



# Embedded Operating Systems

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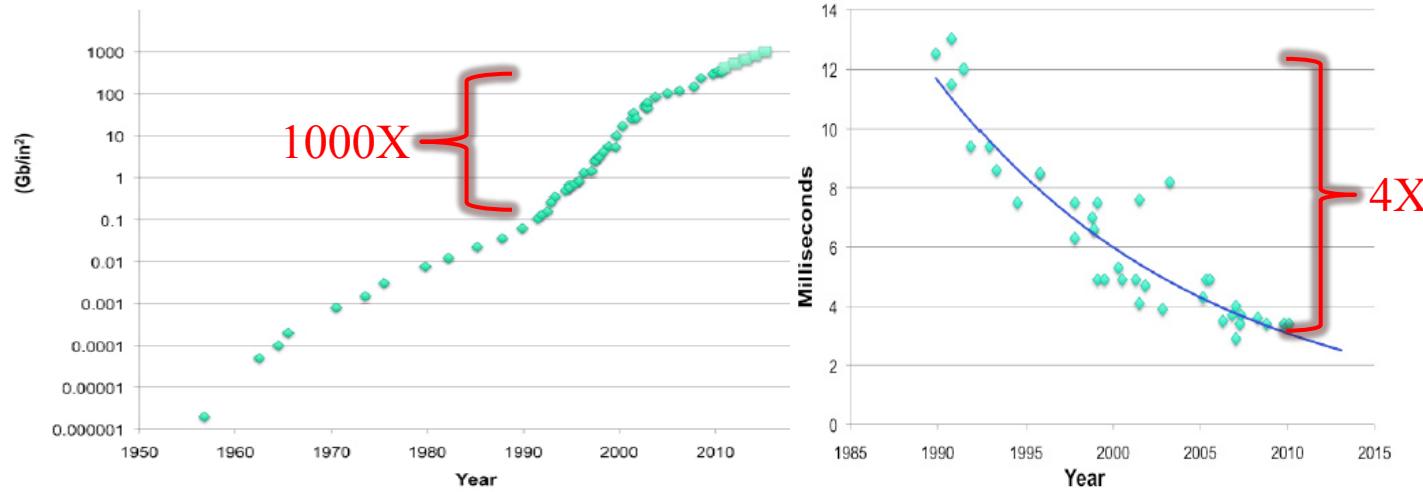
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# Heterogeneous Memory Studies- Nonvolatile Memory

# Booting Time

- ▶ The Increasing Shipments of Mobile Devices
- ▶ The Increasing Amount of Data per Device



- ▶ Examples of Booting/Initialization Time Saving
  - For the resuming of Acer AspireOne, it takes **50.3% time for disk loading**
  - For the initialization of a JPEG decoder on TI DaVince, it can be reduced from **2.012 seconds to 1.044 second with XIP (eXecution-In-Place)**

\* Source: IBM

# Related Work for Fast Booting

- ▶ Keep Execution States in One Image
  - Resuming system from hibernation <sup>1</sup>
  - Application hibernation
- ▶ Improve the Disk Utilization
  - Modifying file systems <sup>2</sup>
  - Prefetching tasks <sup>3</sup>

## Why Not Just Have No Loading?

[1] Hiroki Kaminaga, “Improving Linux startup time using software resume,” in *Linux Symposium*, 2006.

[2] Avantika Mathur, Mingming Cao and Suparna Bhattacharya, “The new ext4 filesystem: current status and future plans,” in *Linux Symposium*, 2007.

[3] Chi-Ju Chang, Che-Wei Chang, Chuan-Yue Yang, Yuan-Hao Chang and Tei-Wei Kuo, “A Run-Time Page Selection Methodology for Efficient Quality-Based Resuming,” in *RTCSA*, 2011.

# Non-Volatile Memory Devices

## ▶ Programmable Read Only Memory (PROM)

- Storage and low-performance memory

## ▶ NOR Flash

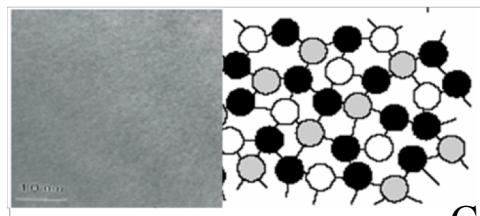
- Byte addressable but bulk erase

## ▶ Phase-Change Memory

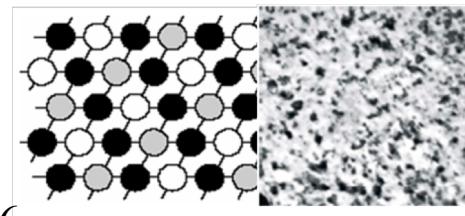
- PCM exploits differences in the electrical resistivity of a material in different phases



taobao.com

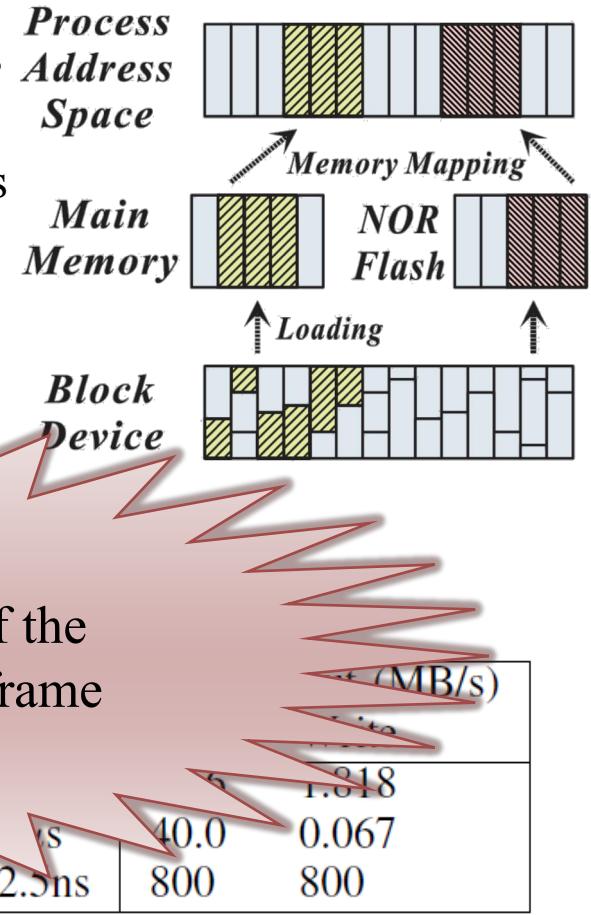


C. Lam, VLSI-TSA, 2006

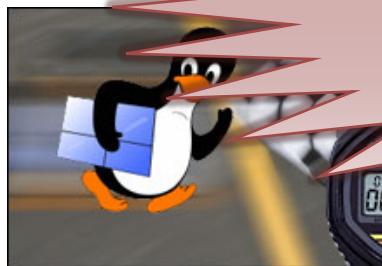


# Execution in Place

- ▶ Execution in Place (XIP) System Architecture
  - Secondary storages preserve the data and binaries during a power-off state
  - Main memory devices cache data and instructions for online execution
  - XIP devices keep execution contexts with byte addressable capability



- Trade-offs



Reduce more than half of the booting time of a digital frame

| Device | Access Time (ns) | Latency (ns) | Bandwidth (MB/s) |
|--------|------------------|--------------|------------------|
| NOR    | 14.24            | 10.4         | 1.318            |
| DDR2   | 12.5ns           | 12.5ns       | 0.067            |

# Polynomial Time Approximation Scheme

- ▶ Steps of the Polynomial Time Approximation Scheme
  - Exhaustively search (a given number of) the to-be-selected tasks of the original integer programming problem
  - Handle the sub-problems with the linear programming techniques
  - Round up the solutions for the original problem

Exhaustive Test Linear Programming Technique Pending Up

Task Set:



NOR Flash:



# Applications of Embedded Systems

# Four Diagnostic Methods

- ▶ In Traditional Chinese Medicine (TCM), there are four diagnostic methods
  - Inspection (望)
    - Check face, body, tongue, ...
  - Auscultation and Olfaction (聞)
    - Listen to and smell the patient
  - Inquiry (問)
    - Ask some questions according to diagnosis principles
  - Palpation (切)
    - Touch the patient and apply the **pulse diagnostics**



# Position for Pulse Diagnostics

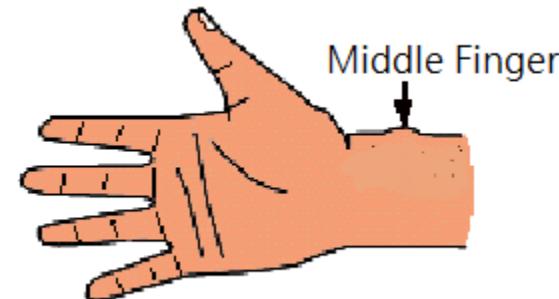
- ▶ Everywhere you can detect the pulse
  - This approach is no more used in the modern TCM
- ▶ Three major positions
  - Neck
  - Radial artery
  - Foot
- ▶ Only radial artery
  - The most popular approach in the modern TCM



# Pulse Diagnostics on Radial Artery

## ▶ The Behavior

- Use the index finger, middle finger and ring finger to probe the pulse of the Radial Artery of patients
- Middle finger is on the edge of the wrist



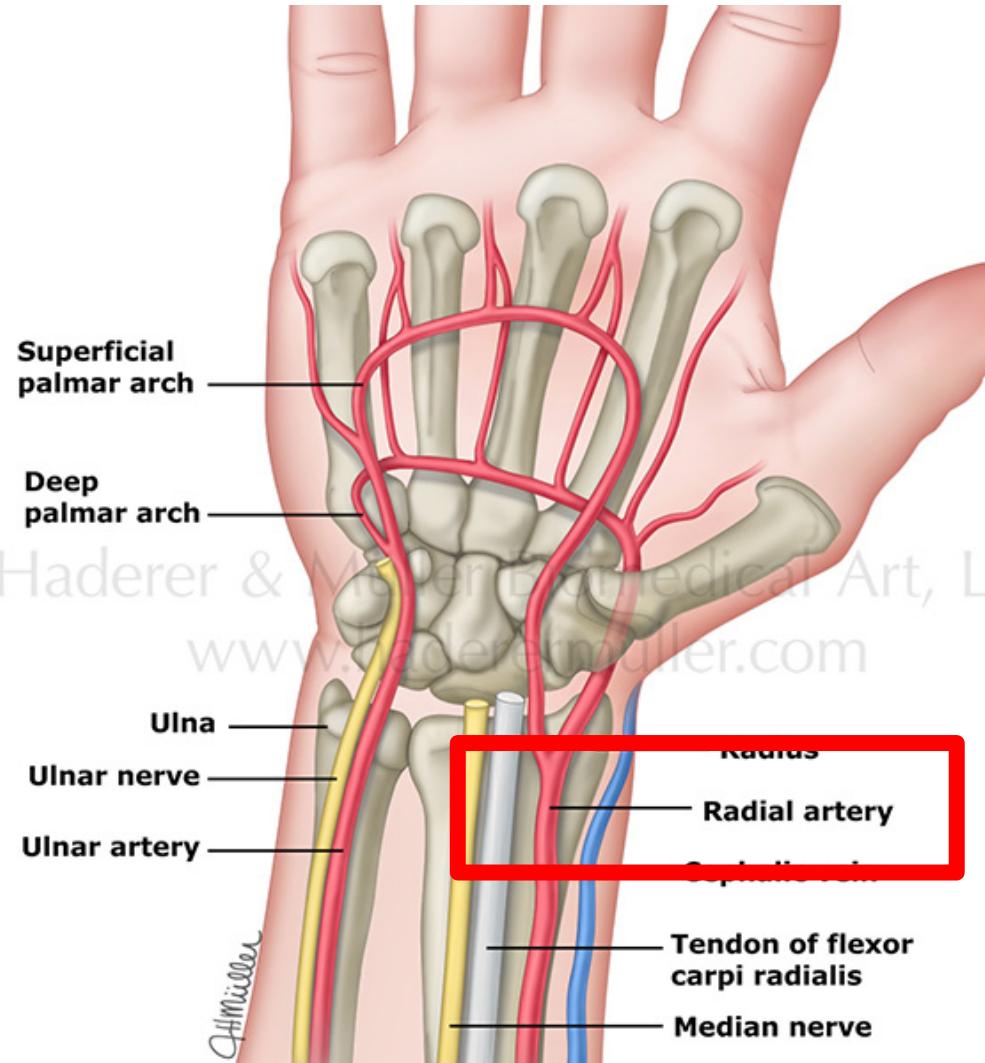
## ▶ The Meaning

- Blood goes through all organs, thus can reflect the status of the organs
- Some problems can be detected by the pulse diagnostics before the sick

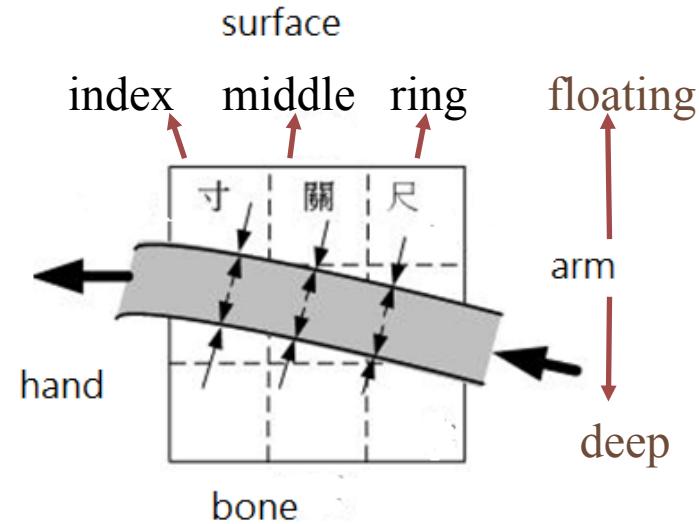
# Methods for Pulse Diagnostics

- ▶ Time
  - The best time for pulse diagnostics is in the morning before the breakfast
- ▶ Posture
  - The radial artery should has the same height with the heart
- ▶ Finger Layout
  - Three fingers should be on the radial artery
- ▶ Breathe
  - Doctors should control their breathe in peace
- ▶ Strength
  - Different strength should be used
- ▶ 50-Count
  - More then 50 times of pulse should be detected

# Radial Artery



Haderer & Mueller Medical Art, L  
www.haderermueller.com



Right and left hands are different

# Classification

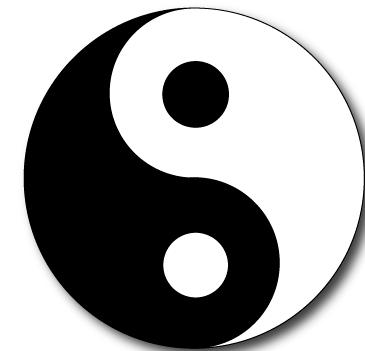
- ▶ Three fingers (doctor) and two hands (patient)
  - Six positions to be measured
- ▶ Six major types of the results of the measurement in each position
  - Floating
  - Deep
  - Slow
  - Fast
  - Powerful
  - Weak
- ▶ Twenty-eight extra types in each position
  - The sharp, size, ...

# Finding the Standard

- ▶ What is the standard (base) of the measurement?
- ▶ Is the standard always the same for all patients?
  - No
  - Different gender, weight, ...
- ▶ Is the standard always the same for one patient?
  - No
  - Different age, ...
- ▶ Is the standard always the same for one patient in the same year?
  - No
  - Different weather, mood, ...

# Standards in Different Seasons

- ▶ Spring
  - Like a string, long and thin
- ▶ Summer
  - Floating and large
- ▶ Fall
  - Floating and short
- ▶ Winter
  - Deep and without a clear shape



# Standards in Different Ages

- ▶ Children
  - One-year-old : 120-140 bpm
  - Five-years-old: 100 bpm
  - Ten-years-old: 90 bpm
- ▶ Adults
  - Normal: 60-80 bpm
  - Athlete: 40-70 bpm
- ▶ Elders
  - Normal: 60 bpm

# Floating Pulse and Deep Pulse

## ▶ Floating Pulse:

- It is easy to detect the pulse when we put fingers smoothly on the surface
- When we give more strength, the pulse will be not clear

## ▶ Deep Pulse:

- It is difficult to detect the pulse when we put fingers smoothly on the surface
- More pressure is needed to detect the pulse

# Powerful Pulse and Weak Pulse

## ▶ Weak Pulse:

- The pulse is always not clear
- We feel quite empty when we try to feel the pulse

## ▶ Powerful Pulse:

- Powerful pulse is not always good
- Sometimes, it implies that too much heat is in the patient

# Case Study 1

- ▶ When the pulse goes floating, tense, and fast
  - The patient might catch a cold
- ▶ Furthermore, if only the index and middle fingers can feel the floating
  - Some problem on the stomach
- ▶ The pulse diagnostics should be combine with other diagnosis methods



# Case Study 2

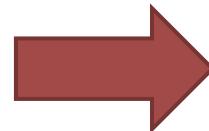
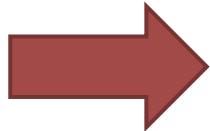
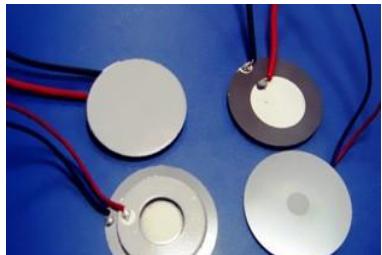
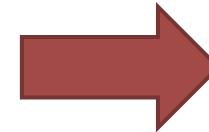
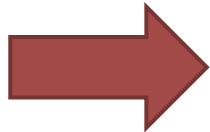
- ▶ For patients which have sleep disorder
  - The pulse is usually deep
- ▶ However, if the patient is quite nerves
  - The pulse is deep, too
  - So we should chat to make the patient relaxed
- ▶ For fat patients
  - The pulse is also deep
  - So we should adjust the standard according the weight of the patient
- ▶ More rules in the decision tree?
  - Of course!

# Devices to Measure the Pulse



- ▶ There are some devices which can measure the pulse
  - Including the heart rate, heart rate variability, blood pressure, and some rough types of pulse Diagnostics
  - Fast fourier transform (FFT) can be used to derive the information in the frequency domain
- ▶ For advanced devices, now we only have the devices for measuring the Electrocardiography (ECG)

# Challenging Issue

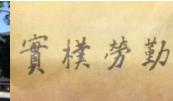


Error Analysis

Machine Learning

Validation

Different Measurement



# Related Work

- ▶ Prof. Wei-Kung Wang in Academia Sinica proposes a framework to understand the relation between the behavior of pulse and the status of organs
  - Transform the signal of measured pressure to the weight of each frequency
  - Explore the relation of the value of each frequency and the organs
- ▶ Some device and identify the six major types of pulse diagnostics
  - However, it is difficult to find out the standard automatically
  - Medical doctors should be involved in the initialization of each device for each patient