Санкт-Петербургский политехнический университет Петра Великого

Институт компьютерных наук и технологий
Высшая школа информатики и вычислительной техники

Лабораторная работа № 4

Дисциплина: Низкоуровневое программирование

Тема: Раздельная компиляция

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Оглавление

Техническое задание

1. Формулировка задачи

1) На языке С разработать функцию, реализующую определенную вариантом задания функциональность. Поместить определение функции в отдельный исходный файл, оформить заголовочный файл. Разработать тестовую программу на языке С.

2) Собрать программу «по шагам». Проанализировать выход препроцессора и компилятора. Проанализировать состав и содержимое секций, таблицы символов, таблицы перемещений и отладочную информацию, содержащуюся в объектных файлах иисполняемом файле.

3) Выделить разработанную функцию в статическую библиотеку. Разработать make-файлыд ля сборки библиотеки и использующей ее тестовой программы. Проанализировать ход сборки библиотеки и программы, созданные файлы зависимостей.

2. Вариант задания

Реализовать нахождение наибольшего общего делителя (НОД) для массива чисел.

3. Ходрешения

Листинг 1.1. Заголовочный файл function.h

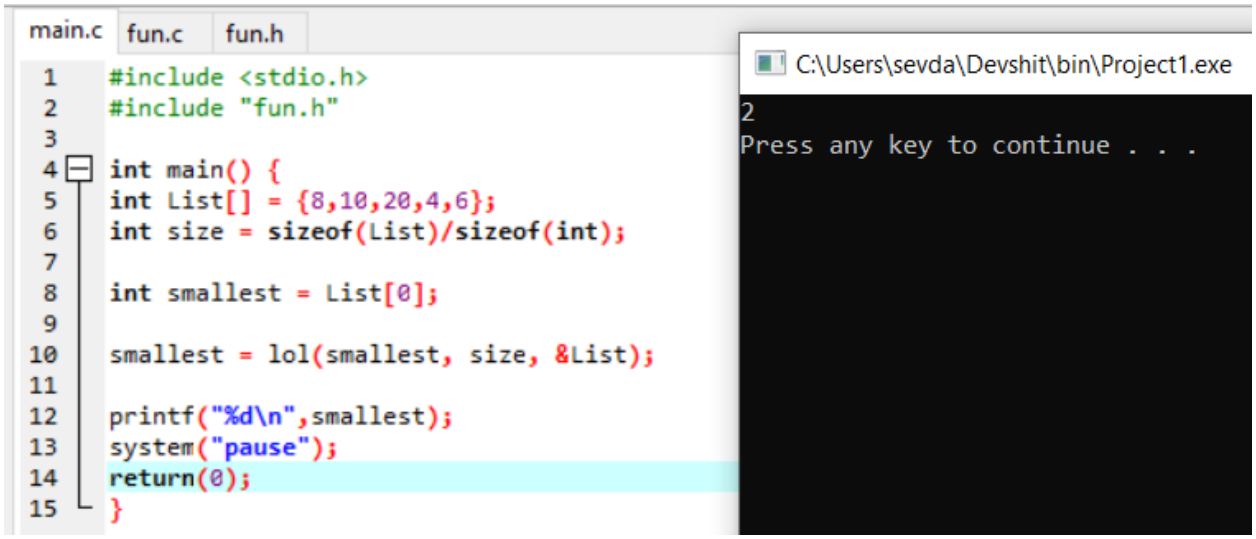
```
#ifndef FUN_H
#define FUN_H
void fun(int n, int *mass);
#endif
```

Листинг 1.2. Основной файл function.c

```
#include "fun.h"
int lol(int smallest, int size,int* List){
int count = 0;
for (count; count < size; count++) {
if (smallest > List[count]) smallest = List[count];
}
int sizeCopy = -(size + 1);

while (sizeCopy < 0) {
sizeCopy += 1;
if (List[size + sizeCopy] % smallest != 0) {
smallest--;
sizeCopy = -(size + 1);
}
}
return smallest;
}
```

Листинг 1.3. Тестовая программа main.c

```
#include <stdio.h>

#include "fun.h"

int main() {

int List[] = {8,10,20,4,6};

int size = sizeof(List)/sizeof(int);

int smallest = List[0];

smallest = lol(smallest, size, &List);

printf("%d\n",smallest);

system("pause");

return(0);

}
```



2. Сборка программы по шагам

Препроцессирование, компиляция и ассемблирование

riscv64-unknown-elf-gcc --save-temps -march=rv32i -mabi=ilp32 -O1 -v main.c >log 2>&1

riscv64-unknown-elf-gcc --save-temps -march=rv32i -mabi=ilp32 -O1 -v function.c >log 2>&1

В файлах main.i и function.i содержится результат препроцессирования

Листинг 2.1. Файл main.i

```
# 1 "main.c"
# 1 "<built-in>"
# 1 "<command-line>"
# 1 "main.c"
# 1 "c:\\users\\sevda\\devshit\\riscv64-unknown-elf\\include\\stdio.h" 1 3
# 29 "c:\\users\\sevda\\devshit\\riscv64-unknown-elf\\include\\stdio.h" 3
# 1 "c:\\users\\sevda\\devshit\\riscv64-unknown-elf\\include\\_ansi.h" 1 3
# 10 "c:\\users\\sevda\\devshit\\riscv64-unknown-elf\\include\\_ansi.h" 3
# 1 "c:\\users\\sevda\\devshit\\riscv64-unknown-elf\\include\\newlib.h" 1 3
# 14 "c:\\users\\sevda\\devshit\\riscv64-unknown-elf\\include\\newlib.h" 3
# 1 "c:\\users\\sevda\\devshit\\riscv64-unknown-elf\\include\\_newlib_version.h" 1
3
# 15 "c:\\users\\sevda\\devshit\\riscv64-unknown-elf\\include\\newlib.h" 2 3
# 11 "c:\\users\\sevda\\devshit\\riscv64-unknown-elf\\include\\_ansi.h" 2 3
# 1 "c:\\users\\sevda\\devshit\\riscv64-unknown-elf\\include\\sys\\config.h" 1 3


# 1 "c:\\users\\sevda\\devshit\\riscv64-unknown-elf\\include\\machine\\ieeefp.h" 1
3
# 5 "c:\\users\\sevda\\devshit\\riscv64-unknown-elf\\include\\sys\\config.h" 2 3
# 1 "c:\\users\\sevda\\devshit\\riscv64-unknown-elf\\include\\sys\\features.h" 1 3
```

```
# 6 "c:\\users\\sevda\\devshit\\riscv64-unknown-elf\\include\\sys\\config.h" 2 3
# 12 "c:\\users\\sevda\\devshit\\riscv64-unknown-elf\\include\\_ansi.h" 2 3
# 30 "c:\\users\\sevda\\devshit\\riscv64-unknown-elf\\include\\stdio.h" 2 3




# 1 "c:\\users\\sevda\\devshit\\riscv64-unknown-elf\\include\\sys\\cdefs.h" 1 3
# 45 "c:\\users\\sevda\\devshit\\riscv64-unknown-elf\\include\\sys\\cdefs.h" 3
# 1
"c:\\users\\sevda\\devshit\\riscv64-unknown-elf\\include\\machine\\_default_types.
h" 1 3
# 41
"c:\\users\\sevda\\devshit\\riscv64-unknown-elf\\include\\machine\\_default_types.
h" 3

# 41
"c:\\users\\sevda\\devshit\\riscv64-unknown-elf\\include\\machine\\_default_types.
h" 3
typedef signed char __int8_t;

typedef unsigned char __uint8_t;
# 55
"c:\\users\\sevda\\devshit\\riscv64-unknown-elf\\include\\machine\\_default_types.
h" 3
typedef short int __int16_t;

typedef short unsigned int __uint16_t;
# 77
"c:\\users\\sevda\\devshit\\riscv64-unknown-elf\\include\\machine\\_default_types.
h" 3
typedef long int __int32_t;

typedef long unsigned int __uint32_t;
# 103
"c:\\users\\sevda\\devshit\\riscv64-unknown-elf\\include\\machine\\_default_types.
h" 3
typedef long long int __int64_t;
```

```
typedef long long unsigned int __uint64_t;
# 134
"c:\\users\\sevda\\devshit\\riscv64-unknown-elf\\include\\machine\\_default_types.
h" 3
typedef signed char __int_least8_t;

typedef unsigned char __uint_least8_t;
# 160
"c:\\users\\sevda\\devshit\\riscv64-unknown-elf\\include\\machine\\_default_types.
h" 3
typedef short int __int_least16_t;

typedef short unsigned int __uint_least16_t;
# 182
"c:\\users\\sevda\\devshit\\riscv64-unknown-elf\\include\\machine\\_default_types.
h" 3
typedef long int __int_least32_t;

typedef long unsigned int __uint_least32_t;
# 200
"c:\\users\\sevda\\devshit\\riscv64-unknown-elf\\include\\machine\\_default_types.
h" 3
typedef long long int __int_least64_t;

typedef long long unsigned int __uint_least64_t;
# 214
"c:\\users\\sevda\\devshit\\riscv64-unknown-elf\\include\\machine\\_default_types.
h" 3
typedef long long int __intmax_t;




typedef long long unsigned int __uintmax_t;
```

```
typedef int __intptr_t;

typedef unsigned int __uintptr_t;
# 46 "c:\\users\\sevda\\devshit\\riscv64-unknown-elf\\include\\sys\\cdefs.h" 2 3

# 1
"c:\\users\\sevda\\devshit\\lib\\gcc\\riscv64-unknown-elf\\8.3.0\\include\\stddef.h"
1 3 4
# 216
"c:\\users\\sevda\\devshit\\lib\\gcc\\riscv64-unknown-elf\\8.3.0\\include\\stddef.h"
3 4
typedef unsigned int size_t;
# 48 "c:\\users\\sevda\\devshit\\riscv64-unknown-elf\\include\\sys\\cdefs.h" 2 3
# 36 "c:\\users\\sevda\\devshit\\riscv64-unknown-elf\\include\\stdio.h" 2 3
# 1
"c:\\users\\sevda\\devshit\\lib\\gcc\\riscv64-unknown-elf\\8.3.0\\include\\stddef.h"
1 3 4
# 149
"c:\\users\\sevda\\devshit\\lib\\gcc\\riscv64-unknown-elf\\8.3.0\\include\\stddef.h"
3 4
typedef int ptrdiff_t;
# 328
"c:\\users\\sevda\\devshit\\lib\\gcc\\riscv64-unknown-elf\\8.3.0\\include\\stddef.h"
3 4
typedef int wchar_t;
# 426
"c:\\users\\sevda\\devshit\\lib\\gcc\\riscv64-unknown-elf\\8.3.0\\include\\stddef.h"
3 4
typedef struct {
  long long __max_align_ll __attribute__((__aligned__(__alignof__(long long))));
  long double __max_align_ld __attribute__((__aligned__(__alignof__(long
double))));
# 437
"c:\\users\\sevda\\devshit\\lib\\gcc\\riscv64-unknown-elf\\8.3.0\\include\\stddef.h"
3 4
} max_align_t;
```

```
# 37 "c:\\users\\sevda\\devshit\\riscv64-unknown-elf\\include\\stdio.h" 2 3



# 1
"c:\\users\\sevda\\devshit\\lib\\gcc\\riscv64-unknown-elf\\8.3.0\\include\\stdarg.h"
1 3 4
# 40
"c:\\users\\sevda\\devshit\\lib\\gcc\\riscv64-unknown-elf\\8.3.0\\include\\stdarg.h"
3 4
typedef __builtin_va_list __gnuc_va_list;
# 41 "c:\\users\\sevda\\devshit\\riscv64-unknown-elf\\include\\stdio.h" 2 3




typedef __gnuc_va_list va_list;
# 60 "c:\\users\\sevda\\devshit\\riscv64-unknown-elf\\include\\stdio.h" 3
# 1 "c:\\users\\sevda\\devshit\\riscv64-unknown-elf\\include\\sys\\reent.h" 1 3
# 13 "c:\\users\\sevda\\devshit\\riscv64-unknown-elf\\include\\sys\\reent.h" 3
# 1 "c:\\users\\sevda\\devshit\\riscv64-unknown-elf\\include\\_ansi.h" 1 3
# 14 "c:\\users\\sevda\\devshit\\riscv64-unknown-elf\\include\\sys\\reent.h" 2 3
# 1
"c:\\users\\sevda\\devshit\\lib\\gcc\\riscv64-unknown-elf\\8.3.0\\include\\stddef.h"
1 3 4
# 15 "c:\\users\\sevda\\devshit\\riscv64-unknown-elf\\include\\sys\\reent.h" 2 3
# 1 "c:\\users\\sevda\\devshit\\riscv64-unknown-elf\\include\\sys\\_types.h" 1 3
# 24 "c:\\users\\sevda\\devshit\\riscv64-unknown-elf\\include\\sys\\_types.h" 3
# 1
"c:\\users\\sevda\\devshit\\lib\\gcc\\riscv64-unknown-elf\\8.3.0\\include\\stddef.h"
1 3 4
# 357
"c:\\users\\sevda\\devshit\\lib\\gcc\\riscv64-unknown-elf\\8.3.0\\include\\stddef.h"
3 4
typedef unsigned int wint_t;
# 25 "c:\\users\\sevda\\devshit\\riscv64-unknown-elf\\include\\sys\\_types.h" 2 3
```

```
# 1 "c:\\users\\sevda\\devshit\\riscv64-unknown-elf\\include\\machine\\_types.h" 1
3
# 28 "c:\\users\\sevda\\devshit\\riscv64-unknown-elf\\include\\sys\\_types.h" 2 3

typedef long __blkcnt_t;

typedef long __blksize_t;

typedef __uint64_t __fsblkcnt_t;

typedef __uint32_t __fsfilcnt_t;

typedef long _off_t;



typedef int __pid_t;

typedef short __dev_t;

typedef unsigned short __uid_t;

typedef unsigned short __gid_t;
```

typedef __uint32_t __id_t;

typedef unsigned short __ino_t;
90 "c:\\users\\sevda\\devshit\\riscv64-unknown-elf\\include\\sys_types.h" 3
typedef __uint32_t __mode_t;

__extension__ typedef long long _off64_t;

typedef _off_t __off_t;

typedef _off64_t __loff_t;

typedef long __key_t;

typedef long _fpos_t;
131 "c:\\users\\sevda\\devshit\\riscv64-unknown-elf\\include\\sys_types.h" 3

```
typedef unsigned int __size_t;
# 147 "c:\\users\\sevda\\devshit\\riscv64-unknown-elf\\include\\sys\\_types.h" 3
typedef signed int _ssize_t;
# 158 "c:\\users\\sevda\\devshit\\riscv64-unknown-elf\\include\\sys\\_types.h" 3
typedef _ssize_t __ssize_t;



typedef struct
{
  int __count;
  union
  {
        wint_t __wch;
        unsigned char __wchb[4];
  } __value;
} _mbstate_t;



typedef void *_iconv_t;




typedef unsigned long __clock_t;




typedef __int_least64_t __time_t;
```

```
typedef unsigned long __clockid_t;

typedef unsigned long __timer_t;

typedef __uint8_t __sa_family_t;

typedef __uint32_t __socklen_t;

typedef int __nl_item;
typedef unsigned short __nlink_t;
typedef long __suseconds_t;
typedef unsigned long __useconds_t;

typedef __builtin_va_list __va_list;
# 16 "c:\\users\\sevda\\devshit\\riscv64-unknown-elf\\include\\sys\\reent.h" 2 3

typedef unsigned long __ULong;
# 34 "c:\\users\\sevda\\devshit\\riscv64-unknown-elf\\include\\sys\\reent.h" 3
# 1 "c:\\users\\sevda\\devshit\\riscv64-unknown-elf\\include\\sys\\lock.h" 1 3
# 11 "c:\\users\\sevda\\devshit\\riscv64-unknown-elf\\include\\sys\\lock.h" 3
typedef int _LOCK_T;
typedef int _LOCK_RECURSIVE_T;
# 35 "c:\\users\\sevda\\devshit\\riscv64-unknown-elf\\include\\sys\\reent.h" 2 3
```

```
typedef _LOCK_RECURSIVE_T _flock_t;




struct _reent;

struct __locale_t;




struct _Bigint
{
  struct _Bigint *_next;
  int _k, _maxwds, _sign, _wds;
  __ULong _x[1];
};


struct __tm
{
  int __tm_sec;
  int __tm_min;
  int __tm_hour;
  int __tm_mday;
  int __tm_mon;
  int __tm_year;
  int __tm_wday;
  int __tm_yday;
  int __tm_isdst;
};
```

```
struct _on_exit_args {
 void * _fnargs[32];
 void * _dso_handle[32];

 __ULong _fntypes;


 __ULong _is_cxa;
};
# 98 "c:\\users\\sevda\\devshit\\riscv64-unknown-elf\\include\\sys\\reent.h" 3
struct _atexit {
 struct _atexit *_next;
 int _ind;

 void (*_fns[32])(void);
        struct _on_exit_args _on_exit_args;
};
# 122 "c:\\users\\sevda\\devshit\\riscv64-unknown-elf\\include\\sys\\reent.h" 3
struct __sbuf {
 unsigned char *_base;
 int _size;
};
# 186 "c:\\users\\sevda\\devshit\\riscv64-unknown-elf\\include\\sys\\reent.h" 3
struct __sFILE {
  unsigned char *_p;
  int _r;
  int _w;
  short _flags;
  short _file;
  struct __sbuf _bf;
  int _lbfsize;
```

```
  void * _cookie;

  _ssize_t (*_read) (struct _reent *, void *,
        char *, int);
  _ssize_t (*_write) (struct _reent *, void *,
        const char *,
        int);
  _fpos_t (*_seek) (struct _reent *, void *, _fpos_t, int);
  int (*_close) (struct _reent *, void *);


  struct __sbuf _ub;
  unsigned char *_up;
  int _ur;


  unsigned char _ubuf[3];
  unsigned char _nbuf[1];


  struct __sbuf _lb;


  int _blksize;
  _off_t _offset;


  struct _reent *_data;



  _flock_t _lock;

  _mbstate_t _mbstate;
  int _flags2;
};
# 292 "c:\\users\\sevda\\devshit\\riscv64-unknown-elf\\include\\sys\\reent.h" 3
typedef struct __sFILE __FILE;
```

```
struct _glue
{
  struct _glue *_next;
  int _niobs;
  __FILE *_iobs;
};
# 324 "c:\\users\\sevda\\devshit\\riscv64-unknown-elf\\include\\sys\\reent.h" 3
struct _rand48 {
  unsigned short _seed[3];
  unsigned short _mult[3];
  unsigned short _add;




};
# 613 "c:\\users\\sevda\\devshit\\riscv64-unknown-elf\\include\\sys\\reent.h" 3
struct _reent
{
  int _errno;




  __FILE *_stdin, *_stdout, *_stderr;

  int _inc;
  char _emergency[25];


  int _unspecified_locale_info;
  struct __locale_t *_locale;

  int __sdidinit;

  void (*__cleanup) (struct _reent *);
```

```
struct _Bigint *_result;
int _result_k;
struct _Bigint *_p5s;
struct _Bigint **_freelist;


int _cvtlen;
char *_cvtbuf;

union
        {
        struct
        {
        unsigned int _unused_rand;
        char * _strtok_last;
        char _asctime_buf[26];
        struct __tm _localtime_buf;
        int _gamma_signgam;
        __extension__ unsigned long long _rand_next;
        struct _rand48 _r48;
        _mbstate_t _mblen_state;
        _mbstate_t _mbtowc_state;
        _mbstate_t _wctomb_state;
        char _l64a_buf[8];
        char _signal_buf[24];
        int _getdate_err;
        _mbstate_t _mbrlen_state;
        _mbstate_t _mbrtowc_state;
        _mbstate_t _mbsrtowcs_state;
        _mbstate_t _wcrtomb_state;
        _mbstate_t _wcsrtombs_state;
 int _h_errno;
        } _reent;



        struct
        {

        unsigned char * _nextf[30];
```

```
        unsigned int _nmalloc[30];
        } _unused;
        } _new;


  struct _atexit *_atexit;
  struct _atexit _atexit0;



  void (**(_sig_func))(int);




  struct _glue __sglue;

  __FILE __sf[3];

};
# 819 "c:\\users\\sevda\\devshit\\riscv64-unknown-elf\\include\\sys\\reent.h" 3
extern struct _reent *_impure_ptr ;
extern struct _reent *const _global_impure_ptr ;

void _reclaim_reent (struct _reent *);
# 61 "c:\\users\\sevda\\devshit\\riscv64-unknown-elf\\include\\stdio.h" 2 3
# 1 "c:\\users\\sevda\\devshit\\riscv64-unknown-elf\\include\\sys\\types.h" 1 3
# 28 "c:\\users\\sevda\\devshit\\riscv64-unknown-elf\\include\\sys\\types.h" 3
typedef __uint8_t u_int8_t;


typedef __uint16_t u_int16_t;


typedef __uint32_t u_int32_t;


typedef __uint64_t u_int64_t;
```

```
typedef __intptr_t register_t;




# 1 "c:\\users\\sevda\\devshit\\riscv64-unknown-elf\\include\\sys\\_stdint.h" 1 3
# 20 "c:\\users\\sevda\\devshit\\riscv64-unknown-elf\\include\\sys\\_stdint.h" 3
typedef __int8_t int8_t ;



typedef __uint8_t uint8_t ;







typedef __int16_t int16_t ;



typedef __uint16_t uint16_t ;







typedef __int32_t int32_t ;



typedef __uint32_t uint32_t ;
```

typedef __int64_t int64_t ;

typedef __uint64_t uint64_t ;

typedef __intmax_t intmax_t;

typedef __uintmax_t uintmax_t;

typedef __intptr_t intptr_t;

typedef __uintptr_t uintptr_t;
47 "c:\\users\\sevda\\devshit\\riscv64-unknown-elf\\include\\sys\\types.h" 2 3

1 "c:\\users\\sevda\\devshit\\riscv64-unknown-elf\\include\\machine\\endian.h" 1 3

```
# 1 "c:\\users\\sevda\\devshit\\riscv64-unknown-elf\\include\\machine\\_endian.h"
1 3
# 7 "c:\\users\\sevda\\devshit\\riscv64-unknown-elf\\include\\machine\\endian.h" 2
3
# 50 "c:\\users\\sevda\\devshit\\riscv64-unknown-elf\\include\\sys\\types.h" 2 3
# 1 "c:\\users\\sevda\\devshit\\riscv64-unknown-elf\\include\\sys\\select.h" 1 3
# 14 "c:\\users\\sevda\\devshit\\riscv64-unknown-elf\\include\\sys\\select.h" 3
# 1 "c:\\users\\sevda\\devshit\\riscv64-unknown-elf\\include\\sys\\_sigset.h" 1 3
# 41 "c:\\users\\sevda\\devshit\\riscv64-unknown-elf\\include\\sys\\_sigset.h" 3
typedef unsigned long __sigset_t;
# 15 "c:\\users\\sevda\\devshit\\riscv64-unknown-elf\\include\\sys\\select.h" 2 3
# 1 "c:\\users\\sevda\\devshit\\riscv64-unknown-elf\\include\\sys\\_timeval.h" 1 3
# 35 "c:\\users\\sevda\\devshit\\riscv64-unknown-elf\\include\\sys\\_timeval.h" 3
typedef __suseconds_t suseconds_t;




typedef __int_least64_t time_t;
# 52 "c:\\users\\sevda\\devshit\\riscv64-unknown-elf\\include\\sys\\_timeval.h" 3
struct timeval {
 time_t tv_sec;
 suseconds_t tv_usec;
};
# 16 "c:\\users\\sevda\\devshit\\riscv64-unknown-elf\\include\\sys\\select.h" 2 3
# 1 "c:\\users\\sevda\\devshit\\riscv64-unknown-elf\\include\\sys\\timespec.h" 1 3
# 38 "c:\\users\\sevda\\devshit\\riscv64-unknown-elf\\include\\sys\\timespec.h" 3
# 1 "c:\\users\\sevda\\devshit\\riscv64-unknown-elf\\include\\sys\\_timespec.h" 1 3
# 45 "c:\\users\\sevda\\devshit\\riscv64-unknown-elf\\include\\sys\\_timespec.h" 3
struct timespec {
 time_t tv_sec;
 long tv_nsec;
};
# 39 "c:\\users\\sevda\\devshit\\riscv64-unknown-elf\\include\\sys\\timespec.h" 2 3
# 58 "c:\\users\\sevda\\devshit\\riscv64-unknown-elf\\include\\sys\\timespec.h" 3
struct itimerspec {
 struct timespec it_interval;
 struct timespec it_value;
```

```
};
# 17 "c:\\users\\sevda\\devshit\\riscv64-unknown-elf\\include\\sys\\select.h" 2 3



typedef __sigset_t sigset_t;
# 34 "c:\\users\\sevda\\devshit\\riscv64-unknown-elf\\include\\sys\\select.h" 3
typedef unsigned long fd_mask;







typedef struct _types_fd_set {
 fd_mask fds_bits[((64)+(((sizeof (fd_mask) * 8))-1))/((sizeof (fd_mask) * 8)))];
} _types_fd_set;
# 60 "c:\\users\\sevda\\devshit\\riscv64-unknown-elf\\include\\sys\\select.h" 3


int select (int __n, _types_fd_set *__readfds, _types_fd_set *__writefds,
_types_fd_set *__exceptfds, struct timeval *__timeout)
                                        ;

int pselect (int __n, _types_fd_set *__readfds, _types_fd_set *__writefds,
_types_fd_set *__exceptfds, const struct timespec *__timeout, const sigset_t
*__set)

                        ;



# 51 "c:\\users\\sevda\\devshit\\riscv64-unknown-elf\\include\\sys\\types.h" 2 3



typedef __uint32_t in_addr_t;
```

```
typedef __uint16_t in_port_t;

typedef __uintptr_t u_register_t;



typedef unsigned char u_char;

typedef unsigned short u_short;

typedef unsigned int u_int;

typedef unsigned long u_long;



typedef unsigned short ushort;
typedef unsigned int uint;
typedef unsigned long ulong;
```

```
typedef __blkcnt_t blkcnt_t;



typedef __blksize_t blksize_t;



typedef unsigned long clock_t;
# 119 "c:\\users\\sevda\\devshit\\riscv64-unknown-elf\\include\\sys\\types.h" 3
typedef long daddr_t;



typedef char * caddr_t;



typedef __fsblkcnt_t fsblkcnt_t;
typedef __fsfilcnt_t fsfilcnt_t;



typedef __id_t id_t;



typedef __ino_t ino_t;
# 157 "c:\\users\\sevda\\devshit\\riscv64-unknown-elf\\include\\sys\\types.h" 3
typedef __off_t off_t;



typedef __dev_t dev_t;
```

```
typedef __uid_t uid_t;

typedef __gid_t gid_t;

typedef __pid_t pid_t;

typedef __key_t key_t;

typedef _ssize_t ssize_t;

typedef __mode_t mode_t;

typedef __nlink_t nlink_t;

typedef __clockid_t clockid_t;
```

```
typedef __timer_t timer_t;



typedef __useconds_t useconds_t;
# 220 "c:\\users\\sevda\\devshit\\riscv64-unknown-elf\\include\\sys\\types.h" 3
typedef __int64_t sbintime_t;


# 1 "c:\\users\\sevda\\devshit\\riscv64-unknown-elf\\include\\sys\\_pthreadtypes.h"
1 3
# 23
"c:\\users\\sevda\\devshit\\riscv64-unknown-elf\\include\\sys\\_pthreadtypes.h" 3
# 1 "c:\\users\\sevda\\devshit\\riscv64-unknown-elf\\include\\sys\\sched.h" 1 3
# 48 "c:\\users\\sevda\\devshit\\riscv64-unknown-elf\\include\\sys\\sched.h" 3
struct sched_param {
  int sched_priority;
# 61 "c:\\users\\sevda\\devshit\\riscv64-unknown-elf\\include\\sys\\sched.h" 3
};
# 24
"c:\\users\\sevda\\devshit\\riscv64-unknown-elf\\include\\sys\\_pthreadtypes.h" 2 3
# 32
"c:\\users\\sevda\\devshit\\riscv64-unknown-elf\\include\\sys\\_pthreadtypes.h" 3
typedef __uint32_t pthread_t;
# 61
"c:\\users\\sevda\\devshit\\riscv64-unknown-elf\\include\\sys\\_pthreadtypes.h" 3
typedef struct {
  int is_initialized;
  void *stackaddr;
  int stacksize;
  int contentionscope;
  int inheritsched;
  int schedpolicy;
  struct sched_param schedparam;
```

```
  int detachstate;
} pthread_attr_t;
# 154
"c:\\users\\sevda\\devshit\\riscv64-unknown-elf\\include\\sys\\_pthreadtypes.h" 3
typedef __uint32_t pthread_mutex_t;

typedef struct {
  int is_initialized;
# 168
"c:\\users\\sevda\\devshit\\riscv64-unknown-elf\\include\\sys\\_pthreadtypes.h" 3
  int recursive;
} pthread_mutexattr_t;







typedef __uint32_t pthread_cond_t;



typedef struct {
  int is_initialized;
  clock_t clock;



} pthread_condattr_t;



typedef __uint32_t pthread_key_t;

typedef struct {
  int is_initialized;
  int init_executed;
```

```
} pthread_once_t;
# 224 "c:\\users\\sevda\\devshit\\riscv64-unknown-elf\\include\\sys\\types.h" 2 3
# 1 "c:\\users\\sevda\\devshit\\riscv64-unknown-elf\\include\\machine\\types.h" 1 3
# 225 "c:\\users\\sevda\\devshit\\riscv64-unknown-elf\\include\\sys\\types.h" 2 3
# 62 "c:\\users\\sevda\\devshit\\riscv64-unknown-elf\\include\\stdio.h" 2 3



typedef __FILE FILE;




typedef _fpos_t fpos_t;




# 1 "c:\\users\\sevda\\devshit\\riscv64-unknown-elf\\include\\sys\\stdio.h" 1 3
# 80 "c:\\users\\sevda\\devshit\\riscv64-unknown-elf\\include\\stdio.h" 2 3
# 181 "c:\\users\\sevda\\devshit\\riscv64-unknown-elf\\include\\stdio.h" 3
char * ctermid (char *);




FILE * tmpfile (void);
char * tmpnam (char *);

char * tempnam (const char *, const char *) __attribute__((__malloc__))
__attribute__((__warn_unused_result__));

int fclose (FILE *);
int fflush (FILE *);
FILE * freopen (const char *restrict, const char *restrict, FILE *restrict);
void setbuf (FILE *restrict, char *restrict);
```

```
int setvbuf (FILE *restrict, char *restrict, int, size_t);
int fprintf (FILE *restrict, const char *restrict, ...)
                __attribute__ ((__format__ (__printf__, 2, 3)));
int fscanf (FILE *restrict, const char *restrict, ...)
                __attribute__ ((__format__ (__scanf__, 2, 3)));
int printf (const char *restrict, ...)
                __attribute__ ((__format__ (__printf__, 1, 2)));
int scanf (const char *restrict, ...)
                __attribute__ ((__format__ (__scanf__, 1, 2)));
int sscanf (const char *restrict, const char *restrict, ...)
                __attribute__ ((__format__ (__scanf__, 2, 3)));
int vfprintf (FILE *restrict, const char *restrict, __gnuc_va_list)
                __attribute__ ((__format__ (__printf__, 2, 0)));
int vprintf (const char *, __gnuc_va_list)
                __attribute__ ((__format__ (__printf__, 1, 0)));
int vsprintf (char *restrict, const char *restrict, __gnuc_va_list)
                __attribute__ ((__format__ (__printf__, 2, 0)));
int fgetc (FILE *);
char * fgets (char *restrict, int, FILE *restrict);
int fputc (int, FILE *);
int fputs (const char *restrict, FILE *restrict);
int getc (FILE *);
int getchar (void);
char * gets (char *);
int putc (int, FILE *);
int putchar (int);
int puts (const char *);
int ungetc (int, FILE *);
size_t fread (void *restrict, size_t _size, size_t _n, FILE *restrict);
size_t fwrite (const void *restrict , size_t _size, size_t _n, FILE *);



int fgetpos (FILE *restrict, fpos_t *restrict);

int fseek (FILE *, long, int);



int fsetpos (FILE *, const fpos_t *);
```

```
long ftell ( FILE *);
void rewind (FILE *);
void clearerr (FILE *);
int feof (FILE *);
int ferror (FILE *);
void perror (const char *);

FILE * fopen (const char *restrict _name, const char *restrict _type);
int sprintf (char *restrict, const char *restrict, ...)
                    __attribute__ ((__format__ (__printf__, 2, 3)));
int remove (const char *);
int rename (const char *, const char *);
# 257 "c:\\users\\sevda\\devshit\\riscv64-unknown-elf\\include\\stdio.h" 3
int fseeko (FILE *, off_t, int);
off_t ftello (FILE *);




int snprintf (char *restrict, size_t, const char *restrict, ...)
                    __attribute__ ((__format__ (__printf__, 3, 4)));
int vsnprintf (char *restrict, size_t, const char *restrict, __gnuc_va_list)
                    __attribute__ ((__format__ (__printf__, 3, 0)));
int vfscanf (FILE *restrict, const char *restrict, __gnuc_va_list)
                    __attribute__ ((__format__ (__scanf__, 2, 0)));
int vscanf (const char *, __gnuc_va_list)
                    __attribute__ ((__format__ (__scanf__, 1, 0)));
int vsscanf (const char *restrict, const char *restrict, __gnuc_va_list)
                    __attribute__ ((__format__ (__scanf__, 2, 0)));
# 284 "c:\\users\\sevda\\devshit\\riscv64-unknown-elf\\include\\stdio.h" 3
int asiprintf (char **, const char *, ...)
                    __attribute__ ((__format__ (__printf__, 2, 3)));
char * asniprintf (char *, size_t *, const char *, ...)
                    __attribute__ ((__format__ (__printf__, 3, 4)));
char * asnprintf (char *restrict, size_t *restrict, const char *restrict, ...)
                    __attribute__ ((__format__ (__printf__, 3, 4)));
```

```
int diprintf (int, const char *, ...)
                __attribute__ ((__format__ (__printf__, 2, 3)));

int fiprintf (FILE *, const char *, ...)
                __attribute__ ((__format__ (__printf__, 2, 3)));
int fiscanf (FILE *, const char *, ...)
                __attribute__ ((__format__ (__scanf__, 2, 3)));
int iprintf (const char *, ...)
                __attribute__ ((__format__ (__printf__, 1, 2)));
int iscanf (const char *, ...)
                __attribute__ ((__format__ (__scanf__, 1, 2)));
int siprintf (char *, const char *, ...)
                __attribute__ ((__format__ (__printf__, 2, 3)));
int siscanf (const char *, const char *, ...)
                __attribute__ ((__format__ (__scanf__, 2, 3)));
int sniprintf (char *, size_t, const char *, ...)
                __attribute__ ((__format__ (__printf__, 3, 4)));
int vasiprintf (char **, const char *, __gnuc_va_list)
                __attribute__ ((__format__ (__printf__, 2, 0)));
char * vasniprintf (char *, size_t *, const char *, __gnuc_va_list)
                __attribute__ ((__format__ (__printf__, 3, 0)));
char * vasnprintf (char *, size_t *, const char *, __gnuc_va_list)
                __attribute__ ((__format__ (__printf__, 3, 0)));
int vdiprintf (int, const char *, __gnuc_va_list)
                __attribute__ ((__format__ (__printf__, 2, 0)));
int vfiprintf (FILE *, const char *, __gnuc_va_list)
                __attribute__ ((__format__ (__printf__, 2, 0)));
int vfiscanf (FILE *, const char *, __gnuc_va_list)
                __attribute__ ((__format__ (__scanf__, 2, 0)));
int viprintf (const char *, __gnuc_va_list)
                __attribute__ ((__format__ (__printf__, 1, 0)));
int viscanf (const char *, __gnuc_va_list)
                __attribute__ ((__format__ (__scanf__, 1, 0)));
int vsiprintf (char *, const char *, __gnuc_va_list)
                __attribute__ ((__format__ (__printf__, 2, 0)));
int vsiscanf (const char *, const char *, __gnuc_va_list)
                __attribute__ ((__format__ (__scanf__, 2, 0)));
int vsniprintf (char *, size_t, const char *, __gnuc_va_list)
                __attribute__ ((__format__ (__printf__, 3, 0)));
```

```
# 339 "c:\\users\\sevda\\devshit\\riscv64-unknown-elf\\include\\stdio.h" 3
FILE * fdopen (int, const char *);

int fileno (FILE *);


int pclose (FILE *);
FILE * popen (const char *, const char *);



void setbuffer (FILE *, char *, int);
int setlinebuf (FILE *);



int getw (FILE *);
int putw (int, FILE *);


int getc_unlocked (FILE *);
int getchar_unlocked (void);
void flockfile (FILE *);
int ftrylockfile (FILE *);
void funlockfile (FILE *);
int putc_unlocked (int, FILE *);
int putchar_unlocked (int);
# 374 "c:\\users\\sevda\\devshit\\riscv64-unknown-elf\\include\\stdio.h" 3
int dprintf (int, const char *restrict, ...)
                __attribute__ ((__format__ (__printf__, 2, 3)));

FILE * fmemopen (void *restrict, size_t, const char *restrict);


FILE * open_memstream (char **, size_t *);
int vdprintf (int, const char *restrict, __gnuc_va_list)
                __attribute__ ((__format__ (__printf__, 2, 0)));
```

```
int renameat (int, const char *, int, const char *);
# 396 "c:\\users\\sevda\\devshit\\riscv64-unknown-elf\\include\\stdio.h" 3
int _asiprintf_r (struct _reent *, char **, const char *, ...)
                __attribute__ ((__format__ (__printf__, 3, 4)));
char * _asniprintf_r (struct _reent *, char *, size_t *, const char *, ...)
                __attribute__ ((__format__ (__printf__, 4, 5)));
char * _asnprintf_r (struct _reent *, char *restrict, size_t *restrict, const char
*restrict, ...)
                __attribute__ ((__format__ (__printf__, 4, 5)));
int _asprintf_r (struct _reent *, char **restrict, const char *restrict, ...)
                __attribute__ ((__format__ (__printf__, 3, 4)));
int _diprintf_r (struct _reent *, int, const char *, ...)
                __attribute__ ((__format__ (__printf__, 3, 4)));
int _dprintf_r (struct _reent *, int, const char *restrict, ...)
                __attribute__ ((__format__ (__printf__, 3, 4)));
int _fclose_r (struct _reent *, FILE *);
int _fcloseall_r (struct _reent *);
FILE * _fdopen_r (struct _reent *, int, const char *);
int _fflush_r (struct _reent *, FILE *);
int _fgetc_r (struct _reent *, FILE *);
int _fgetc_unlocked_r (struct _reent *, FILE *);
char * _fgets_r (struct _reent *, char *restrict, int, FILE *restrict);
char * _fgets_unlocked_r (struct _reent *, char *restrict, int, FILE *restrict);




int _fgetpos_r (struct _reent *, FILE *, fpos_t *);
int _fsetpos_r (struct _reent *, FILE *, const fpos_t *);

int _fiprintf_r (struct _reent *, FILE *, const char *, ...)
                __attribute__ ((__format__ (__printf__, 3, 4)));
int _fiscanf_r (struct _reent *, FILE *, const char *, ...)
                __attribute__ ((__format__ (__scanf__, 3, 4)));
FILE * _fmemopen_r (struct _reent *, void *restrict, size_t, const char *restrict);
FILE * _fopen_r (struct _reent *, const char *restrict, const char *restrict);
FILE * _freopen_r (struct _reent *, const char *restrict, const char *restrict, FILE
*restrict);
int _fprintf_r (struct _reent *, FILE *restrict, const char *restrict, ...)
                __attribute__ ((__format__ (__printf__, 3, 4)));
```

```
int _fpurge_r (struct _reent *, FILE *);
int _fputc_r (struct _reent *, int, FILE *);
int _fputc_unlocked_r (struct _reent *, int, FILE *);
int _fputs_r (struct _reent *, const char *restrict, FILE *restrict);
int _fputs_unlocked_r (struct _reent *, const char *restrict, FILE *restrict);
size_t _fread_r (struct _reent *, void *restrict, size_t _size, size_t _n, FILE
*restrict);
size_t _fread_unlocked_r (struct _reent *, void *restrict, size_t _size, size_t _n,
FILE *restrict);
int _fscanf_r (struct _reent *, FILE *restrict, const char *restrict, ...)
                __attribute__ ((__format__ (__scanf__, 3, 4)));
int _fseek_r (struct _reent *, FILE *, long, int);
int _fseeko_r (struct _reent *, FILE *, _off_t, int);
long _ftell_r (struct _reent *, FILE *);
_off_t _ftello_r (struct _reent *, FILE *);
void _rewind_r (struct _reent *, FILE *);
size_t _fwrite_r (struct _reent *, const void *restrict, size_t _size, size_t _n, FILE
*restrict);
size_t _fwrite_unlocked_r (struct _reent *, const void *restrict, size_t _size, size_t
_n, FILE *restrict);
int _getc_r (struct _reent *, FILE *);
int _getc_unlocked_r (struct _reent *, FILE *);
int _getchar_r (struct _reent *);
int _getchar_unlocked_r (struct _reent *);
char * _gets_r (struct _reent *, char *);
int _iprintf_r (struct _reent *, const char *, ...)
                __attribute__ ((__format__ (__printf__, 2, 3)));
int _iscanf_r (struct _reent *, const char *, ...)
                __attribute__ ((__format__ (__scanf__, 2, 3)));
FILE * _open_memstream_r (struct _reent *, char **, size_t *);
void _perror_r (struct _reent *, const char *);
int _printf_r (struct _reent *, const char *restrict, ...)
                __attribute__ ((__format__ (__printf__, 2, 3)));
int _putc_r (struct _reent *, int, FILE *);
int _putc_unlocked_r (struct _reent *, int, FILE *);
int _putchar_unlocked_r (struct _reent *, int);
int _putchar_r (struct _reent *, int);
int _puts_r (struct _reent *, const char *);
int _remove_r (struct _reent *, const char *);
int _rename_r (struct _reent *,
```

```
        const char *_old, const char *_new);
int _scanf_r (struct _reent *, const char *restrict, ...)
                __attribute__ ((__format__ (__scanf__, 2, 3)));
int _siprintf_r (struct _reent *, char *, const char *, ...)
                __attribute__ ((__format__ (__printf__, 3, 4)));
int _siscanf_r (struct _reent *, const char *, const char *, ...)
                __attribute__ ((__format__ (__scanf__, 3, 4)));
int _sniprintf_r (struct _reent *, char *, size_t, const char *, ...)
                __attribute__ ((__format__ (__printf__, 4, 5)));
int _snprintf_r (struct _reent *, char *restrict, size_t, const char *restrict, ...)
                __attribute__ ((__format__ (__printf__, 4, 5)));
int _sprintf_r (struct _reent *, char *restrict, const char *restrict, ...)
                __attribute__ ((__format__ (__printf__, 3, 4)));
int _sscanf_r (struct _reent *, const char *restrict, const char *restrict, ...)
                __attribute__ ((__format__ (__scanf__, 3, 4)));
char * _tempnam_r (struct _reent *, const char *, const char *);
FILE * _tmpfile_r (struct _reent *);
char * _tmpnam_r (struct _reent *, char *);
int _ungetc_r (struct _reent *, int, FILE *);
int _vasiprintf_r (struct _reent *, char **, const char *, __gnuc_va_list)
                __attribute__ ((__format__ (__printf__, 3, 0)));
char * _vasniprintf_r (struct _reent*, char *, size_t *, const char *, __gnuc_va_list)
                __attribute__ ((__format__ (__printf__, 4, 0)));
char * _vasnprintf_r (struct _reent*, char *, size_t *, const char *, __gnuc_va_list)
                __attribute__ ((__format__ (__printf__, 4, 0)));
int _vasprintf_r (struct _reent *, char **, const char *, __gnuc_va_list)
                __attribute__ ((__format__ (__printf__, 3, 0)));
int _vdiprintf_r (struct _reent *, int, const char *, __gnuc_va_list)
                __attribute__ ((__format__ (__printf__, 3, 0)));
int _vdprintf_r (struct _reent *, int, const char *restrict, __gnuc_va_list)
                __attribute__ ((__format__ (__printf__, 3, 0)));
int _vfiprintf_r (struct _reent *, FILE *, const char *, __gnuc_va_list)
                __attribute__ ((__format__ (__printf__, 3, 0)));
int _vfiscanf_r (struct _reent *, FILE *, const char *, __gnuc_va_list)
                __attribute__ ((__format__ (__scanf__, 3, 0)));
int _vfprintf_r (struct _reent *, FILE *restrict, const char *restrict, __gnuc_va_list)
                __attribute__ ((__format__ (__printf__, 3, 0)));
int _vfscanf_r (struct _reent *, FILE *restrict, const char *restrict, __gnuc_va_list)
                __attribute__ ((__format__ (__scanf__, 3, 0)));
int _viprintf_r (struct _reent *, const char *, __gnuc_va_list)
```

```
                __attribute__ ((__format__ (__printf__, 2, 0)));
int _viscanf_r (struct _reent *, const char *, __gnuc_va_list)
                __attribute__ ((__format__ (__scanf__, 2, 0)));
int _vprintf_r (struct _reent *, const char *restrict, __gnuc_va_list)
                __attribute__ ((__format__ (__printf__, 2, 0)));
int _vscanf_r (struct _reent *, const char *restrict, __gnuc_va_list)
                __attribute__ ((__format__ (__scanf__, 2, 0)));
int _vsiprintf_r (struct _reent *, char *, const char *, __gnuc_va_list)
                __attribute__ ((__format__ (__printf__, 3, 0)));
int _vsiscanf_r (struct _reent *, const char *, const char *, __gnuc_va_list)
                __attribute__ ((__format__ (__scanf__, 3, 0)));
int _vsniprintf_r (struct _reent *, char *, size_t, const char *, __gnuc_va_list)
                __attribute__ ((__format__ (__printf__, 4, 0)));
int _vsnprintf_r (struct _reent *, char *restrict, size_t, const char *restrict,
__gnuc_va_list)
                __attribute__ ((__format__ (__printf__, 4, 0)));
int _vsprintf_r (struct _reent *, char *restrict, const char *restrict, __gnuc_va_list)
                __attribute__ ((__format__ (__printf__, 3, 0)));
int _vsscanf_r (struct _reent *, const char *restrict, const char *restrict,
__gnuc_va_list)
                __attribute__ ((__format__ (__scanf__, 3, 0)));



int fpurge (FILE *);
ssize_t __getdelim (char **, size_t *, int, FILE *);
ssize_t __getline (char **, size_t *, FILE *);


void clearerr_unlocked (FILE *);
int feof_unlocked (FILE *);
int ferror_unlocked (FILE *);
int fileno_unlocked (FILE *);
int fflush_unlocked (FILE *);
int fgetc_unlocked (FILE *);
int fputc_unlocked (int, FILE *);
size_t fread_unlocked (void *restrict, size_t _size, size_t _n, FILE *restrict);
size_t fwrite_unlocked (const void *restrict , size_t _size, size_t _n, FILE *);
# 577 "c:\\users\\sevda\\devshit\\riscv64-unknown-elf\\include\\stdio.h" 3
int __srget_r (struct _reent *, FILE *);
```

```
int __swbuf_r (struct _reent *, int, FILE *);
# 601 "c:\\users\\sevda\\devshit\\riscv64-unknown-elf\\include\\stdio.h" 3
FILE *funopen (const void *__cookie,
  int (*__readfn)(void *__cookie, char *__buf,
         int __n),
  int (*__writefn)(void *__cookie, const char *__buf,
         int __n),
  fpos_t (*__seekfn)(void *__cookie, fpos_t __off, int __whence),
  int (*__closefn)(void *__cookie));
FILE *_funopen_r (struct _reent *, const void *__cookie,
  int (*__readfn)(void *__cookie, char *__buf,
         int __n),
  int (*__writefn)(void *__cookie, const char *__buf,
         int __n),
  fpos_t (*__seekfn)(void *__cookie, fpos_t __off, int __whence),
  int (*__closefn)(void *__cookie));
# 687 "c:\\users\\sevda\\devshit\\riscv64-unknown-elf\\include\\stdio.h" 3
static __inline__ int __sputc_r(struct _reent *_ptr, int _c, FILE *_p) {




 if (--_p->_w >= 0 || (_p->_w >= _p->_lbfsize && (char)_c != '\n'))
  return (*_p->_p++ = _c);
 else
  return (__swbuf_r(_ptr, _c, _p));
}
# 741 "c:\\users\\sevda\\devshit\\riscv64-unknown-elf\\include\\stdio.h" 3
static __inline int
_getchar_unlocked(void)
{
 struct _reent *_ptr;

 _ptr = _impure_ptr;
 return ((--(((_ptr)->_stdin))->_r < 0 ? __srget_r(_ptr, ((_ptr)->_stdin)) :
(int)(*(((_ptr)->_stdin))->_p++)));
}

static __inline int
_putchar_unlocked(int _c)
```

```
{
 struct _reent *_ptr;

 _ptr = _impure_ptr;
 return (__sputc_r(_ptr, _c, ((_ptr)->_stdout)));
}
# 797 "c:\\users\\sevda\\devshit\\riscv64-unknown-elf\\include\\stdio.h" 3

# 2 "main.c" 2
# 1 "fun.h" 1



# 3 "fun.h"
void fun(int n, int *mass);
# 3 "main.c" 2

int main() {
int List[] = {8,10,20,4,6};
int size = sizeof(List)/sizeof(int);

int smallest = List[0];

smallest = lol(smallest, size, &List);

printf("%d\n",smallest);
system("pause");
return(0);
}
```

Листинг 2.2. Файл fun.i

```
# 1 "fun.c"

# 1 "<built-in>"

# 1 "<command-line>"
```

```
# 1 "fun.c"


# 1 "fun.h" 1



void fun(int n, int *mass);
# 3 "fun.c" 2


int lol(int smallest, int size,int* List){
int count = 0;
for (count; count < size; count++) {
if (smallest > List[count]) smallest = List[count];
}
int sizeCopy = -(size + 1);


while (sizeCopy < 0) {
sizeCopy += 1;
if (List[size + sizeCopy] % smallest != 0) {
smallest--;
sizeCopy = -(size + 1);
}
}
return smallest;
}
```

Компиляция

В файле main.s, так как в нем можно заметить обращение к подпрограмме fun.

```
        .file   "main.c"
    .option nopic
    .attribute arch, "rv32i2p0"
    .attribute unaligned_access, 0
    .attribute stack_align, 16
    .text
    .align  2
    .globl  main
    .type   main, @function
main:
    addi    sp,sp,-48
    sw  ra,44(sp)
    lui  a5,%hi(.LANCHOR0)
    addi  a5,a5,%lo(.LANCHOR0)
    lw  a1,0(a5)
    lw  a2,4(a5)
    lw  a3,8(a5)
    lw  a4,12(a5)
    lw  a5,16(a5)
    sw  a1,12(sp)
    sw  a2,16(sp)
    sw  a3,20(sp)
    sw  a4,24(sp)
```

```
    sw    a5,28(sp)
    addi    a2,sp,12
    li    a1,5
    li    a0,8
    call    lol
    mv    a1,a0
    lui    a0,%hi(.LC1)
    addi    a0,a0,%lo(.LC1)
    call    printf
    lui    a0,%hi(.LC2)
    addi    a0,a0,%lo(.LC2)
    call    system
    li    a0,0
    lw    ra,44(sp)
    addi    sp,sp,48
    jr    ra
    .size    main, .-main
    .section    .rodata
    .align    2
    .set    .LANCHOR0,. + 0
.LC0:
    .word    8
    .word    10
    .word    20
    .word    4
```

```
    .word    6
    .section    .rodata.str1.4,"aMS",@progbits,1
    .align    2
.LC1:
    .string    "%d\n"
.LC2:
    .string    "pause"
    .ident    "GCC: (SiFive GCC 8.3.0-2020.04.1) 8.3.0"
```

Листинг 2.4. Файл fun.s

```
                .file    "fun.c"
    .option nopic
    .attribute arch, "rv32i2p0"
    .attribute unaligned_access, 0
    .attribute stack_align, 16
    .text
    .globl    __modsi3
    .align    2
    .globl    lol
    .type    lol, @function
lol:
    addi    sp,sp,-32
    sw    ra,28(sp)
    sw    s0,24(sp)
```

```
    sw    s1,20(sp)
    sw    s2,16(sp)
    sw    s3,12(sp)
    sw    s4,8(sp)
    sw    s5,4(sp)
    sw    s6,0(sp)
    mv    s3,a1
    mv    s4,a2
    ble    a1,zero,.L10
    mv    a5,a2
    slli    a3,a1,2
    add    a3,a3,a2
    mv    s2,a0
    j    .L4
.L3:
    addi    a5,a5,4
    beq    a5,a3,.L2
.L4:
    lw    a4,0(a5)
    ble    s2,a4,.L3
    mv    s2,a4
    j    .L3
.L10:
    mv    s2,a0
.L2:
```

```
    neg    s6,s3
    addi    s5,s4,4
.L5:
    blt    s3,zero,.L1
    mv    a1,s2
    lw    a0,0(s4)
    call    __modsi3
    bne    a0,zero,.L6
    mv    s1,s5
    mv    s0,s6
.L9:
    beq    s0,zero,.L1
    addi    s0,s0,1
    mv    a1,s2
    lw    a0,0(s1)
    call    __modsi3
    addi    s1,s1,4
    beq    a0,zero,.L9
.L6:
    addi    s2,s2,-1
    j    .L5
.L1:
    mv    a0,s2
    lw    ra,28(sp)
    lw    s0,24(sp)
```

```
    lw    s1,20(sp)
    lw    s2,16(sp)
    lw    s3,12(sp)
    lw    s4,8(sp)
    lw    s5,4(sp)
    lw    s6,0(sp)
    addi    sp,sp,32
    jr    ra
    .size    lol, .-lol
    .ident    "GCC: (SiFive GCC 8.3.0-2020.04.1) 8.3.0"
```

Ассемблирование

Листинг 2.5. Заголовки секций файла main.o

```
riscv64-unknown-elf-objdump.exe -h main.o
```

```
main.o:     file format elf32-littleriscv

Sections:
Idx Name          Size      VMA       LMA       File off  Algn
  0 .text         00000080  00000000  00000000  00000034  2**2
                  CONTENTS, ALLOC, LOAD, RELOC, READONLY, CODE
  1 .data         00000000  00000000  00000000  000000b4  2**0
                  CONTENTS, ALLOC, LOAD, DATA
  2 .bss          00000000  00000000  00000000  000000b4  2**0
                  ALLOC
  3 .rodata       00000014  00000000  00000000  000000b4  2**2
                  CONTENTS, ALLOC, LOAD, READONLY, DATA
  4 .rodata.str1.4 0000000a  00000000  00000000  000000c8  2**2
                  CONTENTS, ALLOC, LOAD, READONLY, DATA
  5 .comment      00000029  00000000  00000000  000000d2  2**0
                  CONTENTS, READONLY
  6 .riscv.attributes 0000001c  00000000  00000000  000000fb  2**0
                  CONTENTS, READONLY
```

Листинг 2.6. Таблица символов файла main.o

riscv64-unknown-elf-objdump.exe –t main.o

```
main.o:     file format elf32-littleriscv

SYMBOL TABLE:
00000000 l    df *ABS*  00000000 main.c
00000000 l    d  .text  00000000 .text
00000000 l    d  .data  00000000 .data
00000000 l    d  .bss   00000000 .bss
00000000 l    d  .rodata        00000000 .rodata
00000000 l       .rodata        00000000 .LANCHOR0
00000000 l    d  .rodata.str1.4 00000000 .rodata.str1.4
00000000 l       .rodata.str1.4 00000000 .LC1
00000004 l       .rodata.str1.4 00000000 .LC2
00000000 l    d  .comment       00000000 .comment
00000000 l    d  .riscv.attributes      00000000 .riscv.attributes
00000000 g     F .text  00000080 main
00000000         *UND*  00000000 lol
00000000         *UND*  00000000 printf
00000000         *UND*  00000000 system
```

Листинг 2.7. Таблица перемещений файла main.o

riscv64-unknown-elf-objdump.exe -d -M no-aliases -r main.o

```
main.o:     file format elf32-littleriscv


Disassembly of section .text:

00000000 <main>:
   0:   fd010113                addi    sp,sp,-48
   4:   02112623                sw      ra,44(sp)
   8:   000007b7                lui     a5,0x0
                        8: R_RISCV_HI20 .LANCHOR0
                        8: R_RISCV_RELAX        *ABS*
   c:   00078793                addi    a5,a5,0 # 0 <main>
                        c: R_RISCV_LO12_I       .LANCHOR0
                        c: R_RISCV_RELAX        *ABS*
  10:   0007a583                lw      a1,0(a5)
  14:   0047a603                lw      a2,4(a5)
  18:   0087a683                lw      a3,8(a5)
  1c:   00c7a703                lw      a4,12(a5)
  20:   0107a783                lw      a5,16(a5)
  24:   00b12623                sw      a1,12(sp)
  28:   00c12823                sw      a2,16(sp)
  2c:   00d12a23                sw      a3,20(sp)
  30:   00e12c23                sw      a4,24(sp)
  34:   00f12e23                sw      a5,28(sp)
  38:   00c10613                addi    a2,sp,12
  3c:   00500593                addi    a1,zero,5
  40:   00800513                addi    a0,zero,8
  44:   00000097                auipc   ra,0x0
                        44: R_RISCV_CALL        lol
                        44: R_RISCV_RELAX       *ABS*
  48:   000080e7                jalr    ra,0(ra) # 44 <main+0x44>
  4c:   00050593                addi    a1,a0,0
  50:   00000537                lui     a0,0x0
                        50: R_RISCV_HI20        .LC1
                        50: R_RISCV_RELAX       *ABS*
  54:   00050513                addi    a0,a0,0 # 0 <main>
                        54: R_RISCV_LO12_I      .LC1
                        54: R_RISCV_RELAX       *ABS*
  58:   00000097                auipc   ra,0x0
                        58: R_RISCV_CALL        printf
                        58: R_RISCV_RELAX       *ABS*
  5c:   000080e7                jalr    ra,0(ra) # 58 <main+0x58>
  60:   00000537                lui     a0,0x0
                        60: R_RISCV_HI20        .LC2
                        60: R_RISCV_RELAX       *ABS*
  64:   00050513                addi    a0,a0,0 # 0 <main>
                        64: R_RISCV_LO12_I      .LC2
```

```
                        60: R_RISCV_RELAX       *ABS*
  64:   00050513                addi    a0,a0,0 # 0 <main>
                        64: R_RISCV_LO12_I      .LC2
                        64: R_RISCV_RELAX       *ABS*
  68:   00000097                auipc   ra,0x0
                        68: R_RISCV_CALL        system
                        68: R_RISCV_RELAX       *ABS*
  6c:   000080e7                jalr    ra,0(ra) # 68 <main+0x68>
  70:   00000513                addi    a0,zero,0
  74:   02c12083                lw      ra,44(sp)
  78:   03010113                addi    sp,sp,48
  7c:   00008067                jalr    zero,0(ra)
```

Листинг 2.8. Заголовки секций файла fun.o

```
Sections:
Idx Name          Size      VMA       LMA       File off  Algn
  0 .text         00000080  00000000  00000000  00000034  2**2
                  CONTENTS, ALLOC, LOAD, RELOC, READONLY, CODE
  1 .data         00000000  00000000  00000000  000000b4  2**0
                  CONTENTS, ALLOC, LOAD, DATA
  2 .bss          00000000  00000000  00000000  000000b4  2**0
                  ALLOC
  3 .rodata       00000014  00000000  00000000  000000b4  2**2
                  CONTENTS, ALLOC, LOAD, READONLY, DATA
  4 .rodata.str1.4 0000000a  00000000  00000000  000000c8  2**2
                  CONTENTS, ALLOC, LOAD, READONLY, DATA
  5 .comment      00000029  00000000  00000000  000000d2  2**0
                  CONTENTS, READONLY
  6 .riscv.attributes 0000001c  00000000  00000000  000000fb  2**0
                  CONTENTS, READONLY
```

Листинг 2.9. Таблица символов файла fun.o

```
main.o:     file format elf32-littleriscv

SYMBOL TABLE:
00000000 l    df *ABS*  00000000 main.c
00000000 l    d  .text  00000000 .text
00000000 l    d  .data  00000000 .data
00000000 l    d  .bss   00000000 .bss
00000000 l    d  .rodata        00000000 .rodata
00000000 l       .rodata        00000000 .LANCHOR0
00000000 l    d  .rodata.str1.4 00000000 .rodata.str1.4
00000000 l       .rodata.str1.4 00000000 .LC1
00000004 l       .rodata.str1.4 00000000 .LC2
00000000 l    d  .comment       00000000 .comment
00000000 l    d  .riscv.attributes      00000000 .riscv.attributes
00000000 g     F .text  00000080 main
00000000         *UND*  00000000 lol
00000000         *UND*  00000000 printf
00000000         *UND*  00000000 system
```

Компановка

riscv64-unknown-elf-gcc.exe -v main.o fun.o

Листинг 2.10. Исполняемый файл a.out

riscv64-unknown-elf-objdump.exe –j .txt –d –M no-aliases a.out >a.ds

```
a.out:     file format elf64-littleriscv

0000000000010158 <main>:
   10158:       715d                    c.addi16sp    sp,-80
   1015a:       e486            c.sdsp  ra,72(sp)
   1015c:       e0a2            c.sdsp  s0,64(sp)
   1015e:       fc26            c.sdsp  s1,56(sp)
   10160:       f84a            c.sdsp  s2,48(sp)
   10162:       67f1            c.lui   a5,0x1c
   10164:       11078793                addi    a5,a5,272 # 1c110 <__clzdi2+0x30>
   10168:       638c            c.ld    a1,0(a5)
   1016a:       6790                    c.ld    a2,8(a5)
   1016c:       6b94                    c.ld    a3,16(a5)
   1016e:       6f98            c.ld    a4,24(a5)
   10170:       739c              c.ld          a5,32(a5)
   10172:       e42e            c.sdsp  a1,8(sp)
   10174:       e832            c.sdsp  a2,16(sp)
   10176:       ec36            c.sdsp  a3,24(sp)
```

```
  10178:	f03a           	c.sdsp  a4,32(sp)
  1017a:	f43e           	c.sdsp  a5,40(sp)
  1017c:	002c           	c.addi4spn  a1,sp,8
  1017e:	4529           	c.li    a0,10
  10180:	02a000ef       	jal     ra,101aa <fun>
  10184: 0020                   c.addi4spn              s0,sp,8
10186: 03010913                 addi    s2,sp,48
 1018a: 64f1            c.lui   s1,0x1c
1018c: 400c             c.lw    a1,0(s0)
10186: 03010913                 addi    s2,sp,48
1018a: 64f1             c.lui   s1,0x1c
1018c: 400c             c.lw    a1,0(s0)
  10186:	03010913       	addi    s2,sp,48
  1018a:	64f1           	c.lui   s1,0x1c
  1018c:	400c           	c.lw    a1,0(s0)
  1018e:	13848513       	addi    a0,s1,312 # 1c138 <__clzdi2+0x58>
  10192:	204000ef       	jal     ra,10396 <printf>
  10196:	0411           	c.addi  s0,4
  10198:	ff241ae3       	bne     s0,s2,1018c <main+0x34>
  1019c:	4501           	c.li    a0,0
  1019e:	60a6           	c.ldsp  ra,72(sp)
  101a0:	6406           	c.ldsp  s0,64(sp)
  101a2:	74e2           	c.ldsp  s1,56(sp)
  101a4:	7942           	c.ldsp  s2,48(sp)
  101a6:	6161           	c.addi16sp  sp,80
```

```
   101a8:       8082                    c.jr    ra

00000000000101aa <fun>:
   101aa:       4785                    c.li    a5,1
   101ac:       04a7d663                        bge     a5,a0,101f8 <fun+0x4e>
   101b0:       00458813                        addi    a6,a1,4
   101b4:       fff5031b        addiw  t1,a0,-1
   101b8:       4881                    c.li    a7,0
   101ba:       557d                    c.li    a0,-1
   101bc:       a809            c.j     101ce <fun+0x24>
   101be:       0785                    c.addi  a5,1
   101c0:       078a            c.slli  a5,0x2
   101c2:       97ae            c.add   a5,a1
   101c4:       c390            c.sw    a2,0(a5)
   101c6:       2885                    c.addiw         a7,1
   101c8:       0811            c.addi  a6,4
   101ca:       02688763                        beq     a7,t1,101f8 <fun+0x4e>
   101ce:       00082603                        lw      a2,0(a6)
   101d2:       0008879b                        addiw  a5,a7,0
   101d6:       fe07c4e3                bltz    a5,101be <fun +0x14>
   101da:       ffc82683                lw      a3,-4(a6)
   101de:       fed650e3                bge     a2,a3,101be <fun +0x14>
   101e2:       8742                    c.mv    a4,a6
   101e4:       c314            c.sw    a3,0(a4)
   101e6:       37fd            c.addiw         a5,-1
   101e8:       fca78be3                beq     a5,a0,101be <fun +0x14>
```

```
101ec:	1771		c.addi	a4,-4
101ee:	ffc72683		lw	a3,-4(a4)
101f2:	fed649e3		blt	a2,a3,101e4 <fun +0x3a>
101f6:	b7e1		c.j	101be <fun +0x14>
101f8:	8082		c.jr	ra
```

3. Создание статической библиотеки и make-файлов

Сделаем из fun.c статическую библиотеку fui, тестовую программу main.c оставим без изменений.

получим объектный файлfun.o

riscv64-unknown-elf-gcc.exe -O1 -c fun.c -o fu.o

из получившегося файла делаем библиотеку

riscv64-unknown-elf-ar.exe -rsc fu.a fun.o

собираем исполняющий файл

riscv64-unknown-elf-gcc.exe -O1 --save-temps main.c fu.a

Листинг 3.1. Таблица символов исполняемого файла

Листинг 3.2. Makefile для создания статической библиотеки

```
# Цели
.PHONY: all clean
# Исходные файлы для сборки библиотеки
OBJS= fun.c
#Вызываемые приложения
```

```
AR = riscv64-unknown-elf-ar.exe
CC = riscv64-unknown-elf-gcc.exe
# Файл библиотеки
MYLIBNAME = fu.a
# Параметры компиляции
CFLAGS= -O1
# файлы искать в данном каталоге
INCLUDES+= -I .
# Make ищет файлы ... .h и ... .c в текущей директории
vpath %.h .
vpath %.c .
# $< = %.c
# $@ = %.o
%.o: %.c
  $(CC) -MD $(CFLAGS) $(INCLUDES) -c $< -o $@
# Для того чтобы выполнить задачу "all", требуется построить библиотеку
all: $(MYLIBNAME)
# $^ = (fun.o)
$(MYLIBNAME): fu.o
  $(AR) -rsc $@ $^
```

Листинг 3.3. Makefile для сборки исполняемого файла

```
# Цели
.PHONY: all clean
```

```
# Исходные файлы для сборки библиотеки
OBJS= main.c \
  fu.a
#Вызываемые приложения
CC = riscv64-unknown-elf-gcc.exe
# Компиляция
CFLAGS= -O1 --save-temps
#файлы искать в данном каталоге
INCLUDES+= -I .
# Make ищет файлы … .c и … .a в текущей директории
vpath %.c .
vpath %.a .
# Для того чтобы выполнить задачу "all", требуется построить библиотеку
all: a.out
# Сборка файла
a.out: $(OBJS)
   $(CC) $(CFLAGS) $(INCLUDES) $^
   del *.o *.i *.s *.d
```

Листинг 3.4. Запуск Makefile

Запускаем Makefile.win, потом Makefile1.win со сборкой исполняемого файла.

```
mingw32-make.exe -f Makefile.win Makefile1.win
```

Листинг 3.5. Таблица символов исполняемого файла, созданного с помощью Makefile

Созданный файл идентичен файлу созданному ранее

```
SYMBOL TABLE:
00000000 l    df *ABS*  00000000 main.c
00000000 l    d  .text  00000000 .text
00000000 l    d  .data  00000000 .data
00000000 l    d  .bss   00000000 .bss
00000000 l    d  .rodata        00000000 .rodata
00000000 l       .rodata        00000000 .LANCHOR0
00000000 l    d  .rodata.str1.4 00000000 .rodata.str1.4
00000000 l       .rodata.str1.4 00000000 .LC1
00000004 l       .rodata.str1.4 00000000 .LC2
00000000 l    d  .comment       00000000 .comment
00000000 l    d  .riscv.attributes      00000000 .riscv.attributes
00000000 g     F .text  00000080 main
00000000         *UND*  00000000 lol
00000000         *UND*  00000000 printf
00000000         *UND*  00000000 system
```

Вывод

В этой курсовой работе была разработана функция на языке C, которая находит наименьшее число в списке, и с помощью символа (%) мы находим, можно ли его разделить на 0 или нет, что, если все значения равны, приведет к 0 .

Были изучены особенности каждого этапа пошаговой сборки набора программ, а также инструменты, позволяющие выделить разработанные программы в статическую библиотеку и автоматизировать сборку этой библиотеки.

Проанализированы ход сборки библиотеки и программы, созданные файлы зависимостей.