USB gadget composed with configfs

Composing, implementation and the future

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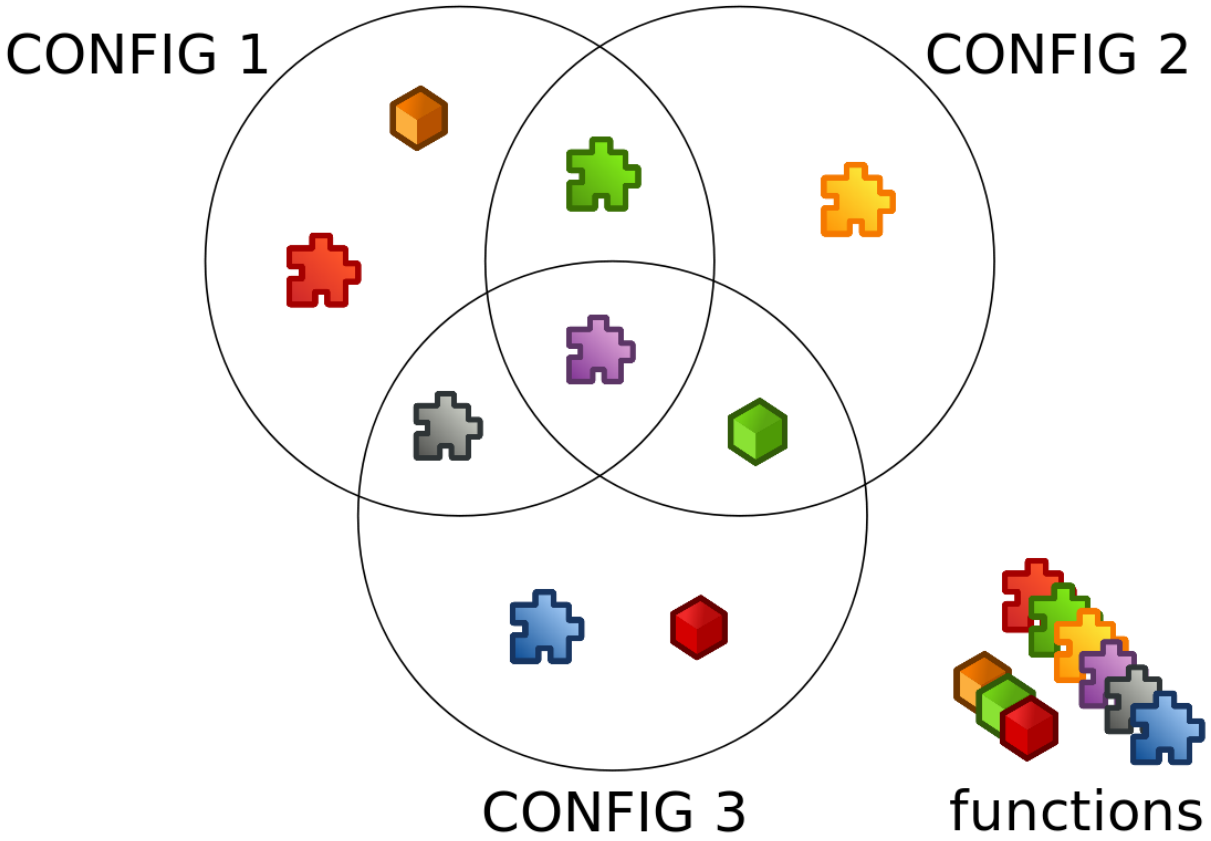
Table of Contents

host += function

- USB: host, device
- extend the host with some function(s)

USB device composition

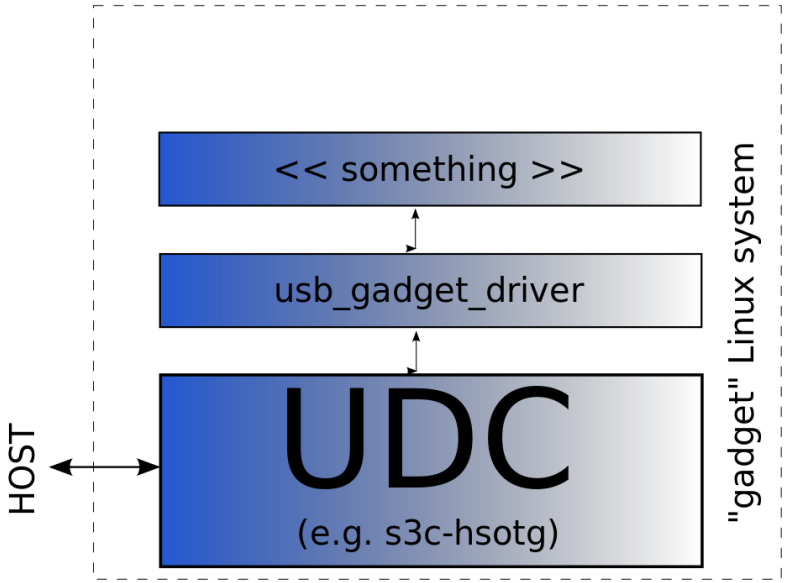


enumeration

- Device connected, presents itself
- Host decides what to do and how to talk to it

gadget = UDC + function(s)

- A piece in hardware: UDC/OTG/
- Functions: HW or SW

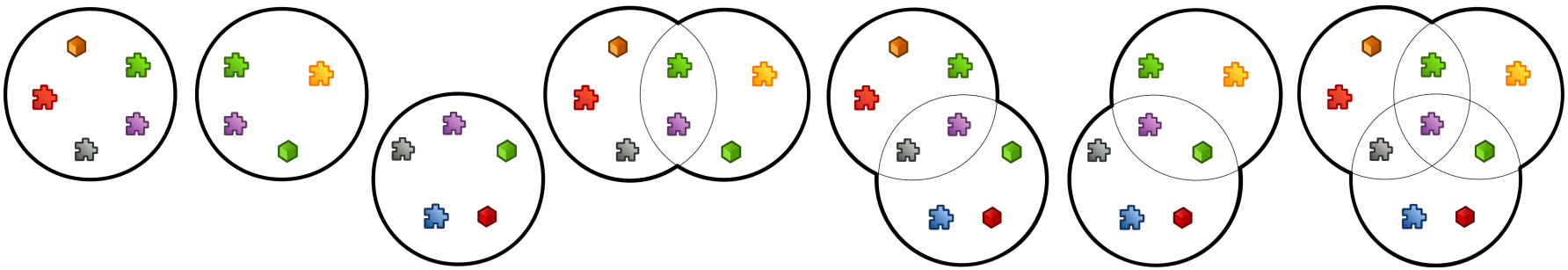


composite framework

- factor out repeated parts of code
  - drivers/usb/gadget/composite.c
- reusable functions' implementations
  - f_acm.c
  - f_serial.c
  - f_obex.c
  - f_ecm.c, f_ecm_subset.c, f_eem.c, f_ncm.c, f_rndis.c
  - f_phonet.c
  - f_mass_storage.c
  - f_uvc.c
  - f_uac1.c, f_uac2.c
  - f_midi.c
  - ...

gadgets proper: g_xyz.c / g_xyz kernel modules

- hardcoded (!) configurations/functions/identity
- module parameters



Greg

Fact

He doesn't want my code!

Fact

He wouldn't want your code, either :O

Why I don't want your code

Linux Kernel Maintainers,
why are they so grumpy

Greg Kroah-Hartman
gregkh@linuxfoudation.org

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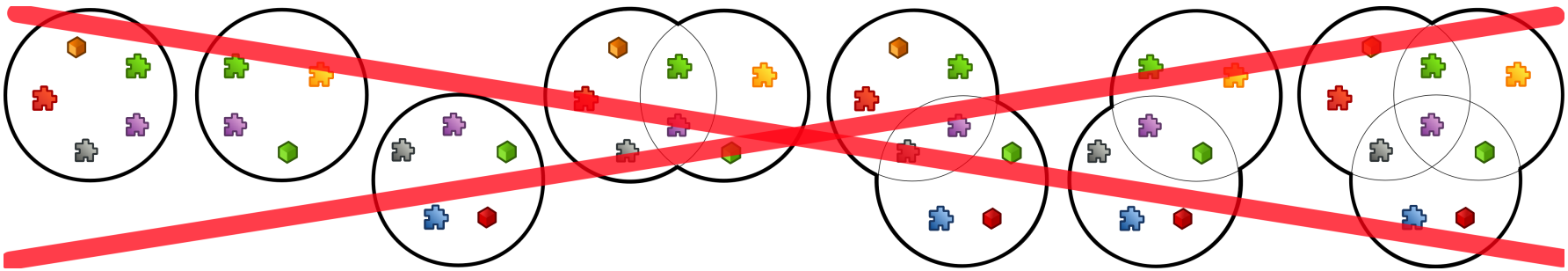


Separate code from data

- decouple the information on actual gadget composition from implementation
- only provide building blocks (mechanism, not policy)

Let the user decide at runtime

action	filesystem
create	make directory
destroy	remove directory
specify value	write
get value	read (execute for directory)
group things	symlink
ungroup things	remove symlink

Command reference

```
mkdir, rmdir
echo 'something' > file, cat file, ls directory
ln -s, rm
```

Examples

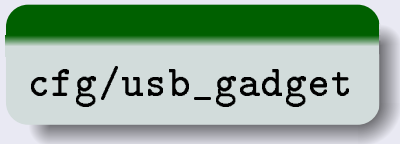
Examples prologue

```
$ modprobe libcomposite
```

Examples

Examples prologue

```
$ modprobe libcomposite
$ mount none cfg -t configfs
```



Examples

Examples prologue

```
$ modprobe libcomposite
$ mount none cfg -t configfs
$ mkdir cfg/usb_gadget/g1
$ cd cfg/usb_gadget/g1
```

```
drwxr-xr-x   .
drwxr-xr-x   ./strings
drwxr-xr-x   ./configs
drwxr-xr-x   ./functions
-rw-r--r--   ./UDC
-rw-r--r--   ./bcdUSB
-rw-r--r--   ./bcdDevice
-rw-r--r--   ./idProduct
-rw-r--r--   ./idVendor
-rw-r--r--   ./bMaxPacketSize0
-rw-r--r--   ./bDeviceProtocol
-rw-r--r--   ./bDeviceSubClass
-rw-r--r--   ./bDeviceClass
```

Examples

Examples prologue

```
$ modprobe libcomposite
$ mount none cfg -t configfs
$ mkdir cfg/usb_gadget/g1
$ cd cfg/usb_gadget/g1
$ echo "0x05e8" > idVendor
$ echo "0xa4a1" > idProduct
```

```
drwxr-xr-x    .
drwxr-xr-x    ./strings
drwxr-xr-x    ./configs
drwxr-xr-x    ./functions
-rw-r--r--    ./UDC
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-rw-r--r--    ./bDeviceProtocol
-rw-r--r--    ./bDeviceSubClass
-rw-r--r--    ./bDeviceClass
```

Examples

Examples prologue

```
$ modprobe libcomposite
$ mount none cfg -t configfs
$ mkdir cfg/usb_gadget/g1
$ cd cfg/usb_gadget/g1
$ echo "0x05e8" > idVendor
$ echo "0xa4a1" > idProduct
$ mkdir strings/0x409
$ echo "serialnumber" > strings/0x409/serialnumber
$ echo "manufacturer" > strings/0x409/manufacturer
$ echo "ECM Gadget" > strings/0x409/product
```

```
drwxr-xr-x   .
drwxr-xr-x   ./strings
drwxr-xr-x   ./configs
drwxr-xr-x   ./functions
-rw-r--r--   ./UDC
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-rw-r--r--   ./idProduct
-rw-r--r--   ./idVendor
-rw-r--r--   ./bMaxPacketSize0
-rw-r--r--   ./bDeviceProtocol
-rw-r--r--   ./bDeviceSubClass
-rw-r--r--   ./bDeviceClass
```

One config, one function

Example

```
$ mkdir functions/ecm.usb0
```

One config, one function

Example

```
$ mkdir functions/ecm.usb0
$ mkdir configs/c.1
$ mkdir configs/c.1/strings/0x409
$ echo Conf 1 > configs/c.1/strings/0x409/configuration
$ echo 120 > configs/c.1/MaxPower
```

One config, one function

Example

```
$ mkdir functions/ecm.usb0
$ mkdir configs/c.1
$ mkdir configs/c.1/strings/0x409
$ echo Conf 1 > configs/c.1/strings/0x409/configuration
$ echo 120 > configs/c.1/MaxPower
$ ln -s functions/ecm.usb0 configs/c.1
```

One config, one function

Example

```
$ mkdir functions/ecm.usb0
$ mkdir configs/c.1
$ mkdir configs/c.1/strings/0x409
$ echo Conf 1 > configs/c.1/strings/0x409/configuration
$ echo 120 > configs/c.1/MaxPower
$ ln -s functions/ecm.usb0 configs/c.1
$ echo s3c-hsotg > UDC
```

Two configs, three functions

Example

```
$ mkdir functions/ecm.usb0
$ mkdir functions/acm.usb0
$ mkdir functions/rndis.usb0
```

Two configs, three functions

Example

```
$ mkdir functions/ecm.usb0
$ mkdir functions/acm.usb0
$ mkdir functions/rndis.usb0
$ mkdir configs/c.{1|2}
$ mkdir configs/c.{1|2}/strings/0x409
$ echo Conf {1|2} > \
configs/c.{1|2}/strings/0x409/configuration
$ echo 120 > configs/c.{1|2}/MaxPower
```

Two configs, three functions

Example

```
$ mkdir functions/ecm.usb0
$ mkdir functions/acm.usb0
$ mkdir functions/rndis.usb0
$ mkdir configs/c.{1|2}
$ mkdir configs/c.{1|2}/strings/0x409
$ echo Conf {1|2} > \
configs/c.{1|2}/strings/0x409/configuration
$ echo 120 > configs/c.{1|2}/MaxPower
$ ln -s functions/rndis.usb0 configs/c.1
$ ln -s functions/acm.usb0 configs/c.1
```

Two configs, three functions

Example

```
$ mkdir functions/ecm.usb0
$ mkdir functions/acm.usb0
$ mkdir functions/rndis.usb0
$ mkdir configs/c.{1|2}
$ mkdir configs/c.{1|2}/strings/0x409
$ echo Conf {1|2} > \
configs/c.{1|2}/strings/0x409/configuration
$ echo 120 > configs/c.{1|2}/MaxPower
$ ln -s functions/rndis.usb0 configs/c.1
$ ln -s functions/acm.usb0 configs/c.1
$ ln -s functions/ecm.usb0 configs/c.2
$ ln -s functions/acm.usb0 configs/c.2
```

Two configs, three functions

Example

```
$ mkdir functions/ecm.usb0
$ mkdir functions/acm.usb0
$ mkdir functions/rndis.usb0
$ mkdir configs/c.{1|2}
$ mkdir configs/c.{1|2}/strings/0x409
$ echo Conf {1|2} > \
configs/c.{1|2}/strings/0x409/configuration
$ echo 120 > configs/c.{1|2}/MaxPower
$ ln -s functions/rndis.usb0 configs/c.1
$ ln -s functions/acm.usb0 configs/c.1
$ ln -s functions/ecm.usb0 configs/c.2
$ ln -s functions/acm.usb0 configs/c.2
$ echo s3c-hsotg > UDC
```

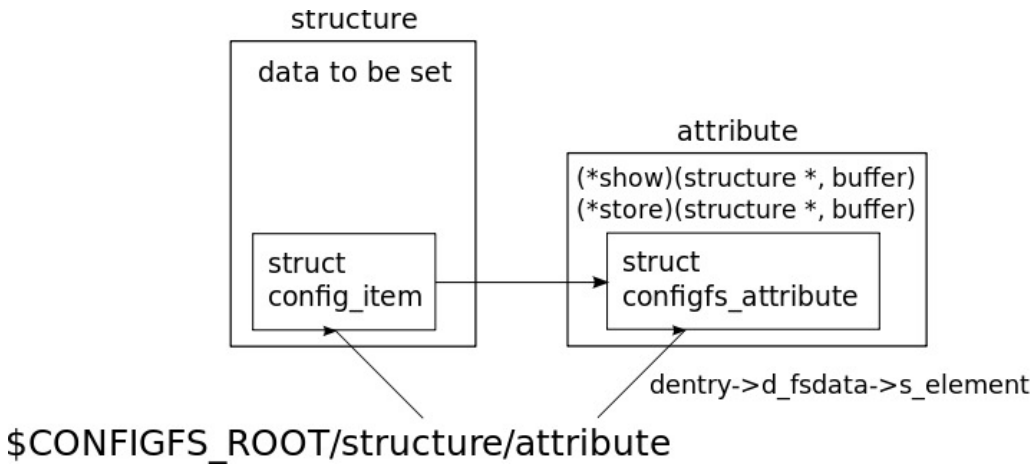
Function registration interface

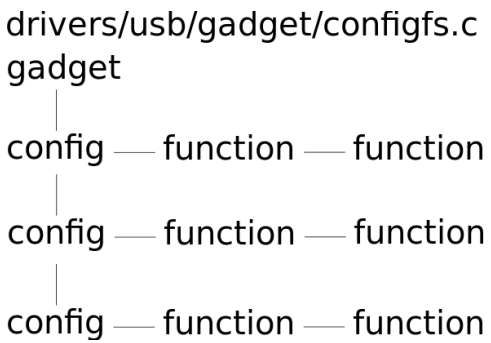
```
$ mkdir function/ecm.usb0

                    request_module()
```

- Sebastian Andrzej Siewior

Configfs proper

- directory : config_item (config_group)
- file : configfs_attribute
- mkdir : configfs_mkdir()->make_item() (make_group())
- read : show()
- write : store()





Some history

- Sebastian Andrzej Siewior
  - idea (Decmber 2011)
  - function registration interface
  - f_acm.c conversion to the function registration interface
  - f_acm.c configfs support (December 2012)
- Andrzej Pietrasiewicz
  - From where he left off, I took over

Status matrix

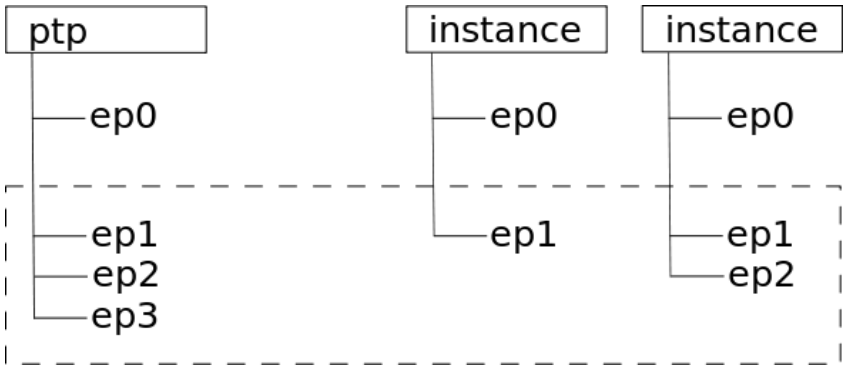
with configfs	f_acm.c	f_ecm.c	f_eem.c	f_ncm.c	f_obex.c	f_phonet.c	f_rndis.c	f_serial.c	f_subset.c	f_mass_storage.c	f_fs.c	f_hid.c	f_loopback.c	f_sourcesink.c	f_midi.c	f_uac1.c	f_uac2.c	f_uvc.c

legacy gadget	components
g_hid	
g_zero	
g_midi	
g_audio	
g_webcam	
g_cdc	
g_ether	
g_ncm	
g_serial	
g_nokia	
g_multi	
g_acm_ms	
g_mass_storage	
g_ffs	

mainline | sent | in progress | todo | unused

FunctionFS

- delegate function implementation to userspace
  - mount FunctionFS
  - write descriptors to ep0
  - read/write/poll ep[1-]
- configfs: only create FunctionFS instances
  - eg $CONFIGFS_ROOT/usb_gadget/gadget/functionfs/ffs.ptp



TODO

- f_sourcesink, f_loopback
- f_uvc
- f_uac1/2, f_midi, f_hid
- remove legacy gadgets - some (perhaps long) time in the future
- gadgets not using composite framework

Userspace tool(s)

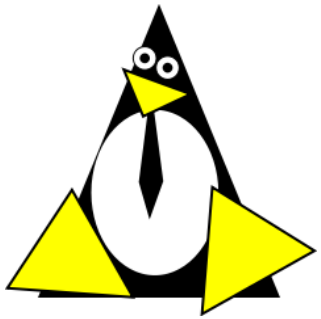
- configfs: just usable from shell; ease of use not considered
- create, keep track of, remove gadgets

FunctionFS 2

- FunctionFS
  - write the descriptors to ep0 in FunctionFS
  - use endpoint ep[1-] files to implement the USB function
- FunctionFS 2
  - pass the descriptors with configfs instead
  - use endpoint ep[1-] files to implement the USB function

xattrs for configfs

- Extend configfs iteslf
- Use case: SMACK labels
- Control USB gadget creation



Q & A

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References

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- http://www.spinics.net/lists/linux-usb/msg76378.html
- http://www.spinics.net/lists/linux-usb/msg83460.html
- http://www.spinics.net/lists/linux-usb/msg86311.html
- http://www.spinics.net/lists/linux-usb/msg86321.html
- http://www.spinics.net/lists/linux-usb/msg86327.html
- http://www.spinics.net/lists/linux-usb/msg86561.html
- http://www.spinics.net/lists/linux-usb/msg90757.html
- http://www.spinics.net/lists/linux-usb/msg90774.html
- http://www.spinics.net/lists/linux-usb/msg90776.html

Images

- http://openclipart.org/detail/174619/4g-modem-and-sim-by-witcombem-174619 - slide 3
- http://openclipart.org/detail/1964/calcubot-by-johnny_automatic - slide 3
- http://openclipart.org/detail/96913/mouse-by-yves_guillou - slide 3
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- http://openclipart.org/detail/6633/neo1973-%28tango%29-by-ryanlerch - slide 3
- http://openclipart.org/detail/17026/icon_puzzle_blue-by-jean_victor_balin - slides 4, 8, 10, 11
- http://openclipart.org/detail/17027/icon_puzzle_green-by-jean_victor_balin - slides 4, 8, 10, 11
- http://openclipart.org/detail/17028/icon_puzzle_grey-by-jean_victor_balin - slides 4, 8, 10, 11
- http://openclipart.org/detail/17029/icon_puzzle_purple-by-jean_victor_balin - slides 4, 8, 10, 11
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- http://openclipart.org/detail/17060/icon_cube_green-by-jean_victor_balin - slides 4, 8, 10, 11
- http://openclipart.org/detail/17061/icon_cube_orange-by-jean_victor_balin - slides 4, 8, 10, 11
- http://openclipart.org/detail/17062/icon_cube_red-by-jean_victor_balin - slides 4, 8, 10, 11
- http://openclipart.org/detail/122449/question-button-by-ricardomaia - slide 5
- http://openclipart.org/detail/3705/usb-plug-by-klaasvangend - slide 5

Images

- http://www.linaro.org/documents/download/304a9a3e4024a2bb70312fc81d79446d51311e50ed8f4 - slides 9, 10
- http://openclipart.org/detail/10833/green-tick-by-ryan_taylor - slide 11
- http://openclipart.org/detail/104197/calendrier–calendar-by-lmproulx - slide 29
- http://openclipart.org/detail/33265/liste-/-list-by-lmproulx - slide 32
- http://openclipart.org/detail/4556/wrench-by-kubble - slide 33
- http://openclipart.org/detail/158689/plumber-penguin-by-tuxwrench - slide 33
- http://en.wikipedia.org/wiki/File:Smack-tux.svg - slide 35