IBM Mainframes –
45 Years of Evolution

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The World's Most Trusted Server
MAINFRAME
2009
IBM
Commemorating 45 Years of Market Leadership

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
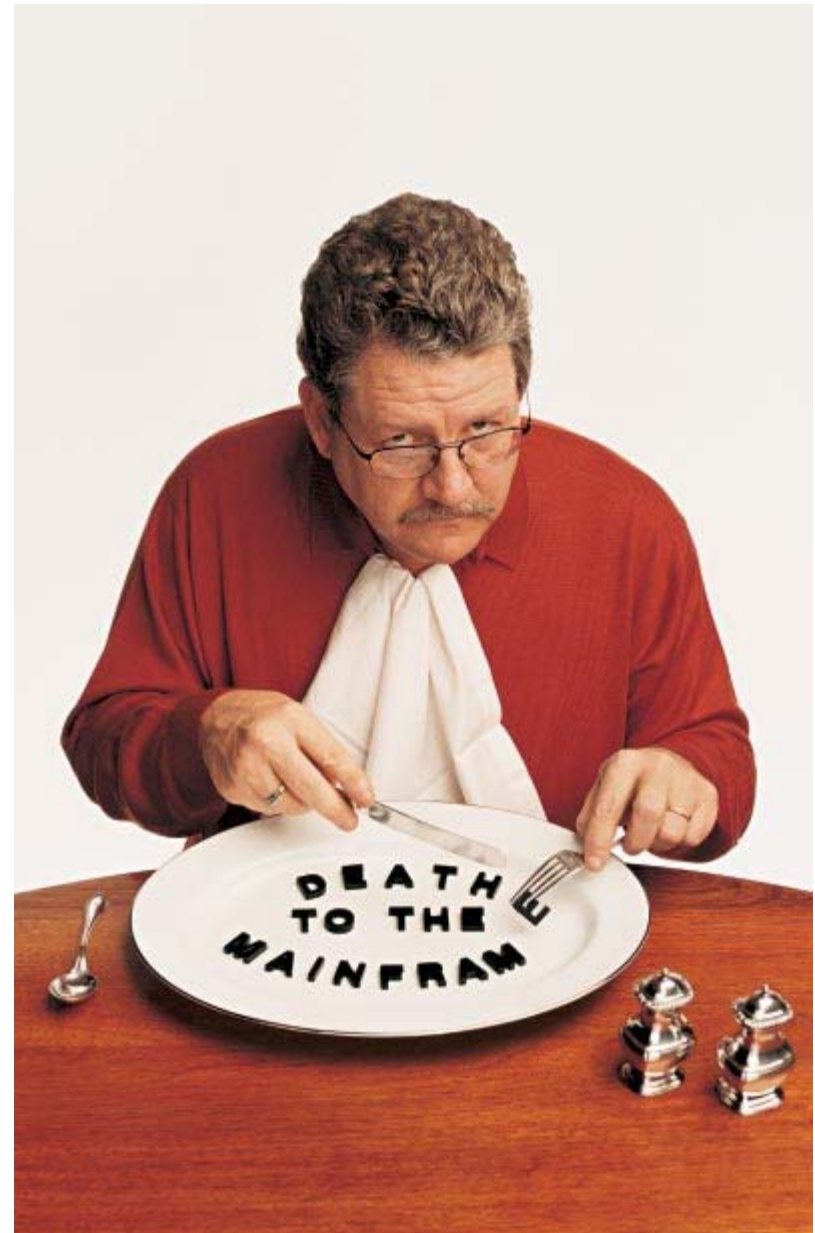
Source: IBM Annual Report 2001

In the Beginning
The First Two Generations

The family tree – 1952 to 1964

- **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
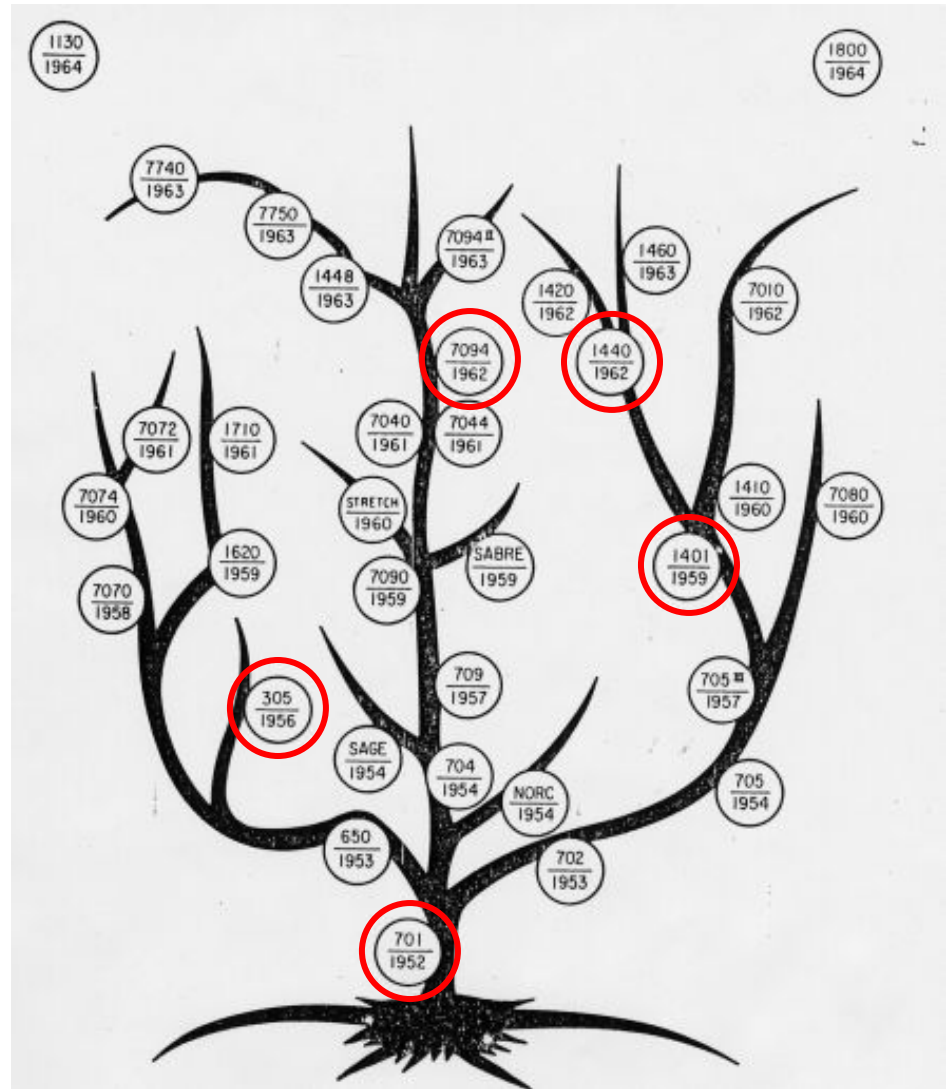
IBM 701 – 1952
1st generation

- **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 through 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**

350 Disk
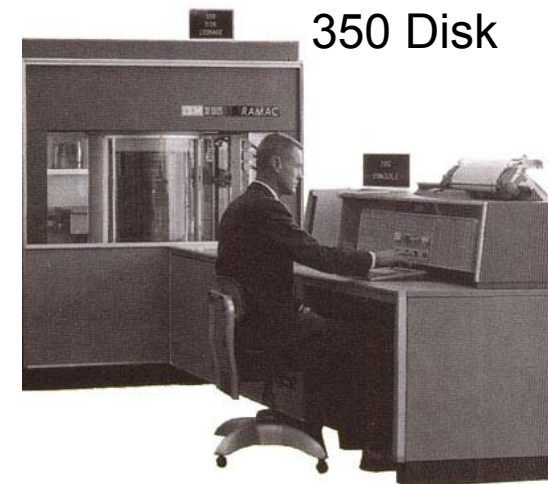
IBM 1401 – 1959
2nd generation

- **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**

1402   1401   1403   729
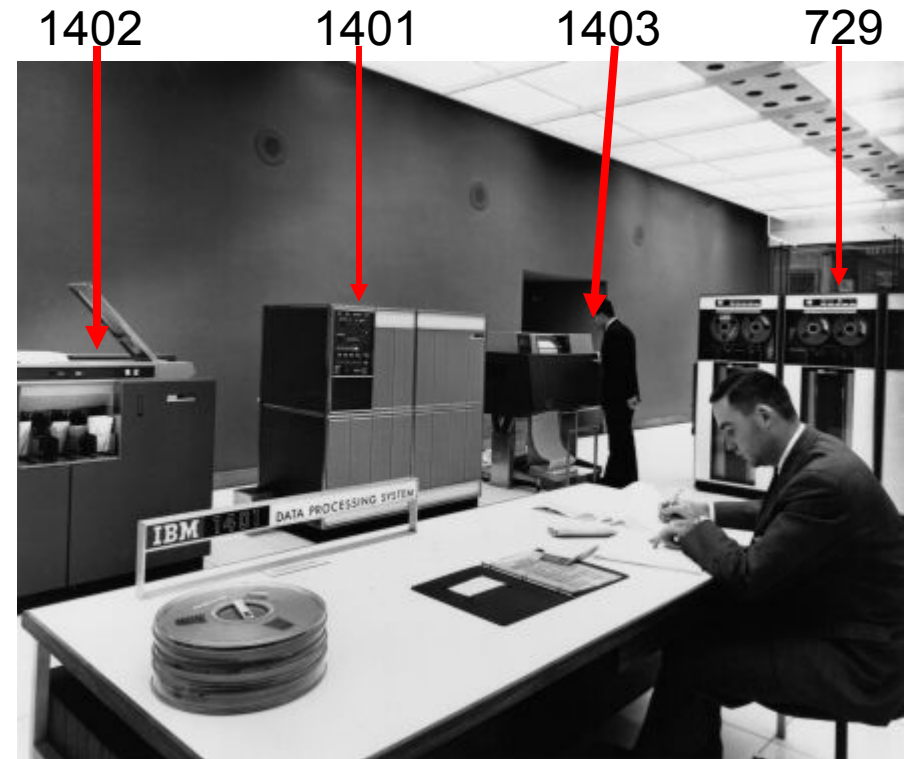
IBM 1440 – 1962
2nd generation

- **Low-cost system specifically designed to solve the increasing data handling problems of smaller volume businesses**
- **The 1440 met the need for a complete accounting system and offered the benefits of a business information system**
- **With a variety of models and special features available for the 1440, a system could be tailored to meet immediate data processing requirements and expanded to absorb increased demands**

1443   1441   1311
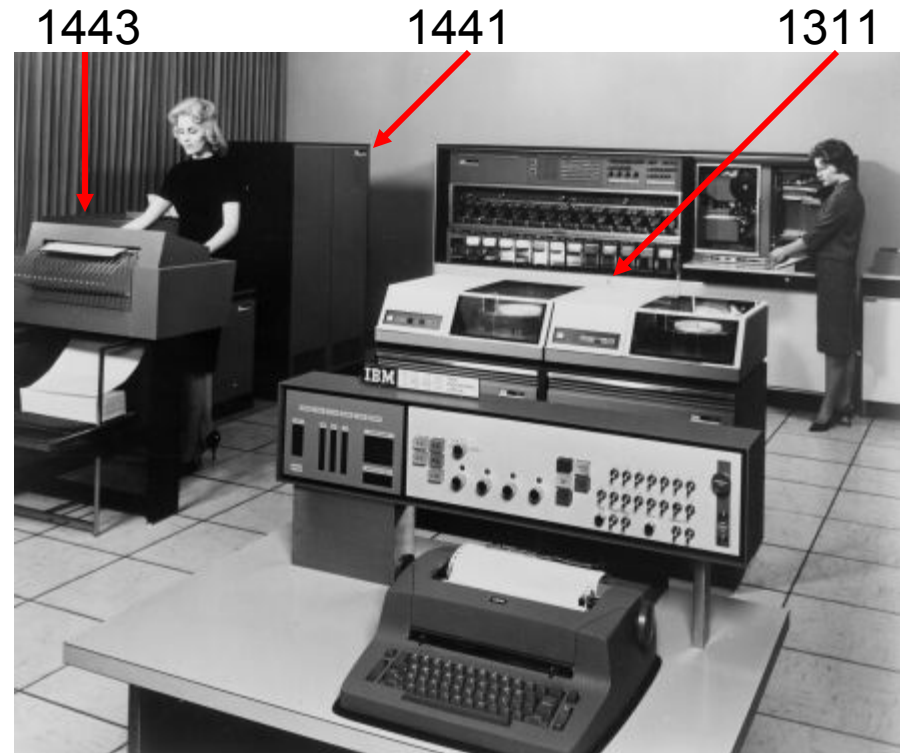
IBM 7094 – 1962
2nd generation

- **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

The April 1964 Revolution
3rd generation

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

S/360-75

2401

2311
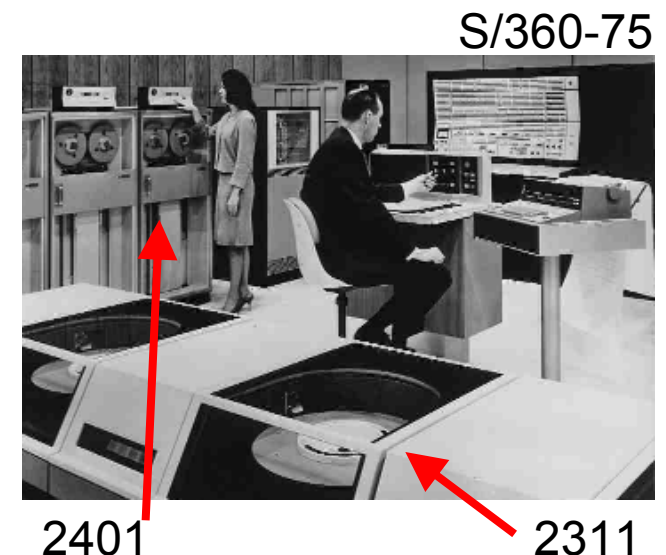
System/360 – a child is born

- **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)
  - Tape Operating System (TOS)
  - Basic Programming Support (BPS)
  - Airlines Control Program (ACP)
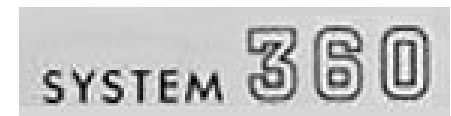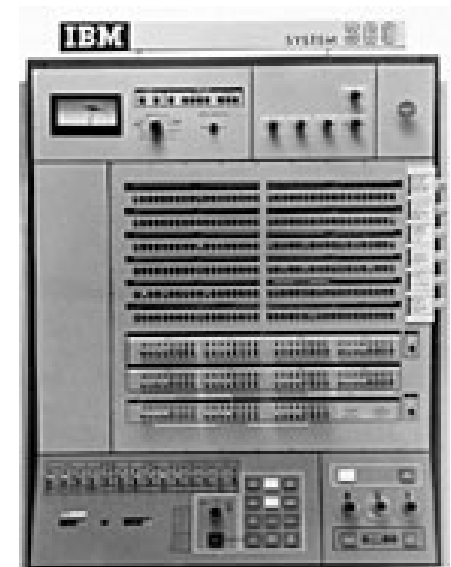
Core Memory

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

2560 Multi-Function Card Machine

- **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"

University of Newcastle Upon Tyne

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 bi-polar 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

3850 Mass Storage Subsystem

S/370-148   3705   3350

3505   3203   3525   3270
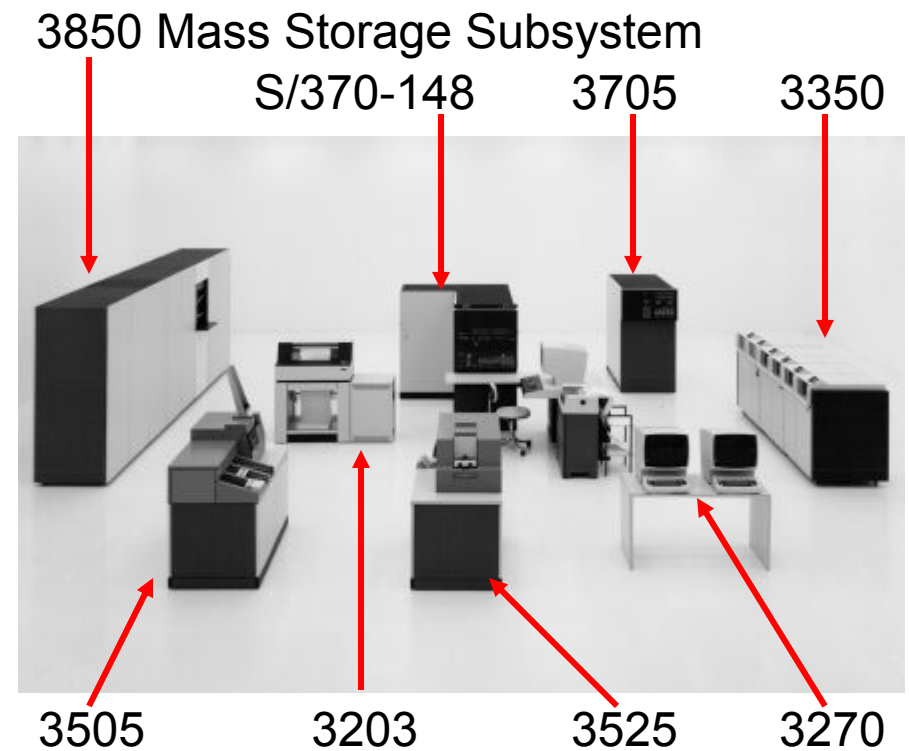
S/370 – the architecture matures

- **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	
	145	September 23, 1970	June, 1971	148
	135	March 8, 1971	April, 1972	138
	158	August 2, 1972	April, 1973	3031
Virtual storage capable models	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

3083

- **Evolution of S/370**
- **3081 introduced Thermal Conduction Modules**
- **New peripherals**
  - 3800 page 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

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

9672-G5

System/390 with Enterprise Systems Architecture – Announced September 1990

- **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 evolution

115/125	138/148	158/168
▼	▼	▼
4331 ➜ 4321	4341	3031/3032/3033
▼	▼	▼
4361	4381	3081/3083/3084
▼	▼ upgrade	▼
9370	4381-E	3090
▼ upgrade	▼	▼ upgrade
9221	9121	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

Multiprise 3000

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

System z9 EC – Announced July 26, 2005

- **Strengthening the role of the mainframe as the data hub of the enterprise**

- **New versatile capacity settings designed to optimize capacity and cost**

- **IBM System z9 Integrated Information Processor (IBM zIIP) is designed to improve resource optimization and lower the cost of eligible work**

- **Continued improvement in IBM FICON performance and throughput**

- **On demand innovative technologies to help meet ever-changing business demands**

System z9 BC – Announced April 27, 2006

- **IBM System z9 technology, for entry level to midsize capacity needs, with a wide choice of capacity settings and highly granular growth options, an increase of 2.6 times more capacity settings than zSeries z890**

- **A broad set of specialty engines to facilitate integration of many types of workloads and fully leverage the power of the mainframe**

- **Helps protect client's investments in mainframe technologies with upgradeability from z890 and z800 servers**

- **Key System z9 features of advanced security, resiliency, virtualization and connectivity technologies delivered in a midrange package**

System z10 EC – Announced February 26, 2008

- **Unprecedented capacity and virtualization to meet consolidation needs**
- **Improvements connecting to data and the network can help provide faster access to data**
- **Just-In-Time deployment of resources**
- **Specialty engines offer an attractive alternative when running new workloads**
- **Enhanced accuracy to a time External Time Source**

System z10 BC – Announced October 21, 2008

- **Industry leading combination of System z10 security, resiliency, virtualization and connectivity technologies packaged specifically as a midrange enterprise solution**

- **Specialty engines offer an attractive alternative when running new workloads**

- **Save energy via consolidation of disparate workloads and reduce costs via virtualization capabilities for more efficient resource sharing**

- **Enables future growth—as a modern platform for a growing portfolio of business solutions**

- **Up to 50% more performance at half the price for incremental Linux workloads compared to the System z9 BC**

IBM System z: Balanced Systems Design

**Balanced System
CPU, nWay, Memory,
I/O Bandwidth**

System I/O Bandwidth
288 GB/sec*

172.8 GB/sec*

96 GB/sec

24 GB/sec

Memory
1.5 TB**

512 GB 256 GB 64 GB

300 450 ~600

**ITR for
1-way**
~920

16-way

32-way

54-way

64-way
Processors

	z10 EC
	z9 EC
	z990
	z890
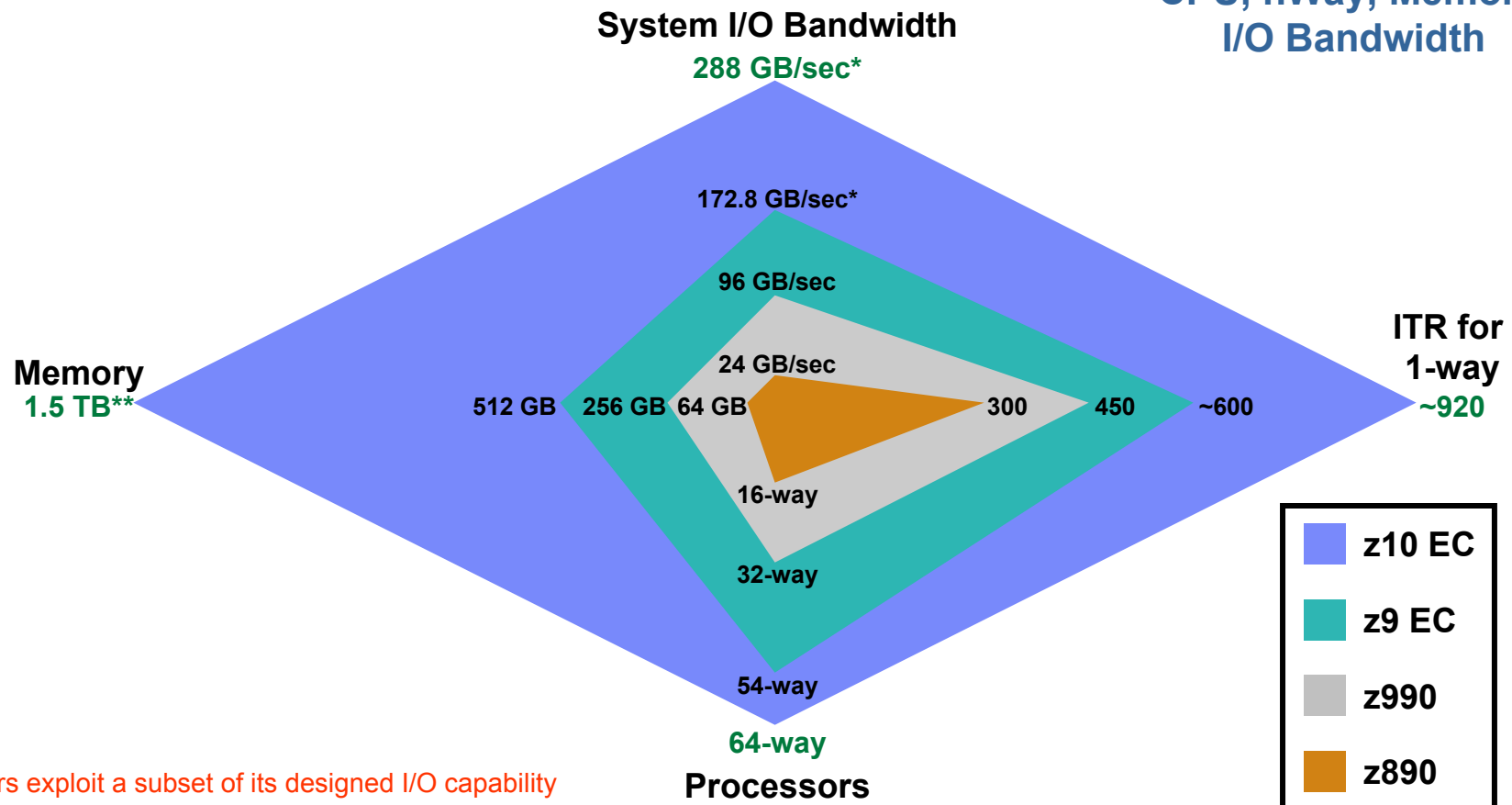
*Servers exploit a subset of its designed I/O capability
** Up to 1 TB per LPAR

9672-G5 to eServer zSeries to System z10

1998-06-23	9672-nn6	G5
1999-05-03	9672-nn7	G6
2000-10-03	2064-1nn	z900
2002-04-30	2064-2Cn	z900 *Turbo*
2009-01-29	2006-0FL	*z800 Linux only model*
2002-02-19	2066	z800
2003-05-13	2084	z990
2004-04-07	2086	z890
2005-07-26	2094	System z9 EC (originally System z9 109)
2006-04-27	2096	System z9 BC
2008-02-26	2097	System z10 EC
2008-10-21	2098	System z10 BC

April 7, 2009 – The 45th Anniversary!

April 7, 2004 – The 40th Anniversary!

Commemorating 45 Years of Market Leadership

Mainframe: The World's Most Trusted Server

Summary

- **From System/360 in 1964 to today's System z 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 DOS/360 to VSE/ESA to z/VSE, we have seen this operating system thrive meeting the needs in smaller 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**

- **And now with Linux on System z, we have a truly open operating environment**

"Legacy systems are systems that work!"

Bibliography

- **Melinda Varian, Princeton**
  – "VM and the VM Community: Past, Present, and Future" presented at SHARE 89, 1997
- **Jeff Gribbin, EDS UK**
  – "Development of 360/370 Architecture – A Plain Man's View", 1989
- **Chuck Boyer**
  – "The 360 Revolution", 2004 available at
    ftp://ftp.software.ibm.com/eserver/zseries/misc/bookoffer/download/360revolution_040704.pdf
- **IBM Archives: Valuable resources on IBM's history**
  – http://www.ibm.com/ibm/history/
- **IBM Systems Journal**
  – "VM/370–a study of multiplicity and usefulness"
    L H Seawright and R A MacKinnon, Volume 18, Number 1, 1979
  – Evolution of a virtual machine subsystem
    E C Hendricks and T C Hartmann, Volume 18, Number 1, 1979
  – "ESA/390 interpretive-execution architecture, foundation for VM/ESA"
    D L Osisek, K M Jackson, and P H Gum, Volume 30, Number 1, 1991
- **IBM Journal of Research and Development**
  – "The Origin of the VM/370 Time-Sharing System"
    R J Creasy, Volume 25, Number 5, 1981

Notices