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**Powerful Embedded Systems**

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# Powerful Embedded Systems



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# Computers from big to small



In the 1980:

- Big: mainframe computer (~ 1M\$)
- Medium size: mini-computers (VAX, PDP-11 ...) (~200 k\$)
- Small: Micro computers (~2 k\$)

Today:

- Big: PCs arranged in computing farms (~100k\$)
- A little less big: Desktop PCs and Laptops (~2k\$)
- Medium size: PDA, handphones (~200 \$)
- Small: Micro controllers in embedded systems (50 c)

# Data Acquisition and Control



- PC with devices directly attached through dedicated interfaces
- A powerful embedded system with attached sensors is connected to a network and controlled from a PC
- A network of “intelligent sensors” is read by an powerful embedded system which in turn is controlled by a PC

# What do we call a “powerful embedded system”?



- Micro-controllers are powerful enough to run a full operating system
- Flash memory to store boot loader or full operating system
- Typical RAM memory sizes of 64 or 128 Mbytes
- Many interfaces allow to connect to the outside world:
  - Ethernet, WiFi
  - I2C bus
  - USB
  - RS-232
  - TFT screen and touch screen

# Where are they used?



- The first such systems were used in network routers
- Now in games consoles
- Mobile phones
- GPS systems
- PDAs

These systems are mass produced and therefore cheap. The components are cheap as well

- Can we make use of this for data acquisition and control applications?

# Our examples



We have 2 types of systems:

- PCEngines Wrap board  
a commercial board designed as router hardware
- A home built ARM-9 system designed for camera readout in an astronomy experiment  
The board has been designed by  
G. Kasprowics, a doctoral student at CERN

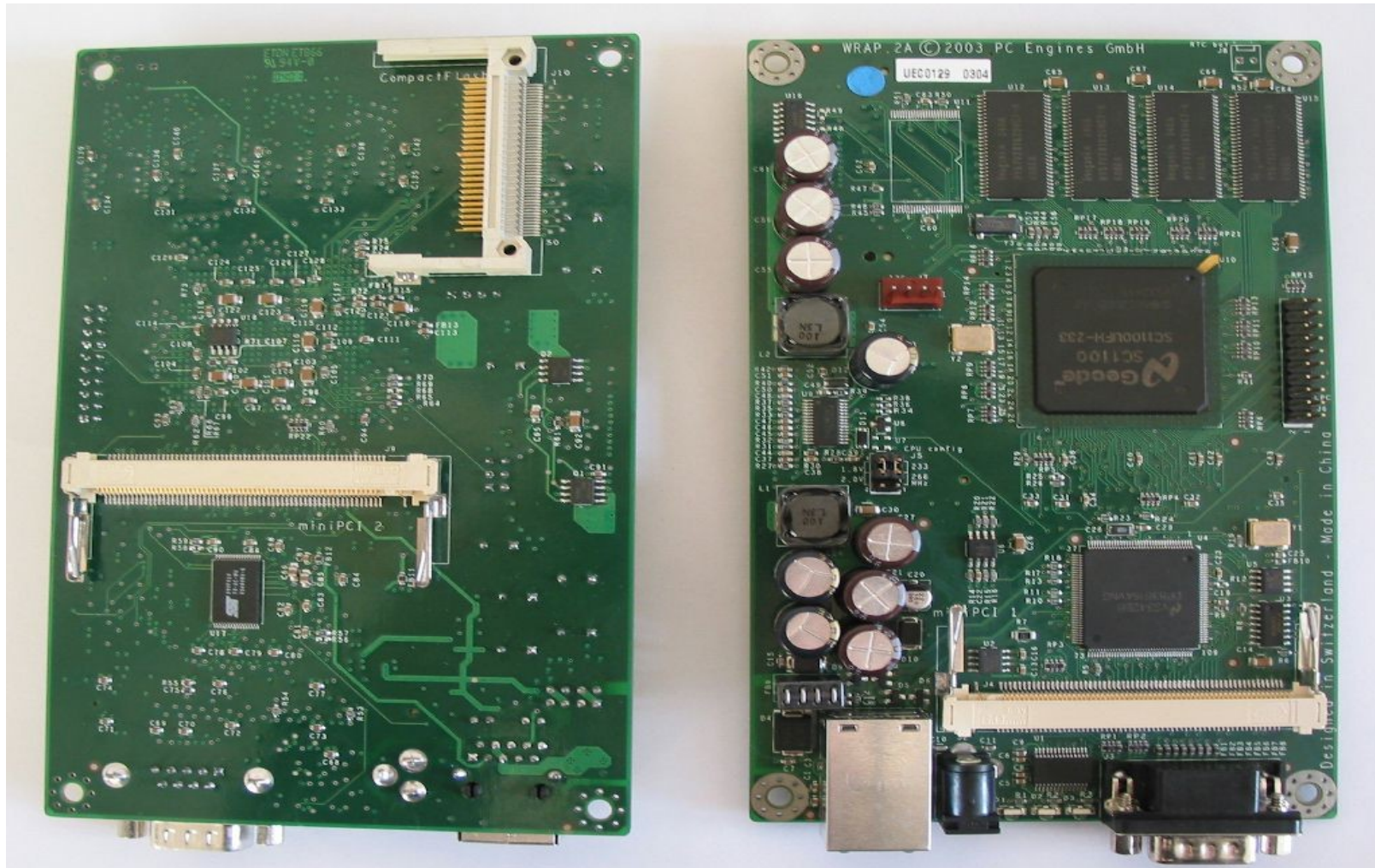
# Micro controller architecture



- Intel compatible
  - Atom, Geode, ...
- Different architecture (needs cross compilers)
  - MIPS
  - PowerPC
  - ARM



# The PC-Engines Wire Router Application Platform (WRAP)



# Information on the WEB



- PC Engines WEB site
- AMD Geode SC1100 WEB site

# The Wrap board



- Runs the Geode chip, a i486 compatible micro controller
- Has a stripped down BIOS similar to a PC
- CF card interface
- Ethernet
- Mini PCI
- LPC bus (could be used to interface sensors)
- Designed as a Wifi to Ethernet gateway

# WRAP features



- Uses the AMD Geode Chip (486 compatible)
- 266 Mhz SC1100 CPU
- 128 Mbytes of RAM
- ~3-5 Watts
- Small (128 kBytes) flash for BIOS
- I2C bus
- LPC (low pin count bus)
- Compact flash interface
- 100 Mbit Ethernet
- Cost: ~ 100 \$ US (the board is now discontinued but replaced by a similar design (ALIX))

# ARM-9 board



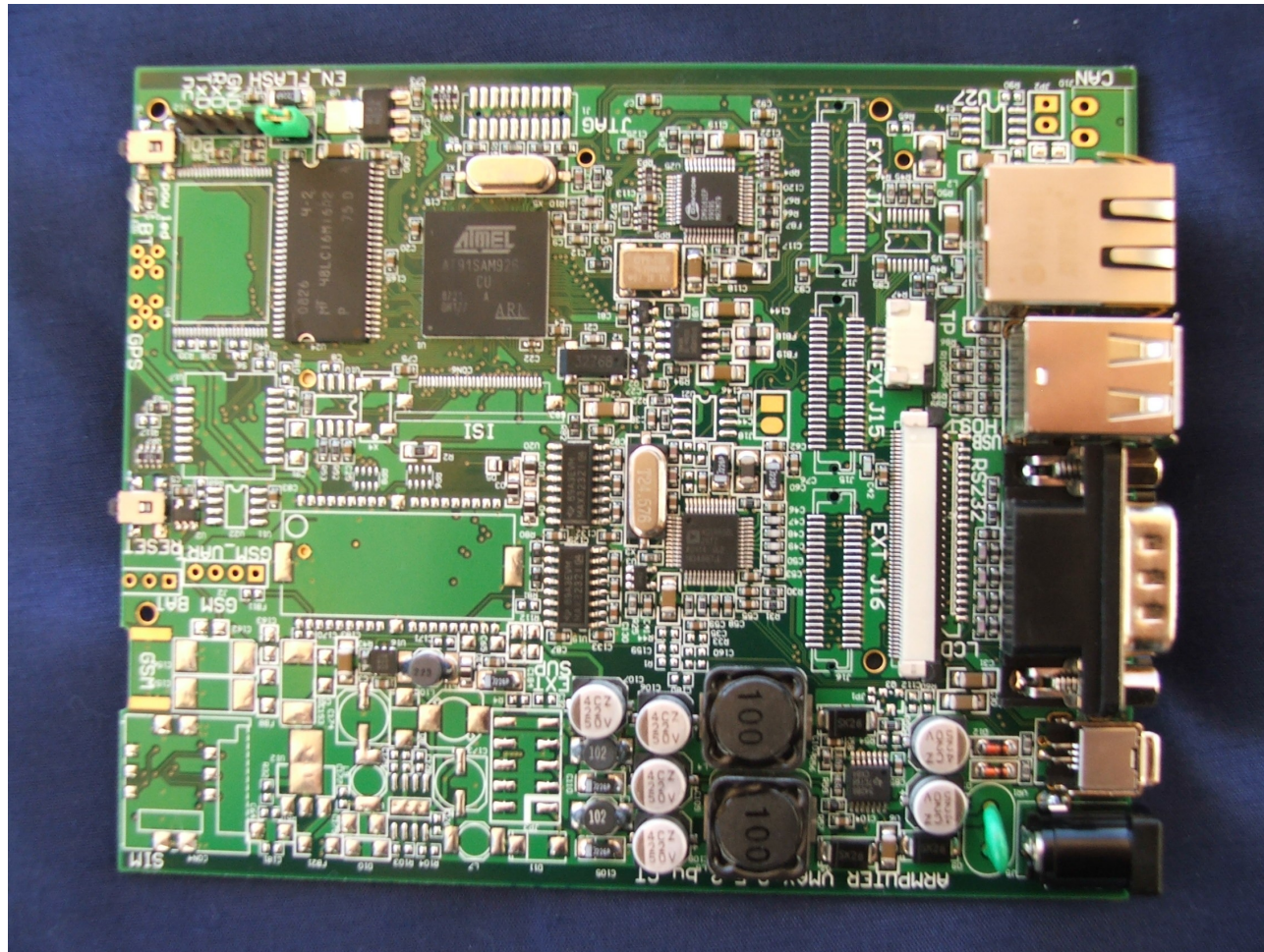
The ARM (Advanced Risc Machine) architecture is very popular for hand held devices

Advantages:

- Cheap
- Powerful
- Many manufacturers have micro-controllers with a big range of interfaces
- Well supported by open source software (Linux and GNU compiler chain + libraries)

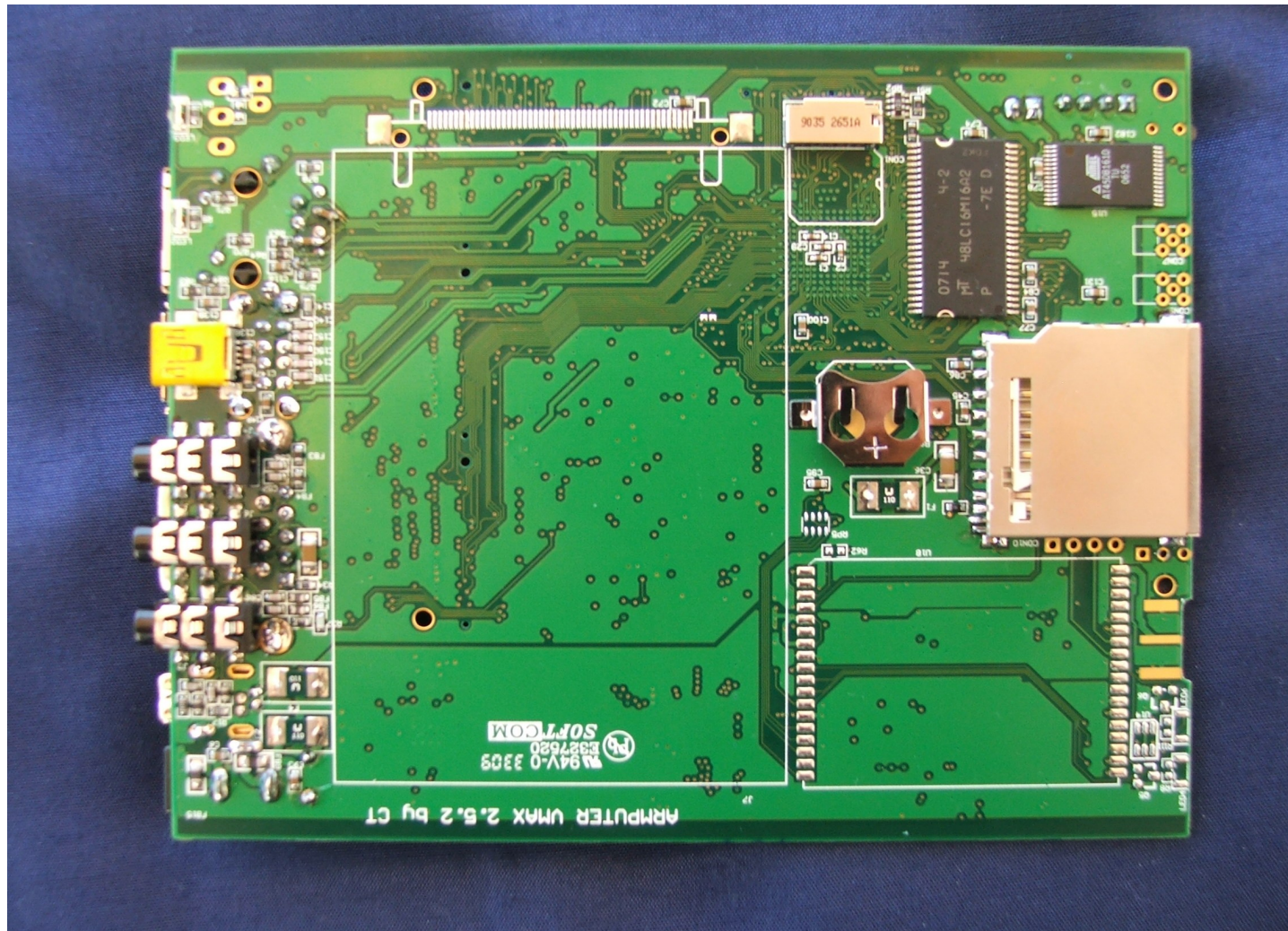


# The ARM board





# The ARM's back side



# Some features



- CPU with arm-9 architecture (at91sam9263)
- Program for booting in ROM
  - Program for booting in ROM
  - 100 Mbit Ethernet connection
  - Memory controller for
    - SDRAM memories
    - Nand flash memories
    - Dataflash memories
  - Asynchronous serial interface (RS-232)
  - Debugging/console port (RS-232)



# More features (ARM)



- I2C bus interface
- TFT screen interface
- Audio interface (can be used for data sampling)
  - 96 ksamples/sec stereo input
  - Stereo outputs
- Harddisk interface
- GSM (not mounted on our boards)
- Bus extension connector (not mounted on our boards)
- 3 USB ports

# The I/O board



- Board specifically designed for this college
- Has a series of I2C and 1-wire devices
- I2C is a 2-wire (data + clock) serial bus invented by Phillips
- Often used on CPU boards for infrastructure (ventilator and temperature control)
- In at91sam9263 I2C is implemented in the chip
- 1-wire bus (Dallas) accessed by I2C to 1-wire bridge

# WEB resources for at91sam9263



- [Atmel at91sam9263 Website](#)
- [Atmel at91sam9263 evaluation kit Website](#)
- [Linux4sam Website](#)