A Look Back At Where We've Been

The Evolution Of Technical Computing and Man-Machine Partnerships (Especially at IBM)

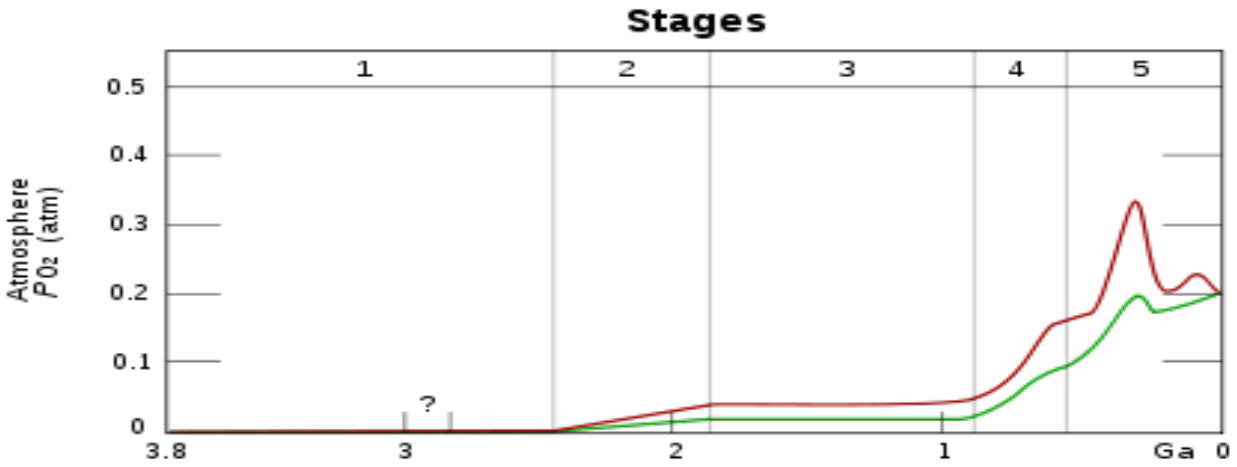
Don Grice

iCAS2015

Interaction of Evolutionary Events

The Great Oxygenation Event

Caused by Cynobacteria and Photosynthesis



O_2 build-up in the Earth's atmosphere. Caused by Cynobacteria
Red and green lines represent the range of the estimates while time is measured in billions of years ago (Ga).
Stage 1 (3.85–2.45 Ga): Practically no O_2 in the atmosphere.
Stage 2 (2.45–1.85 Ga): O_2 produced, but absorbed in oceans and seabed rock.
Stage 3 (1.85–0.85 Ga): O_2 starts to gas out of the oceans, but is absorbed by land surfaces.
Stages 4 and 5 (0.85–present): O_2 sinks filled and the gas accumulates.[3]

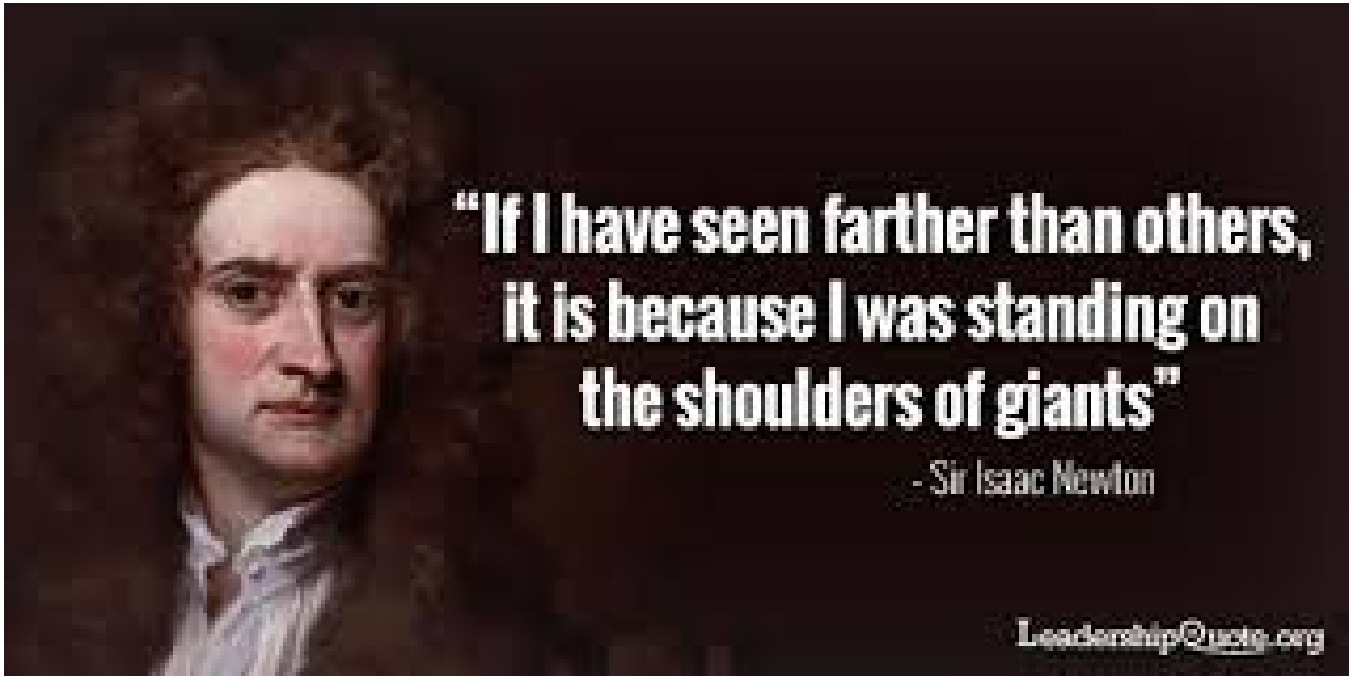
Computing's Parallel Stories

- **The Evolution of :**
  - **Large Computer Systems**
  - **Storage Systems**
  - **Software Systems**
  - **Telephone Systems**
  - **The Internet**
  - **Personal Computer Systems**
  - **Weather/Climate Modeling**

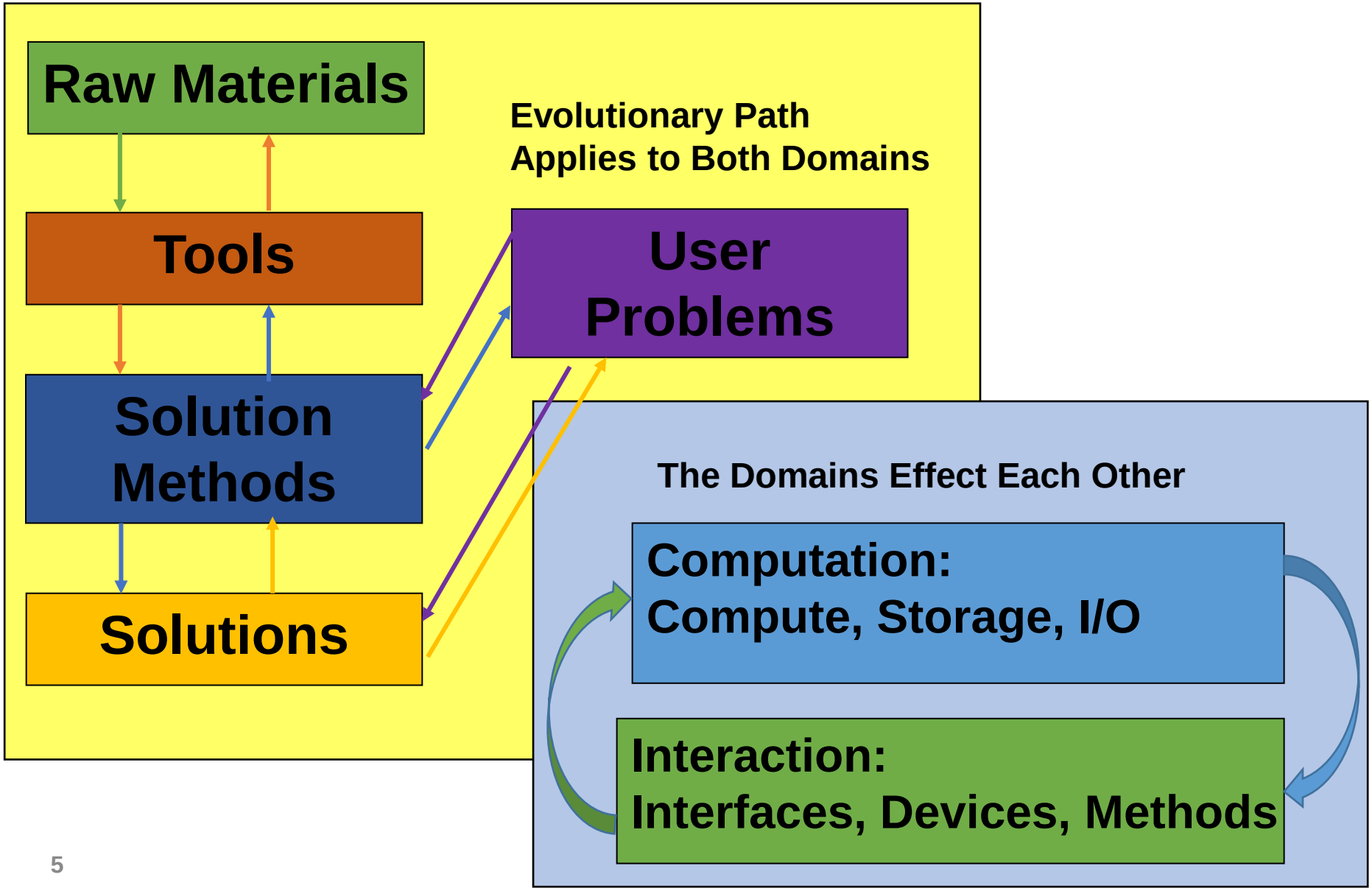
Man-Machine Partnerships need
Machine Computing and Data Handling Capabilities
but also
Ways for the Partners to Communicate

As an Industry and Community:

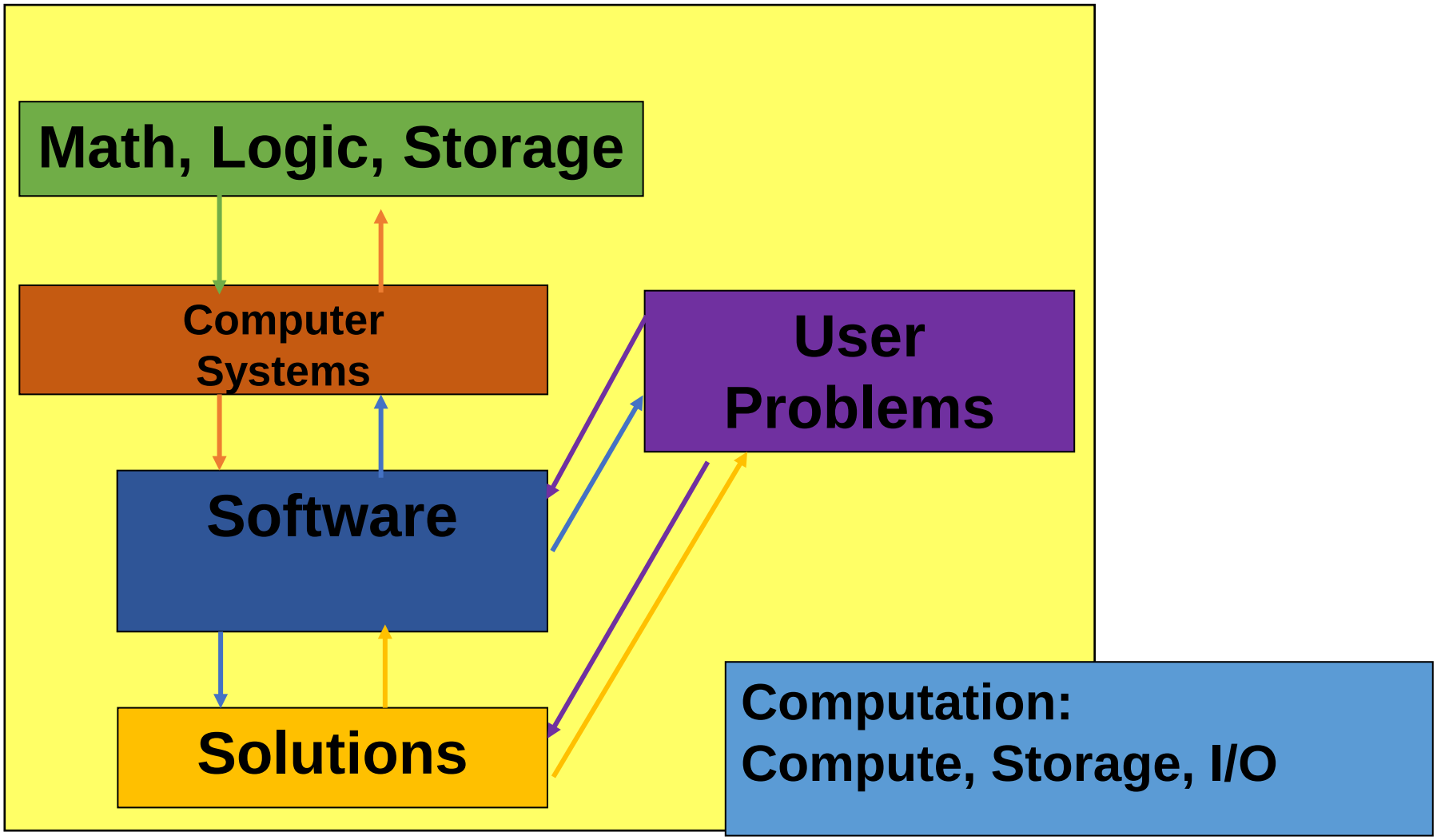
Things have been evolving and progressing based on Collective Memory and Cooperation or at least ‘Coopetition’



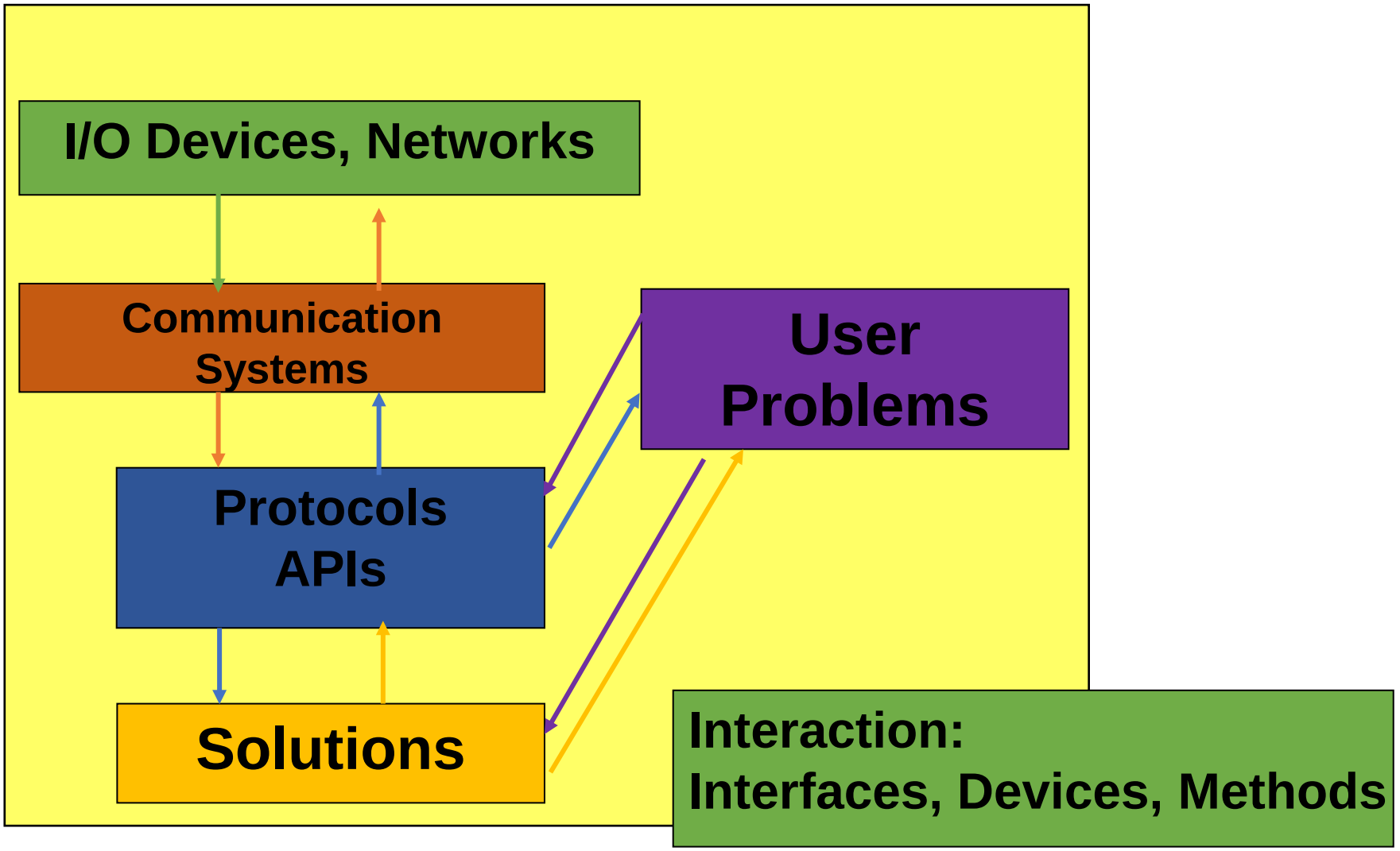
Evolutionary Paths
Computation & Interaction



Evolutionary Paths
Computation



Evolutionary Paths
Interaction



Computation, Communication and Activity Flow

Computation and Activity Occurs In the Boxes

Communication Occurs Between the Boxes

Receiver \ Sender	Man	Environment	Machine
Man	Voice Mail, Email Text, IM Mobile	Sensor Alert Alarm Clock	App Output Alerts
Environment	Light Switch Heat, Cool	Self Driving Cars	Machine Controlled Activity
Machine	Programs App input	Sensor Data	Parallel Work Master/Slave Peer-Peer

Computation, Communication and Activity Flow

Example: Mail vs EMail

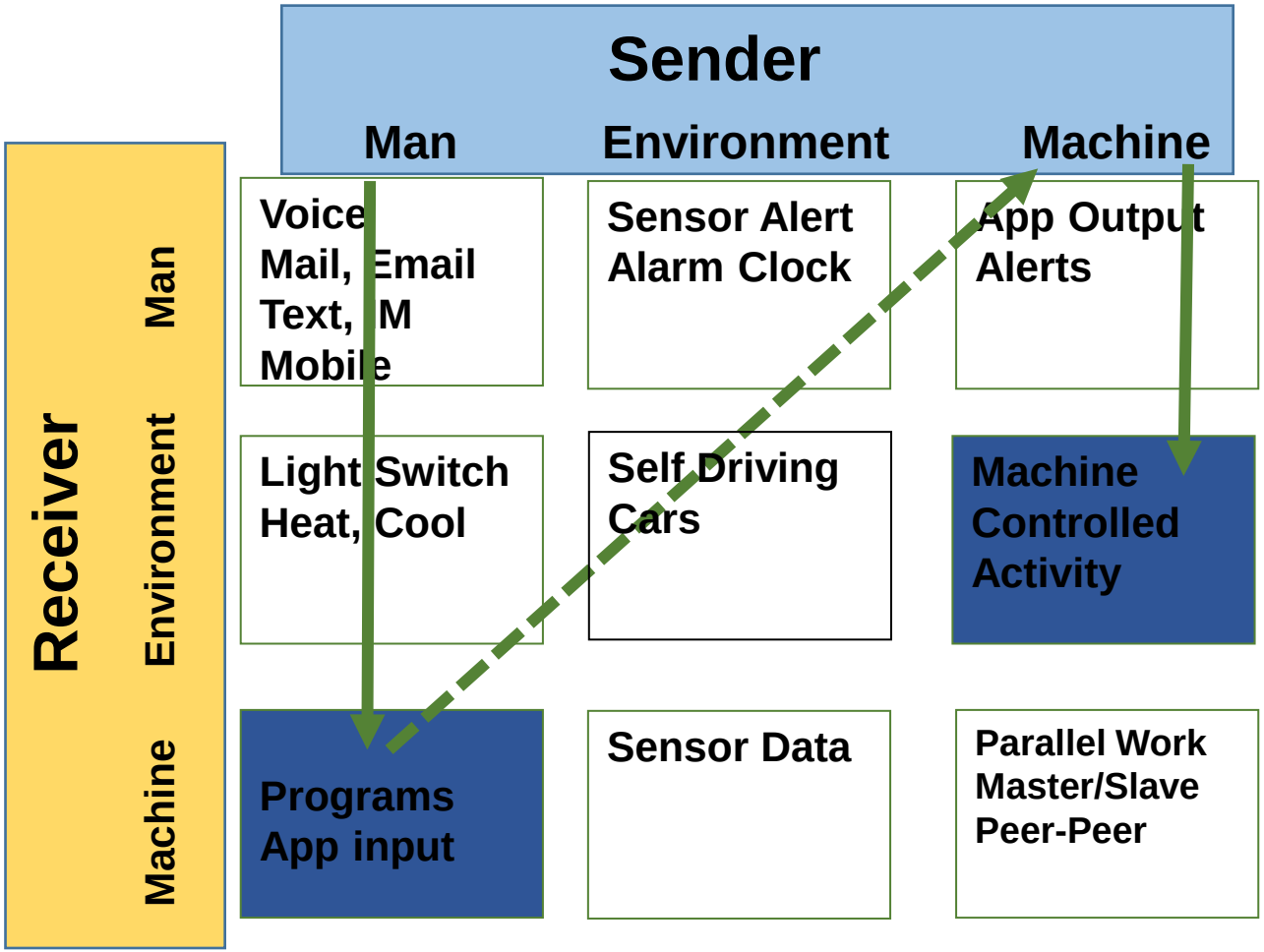
Mail

EMail

Sender	Man	Environment	Machine
Receiver: Man	Voice Mail, Email Text, IM Mobile	Sensor Alert Alarm Clock	Deliver EMail
Receiver: Environment	Light Switch Heat, Cool	Self Driving Cars	Machine Controlled Activity
Receiver: Machine	Send EMail	Sensor Data	Parallel Work Master/Slave Peer-Peer

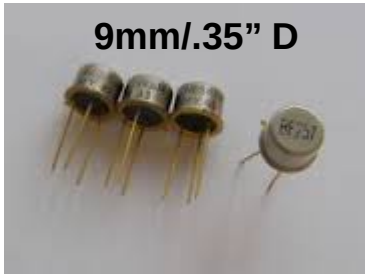
Computation, Communication and Activity Flow

Example: Remote Control Lighting in House



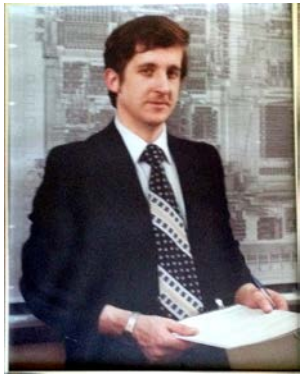
My Adventures with IBM Phase 1

- **1970 Co-Op – Precision Potentiometer Design**
- **1971 Co-Op – Analyzed IBMs first CMOS Wafers**
- **1972 – Joined IBM**
- **1st IBM CMOS Microprocessor Design**
- **128 x 9 b (128B) CMOS Static RAM Design**
- **Distributed Power Supply Design for Communication Loops**
  - **T-05 Bipolar Transistor – 1/package**
  - **Cost Reduced Designs using 4 trans/pkg and then 128 transistor master slice**
- **Analog Phone System Design**
- **Digital Touch Tone design using Digital Filters**
- **1977 - 3277 First IBM CRT Display (Follow on from Release 1 in 1972)**
- **1979 - First IBM Color Display (Built one in the lab in 1978)**
- **1980 – Design system for master slice and custom chip design**
- **1980 – High Level Language Logic Specification -> Chip Layout System**
- **1982 – first 'IPAD' – The Paper Like Terminal (never productized)**
- **1983 – IBM First Signal Processor Design (GPSP)**
- **1984 – IBM Voice Assisted Terminal, Auto Answering Machines, etc.**



My Adventures with IBM Phase 2

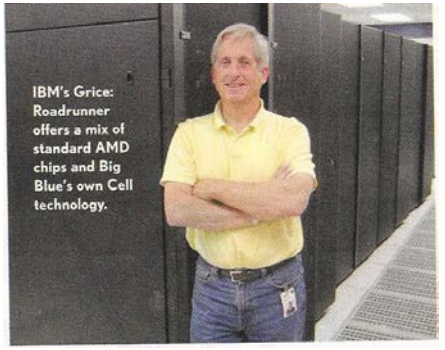
- **1987 - Display and Voice Mission Moves to Raleigh – I switch to HPC design**
- **1988 – IBM PIM Vector Machine – abandoned with deal with SSI**
- **1991 – 4 way HiPPI Coupled Mainframe (SC91)**
- **1992 – Shared L4 Design for Coupled System – also HiPPI attached**
- **1993 – Start of SP family (I was Chief HW Engineer of the SP1)**
- **1993-2006 - Many SP generations – Integrated Switches, Routers, GPFS, etc**
- **2006-2008 Accelerated Computing Initiative using Cell Processor**
  - **RoadRunner is first PF machine**
- **2013 - Open Power Accelerated Computing Initiative using GPUs**



Design System For Custom Chip Layout 1980

Analog Voice Processing 1984

Digital Voice Processing 1984



Road Runner System Design 2008

How Has The Evolution Progressed?

Major Transition Periods

1. Development of Math – including Zero: 3000-2000 BCE
2. Calculation Machines – Abacus: ~400-200 BCE
3. Binary Encoded Math : ~1679
4. Mechanical Computer Era : 1830 - 1946
5. Early Electronic Computer Era : 1946-1972
6. Fortran – first Optimizing Compiler for IBM 701 : 1957
7. Internet Era begins : 1968-present
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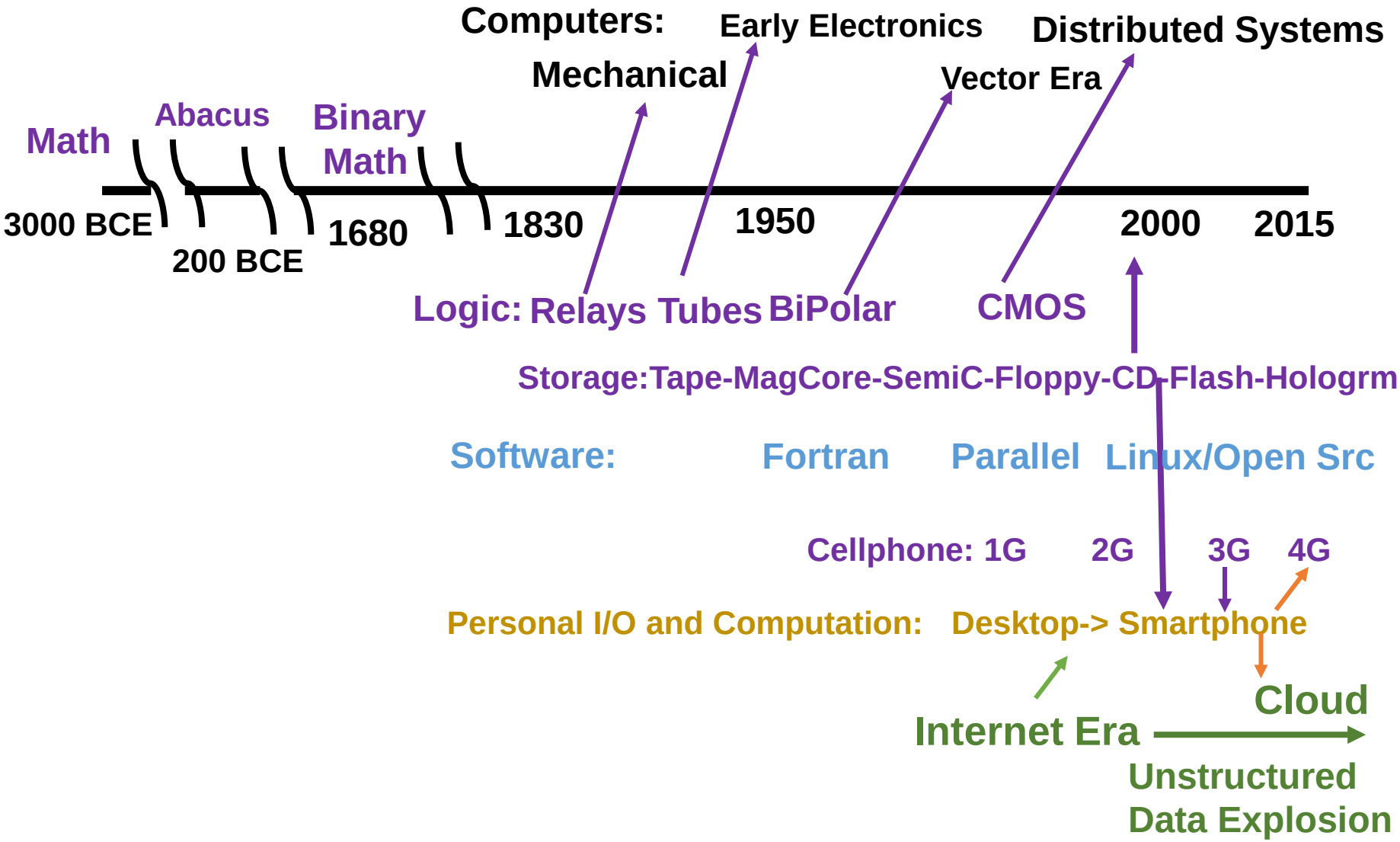
12. Linux begins: 1991; RedHat IPOs : 1999
13. Low Power Computing Era : 2005 – present
14. Unstructured Data Explosion: ~2010

Major Transition Periods Timeline



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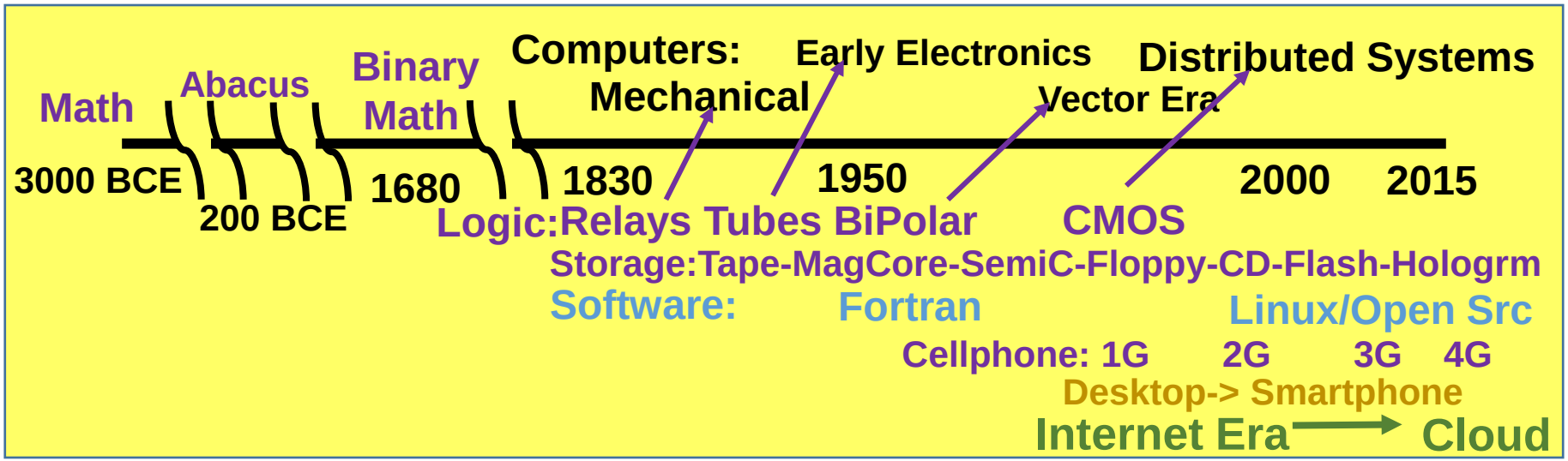

The Evolution of Large Computer Systems

The World Before I Joined IBM

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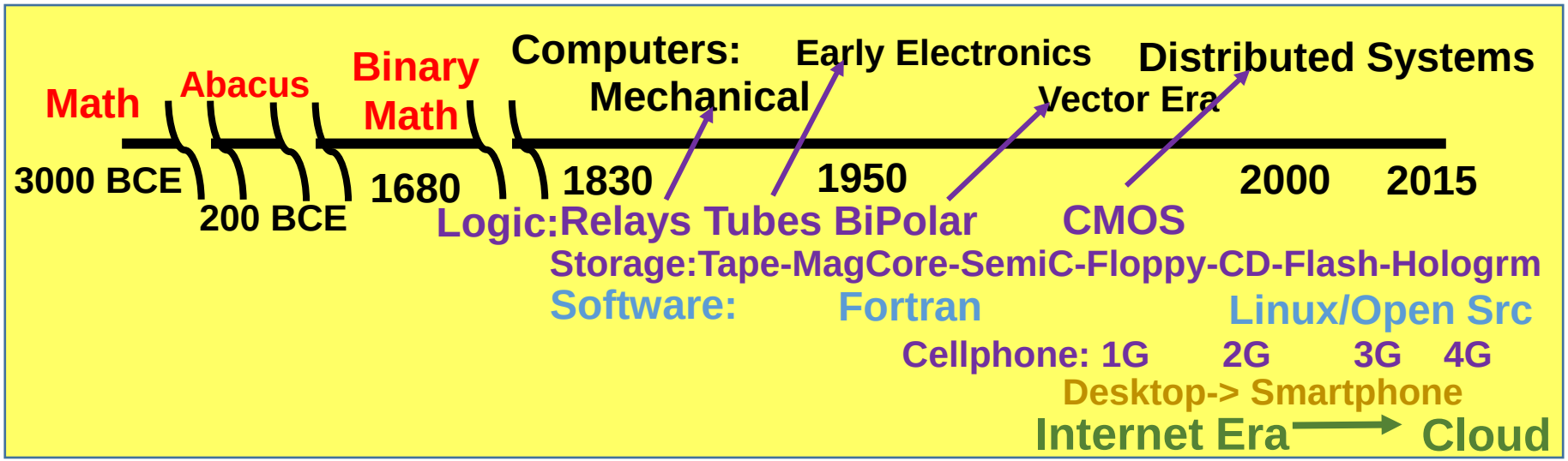
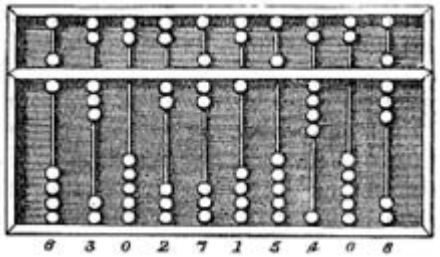


The Invention of Zero

- **Without a Zero as a real ‘Number’ complex math and computers probably wouldn’t exist**
- The Sumerians developed a positional number system 3000-2000BCE
- Babylonians added ‘wedges’ to make an empty column more readable – 300BCE
- Mayans added a ‘Zero’ to their calendars – 350CE
- Indian Mathematicians added it to Math – 628CE
- This was passed on to the Arabic number system
- The Italian Gov’t didn’t trust Arabic numbers and banned the use of ‘zero’
- People used it in secret anyway
  so the Arabic word for zero – ‘sifr’
  became Cipher – which means both Zero and Code

The Invention of the Abacus

- The Sumerians developed a positional number system ~3000BCE
- The Sumerian Abacus using positions was developed 2700-2300BCE
- Greeks had one ~400BCE
- The Chinese had one ~200BCE – Cleared by spinning



Groups of 5 like:

𝍸

(the number represented in the picture is 6,302,715,408)

- The Russians taught it in school until 1990

Binary Numbers

- In China ~900BCE the I Ching
  - Yin (0) Yang (1)
  - Random Hexagrams: 0-63
    point to sections of a book to tell fortunes
- Francis Bacon 1605 – binary encoded alphabet
  to be used by 2 state systems.
  i.e Smoke Signals, Lantern Signals, Drums, etc
  The 'Papal Ballot' is still in use today – black/white
- Gottfried Liebniz 1679 built on I Ching for use
  in mathematics
- George Boole (Boolean Algebra) 1854
- Claude Shannon 1937
  - relays and switches from Telephone Evolution
    as binary computing elements

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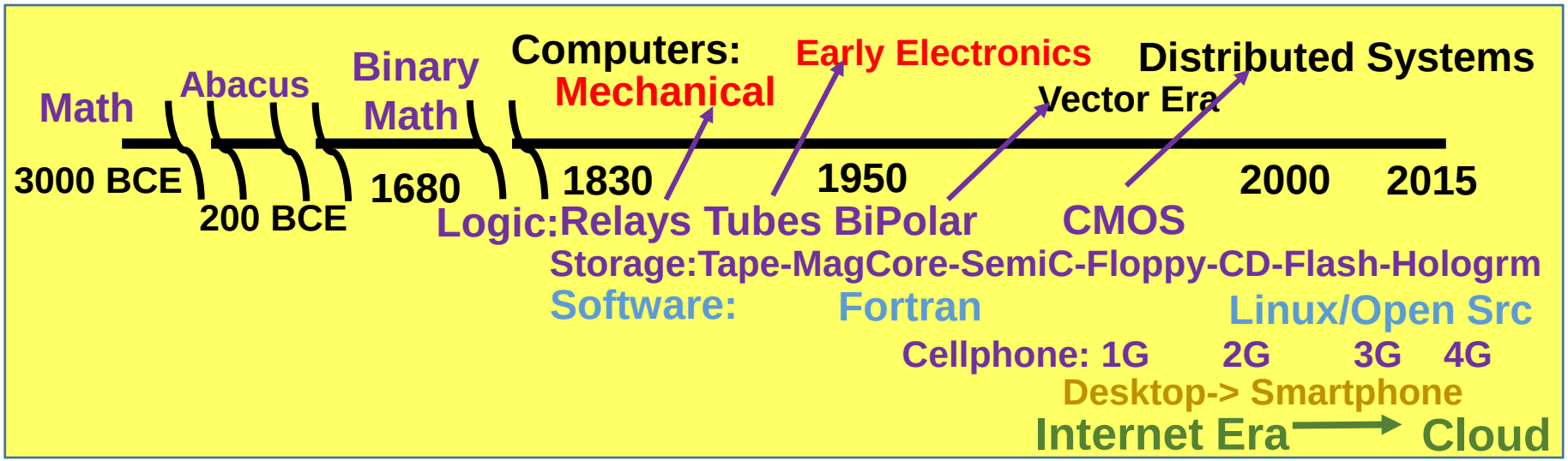
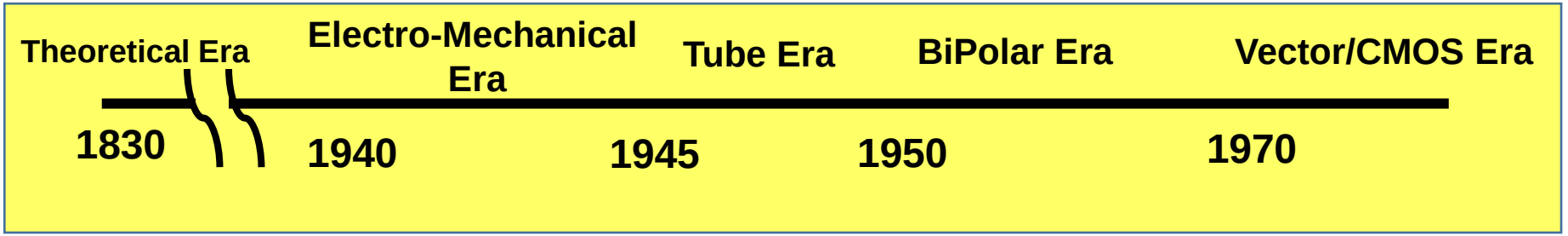


Early Computation Machines – Pre Vector

- Theoretical – not Built
  - 1832-47 - Charles Babbage – Difference Engines #1 and #2
  - 1834 - Analytics Engine – full steam driven computer idea
- Electro Mechanical
  - 1939 - Turing – Bombe
  - 1940 - Stibitz – CNC
  - 1943 - Stibitz – Relay Interpolator
  - 1944 - IBM Harvard Mark-1
- Tubes
  - 1944 – Colossus – Code Breaker
  - 1945 - ENIAC– 5000 Tubes, 350 Mult/Sec – rewired to reprogram – base 10
  - 1946 - IBM SSEC (Apollo Tables) 50 mult/sec
  - 1949 - EDVAC – 6000 Tubes, 340 Multiply/sec – Binary
- Bipolar
  - 1953 - IBM 701
  - 1958 - IBM SAGE (+ Tubes)
  - 1959 - IBM STRETCH
  - 1964 - CDC 6600 3 Million Instr/sec
  - 1968 - CDC 7600



Theoretical Computing Machines

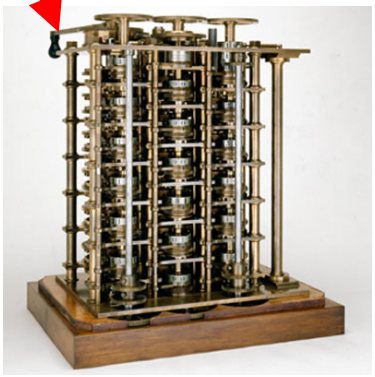
Ada Lovelace and the Babbage machines

Charles Babbage

- 1832 – Difference Engine #1 – never completed
  Motivated by finding errors in math tables
  25,000 moving parts, weighing 4 tons
- 1834 – the Analytical Engines
  Would have been a full fledged 'computer'
  and would have been steam driven
- 1847 – Difference Engine #2 – Eventually built 2002
  8,000 moving parts, weighing 5 tons

Difference Machine #2
Implemented in 2002
4 Crank Rotations/Cycle

Crank



Ada Lovelace

- 1843 – published an article on the steps that the Difference Machine would have to take to solve a problem – the first conceptual 'Computer Program'
- Recognized that symbols didn't have to be just numbers but could be letters or musical notes, etc.
  i.e. Symbolic Programming

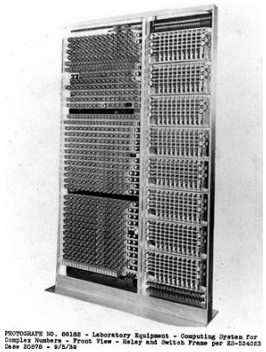
Electro Mechanical Computing Machines (Enabled by the Telephone Evolution)

Electro-Mechanical Machines

Electro-Mechanical: Relays

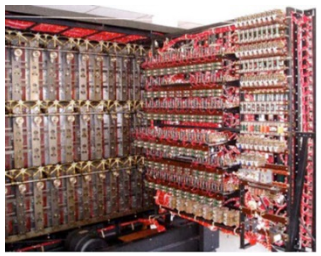
- 1939 - Complex Number Calculator: Stibitz – 450 telephone relays
  First ‘remote access’ computer.
  Divided 2 8 digit complex numbers in 30 seconds
- 1941 - Bombe: Alan Turing
  Electro-Mechanical code breaker based on the Polish Bomba
- 1943 - Relay Interpolator: Stibitz – 440 relays
  Artillery table Interpolator – 1 multiply in 4 seconds
- 1944 - Harvard Mark-1 : IBM
  50 ft camshaft – generated math tables
  Introduced the ‘Harvard Memory Architecture’

CNC

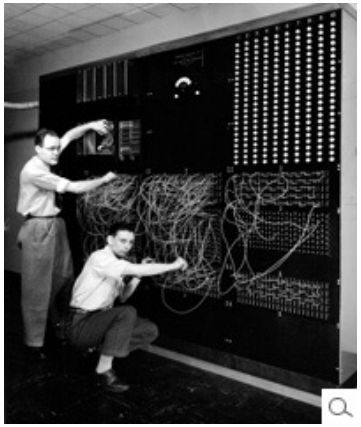


PHOTOGRAPH NO. 66182 - Laboratory Equipment - Computing System for Complex Numbers - Front View - Relay and Switch Frame per ES-324203 Date 10CT42 - 9/5/52

Bombe



Mark-1



Evolution of Logic Switches

Moving from Mechanical to Electrical Development of Electronic Switches

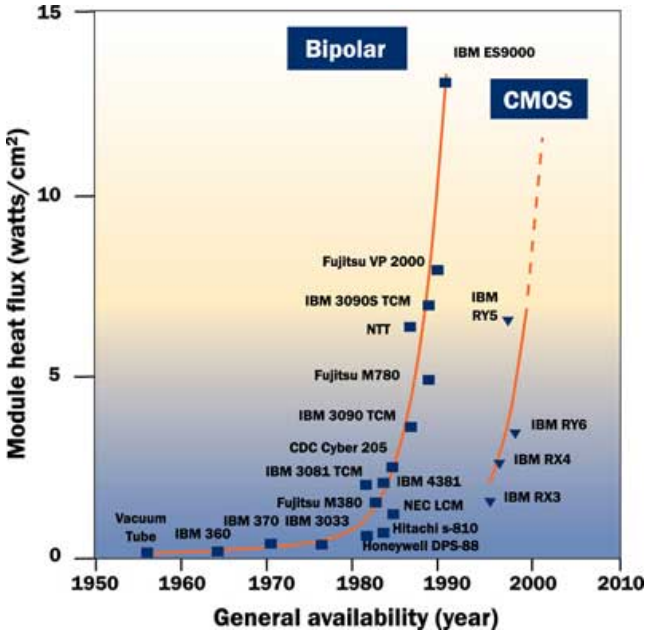
- **Tubes:**
  - **1904 – John Flemming – Edison Telephone Diode Rectifier Vaccuum Tube**
  - **1907 – Lee De Forest Triode Amplifier Tube**

- **Transistors:**

- **BiPolar Transistors**
  - **1948 – William Shockley – Bell Labs– Bipolar Transistor**
  - **1950 – National Bureau of Standards (SEAC) machine 10,500 Germanium Diodes – first semiconductor logic switches in a machine**
  - **Single Transistor Packages – logic and Power Amplifiers**
  - **1970s 4 Transistor Package -> 128 Transistor Master Slice**

- **CMOS Transistors (Motivated by Power Limits and Circuit Density)**
  - **1959 – Bell Labs – FET – was slow and did not have a market**
  - **1962 – RCA produced an experimental 16 device FET chip.**

Power Density required a change in Technology From BiPolar to CMOS



Circuit Density was Also a Big Motivator

Transistors/Chip

BiPolar

1964 -10*1
1968 - 10*2

CMOS

1971 - 10*4
1980 - 10*6
2004 - 10*8
2009 - 10*9
2015 – 5.5x10*9

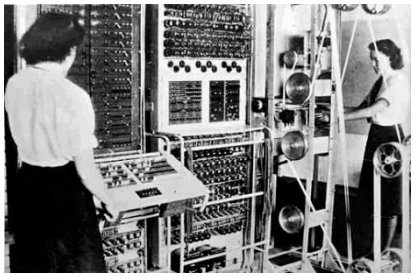
Circuit Count Explosion Created a Need for Better Design Tools

- LSI-> VLSI->ULSI: 10,000 -> 1,000,000,000
- State of the art was Light Pen Designed Chips
- Obviously not Scalable to these Circuit Counts
- High Level Circuit Design Methods
    - Libraries
    - Design Languages and Automatic Layout
- Verification Tools
- Timing Verification Tools
- Specialized HW Simulation Machines
    - YSE, EVE – precursors to FPGAs

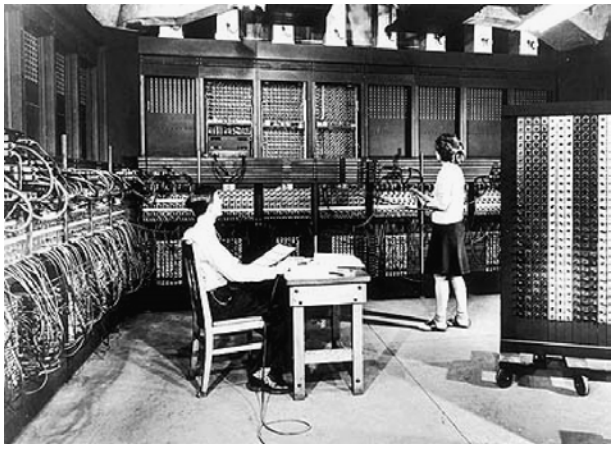
Tube Enabled Computing

Tube Based Computers

- **1944 - Colossus – Tommy Flowers – 1,500 Tubes**
  British Code Breaking Machine
  First Programmable Electronic, Digital Computer
  Programmed with Plugs and Switches



- **1946 – Eniac – 17,000 Tubes**
  Tube Failure every 2 days (15 minutes to find)
  5M hand solder joints were the biggest issue
  Failures were debugged by the programmers crawling in the machine.
  Turing Complete computer that was Base 10
  Also Programmed with Plugs and Switches which took weeks to design and enter
  Input and output decks were IBM Punch Cards
  First Experiment took 1M input cards
  357 Adds/second.



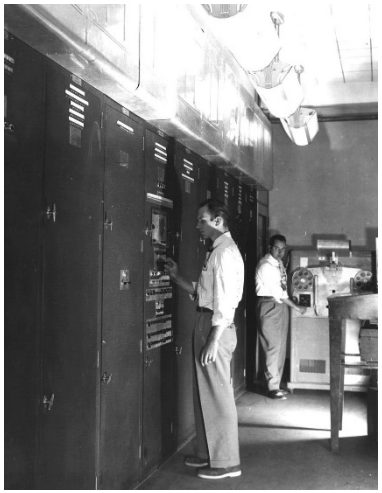
Tube Based Computers (2)

- **1948 - IBM´s Selective Sequence Electronic Calculator computed scientific data. Before its decommissioning in 1952, the SSEC produced the moon-position tables used for plotting the course of the 1969 Apollo 11 flight to the moon.**

50 Multiplies per Second, 20,000 Relays, 12,500 Tubes
Memory: Punched Tape, Tubes, Relays,

- **1949: EDVAC (Electronic Discrete Variable Automatic Computer)**
  Used by the Ballistic Research Lab
  A Binary Computer with Stored Programs
  6,000 Tubes, 12,000 Diodes and 56KW
  30 Full Time Operators per shift
  Control Unit included an Oscilloscope

1200 add/sec and 340 multiplies/sec
Memory: Ultrasonic Mercury Delay Line
(serial access)
1024 44bit words -> 5.5KB



Tube Based Computers (3)

- **1953 - IBM´s 701 was the first commercial Scientific Computer**

  Williams Tube (CRT) Memory introduced the need for ‘refresh cycles’
  Later replaced with Magnetic Core memory
  8KB total memory
  2 Program accessible Registers. Accumulator and Quotient
  2K Multiplies/sec

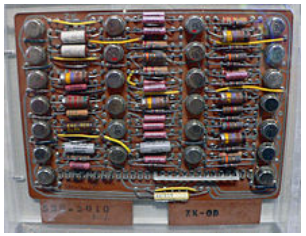
- **1954 - Joint Chiefs of Staff recommend the 701 to be used for the Joint Numerical Weather Prediction project**

Williams Tube
1024b memory

BiPolar Early Machines

- 1958 - IBM (HW) SAGE (Semi-Automatic Ground Environment) with MIT, Honeywell, and SDC
  - Operators directed operations with a light pen.
  - 75K Instr/sec
  - 13,000 Transistors, 60,000 Tubes, 175,000 Diodes, 3MW

- 1959 - IBM STRETCH
  - 170,000 Transistors, 400-600 KFlops
  - Multi-programming, Memory Protection, Memory Interleaving Instr Pipelining, PreFetch, 8b Byte all introduced



- 1964 - CDC 6600 3 Million Instr/sec
  - Used effectively Multi-threaded RISC based processors
    - I/O processors and simpler CPUs
  - Decreased the cycle time dramatically
  - But finding the Parallelism was already an issue
- 1968 - CDC 7600
  - Introduced Instruction Pipe-lining to keep the parts of the machine busy
  - 3x faster than then 6600
  - Introduced ‘C shape’ for service

BiPolar Enabled Computing
The Vector Era

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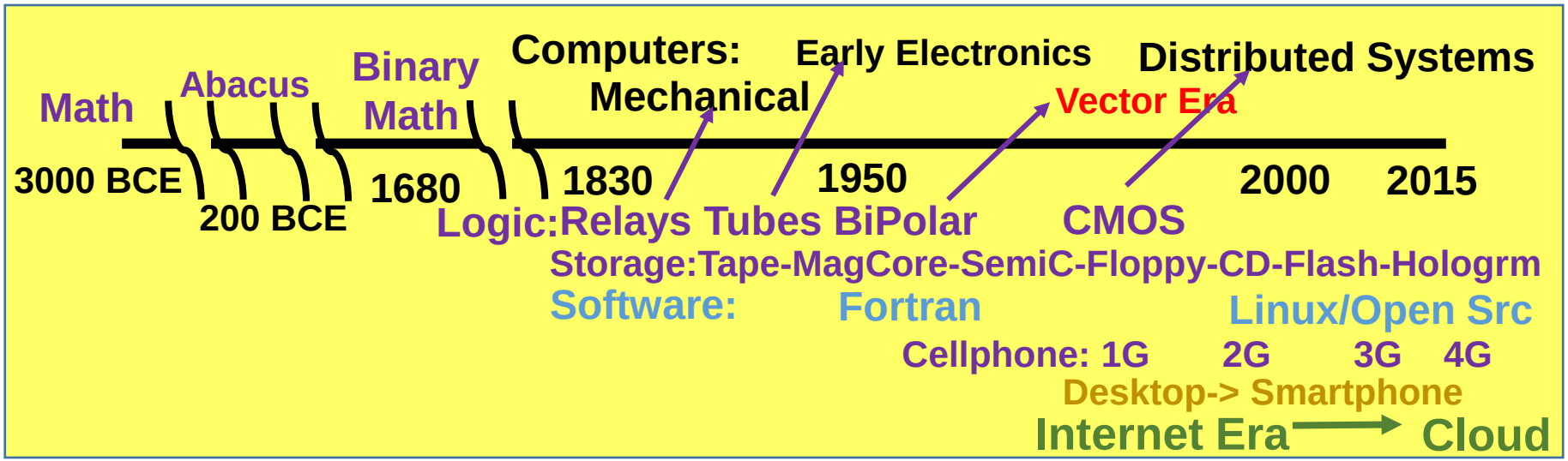
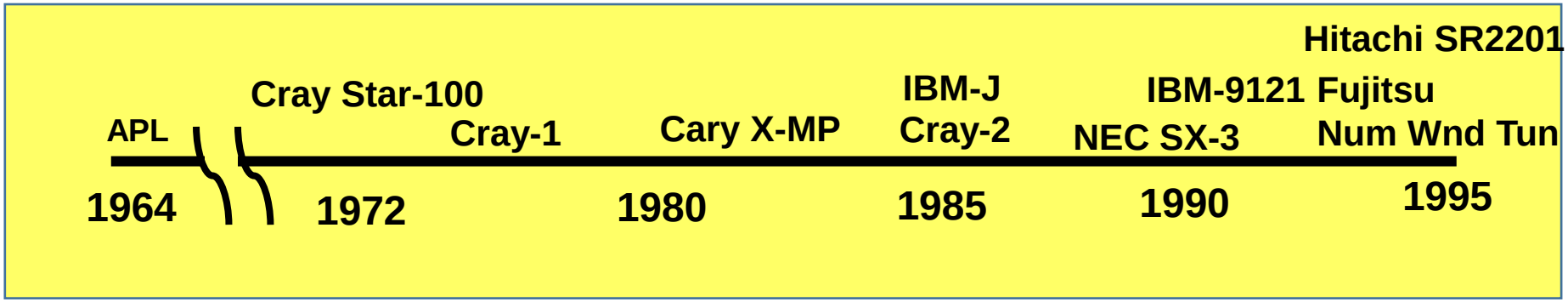


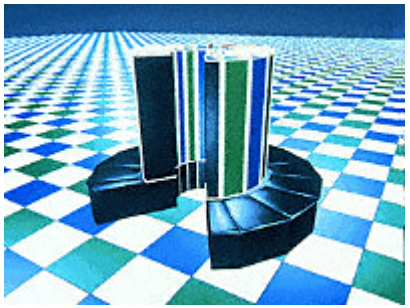
The Vector Era

1. 1972 - CDC Star-100, 100MF,
   Vector inspired by APL (1964)
2. 1976 - Cray-1, 2 Gates/Chip, 80MHz
3. 1982 - Cray X-MP (Steve Chen)
   Parallel Vectors 105MHz
4. 1985 - Cray-2 4 Processors 1.9GF
5. 1985 - IBM ES/3090 Model J Vector Facility (68MHz)
6. 1988 - Cray Y-MP (Steve Chen) 8 Vectors 2.7GF
7. 1988 - Steve Chen – forms SSI with IBM support.
8. 1989 - NEC SX-3/44R 4 Processors
9. 1991 - IBM ES/9000 Vector 9121
10. 1991 - IBM was working on a PIM Vector machine and deferred to SSI
    That lead to the start of the SP Line
11. 1994 - Fujitsu Numerical Wind Tunnel
    166 Vectors 280GF
12. 1996 - Hitachi SR2201 2048 Vectors 600GF

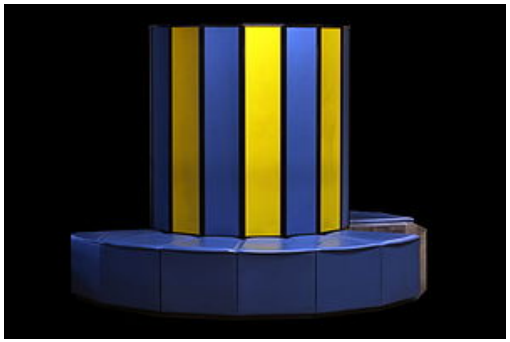


The Vector Era

- **1976 -The Cray I made its name as the first commercially successful vector processor. The fastest machine of its day, its speed came partly from its shape, a C, which reduced the length of wires and thus the time signals needed to travel across them.**
  166 Mflops, 2Flop/Cycle at 83MHz



- **1982 - The Cray XMP, first produced in this year, almost doubled the operating speed of competing machines with a parallel processing system that ran at 420 million floating-point operations per second, or megaflops. Arranging two Crays to work together on different parts of the same problem achieved the faster speed.**



- **1986 - The 3090 vector facility was an optional component of the standard IBM 3090 system and was be viewed as an addition to the instruction execution part of the base machine. 171 new instructions were also introduced with the vector facility.**

VS Fortran and ESSL were developed to take advantage of the special architectural features of 3090 VF

CMOS Enabled Computing
The Distributed Computing Era

Major Transition Periods

1. Development of Math – including Zero: 3000-2000 BCE
2. Calculation Machines – Abacus: ~400-200 BCE
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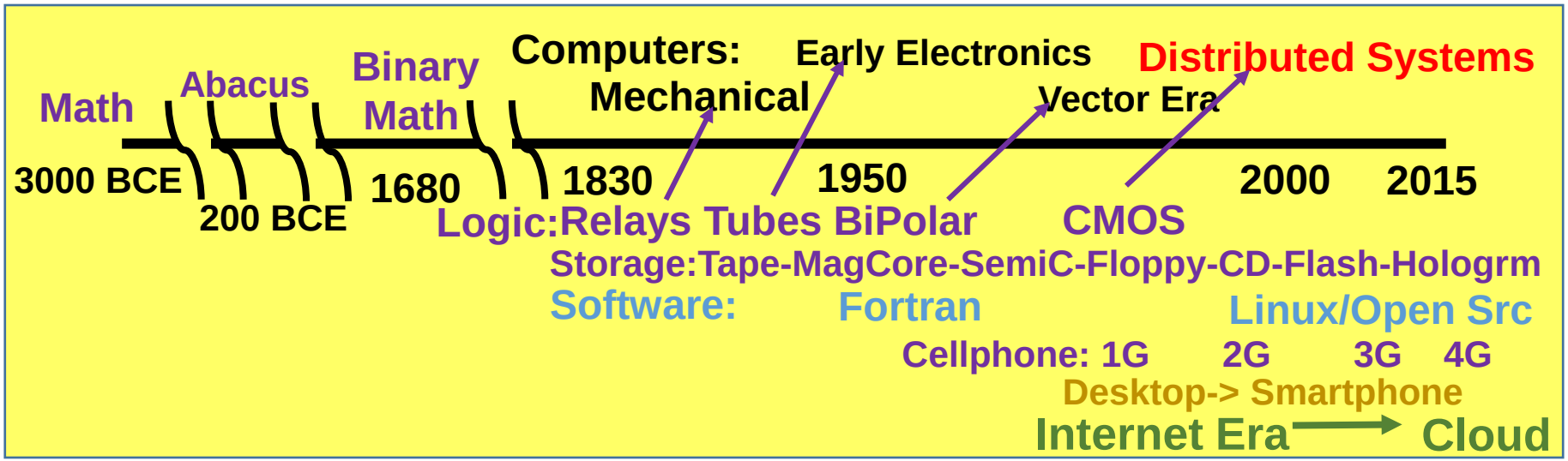
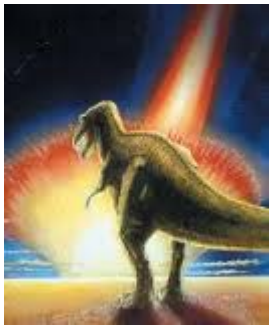


The Massively Parallel (Distributed Memory) Era

“To Plow a Field would you rather have 2 Oxen or 1024 Chickens”
Seymore Cray

A MAJOR Sea Change – More Scalability is needed
(An Extinction Event in the Biological World)
Necessity is the Mother of Invention



Going from a Shared Memory Programming Model
To a Distributed Memory Programming Model
‘Can it Even Work’?

Lots of Evolutionary ‘Mutations’ followed by ‘Natural Selection’

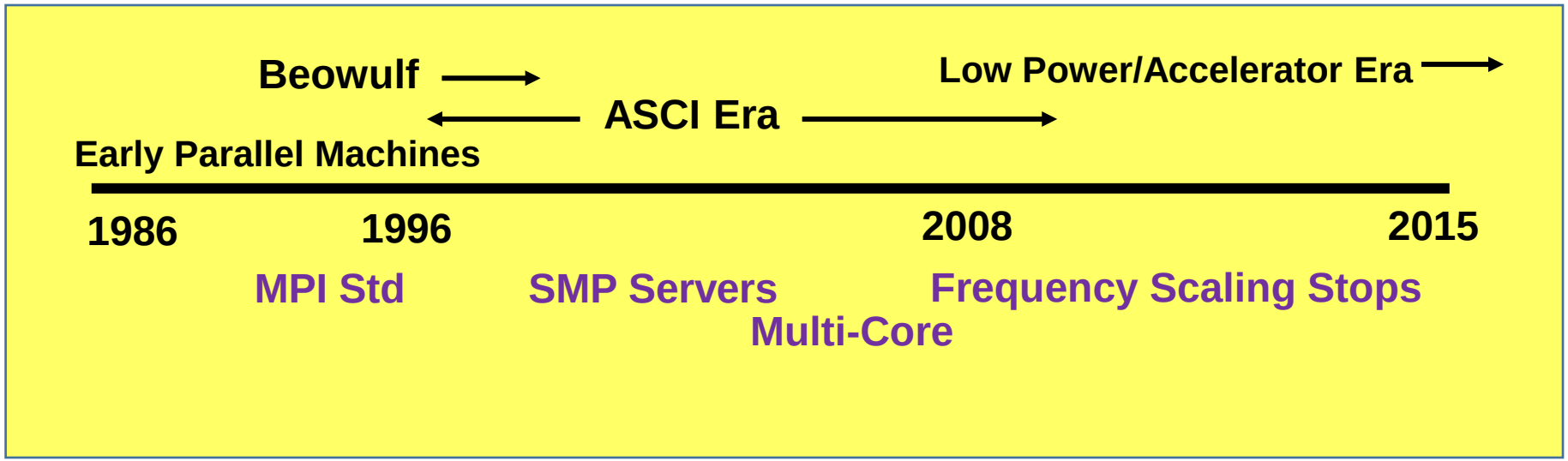
Many HW Architectural Versions
Many SW Architectural and Philosophical Approaches
Lots of Ventures Started and Died Off
The Show Floor at SC was in Continuous Churn

Only a few have survived but Massively Parallel did Evolve as a Viable Solution

The Massively Parallel (Distributed Memory) Era

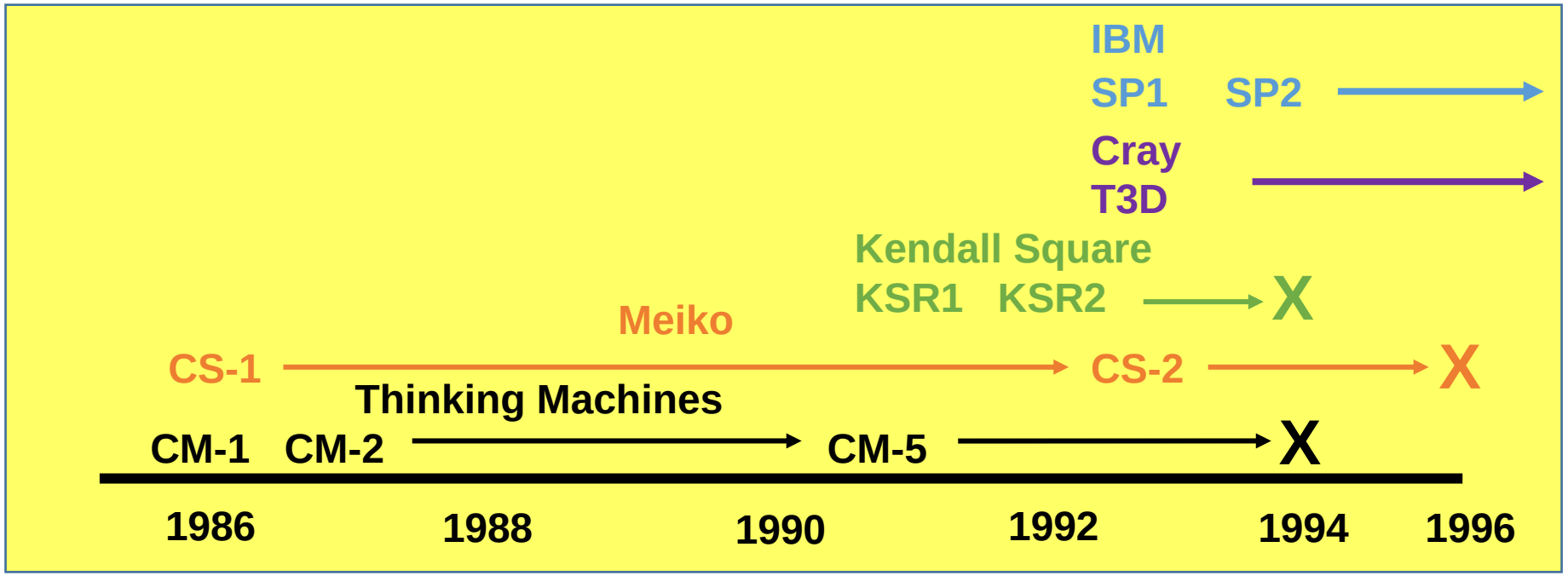
"To Plow a Field would you rather have 2 Oxen or 1024 Chickens"
Seymore Cray

1. **Early Parallel Machines: 1986-1996**
2. **MPI 1.0 Standard : June 1994**
3. **Beowulf Clusters : 1994**
4. **The ASCI Era : 1996-2010**
5. **Post ASCI Era**
   Low Power and Accelerators: 2008 - Present



Early Parallel Machines

1. Thinking Machines CM-1, CM-2, CM-5 : 1986, 1987, 1991
   SIMD, SIMD, MIMD+Fat Tree – Bankrupt – 1994
2. Meiko Scientific – Transputer, then SPARC based CS-1 : 1986
   CS-2 launched 1993 – bankrupt and merged into Quadrix 1996
3. Kendall Square Actually Shared Memory COMA: KSR1, KSR2 : 1991, 1992
   Bankrupt – 1994 (built their own processor and had financial problems)
4. CRAY T3D DEC Alpha + Torus : 1993
5. IBM – SP Power Based + Fat Tree : SP-1: 1993; SP-2: on 11/94 Top500 List
   (Plus 24W ES-9000 HiPPi Attached at SC91 - ☺)



Early Parallel Machines

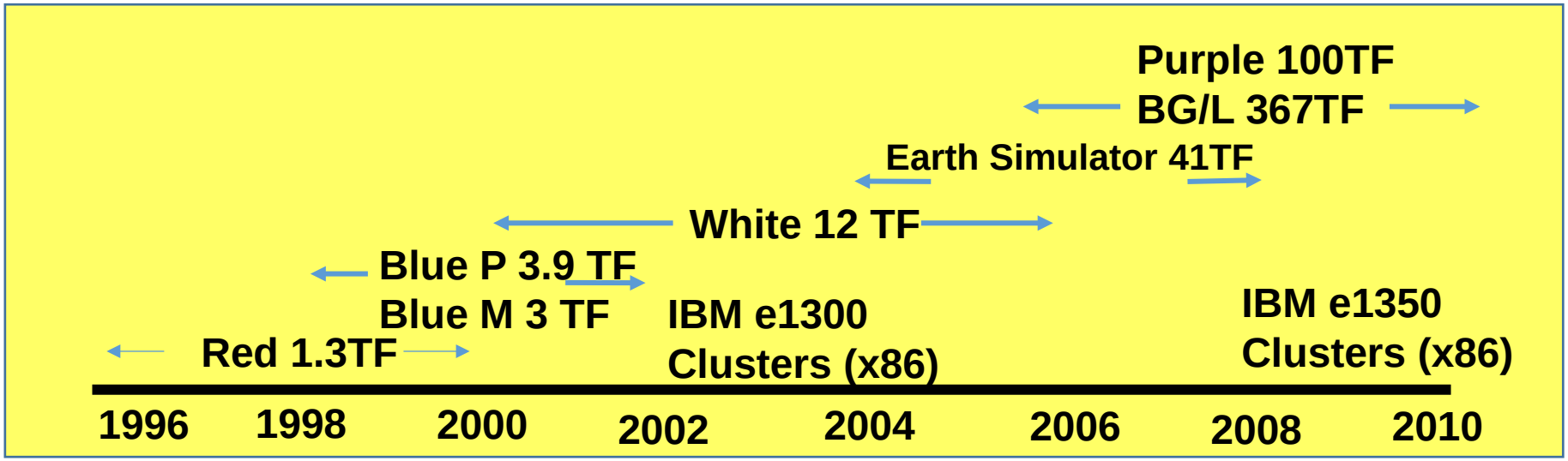
Beowulf Clusters

- Introduced in 1994 by Thomas Sterling and Donald Becker at NASA
- Commodity Based High Performance Parallel Computers
  - ‘Good Enough’ Computing
- Typically Built out of:
  - Commodity HW Servers (‘PC’s)
  - Standard Ethernet Adapters and Switches
  - No Custom HW
  - A Unix-Like OS (Linux these days)
  - Open Source SW like MPI and PVM
  - A Gateway to the Outside World
- It is not ‘just a cluster of servers’
  - Architected to look and behave like a Single Parallel Computer
  - Managed and Scheduled with standard Parallel Computer Tools

The ASCI Era

In Support of the Comprehensive Test Ban Treaty

1. 1997 - ASCI Red 1.3TF Intel Paragon - Sandia
2. 1998 - ASCI Blue Pacific 3.9TF IBM SP - LLNL
3. 1998 - ASCI Blue Mountain 3TF SGI Origin – LANL
4. 2000 - ASCI White 12TF IBM SP – LLNL
5. 2002 - IBM adds e1300 x86 Linux Clusters to the Menu
6. 2004 - Earth Simulator 41TF NEC (not an ASCI machine)
7. 2005 - ASCI Q 20TF Dec Alpha – LANL
8. 2005 - ASCI Purple 100TF IBM SP – LLNL
9. 2005 - BG/L 367 TF IBM BG/L – LLNL
10. 2009 - IBM adds e1350 x86 Clusters to Very High End Menu

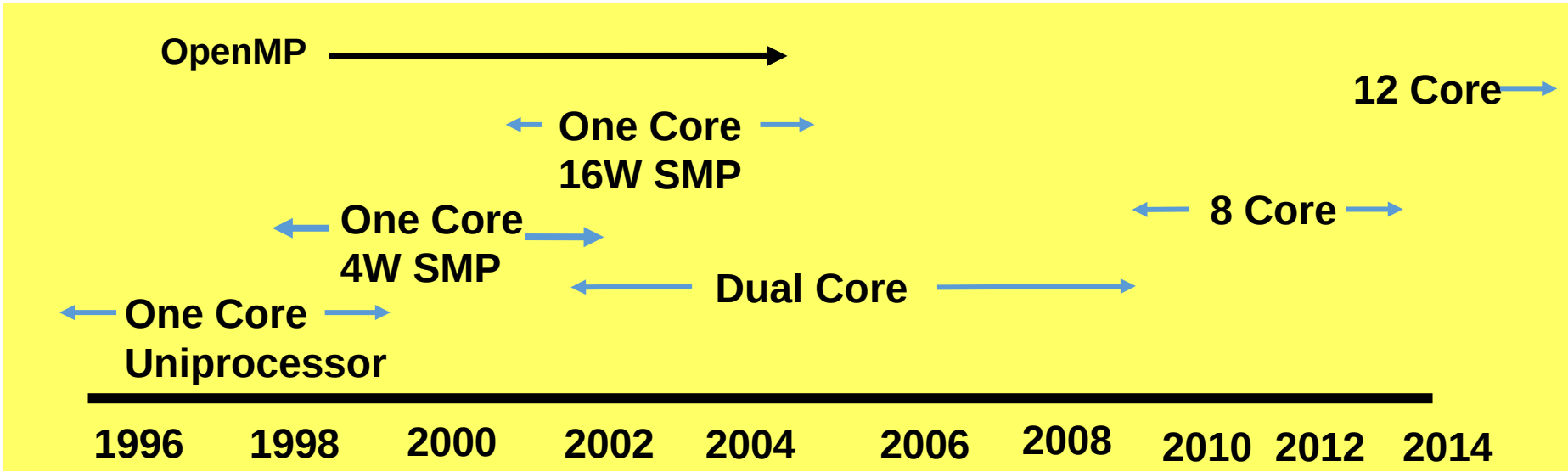


ASCI Era

The ASCI Era Detail

IBM Distributed SMPs and Multi-Core
Evolving from Single Core Uni-Processors
To Clusters of SMPs to Many Core SMPs

1. 1996 - P2SC – Single Core – Uniprocessor
2. 1998 - Asci Blue Pacific – 604e Single Core, 4W SMP
3. 2001 - ASCI White – P3 (630) Single Core – 16W SMP
4. 2001, 2004, 2007 – P4, P5, P6 – Dual Core
5. 2010 – P7 – 8 Cores
6. 2014 – P8 – 12 Cores



ASCI Era

Top 500 List

Turning a HW problem into a SW problem

- ~ 2008 Core Frequency Gains Stopped
- Denard's Law
- Voltage Scaling (3rd dimension)
- Voltage Scales Down with Length
- Frequency Improvement with Technology for constant Power

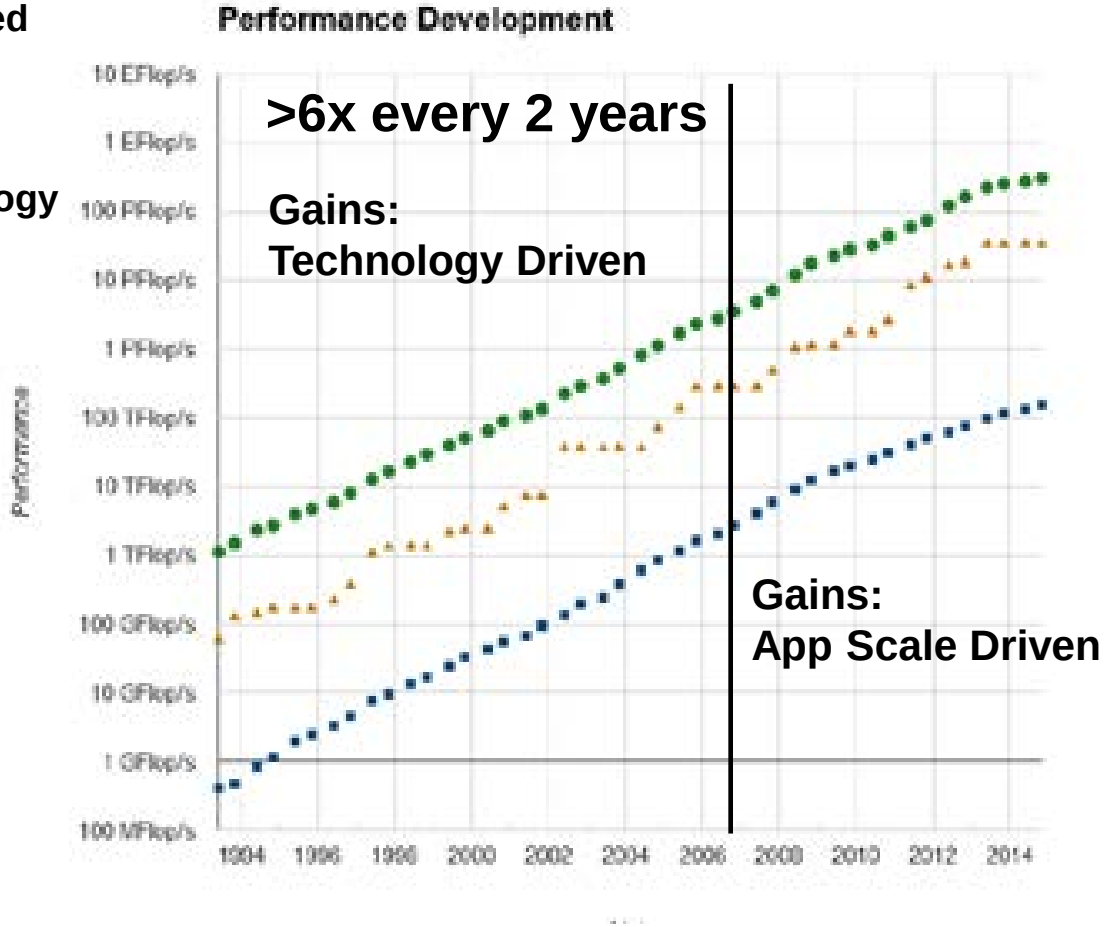
But

- 3rd Dimension no longer scaling
  Noise, Leakage, etc

Therefore:

- Auto Frequency scaling stopped
  Power/Thermal limits

- Power ~ Frequency x Voltage Squared



Energy Efficient Computing

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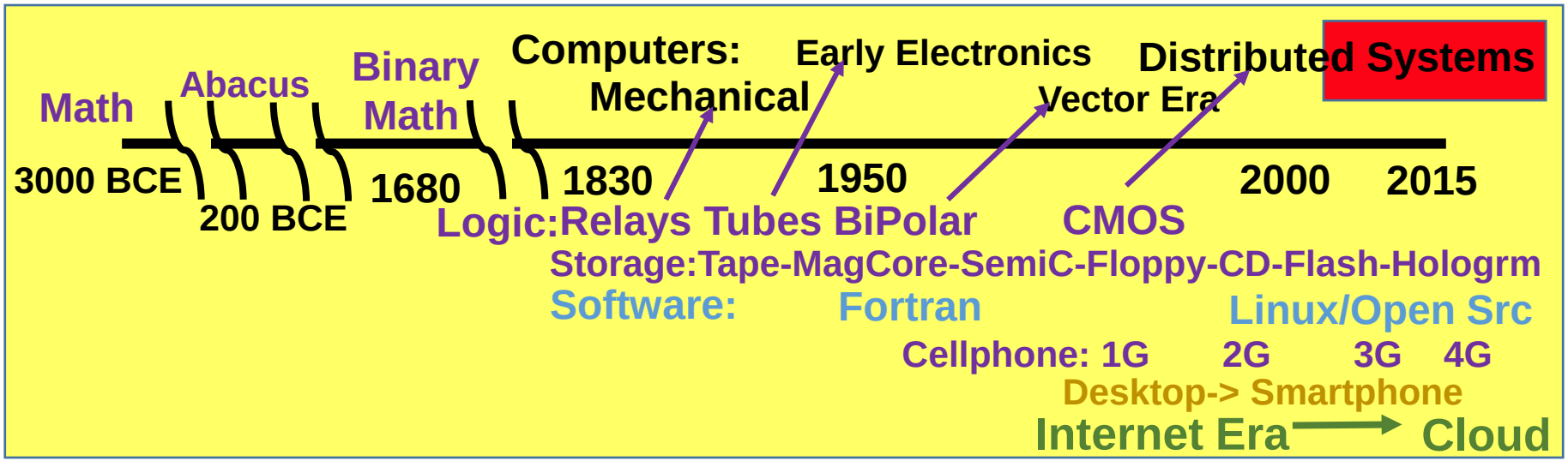
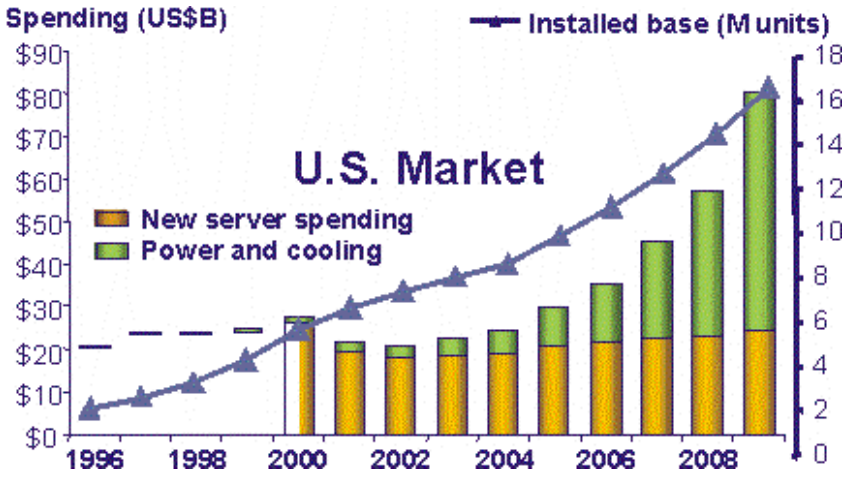
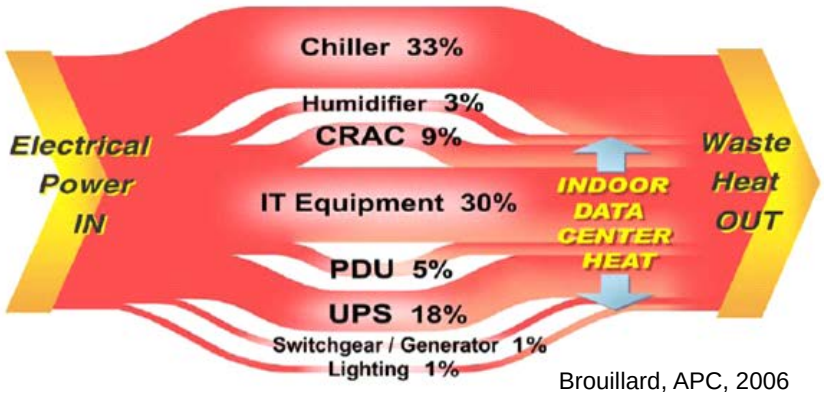


Energy Efficient Computing

- **Energy Costs are becoming an ever increasing concern in large Scale data center operation**
- **The Green500 was introduced to Measure and Motivate Energy Efficient Computing Progress**
  - **Announced at SC06 and first list produced at SC07**



Source IDC 2006, Document# 201722, "The impact of Power and Cooling on Datacenter Infrastructure, John Humphreys, Jed Scaramella"



Brouillard, APC, 2006

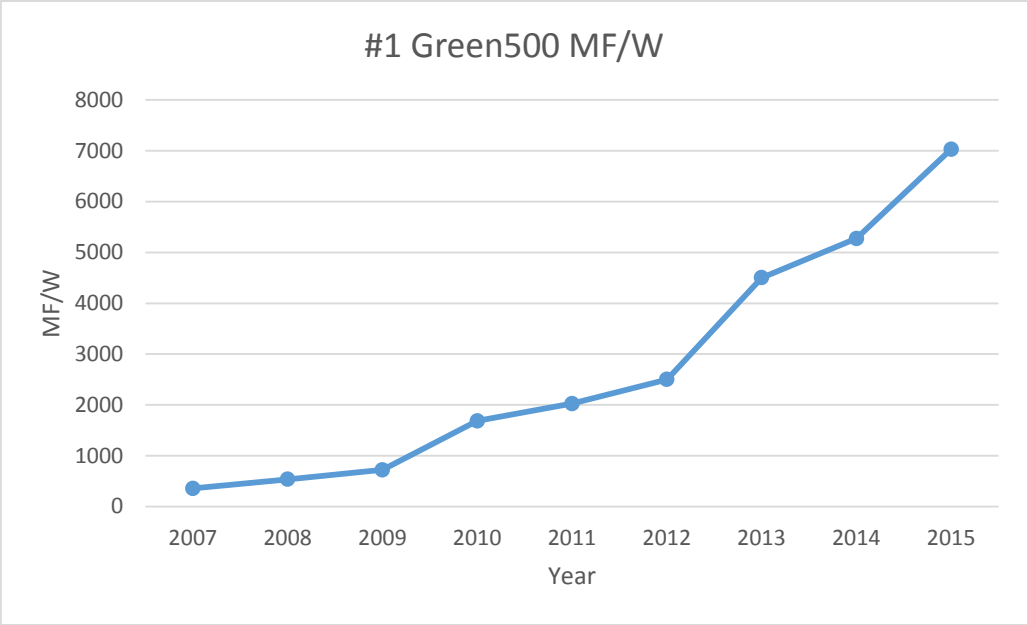
Future datacenters dominated by energy cost; half energy spent on cooling

Approaches and Evolution of Low Power Design in the CMOS Era

- **Lower Frequency for Lower Power**
- **Blue Gene**
  - **1999 - IBM Research Program started**
  - **2004 - BG/L – 2 uni processors, 700MHz**
  - **2007 - BG/P – 2W SMP, 850 MHz**
  - **2011 - BG/Q – 16 Processors, 1.6Ghz**
  - **vs Power Servers - ~2GHz : 2004; ~4GHz : 2007->**

- **Simpler Processors for Lower Power**
- **Cell Processor – Sony PS-2 + 64b math**
  - **2008 - Basis for Roadrunner PF machine**
  - **AMD64 + PowerXCell 8i (3.2GHz) Nodes**
  - **Accelerated Computing Model**
- **Combining Both Ideas**
- **GPUs – lower Freq & Simpler design -> lower power**
  - **High Speed Local Memory – 3D package reduces energy**
  - **NVIDIA K40/K80 – ~560-745MHz**

The Green 500
MF/W over time



Green 500 List Leader MF/W
2007: BG/P - 357
2008: Cell - 536
2009: Cell - 723
2010: BG/Q - 1684
2011: BG/Q - 2026
2012: Xeon Phi - 2499
2013: NVIDIA K20 - 4503
2014: AMD S9150 - 5272
2015: PEZY-SC - 7031

Previous Machines MW/F

2000: ASCI White – 6.02
2004: Earth Simulator – 3.4
2005: ASCI Purple – 10.2
2005: BG/L -146
2008: Jaguar – 18.8

1964: CDC 6600 ~ 2 x 10-5 (20F/W)**
3MF @ 150KW

History of Signal Processing
Real Time Computation

Somewhat Orthogonal to the Large Systems
But Lead to Broader User Interface Choices

Digital Processing in an Analog World

- **Tends to be Real Time Oriented**
- **1976 - Speak and Spell – TI**
- **1983 - MS320 – TI**
- **1983 - IBM (with TI) GPSP**
  - **10MHz – 30 MIPs, Unique Real Time OS**
  - **Speech Augmented Workstation, Modems**
  - **Used the Harvard Memory Architecture for speed**
- **These early efforts provided the foundation for today's Multi-Modal Interfaces.**
  - **Speech input/output – SIRI, etc**
  - **Image enhancement/filtering – Virtual Reality**
  - **Real World Interaction – Smart Cars, etc**

- **Language Oriented I/O:**
  Read >> Hear > Speak >> Type > Write

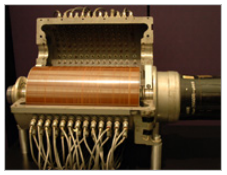
A Picture is worth a Thousand Words

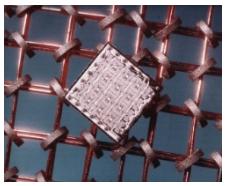
Multi-Modal is Important

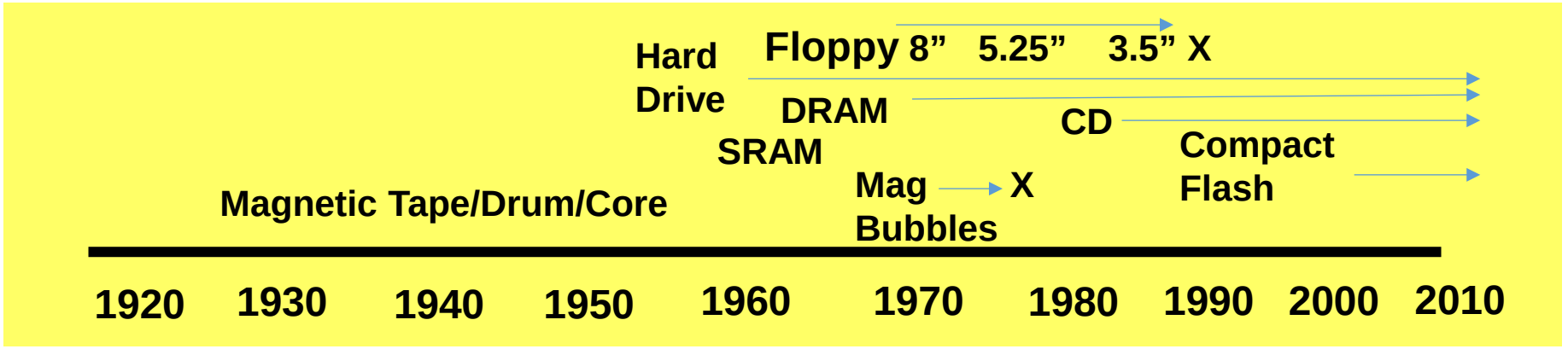
The Evolution of Storage Systems

Storage Technologies

- 1928 - Magnetic Tape
- 1932 - Magnetic Drum
- 1946 - CRT Storage
- 1950 - Magnetic Core
- 1956 - Hard Drive
- 1965 - SRAM (BiPolar RAM)
- 1966 - DRAM Single device design
- 1968 - Twister
- 1970 - Magnetic Bubbles
- 1971 - 8” Floppy
- 1976 - 5 ¼” Floppy
- 1980 - CD
- 1981 - 3 ½” Floppy
- 1987 - 1993 Digital Data Storage Tape
- 1994 - Compact Flash
- 1999 USB Flash
- ~2010 - Holographic Technology Emerging







The Evolution of Software Systems

Major Transition Periods

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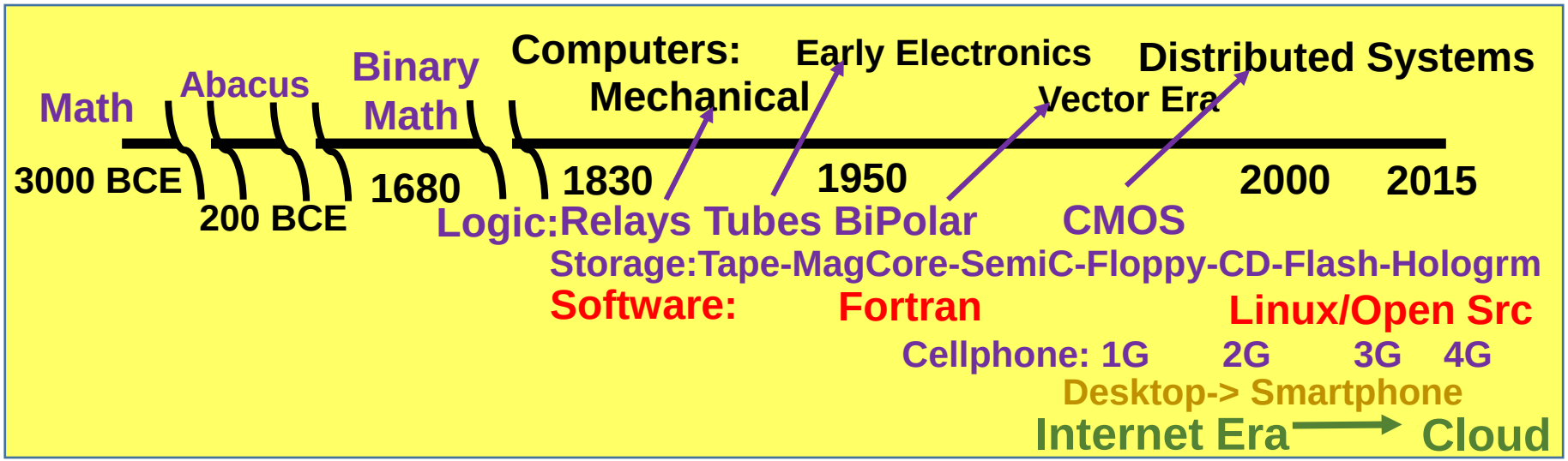


Software

Describe the Computation

THE SERIAL ERA

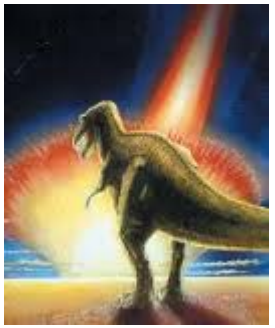
1. 1957 - Fortran
2. 1964 - APL (Influenced the CDC 6600)
3. 1964 - BASIC (Beginners All Purpose Symbolic Instruction Code)
   1975 Bill Gates introduces a Micro-Soft Basic Interpreter
4. 1972 - C
5. 1979 - C++
6. 1983 - Ada (US DoD language standard named for Ada Lovelace)

THE PARALLEL ERA

7. 1985 - Thinking Machines: *Lisp, *C, CM Fortran
8. 1991 - PVM
9. 1993 - HPF -> OpenMP
10. 1993 - Charm++
11. 1993 - Linda (named by Yale for the 'other Lovelace')
12. 1994 - MPI <- IBM's MPL
13. 1994 - Global Arrays
14. 1997 - OpenMP,
15. 1997 - Split-C + PCP + AC -> Unified Parallel C (UPC)
16. 2003 - Coarray Fortran

THE ACCELERATED ERA

17. 2007 - CUDA
18. 2009 - OpenCL
19. 2013 - OpenMP 4.0



Software
Describe the Control - Transition to Open Source

- 1950's-60's Source SW bundled w/HW
  Openly Shared, Modified, and Debugged
- 1953 – Univac A-2 System first 'free and open source SW'
  Fear of 'backdoors' in closed systems was a concern
- Late 60's SW Industry is growing
  - OS's and Compilers maturing
  - Code started to become 'closed'
- 1969 – Gov't Suit vs IBM said that
  Bundled SW was Anti-competitive
- Late 70's – Early 80's SW Licenses appear for 'Program Products'
  - Gates complains that people were sharing SW for free (Pirating)
- Early 80's DEC Users Society (DECUS) tapes used to distribute SW
  - Prior to Internet distribution – provided mechanism for joint development
- 1983 – GNU Project initiates 'Free Software'
- 1989 – First GNU General Public License
- 1991 – Linux Kernel completes the GNU SW Suite
- Mid 90's Website Explosion uses Apache HTTP Server (Free Software)
- 1997 – Netscape Communicator -> Free Software
  - Used in Mozilla Firefox and Thunderbird
- 1998 – Free Software becomes 'Open Source' (splinter movement)
  - Netscape released Source Code for Navigator
- 1998-2008 – Various Legal Challenges to Open Source 'Purity' etc
- 2008 – Google Android w/Open Source Linux

Software
Dealing with the Overall Question

How to Provide the Input Data and Control and Digest the Output

1. **For Natural Language input and output we:**
   - **Read >> Hear >> Speak >> Type > Write**
   - **A Picture is worth 1000 words (or more!)**
   - **Multi-modal Contexts increase our Ingest Rate**
2. **Graphical Output is Critical**
   - **OpenGL started by SGI in 1991**
     2D and 3D rendering, often with GPUs; Grew out of SGI's IRIS GL
   - **DirectX from Microsoft – 1995 with Windows 95**
     Direct3D was a piece of it; Never successfully merged with OpenGL
3. **Asking Complex Questions is Easiest in Natural Language**
   - **1954 - Natural Language started with Translation**
   - **1964 – Eliza and Student – do simple language exchanges**
   - **1978 – Lifer/Ladder – Natural Language interface to US Navy DB**
   - **1980s - Switch to Machine Learning rather than Grammar Rules**
   - **2011 – Watson wins Jeopardy and starts working on Medicine**
4. **Controlling the Overall Workflow vs Single Jobs**
   - **Batch Scheduling dates to the 1950s**
   - **Job Q Schedulers used to keep multi-user machines busy**
   - **Dependencies are now added to allow optimization and Workflows**
     - **Energy Aware, Data Aware, Job Completion Dependency Aware**

The Evolution of Mobile Communication and the Internet

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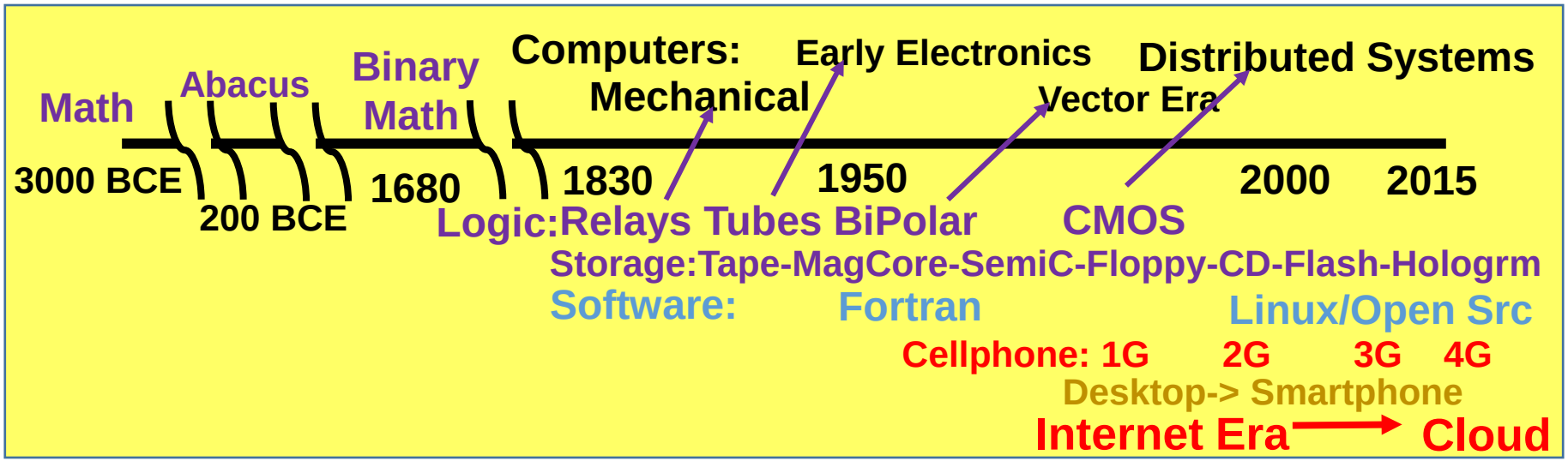
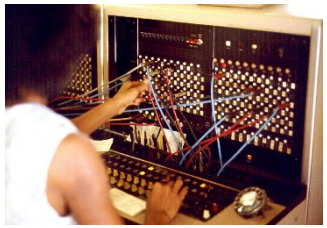


The Evolution of Telephone Switched Network

- 1868 – Bell invents the Telephone
- 1870 – Telephones were point to point only
  A different telephone was needed per connection
- 1878 – Plug network switches were introduced
- 1890 – Multi-panel (multi-stage) switch for scalability
- 1913 – AT&T Crossbar Automated Switch development starts (Relays)
- 1938 – Crossbar goes into limited use in NYC
- 1951 – Customer direct dial of long distance starts
- 1965 – ATT installs first Electronic Switch
- 1970s – Manual Plug systems disappear.

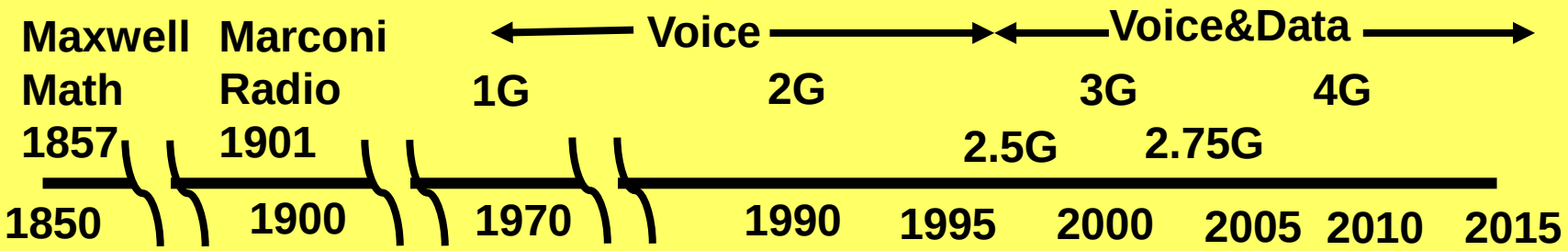
1943



1975

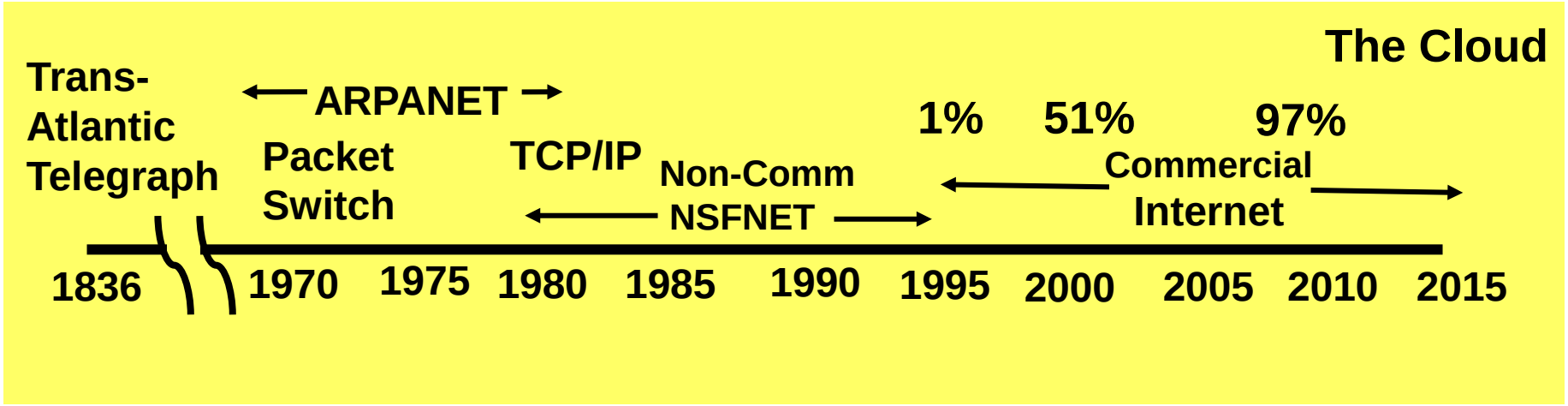
Mobile Network Evolution

- 1857 – Maxwell's Equations for Electromagnetic Radiation
- 1901 – Marconi builds a radio with the equations
- 1970s – 1G (first generation) Cellular Transmission
  Analog transmission in the network;
  Still – 30-50% growth/yr to 20M by 1990
- 1990s – 2G GSM (Global System for Mobile Communication)
  Digital Transmission but almost all Voice
- 1997 - 2.5G GPRS (General Packet Radio Service)
  Packet switched data on GSM network
- 2001 - 3G UMTS (Universal Mobile Telecommunications System)
  Packet and Circuit Switched – Data Rich
  2Mbps – stationary -> 145Kbps when moving
- 2003 - 2.75G EDGE (Enhanced Data Rates for GSM Evolution)
- 2009 - 4G Spec – 1Gbps stationary -> 100Mbps moving
  Reality is 20Mbps and QoS for Streaming etc



Evolution of the Internet

- 1836 - Electric Trans-Atlantic Telegraph
- 1953 - Bell Labs (Clos) multi-stage networks
- 1968 - ARPANET RFP issued (BBN gets Network portion)
- 1970 - Davies (UK) coined ‘packet switch’
  - Network for Mark I -> Mark II ’73-’86
  - *Packet Switch allows multiple networks to be one logical network*
- 1981 - ARPANET picked up Davies packet switch idea
- 1982 - TCP/IP introduced
- 198x-1995 - NSFNET – was non-commercial
- 1995 - Commercial ISPs, Email, IM, VoIP, General Data
- 1993 - Internet was 1% of traffic
- 2000 - Internet was 51% of traffic
- 2007 - Internet was 97% of traffic
- 2011 -The Cloud



The Evolution of Personal Computing Systems

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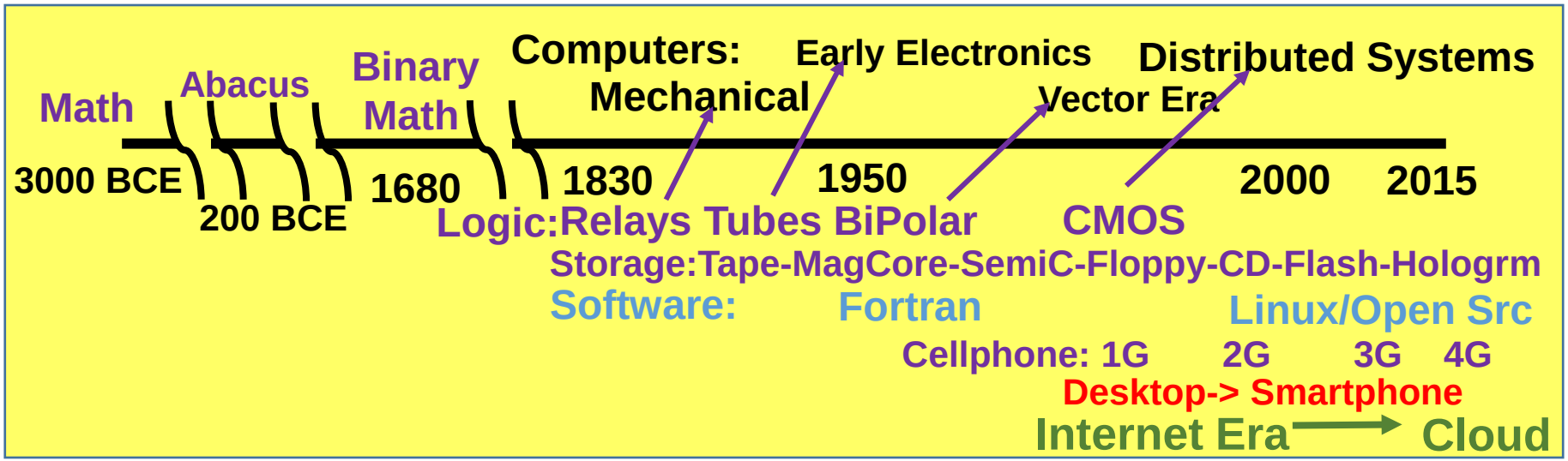
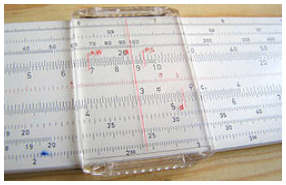


History of the Calculator

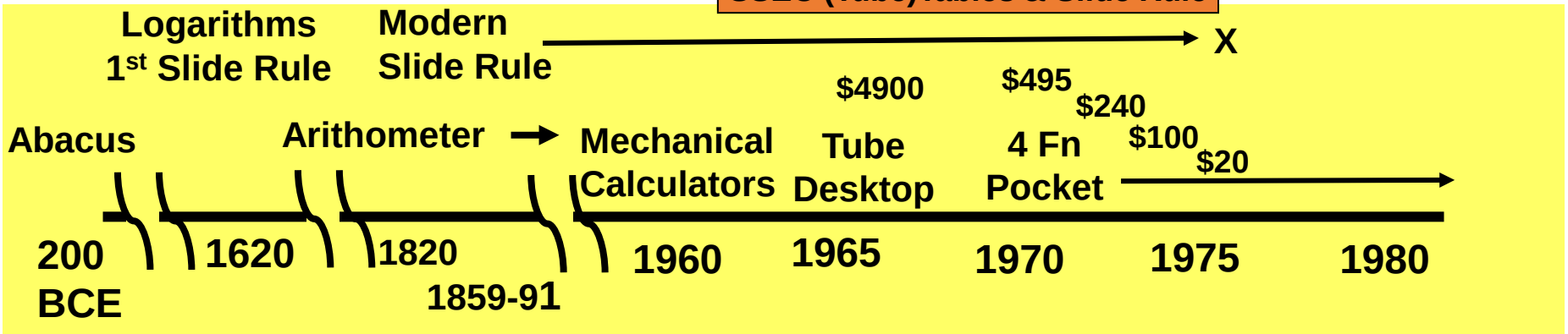
- 400 BCE - Abacus
- 1620 - Slide Rule Invented – when Logarithms were discovered
- 1820 - Mechanical Arithometer
- 1859 - Modern Slide Rule invented by French Military
- 1891 - Modern Slide Rule Manufactured by K&E in the US
- 1960's - Mechanical Calculators (could do x and div)
  - •1963 Anita (UK) desktop calculator; 33 lbs, vacuum tubes
- 1964 - Sony Transistor – no tubes (World's Fair)
- 1968 - HP 9100 ($4900) CRT – Typewriter size
- 'Pocket Calculators'
- 1970 – Sharp QT-8 LSI chip $495
- 1971 - Bowman (USA) 901B $240 4 fn, 8 digit LED display
- 1972 - Casio (Japan) <$100
  - •HP-35 Scientific Fns – end of the slide rule
- 1975 - 4 fn <$20 Teachers want to bar them from school kids won't learn math
- 1975 - Slide Rule Retired

Slide Rule



Arithometer

Apollo 11 (1969)
Flight to Moon
SSEC (Tube)Tables & Slide Rule



IBM Terminals Prior to the PC Era (Dumb Terminals)

2260 (1964)

2741 Selectric (1964)

APL Keyboard
Selectric Ball 987

2250 w/Light Pen (1964)

3277 (1972)
Field Oriented Display

3279 (1979) Color

History of Personal Computing Devices

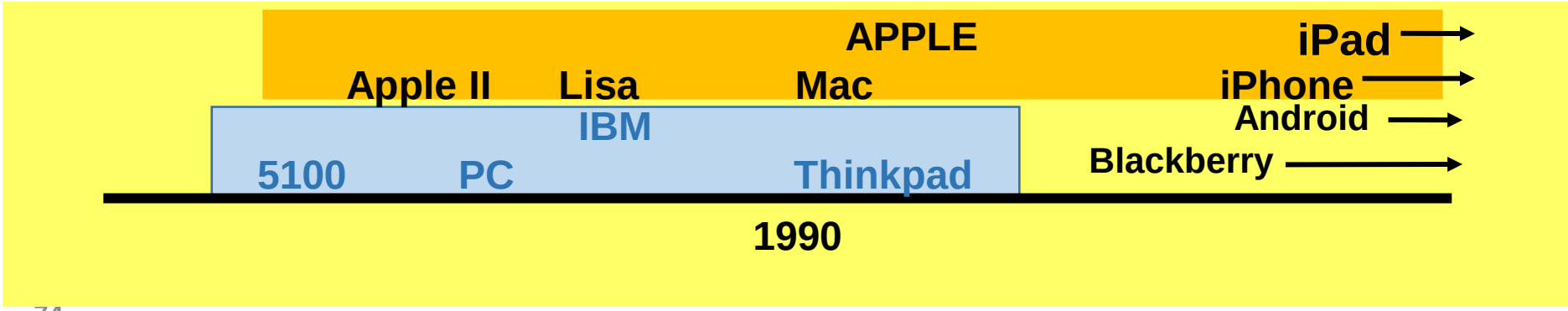
Early Model was a 'Dumb Terminal' attached to a Shared Computer
Distributed Smart Clients Emerged, Returning to 'Thin Client'

Single User Computers

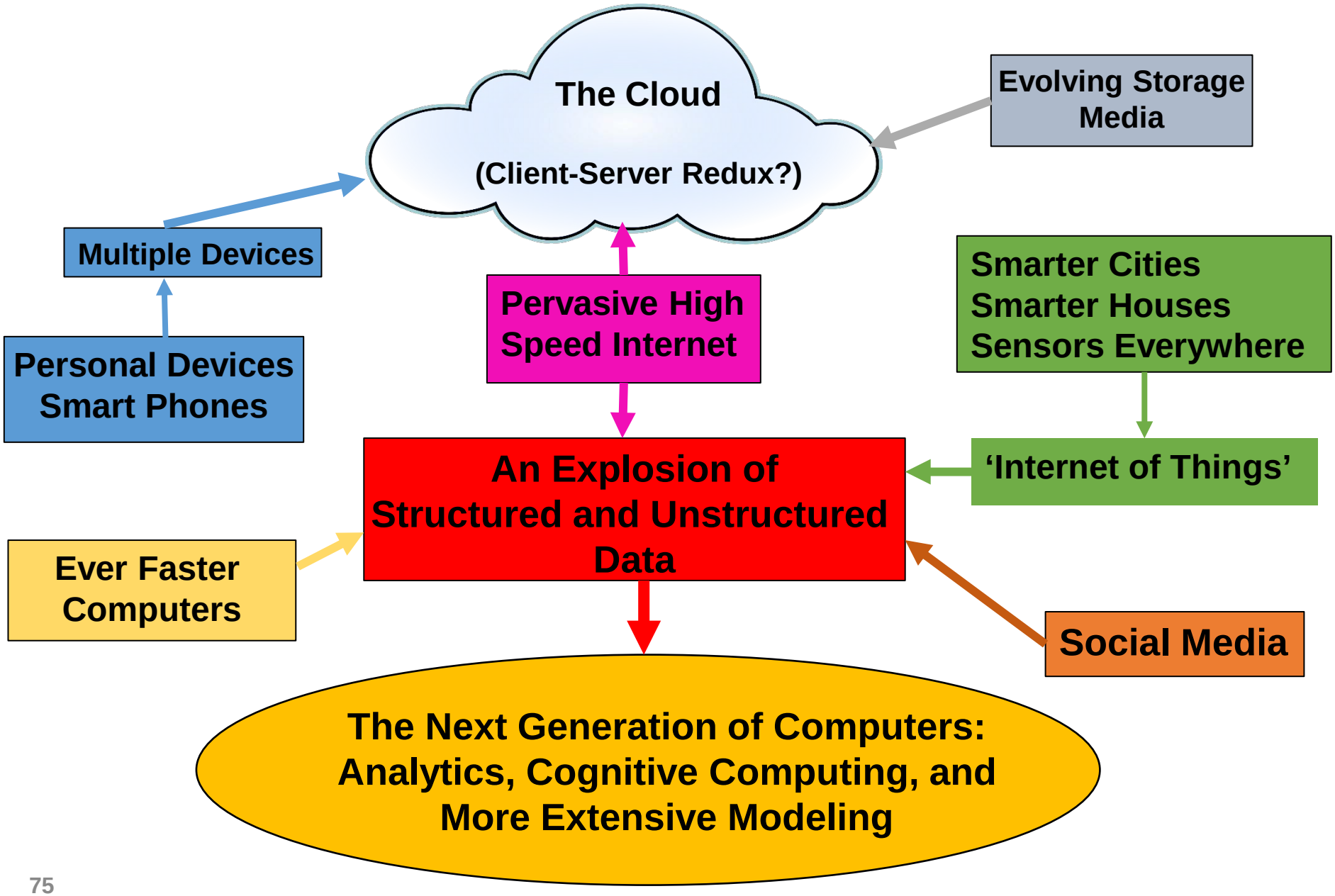
- 1970 – Datapoint 2200 – discrete Intel '8008'
- 1975 - IBM 5100 APL/Basic – 'luggable'
- 1977 - Commodore Pet; Apple II; TRS-80
- 1979 - TI-99 – Cassett Storage, Basic Language support
- 1981 - IBM PC based on Intel '8088'
- 1983 - Apple Lisa
- 1992 - IBM Thinkpad

SmartPhones

- 1992 - IBM Smartphone – Simon Personal Communicator
- 1996 - HP OmniGo 700LX
- 1999-2001 - NTT DoCoMo -> 40M subscribers
- 2003 - Blackberry, 2006-> referred to as 'Crackberry'
- 2007 - Apple iPhone
- 2008 - Android
- 2010 - Apple iPad



Combining All of the Progress



The Evolution of Weather/Climate Modeling

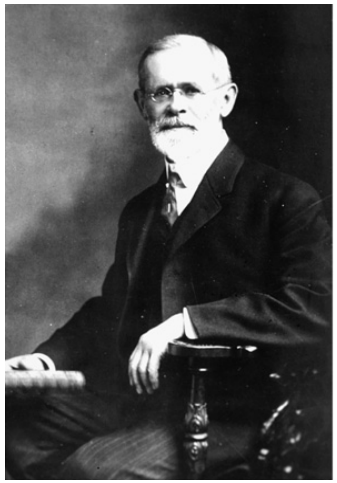
Some History of Weather/Climate Modeling

- **1890 – Cleveland Abbe**
  proposed mathematical approach to forecasting
- **1895 - Vilhelm Bjerknes**
  proposed 2 step prediction:
  1. Diagnostics: Measure Initial Conditions
  2. Prognostics: Laws of motion predict the future
  He listed seven basic variables: pressure, temperature, density, humidity and three components of velocity
  He also proposed the *'Primitive Equations'*
  and created a *graphical method* for solving the equations.
- **1913 – Lewis Fry Richardson joins the Met Office**
  - **Prediction used the 'Index of Weather Maps'**
  - **A previous weather map was found that resembled the current map and was used to predict what might happen (If Weather always did the same thing from some sample space)**
- **1922 - First Forecast done by hand by Richardson**
  - **6 hour forecast took 6 weeks for 2 points and was significantly wrong**
  - **He concluded that Input Smoothing was required**

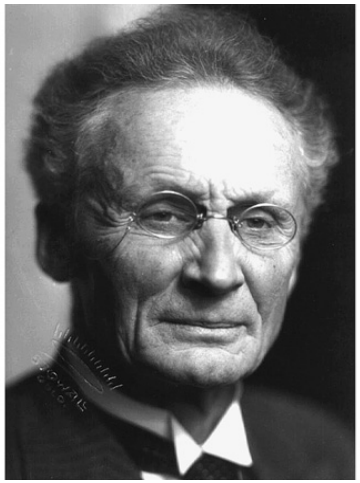
Some History of Weather/Climate Modeling

- 1950 – Jule Charney and the Meteorology Group
  - First Computer Generated Forecast : ENIAC machine
  - Solved the 'Infinitesimal Time Step' and 'Computed Divergence' problems
  - 24 hour forecast took 24 hours – hope was it could forecast before the actual weather took place in the future.
  - Richardson declared it a significant advance:

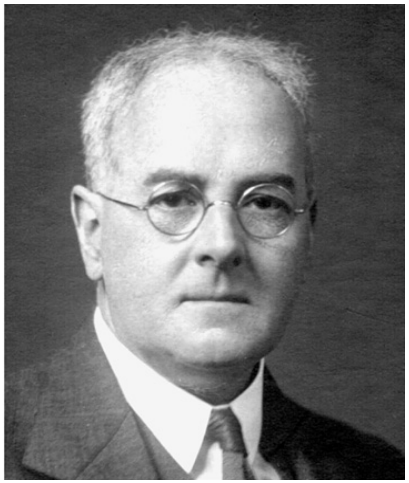
"Perhaps some day in the dim future it will be possible to advance the computations faster than the weather advances . . .. But that is a dream."



Cleveland Abbes



Vilhelm Bjerknes



Lewis Fry Richardson

Jule Charney

Thank you!

(For Everything!)

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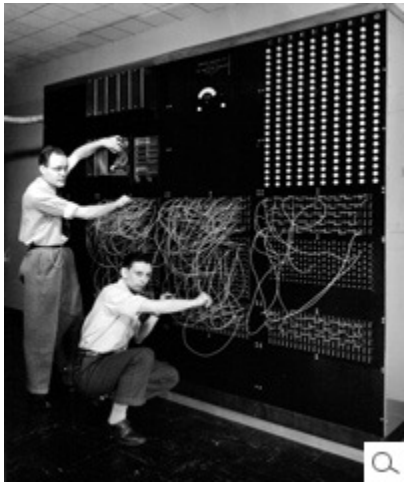
Additional History

1940

The Complex Number Calculator (CNC) is completed. In 1939, Bell Telephone Laboratories completed this calculator, designed by researcher George Stibitz. In 1940, Stibitz demonstrated the CNC at an American Mathematical Society conference held at Dartmouth College. Stibitz stunned the group by performing calculations remotely on the CNC (located in New York City) using a Teletype connected via special telephone lines. This is considered to be the first demonstration of remote access computing.

1943

The Relay Interpolator is completed. The U.S. Army asked Bell Labs to design a machine to assist in testing its M-9 Gun Director. Bell Labs mathematician George Stibitz recommended using a relay-based calculator for the project. The result was the Relay Interpolator, later called the Bell Labs Model II. The Relay Interpolator used 440 relays and since it was programmable by paper tape, it was used for other applications following the war.



1944

Harvard Mark-1 is completed. Conceived by Harvard professor Howard Aiken, and designed and built by IBM, the Harvard Mark-1 was a room-sized, relay-based calculator. The machine had a fifty-foot long camshaft that synchronized the machine's thousands of component parts. The Mark-1 was used to produce mathematical tables but was soon superseded by stored program computers.

1945

John von Neumann wrote "First Draft of a Report on the EDVAC" in which he outlined the architecture of a stored-program computer. Electronic storage of programming information and data eliminated the need for the more clumsy methods of programming, such as punched paper tape — a concept that has characterized mainstream computer development since 1945. Hungarian-born von Neumann demonstrated prodigious expertise in hydrodynamics, ballistics, meteorology, game theory, statistics, and the use of mechanical devices for computation. After the war, he concentrated on the development of Princeton´s

Institute for Advanced Studies computer and its copies around the world.

1946

In February, the public got its first glimpse of the ENIAC, a machine built by John Mauchly and J. Presper Eckert that improved by 1,000 times on the speed of its contemporaries.

Start of project:	1943
Completed:	1946
Programmed:	plug board and switches
Speed:	5,000 operations per second
Input/output:	cards, lights, switches, plugs
Floor space:	1,000 square feet
Project leaders:	John Mauchly and J. Presper Eckert.

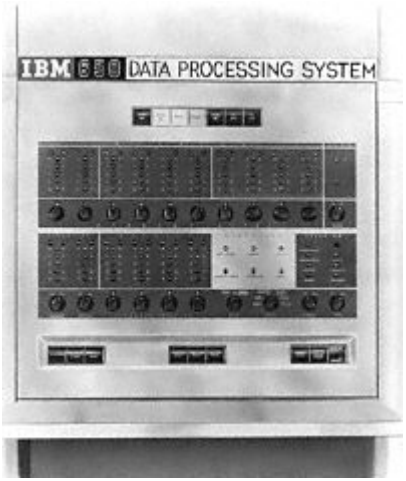
1948

IBM´s Selective Sequence Electronic Calculator computed scientific data in public display near the company´s Manhattan headquarters. Before its decommissioning in 1952, the SSEC produced the moon-position tables used for plotting the course of the 1969 Apollo flight to the moon.

Speed:	50 multiplications per second
Input/output:	cards, punched tape
Memory type:	punched tape, vacuum tubes, relays
Technology:	20,000 relays, 12,500 vacuum tubes
Floor space:	25 feet by 40 feet
Project leader:	Wallace Eckert

IBM 701 - April 7, 1953

- 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.



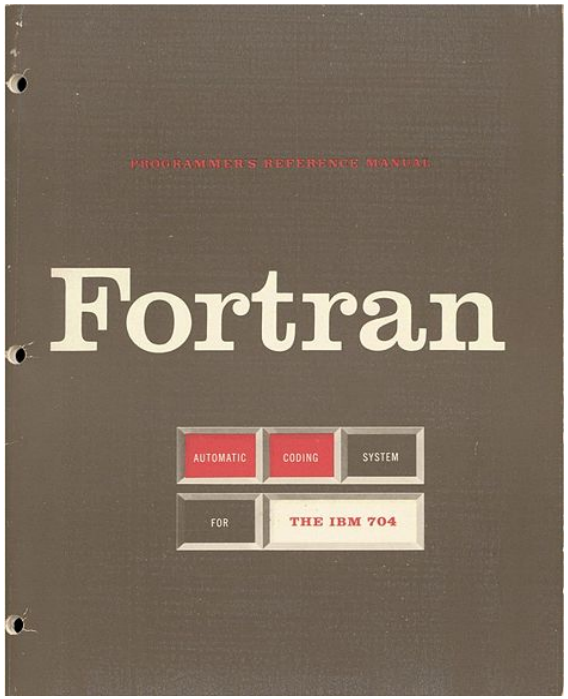
1954

The IBM 650 magnetic drum calculator established itself as the first mass-produced computer, with the company selling 450 in one year. Spinning at 12,500 rpm, the 650´s magnetic data-storage drum allowed much faster access to stored material than drum memory machines.

IBM NORC - 1954

- Naval Ordnance Research Calculator (NORC) -- for several years considered the fastest computer on Earth -- was built by IBM in the early-1950s and formally delivered to the U.S. Navy on December 2, 1954. Capable of executing 15,000 complete arithmetic calculations a second, NORC was constructed at the Watson Scientific Computing Laboratory at Columbia University in New York City and later installed at the Navy's Computation Laboratory at the Naval Proving Ground in Dahlgren, Va.
- With its unsurpassed speed and reliability, NORC handled such problems as intricate ballistic computations that involved billions of multiplications, divisions, additions and subtractions.

Fortran - 1957



- One of the oldest programming languages, FORTRAN was developed by a team of programmers at IBM led by John Backus, and was first published in 1957. The name FORTRAN is an acronym for FORmula TRANslation, because it was designed to allow easy translation of math formulas into code.
- Often referred to as a scientific language, FORTRAN was the first high-level language, using the first compiler ever developed. Prior to the development of FORTRAN computer programmers were required to program in machine/assembly code, which was an extremely difficult and time consuming task.
- Since FORTRAN was so much easier to code, programmers were able to write programs 500% faster than before, while execution efficiency was only reduced by 20%, this allowed them to focus more on the problem solving aspects of a problem, and less on coding.

1958

SAGE — Semi-Automatic Ground Environment — linked hundreds of radar stations in the United States and Canada in the first large-scale computer communications network. An operator directed actions by touching a light gun to the screen.

The air defense system operated on the AN/FSQ-7 computer (known as Whirlwind II during its development at MIT) as its central computer. Each computer used a full megawatt of power to drive its 55,000 vacuum tubes, 175,000 diodes and 13,000 transistors.

1959

IBM´s 7000 series mainframes were the company´s first transistorized computers. At the top of the line of computers — all of which emerged significantly faster and more dependable than vacuum tube machines — sat the 7030, also known as the "Stretch." Nine of the computers, which featured a 64-bit word and other innovations, were sold to national laboratories and other scientific users. L. R. Johnson first used the term "architecture" in describing the Stretch.

IBM 7030 Data Processing System (Stretch) - 1961

- From the original fact sheet:
  - The IBM 7030 Data Processing System is the fastest, the most powerful and versatile in the world. It is now nearing completion at IBM's laboratories in Poughkeepsie, NY. The first system, the original Stretch, is being readied for the Los Alamos Scientific Laboratory under contract to the Atomic Energy Commission.
  - Custom-engineered IBM 7030 systems, based on STRETCH's technology, are being made available by IBM to industry and government under negotiated contract terms. Purchase price of representative systems is more than $10,000,000 with monthly rental of more than $300,000.

1961

According to Datamation magazine, IBM had an 81.2-percent share of the computer market in 1961, the year in which it introduced the 1400 Series. The 1401 mainframe, the first in the series, replaced the vacuum tube with smaller, more reliable transistors and used a magnetic core memory.

Demand called for more than 12,000 of the 1401 computers, and the machine´s success made a strong case for using general-purpose computers rather than specialized systems.

1964

IBM announced the System/360, a family of six mutually compatible computers and 40 peripherals that could work together. The initial investment of $5 billion was quickly returned as orders for the system climbed to 1,000 per month within two years. At the time IBM released the System/360, the company was making a transition from discrete transistors to integrated circuits, and its major source of revenue moved from punched-card equipment to electronic computer systems.

1964

CDC´s 6600 supercomputer, designed by Seymour Cray, performed up to 3 million instructions per second — a processing speed three times faster than that of its closest competitor, the IBM Stretch. The 6600 retained the distinction of being the fastest computer in the world until surpassed by its successor, the CDC 7600, in 1968.
Part of the speed came from the computer´s design, which had 10 small computers, known as peripheral processors, funneling data to a large central processing unit.
Effectively Multi-Threading RISC processors that could run much Faster cycle times.

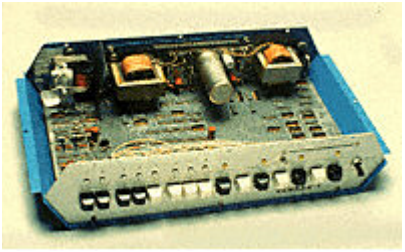
IBM 360 Model 95 - 1968

- From IBM Data Processing Division press release (7/1/68)
  - Formal acceptance of two, new super-speed computers -- IBM System/360 Model 95s -- by NASA's Goddard Space Flight Center was announced today by IBM Corporation.
  - The two computers are the first and only ones in IBM's Model 90 series equipped with ultra-high-speed thin-film memories. Over a million characters (bytes) of information are stored in each on magnetic "spots" four millionths of an inch thick.
  - With an access time of 67 nanoseconds (billionths of a second), these are the fastest, large-scale memories in user operation.

1968

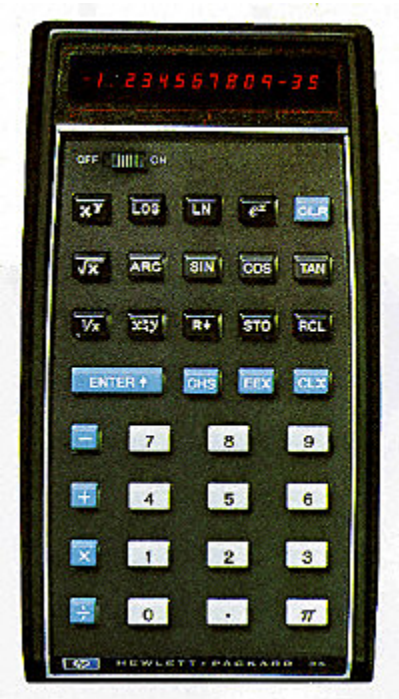
Data General Corp., started by a group of engineers that had left Digital Equipment Corp., introduced the Nova, with 32 kilobytes of memory, for $8,000.

In the photograph, Ed deCastro, president and founder of Data General, sits with a Nova minicomputer. The simple architecture of the Nova instruction set inspired Steve Wozniak´s Apple I board eight years later.



1971 – First PC

The Kenbak-1, the first personal computer, advertised for $750 in Scientific American. Designed by John V. Blankenbaker using standard medium-scale and small-scale integrated circuits, the Kenbak-1 relied on switches for input and lights for output from its 256-byte memory. In 1973, after selling only 40 machines, Kenbak Corp. closed its doors.



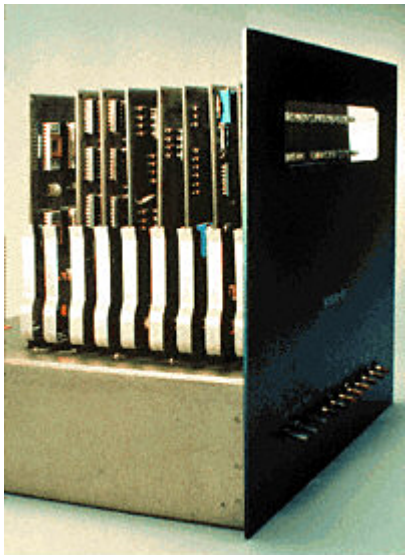
1972

Hewlett-Packard announced the HP-35 as *"a fast, extremely accurate electronic slide rule"* with a solid-state memory similar to that of a computer. The HP-35 distinguished itself from its competitors by its ability to perform a broad variety of logarithmic and trigonometric functions, to store more intermediate solutions for later use, and to accept and display entries in a form similar to standard scientific notation.

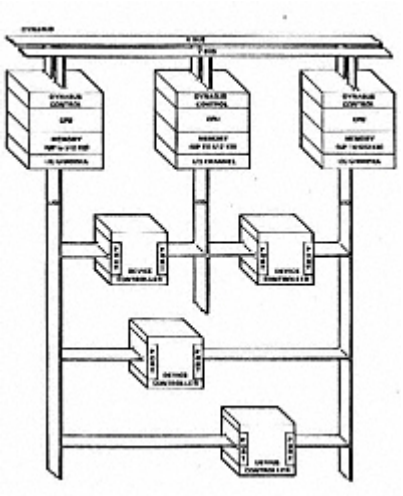
1973

The Micral was the earliest commercial, non-kit personal computer based on a micro-processor, the Intel 8008. Thi Truong developed the computer and Philippe Kahn the software. Truong, founder and president of the French company R2E, created the Micral as a replacement for minicomputers in situations that didn´t require high performance. Selling for $1,750, the Micral never penetrated the U.S. market. In 1979, Truong sold Micral to Bull.

1974

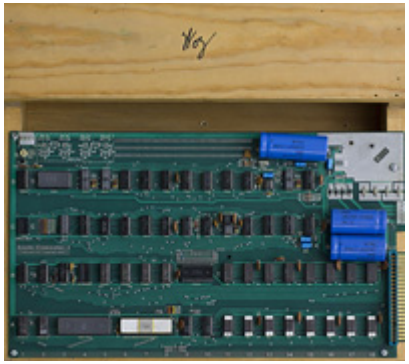


Scelbi advertised its 8H computer, the first commercially advertised U.S. computer based on a microprocessor, Intel´s 8008. Scelbi aimed the 8H, available both in kit form and fully assembled, at scientific, electronic, and biological applications. It had 4 kilobytes of internal memory and a cassette tape, with both teletype and oscilloscope interfaces. In 1975, Scelbi introduced the 8B version with 16 kilobytes of memory for the business market. The company sold about 200 machines, losing $500 per unit.



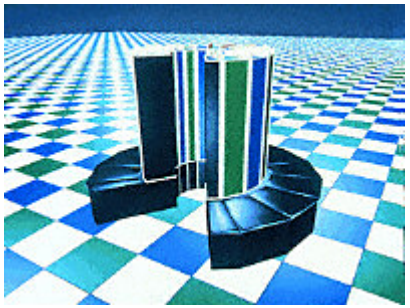
1975

Tandem computers tailored its Tandem-16, the first fault-tolerant computer, for online transaction processing. The banking industry rushed to adopt the machine, built to run during repair or expansion.



1976

Steve Wozniak, a young American electronics expert, designed the Apple-1, a single-board computer for hobbyists. With an order for 50 assembled systems from Mountain View, California computer store The Byte Shop in hand, he and best friend Steve Jobs started a new company, naming it Apple Computer, Inc. In all, about 200 of the boards were sold before Apple announced the follow-on Apple II a year later as a ready-to-use computer for consumers, a model which sold in the millions.



1976

The Cray I made its name as the first commercially successful vector processor. The fastest machine of its day, its speed came partly from its shape, a C, which reduced the length of wires and thus the time signals needed to travel across them.

Project started:	1972
Project completed:	1976
Speed:	166 million floating-point operations per second
Size:	58 cubic feet
Weight:	5,300 lbs.
Technology:	Integrated circuit
Clock rate:	83 million cycles per second
Word length:	64-bit words
Instruction set:	128 instructions

1977

The Apple II became an instant success when released in 1977 with its printed circuit motherboard, switching power supply, keyboard, case assembly, manual, game paddles, A/C powercord, and cassette tape with the computer game "Breakout." When hooked up to a color television set, the Apple II produced brilliant color graphics.

1981

IBM introduced its PC, igniting a fast growth of the personal computer market. The first PC ran on a 4.77 MHz Intel 8088 microprocessor and used Microsoft´s MS-DOS operating system.

1982

The Cray XMP, first produced in this year, almost doubled the operating speed of competing machines with a parallel processing system that ran at 420 million floating-point operations per second, or megaflops. Arranging two Crays to work together on different parts of the same problem achieved the faster speed. Defense and scientific research institutes also heavily used Crays.

1982 - GPSP

IBM – TI Joint Effort on Signal Processing
GPSP (General Purpose Signal Processor)
10 MHz x 3 Ops/cycle -> 30MOps

Needed a new Real Time OS (from scratch)

Had a Harvard Architecture for performance
32K x 16b (64KB) Data memory

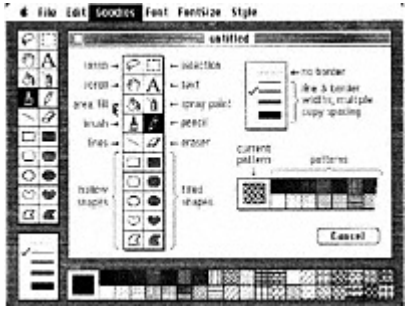
Design ‘error’ of latching an Asynchronous Input in 2 places
Allowed the chip to go into 2 separate states at the ‘right temperature’

Used in:
IBM Voice Card
Modem compression and processing applications

1983

Apple introduced its Lisa. The first personal computer with a graphical user interface, its development was central in the move to such systems for personal computers. The Lisa´s sloth and high price ($10,000) led to its ultimate failure.

The Lisa ran on a Motorola 68000 microprocessor and came equipped with 1 megabyte of RAM, a 12-inch black-and-white monitor, dual 5 1/4-inch floppy disk drives and a 5 megabyte Profile hard drive. The Xerox Star — which included a system called Smalltalk that involved a mouse, windows, and pop-up menus — inspired the Lisa´s designers



1984

Apple Computer launched the Macintosh, the first successful mouse-driven computer with a graphic user interface, with a single $1.5 million commercial during the 1984 Super Bowl. Based on the Motorola 68000 microprocessor, the Macintosh included many of the Lisa´s features at a much more affordable price: $2,500.

Apple´s commercial played on the theme of George Orwell´s "1984" and featured the destruction of Big Brother with the power of personal computing found in a Macintosh. Applications that came as part of the package included MacPaint, which made use of the mouse, and MacWrite, which demonstrated WYSIWYG (What You See Is What You Get) word processing.

1984

IBM released its PC Jr. and PC-AT. The PC Jr. failed, but the PC-AT, several times faster than original PC and based on the Intel 80286 chip, claimed success with its notable increases in performance and storage capacity, all for about $4,000. It also included more RAM and accommodated high-density 1.2-megabyte 5 1/4-inch floppy disks.

1986

Daniel Hillis of Thinking Machines Corp. moved artificial intelligence a step forward when he developed the controversial concept of massive parallelism in the Connection Machine. The machine used up to 65,536 processors and could complete several billion operations per second. Each processor had its own small memory linked with others through a flexible network that users could alter by reprogramming rather than rewiring.

The machine´s system of connections and switches let processors broadcast information and requests for help to other processors in a simulation of brainlike associative recall. Using this system, the machine could work faster than any other at the time on a problem that could be parceled out among the many processors.

1986

IBM and MIPS released the first RISC-based workstations, the PC/RT and R2000-based systems. Reduced instruction set computers grew out of the observation that the simplest 20 percent of a computer´s instruction set does 80 percent of the work, including most base operations such as add, load from memory, and store in memory.

The IBM PC-RT had 1 megabyte of RAM, a 1.2-megabyte floppy disk drive, and a 40-megabyte hard drive. It performed 2 million instructions per second, but other RISC-based computers worked significantly faster.

IBM 3090 Vector Facility - 1986

- The vector facility was an optional component of the standard IBM 3090 system and was be viewed as an addition to the instruction execution part of the base machine. 171 new instructions were also introduced with the vector facility. The vector facility contains a set of vector registers and two vector pipelines, one multiply/divide pipeline and one arithmetic and logical pipeline. Each of the pipelines can produce one result per machine cycle, except for divide operations. The two pipelines can be chained together to produce two vector operations per machine cycle
- VS Fortran and ESSL were developed to take advantage of the special architectural features of 3090 VF, helping to compete against the Cray XMP and YMP products.

IBM RT: Predecessor to RS/6000 – 1986

- From the original Users Guide:

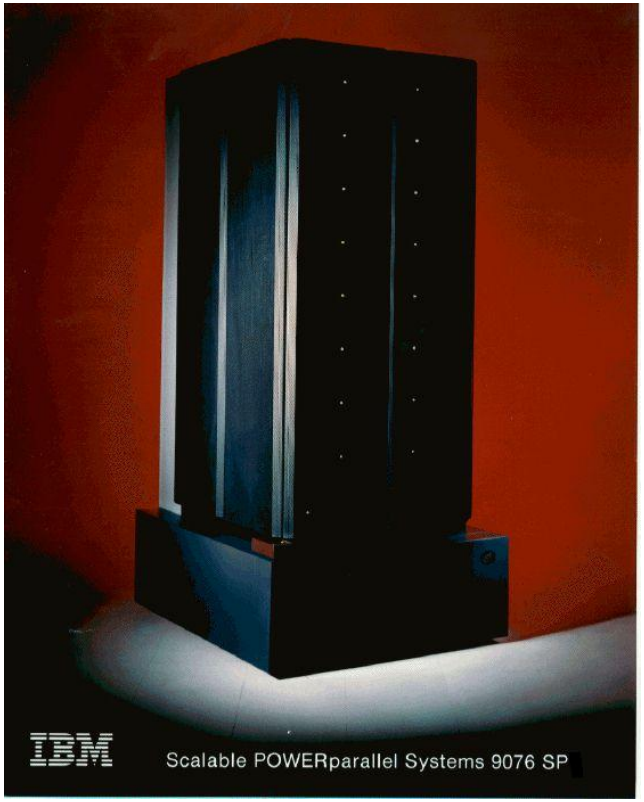
The IBM RT PC microprocessor was developed by IBM and uses an integrated chip set based on a 32-bit reduced instruction set computer (RISC) architecture. The chip set consists of a processor and a storage management unit for virtual machine operations with 40- bit addressing. The IBM RT PC is designed to satisfy computing needs of CAD/CAM, engineering and scientific, academic, and other professional environments. Compatibility with the IBM Personal Computer AT is provided through an optional IBM Personal Computer AT Coprocessor and appropriate software. The RT PC consists of a 6150 or 6151 System Unit composed of a processing unit, keyboard, memory, fixed disk drive, high capacity diskette drive, integrated date/time clock, and keylock.

RISC Systems

- **The A.M. Turing Award**
  1987: John Cocke for significant contributions in the design and theory of compilers, the architecture of large systems and the development of reduced instruction set computers (RISC); for discovering and systematizing many fundamental transformations now used in optimizing compilers including reduction of operator strength, elimination of common subexpressions, register allocation, constant propagation, and dead code elimination

1965	1974	1985	1986	1990	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
		America		POWER	RSC	POWER2			P2SC		POWER3		POWER3-II	POWER4	POWER4+		POWER5
IBM ACS	the 801					PowerPC 601		Power PC 604	PowerPC 603e, 604e							PowerPC 970	
			RT PC							RS64	RS64 II	RS64 III	RS64 IV				
						SP	SP2							SP2 Overview			
			AIX V1/2	AIX V3		AIX V3.2.5	AIX V4.1		AIX V4.2	AIX V4.3			AIX 5L V5.0	AIX 5L V5.1	AIX 5L V5.2		AIX 5L V5.3

IBM SP2 - 1993



- The RS/6000 SP system hosts dozens to hundreds of RISC processor nodes facilitating parallel processing capability. The basic SP building block is the processor node. It consists of a POWER3 or PowerPC Symmetric Multiprocessors (SMP), memory, Peripheral Component Interconnect (PCI) expansion slots for Input/Output (I/O) and connectivity, and disk devices. Nodes have either a Symmetric MultiProcessor (SMP) configuration (using PCI) or a uniprocessor configuration (using MCA). The three types of nodes (thin, wide, and high) may be mixed in a system and are housed in short or tall system frames. Depending on the type of nodes used, an SP tall frame can contain up to 16 nodes and an SP short frame can contain up to 8 nodes. These frames can be interconnected to form a system with up to 128 nodes (512 by special order). Each node contains its own copy of the AIX operating system.

Deep Blue – May 12, 1997

Swift and Slashing, Computer Topples Kasparov

By BRUCE WEBER

In brisk and brutal fashion, the I.B.M. computer Deep Blue unseated humanity, at least temporarily, as the finest chess playing entity on the planet yesterday, when Garry Kasparov, the world chess champion, resigned the sixth and final game of the match after just 19 moves, saying, "I lost my fighting spirit."

The unexpectedly swift denouement to the bitterly fought contest came as a surprise, because until yesterday Mr. Kasparov had been able to summon the wherewithal to match Deep Blue gambit for gambit.

The manner of the conclusion overshadowed the debate over the meaning of the computer's success. Grandmasters and computer experts alike went from praising the match as a great experiment, invaluable to both science and chess (if a temporary blow to the collective ego of the human race) to smacking their foreheads in amazement at the champion's abrupt crumpling.

"All the News That's Fit to Print"

The New York Times

Late Edition

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EARTHQUAKE TOLL IN IRAN ESTIMATED TO CLIMB TO 2,400

TEHERAN APPEALS FOR AID

Scores of Aftershocks Rattle Region as Survivors Begin Rescues and Burials

ENTERING DEBATE, GOVERNOR OFFERS RENT COMPROMISE

A SHIFT TO CENTER

Pataki Says Proposal Will Protect All but Richest Tenants

Pope Urges Lebanon's Muslims and Christians to Forgive

Optimism Dims For Agreement Over Tobacco

Mini-Vans Facing a Midlife Crisis at Age 14

Soccer Moms Losing Some Room to Gain A Sportier Image

Swift and Slashing, Computer Topples Kasparov

Rangers Move On; Knicks Win, Too

Inscrutable Conqueror

Deep (RS/6000 SP) Blue

Families Emerge as Silent Victims Of Tuskegee Syphilis Experiment

INSIDE

2005 - The Green 500

Historically, the Green500 started back in April 2005 – after a keynote talk by Dr. Wu-chun Feng at the IEEE IPDPS Workshop on High-Performance, Power-Aware Computing. The notion was then formally proposed a year later at the aforementioned workshop with a paper and associated talk entitled "Making a Case for a Green500 List," [paper] [talk]. A subsequent presentation at Clusters and Computational Grids for Scientific Computing 2006, "Global Climate Warming? Yes … In The Machine Room," led to more fervent interest, and ultimately, the announcement of the Green500 at SC|06. One year later at SC|07, the inaugural list was released and a new era of Green Supercomputing began.

IBM Blue Gene - 2005

- Blue Gene Solution is the result of an IBM project dedicated to building a family of supercomputers optimized for bandwidth, scalability and the ability to handle large amounts of data while consuming a fraction of the power and floor space required by today's high performance systems..
- Because of unique design points that allow dense packaging of processors, memory and interconnect, Blue Gene offers leadership efficiency in the areas of power and floor space consumption.
- For a number of years Blue Gene was the world's fastest supercomputer. It remains the kind of tool that enables breakthrough science and leads to innovative solutions in a variety of disciplines.

RoadRunner – The first Petaflop Supercomputer - 2008

- The world’s fastest supercomputer at Los Alamos National Laboratory is the first system to break through the "petaflop barrier" of 1,000 trillion operations per second. Compared to most traditional supercomputers today, hybrid design of the supercomputer at Los Alamos delivers world-leading energy efficiency, as measured in flops per watt.

- Designed by IBM, the world's first"hybrid“supercomputer introduces the use of the IBM PowerXCell™ 8i chip, an enhanced Cell Broadband Engine™ (Cell/B.E.™) chip—originally developed for video game platforms—in conjunction with x86 processors from AMD™. The supercomputer was built for the U.S. Department of Energy's National Nuclear Security Administration and is housed at Los Alamos National Laboratory in New Mexico

2011 – IBM Watson

- **Watson is a ‘cognitive computing technology’ that uses natural language input and output to look through massive amounts of structured and unstructured data to find ‘probabilities’ for various answers/approaches**
  - **Was made famous for winning the game show Jeopardy – but is intended for real life applications like Medicine**