IBM

History and Evolution of IBM Mainframes

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History and Evolution of IBM Mainframes

- **The history of SHARE has paralleled that of IBM mainframes for over 50 years. This presentation will cover the history of IBM mainframes from the IBM 701 through IBM S/360 to IBM eServer zSeries and the new IBM System z9. The evolution of OS/360 to z/OS and CP/67 to z/VM will also be covered (with honorable mention of DOS/360 to z/VSE and ACP to z/TCP).**

- **The speaker has worked for IBM for over 32 years including stints as an MVT, VM/370 and DOS/VS systems programmer, IMS application developer and product manager for VM, VSE and Linux for IBM Americas. Today Jim is responsible for all the System z9 and zSeries operating systems in addition to being the Advocate for Infrastructure Solutions for IBM Canada. As a result, he has 'hands-on' experience with most of IBM's mainframes over that period.**

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
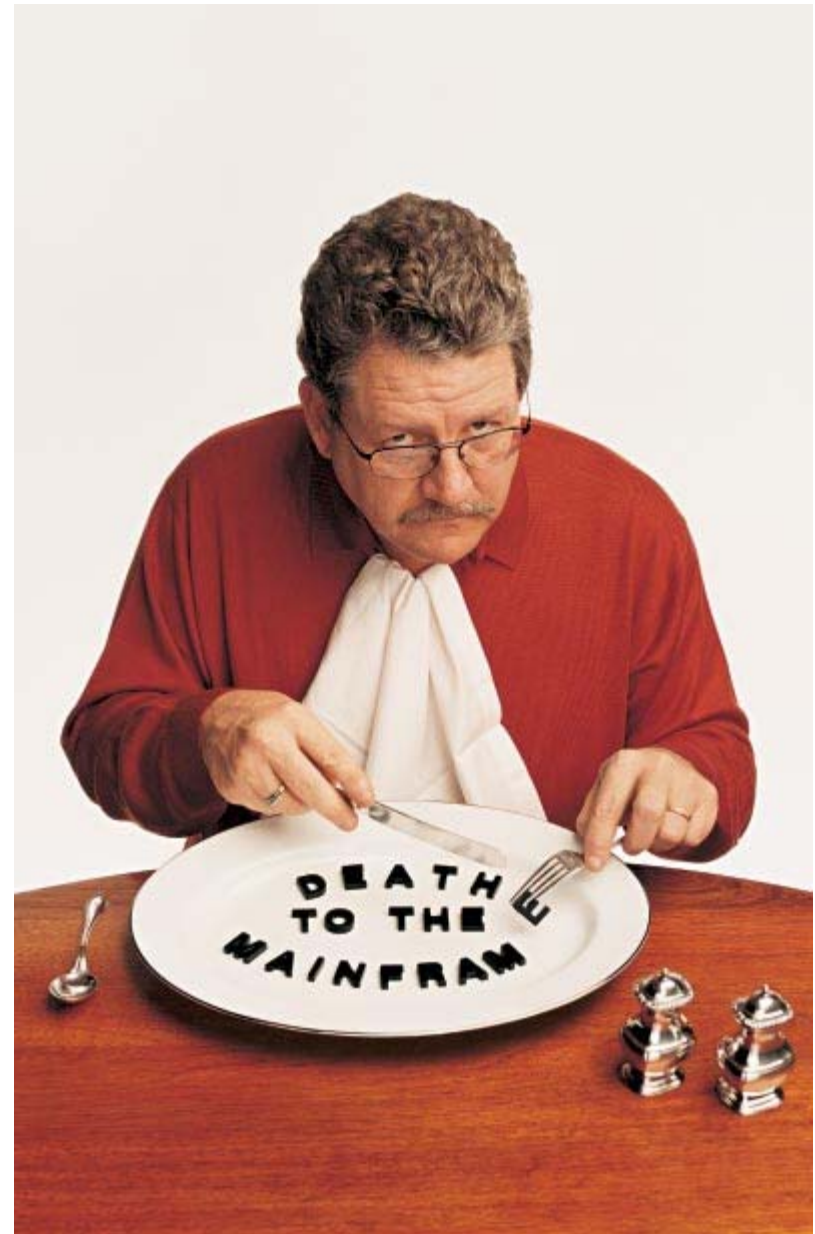
In the Beginning – The First Two Generations

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
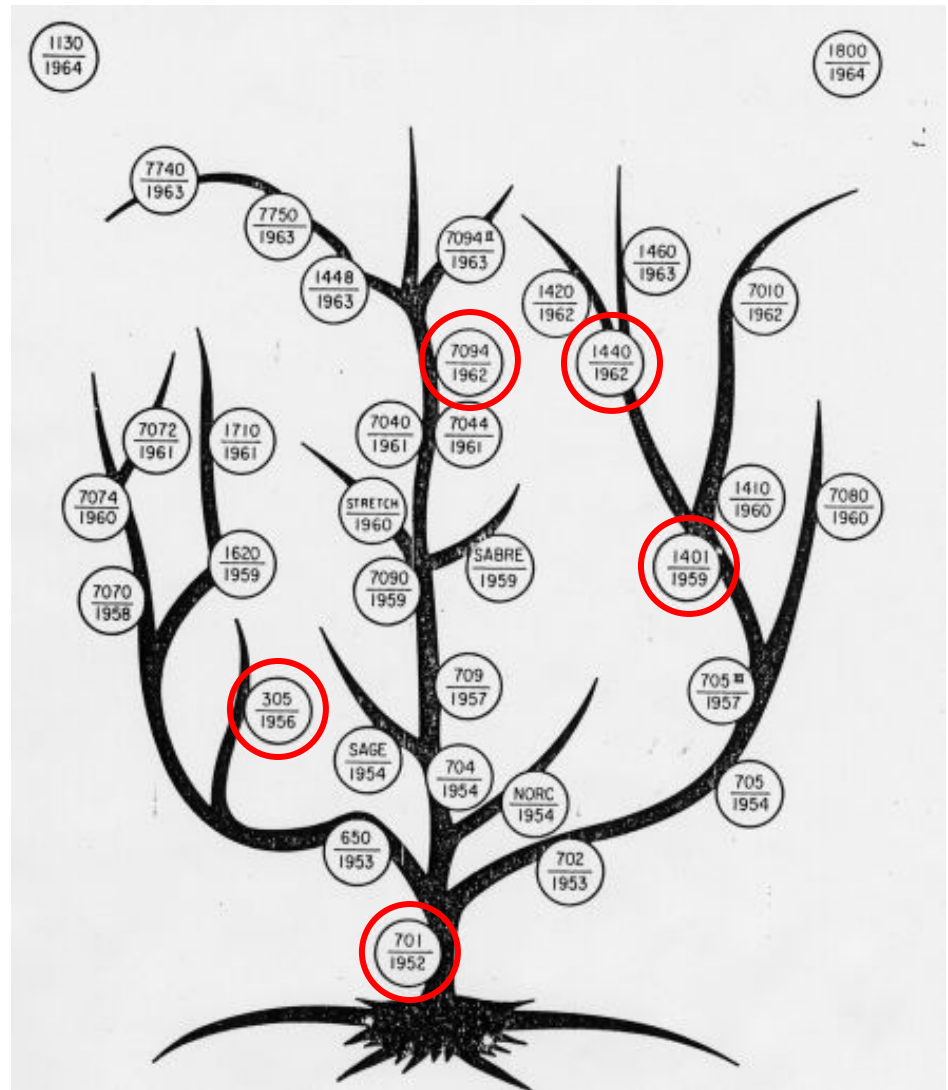
IBM 701 – 1952
1st generation

- **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, 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**


350 Disk
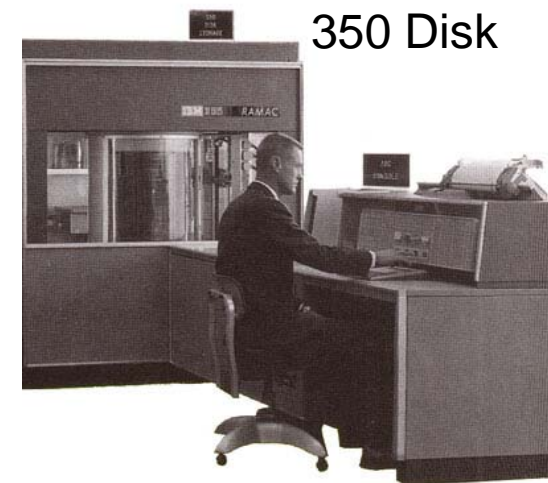
IBM 1401 – 1959
2nd generation

- **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
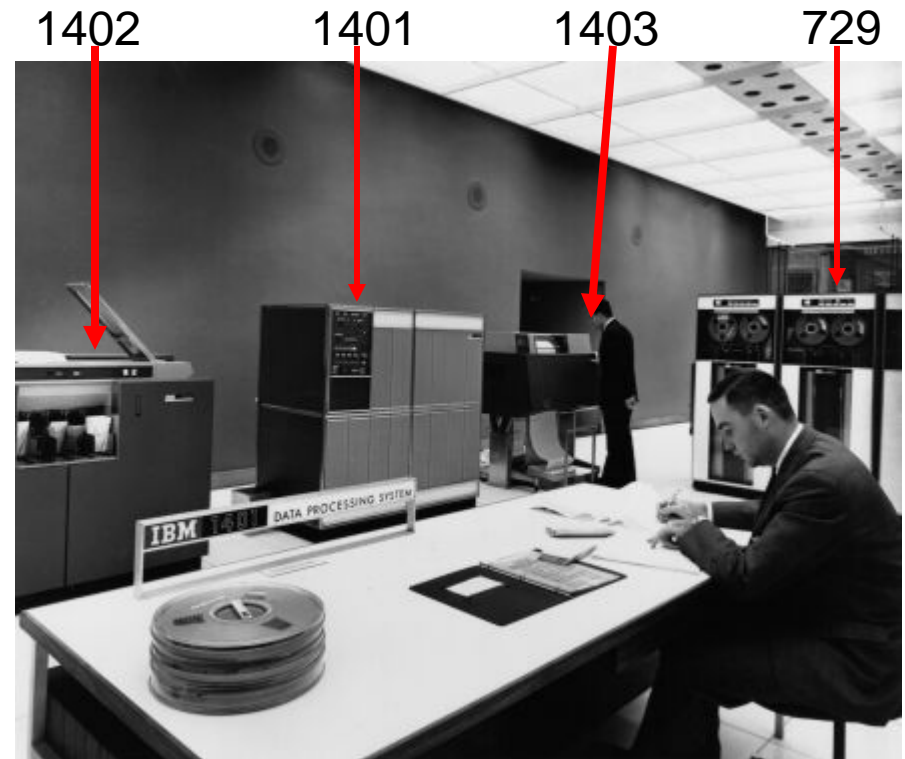
IBM 1440 – 1962
2nd generation

- **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
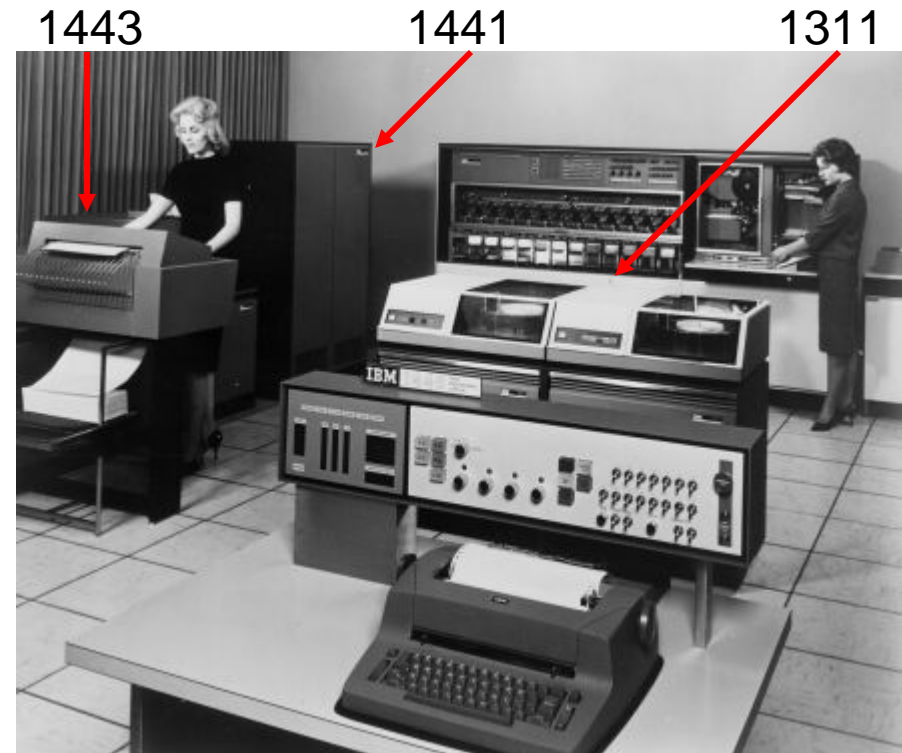
IBM 7094 – 1962
2nd generation

- **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
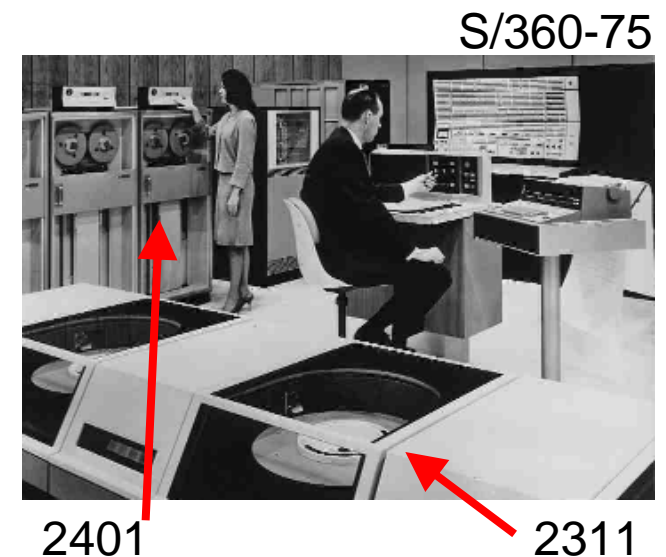
System/360 – a child is born

- **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)
  - TOS, BPS, …
  - ACP

SYSTEM 360
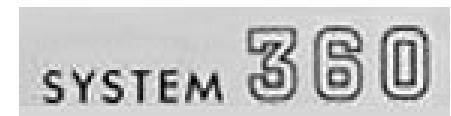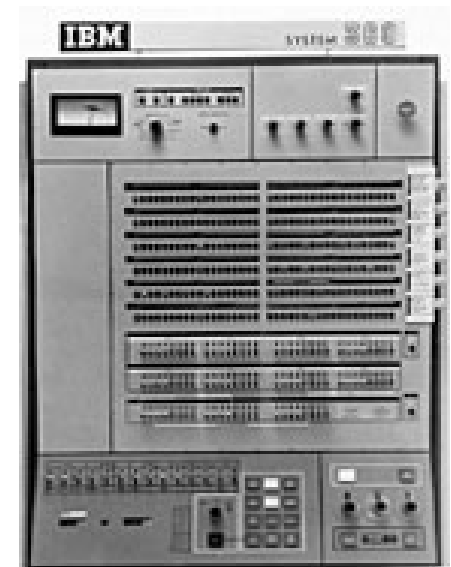
Core Memory

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"

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   S/370-148   3705   3350

3505   3203   3525   3270
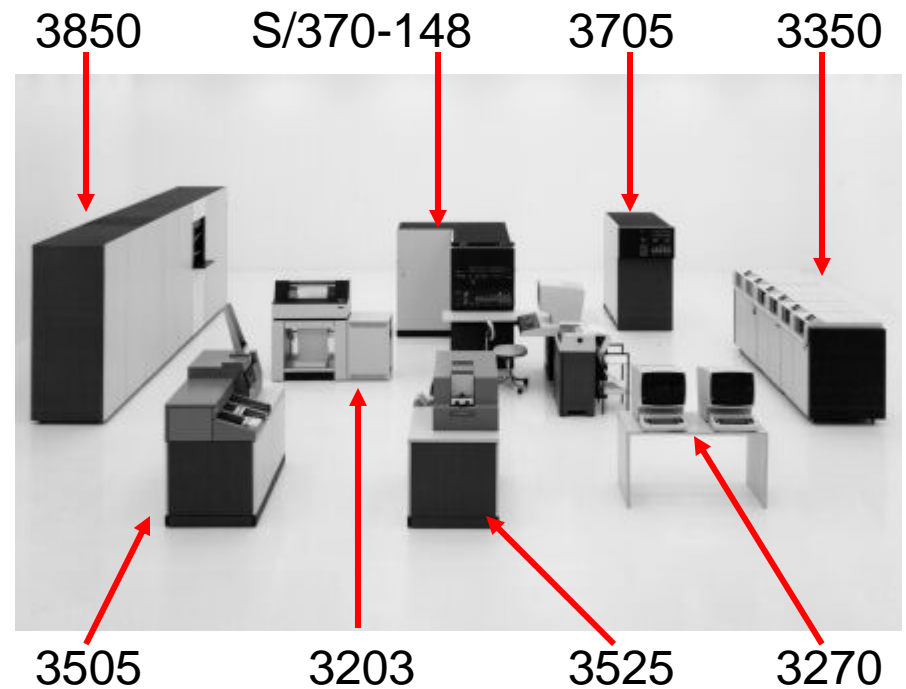
S/370 – the architecture matures

- **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

- **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

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

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

zSeries with z/Architecture – Announced October 2000

zSeries 900

- **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 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 – Announced July 26, 2005

- **IBM System z9 109 (z9-109) delivers excellence in large scale enterprise computing and is designed and optimized as the hub of the on demand enterprise**

- **Built on more than 40 years as an industry-acknowledged leader and taking that leadership to new levels**
  - Scalability
  - Availability and security
  - Balanced system design
  - Virtualization technology

- **Breaking new ground**
  - Designed to minimize outages to help your business stay always on
  - Greater scalability and performance to grow with your business
  - Flexibility to enable efficient response to your business needs

System z9 and zSeries: Balanced System Design

System I/O Bandwidth

Balanced System CPU, n-way, memory, I/O bandwidth*

172.8 GB/sec

96 GB/sec

24 GB/sec

GBs

512 GB

256 GB

64 GB

288.15

450

~ 600

MIPs for 1-way

12-way

16-way

32-way

54-way

CPUs

	System z9 109*
	zSeries 990
	zSeries 900
	Generation 6
	Generation 5
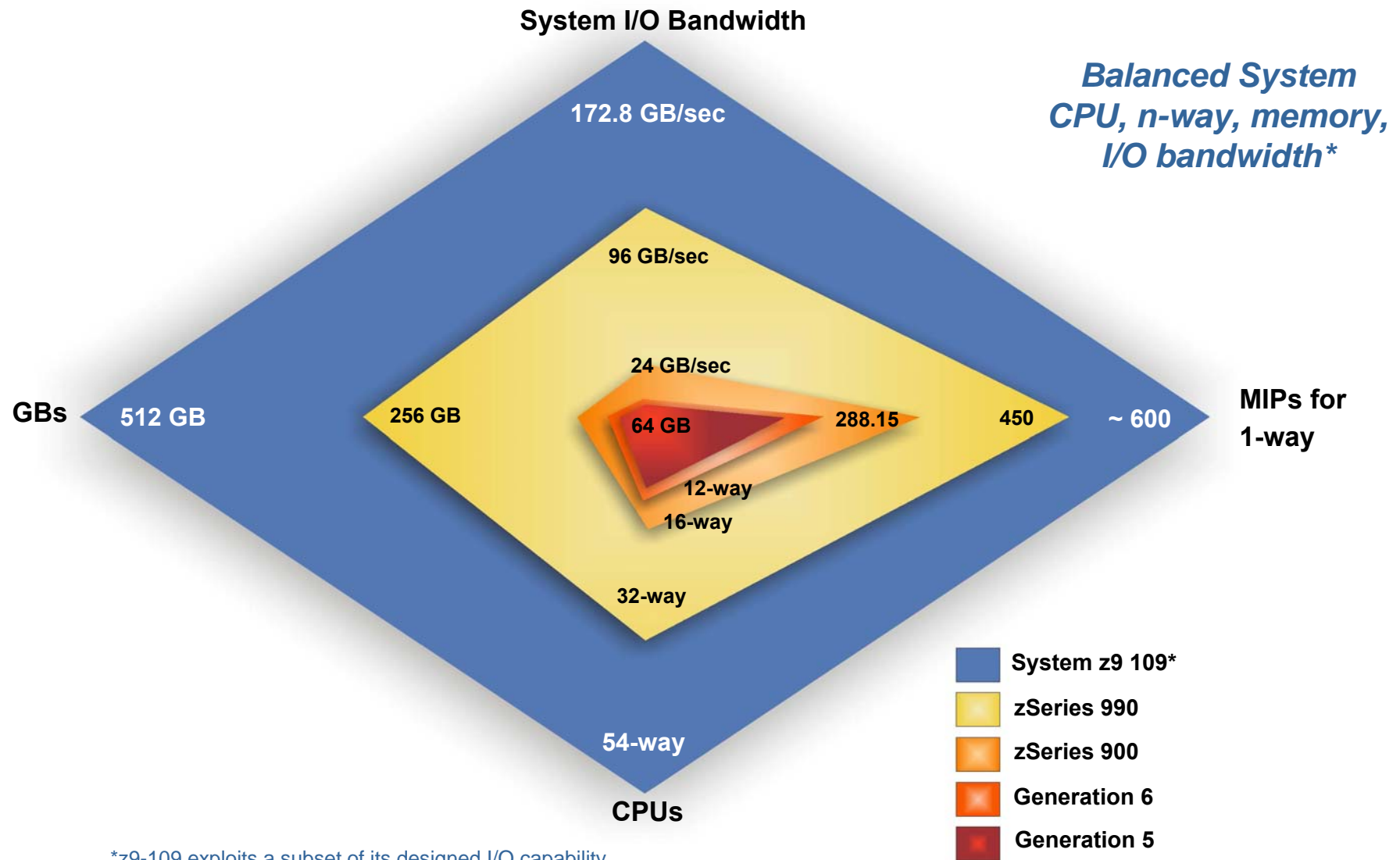
*z9-109 exploits a subset of its designed I/O capability

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 *Turbo*
2002-02-19	2066	z800
		(Linux only model 2002-01-29)
2003-05-13	2084	z990
2004-04-07	2086	z890
2005-07-26	2094	System z9 109

April 7, 2004 – The 40th Anniversary!

April 7, 2004 – The 40th Anniversary!

System/360 and the new world of on demand business

The 360 Revolution
Chuck Boyer

http://ibm.com/eserver/zseries/timeline/
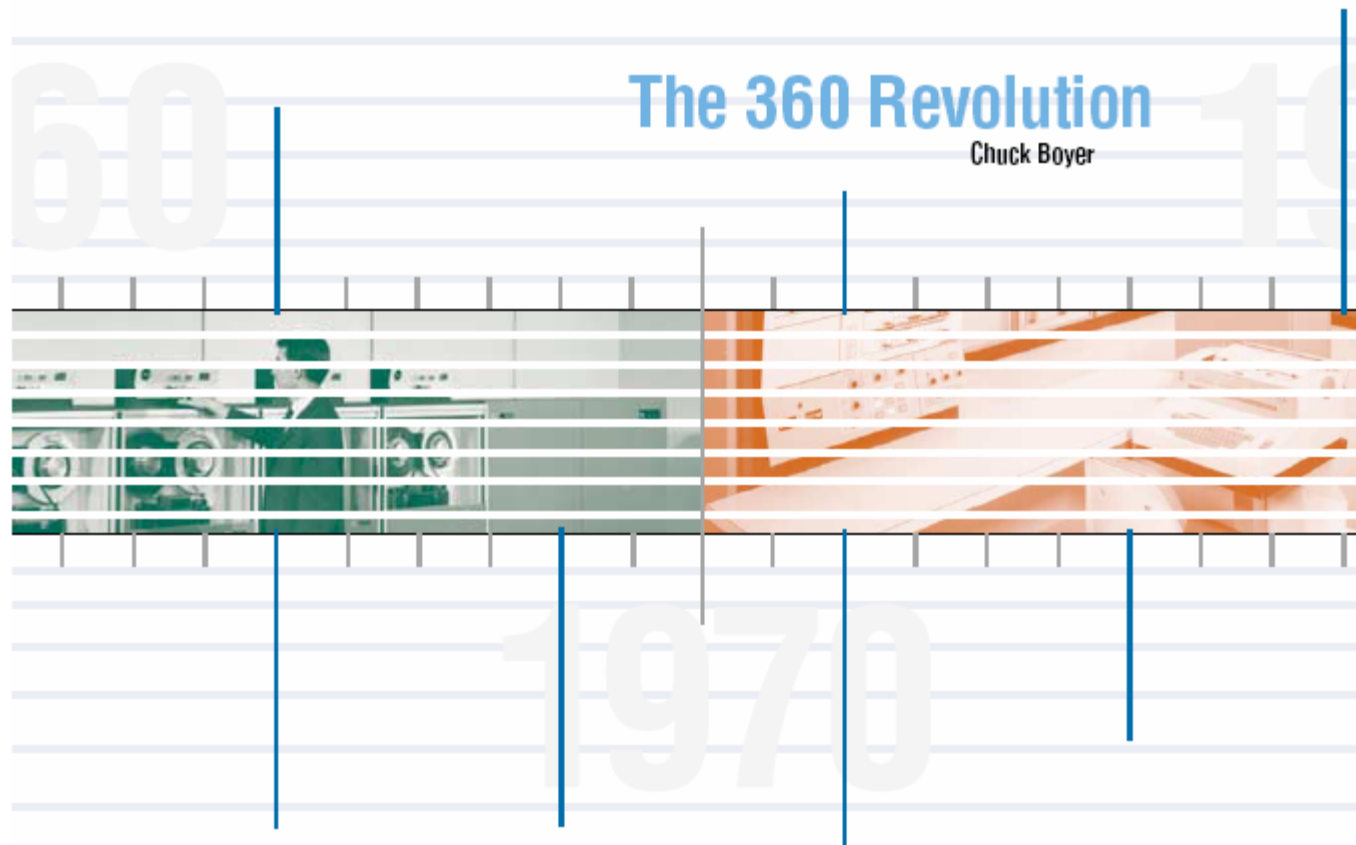
Summary

- **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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Notices