Operating Systems

SSH, make, C and other bits needed for NSWI004

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Running the Terminal

Running the Terminal

Where to find it

- GUI menu: *System* or *Utilities* or *Accessories*
- Application name: *Terminal* or *RXVT* or *Console*

Some other tips

- Ensure you use readable font (face and size) – you will be using it a lot
- Use tabs and multiple windows
- `export TERM=xterm` when keyboard/output behaves in a funny way

Remote Login etc.

Logging to a Remote Machine via SSH

```
ssh remotelogin@remote.machine.hostname
```

First login

```
The authenticity of host 'u-pl15 (195.113.21.145)' can't be
established.
ECDSA key fingerprint is
SHA256:U6u6eLekctQDr9uy4CKZJeDFjcCWqCI/v9owL1NODcE.
Are you sure you want to continue connecting (yes/no)? yes
Warning: Permanently added 'u-pl15,195.113.21.145' (ECDSA) to the
list of known hosts.
```

Configuring SSH Login

Put the following into `~/.ssh/config`

```
Host osy
    User USERNAME
    PreferredAuthentications publickey,password
    HostName uniform.ms.mff.cuni.cz
```

and you can login simply by typing `ssh osy`

Password-less login

SSH supports public/private key login.
You need to generate public/private key pair first.

Do I have one?

`ls ~/.ssh` look for `id_rsa` and `id_rsa.pub` or similar pair.

Generating a new one

```
ssh-keygen -t RSA
```

Pass-phrase improves security of the key but also slows-down its usage (unless you use SSH agent).

Password-less login (cont.)

Setting up the password-less login to uniform

1. Get your public key (`cat ~/.ssh/id_rsa.pub`)
2. Login to `uniform.ms.mff.cuni.cz` normally
3. Copy the public key to the end of `~/.ssh/authorized_keys` file
   `echo 'public-key-here' >> ~/.ssh/authorized_keys`
4. Test password-less login

Issues

- Check that `~/.ssh` has `rwx------` permissions
- Check that `authorized_keys` has at most `rw-r--r--`
- Check that you copied the public key correctly (single line etc.)

Password-less login on Windows

1. Install PuTTY (http://www.putty.org/)
2. Run PuTTY Key Generator
   - RSA key
   - Save public and private key pair
3. PuTTY configuration
   - Session – Host Name: `LOGIN@uniform.ms.mff.cuni.cz`
   - Copy public key to `authorized_keys` (right click inserts)
   - Connection – SSH – Auth – Private key file

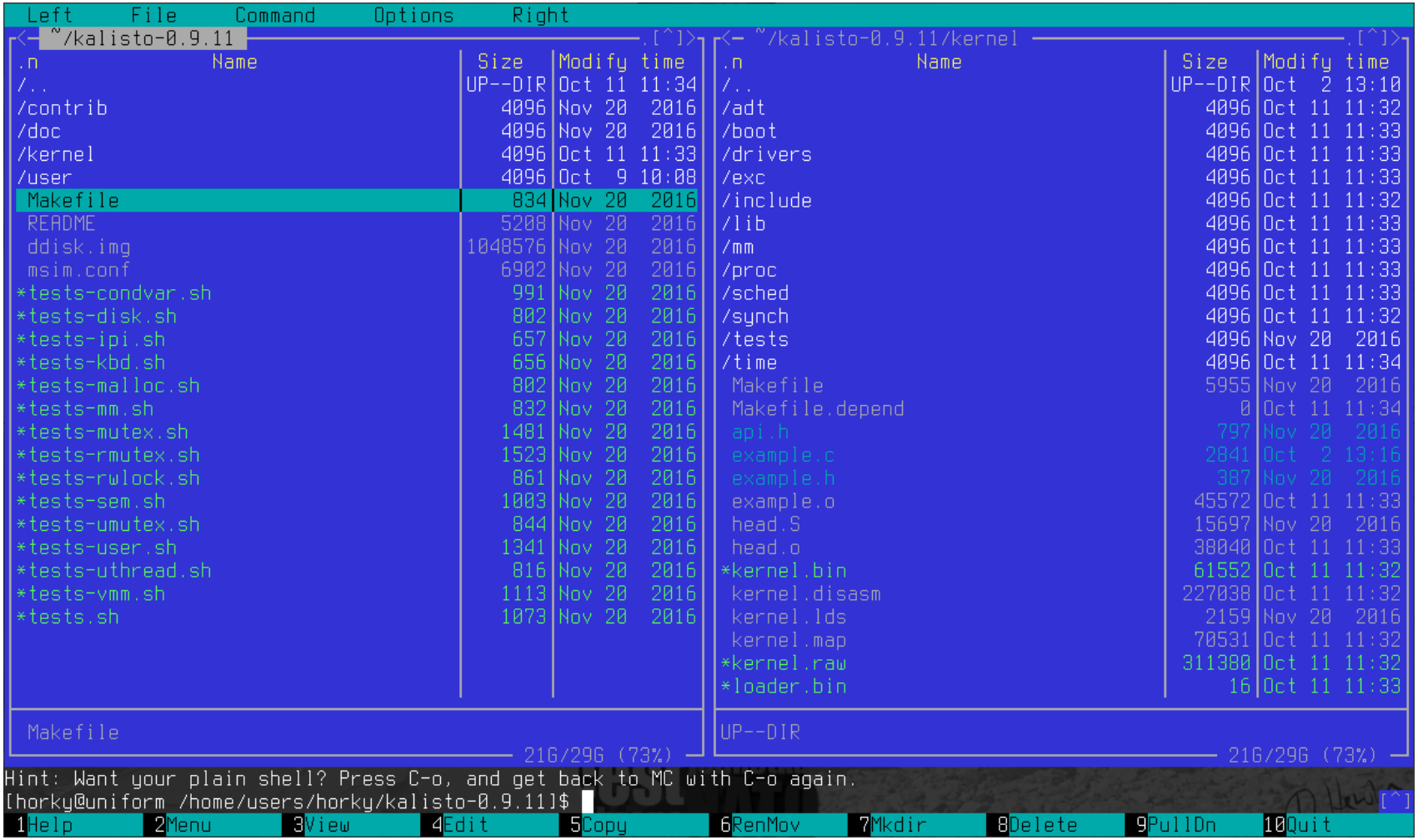
Using the Filesystem

The Basics

- `cd`
- `ls`, `ls -l`
- `find`
- `chmod`

Midnight Commander

Remember at least the `mc` command :-)



Downloading, Unpacking, ...

For downloading, use `wget`.

To unpack, use `tar` with proper switches.

- `x` to extract
- `f` to work with file (must use)
- `j` to work with `.bz2`
- `z` to work with `.gz`

```
tar xjf kalisto-0.9.11.tar.bz2
```

Accessing Remote Files via SSH FS

- `mkdir remote-fs`
- `sshfs osy:kalisto-0.9.11/ remote-fs/`
- Work with files on `uniform` locally in `remote-fs` directory
- But compile remotely!
- Do not forget to unmout: `fusermount -u remote-fs`

Inspecting Text Files

- `cat FILENAME` to dump contents to terminal
- `less FILENAME` to scroll through file (or pipe)
  - Use `/` to search
  - Use `q` to quit
- `grep` to search for a pattern

Using Make Build System

Running Make

If there is `Makefile` in the current directory, just type `make`.

Common targets

- `make clean` Remove all generated files.
- `make doc` Generate documentation.
- `make FILENAME` Regenerate particular file.
- `make -B …` Force rebuild.

Anatomy of a `Makefile`

```
all: program

.PHONY: all clean

clean:
	rm -f *.o program

program: main.o
	gcc main.o -o program

main.o: main.c
	gcc -g -Wall -c -o main.o main.c
```

Anatomy of a `Makefile` II

```
all: program

.PHONY: all clean

clean:
	rm -f *.o program

program: main.o
	gcc main.o -o $@

%.o: %.c
	gcc -g -Wall -c -o $@ $<
```

Anatomy of a `Makefile` II$\frac{1}{2}$

```
all: program
.PHONY: all clean
clean:
	rm -f *.o program

program: main.o
	gcc main.o -o $@

%.o: %.c
	gcc -g -Wall -c -o $@ $<
```

Anatomy of a Makefile III

```
CC = gcc
CFLAGS = -g -Wall
LD = gcc

all: program
.PHONY: all clean
clean:
	rm -f *.o program

program: main.o
	$(LD) main.o -o $@

%.o: %.c
	$(CC) $(CFLAGS) -c -o $@ $<
```

Anatomy of a `Makefile` IV

```
CC = gcc
CFLAGS = -g -Wall
LD = gcc
SOURCES = main.c
OBJECTS := $(addsuffix .o,$(basename $(SOURCES)))

all: program
.PHONY: all clean
clean:
        rm -f *.o program

program: $(OBJECTS)
        $(LD) $(OBJECTS) -o $@

%.o: %.c
        $(CC) $(CFLAGS) -c -o $@ $<
```

Anatomy of a Makefile V

```
CC = gcc
CFLAGS = -g -Wall
LD = gcc
SOURCES = main.c
OBJECTS := $(addsuffix .o,$(basename $(SOURCES)))
DEPEND = Makefile.depend
...

%.o: %.c
        $(CC) $(CFLAGS) -c -o $@ $<

-include $(DEPEND)
$(DEPEND):
    -makedepend -f - -- $(CCFLAGS) -- $(SOURCES) > $@ 2> /dev/null
    -[ -f $(DEPEND).prev ] && diff -q $(DEPEND).prev $@ \
        && mv -f $(DEPEND).prev $@
```

From C++ to C

Things You Cannot Use

- Classes and namespaces
- STL and templates in general
- Function overloading
- Exceptions, RTTI and type casting
- `new`, static initialization
- Streams

There are ways to bypass these limitations. Not all of them are nice.

Actually, it is possible to write OS kernel in C++ and use namespaces, exceptions etc. But the OS has to provide run-time support for these constructs. Kalisto provides no such support at the moment.

Missing Classes and Namespaces

- `object.function(…)` is actually `classname_function(object, …)`
- Prefix identifiers with namespace name
  - pthreads are a pretty good example
  - Rest of POSIX is definitely not

Missing STL and Templates

- Templates can be (lamely) emulated with X macros
- Generic data structures are possible
  - Simplified linked list in Kalisto
  - Full-fledged generic RB-tree, B+ trees or hash tables in HelenOS

Using `list_t`

```
#include <adt/list.h>

/* Structures that are in a list. */
struct my_struct { link_t link; ... }

/* List declaration and initialization. */
static list_t my_list;
list_init (&my_list);

/* Adding to a list. */
struct my_struct *x = malloc(sizeof(struct my_struct));
link_init (&x->link);
list_append (&my_list, &x->link);

/* Iterate through items, it points to my_struct */
list_foreach (my_list, struct my_struct, link, it) { ... }
```

No Function Overloading

- `_Generic` macro in C11
- Wrapper functions with different names

Error Handling

- Function always returns an error code
  - `EOK` or `0` on success
  - Other values passed through parameters
- Error is signalled by negative response, valid handle is always positive
  - `open()` could have had behaved in this way too
- Error is signalled via `errno`

Always check for errors. Especially in OS code!

Only `malloc` is available

- Check for errors
- Use `sizeof`
- Initialize afterwards

Static Initialization

- Unavailable directly
- Compiler extensions (`__attribute__((constructor))`)
- For OS, better to call them directly (ensures proper ordering)

Type Casting

No run-time support, static cast only.

Streams and I/O

- No `<<` and `>>` operators for I/O
- `printf` for formatted output
- `FILE *` and `fopen`, `fread`/`fwrite` and `fclose`

```
int i = 42;
const char *s = "Hello";
size_t x = sizeof(i);

printf("i = %d [%zuB], s = \"%s\"\n", i, x, s);
// i = 42 [4B], s = "Hello"
```

Beware of Undefined Behaviour

```
int i = INT_MAX + 1
```

- We might expect it wraps around to `INT_MIN`
- That is what the CPU instruction probably does
- But C standard says this is undefined so
  - it may work as we expect
  - or the whole program can do anything

Practical use? Optimizations ...

For example, knowing that `i++` on `int i = 0` may never overflow (because it is undefined) compiler it can safely assume that `i > 0`.

Other Bits

`no previous prototype for` function with no arguments

Function with no arguments has to be declared as (notice `void` parameters):

```
void driver_init(void)
```

Idiom for multi-command macro

```
#define SHORTCUT(x,y) do { cmd1(x); cmd2(y) } while (0)
```

Debugging macro

```
#define dprintf(fmt, ...) \
    printf("[DEBUG %s:%d %s()] " fmt, \
        __FILE__, __LINE__, __FUNCTION__, \
        #__VA_ARGS__)
```

Questions? Comments?