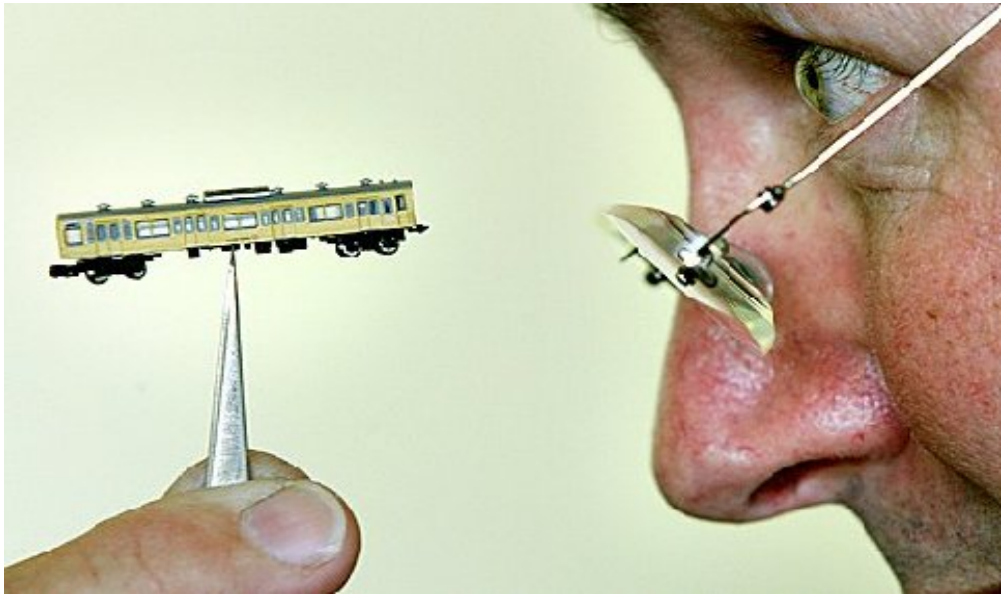
Do More With Less



On Driver-less Interfacing

with Embedded Devices

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handhelds.org

IPKGFIND

NSLU2-Linux

genesi

debian

Peter Korsgaard

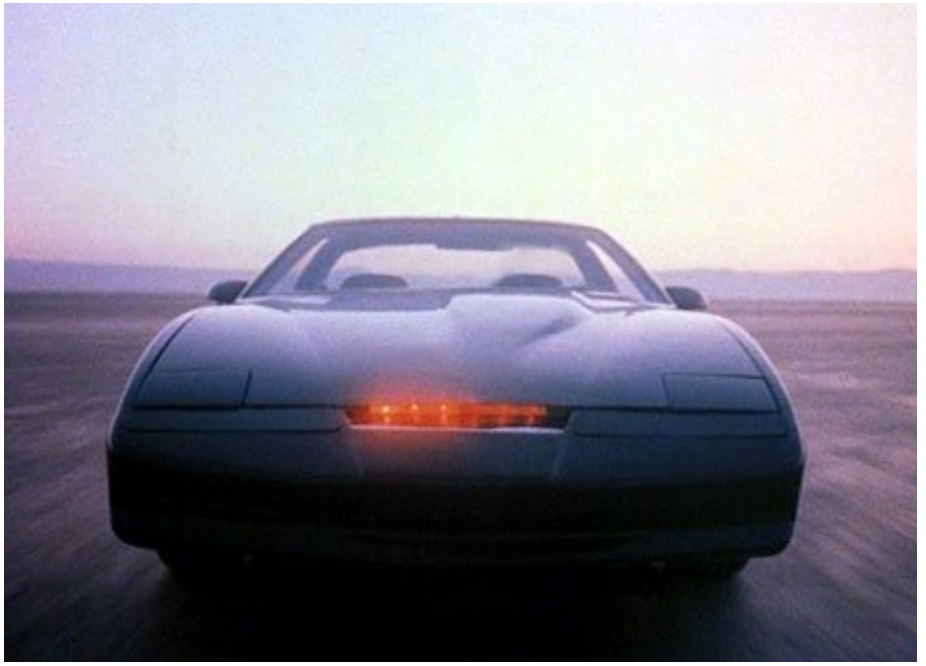
BARCO

Visibly yours

BuildRoot

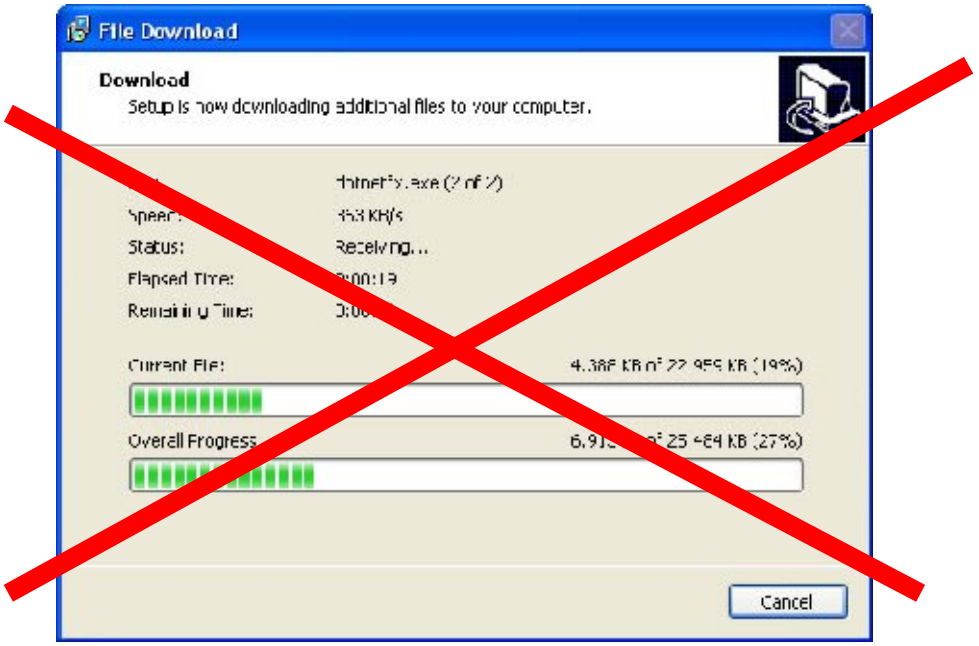
Making Embedded Linux Easy

Driver-less



Interfacing?

Interfacing without having to install any custom SW on PC



Embedded == Custom Stuff

Embedded == Custom Stuff

But Why?

.. Its

.. Its

.. At First

Time Pressure

Flexibility

I'm Special

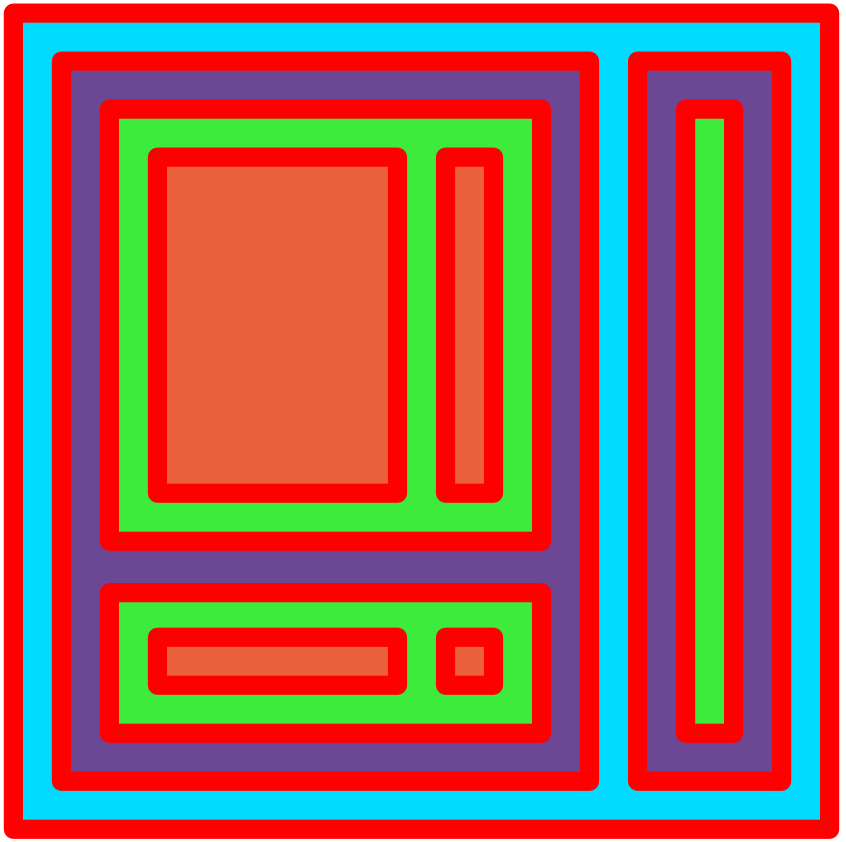
Does It Need To Be So?

- While these are sometimes valid concerns, often standard interfaces can be used instead
- Work done with Fabien Chouteau

Primer


USB
UNIVERSAL SERIAL BUS
Host
Devices

- Device
  - Configuration (mode)
    - Interface (functionality)
      - Endpoint (pipe)



A device with multiple interfaces is called a composite device

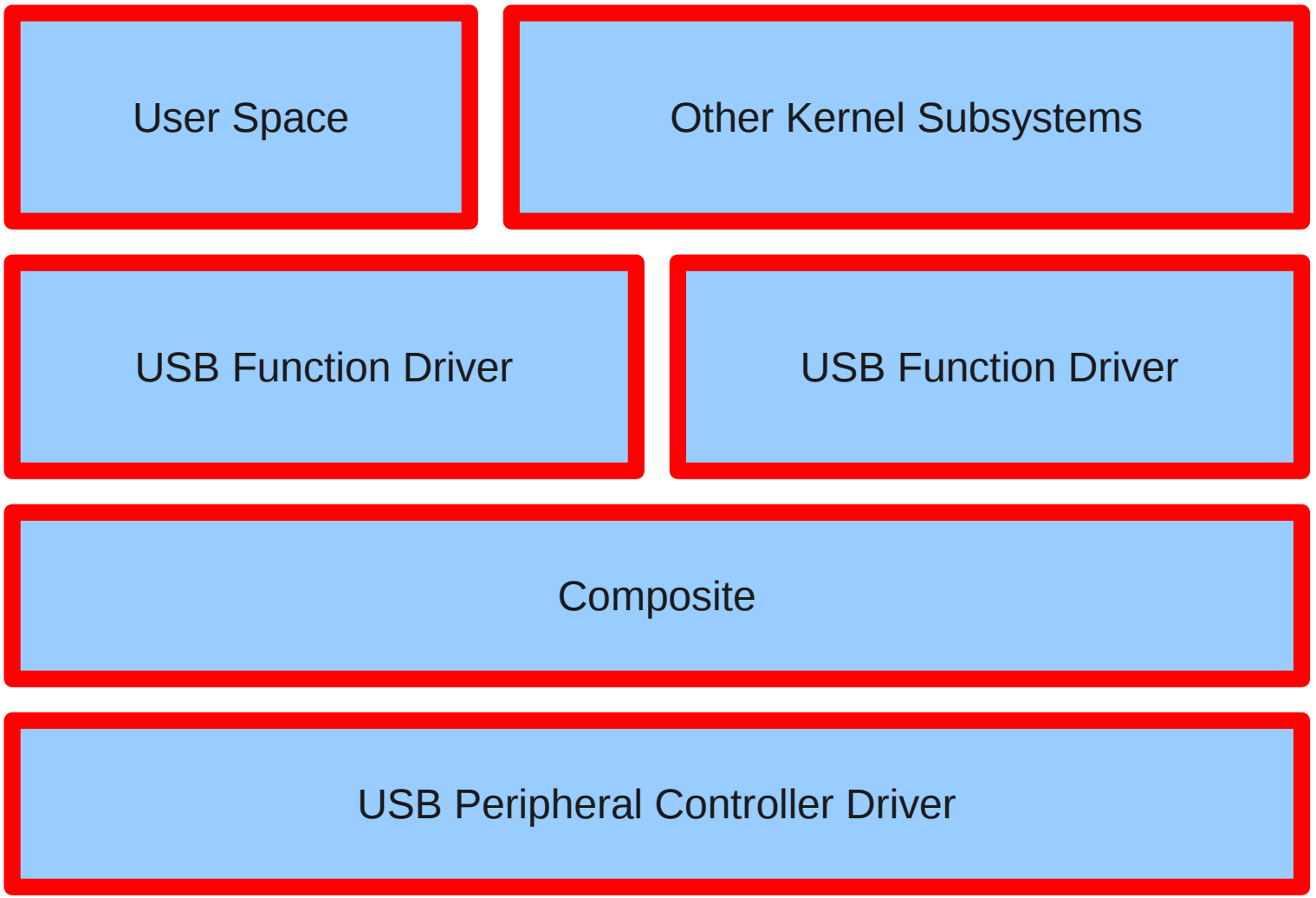
Functions can implement

- Specific vendor protocols (custom)
- USB class protocols (standard)

Class protocols most interesting as OS'es have built in drivers

- HID (keyboard/mouse/..)
- Storage (Hard drivers, USB sticks)
- Audio (headsets, speakers)
- Video (webcams)
- ..

Linux USB Gadget Stack



Examples

Function Keys

Display with function keys used to control PC

Issues

Historically interfaced to PC using custom serial protocol

- Custom PC SW needed
- Support issues
- Not usable during BIOS/BOOT
- New PCs lack serial

Solution

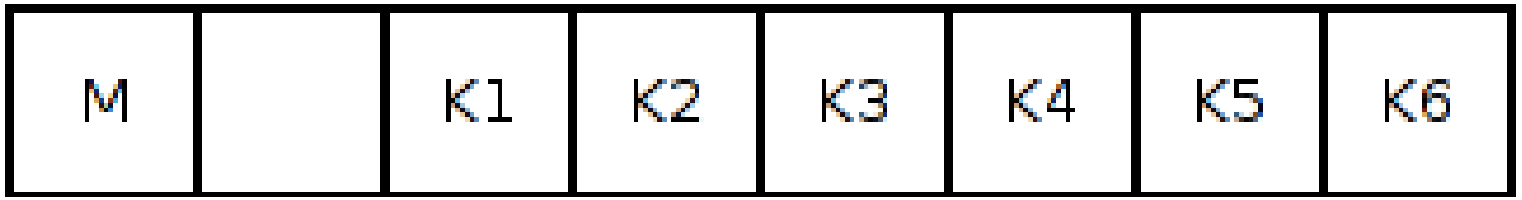
Emulate USB HID keyboard

Human Interface Devices Class

- HID descriptors to specify device type and supported report (message) formats
- Reports to device to set properties (E.G LEDs on keyboard)
  - On control endpoint
- Reports from device to report changes (E.G. key presses / releases)
  - On interrupt endpoint

HID Keyboard (Boot) Protocol

- 1 byte reports to device
  - Bitmask of LED states (numlock, capslock, ..)
- 8 byte reports from device
  - Modifier key mask (alt, ctrl, ..) and currently pressed keys



See HID usage tables for key code definitions

Implementation

- HID gadget function driver
- Mainline since 2.6.35
- Split kernel / user space implementation
  - HID descriptor handling in kernel,
  - /dev/hidgX character device to get/set HID reports
- See Documentation/usb/gadget_hid.txt for details

Kernel Side

- Platform device in platform code defining HID device descriptor(s)
  - Can emulate as many devices as controller has endpoints
- g_hid USB gadget driver

Kernel Side

```
static struct hidg_func_descriptor hid_data = {
        .subclass               = 0, /* No subclass */
        .protocol               = 1, /* Keyboard */
        .report_length          = 8,
        .report_desc_length     = 63,
        .report_desc            = {
                0x05, 0x01,   /* USAGE_PAGE (Generic Desktop)  */
                0x09, 0x06,   /* USAGE (Keyboard)              */
                0xa1, 0x01,   /* COLLECTION (Application)       */
                ...
        }
};

static struct platform_device hid = {
        .name                   = "hidg",
        .id                     = 0,
        .num_resources          = 0,
        .resource               = 0,
        .dev.platform_data      = &hid_data,
};

platform_device_register(&hid);
```

User Space Side

Read/write to /dev/hidgX

E.G. To send 'a':

```
echo -en '\0\0\4\0\0\0\0\0' >/dev/hidg0
echo -en '\0\0\0\0\0\0\0\0' >/dev/hidg0
```

Demo

Similar Setups

Yubico UbiKey one-time password generator

ThinkGeek Phantom Keystroker

Potential Pitfalls

Key codes in HID reports are scancodes
Corresponding key depends on PC keyboard layout

Example 2

Data Transfers

Firmware Upgrades through USB

Issues

Historically using custom serial protocol

- Custom PC SW needed
- Support issues
- New PCs lack serial

Solution

Emulate USB memory stick

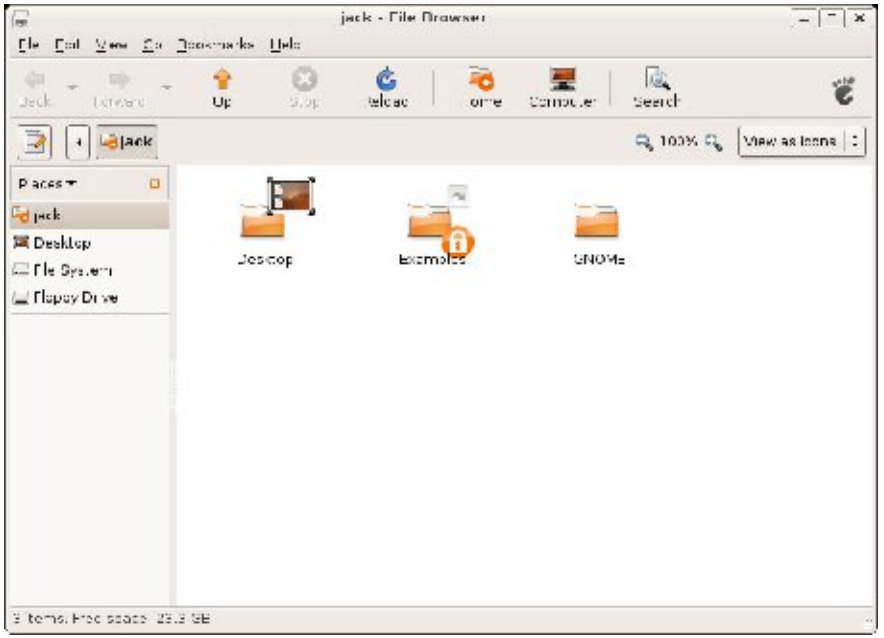
Alternatively access USB stick if host port available

Pitfalls

- Mass Storage == Block device
- Filesystems / OSes don't support concurrent access
- Need to detect when it is safe to access device

Use Case

- Provide virtual drive where firmware upgrade can be copied to
- Perform upgrade when unplugged



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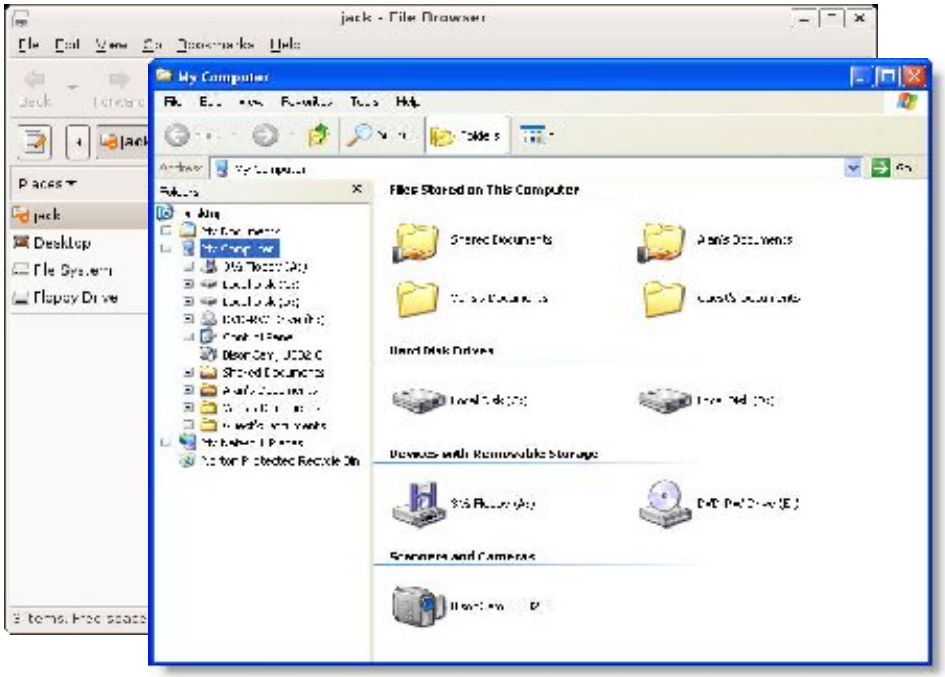

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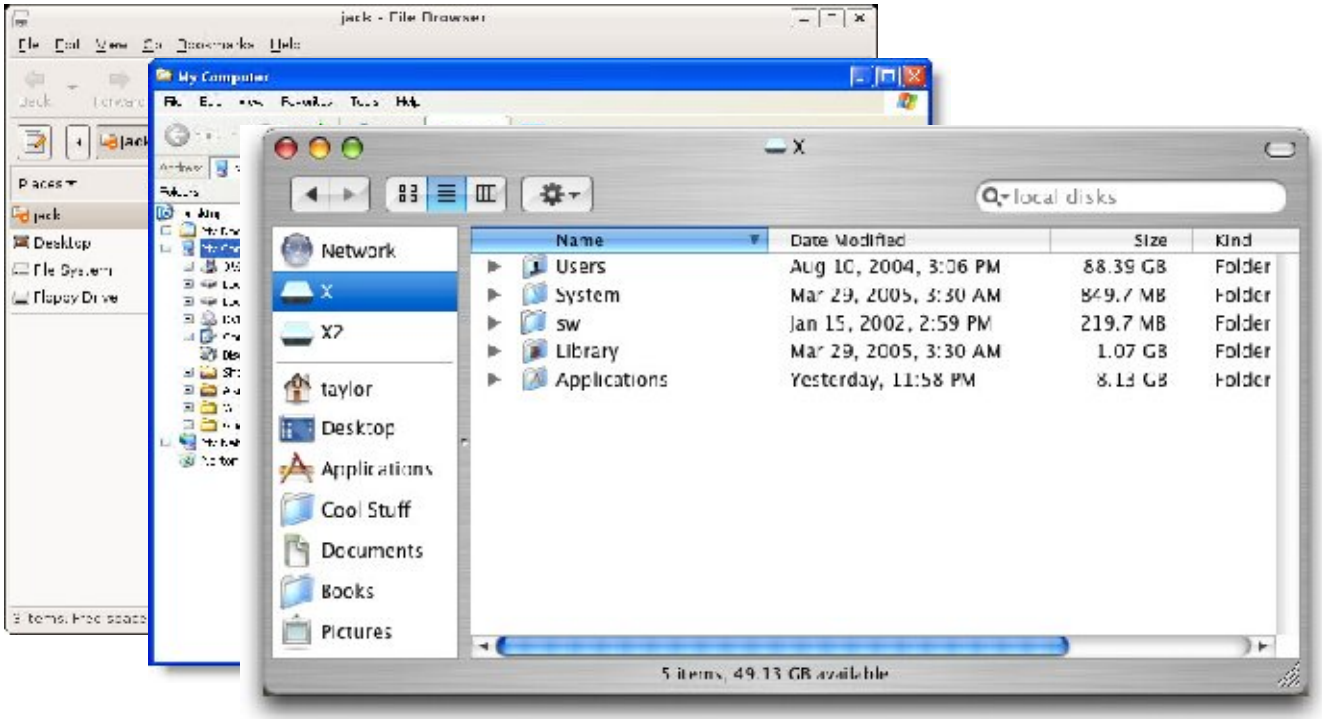


Implementation

- File storage gadget function driver in kernel
- Userspace notification on unplug / eject
- Mainline since 2.6.35
- Sysfs attributes:
  - /sys/<gadget>/suspended
  - /sys/<gadget>/lunX/file

Implementation

- User space program that on unplug / eject:
  - Ejects file
  - Loopback mounts filesystem
  - Inspects it for interesting files
  - Recreates file system
  - Adds file to file storage driver

Implementation

- File system could simply be a pregenerated template
  - Prepopulated with any needed help/documentation files
- Stored on local storage or RAM (tmpfs)
  - If tmpfs, sparse file interesting
  - FAT table / help file << filesystem size

Demo

- Check for image files
- Show on framebuffer

Similar Setups

- Same approach could be used to transfer data from device
- Several 3G modems have Windows drivers on emulated USB drive

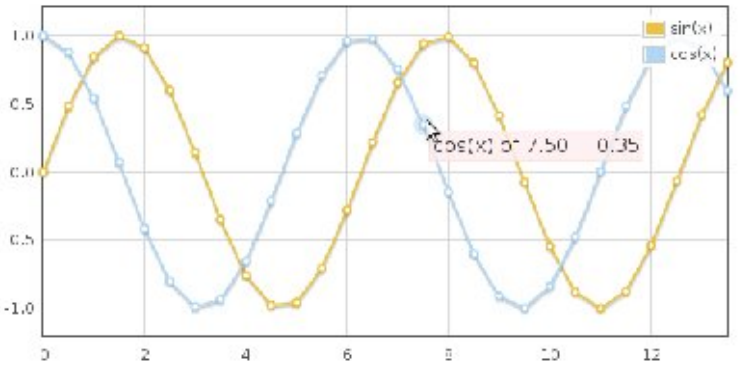
Alternatives

- Device Firmware Upgrade (DFU)
- Picture Transfer Protocol (PTP)
  - Gadgetfs implementation: http://git.denx.de/?p=ptp-gadget.git
- Media Transfer Protocol (MTP)
  - MeeGo implementation: http://wiki.meego.com/Buteo/MTP

- None are as generic or well supported

Web Interfaces

- Good Alternative to custom PC GUI Software
- Many open source libraries exists
  - JQuery UI (GUI Widgets)
  - Flot (Graphs)
  - ..



- Modern AJAX is nice for embedded
  - Heavy processing on client side

Conclusion

- USB Class protocols can be (ab)used for driver-less interfacing
- Easiest PC SW support is NO SW
- Easy to integrate, in mainline
- Extends to lots of other areas

Thanks!

Questions?