Embedded Software Development

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Lab Presentation

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Embedded Software Development

Outline

• What is embedded software?
• Various generations of embedded systems
• Development process of an embedded system
• Components of an embedded system
• References
Embedded Software Development

What is embedded software?

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What is embedded software?

What is an embedded system?

- Embedded system
  - system that uses processors and special hardware
    - for dedicated control functions

- Embedded system characteristics
  - do not usually come with peripheral devices
    - such as fancy displays, disk drives or printers

- Examples
  - toaster oven
  - aircraft controllers

- Characteristics
  - limited memory, diskless, no output screen, poor perf.
What is embedded software?

What makes embedded systems different?

• Real time operation
  – operations should be carried out real time

• Size
  – size is a huge hardware constraint

• Cost
  – cost must be low

• Operation
  – in most cases, a dedicated control function

• Energy
  – energy consumption must be low
What is embedded software?

Embedded Software Basics

Mobile phone (equipment)
Baseband chip (LSI)

- Wireless system IF
- Speaker
- Microphone
- LCD display
- Switches
- Camera IF

LSI embedded processor
DSP

Application processor

Software embedded in LSI:
invisible from outside of LSI

Software embedded in the equipment:
invisible from outside of the equipment
What is embedded software?

Embedded Software Basics

![Pie chart showing the percentage of programming languages used.]

- C: 63.5%
- C++: 33.6%
- Assembly language: 1.0%
- Java: 0.7%
- Others: 0.4%
Embedded Software Development

Various generations of embedded systems

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Various generations of ES

Generations summary I

- **Generation 0**
  - development done through sneaker-net
  - no operating system
  - simple software only

- **Generation 1**
  - native development on single board computers
  - development of a dedicated OS

- **Generation 2**
  - embedded hardware with serial or cross line development
  - concept of a kernel
Various generations of ES

Generations summary II

- **Generation 3**
  - development on SBC or embedded hardware
  - Ethernet based communication with support for Unix
  - scalable OS with support for file sys, network, I/O

- **Generation 4**
  - any tool, any connection and any target
  - published API
  - Internet part of development environment

- **Generation 5**
  - virtual application platform such as Java maybe
  - communications centric
Embedded Software Development
Development process of an embedded system

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Dev Process of an ES
Host and Target Systems

Host
- Development Platform
- General Purpose
- More capable processor
- More memory
- Different I/O
- Capable OS
- Development Tools
  - Editor
  - Compiler
  - Debugger

Target
- Embedded Hardware Platform
- Special purpose
- Limited processor, memory, I/O
- Stripped down OS/kernel
- No development tools

Comm Link

[HT-01]
Dev Process of an ES
Embedded vs. Classical SW Development

- Classical software development
  - edit source file
  - build, compile and link source code
  - execute code on host system

- Embedded software development
  - edit source file on host system
  - compile and assemble to machine code on host system
  - link all object files and libraries and resolve symbols on host
  - assign memory addresses to code and data on host
  - now copy above image to target memory
  - execute image
Dev Process of an ES
Development Process I

- Cycles of editing-testing-debugging
- Processor and hardware once chosen remains fixed
- Software needs multiple iterations
- Cost of system
  - cost of processor low
  - cost of targeted system high
Dev Process of an ES
Development Process II
Dev Process of an ES
Development Process III

Approaches During Edit-Test-Debug Cycle
- Using a Target System
- Using an Emulator for Target System
- Using Target Processor and ICE
- Using a Simulator for Hardware
- Using IDE or Prototyping Tool

[DP-01]
Dev Process of an ES
Development Process IV

- System requirements gathering
- System design
  - hardware and software
  - hardware divided into mechanical/electrical
- Software requirements gathering
- Software cycle
  - design, implementation and testing
- Integration testing
  - hardware and software included
Embedded Software Development

Components of an embedded system

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Components of an embedded system

List of components used

- RTOS
- Simulator
- SDK
- IDE
- Cross Assembler and Compiler, Linker and Locater
- Debugging tools
Components of an embedded system

RTOS

- Considered real-time
  - if able to execute program with specified time frame
- Examples are ThreadX and VxWorks
- Considered for mission critical applications
- Keeps track of resources
  - and discards new tasks if they found too big
- Function of a real time kernel
  - booting
  - task scheduling
  - function libraries
Components of an embedded system

Simulator I

[Sim-01]
Components of an embedded system

Simulator II

- Use knowledge of target processor on host system
- Cross compilation of code carried out
  - on host system
- Simulation of target system processor
  - uses linker and locator to port code in RAM
- Monitoring of performance of code at every step
  - of execution
- Detailed information on
  - registers
  - throughput
  - system response
Components of an embedded system

SDK

- Xilinx software development kit
- Zynq-7000 Aps SoCs and Microblaze support
- Based on Eclipse 4.3.2
- Interfaces to the hardware environment directly
- Xilinx Software Command Line Tool
  - used for scripting actions
- Editor, build tool, flash memory mgmt included
- GDB debug integration
Components of an embedded system

IDE

- Provides status of RAM and ports
- Register status during execution phase
- Status of stack and program flow
- Provides verification of performance of system
- Includes hardware emulator on host system
- Supports breakpoint based debugging of code
- Allow for user-defined assemblers for new processors
- Keil µVision 3 RTX1 an example for ARM processors
Components of an embedded system
Cross Assembler, Compiler, Linker and Loader

- Identify target machine
  - CPU type, company name and system type
  - (i386-redhat-linux)

- Cross Assembler
  - typically on host systems that output assembly code
    - for target systems

- Cross Compiler
  - capable of executing code for different platforms

- Linker
  - combines object files and resolution of var. and fn. ref.

- Locater – converts above code to an image
Components of an embedded system

Debugging Tools

- Host Computer
  - Development Tools
    - Editor
    - Compiler
    - Debugger
- Remote Debugger Frontend
- Comm Link
- Simulator
  (Running on Host or other workstation)
- Target Processor
  Remote Debugger Backend
- Target Processor
  In-Circuit Emulator

[HT-01]
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References

- Software environments for Embedded Systems
  http://bwrcs.eecs.berkeley.edu/Classes/CS252/Notes/Lec26a-sw.pdf
- [DP-01] Embedded Software Development Processes and Tools
- [Sim-01]
END OF FOILS

QUESTIONS???