Univerzitetni študijski program, 3. letnik

Sistemska programska oprema

predavatelj: doc. Tomaž Dobravec

Objektni moduli

Objektni moduli

- Program je običajno sestavljen iz več ločenih (medseboj odvisnih ali neodvisnih) delov
- Vsak del je lahko pisan v svojem programskem jeziku
- Pred začetkom izvajanja programa mora povezovalnik vse njegove dele povezati v celoto

Da vse skupaj deluje pravilno, morajo biti deli programa predstavljeni na standarden način: objektna datoteka.

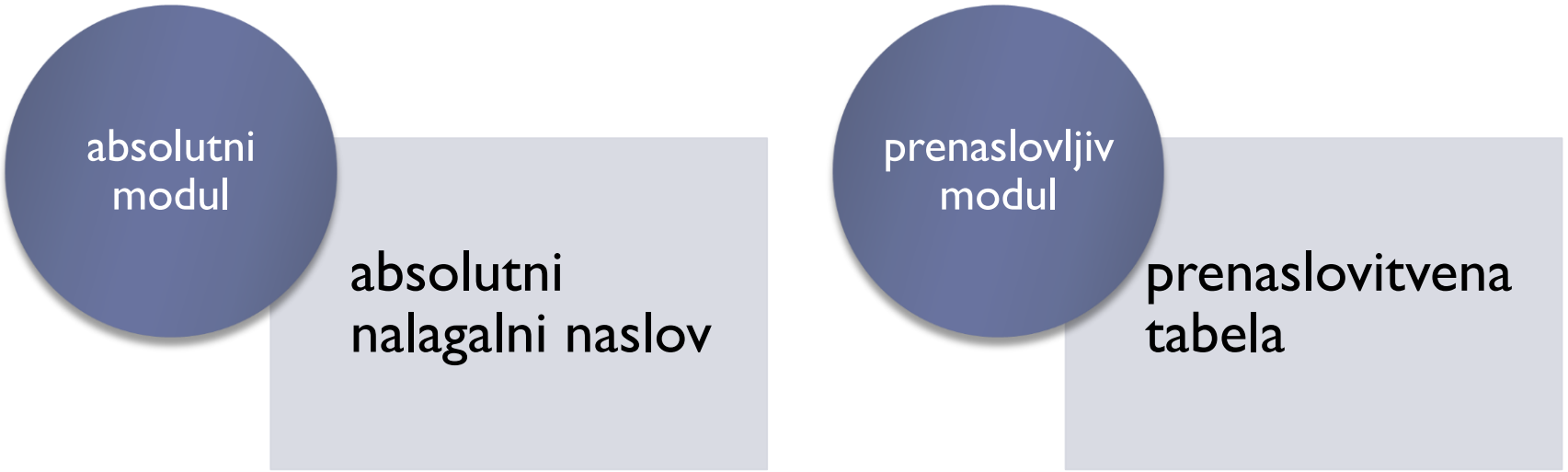
Objektni moduli

Sestavni deli objektnega modula so:

- Objektna koda
- Predviden nalagalni naslov ali prenaslovitvena tabela
- Globalni simboli

Objektni moduli

Nalagalni naslov ali prenaslovitvena tabela?



Objektni moduli

Globalni simboli so zapisani v dveh tabelah:

- Tabela vstopnih simbolov

  ime simbola in njegova vrednost

- Tabela zunanjih simbolov

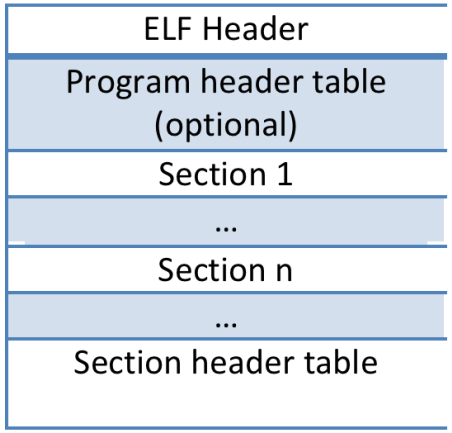
  ime simbola ter vsa mesta, kjer se ta simbol v kodi pojavi

Standardni zapisi objektnih modulov

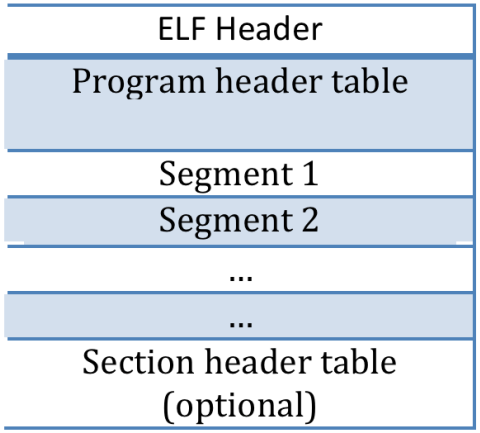
- COFF
  - prvič uporabljen v Unix system V (nadomestek za a.out)
  - predhodnik formata ELF;
  - danes se uporablja v Windows PE/COFF formatu
  - magična številka: `4C01`
- ELF
  - zasnovan pri Unix System Laboratories
  - trenutno ga uporabljajo vsi Linux sistemi
  - magična številka: `7F45C446`
- Mach-O
  - standardni format za MacOS
  - magična številka: `CAFEBABE` ali `FEEDFACE` ali `FEEDFACF`

ELF

a) Objektni modul



b) Izvedljivi modul



ELF formati podatkov

Ime	Velikost (v bajtih)	Pomen
`Elf32_Addr`	4	Unsigned program address
`Elf32_Half`	2	Unsigned medium integer
`Elf32_Off`	4	Unsigned file offset
`Elf32_Sword`	4	Signed large integer
`Elf32_Word`	4	Unsigned large integer
`unsigned char`	1	Unsigned small integer

ELF zaglavje (header)

```
#define EI_NIDENT 16

typedef struct {
off len
0   16    unsigned char e_ident[EI_NIDENT];    // identifikacija
16  2     Elf32_Half e_type;                   // tip modula (izvedljiv, izvršljiv, …)
18  2     Elf32_Half e_machine                 // ciljna arhitektura (intel, sparc, …)
20  4     Elf32_Word e_version;                // verzija
24  4     Elf32_Addr e_entry;                  // začetni izvajalni naslov (0 za rel.)
28  4     Elf32_Off e_phoff;                   // prog. header offset
32  4     Elf32_Off e_shoff;                   // section headers offset
36  4     Elf32_Word e_flags;                  // zastavice
40  2     Elf32_Half e_ehsize;                 // velikost tega headerja (vedno 52)
42  2     Elf32_Half e_phentsize;              // velikost prog. headerjev
44  2     Elf32_Half e_phnum;                  // stevilo prog. header (0 če ga ni)
46  2     Elf32_Half e_shentsize;              // velikost opisa sekcije
48  2     Elf32_Half e_shnum;                  // stevilo sekcij
50  2     Elf32_Half e_shstrndx;               // sect. stringi (index v tabeli sect.)
} Elf32_Ehdr;
```

```
lalg$ hexdump -v -C stetje.o
          ident
00000000  7f 45 4c 46 01 01 01 00  00 00 00 00 00 00 00 00  |.ELF............|
          type  mach  versin       entry       phoff
00000010  01 00 03 00 01 00 00 00  00 00 00 00 00 00 00 00  |................|
          shoff       flags       ehsz  phes  phnu  shes
00000020  4c 01 00 00 00 00 00 00  34 00 00 00 00 00 28 00  |L.......4.....(.|
          shnu  sidx
00000030  0b 00 08 00 55 89 e5 a1  00 00 00 00 83 c0 01 a3  |....U...........|
```

Prva vrstica (16 bitov e_ident):

Magic number: **7F 45 4C 46**
File class: 01 (32-bit objects)
Data encoding: 01 (little-endian)
File version: 01 (current)

Podatki o sekcijah v zaglavju

```
#define EI_NIDENT 16

typedef struct {
off len
0   16    unsigned char e_ident[EI_NIDENT];     // identifikacija
16  2     Elf32_Half e_type;                    // tip modula (izvedljiv, izvršljiv, …)
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46  2     Elf32_Half e_shentsize;               // velikost opisa sekcije
48  2     Elf32_Half e_shnum;                   // stevilo sekcij
50  2     Elf32_Half e_shstrndx;                // sect. stringi (index v tabeli sect.)
} Elf32_Ehdr;
```

```
lalg$ hexdump -v -C stetje.o
          ident
00000000  7f 45 4c 46 01 01 01 00  00 00 00 00 00 00 00 00  |.ELF............|
          type  mach  versin       entry       phoff
00000010  01 00 03 00 01 00 00 00  00 00 00 00 00 00 00 00  |................|
          shoff       flags       ehsz  phes  phnu  shes
00000020  4c 01 00 00 00 00 00 00  34 00 00 00 00 00 28 00  |L.......4.....(.|
          shnu  sidx
00000030  0b 00  08 00  55 89 e5 a1  00 00 00 00 83 c0 01 a3  |....U...........|
```

ELF – opis sekcije

```
typedef struct {
      Elf32_Word  sh_name;    // index v tabeli stringov
      Elf32_Word  sh_type;    // tip sekcije
      Elf32_Word  sh_flags;
      Elf32_Addr  sh_addr;
      Elf32_Off   sh_offset;  // ofset v datoteki
      Elf32_Word  sh_size;    // dolžina sekcije
      Elf32_Word  sh_link;
      Elf32_Word  sh_info;
      Elf32_Word  sh_addralign;
      Elf32_Word  sh_entsize;
}
```

sh_type

Name	Value
SHT_NULL	0
SHT_PROGBITS	1
SHT_SYMTAB	2
SHT_STRTAB	3
SHT_RELA	4
SHT_HASH	5
SHT_DYNAMIC	6
SHT_NOTE	7
SHT_NOBITS	8
SHT_REL	9
SHT_SHLIB	10
SHT_DYNSYM	11
SHT_LOPROC	0x70000000
SHT_HIPROC	0x7fffffff
SHT_LOUSER	0x80000000
SHT_HIUSER	0xffffffff

```
lalg$ i=8; hexdump -n 40 -s $[$i*40+0x14c] -C stetje.o
          name         type         flags        addr
0000028c  11 00 00 00 03 00 00 00  00 00 00 00 00 00 00 00  |................|
          offset       len          link         info
0000029c  f8 00 00 00 51 00 00 00  00 00 00 00 00 00 00 00  |....Q...........|
          align        entsize
000002ac  01 00 00 00 00 00 00 00                           |........|
000002b4
```

ELF – simbolna tabela

```
typedef struct {
      Elf32_Word st_name;                indeks v tabelo nizov
      Elf32_Addr st_value;
      Elf32_Word st_size;
      unsigned char st_info;
      unsigned char st_other;
      Elf32_Half st_shndx;
} Elf32_Sym;
```

```
lalg$ hexdump -C -n 208 -s 0x0304  stetje.o
           name         value          size         i  o  shidx
00000304  00 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00  |................|
00000314  01 00 00 00 00 00 00 00  00 00 00 00 04 00 f1 ff  |................|
00000324  00 00 00 00 00 00 00 00  00 00 00 00 03 00 01 00  |................|
00000334  00 00 00 00 00 00 00 00  00 00 00 00 03 00 03 00  |................|
00000344  00 00 00 00 00 00 00 00  00 00 00 00 03 00 04 00  |................|
00000354  0a 00 00 00 04 00 00 00  04 00 00 00 01 00 04 00  |................|
00000364  00 00 00 00 00 00 00 00  00 00 00 00 03 00 05 00  |................|
00000374  00 00 00 00 00 00 00 00  00 00 00 00 03 00 07 00  |................|
00000384  00 00 00 00 00 00 00 00  00 00 00 00 03 00 06 00  |................|
00000394  13 00 00 00 00 00 00 00  04 00 00 00 11 00 04 00  |................|
000003a4  1c 00 00 00 00 00 00 00  1f 00 00 00 12 00 01 00  |................|
000003b4  20 00 00 00 1f 00 00 00  4b 00 00 00 12 00 01 00  | .......K.......|
000003c4  27 00 00 00 00 00 00 00  00 00 00 00 10 00 00 00  |'...............|
```

Nekateri programi za delo z objektnimi datotekami

- hexdump

```
// izpiše dva bajta (od ofseta 46 naprej)
hexdump -C -n 2 -s 46  stetje.o
```

- nm

```
// izpiše vse simbole v datoteki stetje.o
nm stetje.o
```

- objdump

```
// izpiše kodo (disassembler)
objdumo -M intel -d stetje.o
```

- readelf

```
// izpiše vse podatke o objektni datoteki
  readelf -a stetje.o
```