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Informatik
Computer Science

Oberon 07 compiler

Port to Linux/i386

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List of topics

- Concepts
  - Why Linux/i386
  - Vision
- Implementation
  - Technical decisions
  - Code patterns
- Future plans
  - Future plans and improvements

Why Linux/Intel?

- Provide powerful and high performance alternative to traditional C to develop native Unix applications
  - Console applications
  - Server applications
  - Desktop/GUI applications
- x86 is a dominant desktop & server architecture

- Standalone, commandline compiler with Unix integration
  - Full workflow (development, debug, linking) possible in plain console
  - Remote development/debugging (server systems)
  - Automations of builds, patches, compilations...
  - Easy integration with graphical IDE's
- No special environment/library requirements
  - both for compiler and produced code should be native x86 object files
- Library with support for native API (kernel syscalls)
  - Unix system programming
  - fork(), exec(), pipe(), mmap()...
- Support for native (read: C) calling conventions

Is Oberon language alien to Unix environment?

finding Unix & Oberon things in common

- Minimalism
- Scalability
- Unpretentious hardware requirements
- High performance
- Modularity (to some extent)
- Dynamic loading of shared objects
- Enthusiastic usersbase

Combining spirit of Oberon with Unix traditions

- Lighting fast compilation of resulting binaries
- Short time to compile a compiler
- Reasonably small size & memory requirements of generated code
- Reasonably efficient, not overoptimized code

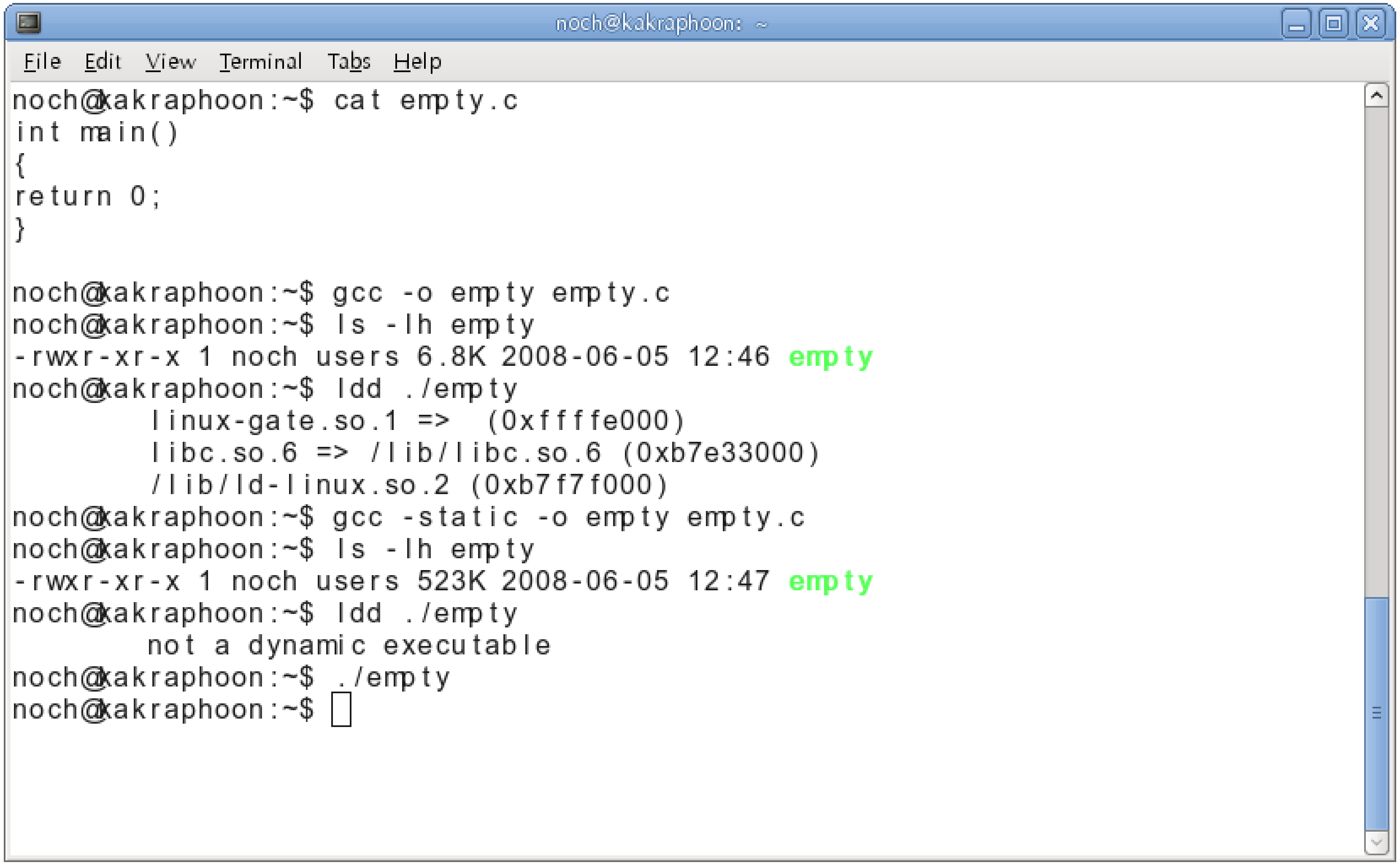
Finding compromise

- To not follow GNU/Linux traditions when it contradicts to Oberon spirit (see above)
  - Decided to not use gcc

To not use gcc

- Because it is not in the spirit of Oberon
  - Slow compilation time
  - produce overoptimized code
  - Recompilation of a compiler takes hours
  - Fat produced binaries
  - High memory requirements of produced binaries
  - Unstable interfaces

Fat code



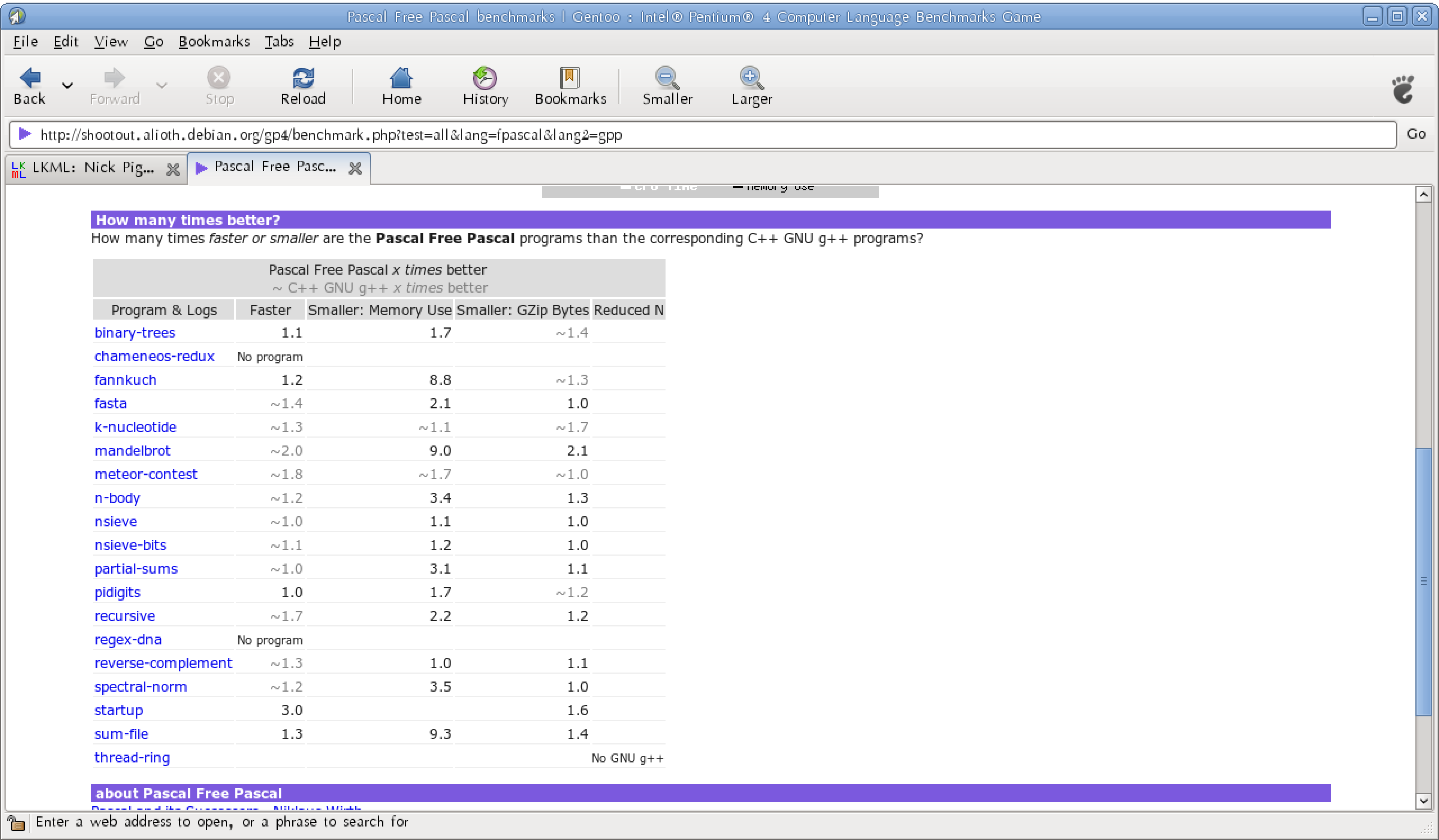
```
noch@kakraphoon:~$ cat empty.c
int main()
{
return 0;
}

noch@kakraphoon:~$ gcc -o empty empty.c
noch@kakraphoon:~$ ls -lh empty
-rwxr-xr-x 1 noch users 6.8K 2008-06-05 12:46 empty
noch@kakraphoon:~$ ldd ./empty
        linux-gate.so.1 =>  (0xffffe000)
        libc.so.6 => /lib/libc.so.6 (0xb7e33000)
        /lib/ld-linux.so.2 (0xb7f7f000)
noch@kakraphoon:~$ gcc -static -o empty empty.c
noch@kakraphoon:~$ ls -lh empty
-rwxr-xr-x 1 noch users 523K 2008-06-05 12:47 empty
noch@kakraphoon:~$ ldd ./empty
        not a dynamic executable
noch@kakraphoon:~$ ./empty
noch@kakraphoon:~$ 
```

optimizations: harm or benefit?

In the thread at LKML http://lkml.org/lkml/2007/10/25/186 about troubles in Linux kernel development as a consequence of gcc strong optimizations Linus Torvalds stated:

I have to admit that for the last five years or so, I've really wanted some other compiler team to come up with a good open-source compiler. Exactly due to issues like this (Q: "Gcc creates bogus code that doesn't work!" A: "It's not bogus, it's technically allowed by the language specs that don't talk about xyz, the fact that it doesn't work isn't our problem").

Memory hunger


Pascal Free Pascal benchmarks | Gentoo : Intel® Pentium® 4 Computer Language Benchmarks Game
File Edit View Go Bookmarks Tabs Help
Back Forward Stop Reload Home History Bookmarks Smaller Larger
http://shootout.alioth.debian.org/gp4/benchmark.php?test=all&lang=fpascal&lang2=gpp
Go
LKML: Nick Pig...
Pascal Free Pasc...
Enter a web address to open, or a phrase to search for

How many times better?

How many times *faster or smaller* are the **Pascal Free Pascal** programs than the corresponding C++ GNU g++ programs?

Pascal Free Pascal *x times* better ~ C++ GNU g++ *x times* better				
Program & Logs	Faster	Smaller: Memory Use	Smaller: GZip Bytes	Reduced N
binary-trees	1.1	1.7	~1.4	
chameneos-redux	No program			
fannkuch	1.2	8.8	~1.3	
fasta	~1.4	2.1	1.0	
k-nucleotide	~1.3	~1.1	~1.7	
mandelbrot	~2.0	9.0	2.1	
meteor-contest	~1.8	~1.7	~1.0	
n-body	~1.2	3.4	1.3	
nsieve	~1.0	1.1	1.0	
nsieve-bits	~1.1	1.2	1.0	
partial-sums	~1.0	3.1	1.1	
pidigits	1.0	1.7	~1.2	
recursive	~1.7	2.2	1.2	
regex-dna	No program			
reverse-complement	~1.3	1.0	1.1	
spectral-norm	~1.2	3.5	1.0	
startup	3.0		1.6	
sum-file	1.3	9.3	1.4	
thread-ring				No GNU g++

about Pascal Free Pascal

Unstable interfaces

From gcc mailing list:

> *«interfacing to gcc internals is strongly discouraged unless this is going to be part of gcc itself. We can't allow outside projects to use gcc internals. We can't guarantee stability of interfaces, and we also need to prevent people from trying to violate the GPL. This is an FSF policy. In order to protect the value of GCC, and in order to prevent people from using devious methods to circumvent the GPL, we are not allowed to let outside projects use gcc internals»*

http://gcc.gnu.org/ml/gcc/2003-07/msg00247.html

> *«Of course, the code is GPL, so you can write your own interfaces if you want, but we will not be able to accept the patches. GCC changes at such a rapid pace that it is very expensive to maintain your own patches, and hence this discourages most people from trying. If someone is able to do this using existing gcc features, then we may obfuscate the feature to prevent this use.»*

http://gcc.gnu.org/ml/gcc/2003-07/msg00437.html

Technical decisions

- Generate assembly
  - It makes life easier (c) :)
  - No external dependency (like libelf)
  - Not necessary to implement elf object file format generation
  - Good abstraction for all object file formats (elf, a.out, coff, misc, pe)
  - Simplifies linking
- Use GNU assembler as a backend
  - «as» available on most platforms, present in major Linux distributions by default
  - low level constructs (movb, movsbl)
  - Compatible with traditional for Unix AT&T syntax

What is Linux API ?

- GNU C library
  - + exists on all desktop/server Linux distributions
  - - wrapper interface to kernel
  - - may be replaced by other implementations in some cases (for example uclibc for embedded systems)
- Linux (POSIX compliant) kernel calls?

Why avoid wrappers?

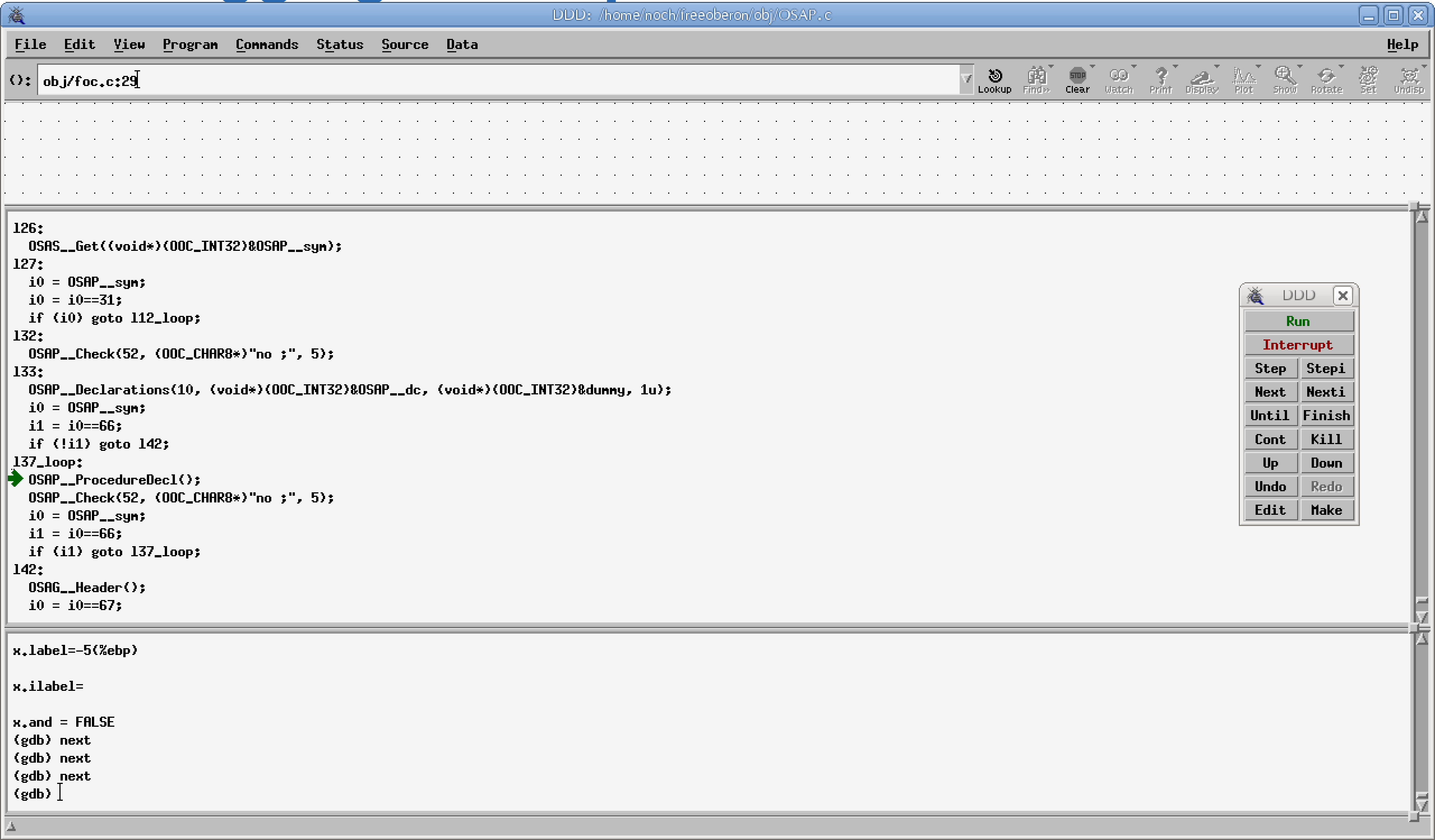
And why avoid GNU libc?

- If libc change, we must change with it
- libc bugs will affect our work
- It is faster to call kernel calls directly
  - Instead of libc like wrapper functions, or mono/.net like environments
- More portable
  - In case of Linux this means supporting whole range of possible builds, not only selected distributions

Choice of tools

- ooc (optimizing oberon-2 compiler)   ooc.sf.net
  - Uses C as a backend assembler
  - - Generates very optimized and unreadable code, which is very hard to debug
  - + Outstanding usability, automatic compilation of all necessary dependency modules,
  - + Comprehensive error messages at runtime, mentioning error position in code
  - + Good Library
- Ofront (OP2 port by Josef Templ)
  - Uses C as a backend assembler
  - + Generates very readable code which is easy to debug
  - - Requires writing makefile
  - - Limited library

Debugging GSA optimized code

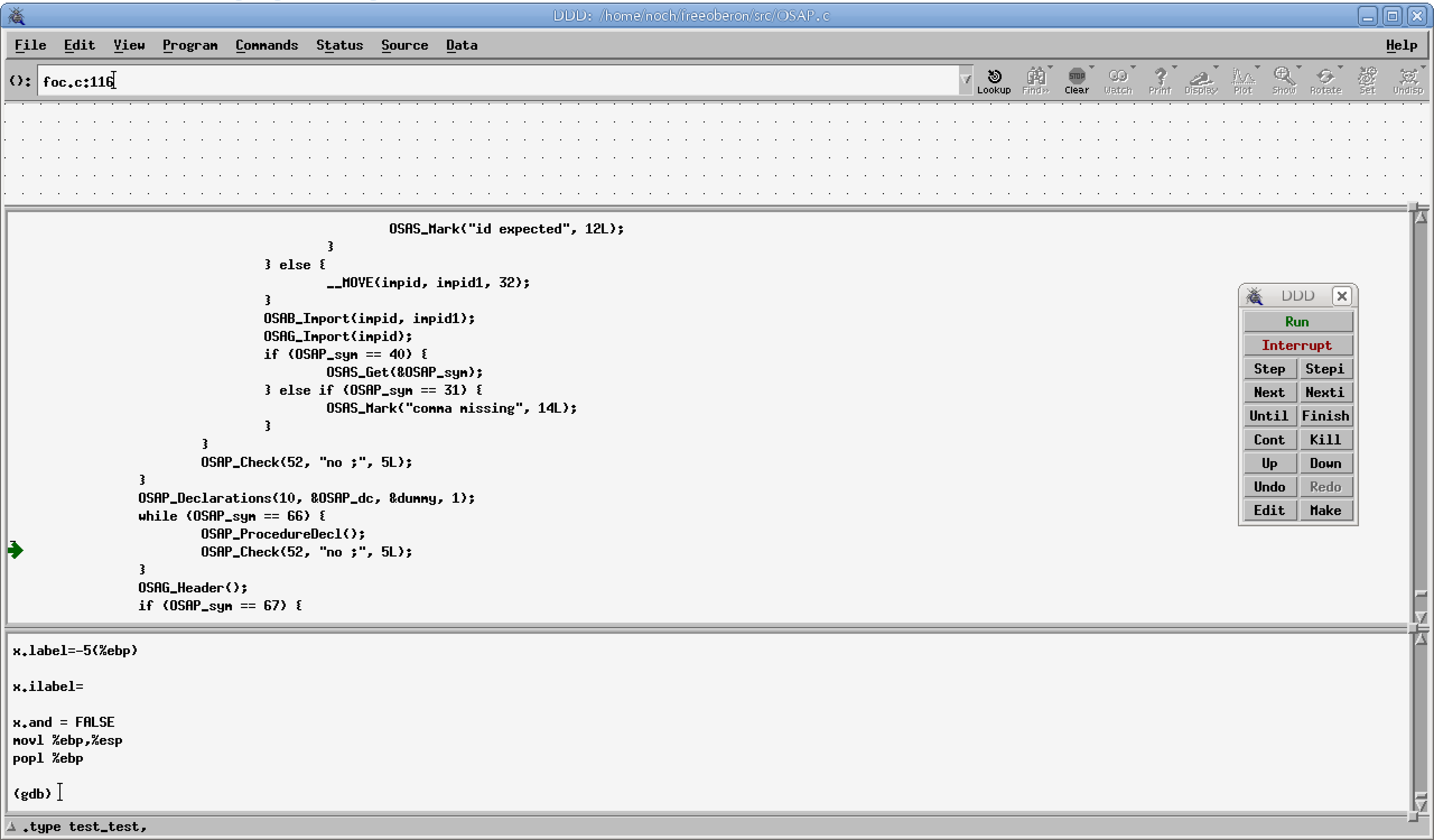


```
(): obj/foc.c:29
```

```
l26:
  OSAS__Get((void*)(OOC_INT32)&OSAP__sym);
l27:
  i0 = OSAP__sym;
  i0 = i0==31;
  if (i0) goto l12_loop;
l32:
  OSAP__Check(52, (OOC_CHAR8*)"no ;", 5);
l33:
  OSAP__Declarations(10, (void*)(OOC_INT32)&OSAP__dc, (void*)(OOC_INT32)&dummy, 1u);
  i0 = OSAP__sym;
  i1 = i0==66;
  if (!i1) goto l42;
l37_loop:
  OSAP__ProcedureDecl();
  OSAP__Check(52, (OOC_CHAR8*)"no ;", 5);
  i0 = OSAP__sym;
  i1 = i0==66;
  if (i1) goto l37_loop;
l42:
  OSAG__Header();
  i0 = i0==67;
```

```
x.label=-5(%ebp)

x.ilabel=

x.and = FALSE
(gdb) next
(gdb) next
(gdb) next
(gdb) 
```

Debugging Ofront produced code



```
(): foc.c:116
```

```
                                        OSAS_Mark("id expected", 12L);
                                }
                        } else {
                                __MOVE(impid, impid1, 32);
                        }
                        OSAB_Import(impid, impid1);
                        OSAG_Import(impid);
                        if (OSAP_sym == 40) {
                                OSAS_Get(&OSAP_sym);
                        } else if (OSAP_sym == 31) {
                                OSAS_Mark("comma missing", 14L);
                        }
                }
                OSAP_Check(52, "no ;", 5L);
        }
        OSAP_Declarations(10, &OSAP_dc, &dummy, 1);
        while (OSAP_sym == 66) {
                OSAP_ProcedureDecl();
                OSAP_Check(52, "no ;", 5L);
        }
        OSAG_Header();
        if (OSAP_sym == 67) {
```

```
x.label=-5(%ebp)

x.ilabel=

x.and = FALSE
movl %ebp,%esp
popl %ebp

(gdb)
```

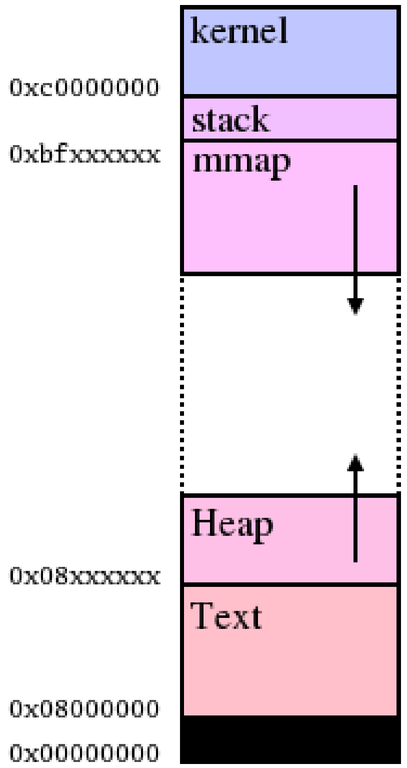
```
.type test_test,
```

Specific code templates avoiding register usage when possible

a := 5	movl $5, _a
a := b + 5	movl _b, %eax addl $5, %eax movl %eax, _a
a := b DIV c	movl _b, %eax cltd idivl _c movl %eax, _a

Memory layout & management

```
    .section .data
    .comm mmap_, 24
    .section .text
    movl $0, mmap_
    # length of requested memory
    #movl $65535, mmap_+4
    # read, write, PROT_WRITE | PROT_READ, 0x02, 0x01
    movl $3, mmap_+8
    # map anonymously (0x20), map_private (0x2)
    movl $34, mmap_+12
    # fd, -1 for portability
    movl $-1, mmap_+16
    # offset is ignored
    movl $0, mmap_+20
NEW(p)        movl $memsize, mmap_+4
               movl $90, %eax
               leal   mmap_, %ebx
               int $0x80
               movl %eax, _ptr
DISPOSE(p)    movl $91, %eax
               movl _ptr, %ebx
               movl (%ebx), %ecx
               movl (%ecx), %ecx
```



Porting to other x86 platforms

It is necessary to change only 2 procedures in generator module:

```
PROCEDURE PutExit(i : INTEGER);
PROCEDURE New*(VAR x, y: Item);
```

Low level library example, kernel interface

```
MODULE Unix;
PROCEDURE write*(CONST s : ARRAY OF CHAR; l : INTEGER);
BEGIN
        ASM
        movl 8(%ebp), %ecx
        movl 16(%ebp), %edx
        movl $1, %ebx
        movl $4, %eax
        int $0x80
        END;
END write;
END Unix.
```

Low level library example, libc interface

```
MODULE Unix;
PROCEDURE write*(CONST s : ARRAY OF CHAR; I : INTEGER);
BEGIN
    ASM
    movl 8(%ebp), %ecx
    pushl %ecx
    call printf
    END;
END write;

END Unix.
```

Standard Library example

```
MODULE Out;
IMPORT Unix, IntStr;
PROCEDURE String* (CONST s : ARRAY OF CHAR);
VAR i : INTEGER;
BEGIN
   i := 0;
       WHILE s[i] # 0X DO
           INC(i);
       END;
   Unix.write(s, i)
END String;
...
```

Compile & run example programs benchmarks

Future plans & improvements

- Automatically resolve module hierarchy
  (make file is not necessary)
- Improve register allocation
- Dynamic module loading(Pos-independent code)
- Improve usability, add debugging possibility, separate directories for libs, config file etc...
- Compile other existing Oberon libraries
- Port to other x86 Unix systems
- Port to other architectures

Thank you!