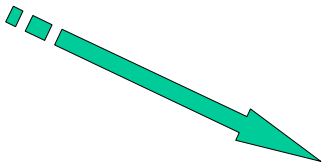
Lecture 14



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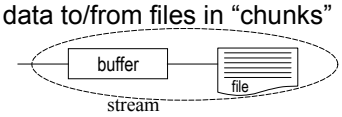
What is a file?

- A file is data stored in secondary storage
- This is usual a disk (hard/floppy/optical etc) connected to the computer bus by means of some interface
- Accessing data in files is much slower than from memory, but files are more permanent and can be larger

Streams in C

- In C each file is associated with a buffer to form a stream
- A buffer is simply an area of memory that is used for temporary storage
- This is because it is more efficient to move data to/from files in "chunks"



Streams in C

- To use a file we must first open a stream, when we are finished the stream must be closed
- When <stdio.h> is included in a program, 3 streams are automatically opened
  - stdin, stdout, stderr
- They are special in that they are normally connected to the keyboard and screen rather than a disk file however as weve already seen they can be redirected
- When the program has finished running these streams are automatically closed

Directories, paths and filenames

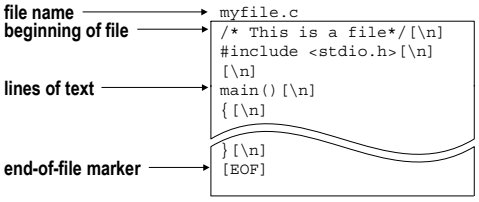
- Most operating systems organise secondary storage in a tree structure using directories.
- A directory is a file containing the names of other files and where they are stored
- Each file is identified by a filename
- Its location is given by a path
- e.g. `/usr/students/1996/A.Person/C/myfile.c`

root of directory tree — director — filename

- If "C" is the current directory we can refer to the file simply as "myfile.c" or we can give the full path

File Structure

- There are 2 sorts of file
  - text files which use ASCII codes to store text data
  - binary files which are used to store raw binary data
- In this course we will only deal with text files



Files in C

- In C, a stream is identified with a pointer-to-FILE datatype
- Here FILE is a special data type defined in `<stdio.h>`

```
FILE *pfile; /* pointer-to-FILE, or stream */
```

- We then have to point it at a particular file

```
pfile=fopen("myfile.c","r"); /* r stands for read */
```

- Function `fopen` is declared in `<stdio.h>` by the prototype

```
FILE* fopen(cons char* filename, const char* mode);
```

Pointer to file — A String — A String

- There are several other functions for file operations see notes pg 73

file1.c

```
/* Example: simple file operations */
/* No error checking is done, so the program may fail
All practical programs should check file operations. */
#include <stdio.h>
#include <stdlib.h>
int main(void)
{
  FILE *pf;  /* file pointer, or stream */
  char str[40];
  int n;
  char c;

  pf = fopen("myfile.old", "w");      /* open a file for writing */
  fputs("Hello world!\n", pf);        /* write to the file */
  fclose(pf);                         /* close the file */

  rename("myfile.old", "myfile.new"); /* rename the file */

  pf = fopen("myfile.new", "a");      /* open file for appending */
  fprintf(pf, "Hello again\n");       /* write a string */
  fprintf(pf, "%d %f\n", 123, 3.1);   /* write numbers */
  fputc('A', pf); fputc('\n', pf);    /* write characters */
  fclose(pf);                         /* close the file */

  pf = fopen("myfile.new", "r");      /* open file for reading */
  fgets(str, 40, pf);                 /* read a line */
  printf(str);                        /* print it to the screen */

  rewind(pf);                         /* rewind file to start */
  fgets(str, 40, pf);                 /* read a line */
  printf(str);                        /* print it to the screen */

  fscanf(pf, "%s", str);              /* read a word */
  printf(str);
  putchar('\n');
  fscanf(pf, "%s", str);              /* ...another word */
  printf("%s\n", str);

  fscanf(pf, "%i", &n);               /* ...a number */
  printf("%i\n", n);

  c = fgetc(pf); putchar(c);          /* ...some characters */
  c = fgetc(pf); putchar(c);
  c = fgetc(pf); putchar(c);

  fclose(pf);                         /* close the file */
  remove("myfile.new");               /* delete the file */

  return EXIT_SUCCESS;
}
```

"Bomb-Proofing" file Operations

- Unfortunately there are many things that can go wrong.
  - Suppose we try to open a file for writing (which generally creates a new file) but the file already exists with read-only permission.
  - In this case the `fopen` will return `NULL`
  - We cant write to a `NULL` stream
  - To avoid the program crashing we should always check the result of file operations

file2.c

```
/* Example: standard file operations, with error checking */
/* All practical programs should check file operations. */
#include <stdio.h>
#include <stdlib.h>
#define STR_SIZE 40
int main(void)
{
  FILE *pf;  /* file pointer, or stream */
  char str[STR_SIZE], name[] = "myfile.tmp";

  /* open a file for writing: */

  pf = fopen(name, "w");  /* pf is NULL if an error occurs */
  if (pf == NULL)
  {
    fprintf(stderr, "Error opening file %s for writing\n", name);
    exit(EXIT_FAILURE);
  }

  fputs("Hello world!\n", pf);      /* write to the file */
  fclose(pf);                       /* close the file */

  /* open a file for reading: */

  pf = fopen(name, "r");  /* pf is NULL if an error occurs */
  if (pf == NULL)
  {
    fprintf(stderr, "Error opening file %s for reading\n", name);
    exit(EXIT_FAILURE);
  }

  fgets(str, STR_SIZE, pf);         /* read a line */
  printf(str);                      /* print it to the screen */
  fclose(pf);                       /* close the file */

  return EXIT_SUCCESS;
}
```

It is useful to send error messages to stderr rather than stdout
If stdout is redirected, stderr still connects to the screen

Copying a file

- This is like the unix `cp` command. We want to be able to enter and copy myfile.c to another
- Poor program with no bomb proofing. So lets improve on it

copy1.c

```
/* Example: copying a file */

/* Like Unix's cp command. When compiled, rename a.out to copy,
then use as: copy filename newname */

/* Warning: THIS SKELETON VERSION CONTAINS NO BOMB-PROOFING! */

#include <stdio.h>

int main(int argc, char *argv[])
{
  FILE *poldfile, *pnewfile;
  int byte;

  poldfile = fopen(argv[1], "r");  /* open existing file */
  pnewfile = fopen(argv[2], "w");  /* open new file */

  while ((byte = fgetc(poldfile)) != EOF)
    fputc(byte, pnewfile);
}
```

copy2.c

```
/* Example: copying a file */

/* Like Unix's cp command. When compiled, rename a.out to copy,
then use as: copy filename newname */

/* This version has pretty good bomb-proofing */

#include <stdio.h>
#include <stdlib.h>

int main(int argc, char *argv[])
{
  FILE *poldfile, *pnewfile;

  /* check the arguments: */

  if (argc != 3) /* argv[0] is the program's name */
  {
    fprintf(stderr, "Error: 2 arguments expected\n");
    exit(EXIT_FAILURE);
  }

  /* open the files: */

  poldfile = fopen(argv[1], "r");  /* open existing file */
  if (poldfile == NULL)
  {
    fprintf(stderr, "Error: couldn't open file %s (read)\n", argv[1]);
    exit(EXIT_FAILURE);
  }

  pnewfile = fopen(argv[2], "w");  /* open new file */
  if (poldfile == NULL)
  {
    fprintf(stderr, "Error: couldn't open file %s (write)\n", argv[2]);
    exit(EXIT_FAILURE);
  }

  /* do the copying: */

  while (1)
  {
    int check;

    byte = fgetc(poldfile);
    if (byte == EOF) /* copying completed */
      break;

    check = fputc(byte, pnewfile);
    if (check == EOF)  /* write error */
    {
      fprintf(stderr, "Error: file %s (write) \n
      exit(EXIT_FAILURE);
    }
  }

  /* notify the copy: */

  fclose(pnewfile);
  pnewfile = fopen(argv[2], "r");
  if (pnewfile == NULL)
  {
    fprintf(stderr, "Error: couldn't open file %s (read)\n", argv[2]);
    exit(EXIT_FAILURE);
  }

  while (1)
  {
    byte = fgetc(pnewfile);
    if (byte == EOF) /* verification completed */
      break;

    if (byte != fgetc(poldfile)) /* copy error */
    {
      fprintf(stderr, "Error: file %s is corrupt\n", argv[2]);
      exit(EXIT_FAILURE);
    }
  }

  return EXIT_SUCCESS;
}
```

Example: Student Marks File

- First well create a file of student names and marks

```
SMITH, Jane, mark = 47
JONES, Blodwyn, mark = 73
BLOGGS, Frederick, mark = 27
GASCOIGNE, Paul, mark = 65
BLAIR, Anthony, mark = 68
MAJOR, John, mark = 70
ASHDOWN, Patrick, mark = 54
```

marks1.c

```
/* Example: writing data to a file */

#include <stdio.h>
#include <stdlib.h>

#define DATA "class.list"

int main(void)
{
  FILE *pf;
  char surname[7][20] = {"SMITH", "JONES", "BLOGGS", "GASCOIGNE",
                         "BLAIR", "MAJOR", "ASHDOWN"};
  char forename[7][20] = {"Jane", "Blodwyn", "Frederick", "Paul",
                          "Anthony", "John", "Patrick"};
  int mark[7] = {47, 73, 27, 65, 68, 70, 54};
  int s;

  pf = fopen(DATA, "w");  /* open new file */
  if (pf == NULL)
  {
    fprintf(stderr, "Error: couldn't open file %s\n", DATA);
    exit(EXIT_FAILURE);
  }

  /* write the data to file: */

  for (s = 0; s < 7; s++)
  {
    fprintf(pf, "%s, ", surname[s]);
    fprintf(pf, "%s, ", forename[s]);
    fprintf(pf, "mark = %i\n", mark[s]);
  }

  fclose(pf);
  fputs("Done.\n", stderr);
  return EXIT_SUCCESS;
}
```

marks2.c

```
/* Example: reading data from a file */
/* We know the number of lines in the file */

#include <stdio.h>
#include <stdlib.h>

#define DATA "class.list"
#define CLASS 7

int main(void)
{
  FILE *pf;
  char surname[CLASS][20];
  char forename[CLASS][20];
  int mark[CLASS];
  int s;

  pf = fopen(DATA, "r");  /* open file to read */
  if (pf == NULL)
  {
    fprintf(stderr, "Error: couldn't open file %s\n", DATA);
    exit(EXIT_FAILURE);
  }

  /* read data from the file: */

  for (s = 0; s < 7; s++)
    fscanf(pf, "%s %s %i", &surname[s], &forename[s], &mark[s]);

  fclose(pf);

  /* print data to stdout: */

  for (s = 0; s < 7; s++)
  {
    printf("%s ", forename[s]);
    printf("%s ", surname[s]);
    printf("got %i%%\n", mark[s]);
  }

  return EXIT_SUCCESS;
}
```

marks3.c

```
/* Example: reading data from a file */
/* The number of lines in the file is unknown */

#include <stdio.h>
#include <stdlib.h>

#define DATA "class.list"
#define MAX_CLASS 10

int main(void)
{
  FILE *pf;
  char surname[MAX_CLASS][40];
  char forename[MAX_CLASS][40];
  int mark[MAX_CLASS];
  int s, lines;

  pf = fopen(DATA, "r");  /* open file to read */
  if (pf == NULL)
  {
    fprintf(stderr, "Error: couldn't open file %s\n", DATA);
    exit(EXIT_FAILURE);
  }

  /* read data from the file: */

  for (s = 0; !feof(pf); s++) /* stop at end of file */
  {
    if (s >= MAX_CLASS)
    {
      fputs("Error: too many lines in file\n", stderr);
      exit(EXIT_FAILURE);
    }
    fscanf(pf, "%s %s %i", &surname[s], &forename[s], &mark[s]);
  }
  lines = s - 1;
  fclose(pf);

  /* print data to stdout: */

  for (s = 0; s < lines; s++)
    printf("%s %s got %i%%\n", forename[s], surname[s], mark[s]);

  return EXIT_SUCCESS;
}
```