# System Programming

## Topic 1: Introduction to System Programming

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"intro update"

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# Table of Contents



# Nutshell

Ken Thompson and Dennis Ritchie at PDP-11 in 1971 (Photo: Courtesy of Bell Labs)

# Principles

https://en.wikipedia.org/wiki/Unix_philosophy

- Small is beautiful.
- Make each program do one thing well.
- Build a prototype as soon as possible.
- Choose portability over efficiency.
- Store data in flat text files.
- Use software leverage to your advantage.
- Use shell scripts to increase leverage and portability.
- Avoid captive user interfaces.
- Make every program a filter.

# Introduction

- Familiarize with UNIX
- Experience systems programming
- Understand fundamental OS concepts
  - Multi-user concepts
  - Basic and advanced I/O
  - Process
  - Interprocess communication

# Why do we have to?

- Unix gives you insights on how other OS works
- You can only catch the tiger by going into the tiger's den
- It is the basis for most other programming and understanding of the system
- It in C helps you understand the general programming concepts

# How are we going to do?

```
1  /*
2   * welcome file
3   */
4
5  #include <stdio.h>
6  //#include <unistd.h>
7
8  int
9  main(int argc, char **argv) {
10     printf("Welcome to System Programming, %s!\n", getlogin())
11 }
```

How to compile

$ cc -Wall -g -o welcome welcome.c

# About this class

Textbook

- "Advanced Programming in the UNIX Environment", by W. Richard Stevens, Stephen A. Rago (3rd Edition)

Assistant

- Yeonjin Noh (nyg0813@gmail.com)
- FTC #804

Grading:

- Attendance 5%
- Assignments 30%
- Quiz 5%
- Midterm Exam 30%
- Final Exam 30%
- Level test on editors

# Syllabus

Week 1 09-07 Introduction to system programming & Shell Survival Kit
Week 2 09-14 (추석)
Week 3 09-21 Files IO & ctag/etag
Week 4 09-28 Files and Directories
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Week 6 10-12 Process Environment
Week 7 10-19 Process Control
Week 8 10-26 (중간고사)
Week 9 11-02 Signals
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Week 12 11-23 Advanced I/O
Week 13 11-30 Interprocess Communication I
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Week 15 12-14 Network IPC Week 16 12-21 (기말고사)

# History

# The UNIX History

For more info : http://www.unix.org/what_is_unix/history_timeline.html

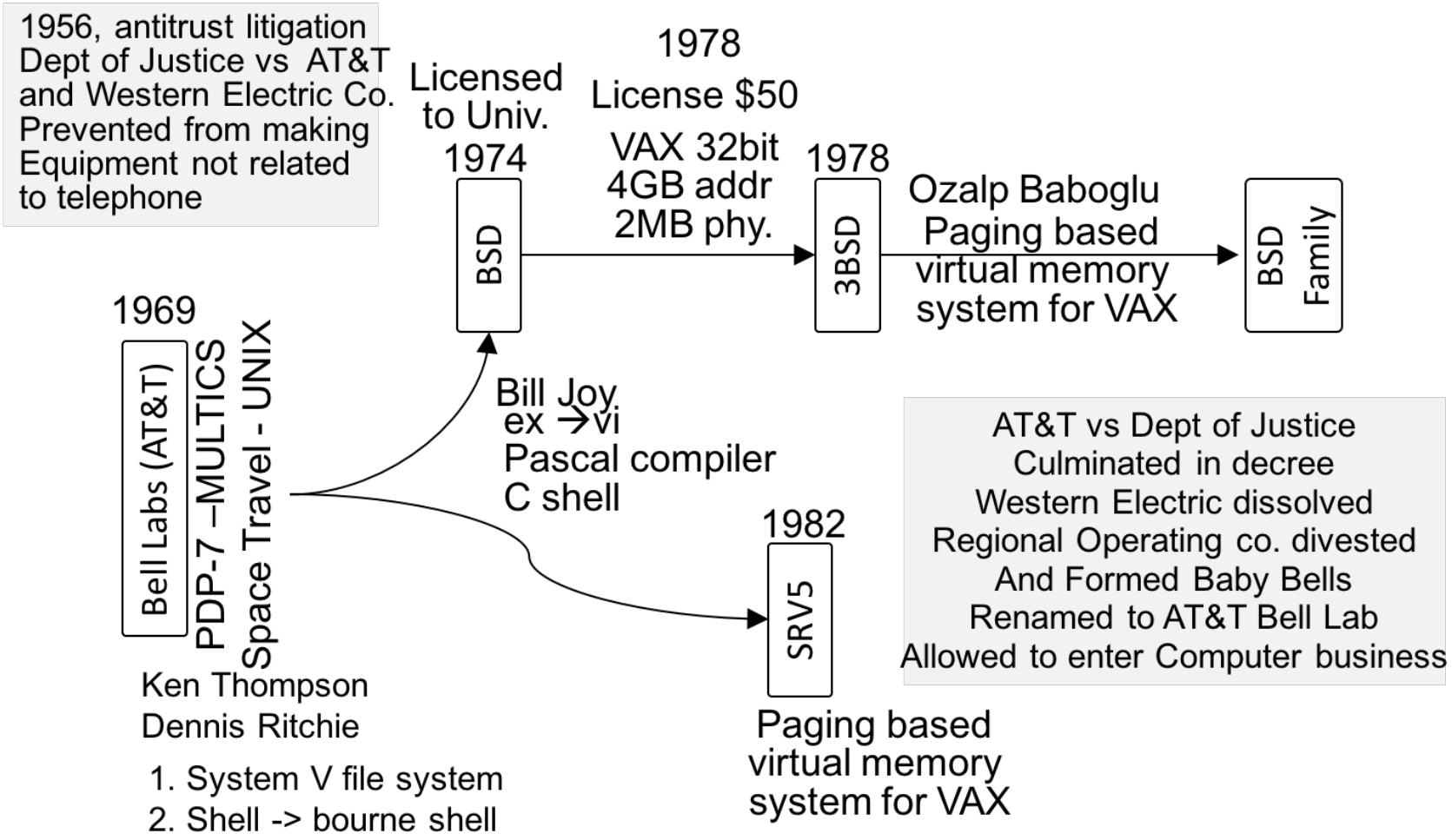
- Originally developed in 1969 at Bell Labs by Ken Thompson and Dennis Ritchie.
- 1973, Rewritten in C. This made it portable and changed the history of OS
- 1974: Thompson, Joy, Haley and students at Berkeley develop the **B**erkeley **S**oftware **D**istribution (BSD) of UNIX
- two main directions emerge: BSD and what was to become "System V"

# UNIX History

- 1984 4.2BSD released (TCP/IP)
- 1986 4.3BSD released (NFS)
- 1991 Linus Torvalds starts working on the Linux kernel
- 1993 Settlement of USL vs. BSDi; NetBSD, then FreeBSD are created
- 1994 Single UNIX Specification introduced
- 1995 4.4BSD-Lite Release 2 (last CSRG release); OpenBSD forked off NetBSD
- 2000 Darwin created (derived from NeXT, FreeBSD, NetBSD)
- 2003 Xen; SELinux
- 2005 Hadoop; DTrace; ZFS; Solaris Containers
- 2006 AWS ("Cloud Computing" comes full circle)
- 2007 iOS; KVM appears in Linux
- 2008 Android; Solaris open sourced as OpenSolaris

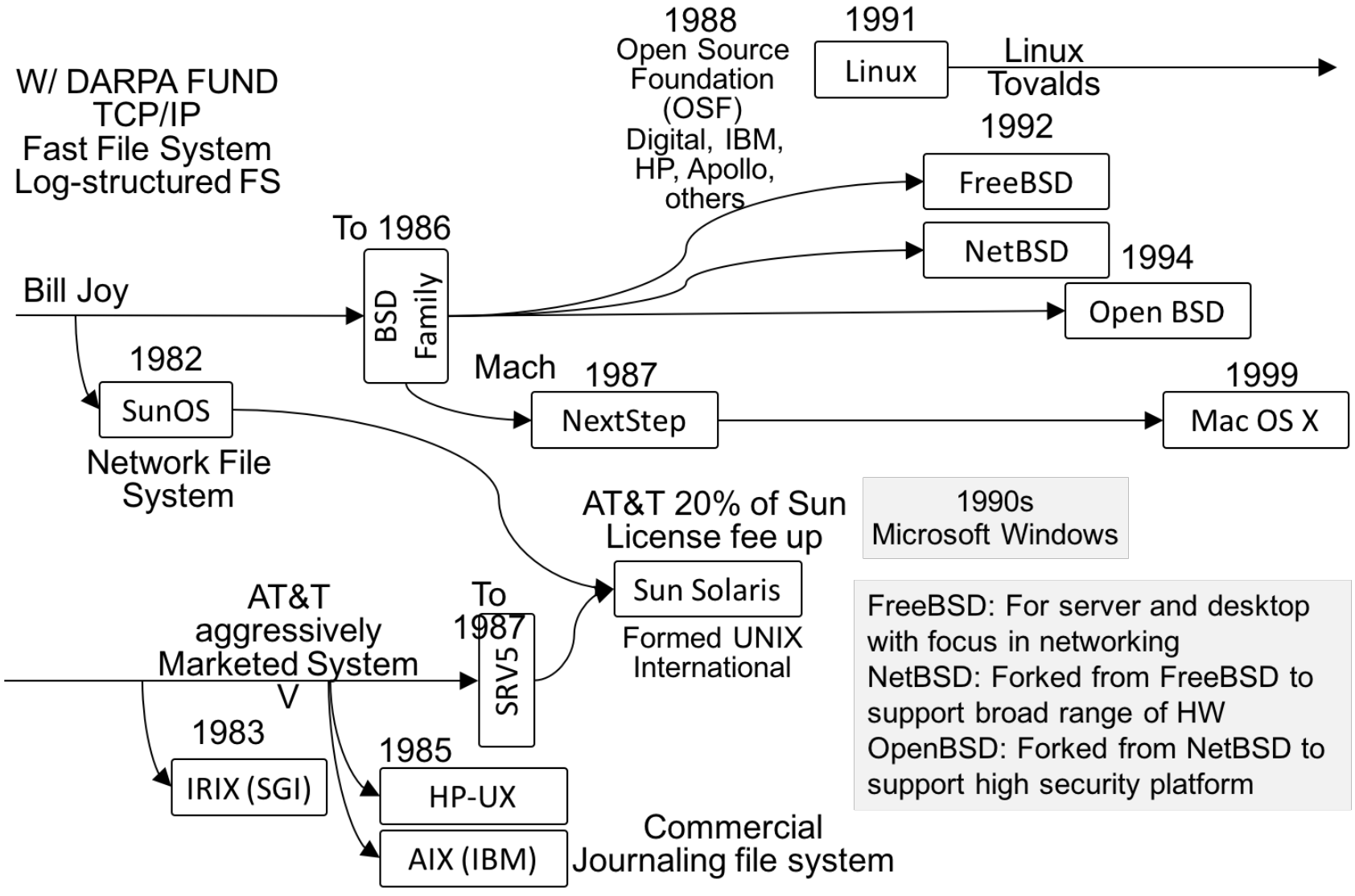
list from www.cs.stevens.edu/~jschauma/631A/

# History




1971 Nov. R&T – UNIX programmer's Manual
1973 Feb. UNIX v3 included cc – rewritten in C
1973 Oct. ACM SOSP – The UNIX Time Sharing System

# History


1988
Open Source Foundation (OSF)
Digital, IBM, HP, Apollo, others
1991
Linux
Linux Tovalds
W/ DARPA FUND
TCP/IP
Fast File System
Log-structured FS
1992
FreeBSD
NetBSD
1994
Open BSD
To 1986
BSD Family
Bill Joy
1982
SunOS
Network File System
Mach
1987
NextStep
1999
Mac OS X
AT&T 20% of Sun
License fee up
Sun Solaris
Formed UNIX International
1990s
Microsoft Windows
AT&T
aggressively
Marketed System
V
To
1987
SRV5
1983
IRIX (SGI)
1985
HP-UX
AIX (IBM)
Commercial
Journaling file system
FreeBSD: For server and desktop with focus in networking
NetBSD: Forked from FreeBSD to support broad range of HW
OpenBSD: Forked from NetBSD to support high security platform

# Some UNIX Versions

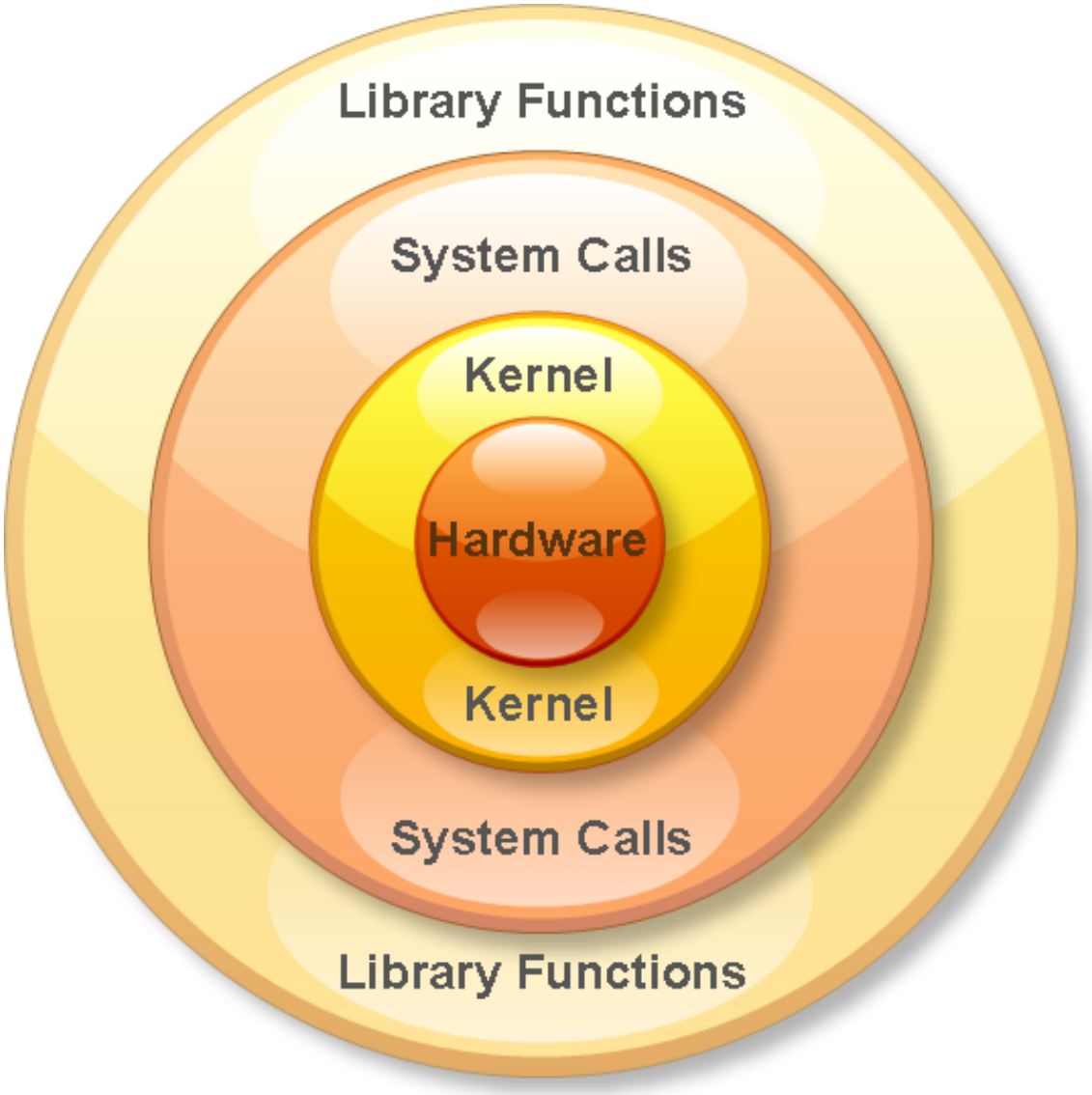
## More UNIX (some generic, some trademark, some just unix-like):

| | | | | |
|---|---|---|---|---|
| 1BSD | 2BSD | 3BSD | 4BSD | 4.4BSD Lite 1 |
| 4.4BSD Lite 2 | 386 BSD | A/UX | Acorn RISC iX | AIX |
| AIX PS/2 | AIX/370 | AIX/6000 | AIX/ESA | AIX/RT |
| AMiX | AOS Lite | AOS Reno | ArchBSD | ASV |
| Atari Unix | BOS | BRL Unix | BSD Net/1 | BSD Net/2 |
| BSD/386 | BSD/OS | CB Unix | Chorus | Chorus/MiX |
| Coherent | CTIX | Darwin | Debian GNU/Hurd | DEC OSF/1 ACP |
| Digital Unix | DragonFly BSD | Dynix | Dynix/ptx | ekkoBSD |
| FreeBSD | GNU | GNU-Darwin | HPBSD | HP-UX |
| HP-UX BLS | IBM AOS | IBM IX/370 | Interactive 386/ix | Interactive IS |
| IRIX | Linux | Lites | LSX | Mac OS X |
| Mac OS X Server | Mach | MERT | MicroBSD | Mini Unix |
| Minix | Minix-VMD | MIPS OS | MirBSD | Mk Linux |
| Monterey | more/BSD | mt Xinu | MVS/ESA OpenEdition | NetBSD |
| NeXTSTEP | NonStop-UX | Open Desktop | Open UNIX | OpenBSD |
| OpenServer | OPENSTEP | OS/390 OpenEdition | OS/390 Unix | OSF/1 |
| PC/IX | Plan 9 | PWB | PWB/UNIX | QNX |
| QNX RTOS | QNX/Neutrino | QUNIX | ReliantUnix | Rhapsody |
| RISC iX | RT | SCO UNIX | SCO UnixWare | SCO Xenix |
| SCO Xenix System V/386 | Security-Enhanced Linux | Sinix | Sinix ReliantUnix | Solaris |
| SPIX | SunOS | Tru64 Unix | Trusted IRIX/B | Trusted Solaris |
| Trusted Xenix | TS | UCLA Locus | UCLA Secure Unix | Ultrix |
| Ultrix 32M | Ultrix-11 | Unicos | Unicos/mk | Unicox-max |
| UNICS | UNIX 32V | UNIX Interactive | UNIX System III | UNIX System IV |
| UNIX System V | UNIX System V Release 2 | UNIX System V Release 3 | UNIX System V Release 4 | UNIX System V/286 |
| UNIX System V/386 | UNIX Time-Sharing System | UnixWare | UNSW | USG |
| Venix | Wollogong | Xenix OS | Xinu | xMach |

adopted from http://www.cs.stevens.edu/~jschauma/631A/

# The Unix Basics

# The UNIX Basics: Architecture




applications > shell

# UNIX Architecture

**Kernel** is a software (SW) that controls the hardware (HW) of the computer and provides an environment under which programs can run.

**System calls:** are entry points into which kernel codes where the functions are implemented.

**Library calls (functios):** are transfers to user code with which performs the desired functions.

An **operating system (OS)** consists of the kernel and all other SWs that make a computer useful and gives the computer its personality. Other SW include system utilities, applications, shells, libraries of common functions etc. For example, for linux, kernel used by GNU OS is GNU(sometimes referred to as GNU linux OS) has an advantage of being more siccunt.

# Logging In

After log in, the system looks up for your login in its password file (/etc/passwd) which is composed of 7 colon separated fields (login name, encrypted password, user ID 205), numeric group ID (105), a comment field, home directory (/home/sar) and shell program (/bin/ksh). That is, sar: x: 205: 105: Sembaty Erios: home/sar: /bin/ksh. (chapter 6).

**Shell:** is a command-line interpreter that reads user input and executes commands. It is a special application that provides an interface for running other applications.

After log in, you type commands to the shell and the system knows which shell to execute for us based on the field in our entry password file.

# Logging In

The system knows which shell to execute for us based on the final field in our entry in the password file.

**There are 5 common shells used** (chapter 2) as shown in Table 1.

| Name | Path | FreeBSD 8.0 | Linux 3.2.0 | Mac OS X 10.6.8 | Solaris 10 |
|---|---|---|---|---|---|
| Bourne shell | `/bin/sh` | • | • | copy of `bash` | • |
| Bourne-again shell | `/bin/bash` | optional | • | • | • |
| C shell | `/bin/csh` | link to `tcsh` | optional | link to `tcsh` | • |
| Korn shell | `/bin/ksh` | optional | optional | • | • |
| TENEX C shell | `/bin/tcsh` | • | optional | • | • |

Table 1: Showing common shells used on UNIX systems

# Files and Directories

**NOTE:** The research Unix system and some older Unix system v-file systems filenames are restricted to 14 characters. BSD versions – extended limit of 255 characters and almost all commercial Unix file systems support 255 character filenames.

**Pathname:** is a sequence of 1 or more filenames separated by slashes (relative pathname) and starting with a slash (an absolute pathname). Relative pathname files are relative to the current directory.

**Working directory:** every process has a working directory (current working directory) which interprets all relative pathnames. A process can change its directory with the chdir function.

**Home directory:** after log in the working directory, it is set to our home directory which is obtained from our entry in the password.

# Input and Output

**File descriptors:** are small non-negative integers that the kernel uses to identify the files accessed by a process. Whenever the kernel opens an existing file or creates a new file, it returns a file descriptor that we use when we want to read or write a file.

**Standard input, standard output and standard error:** usually, all shells provide a way to redirect and/or all the descriptors to any file. If nothing is done, like a simple command 1s, then all d 3 are connected to the terminal (chapter 18). For example; s>file.list executes the 1s command with its standard output redirected to the file named .file.list (chapter 5).

# Programs and Processes

**Program** is an executable file residing on disk in a directory. A program is read into memory and is executed by the kernel as a result of one of the seven exec functions (Section 8.10).

**A process (task):** An executing instance of a program. The UNIX System guarantees that every process has a unique numeric identifier (is always a non-negative integer) called the **process ID**.

**Process Control:** There are three primary functions for process control: fork, exec (has seven variants), and waitpid. Process control of UNIX system is demonstrated by the bare-bornes implementation of the shell-like program (chapter 8).

# Programs and Processes

**Threads:** A thread is a set of machine instructions executing at a time. A process usually has only 1 thread of control. Some problems are easy to solve when more than 1 thread of control operates on different parts of the problem. Multiple threads of control can exploit the parallelism possible on multiprocessor systems.

All threads within a process share **the same address space, file descriptors, stacks and process-related attributes.** Each thread executes on its own stack but any thread can access stacks of other threads in the process. They need to synchronize access to share data amongst themselves to avoid inconsistent.

**Thread ID:** It functions to control threads parallel to other threads used to control a process. Threads are localized to a process (chapter 12). A thread ID from one process has no meaning in another process. We use thread IDs to refer to specific threads as we manipulate the threads within a process.

# Error Handling

Occurrence of an error in UNIX system functions returns **a negative value and the integer errno** is usually set to a value that notifies you. Eg, open function returns either a non-negative file descriptor in all, to indicate all is ok or -1 for error. That is; more functions that return a pointer to an object, return a null pointer to indicate an error. An error from open has about 15 possible errno values, say, file does not exist, permission problem (section 2).

On LINUX, the error constants are listed in the errno (3) manual page. In an environment that supports threads, the process address space is shared by amongst multiple threads with each thread having its own local copy of errno to prevent them from interfering with each other.

# Error Handling

**There are 2 rules to be aware of with respect to errno.**

1. Its value is never cleared by a routine if an error does not occur. Thus, we should examine its value only when the return of errno is never set to 0 by any of the functions and no constants defined in errno.h has a 0 value.

2. The value of errno is never set to 0 by any of the functions and none of the constants defined in <errno.h> has a value 0.

# Error Handling: ANSI C

- Important ANSI C Features:
  - function prototypes
  - generic pointers (`void *`)
  - abstract data types (e.g. `pid_t`, `size_t`)
- Error Handling:
  - meaningful return values
  - `errno` variable
  - look up constant error values via two functions:

```
1  #include <string.h>
2  char *strerror(int errnum) // returns pointer to message string
```

```
1  #include <stdio.h>
2  void perror(const char *msg)
```

# Errors and Warnings

```
$ gcc -Wall -g -o welcome welcome.c
welcome.c:6:81: warning: implicit declaration of function 'getlogin'
       is invalid in C99 [-Wimplicit-function-declaration]
       printf("Welcome to System Programming, %s!\n", getlogin())
                                                              ^
welcome.c:6:81: warning: format specifies type 'char *' but the
       argument has type 'int' [-Wformat]
       printf("Welcome to System Programming, %s!\n", getlogin())
                                                 ~~ ^~~~~~~~~~
                                                 %d
welcome.c:6:92: error: expected ';' after expression
       printf("Welcome to System Programming, %s!\n", getlogin())
                                                                ^
                                                                ;
2 warnings and 1 error generated.
```

# Error Recovery

**Fatal error** has no recovery action. It is where you only print an error message on the user 's screen or to a log file, and then exit.

**Nonfatal errors** are temporary, such as a resource shortage, and occur when there is less activity on the system.

**Resource-related nonfatal errors:-** EAGAIN, ENFILE, ENOBUFS, ENOLCK, ENOSPC, EWOULDBLOCK, and sometimes ENOMEM. EBUSY can be treated as nonfatal when it indicates that a shared resource is in use as well as EINTR when it interrupts a slow system call.

**The recovery action for a resource-related nonfatal error** is to delay and retry later. Eg, network connection is no longer functioning. Some applications use an exponential back off algorithm, which takes a long time in each subsequent iteration and is dependent on the developer.

# User Identification (ID)

The **user ID** from our entry in the password file is a numeric value that identifies us to the system. User whose user ID is 0 either root or the superuser. The entry in the password file normally has a login name of root and the special privileges of this user as superuser privileges (chapter 4).

**Group ID:** here, the password file contains multiple entries specifying the same group ID. Groups are normally used to collect users together into projects or departments and allows sharing of resources, such as files, among members of the same group. The group file (/etc/group) maps group names into numeric group IDs.

For every file on disk, the file system stores both the user ID and the group ID (which values requires only four bytes) of a file's owner assuming that each is stored as a two-byte integer.

# Supplementary Group ID

These **supplementary group IDs** are obtained at login time by reading the file /etc/group and finding the first 16 entries that list the user as a member (chapter 2).

Most versions of the UNIX System allow a user to belong to other groups (it started with 4.2BSD, at least 16 additional groups).

# Signals

Are a technique notifies a process that some condition has occurred. For example, if a process divides by zero, the signal whose name is SIGFPE (floating-point exception) is sent to the process (Chapter 10).

The process has **3 choices for dealing with the signal;-**

1. Ignore the signal. Not recommended for signals that denote a hardware exception, such as dividing by zero or referencing memory outside the address space of the process, as the results are undefined.

2. Let the default action occur. For a divide-by-zero condition, the default is to terminate the process.

3. Provide a function that is called when the signal occurs **(called "catching" the signal)**.

# Signals

**Interrupt key—**(DELETE key or Control-C —) and the **quit key—**(Control-backslash — ): used to interrupt the currently running process. Thus to generate a signal is by calling the kill function (from a process to send a signal to another process).

**Limitations to call a function :** you must be the owner of the other process (or the superuser) to be able to send it a signal.

# Time Values

UNIX systems have **maintained two different time values: Calendar time:** This value counts the number of seconds since the Epoch: 00:00:00 January 1, 1970, Coordinated Universal Time (UTC). (Older manuals refer to UTC as Greenwich Mean Time.) These time values are used to record the time when a file was last modified.

**Process time (CPU time):** measures the central processor resources used by a process and is measured in clock ticks (have historically been 50, 60, or 100 ticks per second)**(section 2.5.4)**.

# Time Values

**Measurement of the execution time of a process (Section 3.9):**

UNIX System maintains three values for a process:

**Clock time (wall clock time) -** amount of time the process takes to run, and its value depends on the number of other processes being run on the system and the measurements are made with no other activities on the system.

**User CPU time -** CPU time attributed to user instructions, that is; attributed to the kernel when it executes on behalf of the process.

**System CPU time -** The sum of user CPU time and system CPU time is often called the CPU time.

# Time Values

**Measurement of the clock time, user time, and system time of any process:** simply execute the time(1) command, with the argument to the time command being the command we want to measure.

**Note:** The output format from the time command depends on the shell being used, because some shells don't run /usr/bin/time, but instead have a separate built-in function to measure the time it takes commands to run (Section 8.17).

# System Calls and Library Functions

An application can either make a system call or call a library routine but library routines invoke a system call **Figure 3.**

The exact number of system calls varies depending on the operating system version (Section 2 of the UNIX Programmer 's Manual defines the general-purpose library functions available to programmers). Linux 3.2.0 has 380 system calls and FreeBSD 8.0 has over 450. The technique used on UNIX systems is for each system call to have a function of the same name in the standard C library. The user process calls this function, using the standard C calling sequence. Which invokes the appropriate kernel service. The exact number of system calls varies depending on the operating system version **(check Section 2 of the UNIX Programmer's Manual defines the general-purpose library functions available to programmers).** Eg, Linux 3.2.0 has 380 system calls and FreeBSD 8.0 has over 450. The technique used on UNIX systems is for each system call to have a function of the same name in the standard C library.

# System Calls and Library Functions

The user process calls this function, using the standard C calling sequence which invokes the appropriate kernel service. From **an implementer's point of view,** the distinction between a system call and a library function is fundamental. **For example; 1-** System calls usually provide a minimal interface while library functions often provide more elaborate functionality. **2-** System calls allocate additional chuck of space on behalf of the process wile library functions manage space from user level.

Unlike **a user**, for the implementer, both system calls and library functions appear as normal C functions. As both exist to provide services for application programs. We can replace the library functions whereas the system calls usually cannot be replaced.

**Section 8.13 -** show an implementation of the system function that invokes the basic process control system calls with **an example in Section 10.18** to handle signals correctly.

# The Editors

# The Editors : Vim

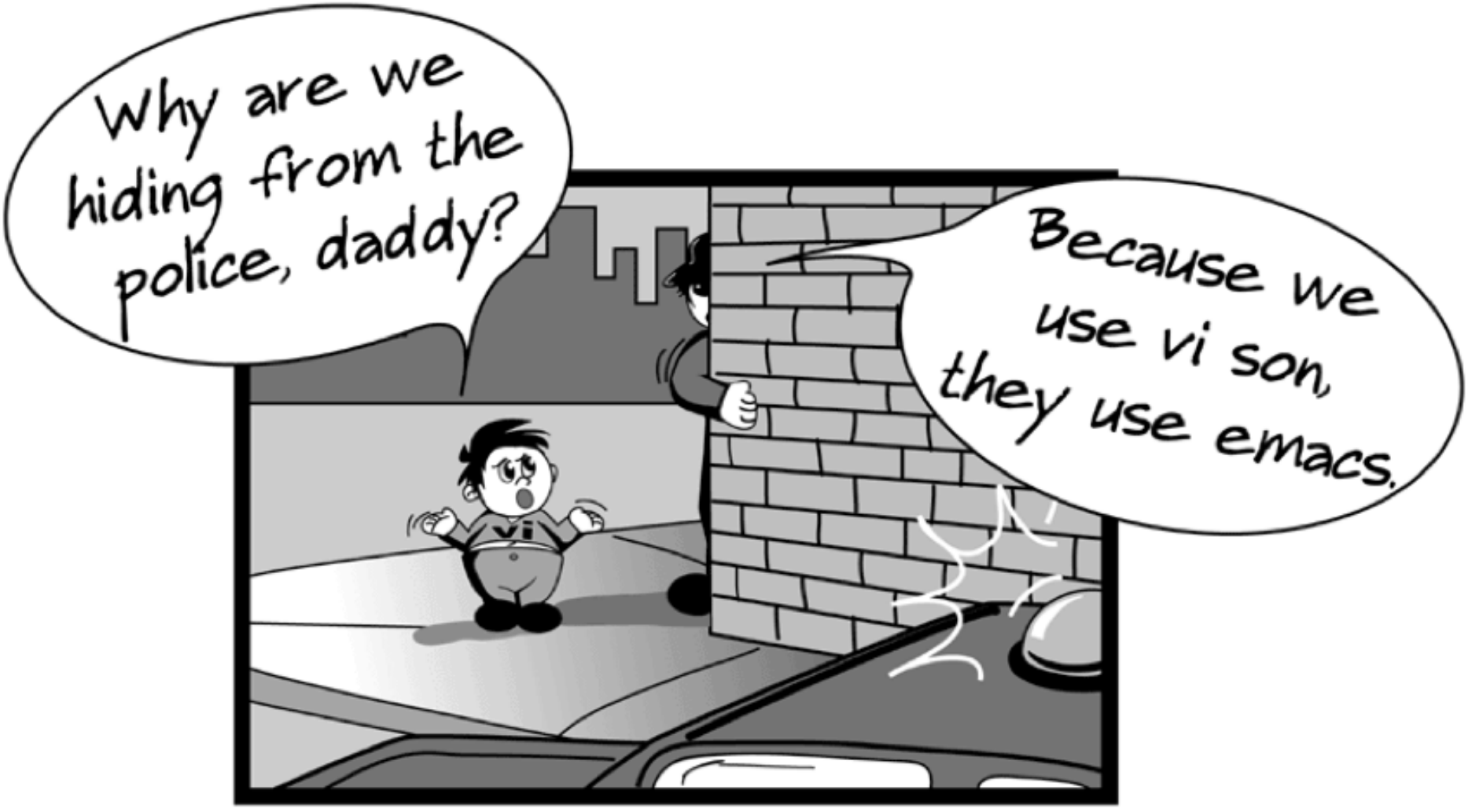
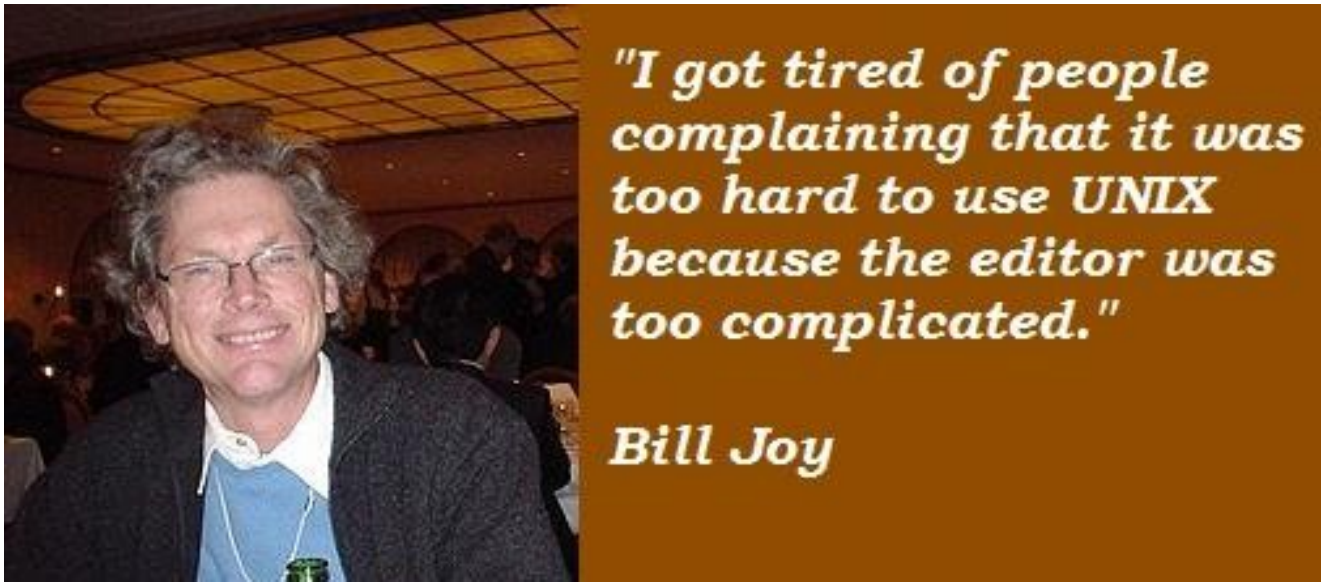



Image from http://michael-prokop.at/computer/tools_vim_en.html

# What is Vi(m)

**Vi** is a visual screen text editor developed by Bill Joy, who later becomes co-founder of Sun Micro Systems

- It is visual version of **ex**, a Unix line editor
- Vi is available on most Unix Systems
- Works with a variety of terminals
- Allows **ex** command from **vi**




# What is Vim

**VIM** is acronym for **Vi** i**M**proved, developed by Bram Moolenaar, a extended version of vi and some of enhancements include

- Completion, comparison, and merging of files
- Split and tabbed windows
- Command histories

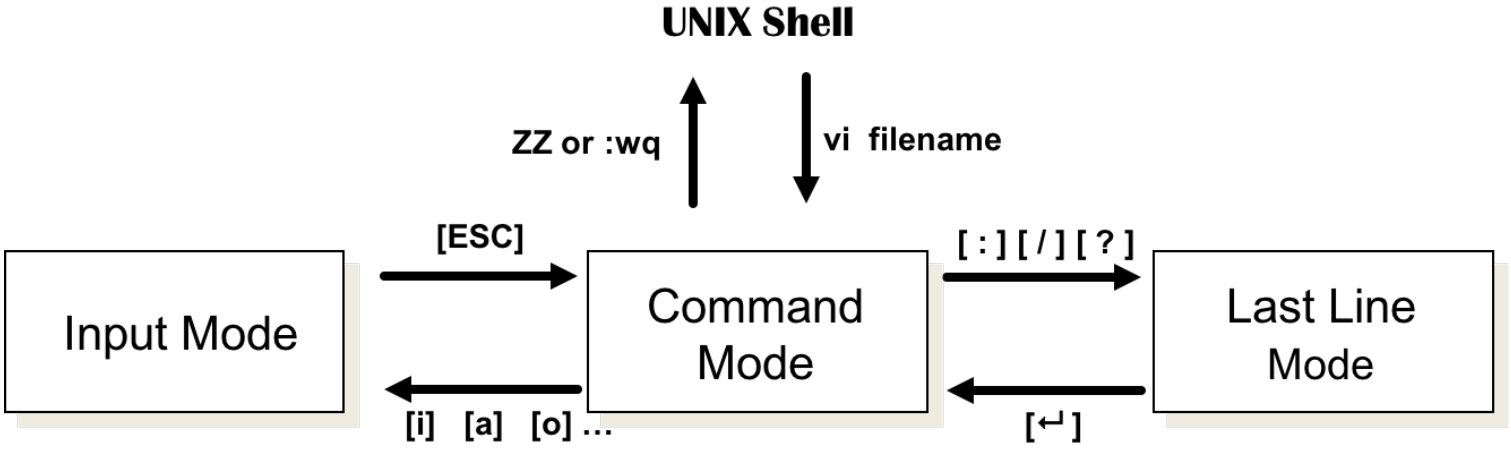
All editing session before saving is done in buffer area

- Nothing is saved as hard data, until you save it

# Modes of vi

There are three mode in vi

- **Command Mode** – A default mode in vi
  - Everything is command before you enter into other modes
- **Input Mode** – What you type is what you see
  - Anything typed in this mode is considered as data
  - Pressing [ESC] always leads to Command mode
- **Last Line Mode** – Only can be accessed from Command mode
  - Three ways to enter Last Line Mode – : (Colon) / (Back Slash) ? (Question Mark)




# Moving Around

VI uses four characters to move around, and each character is mapped to a direction


Moving by units of word, sentence, paragraph

- E.g., 3w moves to three words after the current cursor

w next word

b previous word

( Beginning of sentence

) end of sentence

{ Beginning of paragraph

} end of paragraph

# Deleting

Deleting a character, words, sentence, line, and paragraph

- x erases a character
- Combination of direction commands with d erases a word, sentence, and paragraph.
  - E.g., dw erases a word before the cursor
- dd erases a line
- D to delete rest of line
- X to delete before the cursor
- Xp to transpose

# Searching and Replacing

Searching in vi is done in last line mode

- `/` lets you search a character, word, and words
  - E.g., `/abc` moves the cursor to the location of the pattern
- Search pattern in forward direction: `n`, backward direction: keystrokeN
- Regular expressions can be also used in searching

`r` replaces a character

- Suppose the cursor is on `b`, and by `r` `p` we can change it to "preview"

`breview` → `preview`

# Substitution

**Substituting in vi is done in last line mode**

Find i and substitute with X once

`:s/i/X` → This is preview. → ThXs is preview.
How it is done How it is done

Find i and substitute with X in the same line

`:s/i/X/g` → This is preview. → ThXs is prevXew.
How it is done How it is done

Find i and substitute with X in all the lines

`:%s/i/X/g` → This is preview. → ThXs is prevXew.
How it is done How Xt Xs done

# Undo and Redo

Undo in vi is done by `u`

- Or to do in last line mode you could type in `:undo`
- `U` undo all latest changes on one line

Redo in vi is done by `CTRL` `R`

- Or to do in last line mode you could type in `:redo`

# Simple Tutorial: From Start to quit

This simple tutorial illustrates how to write, delete, copy, paste, replace, save, and quit. Start `vi` by `vi newfile.txt` and type the following

i This is how we write esc o and copy lines esc k y y j
p k y 3 w j ) a space bar esc p o ummm esc b
x r E l r N l r D : w q enter

This will produce following and goes back to command prompt

```
This is how we write
and copy lines
This is how we write and copy lines
END
```

# Simple Tutorial: From Start to quit

i This is how we write esc o and copy lines esc k y y j
p k y 3 w j ) a space bar esc p o ummm esc b
x r E l r N l r D : w q enter

The command in the tutorial

i insert esc back to command mode o add new line after current line k move cursor up yy copy a line j move cursor down p paste after cursor point y3w copy three words ) move to end of sentence a append b move cursor to previous word x erase a character r replace a character l move cursor right :wq write to a file and quit

# Learn by experience

```
1  The five boxing wizards jump quickly.
2  See the quick brown fox jump over the lazy dog.
3  A mad boxer shot a quick, gloved jab to the jaw of his dizzy opponent.
4  We promptly judged antique ivory buckles for the next prize.
5  A quart jar of oil mixed with zinc oxide makes a very bright paint.
6  The job requires extra pluck and zeal from every young wage earner.
```

Complete all tasks with minimum number of retyping, but with commands

- Substitute all j's to z and all z's to j
- Copy lines 1, 3, 5, and 6, and make new paragraph with those lines
- Delete three words "requires extra pluck," and type in "need lot of money" in the place
- Add "caps" at the end of all words with "w", e.g., wizards to "wizardscaps"

# Vi Configurations

Place `.vimrc` to your home direcotry

Have a look at the sample file

https://github.com/resourceful/lecture_sysprog/blob/master/01-intro/misc/.vimrc

# References

Graphical cheat sheet of Vi and VIM

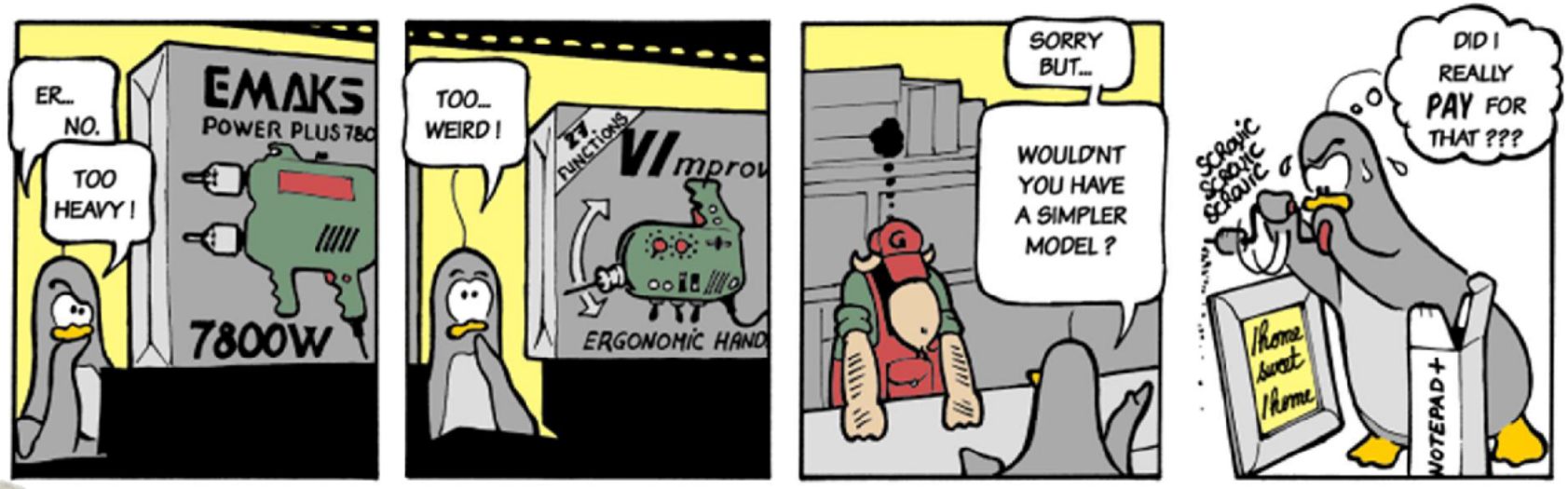
- http://www.viemu.com/a_vi_vim_graphical_cheat_sheet_tutorial.html

Cursor movement Commands

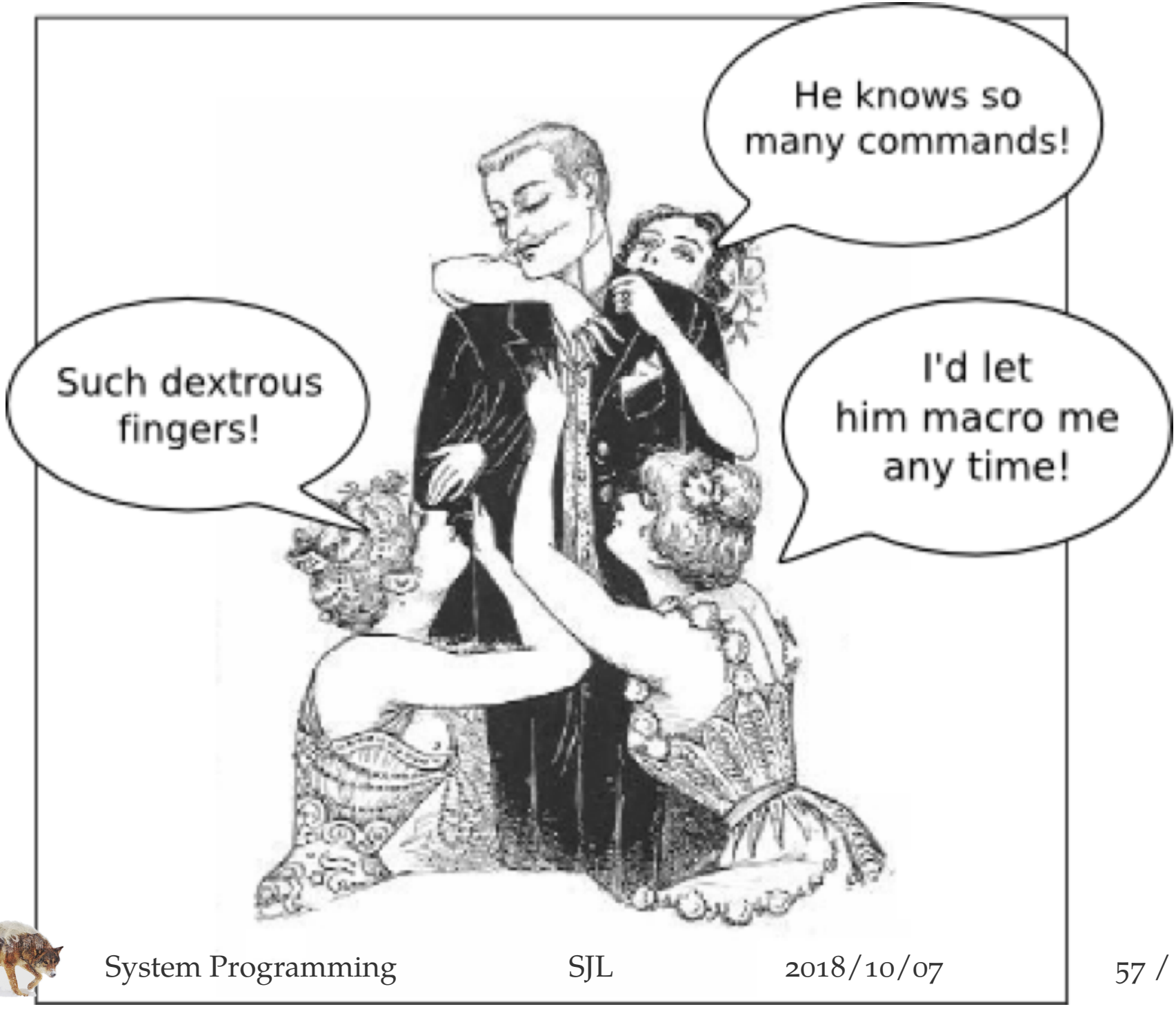
- http://www.kcomputing.com/vi.html

List of Commands

- http://www.smashingmagazine.com/2010/05/03/vi-editor-linux-terminal-cheat-sheet-pdf/




# The Editors : Emacs


He knows so many commands!
Such dextrous fingers!
I'd let him macro me any time!

# What is Emacs

Emacs (Editor MACroS) is the extensible, customizable, self-documenting, real-time display editor

Richard Stallman is the author of Emacs; the author of GCC and GDB

Runs on LISP engines + lots of LISP libraries

Richard Stallman
The founder of GNU

http://www.theregister.co.uk/

# What is Emacs and why use it? (cont'd)

It is not the only good choice, there are options like VI, VIM Works on many platforms and independent of GUI

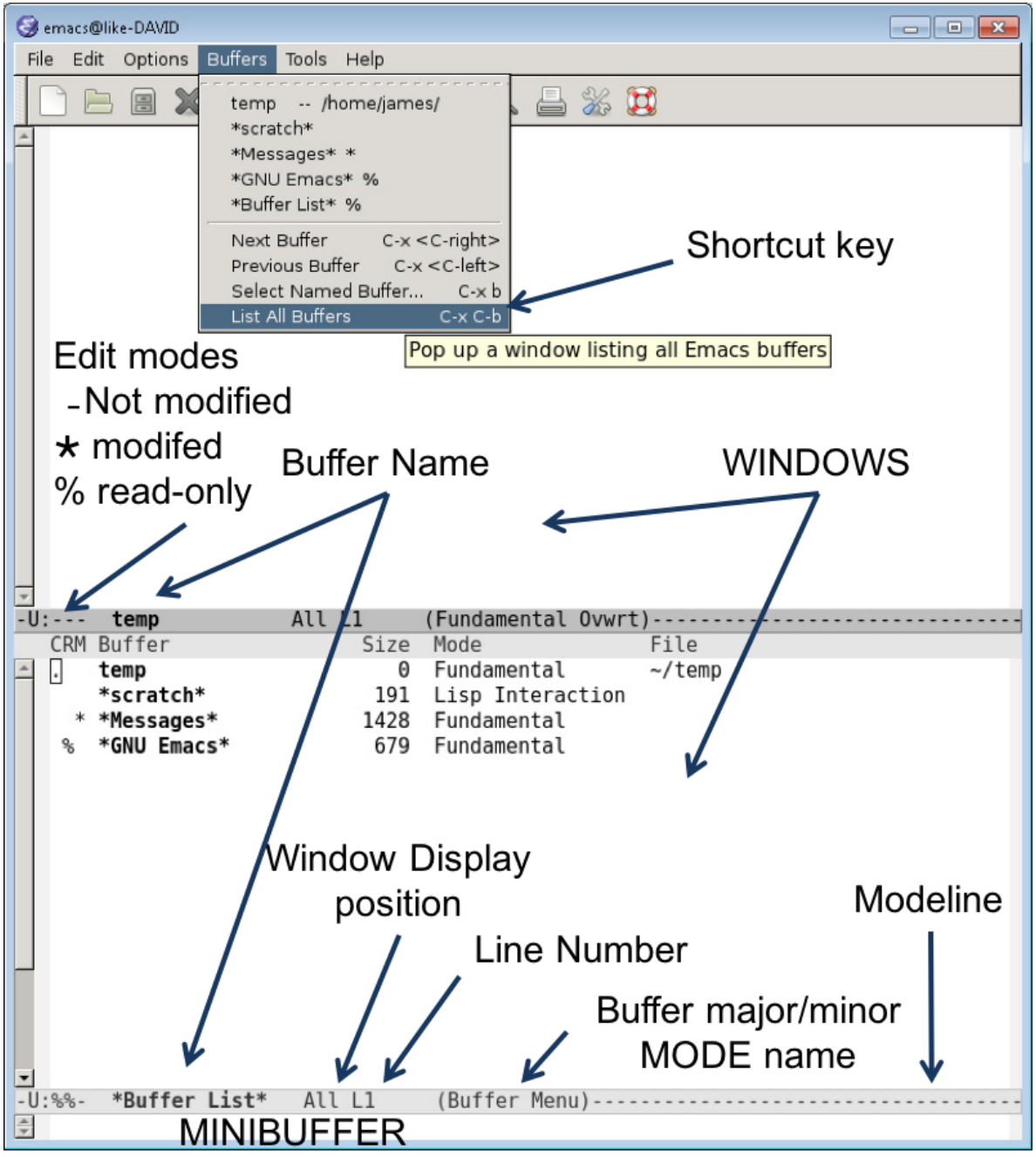
Extremely powerful

vi often does things with fewer keystrokes, but emacs easily surpass vi when it comes to searching and replacing and using macros

# What is Emacs and why use it? (cont'd)

Some of assumptions of Emacs are

- No mouse! – Much more reliable and much faster for experienced user
- No particular keyboard; No particular GUI environment
- Runs through telnet (as well as directly)


emacs@like-DAVID
File Edit Options Buffers Tools Help
temp -- /home/james/
*scratch*
*Messages* *
*GNU Emacs* %
*Buffer List* %
Next Buffer C-x <C-right>
Previous Buffer C-x <C-left>
Select Named Buffer... C-x b
List All Buffers C-x C-b
Shortcut key
Pop up a window listing all Emacs buffers
Edit modes
-Not modified
* modifed
% read-only
Buffer Name
WINDOWS
-U:--- temp All L1 (Fundamental Ovwrt)
CRM Buffer Size Mode File
temp 0 Fundamental ~/temp
*scratch* 191 Lisp Interaction
* *Messages* 1428 Fundamental
% *GNU Emacs* 679 Fundamental
Window Display position
Line Number
Modeline
Buffer major/minor MODE name
-U:%%- *Buffer List* All L1 (Buffer Menu)
MINIBUFFER

# Emacs Preliminaries

In the emacs documentation, key sequences described as:

- C-e – This is Ctrl-e
- C-x C-b – This is Ctrl-x Ctrl-b
- ^b - this is Ctrl-b
- C-x b – This is Ctrl-x b
- M-e – This is Meta-e or Alt-e

On the PC, you can use the Alt key or Esc-release to substitute Meta key

When you press a valid key sequence, emacs executes a command associated with the key

# Moving Around

Emacs uses the control keys to move in the four directions

Ctrl-b ← Ctrl-n ↓ Ctrl-p ↑ Ctrl-f →

To move by units of word, sentence, and paragraph

Meta-b Previous word Meta-f Next word Meta-a Previous sentence Meta-e Next sentence Meta-{ Previous paragraph Meta-} Next paragraph

# Deleting

Delete a word, line, and sentence

Ctrl - d Delete a character Meta - d Delete a word Ctrl - k Delete a line
Meta - k Delete a sentence

## When in Doubt

Use "Get me out of here" command Ctrl - g

# Searching

Ctrl-s asks for searh pattern

- Ctrl-s to search next pattern
- Ctrl-r to search previous pattern
- Regular expressions can be also used in searching with Meta-s

# Substitution

Meta - % to replace or Meta -replace-string

- Requests for search pattern; press enter for substituting pattern
- Replacing the substituting pattern this once SPC
- Skipping to the next without replcacing DEL
- Replace all remaining matches !
- Exiting replace command by RET

# Undo and Redo

Undo an unwanted change is done by Ctrl-_ Redo is reverse of undo,

undo direction is reversed by Ctrl-g and Ctrl-_

# Macro

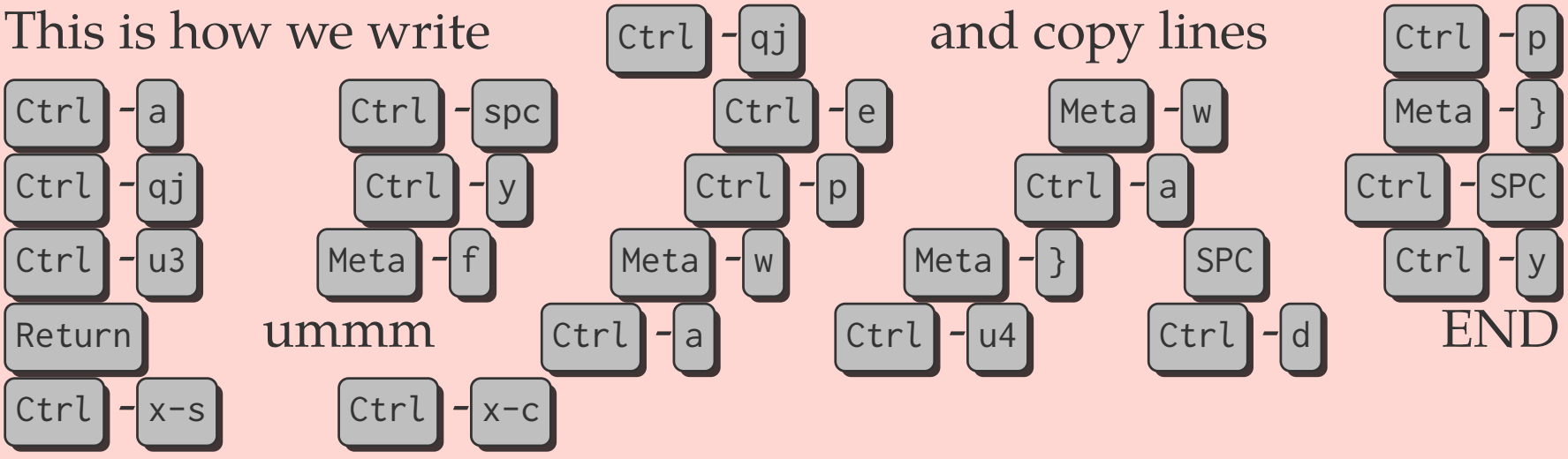
Macros are useful for repeatable key sequences that may be include commands.

Common macro commands

- Ctrl-x - ( – begin macro definition (after this, type whatever actions you would like repeated and stored)
- Ctrl-x - ) – end macro definition
- Ctrl-x - e – execute stored macro
- Ctrl-u5 Ctrl-e – execute stored macro 5 times (Note: Ctrl-u5 can prefix any emacs cmd, even a non-cmd)

# Simple Tutorial: From Start to quit

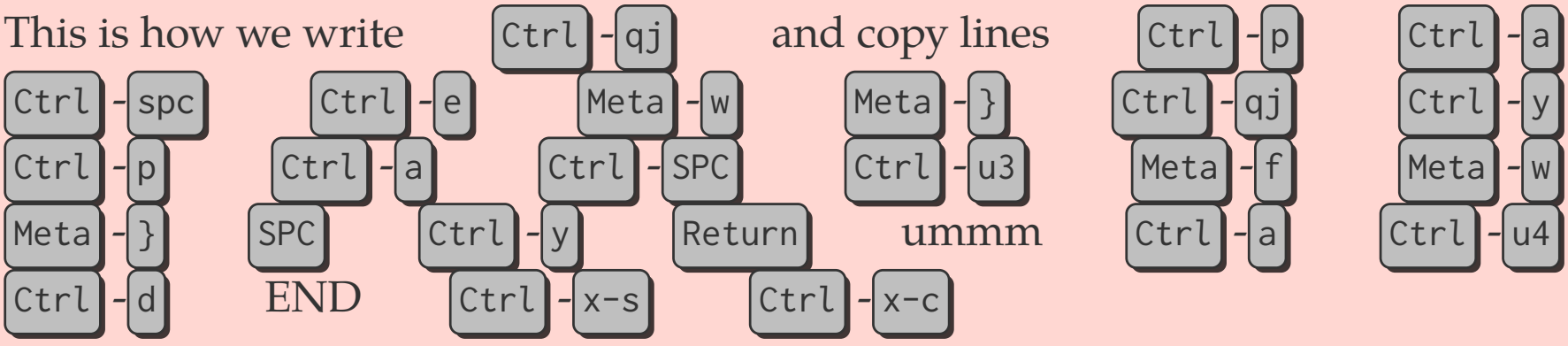
One can type without having to use complex commands but ....




This will produce following and goes back to command prompt

```
This is how we write
and copy lines
This is how we write and copy lines
END
```

# Simple Tutorial: From Start to quit




## Explaining the commands in the tutorial

Ctrl-qj Add a new line Ctrl-p Move to prvious line Ctrl-a Move to beginning of the sentence Ctrl-spc Start highlighting Ctrl-e Move to end of sentence Meta-w Copy highlighted Meta-} Move to end of the paragraph Ctrl-y Paste copied text Ctrl-u3 Repeat command with following number Meta-f Move to next word Ctrl-d Delete a character Ctrl-x-s Save the document Ctrl-x-c Quit

# Learn by experience

```
1  The five boxing wizards jump quickly.
2  See the quick brown fox jump over the lazy dog.
3  A mad boxer shot a quick, gloved jab to the jaw of his dizzy opponent.
4  We promptly judged antique ivory buckles for the next prize.
5  A quart jar of oil mixed with zinc oxide makes a very bright paint.
6  The job requires extra pluck and zeal from every young wage earner.
```

Complete all tasks with minimum number of retyping, but with commands

- Substitute all j's to z and all z's to j
- Copy lines 1, 3, 5, and 6, and make new paragraph with those lines
- Delete three words "requires extra pluck," and type in "need lot of money" in the place
- Add "caps" at the end of all words with "w", e.g., wizards to "wizardscaps"

# References

Reference card with most commands you'll ever need

- http://home.uchicago.edu/~gan/file/emacs.pdf

Official GNU emacs site

- http://www.gnu.org/software/emacs/

An emacs HowTo

- https://www.emacswiki.org