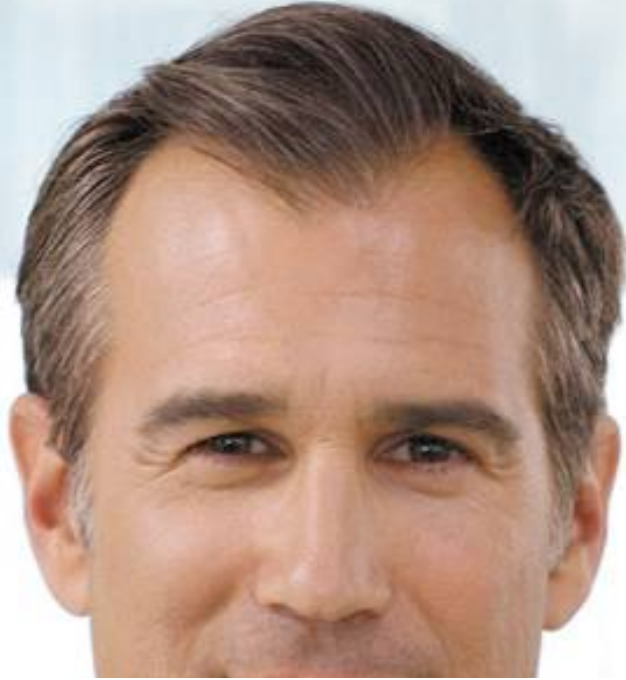
Intel Advantages

Open Industry Standard

Technology Leadership

Product Advantage

Mainframe Versus Industry Standard

Traditional Proprietary Stack
(Mainframe)

Industry Standard Choice
(Intel® Itanium Solutions)

Services

Solutions

OS

Hardware

Closed

CPU Centric Solutions
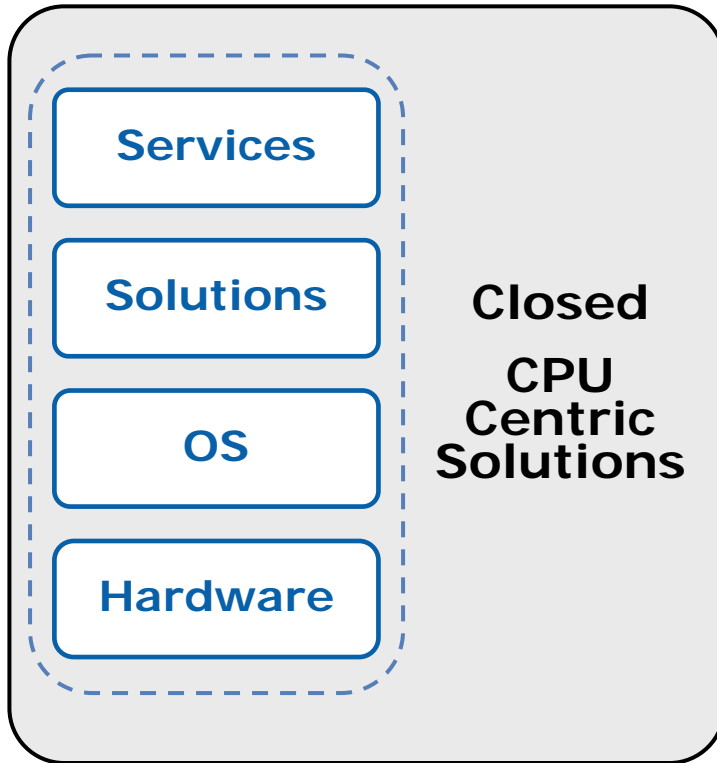
Choice, Flexibility & Value

Services

Open Ecosystem & Solutions

Multiple Operating Systems

Multiple OEMs
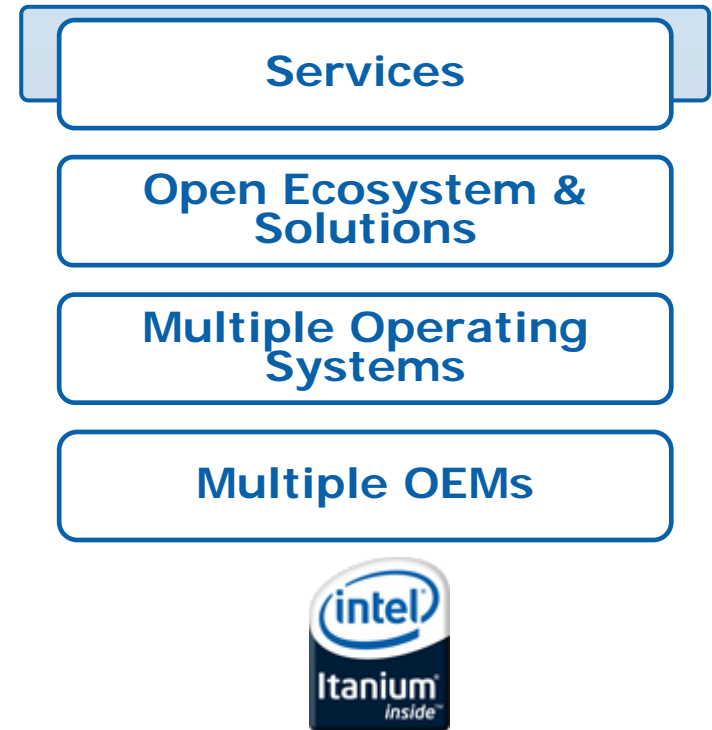
Intel Offers Better Investment Protection and Costs Savings through Open Standards

Growing Itanium® Momentum

Itanium® System Revenue : $1B of system revenue / quarter
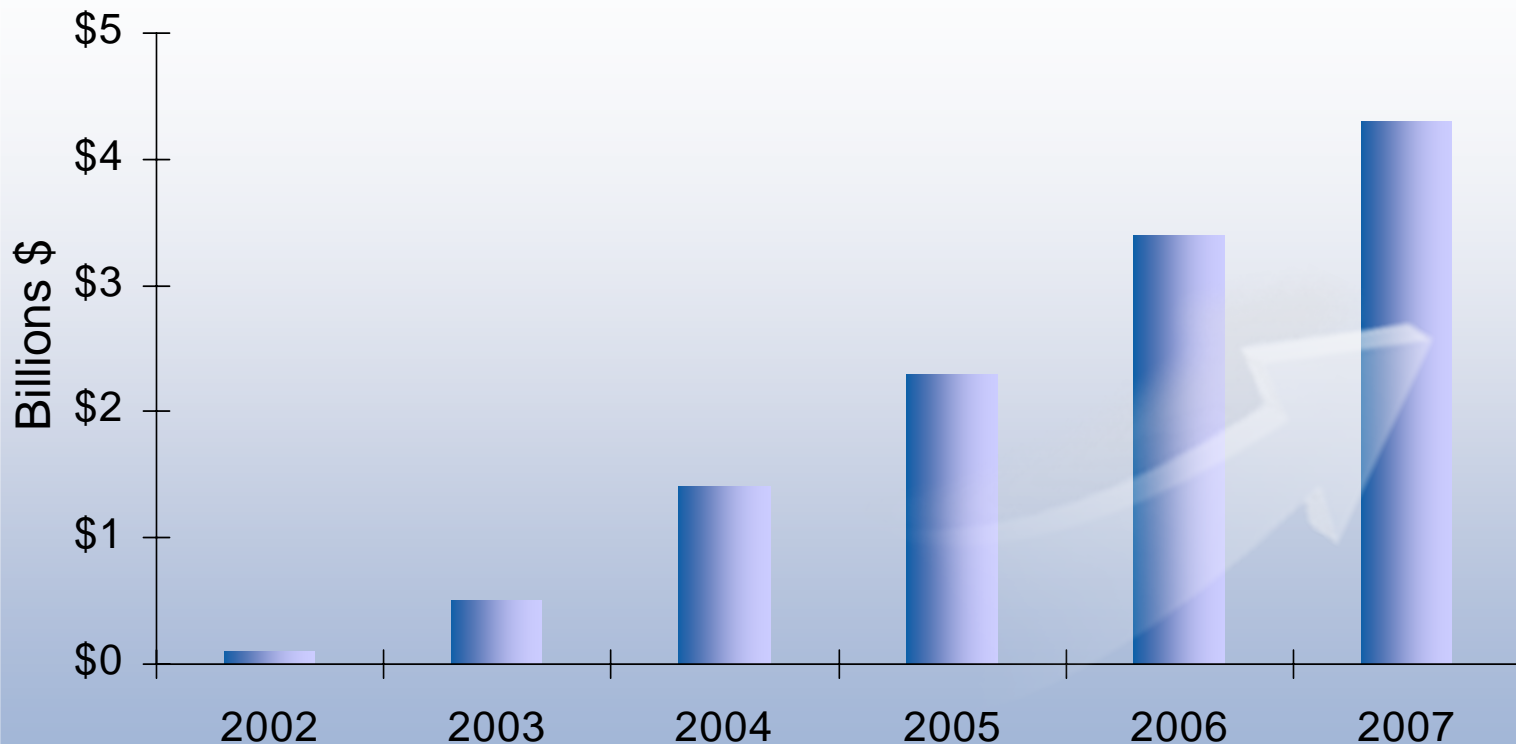
Source: IDC Worldwide Quarterly Server Tracker, Q4'07

Strong Product Roadmap Equals Better Investment Protection

Future

Multi-core, massive caches
High-speed interconnect
Integrated memory controllers
Advanced RAS,
Enhanced virtualization
Chipset design synergies

Kittson

Poulson

Tukwila

Dual-Core Itanium® processor 9100 Series

Increasing value in RISC/Mainframe segment:

Higher Performance, Better RAS, Lower TCO

Intel Technology Advantage

"Tick-Tock" development model provides consistent, predictable platform innovation with decreased risk

45nm manufacturing process leadership today, with two 45nm fabs running today, and an additional two more coming online in 2008

(intel)

Why Does Process Matter?

Scientific Breakthrough:

"The implementation of high-k metal materials marks the biggest change in transistor technology since ... the late 1960s."

– *Gordon Moore*

Silicon Advances Deliver:

- More transistors for new features and capabilities
- Higher performance
- Lower power consumption (switching and leakage)
- Smaller footprint

Intel Today

45nm in 2007
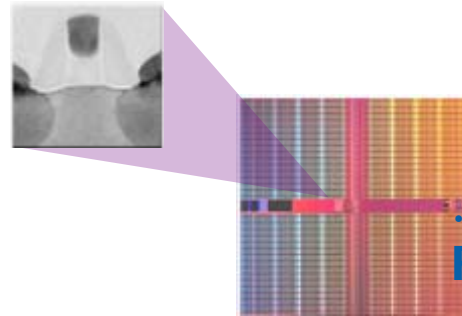
Transistor performance

20%

...and in the Future

32nm in 2009

Transistor performance

Switching power

30%

...relative to Intel 65nm process

Switching power

(intel)

Tick-Tock: Predictable Model for Sustained Microprocessor Leadership

Intel® Core™	Penryn	Nehalem	Westmere	Sandy Bridge
NEW Microarchitecture 65nm	Compaction/ Derivative 45nm	NEW Microarchitecture 45nm	Compaction/ Derivative 32nm	NEW Microarchitecture 32nm
Tock	Tick	Tock	Tick	Tock

Montecito/ Montvale		Tukwila		Poulson
NEW Microarchitecture		NEW Microarchitecture		NEW Microarchitecture

Forecast

All dates, product descriptions, availability and plans are forecasts and subject to change without notice.

High Volume Manufacturing a key Competitive Advantage

Oregon
AFO, F20, D1C

Colorado
Fab 23

Mass.
Fab 17

California
D2

Arizona
Fab12/22

New Mexico
Fab 11/11X

Costa Rica
San Jose A/T

Ireland
IFO/F24

Israel
Fab 8/18

China
Chengdu A/T

China
Shanghai A/T

Philippines
Cavite A/T

Malaysia
Penang A/T
Kulim A/T

Current as of 2/17/05
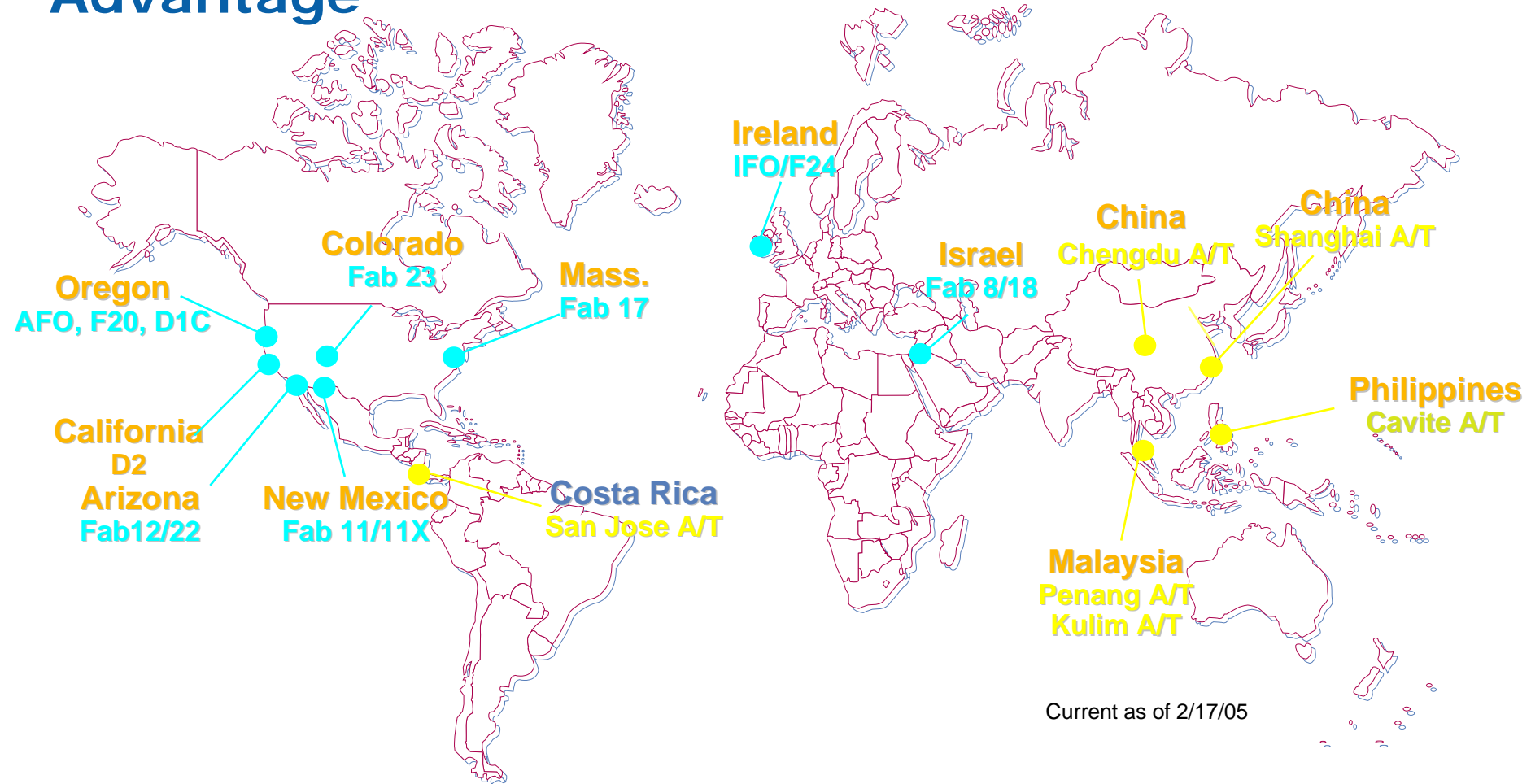
Itanium® processors benefit from manufacturing plants amortized over Intel's PC, mobile and Xeon™ processor volumes

(intel)

Migration Best Practices

Common Migration Paths

Application → Compile → **IA Server**

Port and Recompile
- Translate the source code into object code exercisable on Intel architecture

Old App

Emulation SW

Compile

IA Server
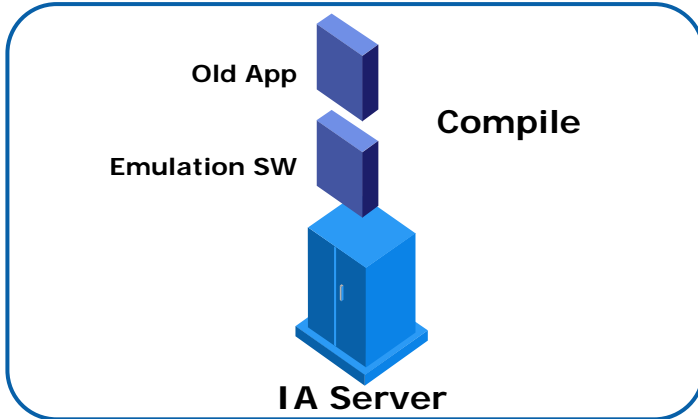
Emulation
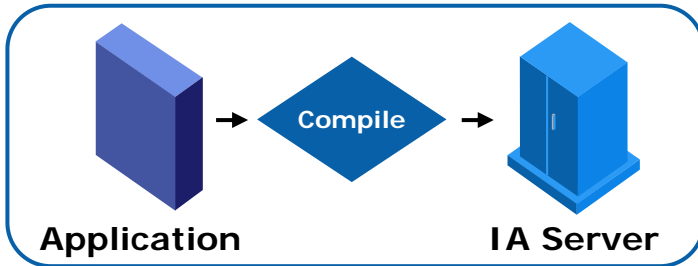- Run software applications on Intel architecture without any source code of binary change

New App

Application   **IA Server**
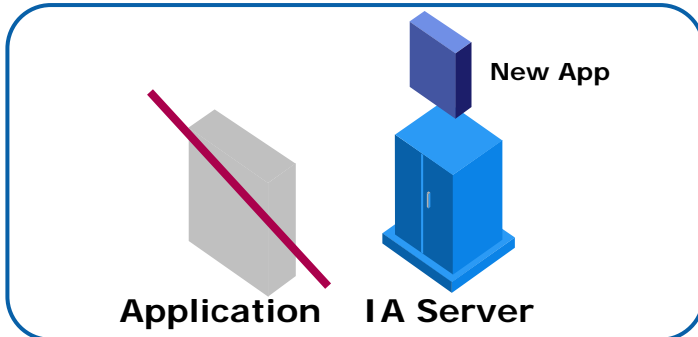
Retire and Replace
- Inefficiencies from old source code written in older programming languages
- Deploy new application written and optimization for new architecture

(intel)

Summary : A Better Alternative

- **Reliability and Security**
- **Performance and Scalability**
- **Cost Savings through Choice**
- **Investment Protection**

Further Reading:

Mainframe Migration TCO Study
http://www.alinean.com/PDFs/Intel-Mainframe_Migration-TCOStudy.pdf

Arabian Automobiles Case Study
http://h71028.www7.hp.com/ERC/downloads/4AA1-6655ENW.pdf

Virtualization on Itanium: Intel enables Choice and Flexibility for Customers
ftp://download.intel.com/products/processor/itanium/IDC_Whitepaper.pdf

Where will you invest tomorrow?

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Intel® Itanium® Processor Family Public Roadmap

Processor Generation	Intel® Itanium® Processor 9000, 9100 Series	Tukwila	Poulson	Kittson
Highlights	Dual Core	Quad Core	Ultra Parallel Micro-architecture	
New Technologies	• On-die 24MB cache • Hyper-Threading Technology • Intel® Virtualization Technology • Intel® Cache Safe Technology • Lock-step data integrity technologies (9100 series) • DBS Power Management Technology (9100 series)	• Large On-Die Cache • High speed point-to-point QuickPath interconnect • Integrated QuickPath memory controllers • Advanced RAS • Enhanced virtualization • Common chipset with Intel® Xeon® processor MP	• Advanced multi-core architecture • Multi-threading enhancements • Instruction-level advancements • 32nm process technology • Large On-Die Cache • New RAS features • Compatible with Tukwila platforms	9th Itanium® Product
Targeted Segments	*Enterprise Business (Database, Business Intelligence, ERP, HPC, …)*			
Availability	2006-07	End 2008	Future	Future

(intel)