Principles and Practices of Microcontroller (Embedded System Design I) -Couse Introduction

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What is an embedded system?

- Has CPU
- Is app-specific
- Has no OS
- Real-time (Automotive)
- Integrated in device
- Memory constrained
- Peripheral
- Low power
- Small size
- Mobile/Network
- Cost constrained

Embedded, everywhere

What is driving the embedded everywhere explosion?

What is driving the embedded everywhere explosion?

- Some facts
- There are about 100 embedded processors in each PC, not just the main processor.
- A car today has about 100 embedded processors. (ABS, sound system, engine control, emissions control, …)
- Washers and Dryers
- Others?

A system to design: Overview

- **A possible implementation**

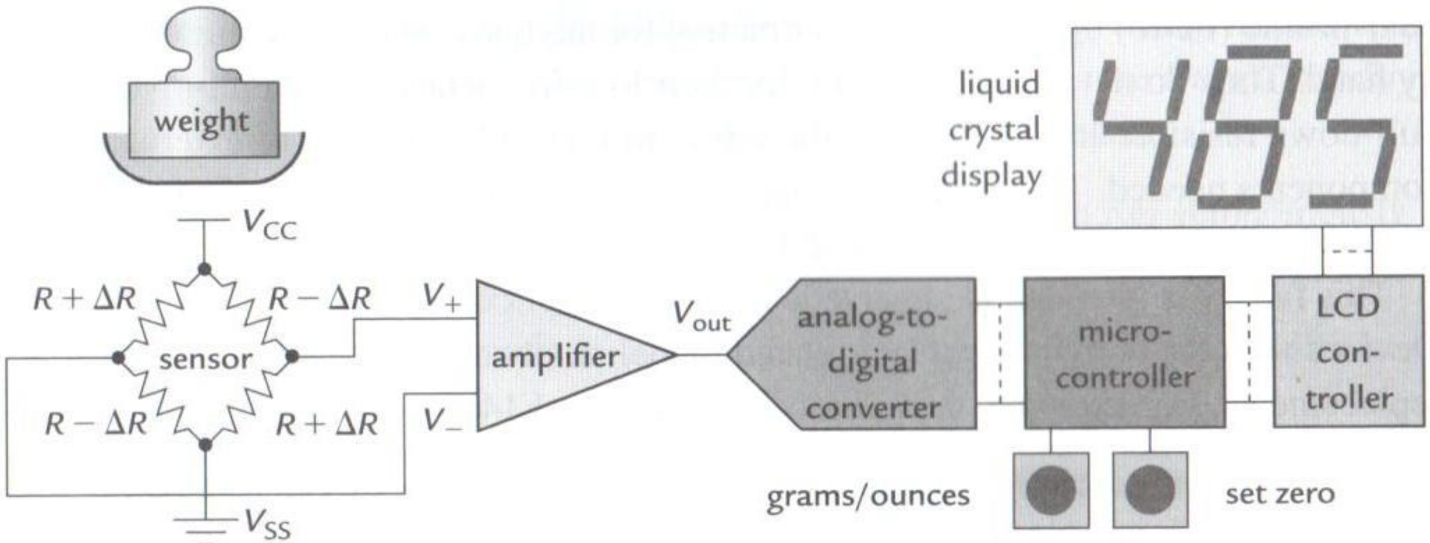
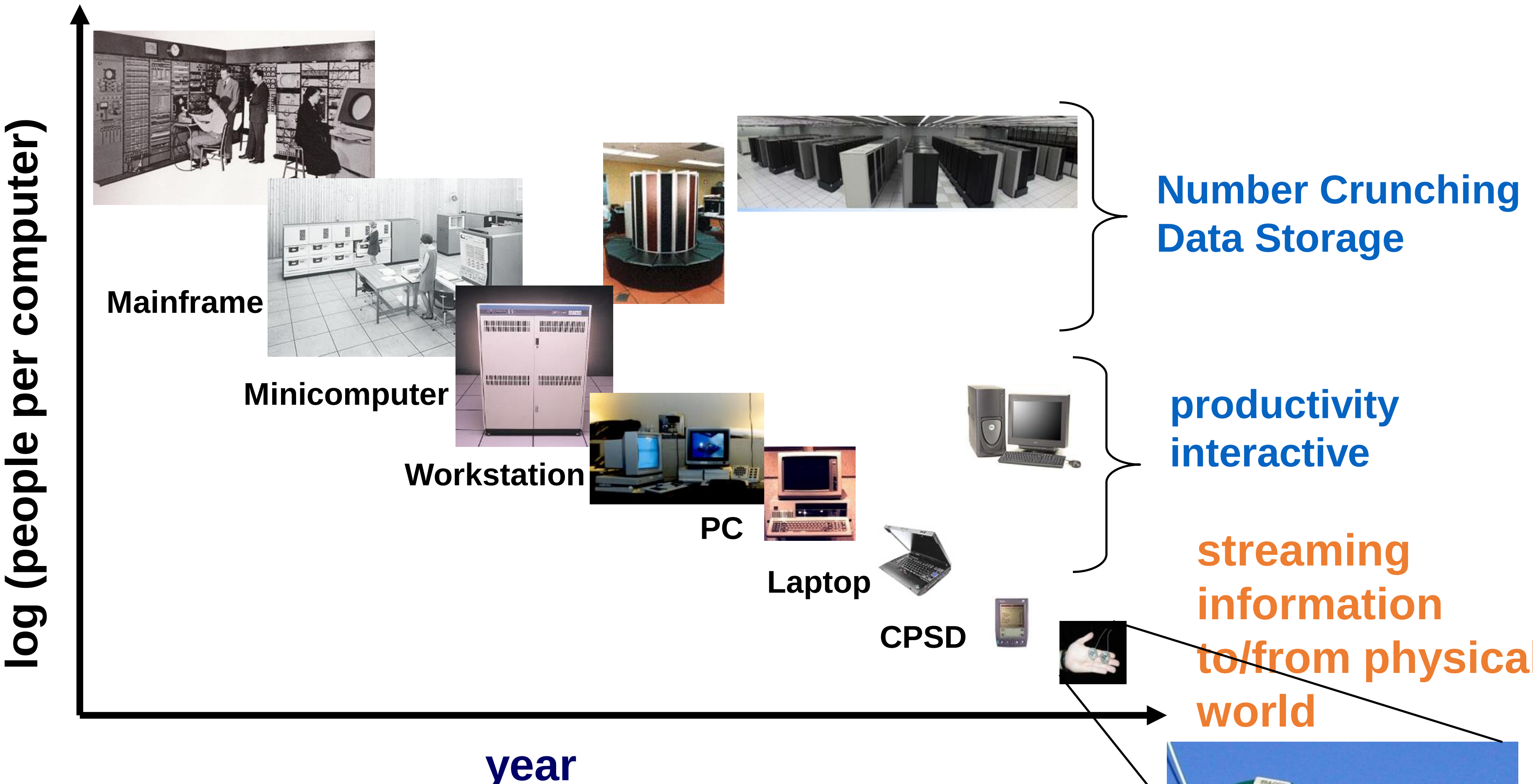


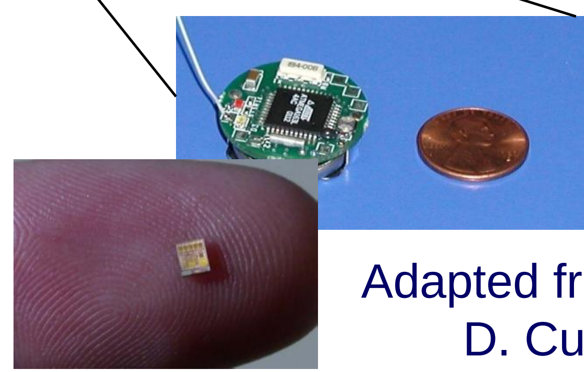
Figure 1.4: Weighing machine with a liquid crystal display, broken down into individual functions.

Outline

- **Technology Trends**
- **Design Questions**
- **Course Introduction**
- **Lab Introduction**

Bell's Law of Computer Classes: A new computing class roughly every decade

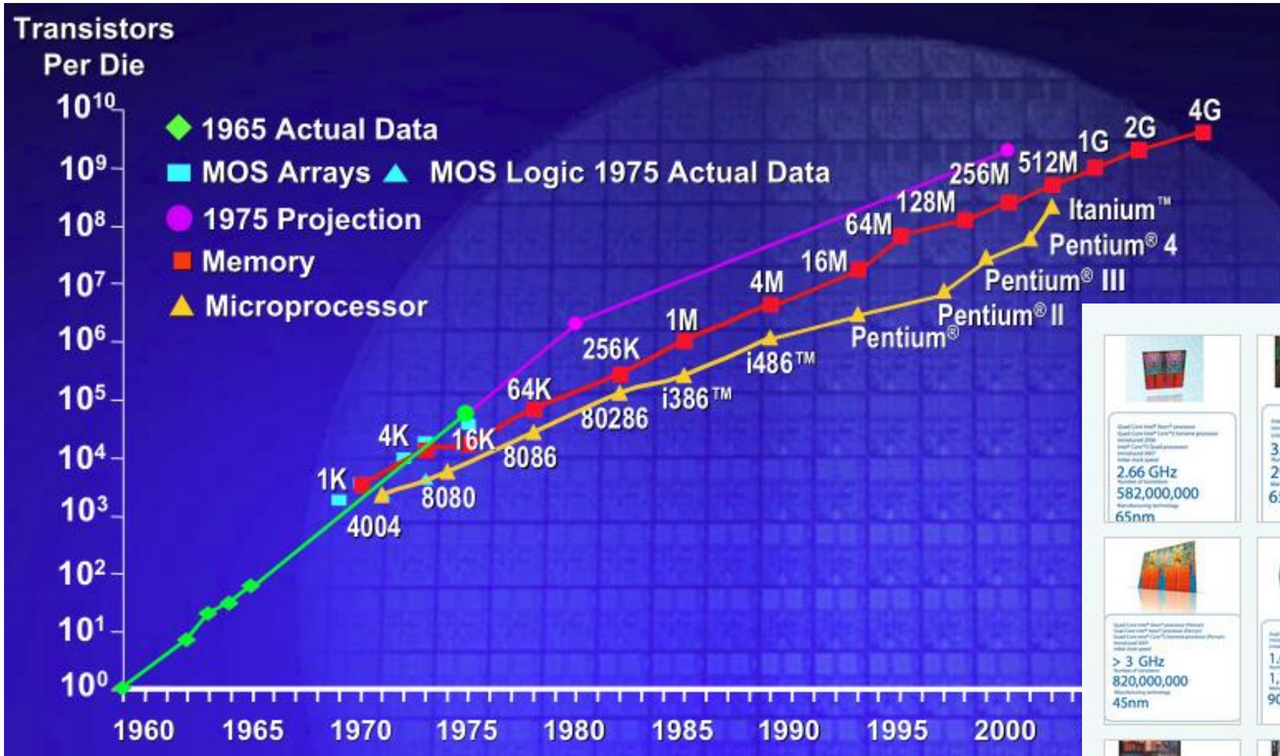




"Roughly every decade a new, lower priced computer class forms based on a new programming platform, network, and interface resulting in new usage and the establishment of a new industry."

Adapted from D. Culler

Moore’s Law:
IC transistor count doubles every two years



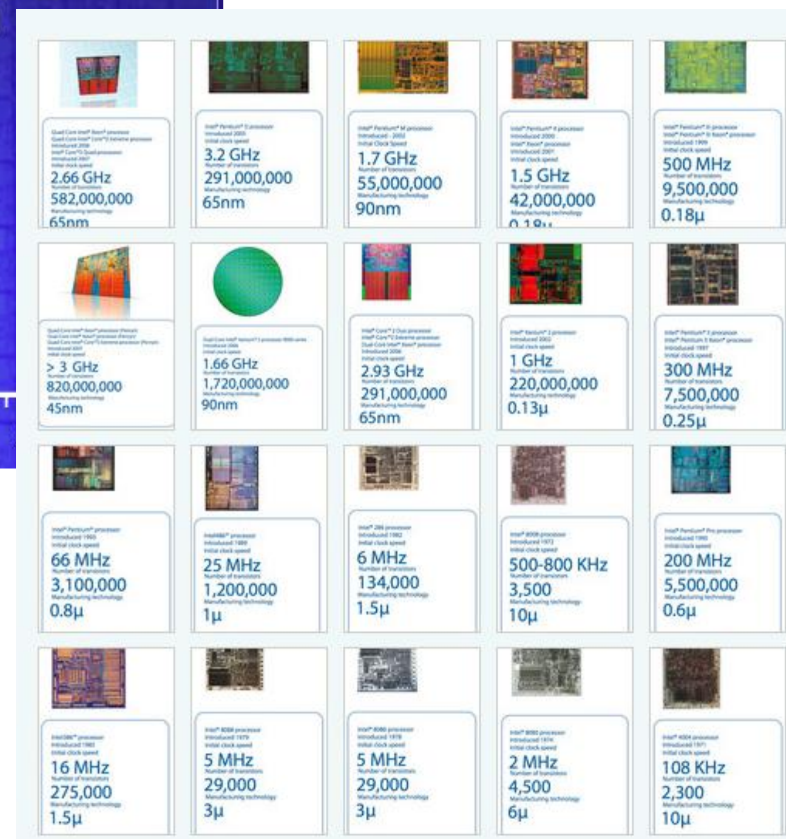
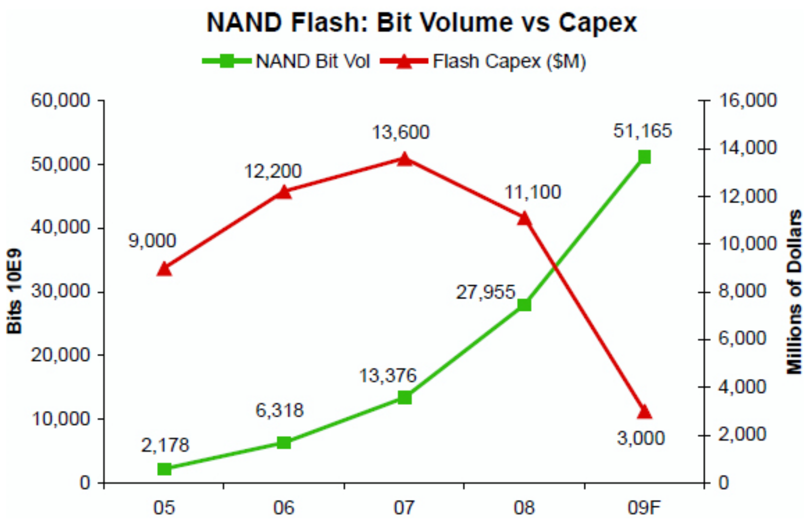
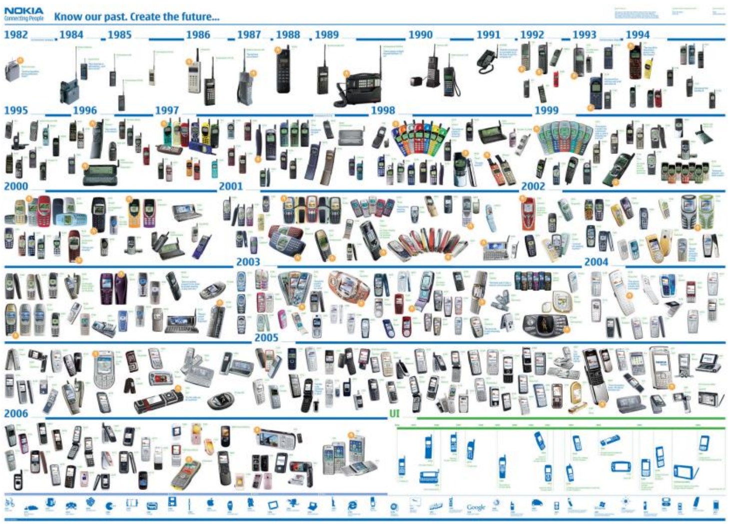


Photo Credit: Intel

Flash memory scaling:
Rise of density & volumes; Fall (and rise) of prices





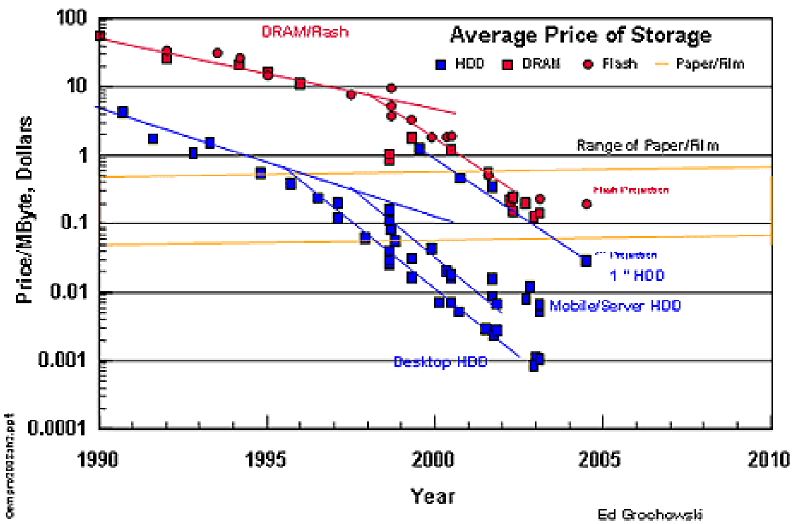
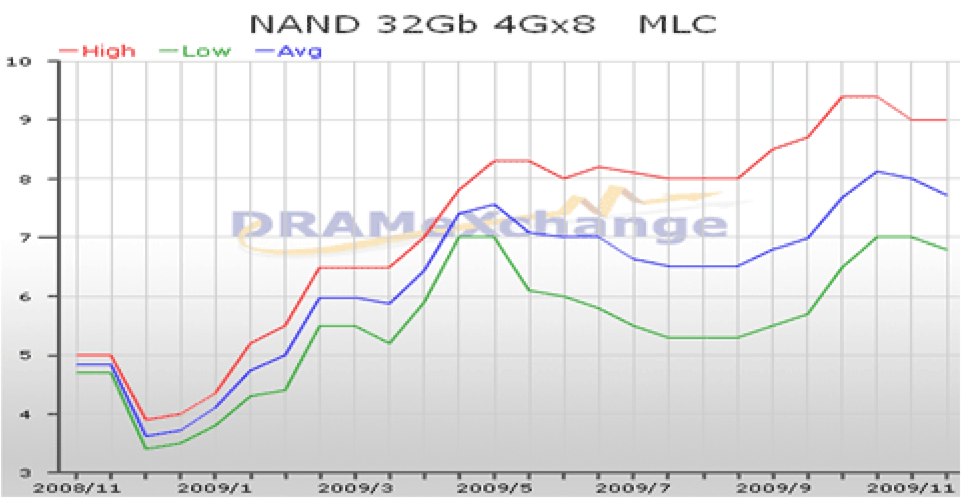
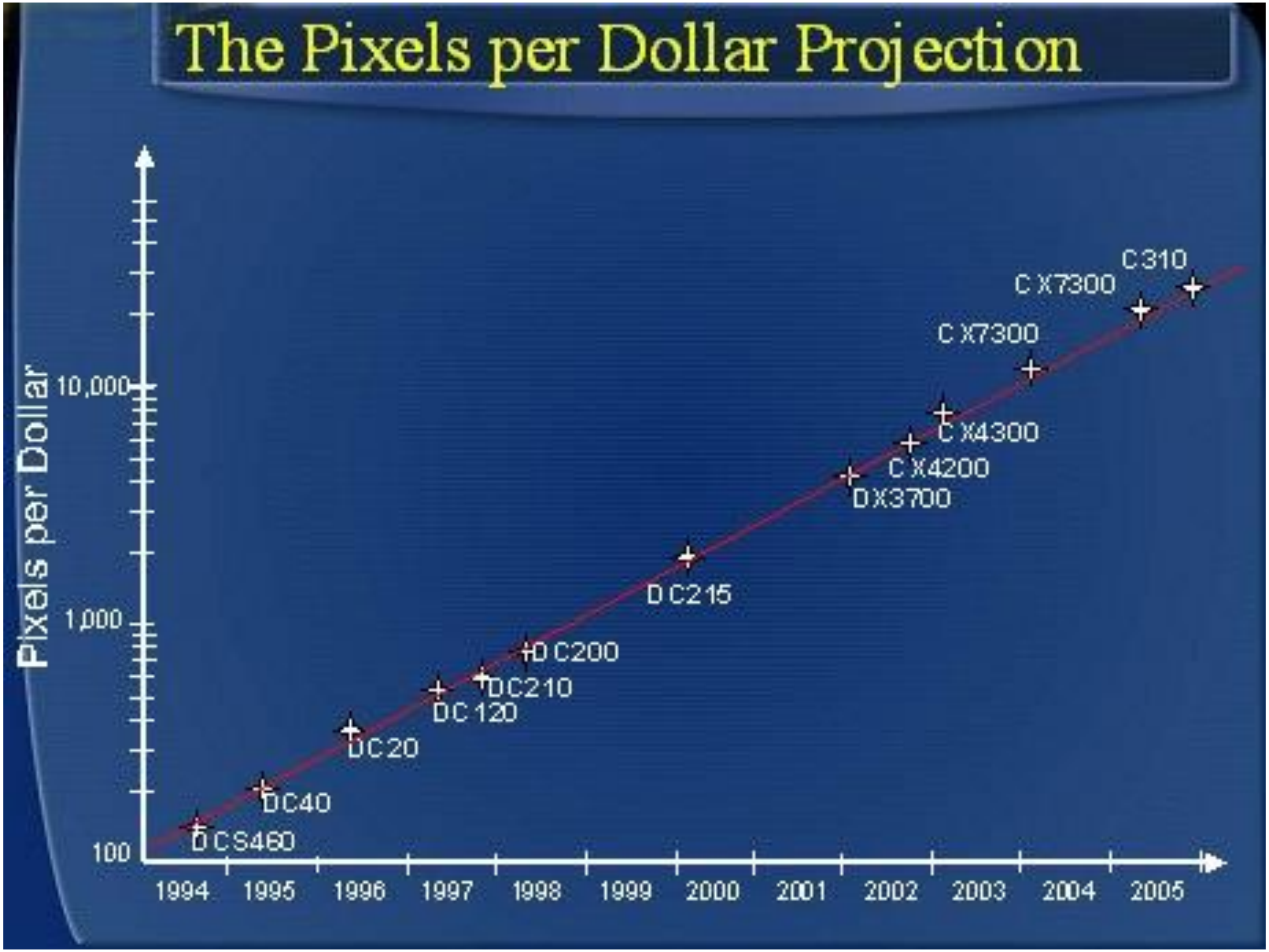


Figure-1 32Gb MLC NAND Flash contract price trend

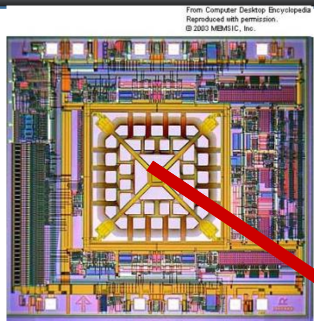


Source: DRAMeXchange, Nov. 2009.

Hendy's "Law": Pixels per dollar doubles annually



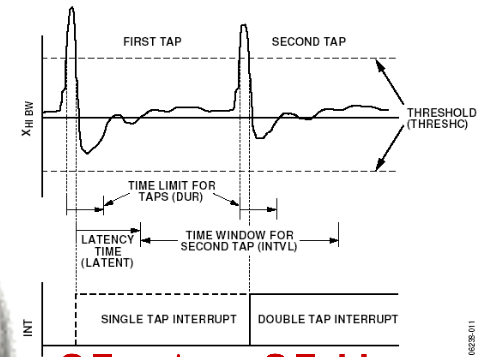
MEMS Accelerometers:Rapidly falling price and power

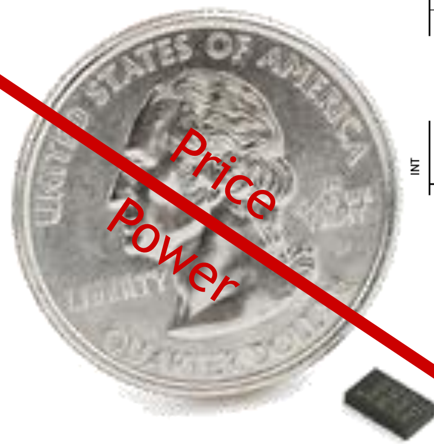


O(mA)

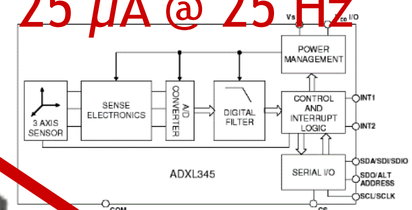
Price

Power





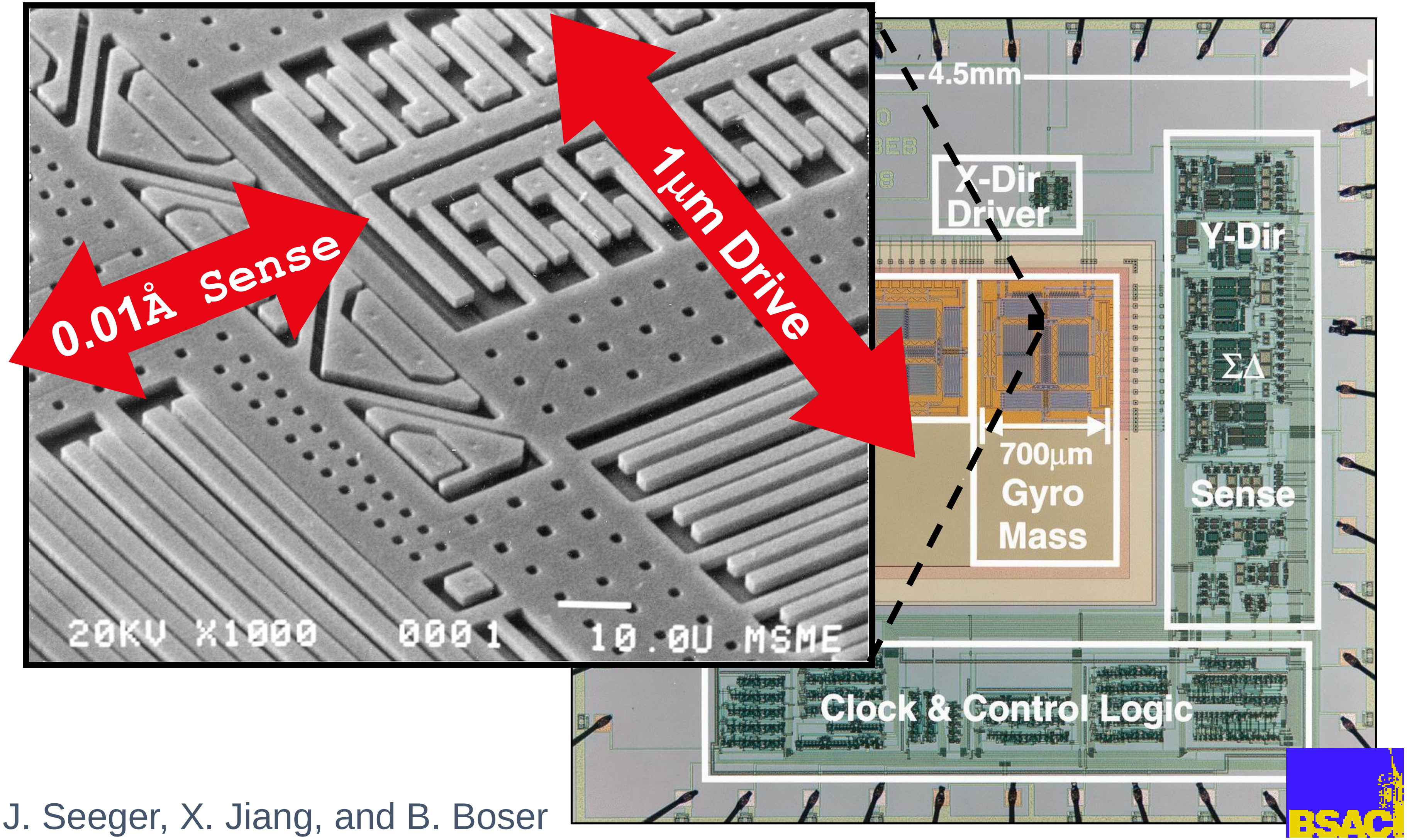
25 μA @ 25 Hz



ADXL345
[Analog Devices, 2009]

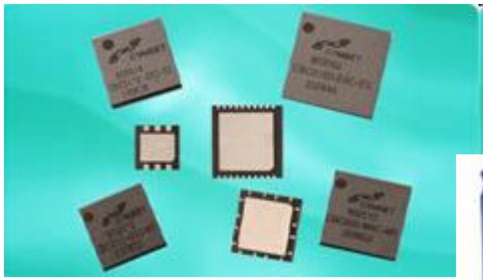
10 μA @ 10 Hz @ 6 bits
[ST Microelectronics, annc. 2009]

MEMS Gyroscope Chip

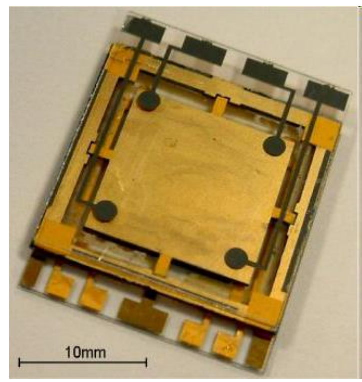


J. Seeger, X. Jiang, and B. Boser

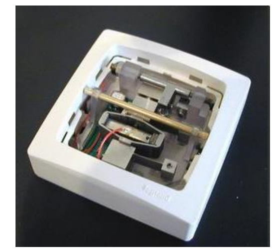
Energy harvesting and storage:Small doesn't mean powerless…



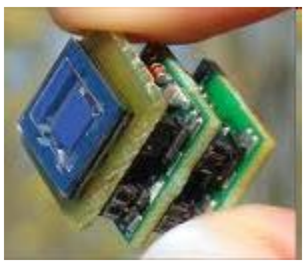
Thin-film batteries



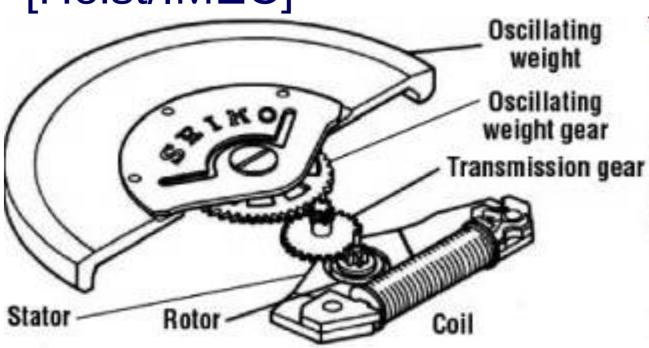
Electrostatic Energy Harvester [ICL]

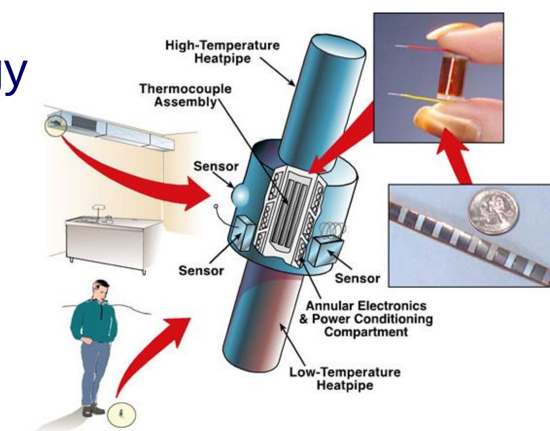


Shock Energy Harvesting CEDRAT Technologies



Piezoelectric [Holst/IMEC]



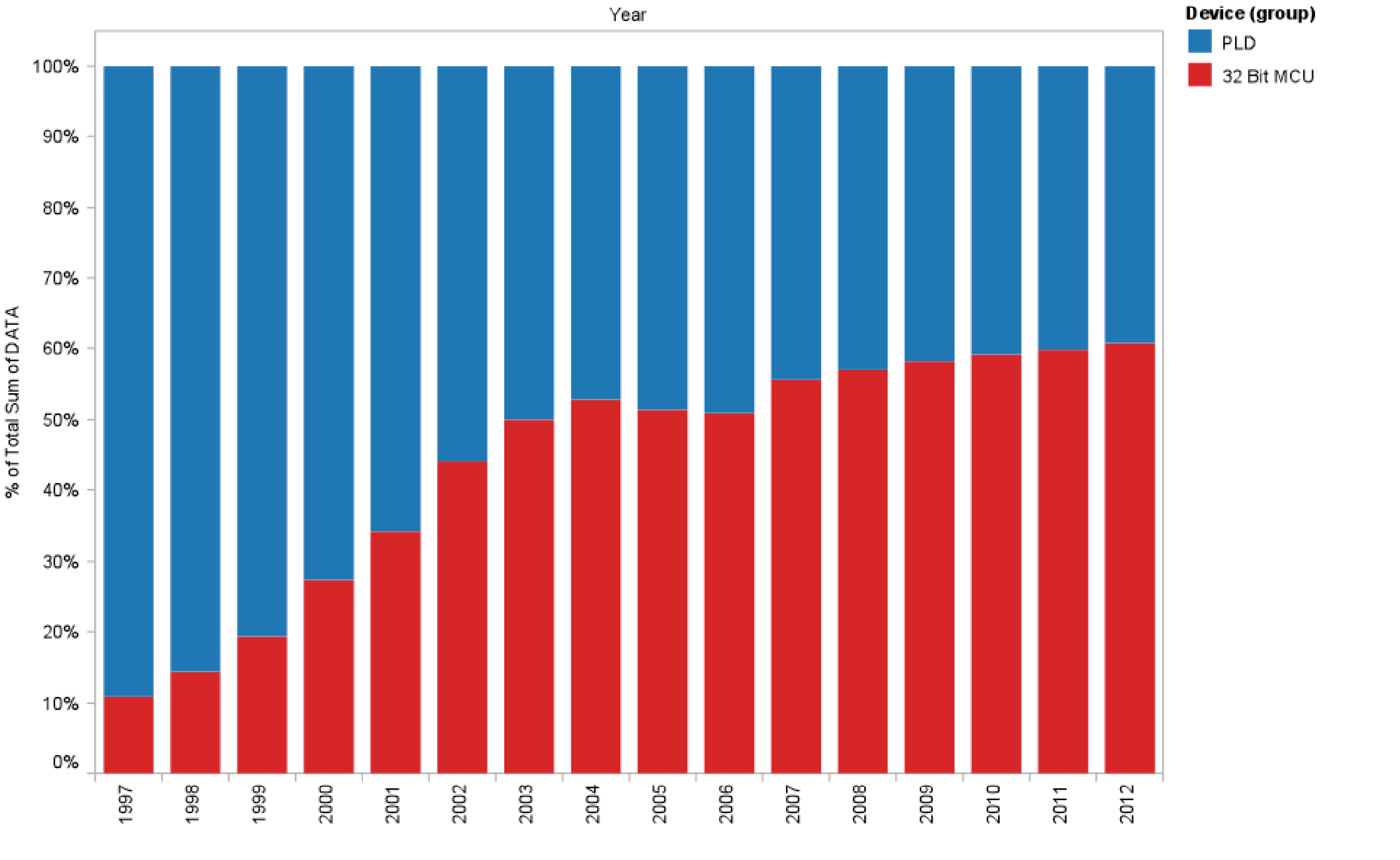


Thermoelectric Ambient Energy Harvester [PNNL]

Outline

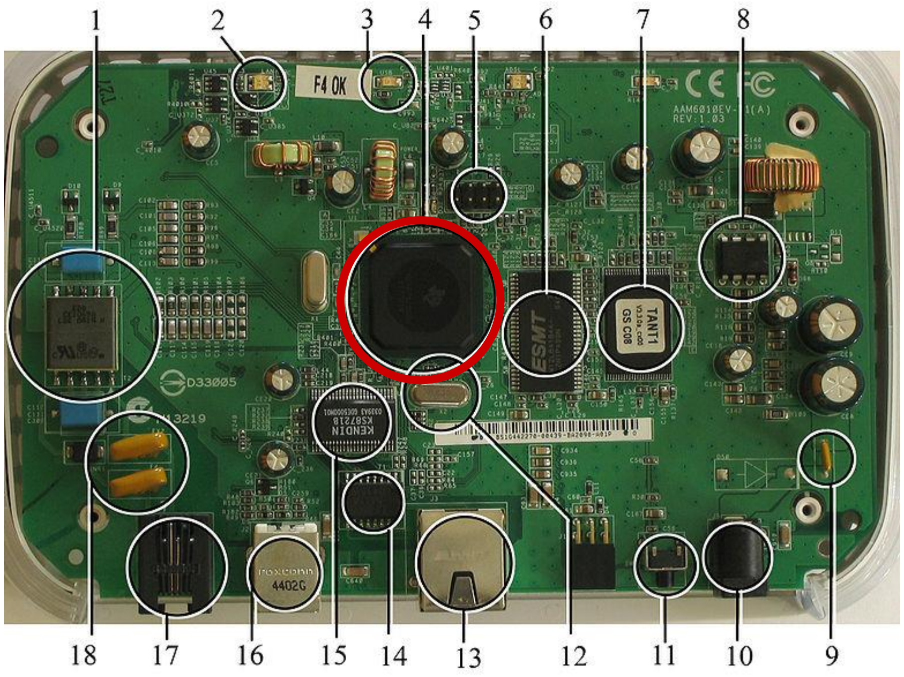
- Technology Trends
- **Design Questions**
- Course Introduction
- Lab Introduction

Why study 32-bit MCUs and FPGAs?



Source: iSuppli

What’s inside a DSL Modem?



1. Telephone decoupling electronics (for ADSL).
2. Multicolor LED (displaying network status).
3. Single color LED (displaying USB status).
4. Main processor, a TNETD7300GDU, TI ARM7.
5. JTAG (Joint Test Action Group) port.
6. RAM, a single ESMT M12L64164A 8 MB chip.
7. Flash memory, obscured by sticker.
8. Power supply regulator.
9. Main power supply fuse.
10. Power connector.
11. Reset button.
12. Quartz crystal.
13. Ethernet port.
14. Ethernet transformer, Delta LF8505.
15. KS8721B Ethernet PHY.
16. USB port.
17. Telephone (RJ11) port.
18. Telephone connector fuses.

Why study the ARM architecture?

Actel
POWER MATTERS

ATMEL

CYPRESS
PERFORM

DUST NETWORKS

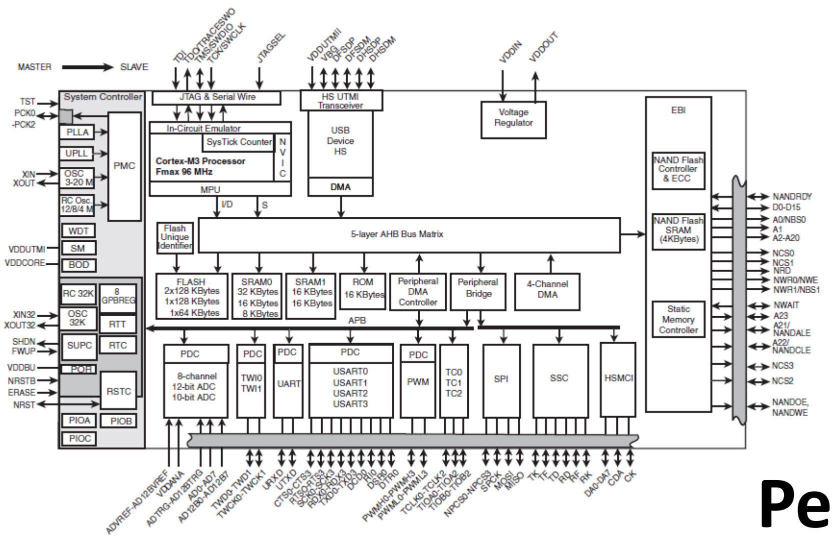
ember

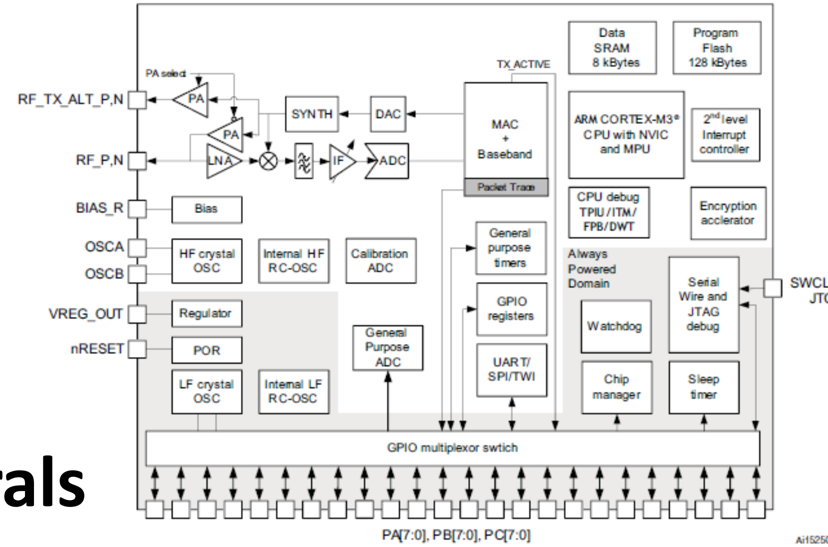
NXP

ST

Texas Instruments

What differentiates these products from one another?

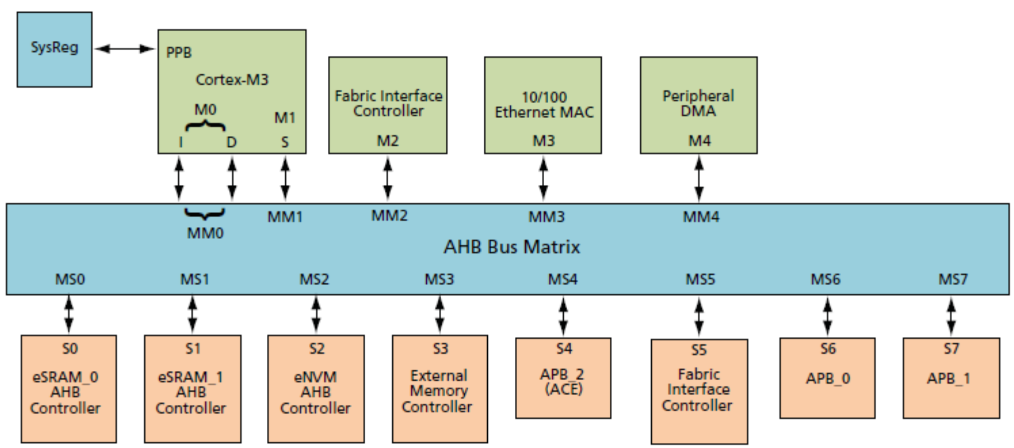




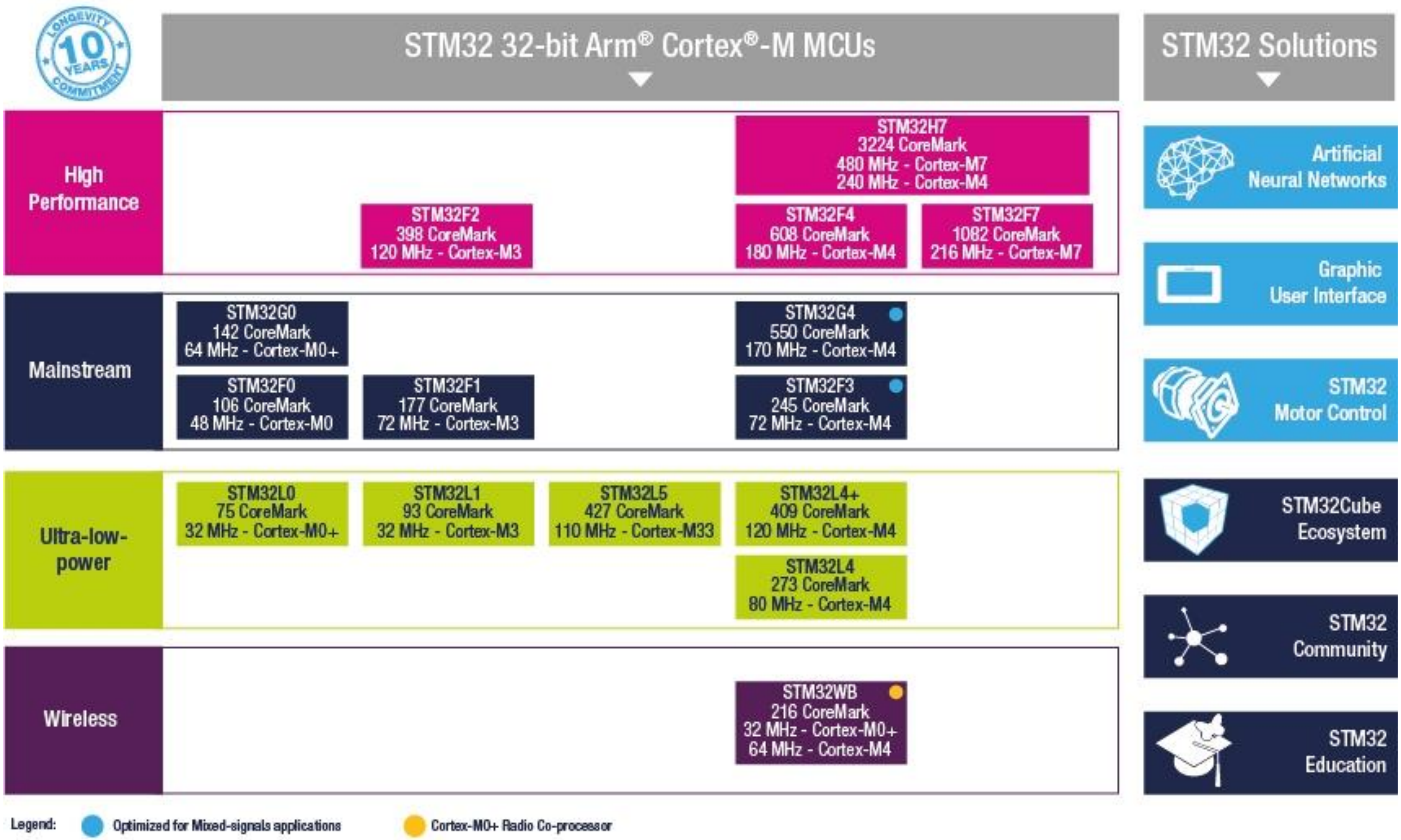
Peripherals

Peripherals

Peripherals

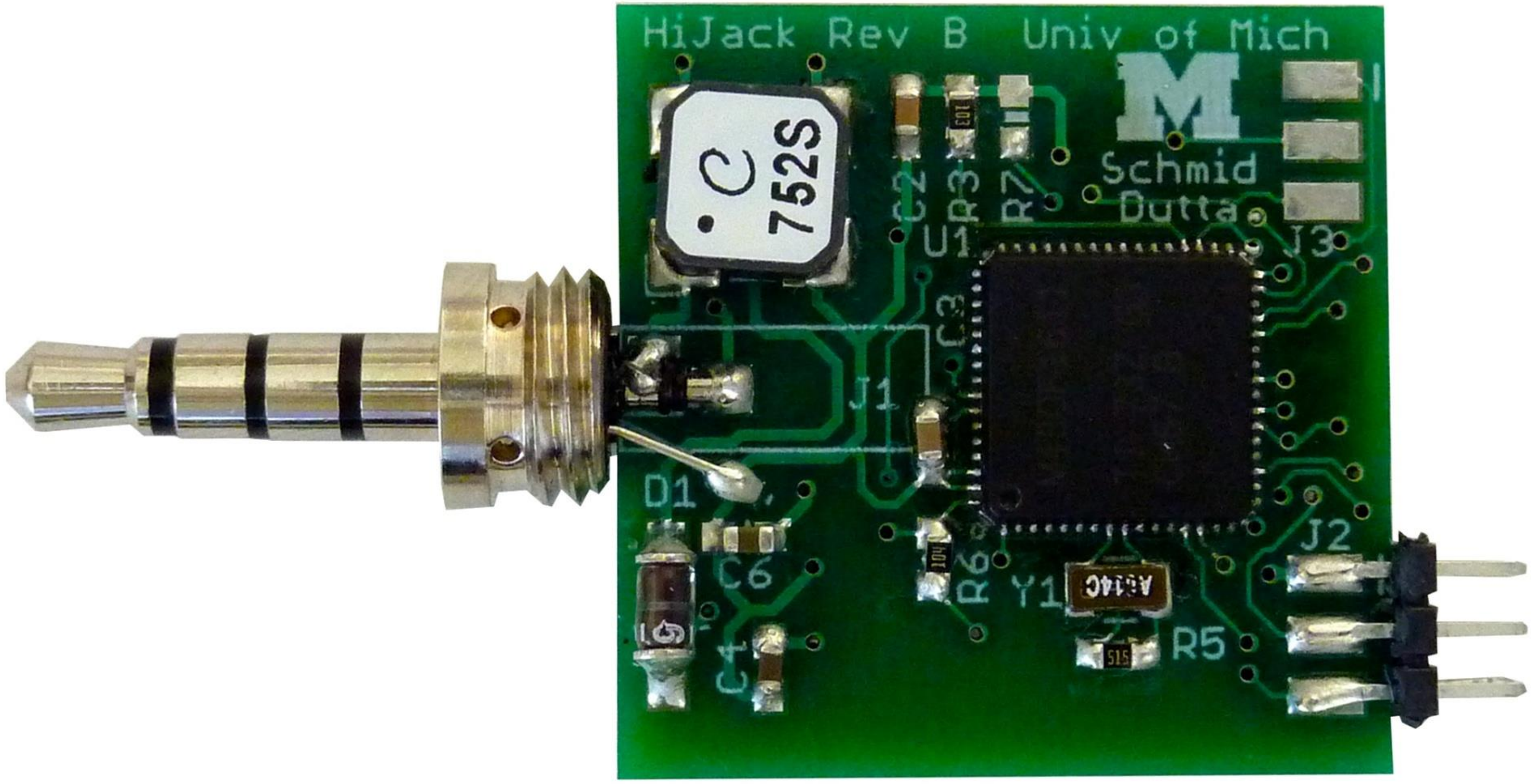


STM32 MCU Family



A embedded systems design example

- **Integrating power, data, and processing**



What else...?

- **Basic skills to attend competitions**
  - DJI RoboMaster Robotic Competition
  - International Competition of Autonomous Walking Intelligent Robots
  - National Electronic Design Contest
  - Tianzhan Cup

- **Start point for being Geeks**
  - Start-up Company
  - Developing a produce
  - Realize your idea

running-robot

Video

竞赛通知 | 全国大学生电子设计竞赛中山大学校内选拔赛(初赛)来啦

信发君 中大SEIT学生园地 10月19日

中山大学2019年
电设校内选拔赛(初赛)

题目概览

A题
简易逻辑分析仪

设计并制作一台具有储存功能的简易逻辑分析仪，可同时显示自制信号发生电路产生的8路数字信号时序，触发方式可调节。

B题
简易水箱液位监控系统

设计并制作一套简易水箱装置，可设定并自动控制水箱液位。在水源有扰动的情况下，依然能够保持水箱液位稳定。

C题
灯（仅限新生）

Outline

- Technology Trends
- Design Questions
- **Course Introduction**
- Lab Introduction

Course Scope

- **Application Oriented Course**
  - State-of-the-art: STM32 Microcontroller (ARM architecture)
  - Architecture of ARM Microprocessor
  - Peripheral (I/O) Interfaces
  - MCU programming
    - ASM and C programming
      - Python and Scarch
    - IDE (Keil)
    - Debug (JTAG and breakpoints)
  - Application of STM32 Microcontroller
  - A lot of fun for embedded system design
    - Robot design
    - IOT system design

Package size down to 4.4 x 3.8 mm

<u>Packages</u>:

LQFP64 (10x10), LQFP100 (14x14)
LQFP144 (20x20)
UFBGA132 (7x7)
WLCSP72 (4.4 x 3.8)

Course Scope

- **Start TODAY!**
- **Tutorials to familiarize you ARM, STM32 Should be fun**
  - Learn how to sensor/control physical world
  - Build hardware (include PCBs)
- **Should be instructive**
  - Program in C, and assembly
  - Learn debugging skills
  - Learn how to interface peripherals to the CPU/MCU
- **Are challenging and time-consuming - plan ahead**

Course Goal

- **Both Theory and Practice Skill**
  - Theory: Computer Architecture
  - Practice: Development Skill
- **Deep understanding on MCU**
- **Learn how to use MCU to develop a specific system**
  - Know development flows
    - Software (Programming)
    - Hardware (Create your own board)
- **Research Problems**
  - RISC-V (open ISA)
  - DNN on MCU
    - Not intelligent enough

Talk is cheap, show me the ‘system’.
-Linus Torvalds

Course Structure

- **Grading**
  - **Project-based (40%)**
    - **Homework (10%)**
    - **Open-end Projects: How to choose the topic will be presented in the next slides (30%)**
  - **With 1 in-class final exam (close book) (30%)**
  - **Technical report (20%)**
    - **Topic will be released later on**
  - **Other factor (10%)**
    - **Your participations**
    - **Minute Quizzes**
      - Short, Random
      - Over previous day’s material

Open-ended Project

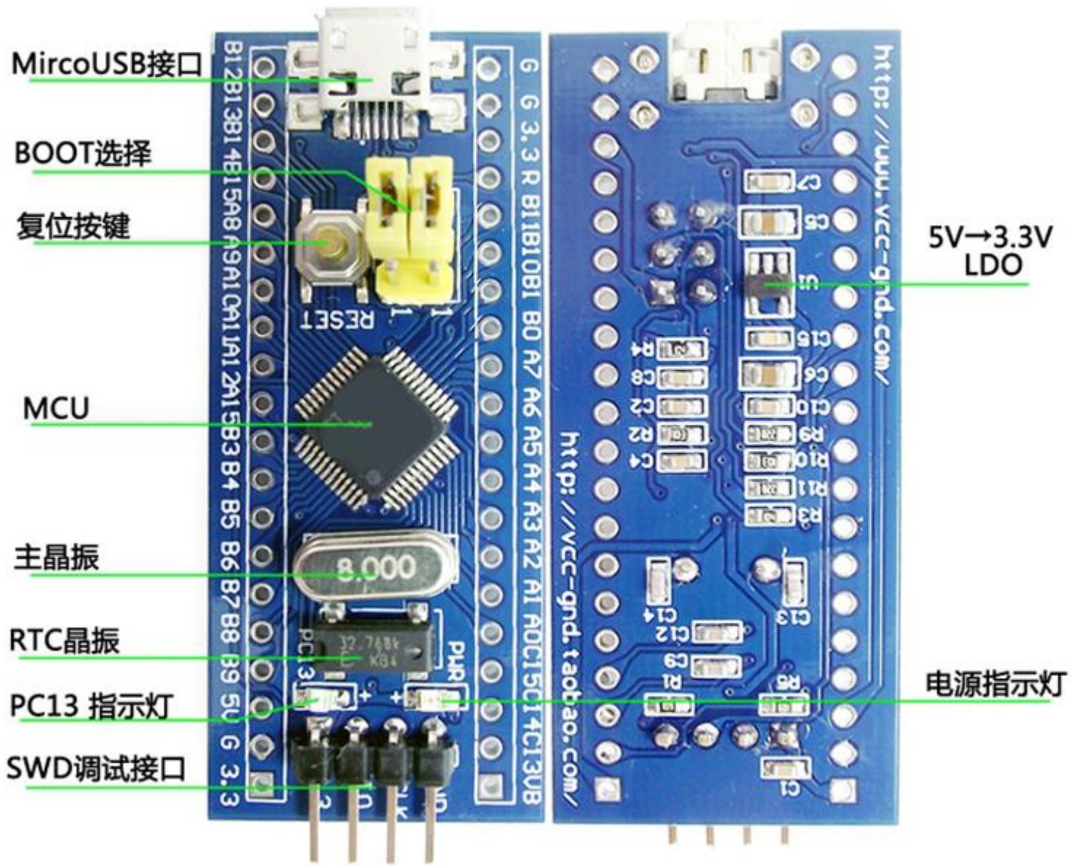
- **Goal: <u>learn how to build embedded systems</u>**
  - By <u>building</u> an embedded system
  - Work in teams
  - Pick a problem of your own interest
  - Meet with instructors to discuss other ideas

- **Should be related to the class and emphasize topics**

- **Scope of project must grow with size of team**

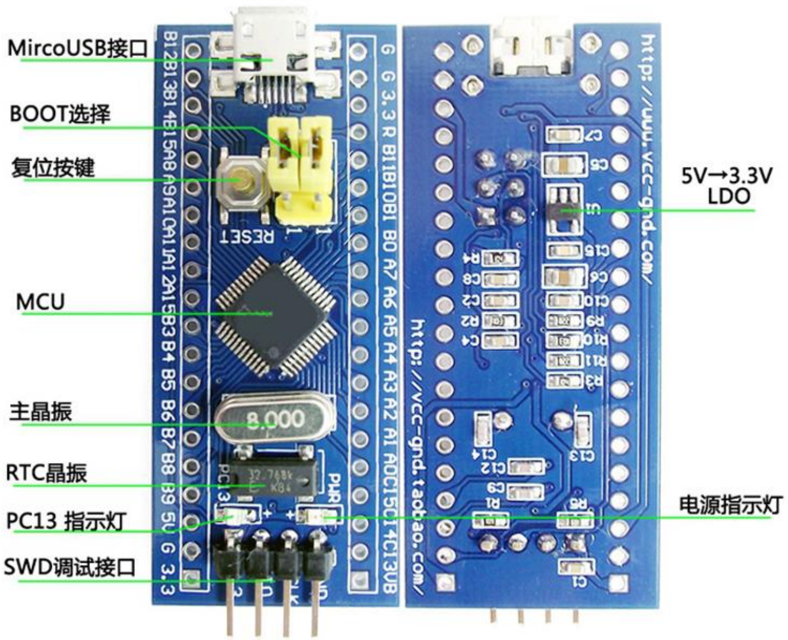
Two Board we will provide

- **STM32F103C8T6 Core Board**



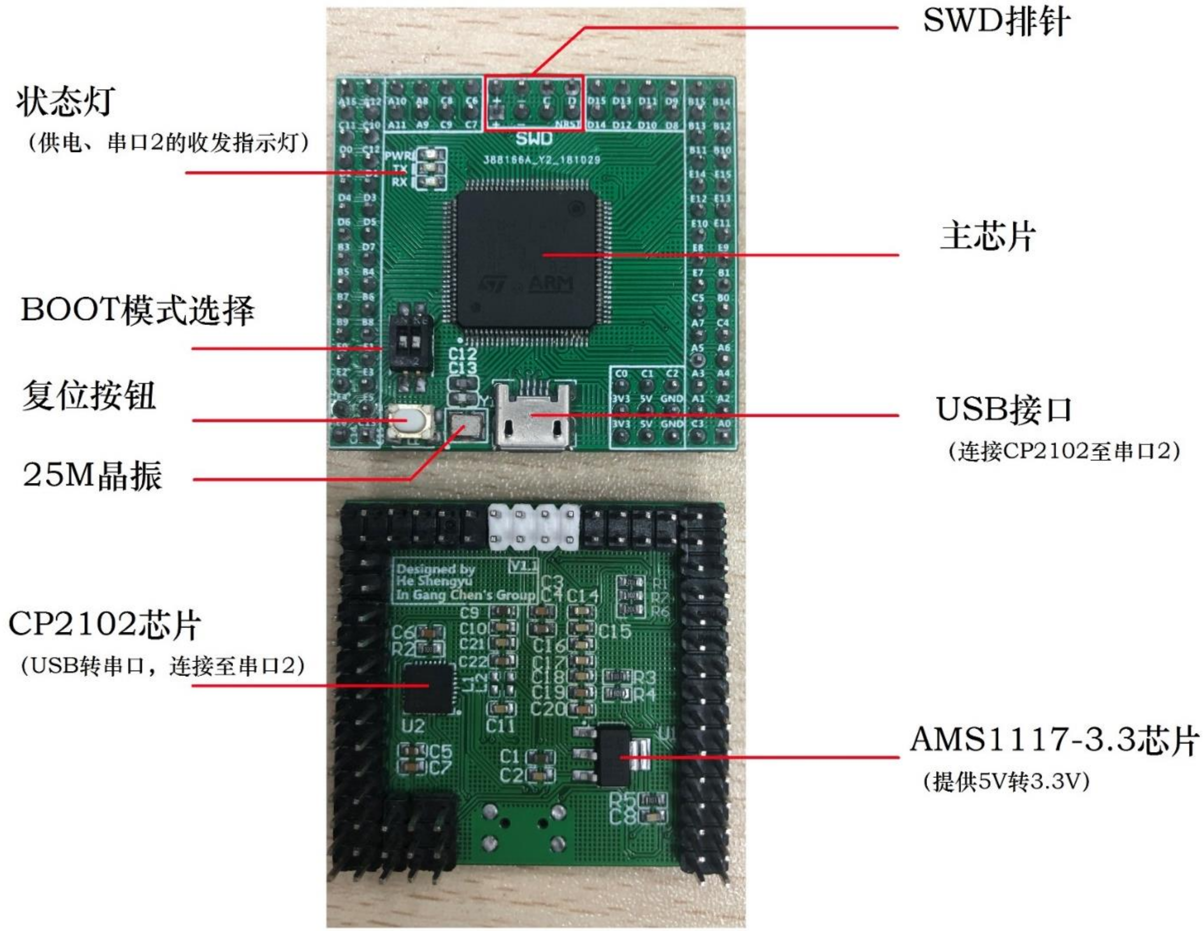
Features of STM32F103C8T6 Chip

- **STM32F103C8T6 Chip**
  - LQFP Package
  - Pin #： 48
  - Cortex-M3 Arm Core
  - 72MHz
  - Memory
    - 64KByte Flash， 20KByte SRAM
  - I/O
    - 2x SPI，3x USART，2x I2C, 1x CAN，37x I/O
  - A/D
    - 2x ADC
  - 3 Timers
  - Support JTAG/SWD



STM32F407VGT6 Core Board

- **STM32F407VGT6 Core Board (Designed by our teams)**



STM32F407VGT6 Chip

- **STM32F407VGT6 Chip**
  - **LQFP Package**
  - **Pin #： 100**
  - **Cortex-M4 Arm Core**
  - **168MHz**
  - **Memory**
    - **1MByte Flash， 192+4KByte SRAM**
  - **I/O**
    - **3x SPI， 3x USART， 3x I2C， 2x CAN**
  - **3x ADC**
  - **Support JTAG/SWD**