

План лекции

Общие сведения

Библиотека `libc`

Библиотека `glibc`

Оглавление руководства по библиотеке `glibc`

Текст подключаемый препроцессором C к файлу `call-as.c`

Общие сведения

Язык C спроектирован как лаконичный язык и не предоставляет встроенных средств на уровне его ключевых слов для выполнения таких распространенных операций, как:

- низкоуровневой или форматированный ввод/вывод;
- управление строками;
- вычисление арифметических и математических функций;
- управление памятью, процессами, файловыми системами, сетевыми соединениями;
- и т. п.

Для решения таких задач применяется стандартная библиотека языка C (также известная как `libc`). Сама по себе она не является частью языка, однако предусмотренный в ней набор функций, а также определений типов и макроопределений составляет системную среду, поддерживающую разработку ПО на C.

В 1978 году **Брайан Керниган** и **Деннис Ритчи** опубликовали первую редакцию книги «Язык программирования С», содержащую систематическое описание такого подхода. Эта книга, известная среди программистов как «**K&R**», служила многие годы неформальной спецификацией языка и выдержала в США около сорока изданий. Подход «**K&R**» и его реализации оказались очень плодотворными и активно использовались при разработке большого числа проектов.

Язык С был и остаётся одним из самых распространённых языков программирования в течение пятидесяти лет и, по сути является - языка общения (*lingua franca*) между разработчиками. Большая группа языков унаследовали базовый синтаксис С (использование фигурных скобок в качестве ограничителей блоков кода, описание переменных, характерные формы операторов `for`, `while`, `if`, `switch` с параметрами в скобках, комбинированные операции `++`, `--`, `+=`, `-=` и другие), из-за чего программы на этих языках имеют характерный внешний вид, ассоциирующийся именно с С. Это такие языки как `C++`, `Objective C`, `Java`, `JavaScript`, `PHP`, `Perl`, `AWK`, `C#`, `Go` и др.

С — язык системного программирования:

- Эффективный машинный код. Используется вместо ассемблера.
- Применяется при разработке системного ПО для платформ от супер ЭВМ до встроенных.
- Неполный список продуктов, реализованных на С.
 - ♦ Ядра ОС `Unix` (и всех ее производных), `MS Windows`, `Linux`, `OS X`, `iOS`, `Android`, `Windows Phone`.
 - ♦ СУБД `Oracle Database`, `MySQL`, `MS SQL Server`, `PostgreSQL`.

- ♦ Первые реализации языков Java, Python, Perl и PHP.
- Cpython - эталонная реализация языка Python.
- Промежуточный язык. В Первых реализациях языков C++, Objective-C, Go — код, написанный на этих языках, транслировался на язык C.
- Реализован для большинства аппаратных платформ и ОС.}

C – отличный язык для выражения общих идей в программировании способом, который удобен большинству программистов. Более того, многие принципы, используемые в C – например, argc и argv для параметров командной строки, будут отображаться во многих других языках, так что вы сможете общаться с людьми, даже если они не знают C, способом, который является общим для вас обоих. Эти сопоставления говорят о существенной «C-ориентации» мышления современных системных программистов.

C - фундаментальная основа квалификации программиста.

Библиотека libc

Библиотека libc была стандартизована в 1989 г. как часть стандарта ANSI C, который в 1990 г. был признан ISO (текущая актуальная версия стандарта, т. н. C18 — ISO/IEC 9899:2018 Information technology — Programming languages — C).

Библиотека состоит из нескольких десятков заголовочных файлов, подключаемых к программному проекту директивами. Эти файлы содержат описания одной или более функций, определения типов данных и макроопределения.

NBND. В стандарте библиотека представлена как описание интерфейса прикладного программирования — API (Application Programming Interface) и для практического применения она должна быть реализована для конкретного компилятора и/или операционной системы.

Таким образом `libc` является неотъемлемой частью каждой реализации языка C.

Существует несколько десятков реализаций `libc`, в том числе такие широко применяемые как:

- GNU C Library — `glibc` — самая распространенная реализация, используемая в ОС Linux;
- Microsoft C Run-time Library, используемая в ОС Windows;
- `libSystem`, используемая в ОС iOS компании Apple;
- `Bionic`, разработанная компанией Google для ОС Android.

Библиотека `libc` оказала основополагающее влияние на реализации большинства современных системы программирования, среди которых C++, Python, Rust, GO и др. Например каждый заголовочный файл из стандартной библиотеки языка C включен в стандартную библиотеку языка C++ под именами, созданными путём отсечения в имени файла расширения `.h` и добавлением символа 'C' в начале имени, например имени `'time.h'` соответствует `'ctime'`.

Единственное отличие между этими заголовочными файлами и традиционными заголовочными файлами стандартной библиотеки языка C заключается в том, что функции должны быть помещены в пространство имен `std::` (хотя некоторые компиляторы сами делают это).

Библиотека glibc

Библиотека glibc обновляется два раза в год. Ее функции, требующие работы в адресном пространстве ядра, используют системные вызовы. В руководстве к актуальной версии glibc функции разбиты на 36 групп различного назначения. Информацию о текущей версии glibc, установленной в конкретной версии ОС Linux можно получит командой:

```
/lib/libc.so.6
```

Ссылки на описание glibc:

<https://www.gnu.org/software/libc/manual/>

Общая характеристика glibc на 25.04.2021 {25.07.23} со стр.

<https://www.openhub.net/p/glibc>

Code Locations: git://sourceware.org/git/glibc.git

In a Nutshell, GNU C Library...

...

has had 37,147 {40307} commits made by 604 {720} contributors representing 1,302,579 {1419588} lines of code

...

is mostly written in C

with an average number of source code comments:

Across all C projects on Open Hub, 19% of all source code lines are comments. This holds true for GNU C Library as well.

...

has a well established, mature codebase maintained by a very large development team with increasing Y - O - Y commits

...

took an estimated 371 **{406}** years of effort (COCOMO model)

starting with its first commit in February, 1995

ending with its most recent commit 7 months ago

COCOMO - Constructive Cost Model

Данные на 25.04.2021 о распределении языков программирования в коде со стр.:

https://www.openhub.net/p/glibc/analyses/latest/languages_summary

Language	Code Lines	Comment Lines	Comment Ratio	Blank Lines	Total Lines	Total Percentage
C	971,675	238,172	19.7%	152,531	1,362,378	74.0%
Assembly	257,940	75,262	22.6%	40,667	373,869	20.3%
C++	17,017	6,662	28.1%	4,131	27,810	1.5%
Autoconf	15,117	153	1.0%	1,719	16,989	0.9%
Make	12,581	2,802	18.2%	2,759	18,142	1.0%
shell script	9,694	2,026	17.3%	1,177	12,897	0.7%
Python	8,863	3,897	30.5%	1,413	14,173	0.8%
TeX/LaTeX	7,163	3,695	34.0%	816	11,674	0.6%
AWK	1,898	373	16.4%	266	2,537	0.1%
Perl	631	143	18.5%	87	861	0.0%
Totals	1,302,579	333,185		205,566	1,841,330	

Освоив соглашения стандарта ABI о связях функций разработчик получает доступ из языка ассемблера и из всех других языков и систем программирования, поддерживающих ABI к примерно 1500 (количество зависит от версии и реализации) функций библиотеки языка glibc, представляющей *золотой фонд программирования*.

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Полное содержание руководства по библиотеке glibc

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Текст подключаемый препроцессором C к файлу `call-as.c`

Для того чтобы продемонстрировать масштаб `glibc` и объем проделанной работы рассмотрим какой текст подключает препроцессор C к файлу `call-as.c` из предыдущей лекции.

```
#include <stdio.h>
/* прототип внешней функции.
   Параметр 1 - количество символов, кот. надо обработать
   Параметр 2 - адрес первого элемента массива
 */
extern void *Read_Sym(int, char*);
/* массив результатов*/
```

```

int Numbers[10];
int main()
{
    char Symbols[14] = "91A23B456C789"; /* исходный массив */
    int i;
    printf ("%s\n", Symbols);
    Read_Sym(8, Symbols);                /* вызов as функции */
    /* печать результата */
    for (i = 0; i < 8; i++)
        printf("%d\t", Numbers[i]);
    return 0;
}

```

Код, формируемый препроцессором, можно получить командой:

```
gcc -m32 -gstabs+ -E -P call-as.c > call-as.1pp
```

Приведенный ниже файл call-as.1pp объемом 306 строк содержит код, полученный препроцессором для фазы компиляции из файла call-as.c объемом 46 строк.

```

typedef unsigned int size_t;
typedef unsigned char __u_char;
typedef unsigned short int __u_short;
typedef unsigned int __u_int;
typedef unsigned long int __u_long;
typedef signed char __int8_t;
typedef unsigned char __uint8_t;
typedef signed short int __int16_t;
typedef unsigned short int __uint16_t;
typedef signed int __int32_t;
typedef unsigned int __uint32_t;

```

```
__extension__ typedef signed long long int __int64_t;
__extension__ typedef unsigned long long int __uint64_t;
__extension__ typedef long long int __quad_t;
__extension__ typedef unsigned long long int __u_quad_t;
__extension__ typedef long long int __intmax_t;
__extension__ typedef unsigned long long int __uintmax_t;
__extension__ typedef __u_quad_t __dev_t;
__extension__ typedef unsigned int __uid_t;
__extension__ typedef unsigned int __gid_t;
__extension__ typedef unsigned long int __ino_t;
__extension__ typedef __u_quad_t __ino64_t;
__extension__ typedef unsigned int __mode_t;
__extension__ typedef unsigned int __nlink_t;
__extension__ typedef long int __off_t;
__extension__ typedef __quad_t __off64_t;
__extension__ typedef int __pid_t;
__extension__ typedef struct { int __val[2]; } __fsid_t;
__extension__ typedef long int __clock_t;
__extension__ typedef unsigned long int __rlim_t;
__extension__ typedef __u_quad_t __rlim64_t;
__extension__ typedef unsigned int __id_t;
__extension__ typedef long int __time_t;
__extension__ typedef unsigned int __useconds_t;
__extension__ typedef long int __suseconds_t;
__extension__ typedef int __daddr_t;
__extension__ typedef int __key_t;
__extension__ typedef int __clockid_t;
__extension__ typedef void * __timer_t;
__extension__ typedef long int __blksize_t;
__extension__ typedef long int __blkcnt_t;
__extension__ typedef __quad_t __blkcnt64_t;
__extension__ typedef unsigned long int __fsblkcnt_t;
__extension__ typedef __u_quad_t __fsblkcnt64_t;
```

```
__extension__ typedef unsigned long int __fsfilcnt_t;
__extension__ typedef __u_quad_t __fsfilcnt64_t;
__extension__ typedef int __fsword_t;
__extension__ typedef int __ssize_t;
__extension__ typedef long int __syscall_slong_t;
__extension__ typedef unsigned long int __syscall_ulong_t;
typedef __off64_t __loff_t;
typedef __quad_t *__qaddr_t;
typedef char *__caddr_t;
__extension__ typedef int __intptr_t;
__extension__ typedef unsigned int __socklen_t;
typedef int __sig_atomic_t;
struct _IO_FILE;
typedef struct _IO_FILE __FILE;
struct _IO_FILE;
typedef struct _IO_FILE FILE;
typedef struct
{
    int __count;
    union
    {
        unsigned int __wch;
        char __wchb[4];
    } __value;
} __mbstate_t;
typedef struct
{
    __off_t __pos;
    __mbstate_t __state;
} _G_fpos_t;
typedef struct
{
    __off64_t __pos;
```



```

__mbstate_t __state;
} _G_fpos64_t;
typedef __builtin_va_list __gnuc_va_list;
struct _IO_jump_t; struct _IO_FILE;
typedef void _IO_lock_t;
struct _IO_marker {
    struct _IO_marker *_next;
    struct _IO_FILE *_sbuf;
    int _pos;
};
enum __codecvt_result
{
    __codecvt_ok,
    __codecvt_partial,
    __codecvt_error,
    __codecvt_noconv
};
struct _IO_FILE {
    int _flags;
    char* _IO_read_ptr;
    char* _IO_read_end;
    char* _IO_read_base;
    char* _IO_write_base;
    char* _IO_write_ptr;
    char* _IO_write_end;
    char* _IO_buf_base;
    char* _IO_buf_end;
    char *_IO_save_base;
    char *_IO_backup_base;
    char *_IO_save_end;
    struct _IO_marker *_markers;
    struct _IO_FILE *_chain;
    int _fileno;

```

```

int _flags2;
__off_t _old_offset;
unsigned short _cur_column;
signed char _vtable_offset;
char _shortbuf[1];
_IO_lock_t *_lock;
__off64_t _offset;
void *__pad1;
void *__pad2;
void *__pad3;
void *__pad4;
size_t __pad5;
int _mode;
char _unused2[15 * sizeof (int) - 4 * sizeof (void *) -
sizeof (size_t)];
};
typedef struct _IO_FILE _IO_FILE;
struct _IO_FILE_plus;
extern struct _IO_FILE_plus _IO_2_1_stdin_;
extern struct _IO_FILE_plus _IO_2_1_stdout_;
extern struct _IO_FILE_plus _IO_2_1_stderr_;
typedef __ssize_t __io_read_fn (void *__cookie, char
*__buf, size_t __nbytes);
typedef __ssize_t __io_write_fn (void *__cookie, const
char *__buf,
    size_t __n);
typedef int __io_seek_fn (void *__cookie, __off64_t
*__pos, int __w);
typedef int __io_close_fn (void *__cookie);
extern int __underflow (_IO_FILE *);
extern int __uflow (_IO_FILE *);
extern int __overflow (_IO_FILE *, int);
extern int _IO_getc (_IO_FILE *__fp);

```

```
extern int _IO_putc (int __c, _IO_FILE *__fp);
extern int _IO_feof (_IO_FILE *__fp) __attribute__
((__nothrow__ , __leaf__));
extern int _IO_ferror (_IO_FILE *__fp) __attribute__
((__nothrow__ , __leaf__));
extern int _IO_peekc_locked (_IO_FILE *__fp);
extern void _IO_flockfile (_IO_FILE *) __attribute__
((__nothrow__ , __leaf__));
extern void _IO_funlockfile (_IO_FILE *) __attribute__
((__nothrow__ , __leaf__));
extern int _IO_ftrylockfile (_IO_FILE *) __attribute__
((__nothrow__ , __leaf__));
```

```
extern int _IO_vfscanf (_IO_FILE * __restrict, const char
* __restrict, __gnuc_va_list, int *__restrict);
extern int _IO_vfprintf (_IO_FILE *__restrict, const char
* __restrict, __gnuc_va_list);
```

```
extern __ssize_t _IO_padn (_IO_FILE *, int, __ssize_t);
extern size_t _IO_sgetn (_IO_FILE *, void *, size_t);
extern __off64_t _IO_seekoff (_IO_FILE *, __off64_t, int,
int);
extern __off64_t _IO_seekpos (_IO_FILE *, __off64_t, int);
extern void _IO_free_backup_area (_IO_FILE *)
__attribute__ ((__nothrow__ , __leaf__));
typedef __gnuc_va_list va_list;
typedef __off_t off_t;
typedef __ssize_t ssize_t;
typedef _G_fpos_t fpos_t;
extern struct _IO_FILE *stdin;
extern struct _IO_FILE *stdout;
extern struct _IO_FILE *stderr;
```

```

extern int remove (const char *__filename) __attribute__
((__nothrow__ , __leaf__));
extern int rename (const char *__old, const char *__new)
__attribute__ ((__nothrow__ , __leaf__));
extern int renameat (int __oldfd, const char *__old, int
__newfd,
    const char *__new) __attribute__ ((__nothrow__ ,
__leaf__));
extern FILE *tmpfile (void) ;
extern char *tmpnam (char *__s) __attribute__
((__nothrow__ , __leaf__)) ;
extern char *tmpnam_r (char *__s) __attribute__
((__nothrow__ , __leaf__)) ;
extern char *tempnam (const char *__dir, const char
*__pfx)
    __attribute__ ((__nothrow__ , __leaf__))
__attribute__ ((__malloc__)) ;
extern int fclose (FILE *__stream);
extern int fflush (FILE *__stream);
extern int fflush_unlocked (FILE *__stream);
extern FILE *fopen (const char *__restrict __filename,
    const char *__restrict __modes) ;
extern FILE *freopen (const char *__restrict __filename,
    const char *__restrict __modes,
    FILE *__restrict __stream) ;
extern FILE *fdopen (int __fd, const char *__modes)
__attribute__ ((__nothrow__ , __leaf__)) ;
extern FILE *fmemopen (void *__s, size_t __len, const char
*__modes)
    __attribute__ ((__nothrow__ , __leaf__)) ;
extern FILE *open_memstream (char **__bufloc, size_t
*__sizeloc) __attribute__ ((__nothrow__ , __leaf__)) ;

```

```
extern void setbuf (FILE *__restrict __stream, char
*__restrict __buf) __attribute__ ((__nothrow__ , __leaf__));
extern int setvbuf (FILE *__restrict __stream, char
*__restrict __buf,
    int __modes, size_t __n) __attribute__ ((__nothrow__
, __leaf__));
extern void setbuffer (FILE *__restrict __stream, char
*__restrict __buf,
    size_t __size) __attribute__ ((__nothrow__ ,
__leaf__));
extern void setlinebuf (FILE *__stream) __attribute__
((__nothrow__ , __leaf__));
```

```
extern int fprintf (FILE *__restrict __stream,
    const char *__restrict __format, ...);
extern int printf (const char *__restrict __format, ...);
extern int sprintf (char *__restrict __s,
    const char *__restrict __format, ...) __attribute__
((__nothrow__));
extern int vfprintf (FILE *__restrict __s, const char
*__restrict __format,
    __gnuc_va_list __arg);
extern int vprintf (const char *__restrict __format,
    __gnuc_va_list __arg);
extern int vsprintf (char *__restrict __s, const char
*__restrict __format,
    __gnuc_va_list __arg) __attribute__
((__nothrow__));
extern int snprintf (char *__restrict __s, size_t
__maxlen,
    const char *__restrict __format, ...)
```

```

        __attribute__((__nothrow__)) __attribute__
((__format__ (__printf__, 3, 4)));
extern int vsnprintf (char *__restrict __s, size_t
__maxlen,
        const char *__restrict __format, __gnuc_va_list
__arg)
        __attribute__((__nothrow__)) __attribute__
((__format__ (__printf__, 3, 0)));
extern int vdprintf (int __fd, const char *__restrict
__fmt,
        __gnuc_va_list __arg)
        __attribute__((__format__ (__printf__, 2, 0)));
extern int dprintf (int __fd, const char *__restrict
__fmt, ...)
        __attribute__((__format__ (__printf__, 2, 3)));

```

```

extern int fscanf (FILE *__restrict __stream,
        const char *__restrict __format, ...) ;
extern int scanf (const char *__restrict __format, ...) ;
extern int sscanf (const char *__restrict __s,
        const char *__restrict __format, ...) __attribute__
((__nothrow__ , __leaf__));
extern int fscanf (FILE *__restrict __stream, const char
*__restrict __format, ...) __asm__ ("\" __isoc99_fscanf") ;
extern int scanf (const char *__restrict __format, ...)
__asm__ ("\" __isoc99_scanf") ;
extern int sscanf (const char *__restrict __s, const char
*__restrict __format, ...) __asm__ ("\" __isoc99_sscanf")
__attribute__((__nothrow__ , __leaf__));

```

```

extern int vfscanf (FILE *__restrict __s, const char
*__restrict __format,
    __gnuc_va_list __arg)
    __attribute__ ((__format__ (__scanf__, 2, 0))) ;
extern int vscanf (const char *__restrict __format,
__gnuc_va_list __arg)
    __attribute__ ((__format__ (__scanf__, 1, 0))) ;
extern int vsscanf (const char *__restrict __s,
    const char *__restrict __format, __gnuc_va_list
__arg)
    __attribute__ ((__nothrow__ , __leaf__))
__attribute__ ((__format__ (__scanf__, 2, 0)));
extern int vfscanf (FILE *__restrict __s, const char
*__restrict __format, __gnuc_va_list __arg) __asm__ ("
"__isoc99_vfscanf")
    __attribute__ ((__format__ (__scanf__, 2, 0))) ;
extern int vscanf (const char *__restrict __format,
__gnuc_va_list __arg) __asm__ (" " "__isoc99_vscanf")
    __attribute__ ((__format__ (__scanf__, 1, 0))) ;
extern int vsscanf (const char *__restrict __s, const char
*__restrict __format, __gnuc_va_list __arg) __asm__ ("
"__isoc99_vsscanf") __attribute__ ((__nothrow__ , __leaf__))
    __attribute__ ((__format__ (__scanf__, 2, 0)));

```

```

extern int fgetc (FILE *__stream);
extern int getc (FILE *__stream);
extern int getchar (void);
extern int getc_unlocked (FILE *__stream);
extern int getchar_unlocked (void);
extern int fgetc_unlocked (FILE *__stream);
extern int fputc (int __c, FILE *__stream);
extern int putc (int __c, FILE *__stream);
extern int putchar (int __c);

```

```

extern int fputc_unlocked (int __c, FILE *__stream);
extern int putc_unlocked (int __c, FILE *__stream);
extern int putchar_unlocked (int __c);
extern int getw (FILE *__stream);
extern int putw (int __w, FILE *__stream);
extern char *fgets (char *__restrict __s, int __n, FILE
*__restrict __stream)
    ;
extern __ssize_t __getdelim (char **__restrict __lineptr,
    size_t *__restrict __n, int __delimiter,
    FILE *__restrict __stream) ;
extern __ssize_t getdelim (char **__restrict __lineptr,
    size_t *__restrict __n, int __delimiter,
    FILE *__restrict __stream) ;
extern __ssize_t getline (char **__restrict __lineptr,
    size_t *__restrict __n,
    FILE *__restrict __stream) ;
extern int fputs (const char *__restrict __s, FILE
*__restrict __stream);
extern int puts (const char *__s);
extern int ungetc (int __c, FILE *__stream);
extern size_t fread (void *__restrict __ptr, size_t
__size,
    size_t __n, FILE *__restrict __stream) ;
extern size_t fwrite (const void *__restrict __ptr, size_t
__size,
    size_t __n, FILE *__restrict __s);
extern size_t fread_unlocked (void *__restrict __ptr,
size_t __size,
    size_t __n, FILE *__restrict __stream) ;
extern size_t fwrite_unlocked (const void *__restrict
__ptr, size_t __size,
    size_t __n, FILE *__restrict __stream);

```



```
extern int fseek (FILE *__stream, long int __off, int
__whence);
extern long int ftell (FILE *__stream) ;
extern void rewind (FILE *__stream);
extern int fseeko (FILE *__stream, __off_t __off, int
__whence);
extern __off_t ftello (FILE *__stream) ;
extern int fgetpos (FILE *__restrict __stream, fpos_t
*__restrict __pos);
extern int fsetpos (FILE *__stream, const fpos_t *__pos);
extern void clearerr (FILE *__stream) __attribute__
((__nothrow__ , __leaf__));
extern int feof (FILE *__stream) __attribute__
((__nothrow__ , __leaf__)) ;
extern int ferror (FILE *__stream) __attribute__
((__nothrow__ , __leaf__)) ;
extern void clearerr_unlocked (FILE *__stream)
__attribute__ ((__nothrow__ , __leaf__));
extern int feof_unlocked (FILE *__stream) __attribute__
((__nothrow__ , __leaf__)) ;
extern int ferror_unlocked (FILE *__stream) __attribute__
((__nothrow__ , __leaf__)) ;
extern void perror (const char *__s);
extern int sys_nerr;
extern const char *const sys_errlist[];
extern int fileno (FILE *__stream) __attribute__
((__nothrow__ , __leaf__)) ;
extern int fileno_unlocked (FILE *__stream) __attribute__
((__nothrow__ , __leaf__)) ;
extern FILE *popen (const char *__command, const char
*__modes) ;
extern int pclose (FILE *__stream);
```

```
extern char *ctermid (char *__s) __attribute__((__nothrow__ , __leaf__));
extern void flockfile (FILE *__stream) __attribute__((__nothrow__ , __leaf__));
extern int ftrylockfile (FILE *__stream) __attribute__((__nothrow__ , __leaf__)) ;
extern void funlockfile (FILE *__stream) __attribute__((__nothrow__ , __leaf__));

extern void *Read_Sym(int, char*);
int Numbers[10];
int main()
{
    char Symbols[14] = "91A23B456C789";
    int i;
    printf ("%s\n", Symbols);
    Read_Sym(8, Symbols);
    for (i = 0; i < 8; i++)
        printf("%d\t", Numbers[i]);
    return 0;
}
```

«Впечатляющий» список разнообразного ПО, разработанного на C с использованием `glibc` можно найти по ссылке:

<https://github.com/kozross/awesome-c>