The GPIO subsystem (uC)

The GPIO pins

All microcontrollers have GPIO pins

- GPIO means "General Purpose Input/Output"
- Some manufacturers call them just PIO or Parallel I/O
- Sometimes their are called I/O pins
- ....

They are usually divided in groups, called "ports"

- Ports are of varying width
  - AVR has 8-bit ports (it's an 8-bit CPU)
  - Some Cortex-M has 12-bit ports
  - Most have 16-bit or 32-bit ports
- Not all bits can be instantiated
  - Sometimes ports may have as few as 0 useful bits
  - Fortunately, vendors use proper "sparse" names

If you use the concept of ports, they *must* be 32b wide

- We have so many numbers in one integer
- Portability is paramount

Alternate Functions

Most GPIO pins have alternate functions

- Each pin has one or several predefined uses
  - PWM, UART, SPI, I2C, ...
- Most pins are part of the GPIO subsystem
- Usually, high-speed signals (e.g. USB) live on dedicated pins

When using GPIO, programs should be portable

- We need an API that always works.
- The same program should build and work everywhere
- The code should never refer to CPU specifics

When using alternate functions, it's a matter of the driver

- The driver (UART, SPI, whatever) is machine specific, so it can know the AF
- Still, we want a consistent API offered by the GPIO API

When offering and alternate function API, GPIO must be 0

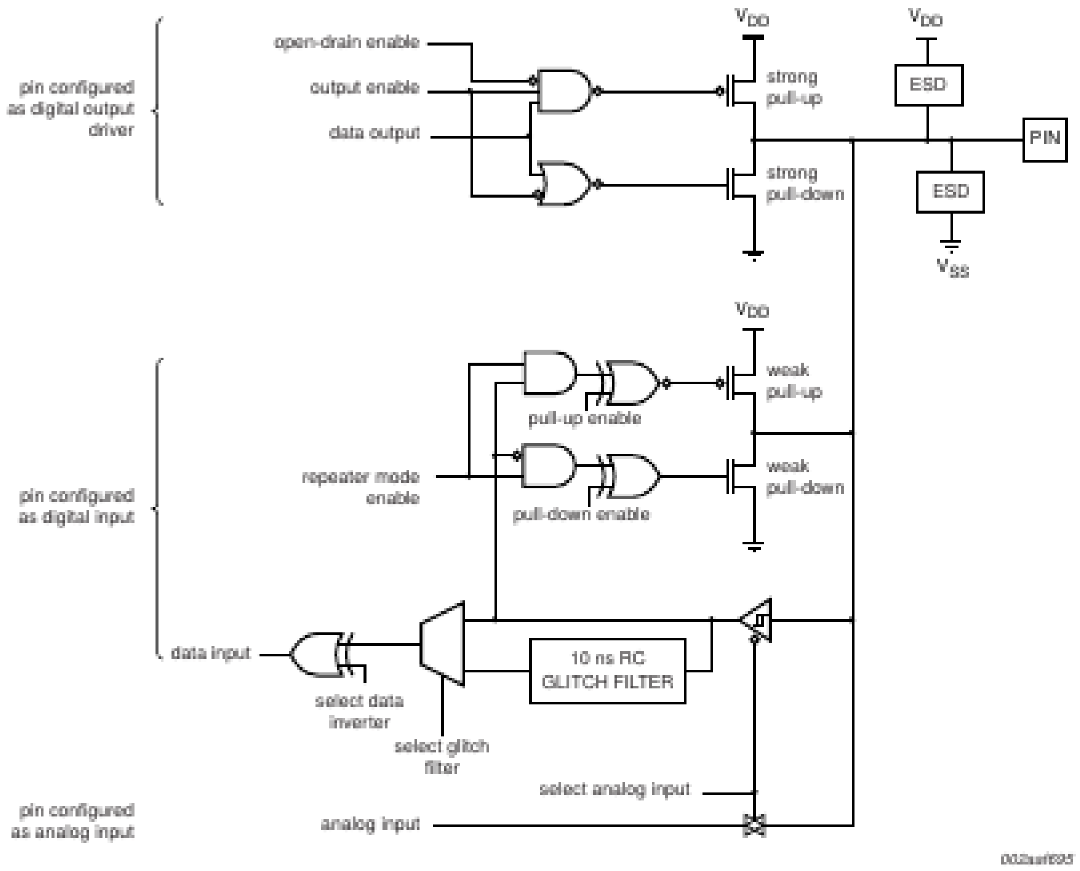
- Portability is paramount

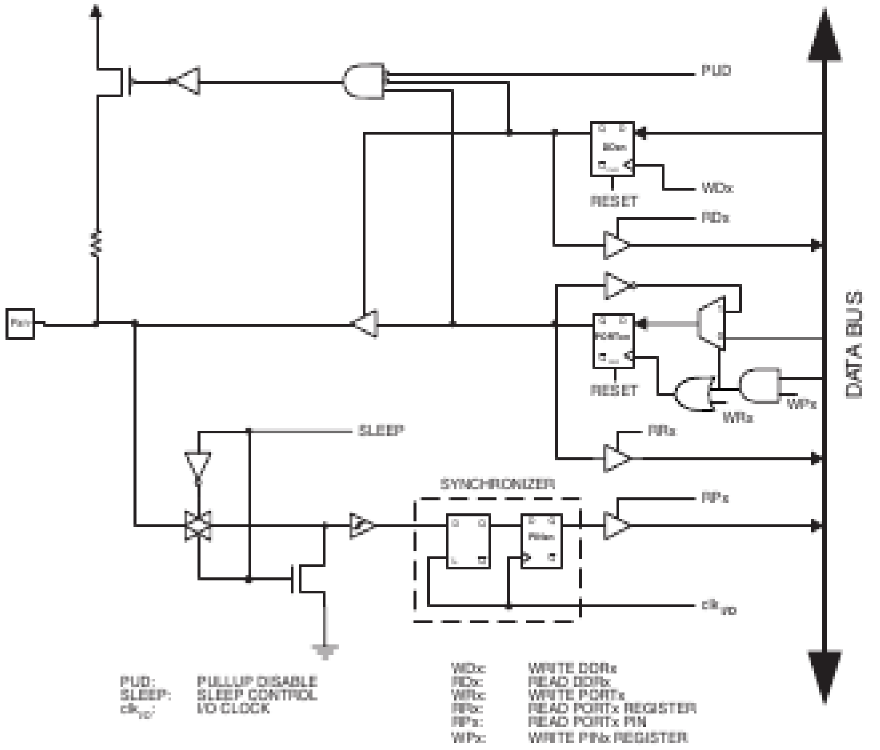
Electrically

Every user manual describes the electrical GPIO

- All of them have input and output modes
- Some can feature pull-up and/or pull-down
- Some can have a open-drain mode

Examples (LPC11 and ATmega):





Still, we want a unified API

GPIO pins are everywhere

Microcontroller ports are only part of the game

- You have GPIO extenders over I2C
- Most peripheral chips offer some GPIO pin
- You can have a remote controller, behind pci/usb/whatever

We need a flexible API that can be extended over time

Vendors solutions are not "usually" up to the task

- They only offer register names
  - "IOSET1 = n"
- Or they offer structures
  - "GPIOC->IDR"
- I'm ready to apologize if you show me good vendor code

The Linux approach grew too complex over time

- It can't be replicated in the microcontroller world

So, this is the API we are going to use

No specific header to include

- The gpio header is included by default by cpu.h

```
GPIO_NR(port, bit)
GPIO_PORT(nr)
GPIO_BIT(nr)

extern void gpio_init(void);

extern int gpio_dir_af(int gpio, int output, int value, int afnum);
extern void gpio_dir(int gpio, int output, int value);

extern int gpio_get(int gpio);
extern uint32_t __gpio_get(int gpio);
extern void gpio_set(int gpio, int value);
extern void __gpio_set(int gpio, uint32_t value);
```

Then, there are constants to help the caller

- GPIO_DIR_IN, GPIO_DIR_OUT, ...

Initialization can be slow (who cares)

Runtime may need to be fast

- Sometimes, the program may directly act on registers

And now the homework

Please read my headers and C files (include/gpio* and lib/gpio*)

- Understand what they do
- Learn from what is good
- Complain about what is bad

Suggest changes to the API to make it better