

History and Evolution of IBM Mainframes over SHARE's 60 Years

Jim Elliott – z Systems Consultant, zChampion, Linux Ambassador
IBM Systems, IBM Canada Ltd.



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 ...

- **The Computing-Tabulating-Recording Company in 1911**

- Tabulating Machine Company
- International Time Recording Company
- Computing Scale Company of America
- Bundy Manufacturing Company

- **Tom Watson, Sr. joined in 1915**

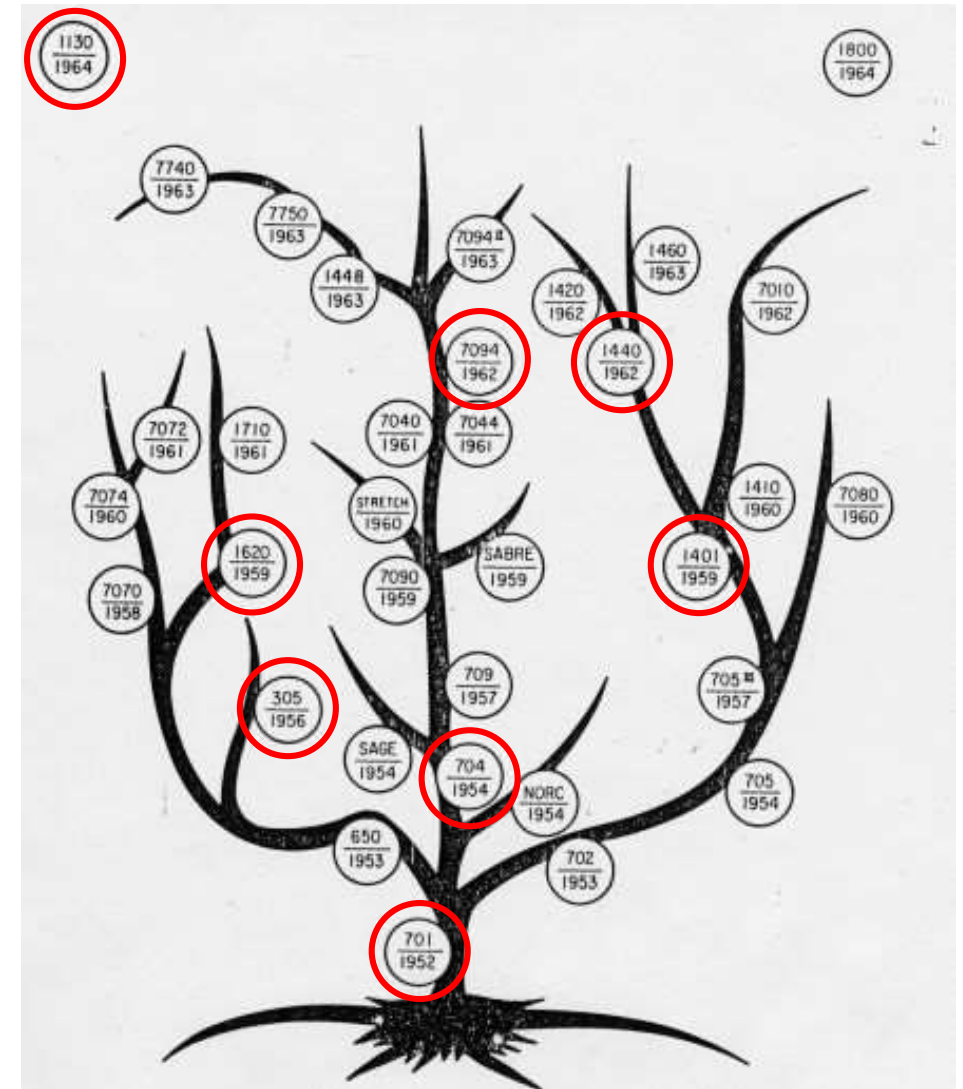
- **International Business Machines**

- 1917 – International Business Machines Co. Limited in Toronto, Canada
- 1924 – International Business Machines Corporation in NY, NY



The family tree – 1952 to 1964

- Plotting the family tree of IBM's "mainframe" computers might not be as complicated or vast a task as charting the multi-century evolution of families but it nevertheless requires far more than a simple linear diagram
- Back around 1964, in what were still the formative years of computers, an IBM artist attempted to draw such a chart, beginning with the IBM 701 of 1952 and its follow-ons, for just a 12-year period
- Although this diagram predated the legendary System/360 and its many offshoots, the IBM computer family tree drawn over 50 years ago shows 33 members in three main branches



Source: IBM Archives

IBM 701 – 1952

1st generation – Announced April 29, 1952



- **What was so special about the 701? Well, a few things. The 701 was a landmark product because it was:**
 - 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;
 - Developed and produced in record time – less than two years from “first pencil on paper” to installation;
 - Key to IBM's transition from punched-card machines to electronic computers; and
 - The first of the pioneering line of IBM 700 series computers, including the 702, 704, 705 and 709.
- **Before production began, Tom Watson Jr. visited with 20 companies that were potential customers, on return he said *“as a result of our trip, on which we expected to get orders for 5 machines, we came home with orders for 18.”***

Source: IBM Archives



IBM 704 – 1954

Announced May 7, 1954 and withdrawn April 7, 1960

- **The IBM 704 Data Processing System was a large-scale computer designed for engineering and scientific calculations**
 - Its predecessor was the 701, and its sister computers were the 702 and 705 Data Processing Systems, designed primarily for commercial applications
- **The principal advanced feature of the 704 was its high-speed magnetic core storage or memory**
 - This replaced the electrostatic or cathode ray tube storage used in the earlier machine systems, the 701 and 702
 - A word or number stored in the magnetic core memory in this fashion was available for calculation in 12 millionths of a second
- **In addition to this high-speed memory, the 704 had a magnetic drum storage unit which could be used for storage of parts of the program, intermediate results, rate tables, or other information**



IBM 305 RAMAC – 1956

Announced September 4, 1956 and withdrawn August 18, 1969



- The 305 was a flexible, electronic, general purpose data processing machine that enabled businesses to record transactions as they occurred and concurrently reflect each entry in affected accounts
- The 305 system consisted of the IBM 305 Processing Unit (containing the magnetic process drum, magnetic core register and electronic logical and arithmetic circuits), the IBM 370 Printer, the IBM 323 Card Punch, the IBM 380 and the IBM 350 Disk Storage Unit.
- The 350 Disk Storage Unit consisted of the magnetic disk memory unit with its access mechanism, the electronic and pneumatic controls for the access mechanism, and a small air compressor
 - Configured with 50 magnetic disks containing 50,000 sectors, each of which held 100 alphanumeric characters, for a capacity of 5 million characters
 - Disks rotated at 1,200 rpm, seek time averaged about 600 milliseconds



IBM 1401 – 1959

2nd generation – Announced October 5, 1959 and withdrawn February 8, 1971

- 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
- The elements of the basic 1401 system are the 1401 Processing Unit, 1407 Console, 1402 Card Read-Punch, 1403 Printer, and 729 Tape
- The 1401 may be operated as an independent system, in conjunction with IBM punched card equipment, or as auxiliary equipment to IBM 700 or 7000 series systems

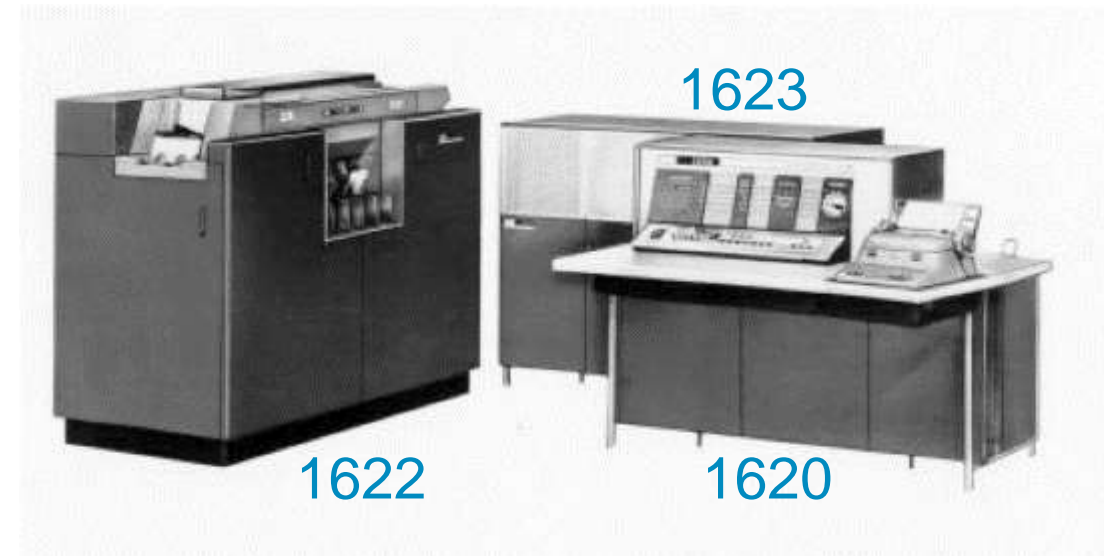


IBM 1620 – 1959

Announced October 21, 1959 and withdrawn November 19, 1970



- **The IBM 1620 was a general-purpose, stored-program data processing system for small businesses, research and engineering departments of large companies, and schools requiring solutions to complex problems in the areas of engineering, research, and management science**
 - Punched card, paper tape and keyboard input; card, paper tape and printed output
 - Large-capacity core storage, up to 60,000 digits
 - High internal processing speeds with access time of 20 microseconds
 - A comprehensive but simplified operator's console
 - Decimal and alphameric notation eased program writing and clarified report writing
 - Variable field and record length for optimum use of storage
 - Automatic floating point feature available

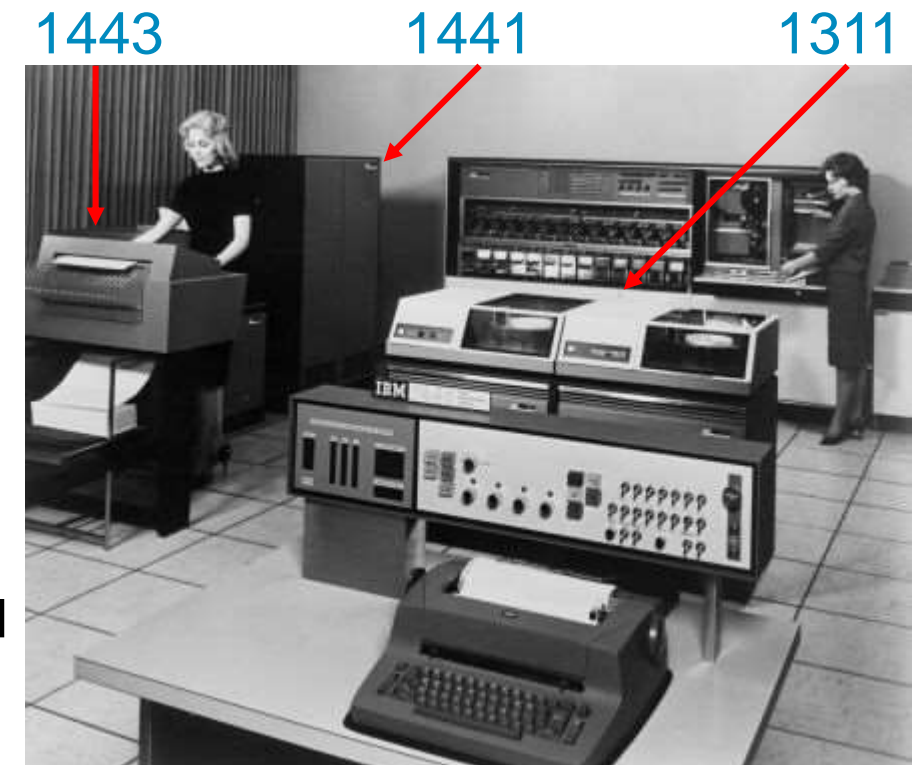


IBM 1440 – 1962

Announced October 11, 1962 and withdrawn February 8, 1971



- **The 1440 was a low-cost system specifically designed to solve the increasing data handling problems of smaller volume businesses**
- **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 1441 Processing Unit contained core storage (up to 16,000 alphanumeric storage positions were available), arithmetic and logic circuits.
 - IBM 1442 Card Read-Punch provided card input and output for the system
 - IBM 1443 Printer provided alphanumeric printed output at a basic rate of 150 lines a minute and could print up to 430 lines a minute, depending upon the typebar used
 - IBM 1311 Disk Storage Drive provided access to removable and interchangeable disk packs which provided storage capacity for 2 to 3 million characters in each pack



Source: IBM Archives

IBM 7094 – 1962

Announced January 15, 1962 and withdrawn July 14, 1969



- **Built for large-scale scientific computing, the IBM 7094 Data Processing System featured outstanding price/performance and expanded computing power**
 - Compatible with the IBM 7090, the IBM 7094 had 1.4 to 2.4 times the internal processing speed
- **The 7094, combined with major input/output improvements through IBM 729 VI and IBM 7340 Hypertape units along with programming systems such as 7090/7094 FORTRAN**
- **A basic machine operating cycle of 2 microseconds**
- **A new processing unit which had major speed effects on:**
 - Floating point operations fixed point multiply and divide operations
 - Index transfer instructions
 - Conditional transfer instructions
 - Compare operations
 - Two instructions per core storage cycle, substantially reducing instruction cycle time

7094

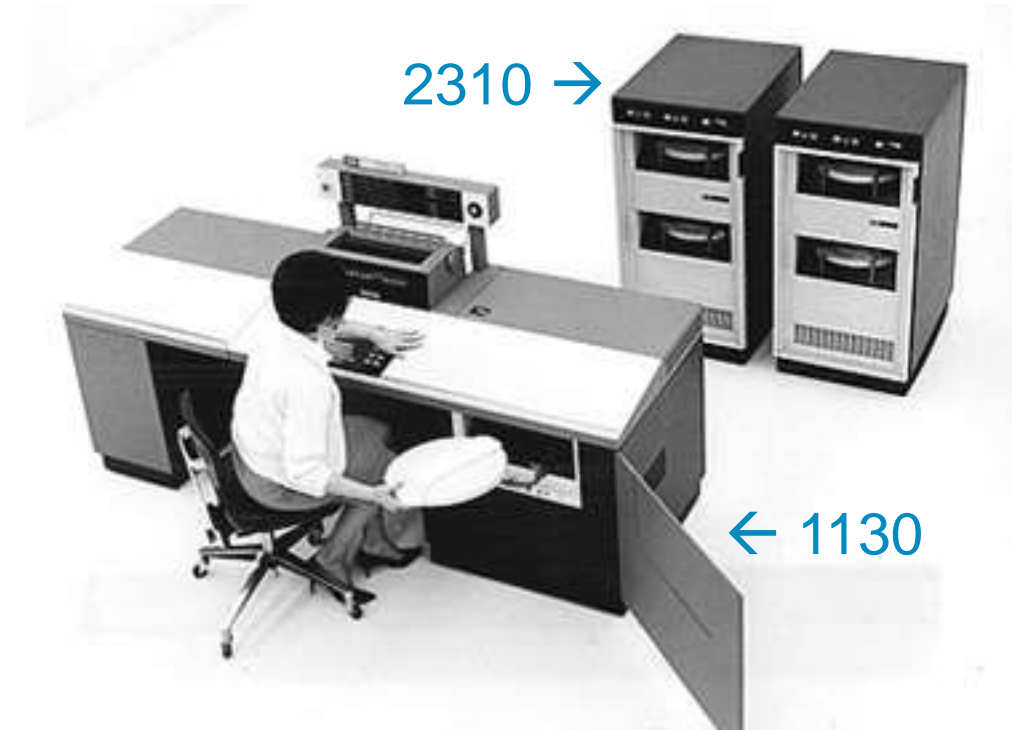


Source: IBM Archives

IBM 1130 – 1965

Announced on February 11, 1965

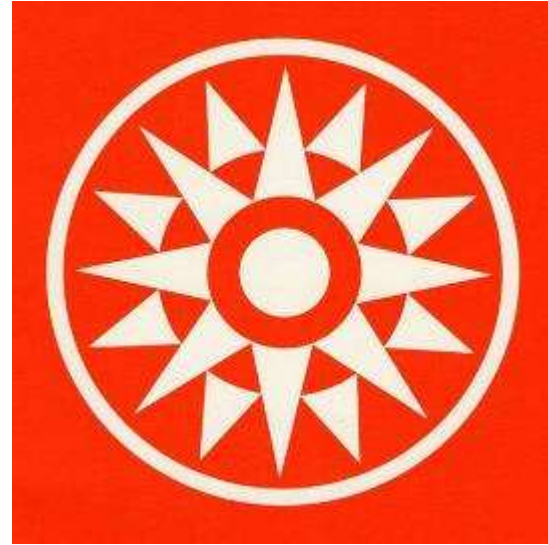
- A stored-program computing system designed for use in engineering, research, management science, and business applications through a wide range of system configurations
- Stored-program control including Boolean logic capabilities and double-precision arithmetic
- Fast access core storage with 16-bit words in blocks of 4096, 8192, 16,384, or 32,768 words
- High-speed parallel binary logic, with a choice of 2.2- or 3.6-microsecond core storage access
- All models of processors contain direct access disk storage capabilities ranging from 512,000 sixteen-bit words to 5,632,000 words
- Overlapped high-speed data transfer to core storage from direct access disk storage at 35,000 words per second, accomplished on a cycle-stealing basis concurrently with computing operations
- Optical mark page reader for direct data entry



Source: IBM Archives

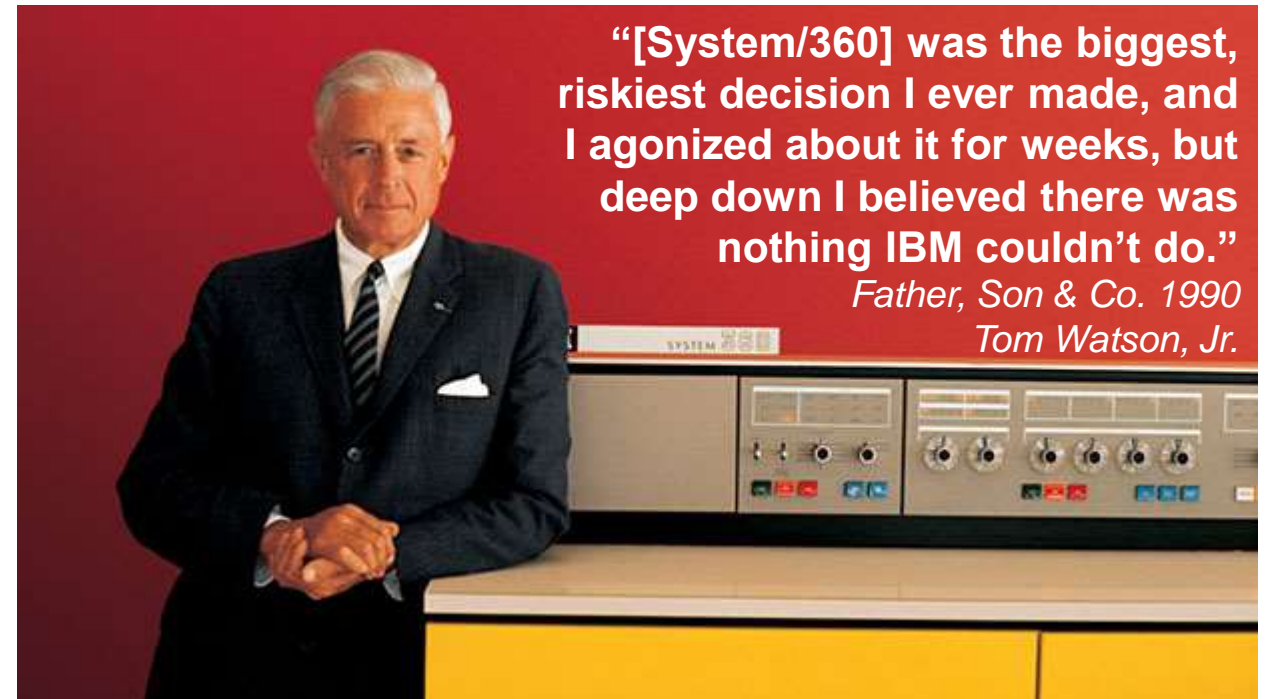
The April 1964 Revolution

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 designed to solve these customer concerns



Source: IBM Archives

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 \$5 Billion in 1964 to develop a family of five increasingly powerful computers that ran the same operating systems and could 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
 - Core memory



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 (later 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/360 (TOS)
- Basic Programming Support (BPS)
- Airlines Control Program (ACP)



System/360 Model 50

Announced April 7, 1964 and withdrawn March 15, 1977



- At announcement there were three mid-range models, the Model 30, the Model 40, and the Model 50
- The IBM System/360 Model 50 had approximately ten times the internal power of the Model 30 when performing a mix of computations
- The high performance of its logical structure is principally due to:
 1. Central storage ranging from 64 KB to 512 KB with a 2-microsecond processor storage cycle time
 2. Read only storage containing a microprogram that controls system operation
 3. Both arithmetic and storage operations are carried out using a full 32-bit word in parallel
 4. Overlap of channel (r/o) operations with CPU operations



Source: Computer History Museum

System/360 Model 20

Announced in November 1964 (first ship in 1966)

- The System/360 Model 20 was the smallest member of the IBM System/360 family and supported only a subset of the System/360 instruction set, 24 KB of memory, with binary numbers limited to 16 bits and no floating point
- In later years it would have been classified as a 16-bit minicomputer rather than a mainframe, but the term “minicomputer” was not current, and in any case IBM wanted to emphasize the compatibility of the Model 20 rather than its differences
- Most popular S/360 built with over 7,400 delivered, was very commonly used as a 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 (TSS) – The “official” operating system from the 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
 - VP/CSS was developed by National CSS for a commercial time-sharing offering (based on CP/CMS)
- **Two models, the Model 1 was a “simplex” system and the Model 2 was a “duplex” system**
- **32-bit addressing (unlike S/390 and later systems)**



“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 50s 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**



Source: Salt Lake Air Route Traffic Control Center Alumni

System/370

Announced June 30, 1970



- **Compatible upgrade from S/360**
- **Original models were the 145, 155, 165 and 195**
- **370 Model 145 was 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



Source: IBM Archives

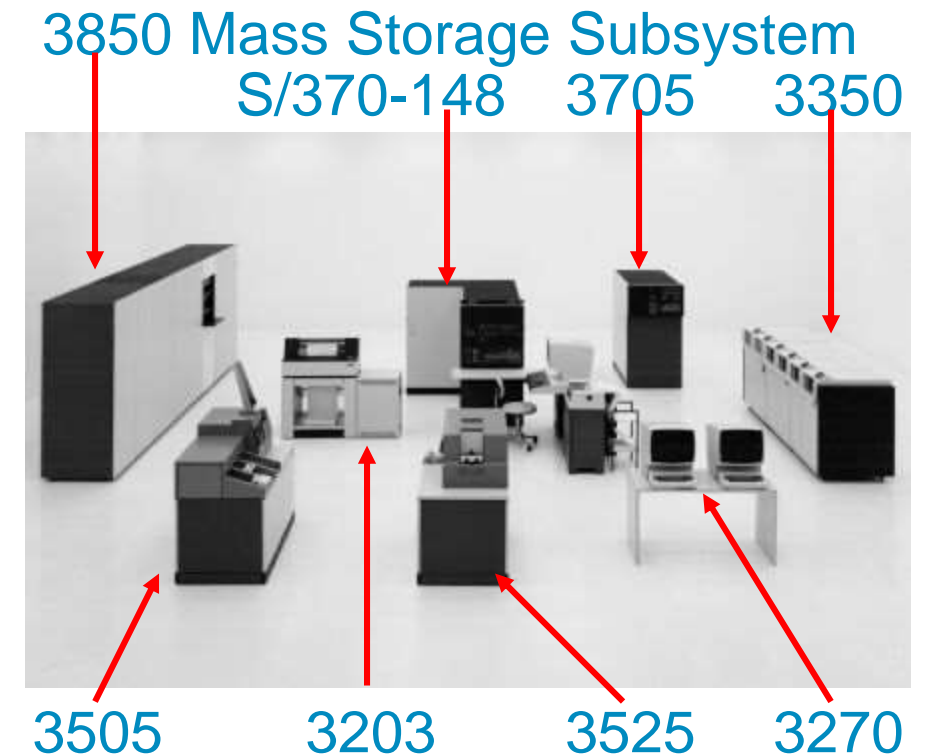


System/370 with Virtual Storage

Announced August 2, 1972



- **Compatible upgrade from S/370 with virtual storage**
- **Integrated 3278 display consoles instead of 3210/3215**
- **Family of operating systems**
 - OS/360 → OS/VS
 - DOS/360 → DOS/VS
 - CP/67 → VM/370
- **The family grows:**
 - 115 (up to 384 KB) and 125 (up to 512 KB)
 - 138 (up to 1 MB) and 148 (up to 2 MB)
 - 158 (up to 6 MB) and 168 (up to 8 MB)
- **First popular multiprocessor models (158MP, 168MP)**



S/370 – the architecture matures

Announced March 25, 1977 and withdrawn February 5, 1985



- **Originally just the 3033 was announced**
 - The 3031 and 3032 were announced in October 1977
- **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



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 initially by VM/XA Migration Aid
- Multiple High Performance Guest Support Facility (MHPGSF) to support V=F guests on VM/XA SP
 - Renamed to Processor Resource/Systems Manager (PR/SM) when Logical Partitions (LPAR) announced

- **370-XA channel design**

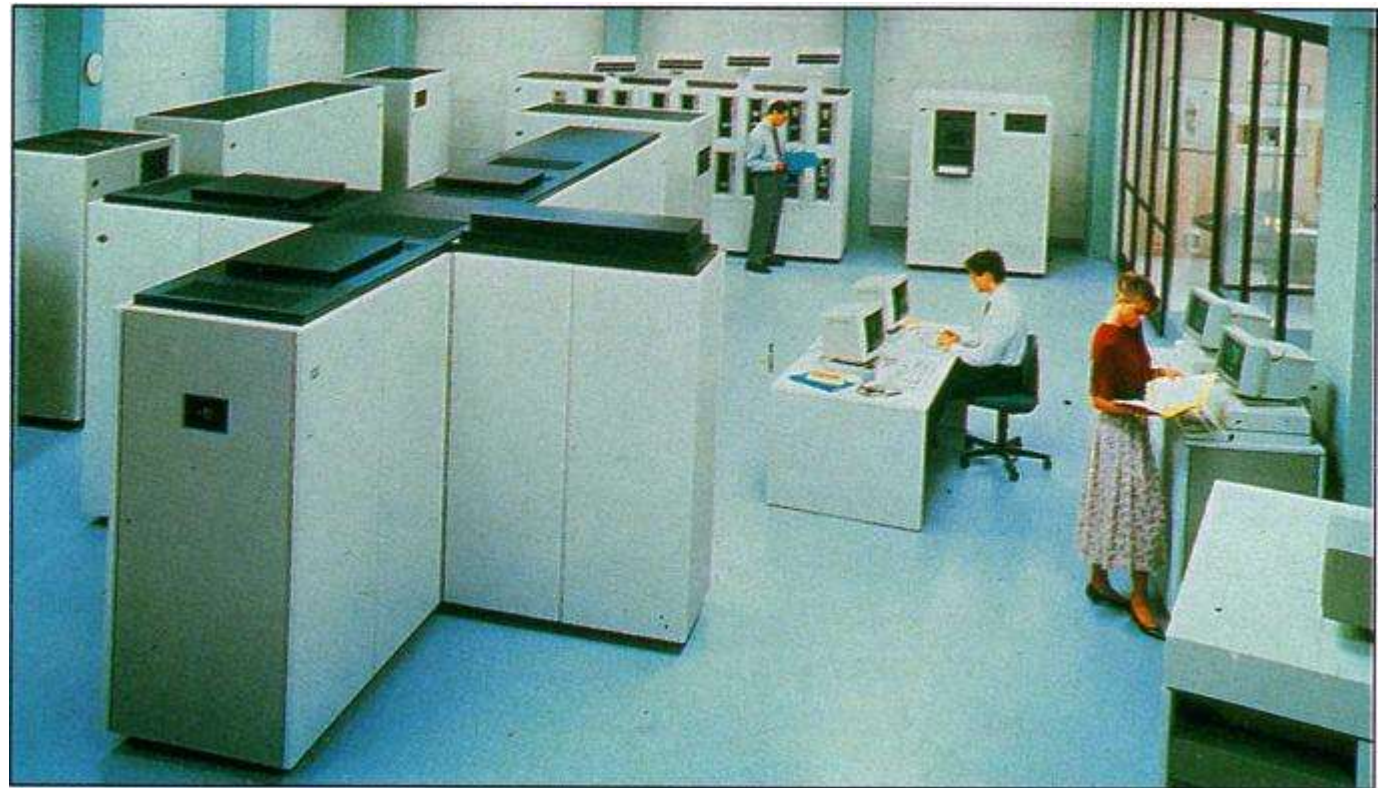
- CHPIDs
- Subchannels

System/370 with Enterprise Systems Architecture

ES/9000 Announced September 1990

- **ES/9000 family**
 - 9021 follow-on to 3090
 - 9121 follow-on to 4381
 - 9221 follow-on to 9370
- **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 CMOS Mainframes

Announced Sep 13, 1994



- **Evolution of ESA/370**
- **1994 – S/390 Parallel Transaction Server (9672 Enn/Pnn models)**
 - Family of CMOS processors
- **1994 – S/390 Parallel Enterprise Server (9672-Gnn)**
- **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)



Source: London Daily Telegraph

eServer zSeries with z/Architecture

Announced October 3, 2000 (z900) and February 19, 2002 (z800)



▪ 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 29, 2002
- Integrated Facility for Linux on z900/z890
 - Also available on 9672-G5/G6 and MP3000

▪ Family of operating systems

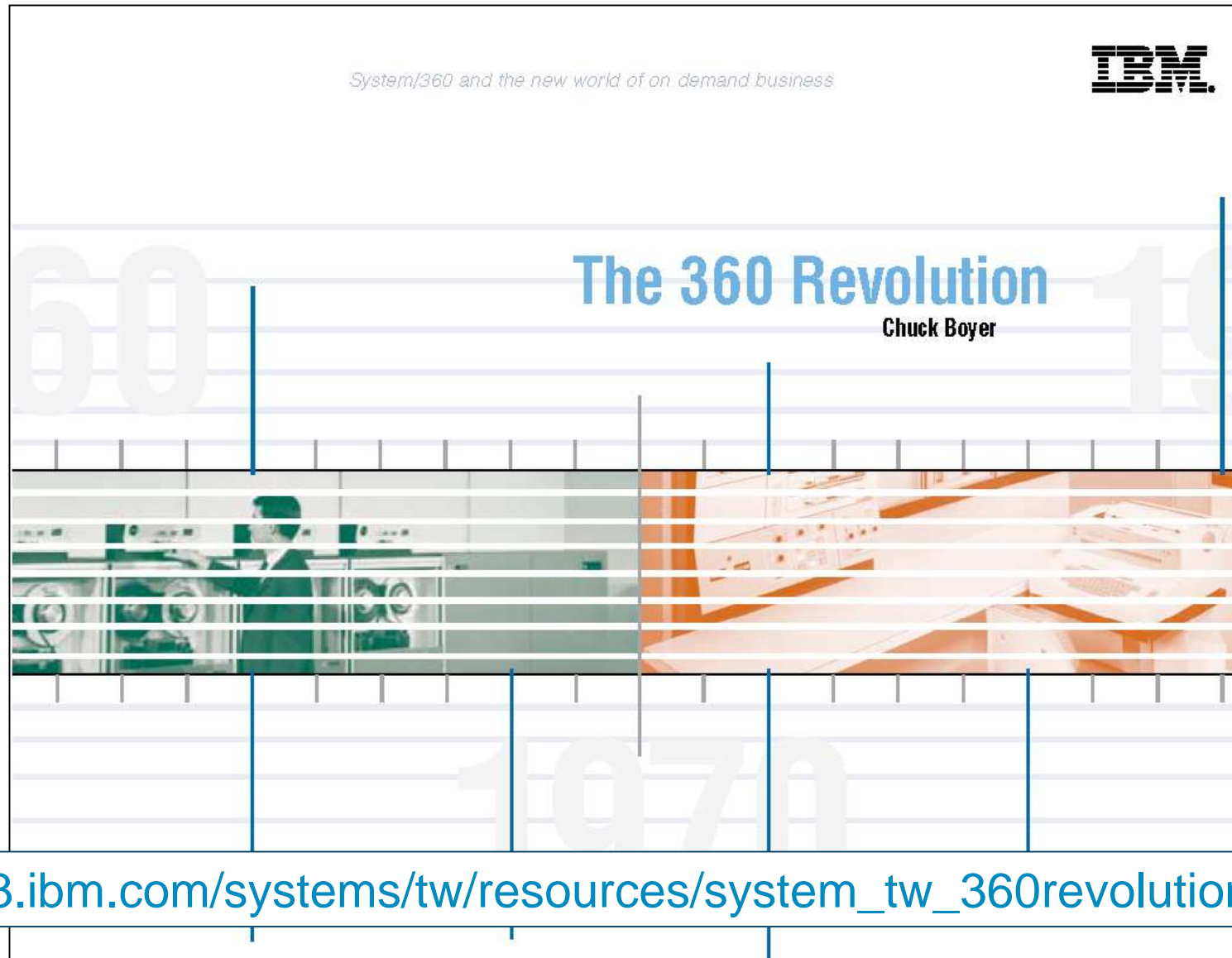
- OS/390 → z/OS
- VSE/ESA → z/VSE
- VM/ESA → z/VM
- TPF → z/TPF
- Linux for S/390 → Linux for zSeries

zSeries 900



 **server®**

April 7, 2004 – The 40th Anniversary



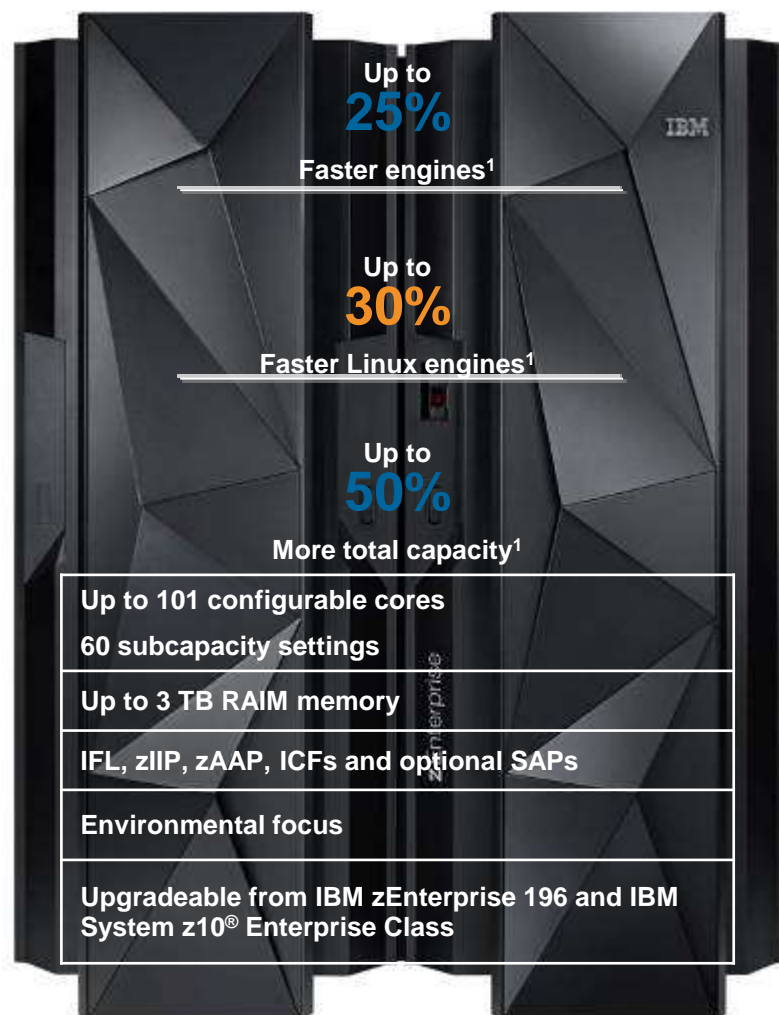
http://www-03.ibm.com/systems/tw/resources/system_tw_360revolution_040704.pdf

April 7, 2009 – The 45th Anniversary



zEnterprise satisfies the most robust enterprise requirements

Announced August 28, 2012 (zEC12) and July 23, 2013 (zBC12)



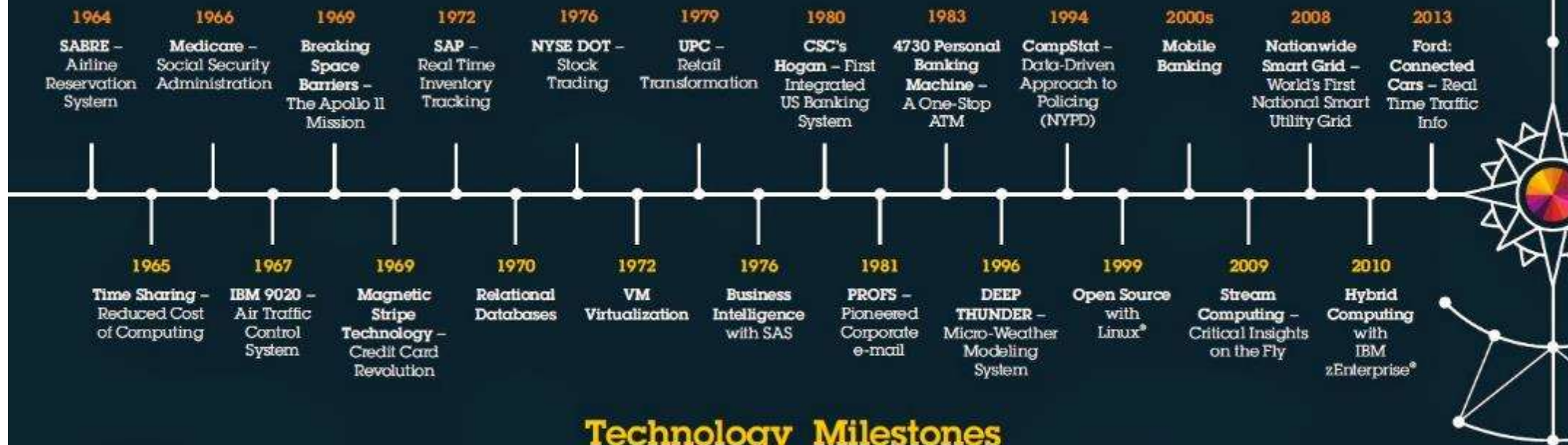
- **Advanced Technology 5.5 GHz processor chip for performance boost for all workloads**
 - Over 78,000 MIPS for large scale consolidation
- **Processor chip optimized for software performance**
- **Innovation to drive availability to superior levels**
 - IBM zAware offers snap-shot of the current state of your business
 - FLASH Express and pageable large pages to drive availability and performance for critical workloads
- **Trusted resilience is a zEnterprise standard**
 - High speed cryptography integrated as part of the chip
 - Enhanced functions with new Crypto Express4S
 - PR/SM™ received EAL5+ certification



IBM® Mainframe50

Celebrating 50 years of groundbreaking innovations

Industry Milestones

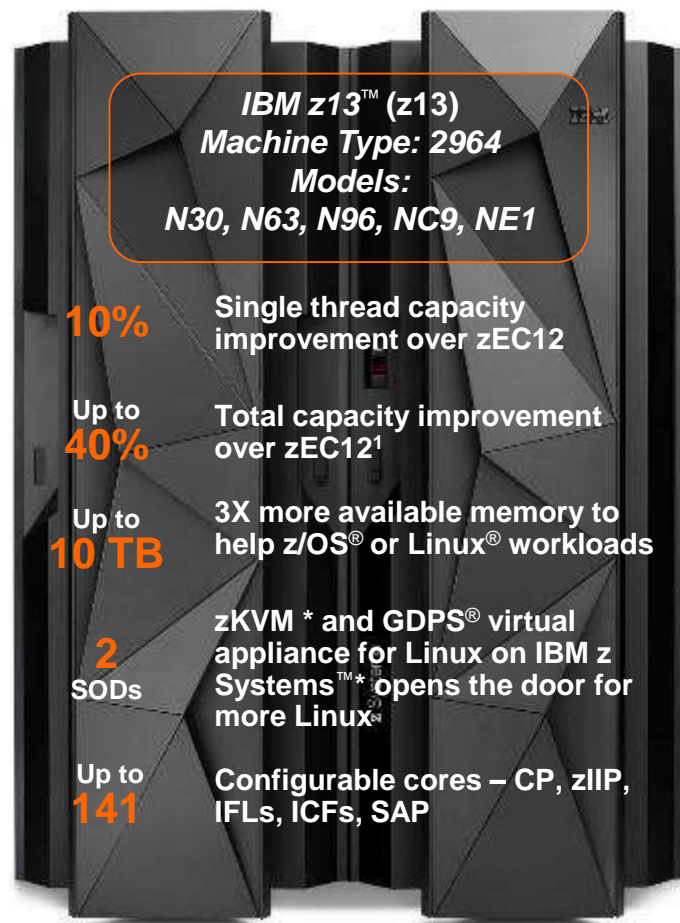


Technology Milestones



The IBM z13: The mainframe optimized for the digital era

Announced on January 14, 2015



- Substantial economies of scale with **simultaneous multi-threading delivering more throughput** for Linux and zIIP-eligible workloads
- Larger **caches to optimize** data serving environments
- **Single Instruction Multiple Data (SIMD)** improves performance of complex mathematical models
- Up to 2X **improved cryptographic performance** with enhanced Central Processor Assist for Cryptographic Functions (CPACF)
- **Compress more data** helping to save disk space and cut data transfer time with improved on **chip hardware compression**
- **Better and faster memory management and execution time** with new hardware instructions and functional facilities to optimize compilers
- New **8-core Processor Design in 22nm Silicon Technology** with **wider instruction pipeline**

Summary

- From System/360 in 1964 to today's z Systems, 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 z Systems virtualization technology
- And with Linux on z Systems, we have a truly open operating environment

“Legacy systems are systems that work!”

Thanks!


Jim Elliott

z Systems Consultant

zChampion and Linux Ambassador

IBM Systems

 @jlelliotton

 Jim.Elliott.Canada



IBM Canada Ltd.

*3600 Steeles Avenue East
Markham, ON L3R 9Z7*

905-316-5813

Jim_Elliott@ca.ibm.com

ibm.com/vm/devpages/jelliott/

Please fill out your
session evaluation form

