



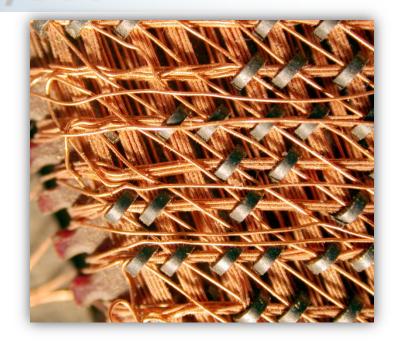
# **Pre-UNIX History**

- IBM System/360 a mainframe computer system family introduced in 1964. (Previous picture is a mid-series model 50).
- Featured 32-bit words with 16 32-bit registers and 4 64-bit floating point registers.
- Big endian byte-ordering
- EBCDIC instead of ASCII character encoding
- In EBCIDIC, incrementing the character code for "I" does not produce the code for "J", and likewise there is a gap between the codes for "R" and "S". Thus programming a simple control loop to cycle through only the alphabetic characters is problematic.



## IBM S/360





Removable disk packs with six 14" diameter platters stored 7.25 megabytes. Data transfer rate was 156 kB/s. Speed ranged between 0.0018 to 0.034 MIPS. Internal main core memory ranged from 4kB to 8kB.



# **History**

# Isn't this covered in the History department?



Dennis Ritchie and Ken Thompson



# Back in the long ago time...

- 1940-50 Single-user, huge computers
- 1960 Batch systems punch cards
- Late 60's-70's Timesharing
- 1964 joint project between AT&T Bell Labs, GE, and MIT to develop a new OS.
  - Goal: develop an OS that could provide computational power, data storage and the ability to share data among multiple users.
    - Their dream operating system
  - Result: Multiplexed Information & Computer Service – MULTICS on PDP-7



# **Prehistoric Computing**

- Due to "friction" within the joint effort Bell withdrew in 1969. Multics never became what they had hoped.
- Two Bell Lab scientists, Ken Thompson and Dennis Ritchie, kept the idea alive by continuing the research on their own.
- They were still left without a "Convenient interactive computing service"\*.
- Through informal discussions with peers they developed their idea of a new OS
- \* Ritchie, D.M. "The Evolution of the Unix Time-sharing System", AT&T Bell Laboratories Technical Journal, Oct. 1984, Vol 63, No.8, Part 2, pp. 1577-1594.



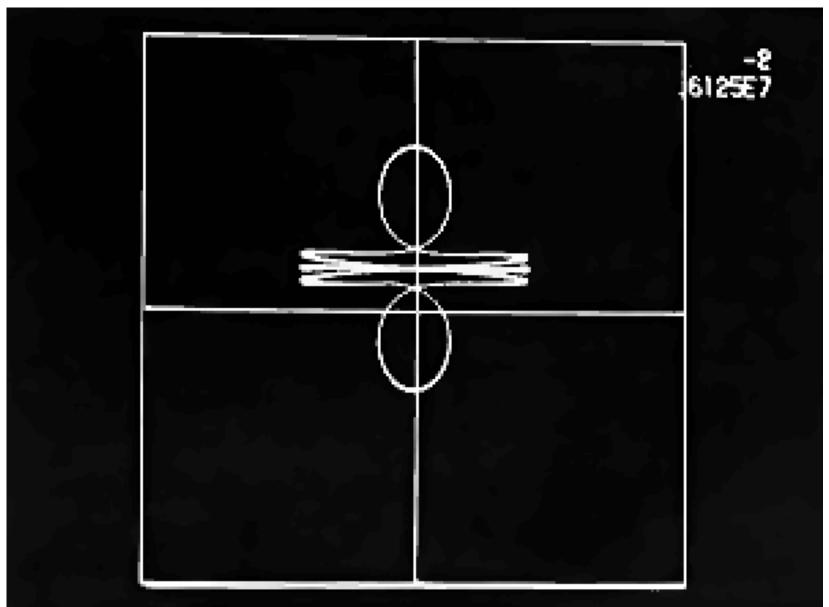
# **Unintended Consequences!**

- At the same time Ken Thompson wrote (choose one):
  - a game
  - a serious scientific astronomical simulation program
- called "space travel" in Fortran to run on GECOS OS (Honeywell 635).
- The spaceship was hard to control and expensive to run. He was told to get the game off the mainframe computer.
- They ported it. Serendipity!
  Ancient Geek History...





# **Space Travel**





# \$72K gets you 18-bits

- Thompson ported the game to a little used PDP-7 computer.
- Unics (later Unix) was born as a pun on Multics.
- Mostly in Assembler
- Led to development of "C" in 1972





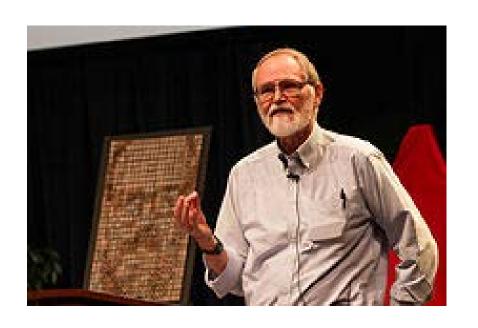
- Dennis Ritchie developed "B"
- Then wrote "C"
  - A compiled language.
- 1973 entire UNIX OS ported to "C"

 Because of a 1956 Consent Decree AT&T could not market Unix, so they provided it to academia.





- Brian Kernigan also worked at Bell labs
- Contributed to development of Unix
- Co-wrote (with Ritchie) book on C
- Wrote original implementation of Hello World!





- Bill Joy while student at Berkeley
- Played integral role in developing BSD UNIX
- Creates vi in 1978
- Wrote csh
- Wrote TCP/IP stack for BSD
- In 1982 founds Sun Microsystems





- Late 70's: Thompson took a sabbatical to teach UNIX at UC Berkley
  - Birth of Berkeley Standard Distribution (BSD UNIX) many new features

 AT&T Bell Labs realized the commercial potential and began distributing System III, then System V

- Commercialization of Unix (70's / 80's)
  - AT&T, Sun, SGI, HP, DEC, NCR, IBM, Apollo

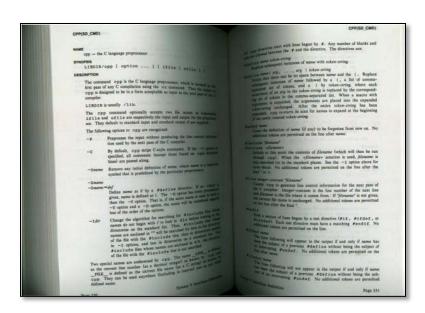


- From the late 1970s to early 1980s, UNIX evolved into two related but distinct camps.
- One camp centered about a commercial UNIX developed by American Telephone and Telegraph (AT&T).

The AT&T versions were named System III and

later System V.

- BSD SystemV
- SunOS -> Solaris





- The other popular UNIX variant was BSD UNIX, funded by the Department of Defense's Advanced Research Projects Agency - DARPA.
- Networking was added to BSD UNIX making it an important force in the early development of the Internet, also funded by DARPA.
- BSD UNIX formed the basis for the early SunOS, IRIX, NeXTSTEP and later versions of BSD.
- The most common current BSD-styled UNIXes are the BSD triplets, OpenBSD, FreeBSD, NetBSD.

BSD daemon: Beastie (slurred BSD)



### **Towards A Standard UNIX**

- Late 1980s two version of UNIX
  - 4.3BSD
  - System V Release 3
- Standardizing Efforts
  - Initial efforts failed
  - Successful effort POSIX (Portable Operating System)
    - Set of library procedures open, read, fork, ...
    - Committee took intersection of System V and BSD
  - Industrial Split
- IBM, DEC, HP consortium OSF (Open Software Foundation) met IEEE standard and included also windowing system X11, graphical user interface MOTIF
- AT&T consortium UI (UNIX Int.) based on System V
- Multiple UNIX implementations: HP-UX, AIX, Solaris



### **POSIX**

Portable Operating System Interface for Unix

- POSIX is a family of IEEE standards describing an API, shell, & utility interfaces for software compatible with variants of the Unix OS.
- POSIX is not an implementation it is a description!
- Most vendors are supporting POSIX (by making sure their version of Unix adheres to the standard).
- The UNIX Subsystem built in to the Enterprise and Ultimate editions of Windows Vista and 7.



# **POSIX Controversy Example**

- 512- vs 1024-byte blocks
- POSIX mandates 512-byte block sizes for the df and du utilities, reflecting the default size of blocks on disks.
- When implementing the GNU OS, Richard Stallman objected - most people think in terms of 1024 byte (1 KB) blocks.
- The environmental variable POSIXLY\_CORRECT forces the standards-compliant behaviour. (POSIX\_ME\_HARDER is obsoleted) Truth!

### MINIX

## 1987 - New UNIX-like system

- Small enough and open with source code available
- Functionally almost equivalent to Version 7 UNIX
- Based on micro-kernel design, i.e., minimal functionality in kernel to make it reliable and efficient
  - Memory management and file system in user processes
  - Easy to understand
  - Easy to maintain due to their highly modular structure
    - Other Micro-kernels
    - Mach CMU 1986
    - ChorusOS INRIA 1988 (for embedded systems)

### LINUX

### Linus Torvalds - Finland - UNIX clone - Linux

- 1991 Linux 0.01
  - MINIX influenced ex: source tree structure, file system layout
  - Monolithic (not micro-kernel design)
  - Originally run on 386 architecture
- 1993 Slackware Linux \*
- 1994 Linux 1.0
  - New file system
  - Memory-mapped files
  - BSD-like networking w/sockets, TCP/IP
  - New device drivers
- 1996 Linux 2.0
  - Support for 64-bit architectures
  - Symmetric multiprogramming
  - New networking protocols
- Business Model free software
  - 80% of 150 Linux system calls are exact copies of the corresponding system calls in POSIX, BSD or System V.





### Linux Version 2.6+

- Compliant with IEEE POSIX standard
- All features of a modern UNIX OS
  - Virtual memory, virtual file system, lightweight processes, Unix signals, SVR4 (System V, Release 4) inter-process communications, support for Symmetric Multiprocessors (SMP)
- Monolithic kernel
  - Most commercial UNIX variants are monolithic
  - Exceptions: Apple MAC OS X and GNU Hurd OS (both derived from CMU Mach OS) follow microkernel approach
- Support for modules on demand automatic load/unload
  - Only SVR4.2 and Solaris kernel have similar feature
- Kernel threading
  - Kernel organized as a set of kernel threads
  - Only Solaris and SVR4.2 are organized like this



### Linux Version 2.6+ 5.15 Now

- Multithreaded application support
  - Multi-threaded user application composed of many light-weight processes (LWP) - processes that can operate in common address space, physical memory pages, opened files, etc.
  - Linux defines its own LWP different from SVR4 and Solaris
- Preemptive kernel
  - Kernel 2.6's compiled with "preemptible kernel" option, can arbitrarily interleave execution flows while in privileged mode
  - Only Solaris and Mach 3.0 have preemptible kernels
- Multi-processor support
  - Support of SMP for different memory models
- File System Linux has several standard file systems
  - Old Ext2 file system (if no specific needs)
  - Ext3 file system (no lengthy file system checks after system crash)
  - ReiserFS file system (for small files)



### **Get The Slack**

- Slackware created by Patrick Volkerding in 1993
- A free and open source Linux OS
- One of earliest OS's built on the Linux kernel
- Is oldest currently being maintained
- Aims:
  - Design stability and simplicity
  - To be most UNIX-like distribution
- 1.0 (1993) 24 3.5" floppy disks
- 2.1 (1994) 73 3.5" floppy disks
- 3.0 (1995) CD ROM disc \* Internet hunt 11/95
- 15.0 (February 2022)



### Ubuntu

- Ubuntu 1.0 (2004) based on Debian GNU/Linux
- From Canonical (British)
- Most popular distro 50% market share
- 1st most popular server
- 6-month release cycle
- Long Term Support releases
  - 3/5 year desktop/server update guarantee
- Can make public/private cloud





### **CentOS**

- Community Enterprise Operating System
- First release in May 2004 as a fork from Red Hat
  - Red Hat Enterprise Linux (RHEL) (Paid)
- Supports x86-64
- AltArch releases for IA-32, Power PC, ARM
  - Alternative Architecture Special Interest Group
- Approx. 30% of Linux web servers run CentOS





### What is a Distribution?

# distribution

e.g. Debian, Red Hat, SUSE, Mandriva

distribution specific applications
(e.g. for configuration, installation like Yast, mcc)

### proprietary applications

(e.g. Adobe Reader, graphics driver)

### Linux kernel

### free applications

(e.g. KDE, OpenOffice, Apache)

### **Manuals**

### Support

(phone mail, etc)



- Differences between flavors of UNIX become more apparent the more sophisticated the user becomes.
  - At the most basic level, all UNIX variants share a common set of user level commands that function in a nearly identical manner with the exception of some option flags.
  - More sophisticated users will note the different option flags.
  - Programmers will note that the BSD and System V families of UNIX have significant differences in libraries and system calls.
- Differences between UNIX variants will be most apparent to the system administrator.



## Example:

- BSD UNIXes use a small collection of run control files (e.g. /etc/rc, /etc/rc.local) which each start multiple service daemons
- Run control files on System V UNIXes are numerous, with each one starting just one service. They are stored in a separate directory and links from the files into directories named for the various run levels are used to specify which services to start at given level and the order to start them in.



### **Broad Unix Features**

- Uses a simple, uniform file model
- Includes devices and access to other services
- A flexible, hierarchical file system
- Written in the high-level language ("C")
- Easy to read, understand, change, and port
- The command prompt is a simple user process
- Shell is convenient job programming language
- Includes support for regular expressions



# **Unix Philosophy**

- Write programs that do one thing
  - Do it well
- Write programs to work together
- Write programs to handle text streams
  - Essentially a universal interface



### **UNIX** and Time

- UNIX is old
- UNIX time is a system defined as the number of seconds elapsed since midnight Coordinated Universal Time (UTC) January 1, 1970, not counting leap seconds.
  - UTC did not exist in its current form until 1972
- The Unix epoch is 00:00:00 UTC on 1 January 1970 = 0
- It increases by exactly 86,400 per day since the epoch
- On September 9, 2001, at exactly 01:46:40 (UTC) the decimal representation of Unix time was equal to 100000000, which was celebrated as the Unix billennium
- On February 13, 2009, at exactly 23:31:30 (UTC) the decimal representation of Unix time was equal to 1234567890. Parties were held around the world.



# Party like it's 1234567890





### Year 2038 Problem

- UNIX stores system time as signed 32-bit integer
- UNIX keeps time as a count of seconds (ignoring leap seconds) since:
- 00:00:00 Jan 1 1970 GMT
- On 32-bit systems this count (or the integral portion thereof) overflows on:

Tue Jan 19 03:14:08 2038 (UTC)

At that time the date suddenly becomes:

Fri Dec 13 20:45:52 1901

- Y2K all over again?
- What is a leap second?



# Leap Second?

- What is a leap second?
- A leap second is a positive or negative one-second adjustment to the Coordinated Universal Time (UTC) time scale that keeps it close to mean solar time







# Leap Second

- Most recent leap second occurred:
- UTC December 31, 2016 at 23:59:60

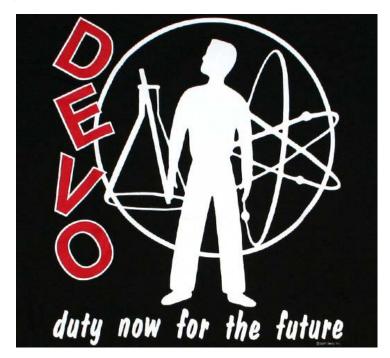




# **Duty Now For The Future**

- In May 2006 a future-time kludge in AOLserver software exceeded the 2038 cutoff date.
  - It crashed

Start now....
 2038 – 2022= 16
 This is your problem

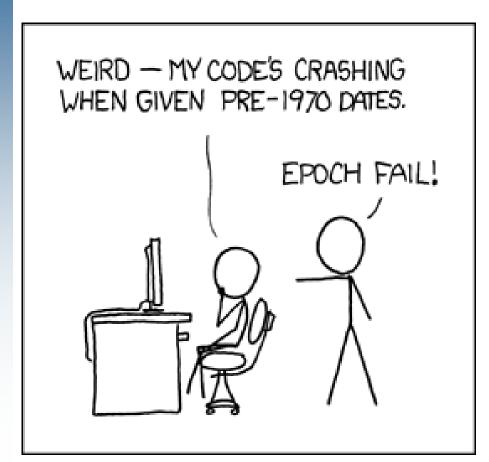


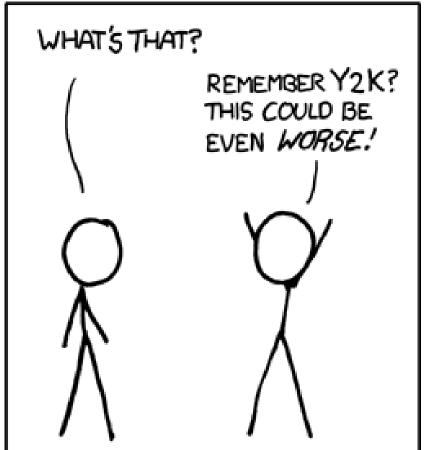
 64-bit Solaris and Linux, running 64-bit apps, will correctly handle dates for 292 billion years.



### **XKCD**

I'M GLAD WE'RE SWITCHING TO 64-BIT, BECAUSE I WASN'T LOOKING FORWARD TO CONVINCING PEOPLE TO CARE ABOUT THE UNIX 2038 PROBLEM.







### **32-bit Counters**

- SNMP Simple Network Management Protocol
- Cisco etc. that follow RFC1213
- Uptime counter stored as 32-bit counter 1/100 s
- Wraps around every 496 days
- Can be ± 1 year if polled at rollover
- Can rollover traffic counters on Gig circuits if polling interval is too long
  - 15 min too slow
  - 5 min ok



### **UNIX/Linux**

 UNIX/Linux has since grown to become the most widely used operating system

- Personal Workstation
- File and Print Server
- Internet Service Provider
- Three-tier Client/Server
- Turnkey System
- Embedded Systems
- Smart Phones









### **IP Enabled Smart Sensors**

- Can be implemented on microcontrollers and radios that cost less than \$2.00.
- An IPv6 stack can be built in:
  - ◆ < 12 Kb code
    </p>
  - < 2Kb memory requirement</p>
- Server often a standard Apache Webserver

Picotux – smallest Linux hardware available



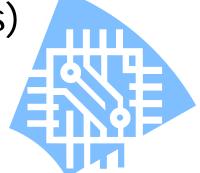


### **Embedded Fabric**

# Ubiquitous networking ♦ Pervasive computing

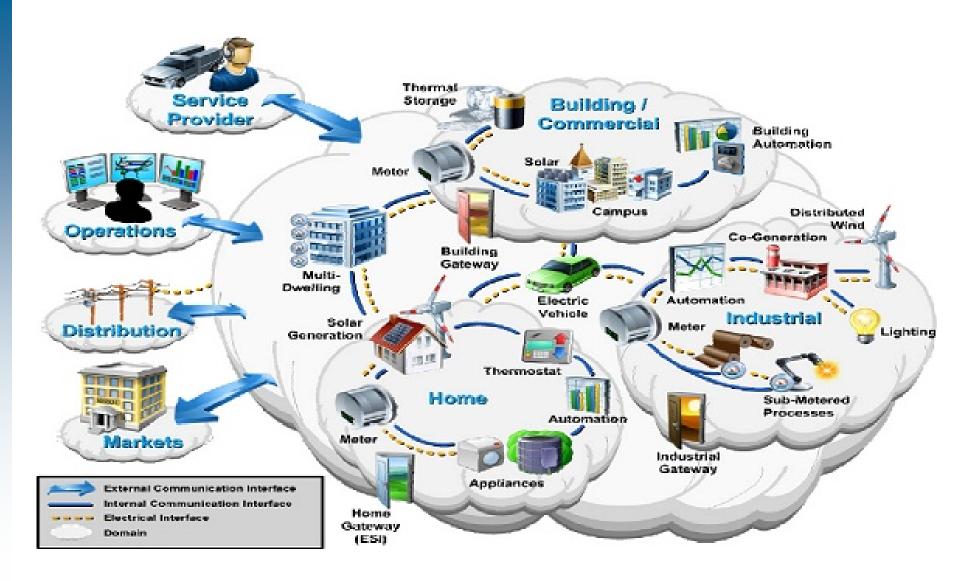
- Multimedia (why buy a television?)
- Phones RIP Landlines
- Signage
- Geolocation
- Narrowcasting
- Automobiles
- Sensor networks (roads, homes, us)
- Storage



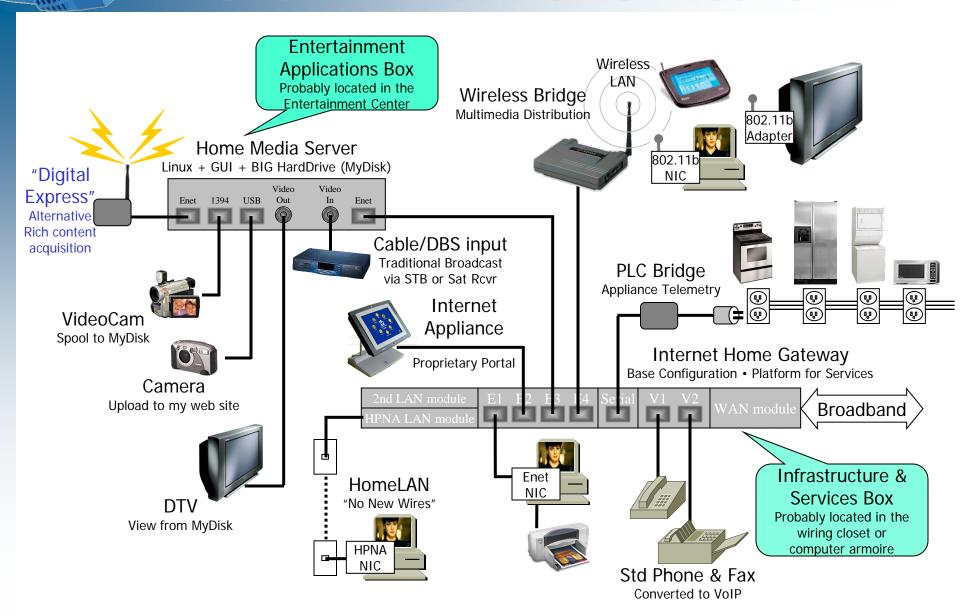




# **Future: IP to the Edge**



# The "Connected Home" Network



# Linux will be a part of your future





Earlier predictions about the future may have not quite come to pass.

Linux is a safe bet – because its already here, and growing rapidly.



### Remember

- Ken Thompson Bell Labs, UNIX
- Dennis Richie Bell Labs, UNIX, C
- Brian Kernighan Bell Labs, UNIX, C
- Bill Joy Berkeley, Vi, Sun
- Linus Torvalds Linux
- UNIX Epoch 2038 32 bit counter
- Post rollover year will be 1901