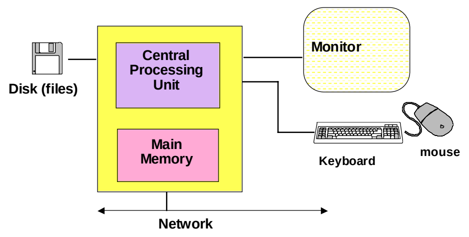
CSE 142
Programming I

Input/Output, Libraries, and Files

Textbook Readings

- Loose ends; combination of review and scattered textbook material
- Libraries:
  - Chapter 2 (here and there)
  - Chapter 13.2 (skim)
- Files:
  - Chapter 2.7 pp. 72-74
  - Chapter 5.5 pp. 234-236
  - Chapter 12.1

Review: what's input/output?



Why File I/O?

- Large volume of input data
- Large volume of output data
- More permanent storage of data
- Transfer to other programs
- Multiple simultaneous input and/or output streams

Files

- A "file" is a collection of data on disk
  - managed by the user and the operating system
  - permanent
- A "file name" is how the user and OS know the file
  - follows OS naming rules (DOS: 8.3)
- We'll review the files used in compiling
- We'll review keyboard I/O
- We'll look at using text files in a C program
- First we'll look at data files

DATA FILES

- Business Data: customer files, payroll files, …
- Scientific Data: weather data, environmental data, topographic maps, …
- Image Data: web images, satellite images, medical images, …
- Web Data: HTML, GIF, JPEG, PNG, XML, …

Business Data File

NAME	SSN	BIRTH	ADDRESS
John Jones	532456895	7/1/75	916 4th NE, Seattle 98105
Sally Smith	872996547	9/3/79	526 5th NE, Seattle 98105

Scientific Data File

X	Y	ELEVATION	RAINFALL
300	**450**	**1900**	**3.45**
275	**900**	**300**	**12.62**

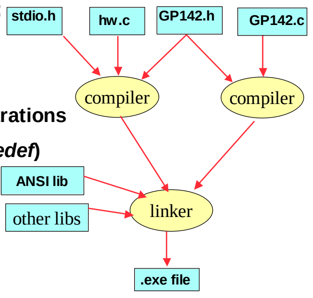
Review: Files Used in Compiling

- **Source Files**
  - **.c files:** **C programs and functions**
  - **.h ("header") files:** **fragments of C code**

  real-world projects may contain hundreds of source files!
- **Compiled Files** **(system-dependent names)**
  - **object files:** **compiled C code ready to link**
  - **libraries:** **collections of compiled C functions**
  - **executable files:** **linked machine-language, ready to load into memory**

Header files (.h)

- **Fragments of C code:**
  - **Function Prototypes**
  - **Symbolic Constants**
  - **Global Variable Declarations**
  - **Type Definitions (*typedef*)**



Libraries

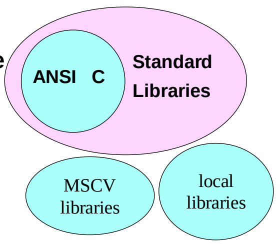
Files of compiled, pre-written functions

Why?

Reuse existing code

Enhance portability

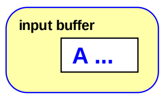
Hide system dependencies



Keyboard I/O Dangers

What happens if the user types A in the following situation?

```
int score ;
scanf(“%d”, &score) ;
while (score != 0)  {
    printf(“%d \n”, score) ;
    scanf(“%d”, &score) ;
}
```



scanf's Return Value

- *scanf* returns an *int*
  - tells the number of values successfully read: see Section 5.5.
  - Can be used to see if the number of values read is the number expected. If not, there must have been an error.

```
int status, id, score ;
double grade ;
status = scanf("%d %lf %d", &id, &grade, &score) ;
if (status < 3)
    printf("Error in input \n") ;
```

More Robust Input

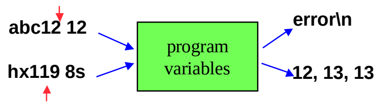
```
/* Robustly read an integer, consuming nondigits */

int read_int (void)
{
    int status, input ;
    char junk ;
    status = scanf("%d", &input) ;
    while (status < 1) {                    /* unsuccessful read */
        scanf("%c", &junk) ;                       /* consume 1 char */
        status = scanf("%d", &input) ;  /* try again */
    }
    return(input) ;
}
```

Files as Streams of Characters

keyboard/screen are special cases

input / output streams of characters

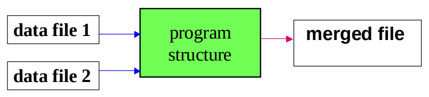


Multiple streams can be used simultaneously

In reality, stream flows through a buffer rather than directly into or out of variables.

Files as Records with Fields

Business and Scientific Data



Files vs. File Variables

- Reminders:
  - A file is a collection of data on disk
  - A file name is how the user and OS know the file
    - permanent name, follows OS naming rules
- A file variable is a variable in the C program which represents the file
  - temporary: exists only when program runs
  - follows C naming rules

What's in *stdio.h?*

- Prototypes for I/O functions.
- Definitions of useful *#define* constants
  - Example: EOF for End of File
- Definition of *FILE struct* to represent information about open files.
  - File variables in C are <u>pointers</u> to the FILE *struct*.

    *FILE *myfile;*

Opening A File

- "Opening" a file: making a connection between the operating system (file name) and the C program (file variable)
  - library function *fopen*
  - specify "r" (read, input) or "w" (write, output)
    - NB String "r", not char 'r' !
- Files must be opened before they can be used
- Files stdin/stdout (used by scanf/printf) are automatically opened & connected to the keyboard and display

File Open Example

```
/*usually done only once in a program*/
/*usually done near beginning of program*/

FILE *infilep, *outfilep;  /*file variables*/
char ch;

/* Open input and output files */
infilep   = fopen ("Student_Data",          "r" ) ;
outfilep = fopen ("New_Student_Data", "w") ;
```

Closing A File

•Usually done only once in a program

•Usually done near end of program

•Closing an output file is essential, or data may be lost!

```
FILE *infilep;  /*file variable*/
...
infilep   = fopen ("Student_Data",          "r" ) ;
.../*process the file */

.../*when completely done with the file:*/
fclose (infilep);
```

End of File (EOF)

•defined in *stdio.h*

•*#define EOF* (*some negative value*)

–Usually -1 (but don't depend on its value)

–I/O library routines use EOF in various ways to signal end of file.

–Your programs can check for EOF

•EOF is a status, not an input value

Four Essential Functions for Text I/O

•*fopen* and *fclosed*: already discussed

•*fscanf*: works just like *scanf*, but 1st parameter is a file variable

```
status = fscanf (filepi, "%...", &var, ... ) ;
 /* fscanf returns EOF on end of file */
```

•*fprintf*: works just *printf*, but 1st parameter is a file variable

```
fprintf (filepo, "%...", var, ... ) ;
```

•File must already be open before before *fscanf* or *fprintf* is used!

Building Applications with Files

•With *fopen, fclose, fprintf*, and *fscanf* you can write lots of useful programs involving files

•Many errors and exceptions can arise when using files

–A robust program must handle errors

•Lecture packet has a few examples

–not necessarily complete

•See textbook for more examples

File Copy Example

```
/* Problem: copy an input file to an output file */
/* Technique: loop, copying one char at a time until EOF*/
/* files must already be open before this*/
status =  fscanf (infilep, "%c", &ch);
while ( status != EOF ) {
    fprintf (outfilep, "%c", ch) ;
    status =  fscanf (infilep, "%c", &ch);
    }
printf ("File copied.\n") ;
fclose (infilep) ;
fclose (outfilep) ;
```

File Copy (Compact Edition)

```
/* Many C programmers use this style*/
...
while ( fscanf (infilep, "%c", &ch) != EOF )
    fprintf (outfilep, "%c", ch) ;

printf ("File copied.\n") ;
fclose (infilep) ;
fclose (outfilep) ;
```

File Example: Implementing a Database Query

```
#include <stdio.h>

int main(void)
{   FILE *inp, *outp;
    int age,  j;
    char name[20], ssn[9], ch;

    inp  = fopen ("db_file", "r" ) ;
    outp  = fopen ("result_file", "w") ;

    /* loop till the end-of-file * /
    while (fscanf (inp, "%c", &name[0]) != EOF) {

        /* read name, ssn, age * /
        for (j = 1;  j < 20;  j++)   fscanf(inp, "%c", &name[j]);
        for (j = 0;  j < 9;  j++)    fscanf(inp, "%c",&ssn[j]);
        fscanf(inp,  "%d",   &age);
        /* read line feed character */
        fscanf(inp, "%c", &ch);

         /* copy name, ssn to output if age > 20 */
         if (age > 20)  {
            for  (j = 0; j < 20; j++)  fprintf(outp, "%c", name[j]);
            for (j = 0; j < 9; j++)    fprintf(outp, "%c, ssn[j]);
            fprintf(outp, "\n");
         }
    }
    fclose (inp) ;  fclose (outp) ;
    return (0);
}
```

Equivalent query in SQL database language:

```
SELECT NAME, SSN
FROM DB_FILE
WHERE AGE > 20;
```

File Example: Expanding tabs

```
Input:    a b \t c
          d \t e f
Output:   a b      c
          d   e f
```

```
#include <stdio.h>
int main(void)
{   FILE *infilep, *outfilep;
    char ch;
    int column = 0;

    /* Open input and output files */
    infilep   = fopen ("prog.c",              "r" ) ;
    outfilep = fopen ("tabless-prog.c", "w") ;

    /* process each input character */
    while ( fscanf (infilep, "%c", &ch) != EOF ){
        if (ch == '\n' || ch == '\r') {
            /* end of line: reset column counter */
            column = 0;
            fprintf (outfilep, "%c", ch) ;
        } else if (ch == '\t') {
            /* tab: output one or more spaces, */
            /* to reach the next multiple of 8.    */
            do {
                fprintf (outfilep, "%c", '  ') ;
                column++;
            } while ( (column % 8) != 0 );
        } else {
            /* all others: count it, and copy it out */
            column ++;
            fprintf (outfilep, "%c", ch) ;
        }
    }
    fclose (infilep) ;
    fclose (outfilep) ;
    return 0;
}
```

File Example: Merging two sorted files

```
#include <stdio.h>
#define MAXLINE 10000          /*ASSUMES no line longer*/
int main(void)
{   FILE *in1p, * in2p, *outp;
    char buffer1[MAXLINE], buffer2[MAXLINE];
    char *stat1, *stat2;

    in1p  = fopen ("sorted-file1", "r" ) ;
    in2p  = fopen ("sorted-file2", "r" ) ;
    outp  = fopen ("merged-file", "w") ;

    stat1 = fgets(buffer1, MAXLINE, in1p);
    stat2 = fgets(buffer2, MAXLINE, in2p);
    while ( stat1 != NULL && stat2 != NULL) {
        if (strcmp(buffer1, buffer2) < 0) {
            fprintf (outp, "%s", buffer1) ;
            stat1 = fgets(buffer1, MAXLINE, in1p);
        } else
            fprintf (outp, "%s", buffer2) ;
            stat2 = fgets(buffer2, MAXLINE, in2p);
        }
    }
    while( stat1 != NULL) {
        fprintf (outp, "%s", buffer1) ;
        stat1 = fgets(buffer1, MAXLINE, in1p);
    }
    while( stat2 != NULL) {
        fprintf (outp, "%s", buffer2) ;
        stat2 = fgets(buffer2, MAXLINE, in2p);
    }
    fclose (in1p) ;  fclose (in2p) ;  fclose (outp) ;
    return 0;
}
```

really should CHECK that no line is longer than MAXLINE