



IBM System z

History and Evolution of IBM Mainframes



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Simplify your IT.

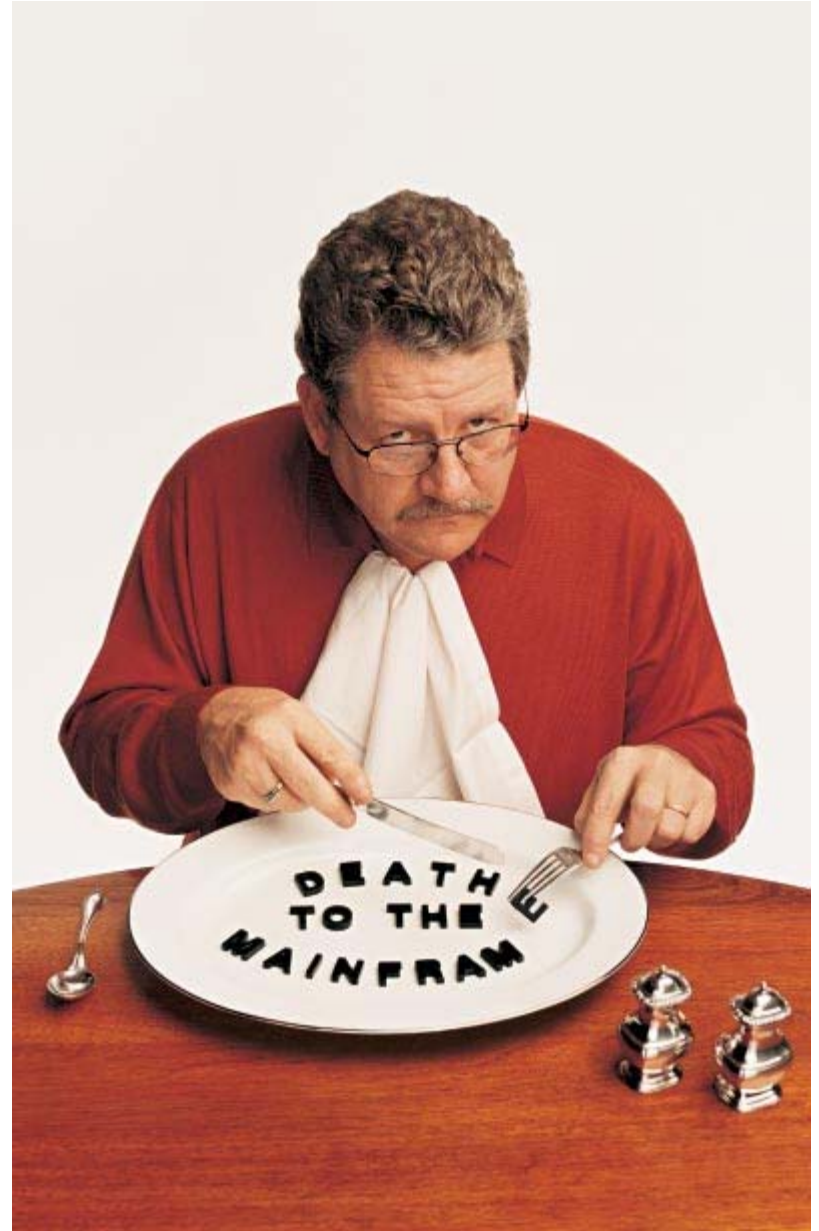
Mainframe 101

- **The name given to a large, powerful computer system that was used by all of the major companies of the world to run their computerized business systems – central “glass house” data center**
- **Mainframe perceptions emerging over many years include –**
 - Highest quality of service
 - Professionally managed and run
 - High cost
 - Slow to bring in a new applications
- **Early 1990s – Mainframe became a dirty word**
 - UNIX and Client/Server offer the “downsized” solution
 - Many declare the Mainframe as dead a dinosaur
- **But all this was before 1994 when IBM started to ‘modernize’ S/390**

Reports of the death of the mainframe were premature

- **“I predict that the last mainframe will be unplugged on March 15, 1996.”**
 - Stewart Alsop, March 1991
- **“It’s clear that corporate customers still like to have centrally controlled, very predictable, reliable computing systems – exactly the kind of systems that IBM specializes in.”**
 - Stewart Alsop, February 2002

Source: IBM Annual Report 2001



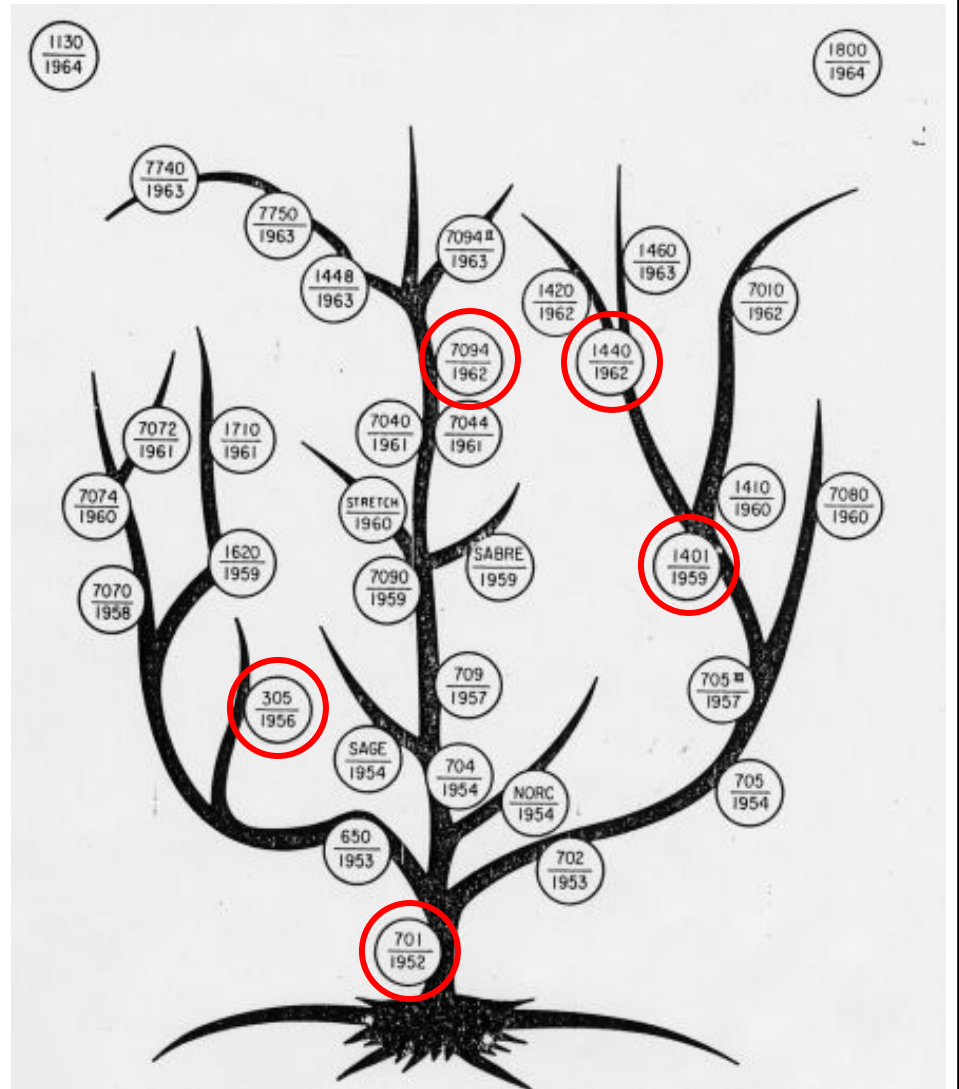


IBM System z

In the Beginning – The First Two Generations

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- **Several mainframe families announced, designed for different applications**
- **Every family had a different, incompatible architecture**
- **Within families, moving from one generation to the next was a migration**
 - Common compilers made migration easier – COBOL and FORTRAN



IBM 701 – 1952

1st generation

- The first IBM large-scale electronic computer manufactured in quantity
- IBM's first commercially available scientific computer
- The first IBM machine in which programs were stored in an internal, addressable, electronic memory
- The first of the pioneering line of IBM 700 series computers, including the 702, 704, 705 and 709

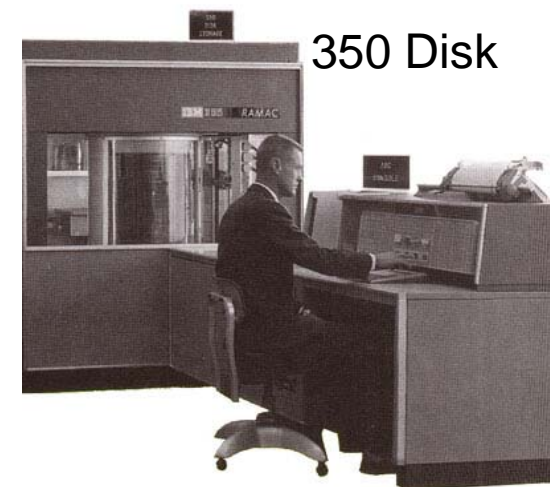


701

IBM 305 RAMAC – 1956

1st generation

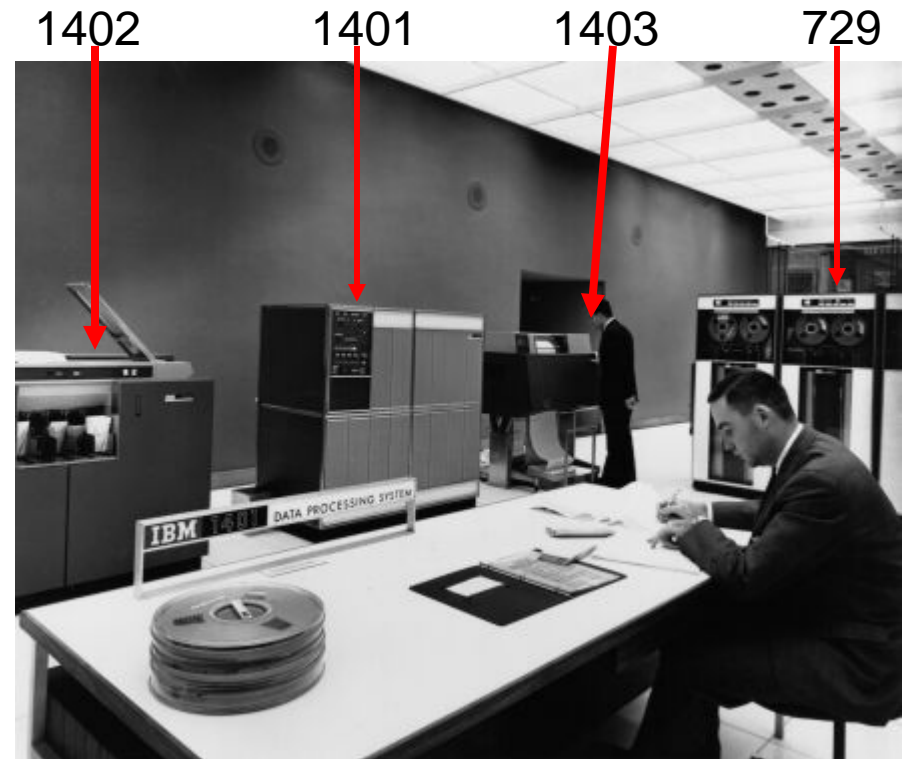
- The first computer to include a disk drive (named the IBM 350 Disk File)
- Prior to this magnetic computer storage had consisted of core memory, tape, and drums
- The 350 Disk File consisted of a stack of fifty 24" discs
- The capacity of the entire disk file was 5 million 7-bit characters, which works out to about 4.4 MB in modern parlance



IBM 1401 – 1959

2nd generation

- The all-transistorized IBM 1401 Data Processing System placed the features found in electronic data processing systems at the disposal of smaller businesses, previously limited to the use of conventional punched card equipment
- These features included: high speed card punching and reading, magnetic tape input and output, high speed printing, stored program, and arithmetic and logical ability



IBM 7094 – 1962

2nd generation

- Built for large-scale scientific computing
- Compatible with the IBM 7090, the advanced solid-state IBM 7094 offered substantial increases in internal operating speeds and functional capacities
- New expanded functions provided with the IBM 7094 were: double-precision floating-point operations and seven index registers

7094





IBM System z

The April 1964 Revolution – *3rd generation*



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During the 1950s, Data Processing came of age

- Data Processing machines existed – sorters, collators, tabulators
- "Computers" were devoted almost entirely to the processing of computationally intensive tasks
- Demand for computers, as data processing machines, boomed and new machines were built to meet this demand
- Customers were getting very frustrated with migration costs that came with processor upgrades

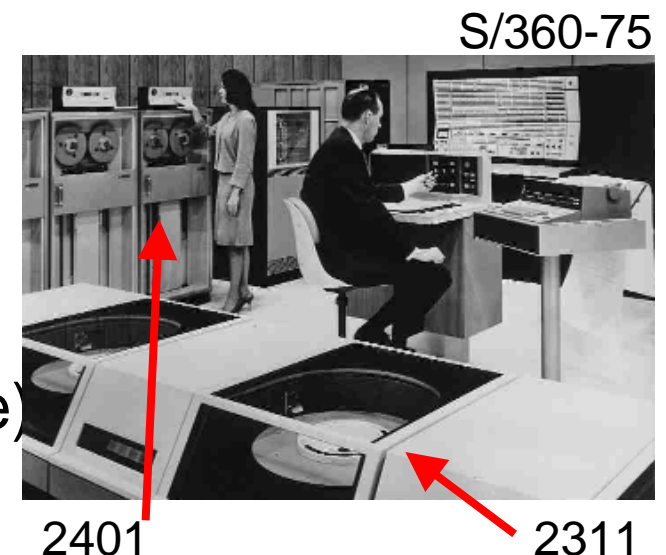
**"[System/360] was the biggest, riskiest
decision I ever made, and I agonized
about it for weeks, but deep down I believed
there was nothing IBM couldn't do."**

*Father, Son & Co. 1990
Tom Watson, Jr.
IBM President 1952
IBM President and CEO 1956
IBM Chairman and CEO 1961-1971*



System/360 – Announced April 7, 1964

- IBM decided to implement a wholly new architecture specifically designed both for data processing and to be compatible across a wide range of performance levels
- IBM invested \$5B to develop a family of five increasingly powerful computers that run the same operating systems and can use the same 44 peripheral devices with the same architecture
 - Architecture published in the S/360 Principles of Operation
 - 24-bit addressing (32-bit architecture)
 - Solid logic circuit cards



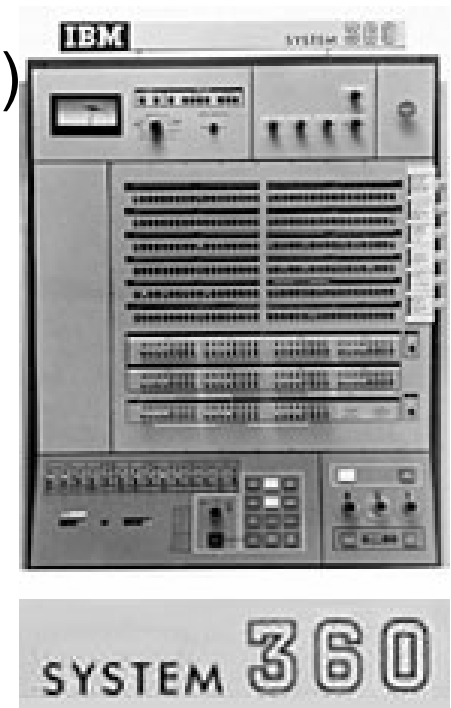
System/360 – a child is born

■ Hardware

- One main storage, maximum size is 16MB
- One or two Central Processing Units (CPUs)
- One to seven Channels
 - Selector or Byte Multiplexor
 - Block Multiplexor
- Control Units (which connect to Channels)
- Devices (which connect to Control Units)

■ Family of operating systems

- Operating System/360 (OS/360)
- Disk Operating System/360 (DOS/360)
- TOS, BPS, ...
- ACP



Core Memory



S/360 family

Model	Announced	First Shipped	
30	April 7, 1964	June, 1965	
40	April 7, 1964	April, 1965	
50	April 7, 1964	August, 1965	
20*	November 18, 1964	April, 1966	
65	April 22, 1965	November, 1965	
75	April 22, 1965	January, 1966	
44	August 16, 1965	June, 1966	
67	August 16, 1965	May, 1966	Virtual storage
91	January 18, 1966	October, 1967	
25	January 3, 1968	October, 1968	
85	January 30, 1968	December, 1969	High speed cache
195	August 20, 1969	March, 1971	

System/360 Model 20

1966

- Special purpose
“entry level” S/360
- 24K of core memory
- Half the registers of other models
- Instruction set that was not binary-compatible with the rest of the S/360 family
- Popular as an RJE workstation



System/360 Model 67

- **First IBM system with virtual storage capabilities**
 - S/360 Model 65 with addition of the Dynamic Address Translation facility
- **Operating systems**
 - Time Sharing System –
The “official” operating system from IBM Data Systems Division
 - Control Program/67 with the Cambridge Monitor System –
The “unofficial” operating system from the IBM Cambridge Scientific Center

S/360-67



“DAT box”

System/370 – Announced June 30, 1970

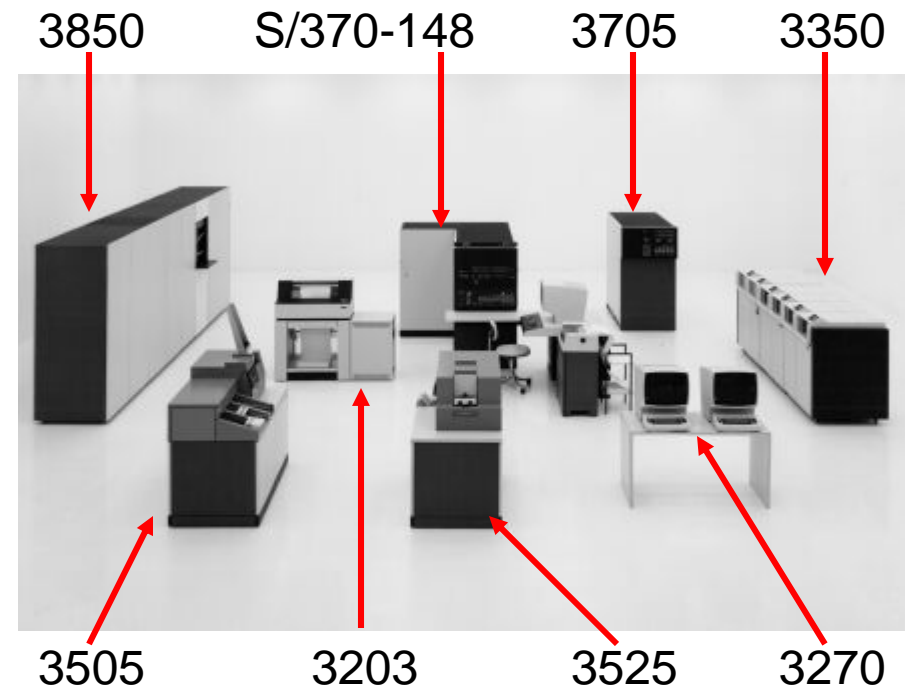
- **Compatible upgrade from S/360**
- **370 Model 145 is the first computer with fully integrated monolithic memory (circuits in which all of the same elements – resistors, capacitors and diodes – are fabricated on a single slice of silicon) and 128-bit bipolar chips**
- **New peripherals**
 - 3330/3340/3350 disk
 - 3211 printer

"We are confident that the performance of System/370, its compatibility, its engineering and its programming will make it stand out as the landmark for the 1970s that System/360 was for the Sixties."

Tom Watson, Jr.
IBM Chairman and CEO
1961-1971

System/370 with Virtual Storage – Announced August 2, 1972

- Compatible upgrade from S/370 with virtual storage
- First multiprocessor models (158MP, 168MP)
- Family of operating systems
 - OS/360 → OS/VS
 - DOS/360 → DOS/VS
 - CP/67 → VM/370



S/370 – the architecture matures

- **Virtual storage**
 - 2KB or 4KB pages of memory
 - 64KB or 1MB segment sizes
 - Translation of virtual addresses to real addresses using Dynamic Address Translation (DAT) logic
 - Segment tables point to page locations
- **Channel architecture**
 - 256 channels
- **CPU changes**
 - Extended MP support via CPU address



3033



3031

S/370 family

	Model	Announced	First Shipped	Replacement
	155	June 30, 1970	January, 1971	158
	165	June 30, 1970	April, 1971	168
	195	June 30, 1970	August, 1973	
Virtual storage capable models	145	September 23, 1970	June, 1971	148
	135	March 8, 1971	April, 1972	138
	158	August 2, 1972	April, 1973	3031
	168	August 2, 1972	May, 1973	3033
	125	October 4, 1972	April, 1973	4331/4361
	115	March 13, 1973	March, 1974	4331/4361
	138	June 30, 1976	November, 1976	4341/4381
	148	June 30, 1976	January, 1977	4341/4381

System/370 with Extended Architecture

- **Evolution of S/370**
- **3081 introduced Thermal Conduction Modules**
- **New peripherals**
 - 3800 printer
 - 3370/3380 disk
 - 3480 tape
- **Family of operating systems**
 - OS/VS → MVS/SP → MVS/XA
 - DOS/VS → VSE/SP
 - VM/370 → VM/SP, VM/SP HPO
 - VM/370 → VM/XA MA → VM/XA SF → VM/XA SP

3083



370-XA – radical surgery for the architecture

- **Extended storage addressing**
 - 24-bit or 31-bit addressing
 - 4KB pages in 1MB segments
- **Interpretive execution facility**
 - Start Interpretive Execution (SIE) instruction
 - SIE runs until interception condition raised
 - Used by VM/XA
 - Multiple High Performance Guest Support Facility (MHPGSF) to support V=F guests on VM/XA SP
 - Rename Processor Resource/Systems Manager (PR/SM) when Logical Partitions (LPAR) announced
- **370-XA channel design**
 - CHPIDs
 - Subchannels

System/370 with Enterprise Systems Architecture

- **Extension of 370-XA**
 - Expanded Storage
 - Multiple 31-bit address spaces
- **Common set of peripheral devices**
 - 3390 disk
 - 3490 tape
- **Family of operating systems**
 - MVS/XA → MVS/ESA
 - VSE/SP → VSE/ESA
 - VM/XA SP → VM/ESA

3090



System/390 with Enterprise Systems Architecture – Announced September 1990

9672-G5



- **Evolution of ESA/370**
- **1994 – S/390 Parallel Transaction Server**
 - Family of CMOS processors
- **1998 – System/390 Generation 5 server – more than 1,000 MIPS**
- **1999 – System/390 Generation 6 server – copper chip technology**
- **Common set of peripheral devices**
 - RAMAC, Enterprise Storage Subsystem disk
 - 3590 Magstar tape
- **Family of operating systems**
 - MVS/ESA → OS/390
 - VSE/ESA
 - VM/ESA
 - Linux for S/390 (December 1999)

ES/9000



S/370 to ES/9000

115/125



4331 → 4321



4361



9370

▼ upgrade

9221

138/148



4341



4381

▼ upgrade

4381-E



9121

158/168



3031/3032/3033



3081/3083/3084



3090

▼ upgrade

9021

Parallel Transaction Server to G6

1994-04-06	9672-Enn, 9672-Pnn	Parallel Transaction Server
1994-09-13	9672-Rn1	Parallel Enterprise Server
1995-06-12	9672-Rn2, 9672-Rn3	
1996-09-10	9672-Rn4	G3
1996-09-10	2003	Multiprise 2000
1997-06-09	9672-Rn5	G4
1998-06-23	9672-nn6	G5
1999-09-20	7060	Multiprise 3000
1999-05-03	9672-nn7	G6



zSeries with z/Architecture – Announced October 2000

- **Evolution of ESA-390**
 - 24-bit, 31-bit, and 64-bit addressing supported concurrently
 - z900 – up to 16 processors
 - z800 – up to 4 processors
 - Linux-only model in January 2002
 - General purpose model in February 2002
 - Integrated Facility for Linux on z900/z890
- **Family of operating systems**
 - OS/390 → z/OS
 - VSE/ESA → z/VSE
 - VM/ESA → z/VM
 - TPF → z/TPF
 - Linux for S/390 → Linux for zSeries

zSeries 900



zSeries Enhanced

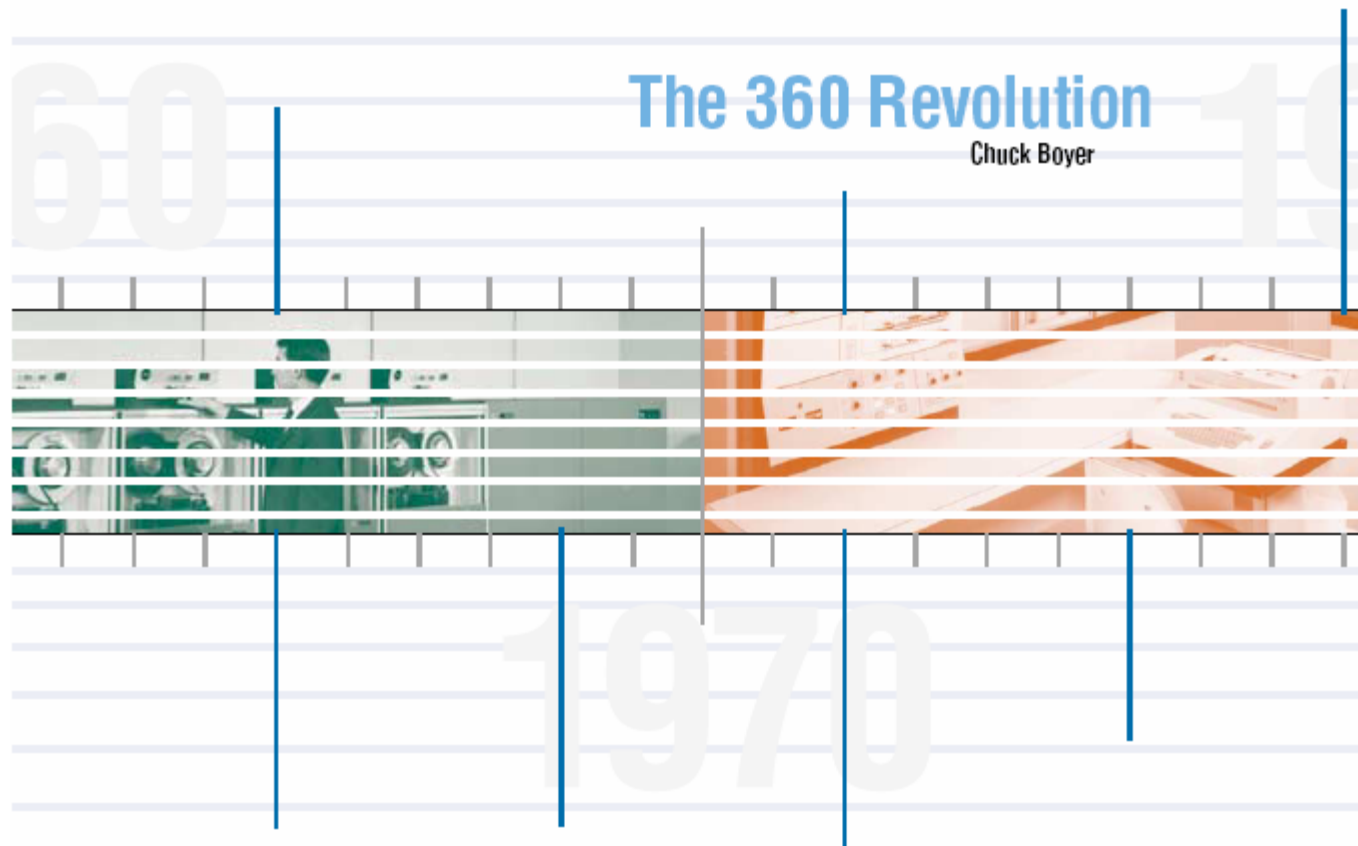
- **May 2003**
 - z990 – up to 32 processors – configurable as CPs, IFLs, SAPs
 - Up to 256GB memory
- **October 2003**
 - The Mainframe Charter
- **April 2004**
 - z890 – up to 4 configurable processors
 - zSeries Application Assist Processor
- **October 2004**
 - Crypto Express 2
- **January 2005**
 - FICON Express 2

zSeries 990



April 7, 2004 – The 40th Anniversary!

System/360 and the new world of on demand business



<http://ibm.com/eserver/zseries/timeline/>

IBM System z9

Designed to help meet the demands of enterprise of all sizes

The IBM System z9 Enterprise Class (z9 EC) and the IBM System z9 Business Class (z9 BC) deliver excellence in enterprise computing and are designed and optimized for on demand business

z9 EC



- **Built on more than 40 years of industry leadership and taking that leadership to new levels**
 - Scalability
 - Availability
 - Security
- **It's time to rethink the role of the mainframe**
 - A mainframe for everyone
 - Helping to drive increased value from data and applications including the announcing of the availability of System z9 Integrated Information Processor (zIIP)
 - Helping to simplify management and reduce costs of storage subsystems with new connectivity options



z9 BC

Now there is a System z9 for everyone

System z9 EC – Announced July 26, 2005

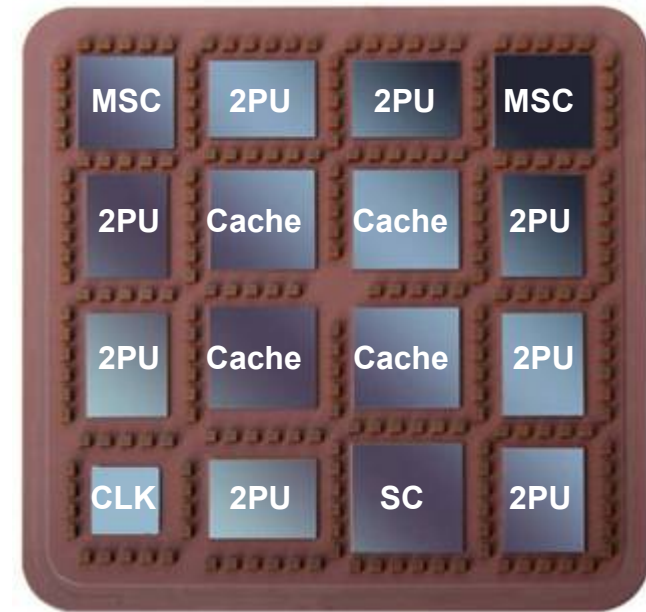
- **Capacity to meet your business objectives**
 - Capacity on demand for minimal downtime
 - Sub-capacity settings on z9 EC model S08
 - Large mainframe server in a single footprint with the S54
 - Leadership capabilities to help improve I/O access
 - Up to 64 STIs at 2.7 GB/s
 - Total system I/O bandwidth of 172 GB/s
- **Helping lower risk of downtime**
 - Leader in high availability clustering
 - Superior access to applications via comprehensive protection from unplanned and planned outages
- **Security features to help address compliance**
 - Industry certifications and regulatory compliance
 - Leadership capabilities in cryptography and encryption



z9 EC Model Structure

A flexible model structure

- **One machine type – 2094**
- **Five models – S08, S18, S28, S38, and S54**
- **Model number indicates PUs (cores) available for characterization**
 - PU characterization is identified by number of features ordered
- **1 multi-chip processor module (MCM) per book**
 - 8 processor chips/16 processors per MCM
- **2 System Assist Processors (SAPs) per book**
- **2 spares standard per server**



Models	Books	Available PUs	Max Available Sub-capacity CP PUs	Standard SAPs	Standard Spares	CP/IFL/ICF/zAAP/zIIP *****	Max Memory	Max Channels
S08*	1	12	8	2	2	8	128 GB	960 **
S18*	2	24	8	4	2	18	256 GB	1024 ***
S28*	3	36	8	6	2	28	384 GB	1024 ***
S38*	4	48	8	8	2	38	512 GB	1024 ***
S54*	4	64	8	8	2	54	512 GB	1024 ***

Notes:

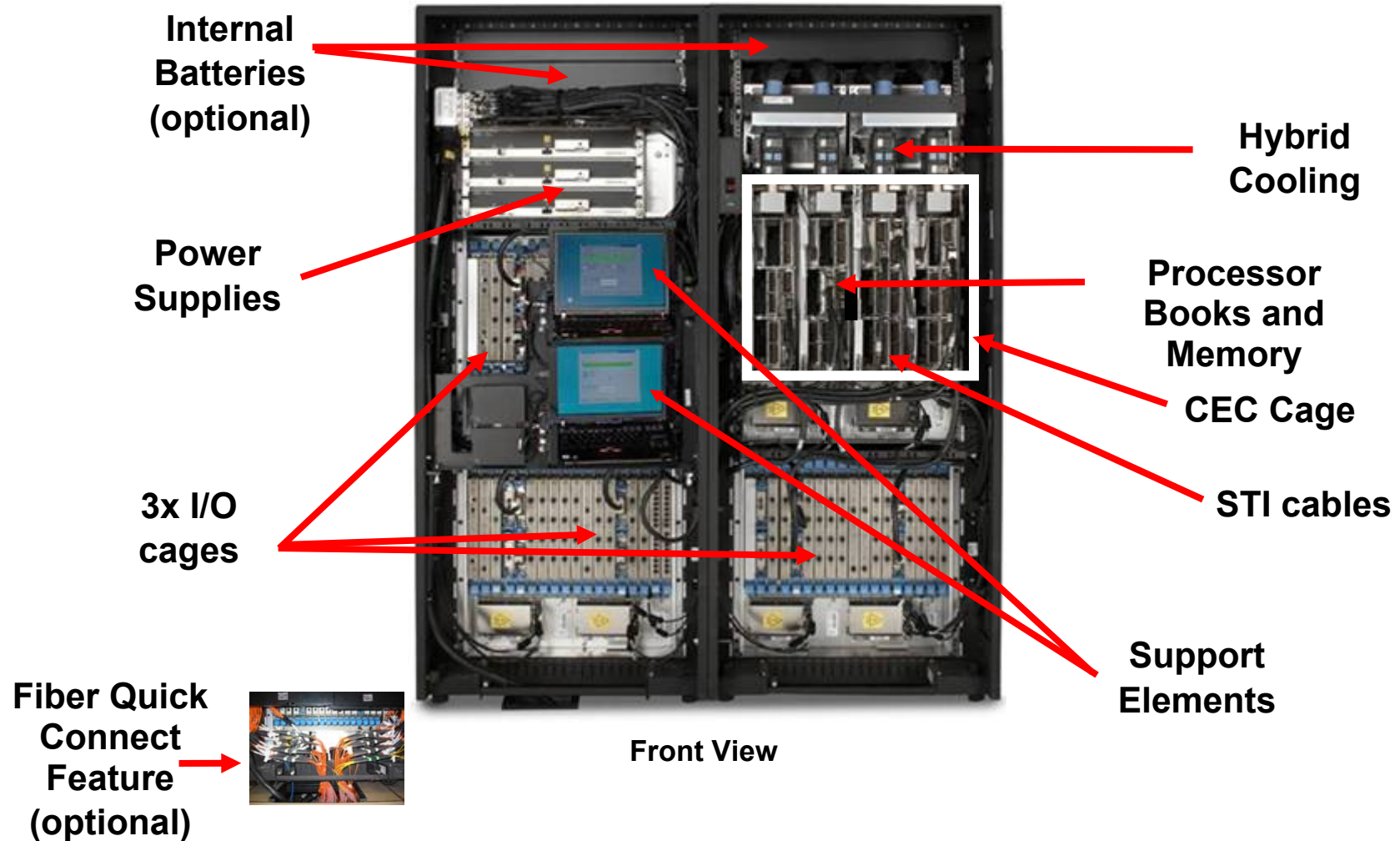
* Must have a minimum of 1 CP, IFL or ICF

** There is a max of 64 ESCON features/960 active channels and a max of 64 FICON features/256 channels on Model S08.

*** The one for one relationship of zAAP or zIIP to CP still exists, but one CP can satisfy requirement for either or both specialty engines

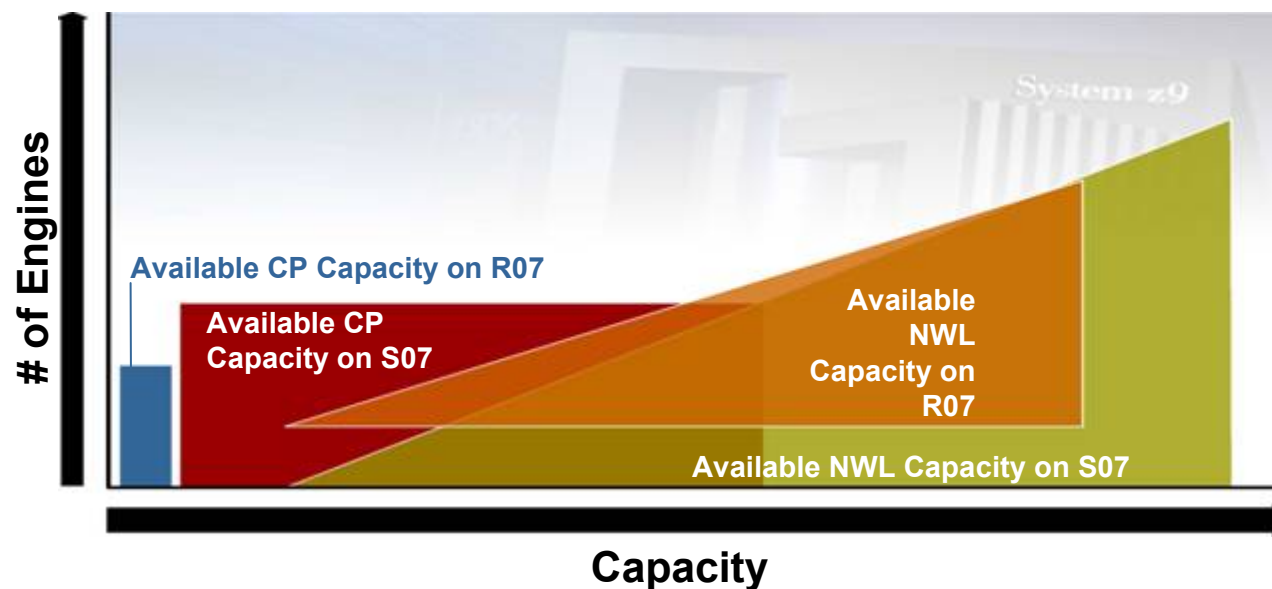
**** Maximum of 16 ICFs

z9 EC – Under the covers (Model S38 or S54)



z9 BC – Announced April 27, 2006

- Based on System z9 technology
- Designed for flexibility in 2 models
- More engines for more workloads
- On demand upgrade capability
- Single frame – available for either raised or non raised floor

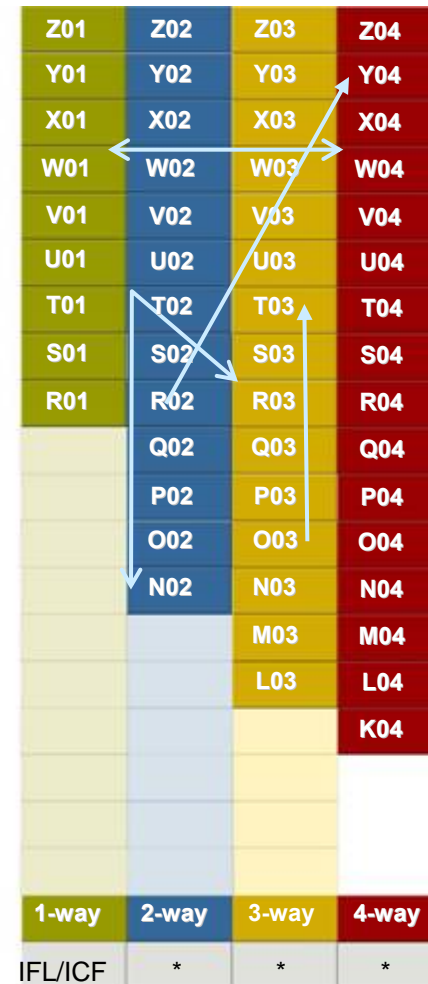
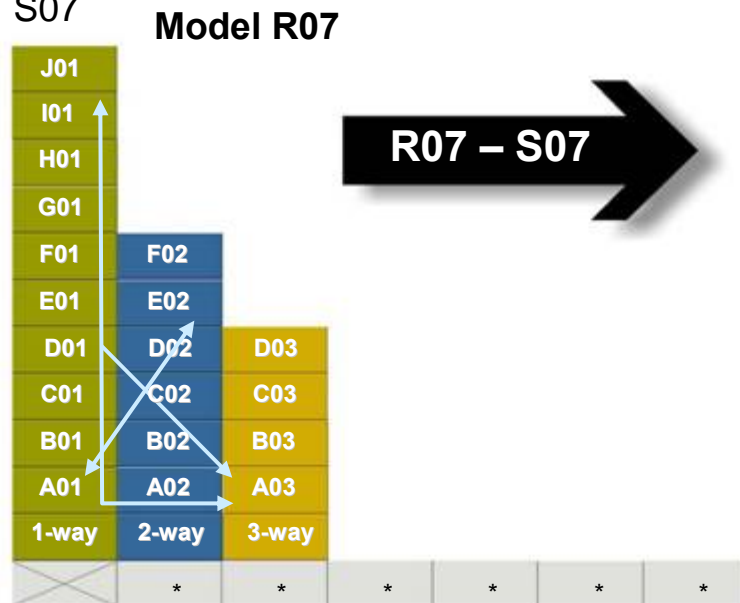


Improved granularity and scalability

A choice that is just right

z9 BC Model R07

- Low entry point
- Granularity for cost effective growth
- System z9 I/O packaging on a smaller scale
- More specialty engines compared to z890
- Any to any capacity upgradeability within the Model R07 and an upgrade path to the S07



z9 BC Model S07

- Granularity designed for flexibility and growth
- Any to any capacity upgradeability within the Model S07 and upgradeable to the z9 EC
- More specialty engines including Linux only and ICF only servers

* Specialty Engines

IBM System z9 BC model comparison

Model R07

- **Processor Units (PUs)**
 - 7 PUs + 1 SAP
 - 1 – 3 CPs
 - 0 – 3 zAAPs or zIIPs
 - 0 – 6 IFLs or ICFs
 - 20 Capacity Settings
- **Memory**
 - 8 – 64GB
- **I/O**
 - 240 ESCON
 - 64 FICON Express4
 - 32 OSA-Express2 (2-port)
 - 24 on A01
 - 8 Crypto Express2
 - 16 STIs

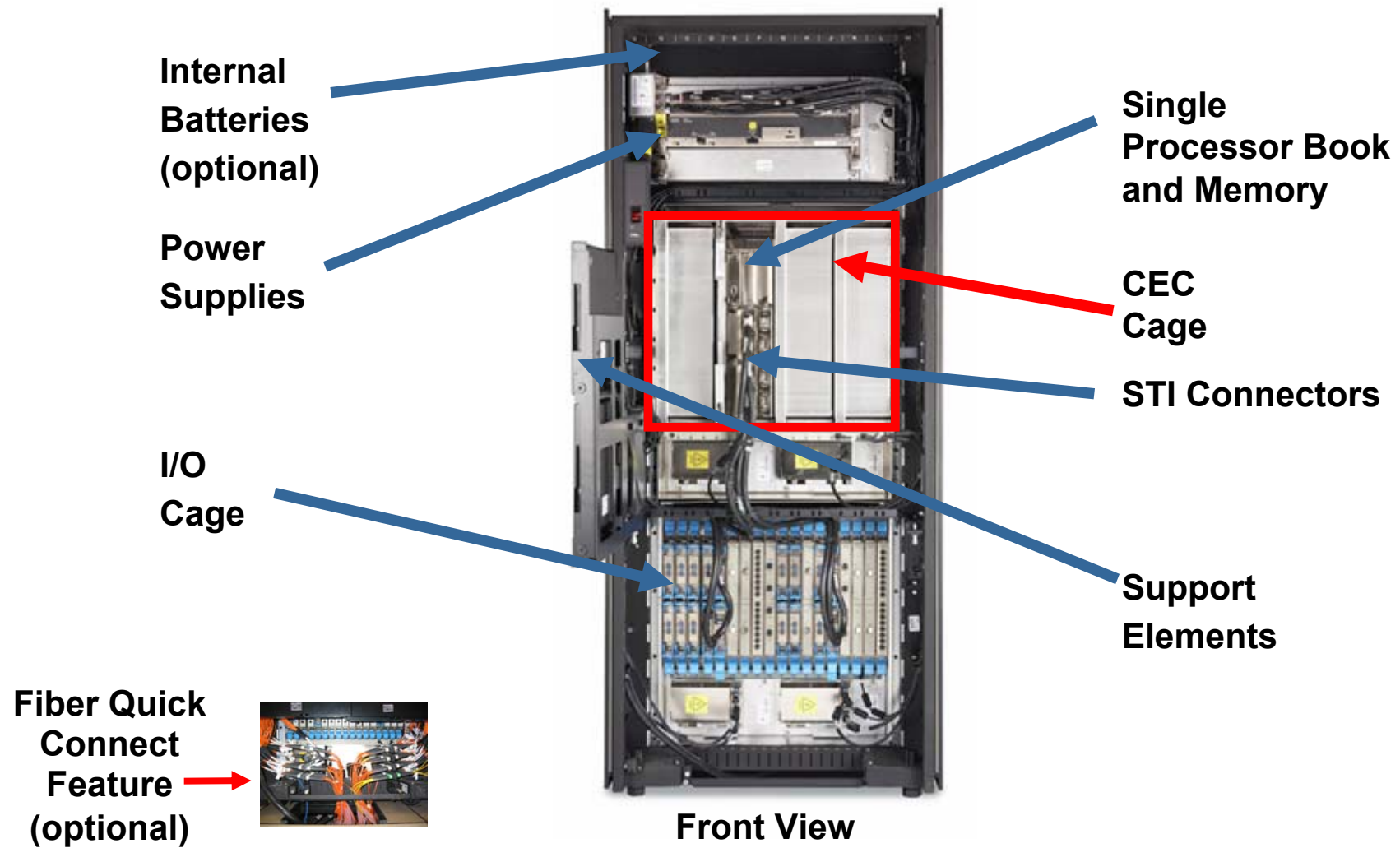


Model S07

- **Processor Units (PUs)**
 - 7 PUs + 1 SAP
 - 0 – 4 CPs
 - 0 – 3 zAAPs or zIIPs
 - 0 – 7 IFLs or ICFs
 - 53 Capacity Settings
- **Memory**
 - 8 – 64GB
- **I/O**
 - 420 ESCON
 - 112 FICON Express4
 - 48 OSA-Express2 (2-port)
 - 16 Crypto Express2
 - 16 STIs

Both models have Sub-capacity CBU CPs and Specialty Engine CBU capabilities for more robust disaster recovery possibilities

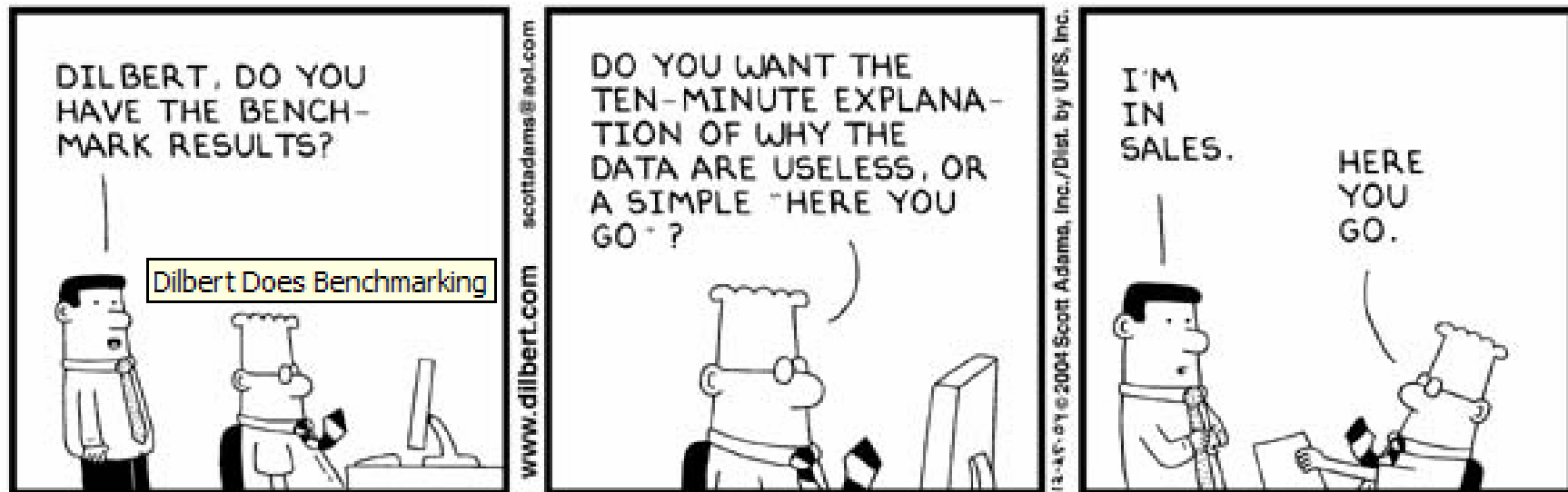
z9 BC – Under the covers



A word about performance ...

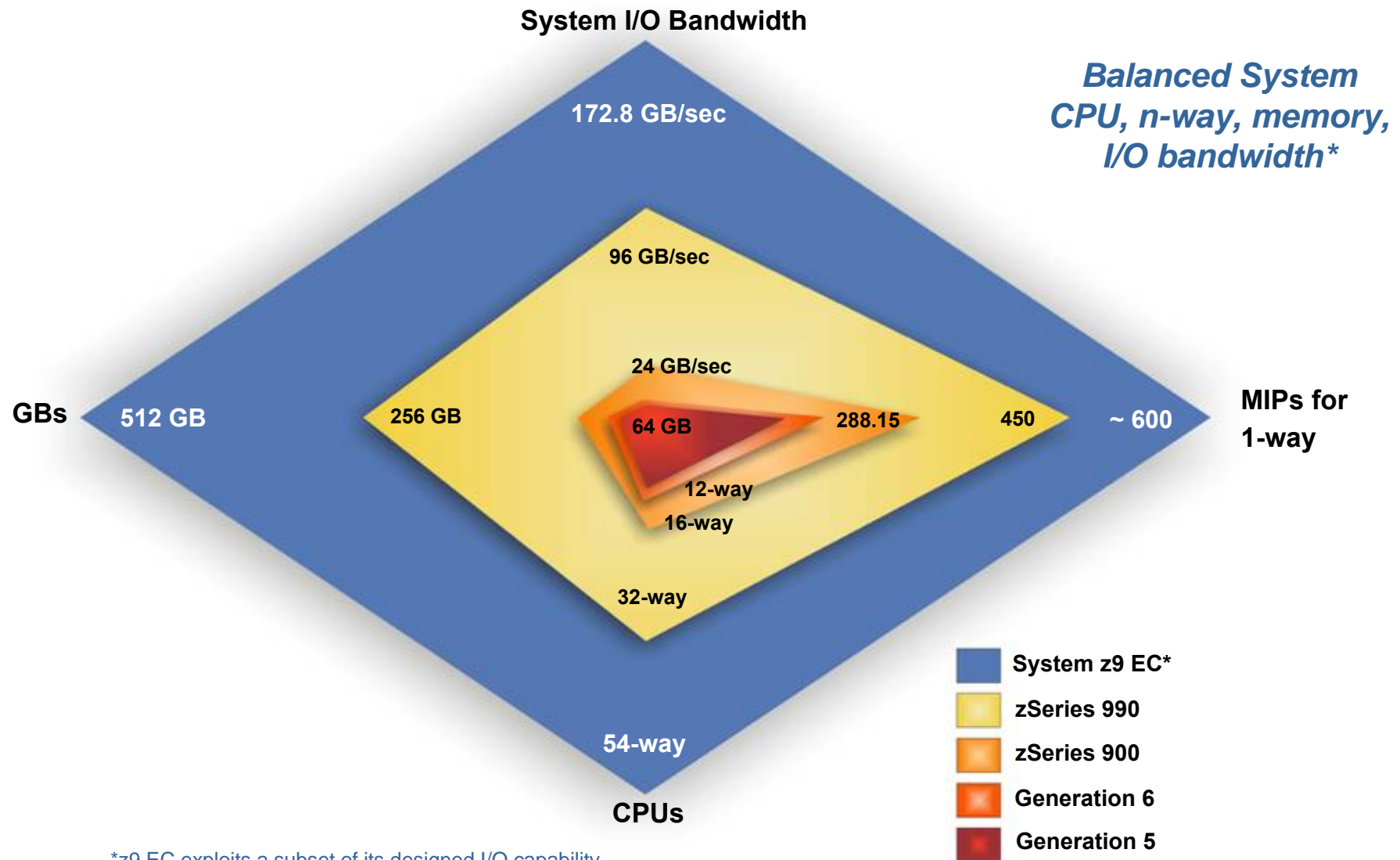
Dilbert Comments on Benchmarking

Humor



- MIPS – A meaningless indicator of performance
- Ghz is meaningless indicator of performance
- Bus speed is important to overall performance
- Balanced systems design

System z9 and zSeries: Balanced System Design



*z9 EC exploits a subset of its designed I/O capability

9672-G5 to eServer zSeries to System z9

1998-06-23	9672-nn6	G5
1999-05-03	9672-nn7	G6
2000-10-03	2064-1nn	z900
2002-04-30	2064-2Cn	z900 <i>Turbo</i>
2002-02-19	2066	z800 <i>(Linux only model 2002-01-29)</i>
2003-05-13	2084	z990
2004-04-07	2086	z890
2005-07-26	2094	System z9 EC
2006-04-27	2096	System z9 BC

Now there is a System z9 for everyone ...



... which one is right for you?

Summary

- From System/360 in 1964 to today's System z9 and zSeries, we have seen an evolution that has preserved customer investments in a unique way
- From OS/360 to MVS to OS/390 to z/OS, we have seen an evolution of the operating system that is core to most corporate IT environments
- From CP/67 as a research project and VM/370 as a migration tool, VM has evolved to today's z/VM as the core of IBM's zSeries virtualization technology
 - Virtualization is now considered “standard” in the industry and all virtualization solutions owe much to the VM family

“Legacy systems are systems that work!”

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