ARPANET

- The Department of Defense sponsored research into building a reliable packet-switched network
- This became the ARPANET and eventually the internet
- The original network model was to have several nodes and links connecting them totally under control of the network control group
  - Clients wising to connect to the network had to build a bit-serial interface device to their computer and plug the other end into one of the network nodes
- The original protocol on the ARPANET guaranteed delivery of packets both between clients and between nodes
  - This resulted in much net traffic when a node went down and several undeliverable packets chased possible routs to the downed node until the slower protocol discovered that the node was unreachable
- The original routing algorithm did not need global information
  - Each node kept a table, for each link, how long it would take a packet to be delivered to each node of the network
  - It then constructed a table of best routes and how good they were for each node
  - It then sent this table to each of its neighbors who could then update their tables
  - Of course, the route to one's self was zero and this made the system work
- Eventually a centrally controlled routing strategy was developed

Xerox Contributions - Xerox PARC

- Started in 1970 with the mission to create "the architecture of information"
- In 1972 the first version of Smalltalk is deployed
- In 1973 the first laser printer, called EARS (for Ethernet-Alto research character generator scanning laser output terminal) is in service, printing documents at 1 page/second at 500 spots per inch (spi)
- A patent memo describing a new networking system uses the term "Ethernet" for the first time
  - The Alto personal computer becomes operational
  - The Alto will feature the world's first What-You-See-Is-What-You-Get (WYSIWYG) editor, a commercial mouse for input, a graphical user interface (GUI), and bit-mapped display, and will offer menus and icons, link to a local area network and store files simultaneously
    - The mouse was invented previously by Doug Englebart for the NLS system
  - Personal distributed computing is invented
    - A machine that runs just as fast during the day as at night
  - In 1974 PRESS, a Page Description Language, is developed
  - The Bravo word-processing program is completed, and work on Gypsy, the first bitmap What-You-See-Is-What-You-Get (WYSIWYG) cut & paste editor, begins. Bravo and Gypsy programs together represent the world's first user-friendly computer word-processing system.
  - BITBlt, an algorithm that enables programmers to manipulate images very rapidly without using special hardware, is invented. The computer command enables the quick manipulation of the pixels of an image and will make possible the development of such computer interfaces as overlapping screen windows and pop-up menus.
  - In 1975 engineers demonstrate a graphical user interface for a personal computer, including icons and the first use of pop-up menus. This interface will greatly influence the development of Windows and Macintosh interfaces
  - In 1980 the Interpress page description language is completed
    - Eventually, upset with the inappropriate actions by Xerox management, several researchers leave Xerox and found Adobe and create Postscript
  - In the mid '80s Xerox markets Lisp workstations that use the Interlisp-D programming language to support artificial intelligence programming as well as applications utilized within Xerox

The Data General NOVA Computer

- When Digital Equipment Corporation was deciding the next computer to make there were 5 contenders
  - The winner was the pdp-11 that eventually became the VAX
- A group decided that they had designed a good machine left the company and formed Data General and produced the NOVA line of computers
- Characteristics
  - 16-bit word length - 32768 word memory
  - Instructions had an 8-bit displacement
    - index 00 - the low 256 words of memory
    - index 01 - relative to PC
    - index 10 - relative to contents of ACC 2
    - index 11 - relative to contents of ACC 3
  - An indirect bit allowed indirect addressing
  - Certain words were "autoindexing" and would automatically increment if referenced as an indirect address

The Data General NOVA Instruction Set

- Instructions
  - JMP - jump
  - JSR - jump and set ACC 3 with PC+1
  - ISZ - increment and skip if result zero
  - DSZ - decrement and skip if result zero
  - LDAn - load accumulator
  - STAn - store accumulator
  - IO - various IO instructions

Arithmetic and Logical instructions

- Could specify
  - two accumulators (could be the same)
  - and a function
    - Complement
    - Negate
    - Move
    - Increment
    - Add Complement
    - Subtract
    - Add
    - And
  - the carry in
    - Carry
    - Complement of Carry
    - 0
    - 1
  - the shift
    - None
    - left
    - Right
    - Swap
  - a bit indicating if the result is only tested
  - and a Skip Command to skip if
    - No skip
    - Always skip
    - zero carry
    - Nonzero carry
    - zero result
    - nonzero result
    - skip either carry or result is zero
    - skip both carry and result nonzero

The Xerox ALTO

- A microcoded computer
  - emulated a Data General NOVA computer
    - Used 16-bit address instead of Data General's 15-bit addresses
    - Did not allow multilevel indirect addresses
    - Did not implement auto increment locations
  - all IO performed by microcode
    - when it became time for the device to transfer a word the appropriate micro task was run and the word transferred from or to memory
    - Double word operations could be done in 1 microsecond for an IO bandwidth of up to 32 MBits/second
      - Comparable to many mainframes of the day
- Fast Task switcher
  - Microcode had a 16 word register of task program counters
  - Could switch tasks by selecting which word in register was used for program counter
  - IO service routines in microcode
    - rapid switching of micro tasks made individual word transfers possible for IO
    - Tasks for
      - disk reads
      - disk writes
      - bit mapped display
      - keyboard sensing
      - mouse tracking
      - NOVA emulator (lowest priority)
      - etc.
- Bit mapped display
  - scatter gather for each scan line
  - invert video
  - automatic curser display
  - Display task in microcode took up more than half of the CPU when displaying a full 606 x 808 pixels
    - Some programs would turn off much of the display to calculate faster
- BCPL computer language used for all NOVA emulator programming for the system
  - Only datatype was the 16-bit word
  - How variables were used determined what they were
    - integers
    - arrays
    - functions
    - pointers
- The operating system was object oriented
  - A vector would represent an object
  - Methods were called by calling one of the functions in the vector
    - For example, the getcharacter method was in position 0 for a stream
    - You were required to pass in the vector/object as the first argument of the function
    - You could write your own stream objects if you followed the conventions

Ethernet

- Based on aloha net in Hawaii
- All computers on a net on a common wire
  - Collision detection allowed almost 100% throughput
  - First transceiver built by outside contractor because PARC had software people and not hardware people
- Ethernet protocols
  - Many protocols tried
  - PUP - PARC Universal Packet - became the standard for PARC and was used on the ARPANET to some extent
  - ALTO computers had a hardwired 8-bit address
  - Initial protocols were designed to work even without routers/gateways or name services
  - Principle of "best effort" for packet delivery
    - Routers could trash packets without notification if necessary

User Interface Development

- The ALTO was the first convenient personal bitmapped display computer
- Many editors, both text and graphical, were tried out
  - The idea that a document could be edited and seen before it was printed was new
  - Using many different fonts was new
- Bravo editor
  - single character commands
  - selection with mouse
  - user had to be aware of mode command/insertion
- Gypsy editor
  - This was a "modeless" editor - typing always went into the document
- The "Laurel editor" was the editor attached to the mail application
  - instead of "cut" and "paste" the selection point was always used for insertion
    - typing went in at the insertion point
    - anything "shift selected" was copied and inserted at the insertion point
    - anything "control-shift selected" was moved to the insertion point
  - This allowed pulling many things to the insertion point without losing one's place
  - Unfortunately, Apple and Microsoft copied Xerox before we got it right

Smalltalk

- Based on SIMULA 67 and a remark by Alan Kay, "What if the object oriented paradigm were extended to everything?"
  - Even integers and booleans were objects in Smalltalk
- Smalltalk 72 was an interpreted language because even the parsing of the language could be modified by "methods"
  - Had a window interface with mouse interaction
  - (Also a music synthesizer interface)
- Smalltalk 76 was compiled into byte codes
  - Language redefined to allow compilation
    - interpreted by special microcode in the ALTO

Interlisp-D

- Interlisp-D was the extension of interlisp to work with bit mapped displays
- Interlisp-D was also byte coded and interpreted by special microcode
- Many programming tools were developed for interlisp and it still is comparable to many current software development environments

Interpress and Postscript

- Working with the Cedar programming environment John Warnock and Martin Newell find that they have to write a program every time they want to test some graphical code
  - They develop a simple language, based on forth, to make running experiments easier
- They call it JaM for John and Martin
- This is seen as a "good thing" and a more structured language, called interpress, is developed to describe printed documents
  - Xerox, in their infinite wisdom, keeps the language secret for "competitive advantage" resulting in no interpress documents generated by outsiders for Xerox printers and the founding of Adobe by Xerox researchers that don't agree
    - Postscript is the result at Adobe and is closer to the spirit of the original JaM, i.e., a programming language

People

- Chief researcher in early PARC
  - Butler Lampson
- Jack of all trades - helped everywhere
  - Ed McCreight
- Instigator of Smalltalk
  - Alan Kay
- ALTO
  - Chuck Thacker
- EARS
  - Ron Rider
- Interlisp
  - Dan Bobrow
  - Larry Masinter