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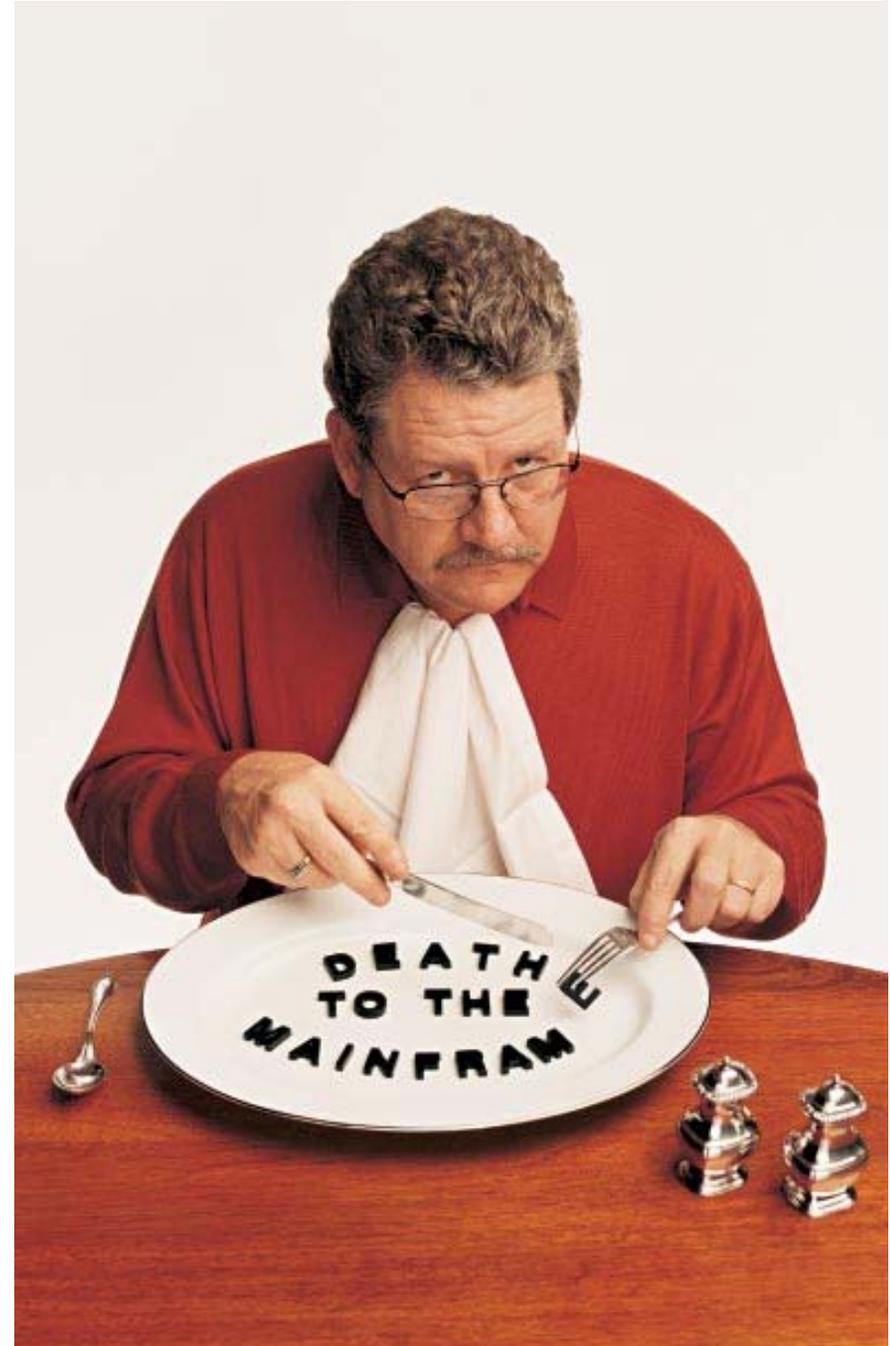


# IBM Mainframes – 45+ Years of Evolution



## 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*



## Well, maybe a little before...

- IBM started out as a merger of three US companies, which became units of CTR
  - Computing Scale
  - Tabulating Machine
  - Time Recording
- The Canadian unit became the International Business Machines Co. Ltd. in 1917
- The parent became International Business Machines Corporation in 1924

Vol. 2, No. 1 INTERNATIONAL BUSINESS MACHINES January, 1920

*The More It Costs to Do Business  
The Less You Can Tolerate Waste*

ASCENDING operating costs call for increased accuracy, greater simplicity—Complete and assured protection—in all computing departments of the business world.

You get those necessary factors in the simplest, safest, most practical form through International Time and Cost Recorders, Tabulating Machines and Computing Scales.

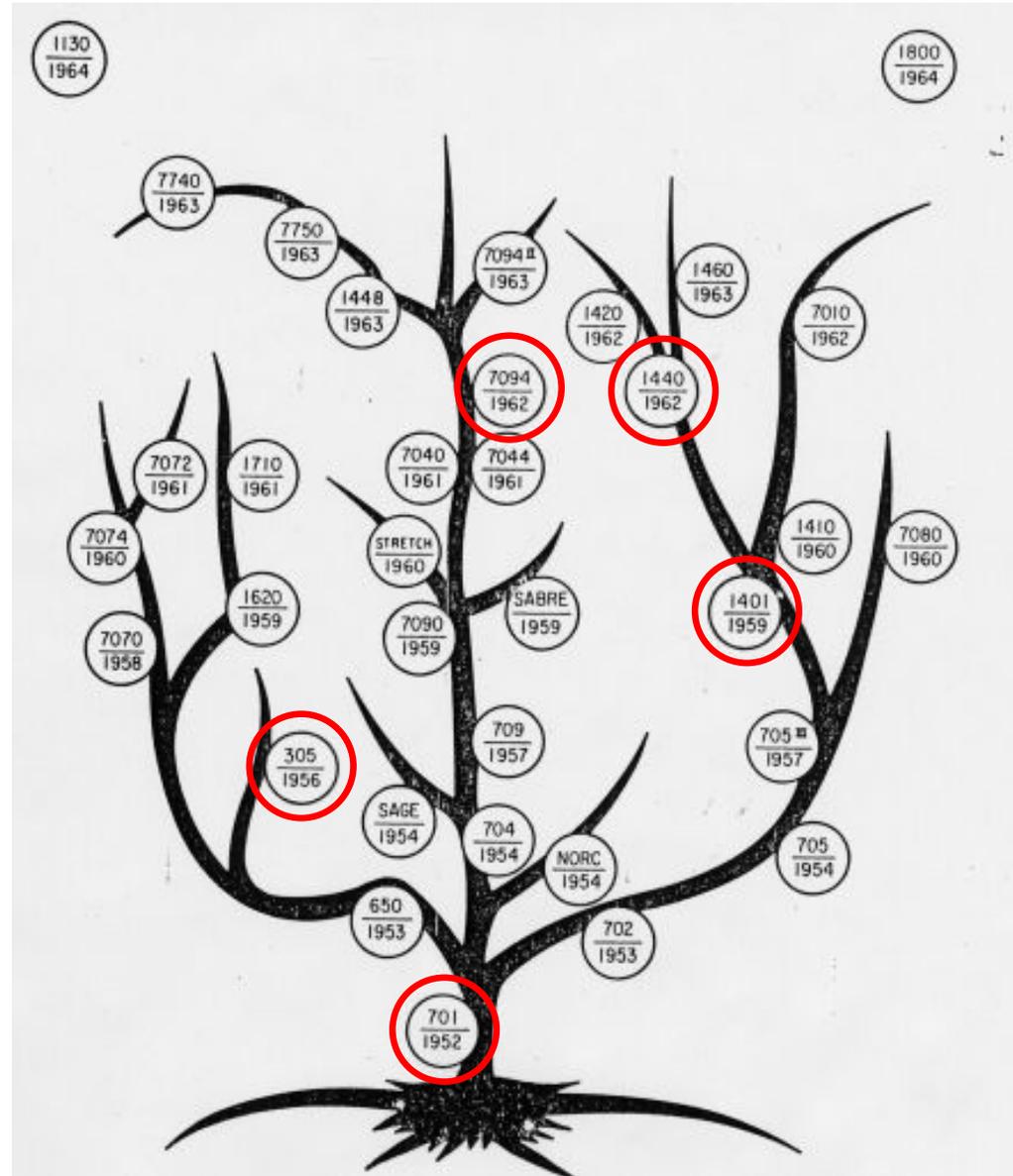
Write us for full details on the kind of "International" efficiency which interests YOU

**Computing-Tabulating-Recording  
Company**

50 BROAD ST., NEW YORK, N. Y.

## 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

### *1<sup>st</sup> 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

### *1<sup>st</sup> generation*

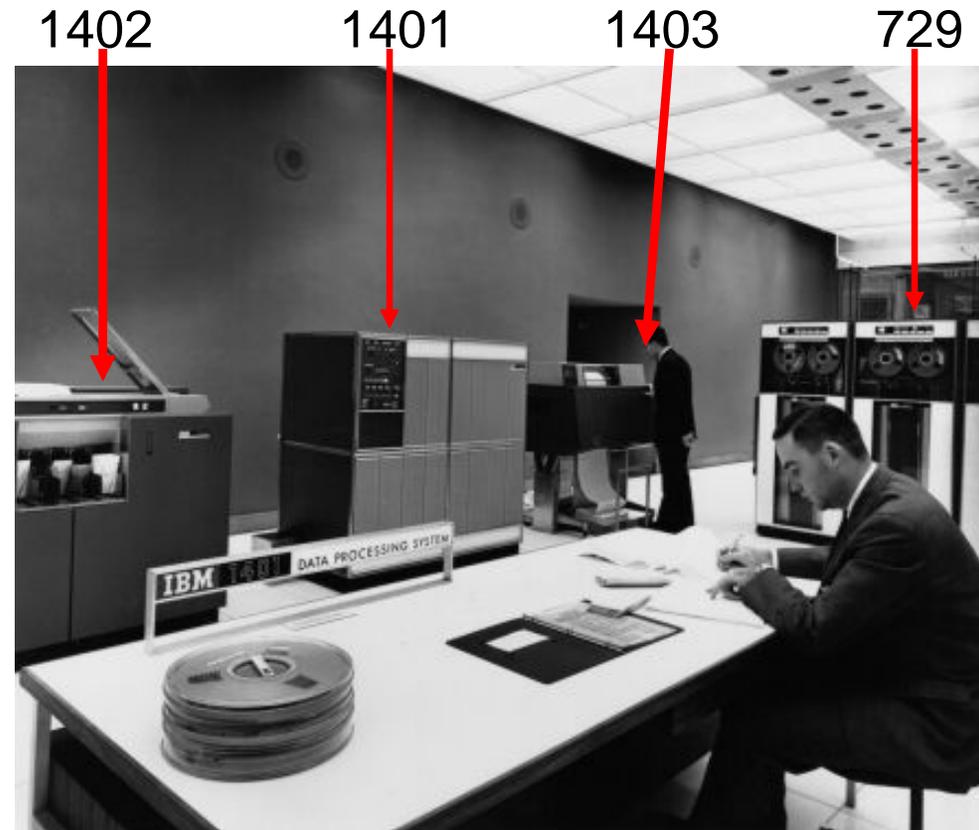
- The first computer to include a disk drive (named the IBM 350 Disk File)
- Prior to this magnetic computer storage had consisted of core memory, tape, and drums
- The 350 Disk File consisted of a stack of fifty 24 inch discs
- The capacity of the entire disk file was 5 million 7-bit characters, which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



## IBM 1401 – 1959

### *2<sup>nd</sup> generation*

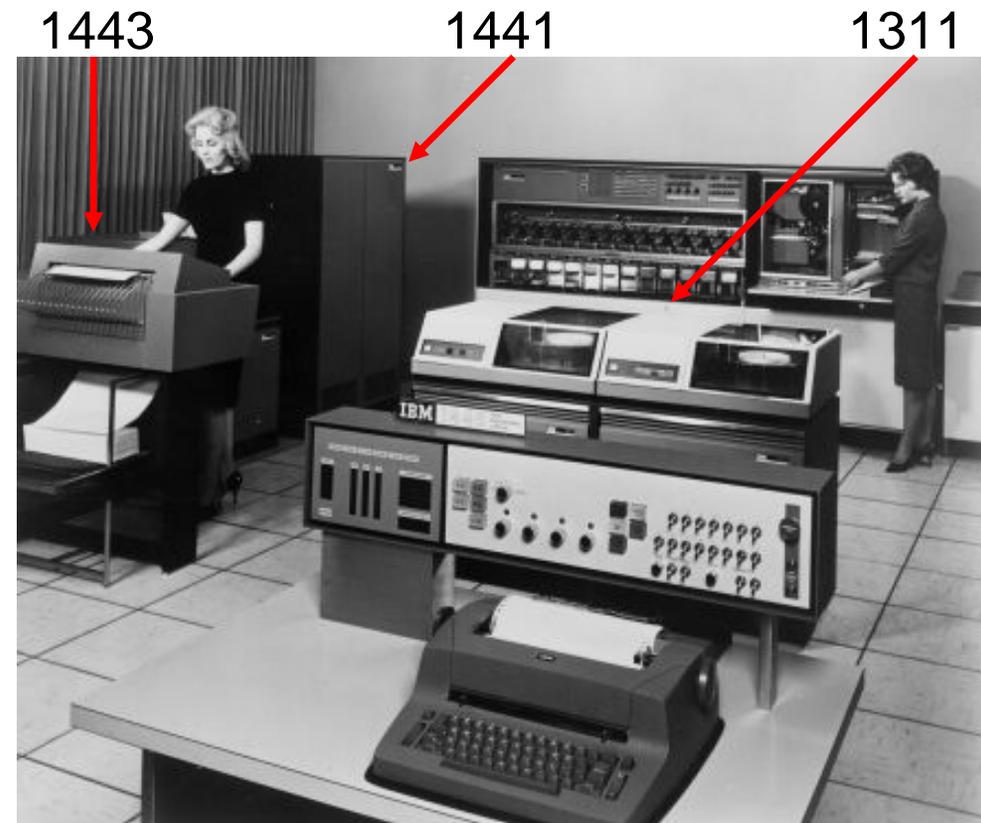
- The all-transistorized IBM 1401 Data Processing System placed the features found in electronic data processing systems at the disposal of smaller businesses, previously limited to the use of conventional punched card equipment
- These features included: high speed card punching and reading, magnetic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



## IBM 1440 – 1962

### *2<sup>nd</sup> 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**



## IBM 7094 – 1962

### *2<sup>nd</sup> 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**

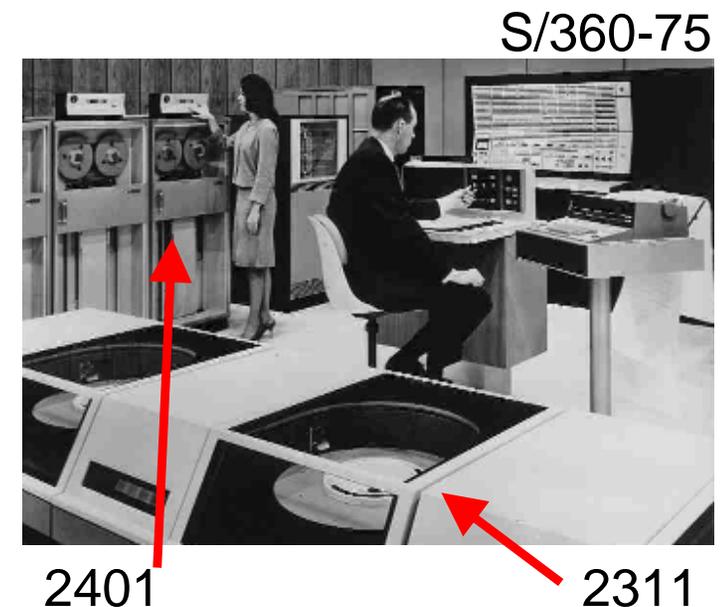
**“[System/360] was the biggest, riskiest  
decision I ever made, and I agonized  
about it for weeks, but deep down I believed  
there was nothing IBM couldn't do.”**

*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



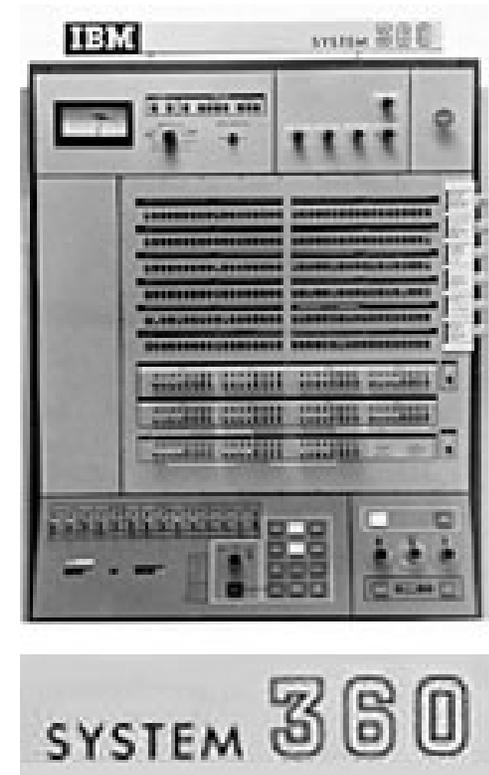
## System/360 – a child is born

### ■ 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 from IBM

- 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            | Withdrawn |
|-----------------|-----------|--------------------------|-----------|
| 20 <sup>5</sup> | 18-Nov-64 | Apr-66                   | n/a       |
| 22              | 7-Apr-71  | Jun-71                   | 7-Oct-77  |
| 25              | 3-Jan-68  | Oct-68                   | 7-Oct-77  |
| 30              | 7-Apr-64  | Jun-65                   | 22-Jun-70 |
| 40              | 7-Apr-64  | Apr-65                   | 7-Oct-77  |
| 44              | 16-Aug-65 | Jun-66                   | 24-Sep-73 |
| 50              | 7-Apr-64  | Aug-65                   | 15-Mar-77 |
| 60              | 7-Apr-64  | Not Shipped <sup>1</sup> | 22-Apr-65 |
| 62              | 7-Apr-64  | Not Shipped <sup>1</sup> | 22-Apr-65 |

| Model | Announced    | First Shipped            | Withdrawn |
|-------|--------------|--------------------------|-----------|
| 65    | 22-Apr-65    | Nov-65 <sup>6</sup>      | 15-Mar-77 |
| 67    | 16-Aug-65    | May-66 <sup>6,7</sup>    | 15-Mar-77 |
| 70    | 7-Apr-64     | Not Shipped <sup>2</sup> | 22-Apr-65 |
| 75    | 22-Apr-65    | Jan-66                   | 15-Mar-77 |
| 85    | 30-Jan-68    | Dec-69                   | 24-Jun-71 |
| 91    | 18-Jan-66    | Oct-67                   | 20-Feb-67 |
| 92    | 17-Aug-64    | Not Shipped <sup>3</sup> | n/a       |
| 95    | <sup>4</sup> | Feb-68                   | n/a       |
| 195   | 20-Aug-69    | Mar-71                   | 9-Feb-77  |

1. Replaced by Model 65.
  2. Replaced by Model 75.
  3. Redesignated as Model 91.
  4. Offered on special government contract.
  5. Model 20 architecture differed in some respects from other S/360 models.
  6. MP models of the Model 65 and Model 67 were made available in 1968.
  7. The S/360-67 was the first Virtual Storage mainframe from IBM.
- n/a Not available.

- Sources: A. Pedegs, "System/360 And Beyond," IBM Journal Of Research And Development, Vol. 25, No. 5, September 1981, Table 2, p. 387; various data on file in IBM Corporate Archives.

# 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**

2560 Multi-Function Card Machine



## 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 (TSS) – The “official” operating system from IBM Data Systems Division
  - Control Program/67 (CP/67) with the Cambridge Monitor System CMS) – The “unofficial” operating system from the IBM Cambridge Scientific Center
  - Michigan Terminal System (MTS) from the University of Michigan

S/360-67



“DAT box”

## IBM 9020 System

### *Air Traffic Control system*

- **The 9020 was a conglomeration of IBM System 360 computers**
  - Models were made up of IBM System 360 Model 65s hooked together into a highly redundant and reliable single system image and Model 50's as IO Control Elements
- **Here is a picture of the operator control panel for one computing element of a 9020E system, which looked a great deal like a Model 65 panel, but with additions specific to the air traffic control configuration**
- **A complete 9020E was made up of three or four Model 65s, three Model 50s, storage units, and peripheral adapters for things like displays and incoming radar data**



## 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

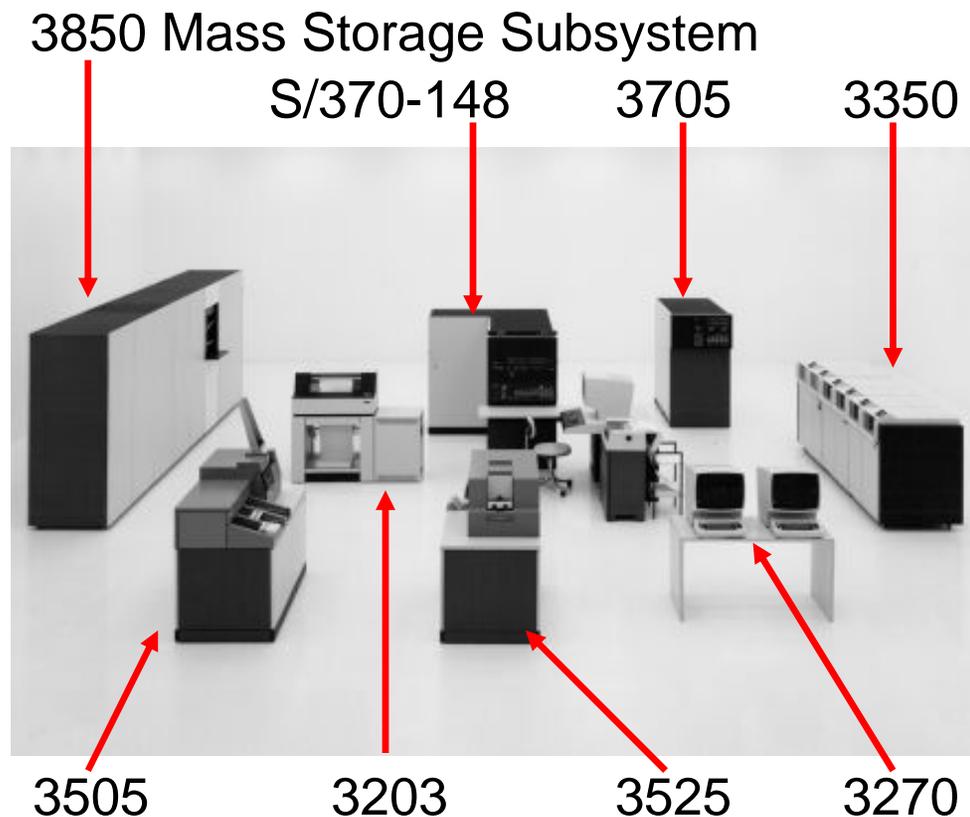
**“We are confident that the performance of System/370, its compatibility, its engineering and its programming will make it stand out as the landmark for the 1970s that System/360 was for the Sixties.”**

**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 popular 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



## S/370 family

| Model | Announced | First Shipped | Withdrawn |
|-------|-----------|---------------|-----------|
| 115   | 13-Mar-73 | Mar-74        | 9-Mar-81  |
| 115-2 | 10-Nov-75 | Apr-76        | 9-Mar-81  |
| 125   | 4-Oct-72  | Apr-73        | 9-Mar-81  |
| 125-2 | 10-Nov-75 | Feb-76        | 9-Mar-81  |
| 135   | 8-Mar-71  | Apr-72        | 16-Oct-79 |
| 135-3 | 30-Jun-76 | Feb-77        | 16-Oct-79 |
| 138   | 30-Jun-76 | Nov-76        | 1-Nov-83  |
| 145   | 23-Sep-70 | Jun-71        | 10-Nov-71 |
| 145-3 | 30-Jun-76 | May-77        | 16-Oct-79 |

| Model | Announced | First Shipped       | Withdrawn |
|-------|-----------|---------------------|-----------|
| 148   | 30-Jun-76 | Jan-77              | 1-Nov-83  |
| 155   | 30-Jun-70 | Jan-71 <sup>1</sup> | 23-Dec-77 |
| 158   | 2-Aug-72  | Apr-73              | 15-Sep-80 |
| 158-3 | 26-Oct-76 | Sep-76 <sup>2</sup> | 15-Sep-80 |
| 165   | 30-Jun-70 | Apr-71 <sup>1</sup> | 23-Dec-77 |
| 168   | 2-Aug-72  | May-73              | 15-Sep-80 |
| 168-3 | 18-Feb-76 | Jun-76 <sup>2</sup> | 15-Sep-80 |
| 195   | 30-Jun-70 | Aug-73              | 9-Feb-77  |
| 148   | 30-Jun-76 | Jan-77              | 1-Nov-83  |

1. Shortly after the August 2nd, 1972 announcement, DAT box (address relocation hardware) upgrades for the S/370-155 and S/370-165 were quietly announced, but were available only for purchase by customers who already owned a Model 155 or 165. After installation, these models were known as the S/370-155-II and S/370-165-II. The original S/370-155 and S/370-165 were the only S/370 machines which were not Virtual Storage capable.
2. An Attached Processor (AP) model of the S/370-158 and Multi-Processor models of the S/370-158 and S/370-168 were made available in 1976 with the "-3" update.
  - Sources: A. Pedegs, "System/360 And Beyond," IBM Journal Of Research And Development, Vol. 25, No. 5, September 1981, Table 2, p. 387; various data on file in IBM Corporate Archives.

## S/370 family continues

3032

| Model               | Announced | First Shipped         | Withdrawn |
|---------------------|-----------|-----------------------|-----------|
| 3031                | 6-Oct-77  | Mar-78 <sup>2</sup>   | 5-Feb-85  |
| 3032                | 6-Oct-77  | Mar-78                | 5-Feb-85  |
| 3033                | 25-Mar-77 | Mar-78 <sup>1,3</sup> | 5-Feb-85  |
| 3033-N              | 1-Nov-79  | Jan-80                | 5-Feb-85  |
| 3033-S              | 12-Nov-80 | 1981 1Q               | 5-Feb-85  |
| 3081                | 12-Nov-80 | 1981 4Q               | 4-Aug-87  |
| 4331 <sup>4</sup>   | 30-Jan-79 | Mar-79                | 10-Sep-84 |
| 4361                | 15-Sep-83 | n/a                   | 17-Feb-87 |
| 4341                | 30-Jan-79 | n/a                   | 11-Feb-86 |
| 4381                | 15-Sep-83 | n/a                   | 19-Aug-92 |
| 4381-E <sup>5</sup> | Feb-88    | n/a                   | Aug-88    |

1. An MP model of the 3033 was made available in 1978.
  2. An AP model of the 3031 was made available in 1979.
  3. An AP model of the 3033 was made available in 1980.
  4. The 4321 was a half speed model of the 4331-2 made available only in the US.
  5. The 4381-E models were 4381-2 models modified to support ESA/370 via LICC.
- n/a Not available.

- Sources: A. Pedegs, "System/360 And Beyond," IBM Journal Of Research And Development, Vol. 25, No. 5, September 1981, Table 2, p. 387; various data on file in IBM Corporate Archives.



## System/370 with Extended Architecture

- **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

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



# 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
  - AIX/ESA
  - Linux for S/390 (December 1999)

9672-G5



ES/9000



## S/370 to ES/9000 evolution

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

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



Multiprise 3000

## eServer 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



**@server<sup>®</sup>**

## eServer 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



## 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 zEnterprise system – Best in class technologies

*Announced 2010-07-22*



Unified management for a smarter system:  
**zEnterprise Unified Resource Manager**

The world's fastest and most scalable system:  
**zEnterprise™ 196 (z196)**

- Ideal for large scale data and transaction serving and mission critical applications
- Most efficient platform for Large-scale Linux® consolidation
- Leveraging a large portfolio of z/OS® and Linux on System z applications
- Capable of massive scale up, over 50 Billion Instructions per Second (BIPS)

- Provides platform, hardware and workload management
- Unifies management of resources, extending IBM System z® qualities of service across the infrastructure

Scale out to a trillion instructions per second:  
**zEnterprise BladeCenter® Extension (zBX)**

- Selected IBM POWER7® blades and IBM x86 Blades<sup>1</sup> for tens of thousands of AIX® and Linux applications
- High performance optimizers and appliances to accelerate time to insight and reduce cost
- Dedicated high performance private network

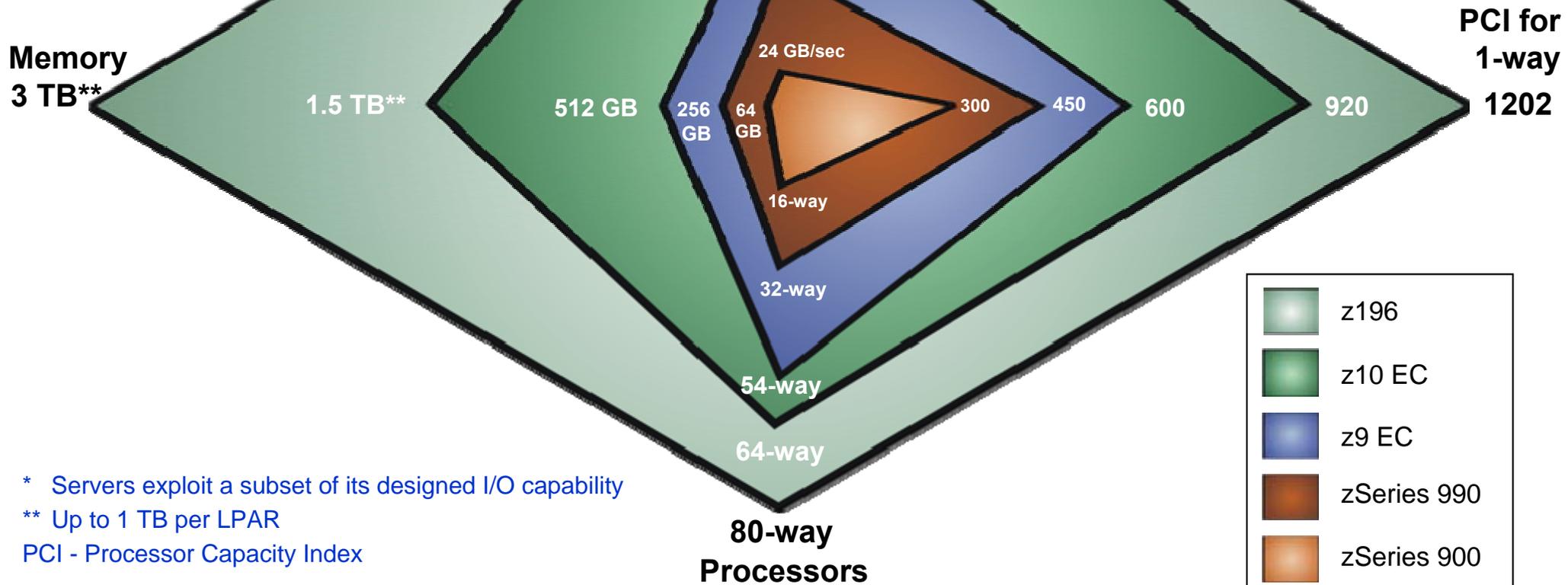


<sup>1</sup> All statements regarding IBM future direction and intent are subject to change or withdrawal without notice, and represents goals and objectives only.

# IBM System z: System Design Comparison

**System I/O Bandwidth**  
288 GB/Sec\*

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



\* Servers exploit a subset of its designed I/O capability

\*\* Up to 1 TB per LPAR

PCI - Processor Capacity Index

## 9672-G5 to eServer zSeries to System z10 to zEnterprise

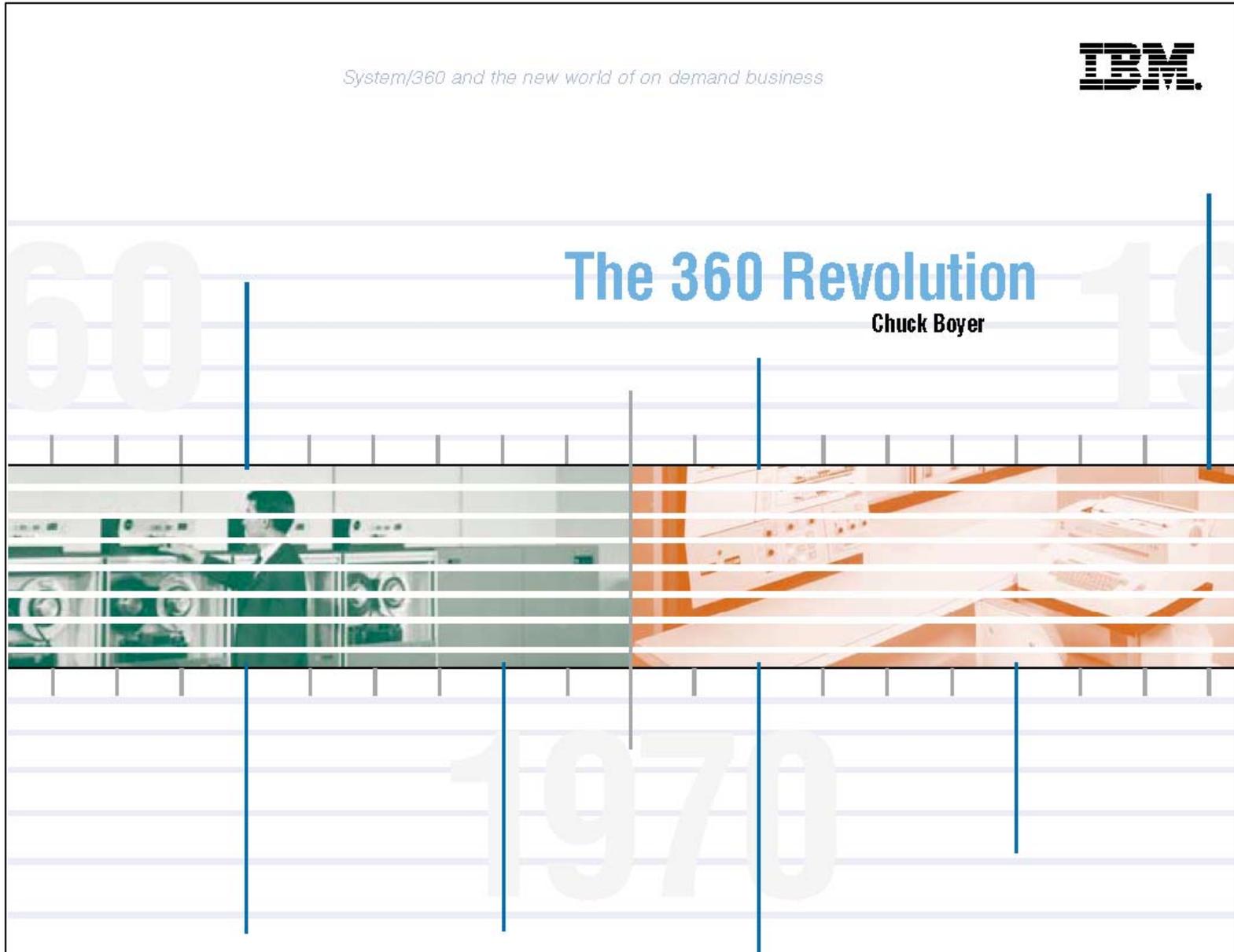
|                   |                 |  |
|-------------------|-----------------|--|
| <b>1998-06-23</b> | <b>9672-nn6</b> | <b>G5</b>                                      |
| <b>1999-05-03</b> | <b>9672-nn7</b> | <b>G6</b>                                      |
| <b>2000-10-03</b> | <b>2064-1nn</b> | <b>z900</b>                                    |
| <b>2002-04-30</b> | <b>2064-2Cn</b> | <b>z900 <i>Turbo</i></b>                       |
| <b>2009-01-29</b> | <b>2006-0FL</b> | <b><i>z800 Linux only model</i></b>            |
| <b>2002-02-19</b> | <b>2066</b>     | <b>z800</b>                                    |
| <b>2003-05-13</b> | <b>2084</b>     | <b>z990</b>                                    |
| <b>2004-04-07</b> | <b>2086</b>     | <b>z890</b>                                    |
| <b>2005-07-26</b> | <b>2094</b>     | <b>System z9 EC (originally System z9 109)</b> |
| <b>2006-04-27</b> | <b>2096</b>     | <b>System z9 BC</b>                            |
| <b>2008-02-26</b> | <b>2097</b>     | <b>System z10 EC</b>                           |
| <b>2008-10-21</b> | <b>2098</b>     | <b>System z10 BC</b>                           |
| <b>2010-07-22</b> | <b>2817</b>     | <b>zEnterprise 196</b>                         |

# April 7, 2009 – The 45th Anniversary!



# April 7, 2004 – The 40<sup>th</sup> Anniversary!

[ftp://ftp.software.ibm.com/eserver/zseries/misc/bookoffer/download/360revolution\\_040704.pdf](ftp://ftp.software.ibm.com/eserver/zseries/misc/bookoffer/download/360revolution_040704.pdf)





## Summary

- From System/360 in 1964 to today's zEnterprise System, 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 System z 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**
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