The enumerated data type – File handling

Basics of Programming 1

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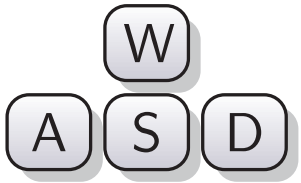
Content

Chapter 1

The enumerated type

The enumerated type – Motivation

- We are writing a game, in which the user can control direction of the player with 4 keys.



- As the input from user needs to be read (checked) frequently, we create a `read_direction()` function for this task.
- This function reads from the keyboard and returns the direction to the calling program segment.
- What type should the function return with?

The enumerated type – Motivation

- Idea Nr. 1: Let's return with the key pressed. ('a','s','w','d'):

```c
char read_direction(void)
{
  char ch;
  scanf("%c", &ch);
  return ch;
}
```

link

The enumerated type – Motivation

- Idea Nr. 1: Let's return with the key pressed. (`'a'`,`'s'`,`'w'`,`'d'`):

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- Problems:
  - We have to decode characters into directions many times at different parts of the source code.
  - If we change to use the arrow keys $\leftarrow \downarrow \uparrow \rightarrow$ for control, we have to modify the source code a thousand time and place.

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6  }
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- Problems:
  - We have to decode characters into directions many times at different parts of the source code.
  - If we change to use the arrow keys $\leftarrow \downarrow \uparrow \rightarrow$ for control, we have to modify the source code a thousand time and place.
- Solution:
  - We have to decode in place (inside the function), and should return with direction.
  - But how can we do that?

The enumerated type – Motivation

- Idea Nr. 2: Let's return with `int` values 0,1,2,3:

'a'	0	←
'w'	1	↑
'd'	2	→
's'	3	↓

```c
int read_direction(void) {
  char ch;
  scanf("%c", &ch);
  switch (ch) {
  case 'a': return 0; /* left */
  case 'w': return 1; /* up */
  case 'd': return 2; /* right */
  case 's': return 3; /* down */
  }
  return 0; /* default is left :) */
}
```

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  return 0; /* default is left :) */
}
```

- Problem:
  - In other parts of the program we have to use numbers 0-3 for the directions, so the programmer must remember the number-direction assignments.

The enumerated type – Motivation

- We need a type named `direction`, that can store `LEFT`, `RIGHT`, `UP`, `DOWN` values.
- We can do such thing in C!

  Declaration of the appropriate enumerated type (`enum`):

```
1 enum direction {LEFT, RIGHT, UP, DOWN};
```

- How to use the type:

```
1 enum direction d;
2 d = LEFT;
```

The enumerated type – Motivation

- The final solution with the new type

```
1  enum direction {LEFT, RIGHT, UP, DOWN};
2  typedef enum direction direction; /* simplification */
3
4  direction read_direction(void)
5  {
6    char ch;
7    scanf("%c", &ch);
8    switch (ch)
9    {
10   case 'a': return LEFT;
11   case 'w': return UP;
12   case 'd': return RIGHT;
13   case 's': return DOWN;
14   }
15   return LEFT;
16 }
```

link

The enumerated type – Motivation

- Usage of the function:

```
1  direction d = read_direction();
2  if (d == RIGHT)
3    printf("You were eaten by a tiger\n");
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- Without the enumerated type, it would look like this:

```
1 int d = read_direction();
2 if (d == 2) /* "magic" constant, what does it mean? */
3   printf("You were eaten by a tiger\n");
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- The enumerated type...
  - replaces "magic constants" with informative code,
  - focuses on content instead of representation,
  - allows a higher level programming.

The enumerated type – Definition

The enumerated (enum) type

Joins into one type integer type constants referenced by symbolic names.

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enum [<enumeration label>]opt
{ <enumeration list> }
[<variable identifiers>]opt;
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1 enum direction {LEFT, RIGHT, UP, DOWN} dir1, dir2;
```

enum examples

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```
1  enum month {
2    JAN,   /*  0 */
3    FEB,   /*  1 */
4    MAR,   /*  2 */
5    APR,   /*  3 */
6    MAY,   /*  4 */
7    JUNE,  /*  5 */
8    JULY,  /*  6 */
9    AUG,   /*  7 */
10   SEPT,  /*  8 */
11   OCT,   /*  9 */
12   NOV,   /* 10 */
13   DEC    /* 11 */
14 };
15
16 enum month m=OCT; /*9*/
```

enum examples

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```c
enum month {
  JAN,   /*  0 */
  FEB,   /*  1 */
  MAR,   /*  2 */
  APR,   /*  3 */
  MAY,   /*  4 */
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  JULY,  /*  6 */
  AUG,   /*  7 */
  SEPT,  /*  8 */
  OCT,   /*  9 */
  NOV,   /* 10 */
  DEC    /* 11 */
};

enum month m=OCT; /*9*/
```

```c
enum {
  RED,        /*  0 */
  BLUE = 3,   /*  3 */
  GREEN,      /*  4 */
  YELLOW,     /*  5 */
  GRAY = 10   /* 10 */
} c;

c = GREEN;
printf("c: %d\n", c);
```

```
c:  4
```

Chapter 2

File handling

Files

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Data stored on a physical media (hard disk, CD, USB drive)

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  3. Closing the file
- Two types of files:

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- Two types of files:
  - Text file

Files

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- Data stored in a file is not lost after the program is finished, it can be reloaded.
- Independently of the media, files are handled in a uniform way
- File handling:
  1. Opening the file
  2. Data writing / reading
  3. Closing the file
- Two types of files:
  - Text file
  - Binary file

Text vs. Binary

Text file – contains text, divided into lines

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Binary file – contains binary coded data of arbitrary structure

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- As long as it makes sense, use a text file – it is more friendly.
- It is a big advantage, if not only programs, but humans too are able to read and edit our data.

Writing into a text file

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```c
#include <stdio.h> /* fopen, fprintf, fclose */
int main(void)
{
  FILE *fp;
  int status;

  fp = fopen("hello.txt", "w");  /* file open */
  if (fp == NULL)                 /* no success */
    return 1;

  fprintf(fp, "Hello, World!\n");  /* writing */

  status = fclose(fp);             /* closing */
  if (status != 0)
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  return 0;
}
```

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`mode`		description
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- If opening was not successfull, it returns with NULL

Closing a file


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int fclose(FILE *fp);
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- It closes the file referenced by the `fp` identifier
- If the closing is successful[1], it returns with 0, otherwise it returns with `EOF`.

[1] closing a file may not be successful: for example somebody has removed the pendrive while we were writing onto it.

Writing onto screen / into text file / into string


```
int  printf(           char *control, ...);
int fprintf(FILE *fp,  char *control, ...);
int sprintf(char *str, char *control, ...);
```

[2] If we write into a string, it automatically adds the terminating 0, but it is not counted in the return value

Writing onto screen / into text file / into string


```
int  printf(           char *control, ...);
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```

- The text given in the `control` string will be written
  - onto the screen
  - into a text file (previously opened for writing) with `fp` identifier
  - into a string with `str` identifier (string must be long enough)
- Using of control character (eg. `%d`) is the same as with `printf`
- Return value is the number of successfully written characters[2], it is negative in case of error

[2] If we write into a string, it automatically adds the terminating 0, but it is not counted in the return value

Reading from keyboard / text file / string

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```
int  scanf(           char *control, ...);
int fscanf(FILE *fp,  char *control, ...);
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Reading from keyboard / text file / string


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int  scanf(           char *control, ...);
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int sscanf(char *str, char *control, ...);
```

- Reads in the format specified in the `control` string from the
  - keyboard
  - a text file (previously opened for reading) with `fp` identifier
  - from a string with `str` identifier
- Return value is the number of read elements, it is negative in case of error

Reading from text file

Let's write a program, that prints (onto the screen) the content of a text file

```c
#include <stdio.h>
int main()
{
  char c;
  FILE *fp = fopen("file.txt", "r"); /* open file */
  if (fp == NULL)
    return -1; /* was not successfull */

  /* reading until successful (we read 1 character) */
  while (fscanf(fp, "%c", &c) == 1)
    printf("%c", c);

  fclose(fp); /* close file */
  return 0;
}
```

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- Memorize the way we read until the end of the file!

Reading from text file

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A text file contains the coordinates of 2D points. Each of its line has the following format

```
x:1.2334, y:-23.3
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Let's write a program that reads and processes the coordinates!

Reading from text file

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A text file contains the coordinates of 2D points. Each of its line has the following format

`x:1.2334, y:-23.3`

Let's write a program that reads and processes the coordinates!

```
1  FILE *fp;
2  double x, y;
3  ...
4  /* reading as long as it is successful */
5  /* (we read 2 numbers)                 */
6  while (fscanf(fp, "x:%lf, y:%lf", &x, &y) == 2)
7  {
8    /* processing */
9  }
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Reading from text file

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```

- Once again, take a look at how we read until the end of the file!

Keyboard? Monitor?

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scanf("%c", &c);
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- The type of perphery or other file that is assigned to it depends on the operating system.
- Its default interpretation is as in the figure.
  - keyboard (through a console application) → stdin
  - stdout → (through a console application) monitor

Redirecting

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- If we start our program in the follwoing way, we can redirect the standard output: it will not print on the monitor, but into the `out.txt` text file

```
c:\>prog.exe > out.txt
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- The standard input can also be redirected to a text file.

```
c:\>prog.exe < in.txt
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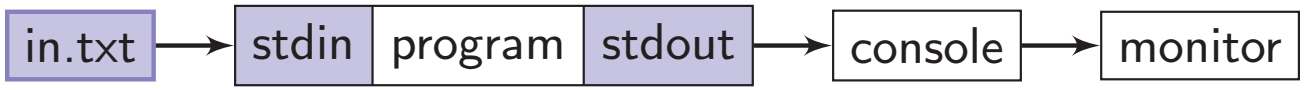

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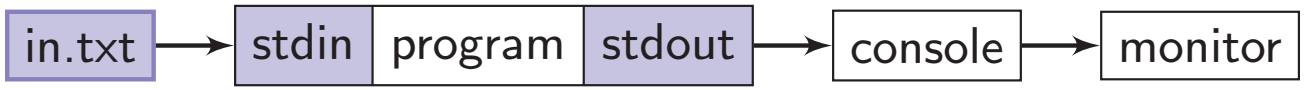

- Of course, the 2 can be combined

```
c:\>prog.exe < in.txt > out.txt
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stdin and stdout

- stdin and stdout are text files that are automatically opened when starting the program

stdin and stdout

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- stdin and stdout are text files that are automatically opened when starting the program
- the code segments below are equivalent

```c
char c;
printf("Hello");
scanf("%c", &c);
printf("%c", c);
```

```c
char c;
fprintf(stdout, "Hello");
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stdin and stdout

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- stdin and stdout are text files that are automatically opened when starting the program
- the code segments below are equivalent

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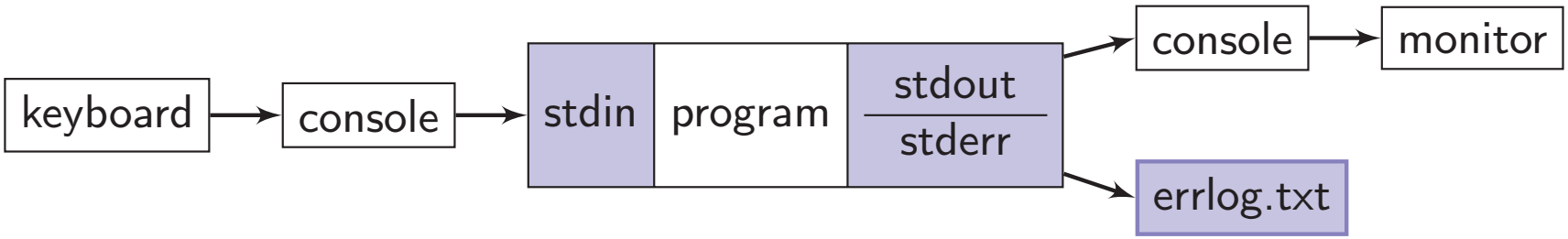
- When writing data from a text file into a text file, instead of opening a file, use the standard input and output, and the redirection options of the operating system
- We can read from the console also until the end of the file: we can emulate the end of file by entering Ctrl+Z (windows) or Ctrl+D (linux).

stdout and stderr

- The output and the error messages of the program can be separated by using the standard error output `stderr`

```
c:\>prog.exe 2> errlog.txt
```




```c
if (error)
{
  /* useful information for the user */
  printf("Please, switch it off\n");
  /* detailed information to the error output */
  fprintf(stderr, "Error code 61\n");
}
```

Binary files

- Binary file: The bit-by-bit copy of the content of the memory onto a physical data media

[3] For the sake of analogy, in case of text file it is typical to use `t` (`text`), but actually `fopen` will not care about it.

Binary files

DEPARTMENT OF NETWORKED SYSTEMS AND SERVICES

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Binary files

- Binary file: The bit-by-bit copy of the content of the memory onto a physical data media
- The actual data depends on the inner representation
- Use it only if storing as text would be very weird – and use it in tasks if asked 
- Opening and closing the file is similar to the case of text files, but now the `b` character must be used in the `mode` string[3]

`mode`		description
`"rb"`	read	reading, the file must exist
`"wb"`	write	writing, overwrites, if needed a new is created
`"ab"`	append	writing, continues at the end, if needed a new is created

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Reading and writing a binary file


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size_t fwrite (void *ptr, size_t size,
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- Return value is the number of read elements

Binary files – example

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- This dog_array array contains 5 dogs

```
1  typedef enum { BLACK, WHITE, RED } color_t;
2
3  typedef struct {
4    char name[11];    /* name max 10 chars + terminating */
5    color_t color;    /* colour */
6    int nLegs;        /* number of legs */
7    double height;    /* height */
8  } dog;
9
10 dog dog_array[] = /* array for storing 5 dogs */
11 {
12   { "max",   RED,    4, 1.12 },
13   { "cesar",  BLACK, 3, 1.24 },
14   { "buddy",  WHITE, 4, 0.23 },
15   { "spider", WHITE, 8, 0.45 },
16   { "daisy",   BLACK, 4, 0.456 }
17 };
```

link

Binary files – examples

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- Writing the dog_array array into a binary file is this easy!

```
1  fp = fopen("dogs.dat", "wb"); /* error handling!!! */
2  if (fwrite(dog_array, sizeof(dog), 5, fp) != 5)
3  {
4    /* error message */
5  }
6  fclose(fp); /* here also!!! */
```

Binary files – examples

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```

- Re-reading the dog_array array is not less easier too.

```
1  dog dogs[5]; /* allocating memory */
2  fp = fopen("dogs.dat", "rb");
3  if (fread(dogs, sizeof(dog), 5, fp) != 5)
4  {
5    /* error message */
6  }
7  fclose(fp);
```

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Binary files – example

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     - etc.
  2. The data must be converted first, and then written (saved)

Binary vs text

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- Use text files, it is beneficial for everyone!

[4] we assume that the name of the dog has no whitespace characters in it

Binary vs text

- Use text files, it is beneficial for everyone!
- Writing the `dog_array` array into text file

```
1 for (i = 0; i < 5; ++i) {
2   dog d = dog_array[i];
3   fprintf(fp, "%s,%u,%d,%f\n",
4     d.name, d.color, d.nLegs, d.height);
5 }
```

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Binary vs text

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5  }
```

- Reading the dog_array array from text file[4]

```
1  dog dogs[5]; /* allocating memory */
2  for (i = 0; i < 5; ++i) {
3    dog d;
4    fscanf(fp, "%s,%u,%d,%lf",
5      d.name, &d.color, &d.nLegs, &d.height);
6    dogs[i] = d;
7  }
```

[4] we assume that the name of the dog has no whitespace characters in it

Statusflag functions


```
int feof(FILE *fp);
```

- true if we have reached the end of file, false otherwise

```
int ferror(FILE *fp);
```

- true if there was an error during read or write, false otherwise

- Most of the time we don't need them: we can use the return value of read and write functions.

Statusflag functions

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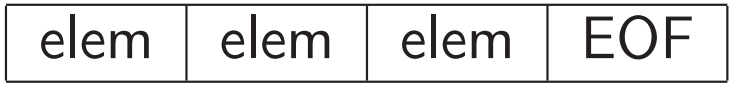
- Typical mistake

```
1  while (!feof(fp))
2  {
3      /* read data element */
4
5      /* process data element */
6  }
```



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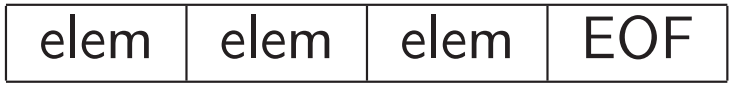

- `feof()` is true only if we already have read the end of file symbol.

Statusflag functions

DEPARTMENT OF NETWORKED SYSTEMS AND SERVICES

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while (!feof(fp))
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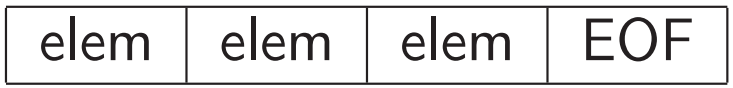

- `feof()` is true only if we already have read the end of file symbol.
- What have we learned about data series with termination?

```c
/* read data element */
while (!feof(fp))
{
  /* process data element */
  /* read data element */
}
```

Thank you for your attention.