Designing the Next-Generation of Handheld Devices

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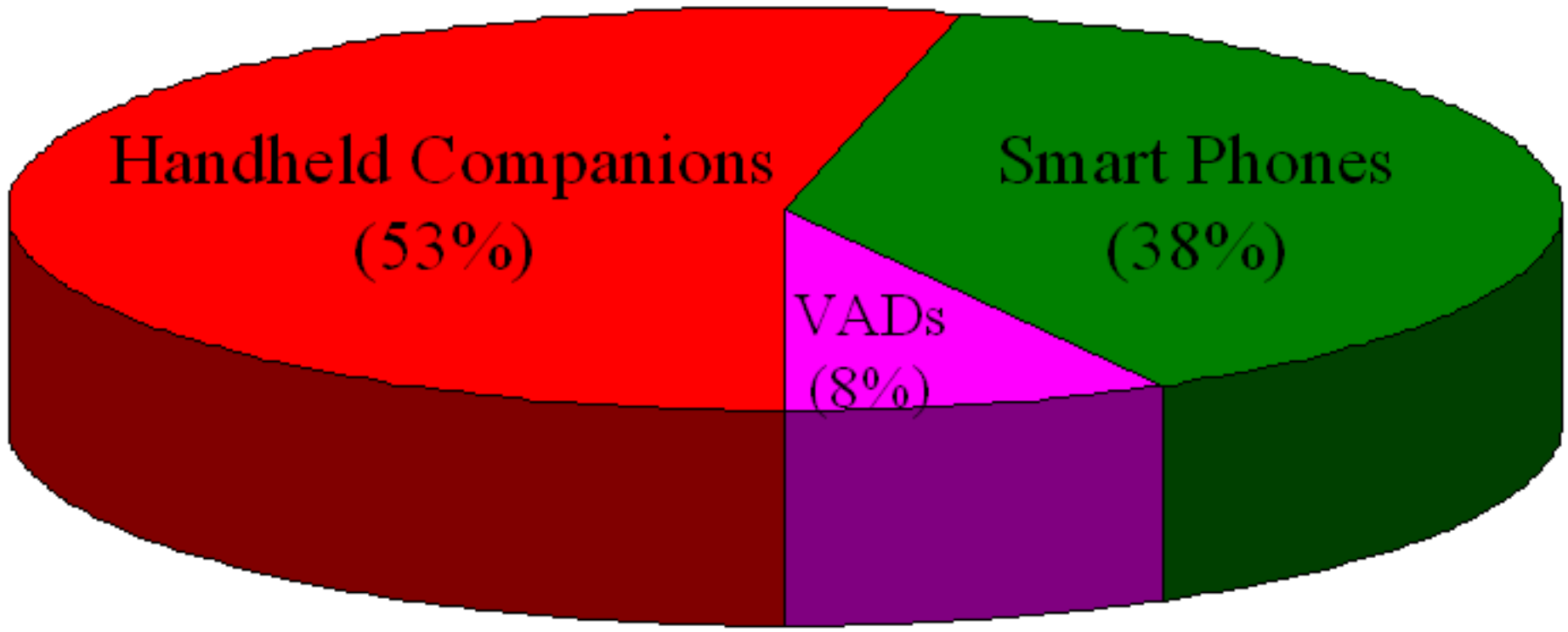
Presentation Focus

Development of system hardware and system software for programmable handheld devices, based on 32-bit CPUs and operating systems

Presentation Overview

- Market Opportunity & Design Challenges
- How Handheld Design is Different
- Designing a Handheld

Worldwide Smart Handheld Market - 2004*



63.4 Million Smart Handheld Units Sold ($26.3B)

(2000 - 12.1 Million Units)

*IDC - The Smart Handheld Devices Forecast and Analysis 2000 - 2004

Opportunity

- Mass Markets
  - Merging multiple handhelds into one
  - Bringing handhelds to everybody
- Vertical markets
  - Bringing smart handhelds to new segments
  - Upgrading "fixed-function" handhelds
- All Markets
  - Leveraging new technologies

What This Means for Engineers

Opportunity

↓

Volatility & Innovation

↓

Design Challenges

"make it smaller" "ruggedize it" "make it run for weeks on a single charge"
"make it hands-free" "add location-based services" "use this new wireless technology"

How Handheld Design is Different

- Designers of handheld devices must overcome all of the challenges of traditional embedded design, yet they must also…

- …make it fit
- …make it last

How Handheld Design is Different

It all comes down to...

"Form Factor" & "Battery Life"

Designing a Handheld

- Define user requirements
- Select a Form Factor
- Select a CPU & OS
- Design system hardware platform
- Develop system software platform

Define User Requirements

- Will it be used outside?
- What types of data will be displayed?
- How will the user input data?
- Is it likely to be dropped on a hard surface?
- Could it get wet?
- Will the user have ready access to AC power?
- How will the user talk to the network?

Select a Form Factor

- PDA
- Cell-phone
- Smartphone
- Web Tablet
- Wearable Computer
- Wireless Terminal

Select a Form Factor

- Develop Mechanical Specifications
  - Package form factor and materials
  - Display, battery, electronics, and input integration
  - Manufacturability and assembly issues
  - Environmental and ruggedization issues

Select a CPU

- ARM architecture is entrenched
- Pocket PC 2002 is only on ARM
- PalmOS 5.0 is based on ARM
- MIPs and x86 have intriguing options
  - Alchemy/AMD
  - National Semiconductor

Select a CPU

- Important features
  - Power modes
  - Voltage and clock scaling
  - Lots of peripheral integration

Select an Operating System

- Palm OS is market leader
  - Will licensing restrictions loosen?
- Microsoft's Pocket PC is coming on strong
  - Will it overtake Palm?
- Symbian's EPOC
  - Strong in cellular
- Linux
  - Will embedded growth translate to handhelds?

Hardware Platform

- Power Supply
- Test & Debug
- Memory
- User Input
- Display
- Audio
- Communications
- Expansion

Hardware Platform - Power Supply

- Regulators
  - Linear
    - Cheap & simple, low noise
  - Switched-Mode
    - High efficiency
- Boost Supplies
  - Allow operation from fewer/smaller batteries
- Watch out for current transients
- Segment the power system

Hardware Platform - Test & Debug

- Small boards limit test points
- Small boards limit debug connectors

- Options
  - Single debug connector with all debug hardware on daughterboard
  - Large board for development; respin in production

Hardware Platform - Memory

- Non-volatile
  - Linear Flash
    - allows XIP, can reduce DRAM requirements
  - Peripheral Flash Storage Devices
    - can be less expensive, straightforward parameter storage
- Volatile/SDRAM
  - Must battery backup
  - New CPUs supporting 2.5V parts

Hardware Platform - User Input

- Very dependent on user environment
  - Keypads, buttons, and touchpads imply larger device
  - Touchscreens allow smaller device, but can be fragile
  - Speech input allows small device, but ambient and audio subsystem noise are issues

Hardware Platform - Display

- Very dependent on user environment
  - Affects device size
  - Affects device battery life
  - Different "lighting" techniques

Hardware Platform - Audio

- Can greatly impact battery life
- Audio component placement affects sound input and output quality

Hardware Platform - Comms

- Wireless Data and Voice
  - 802.11 is power-hungry
  - Bluetooth is not ubiquitous
    - New technologies (e.g., UWB) are intriguing
- Location
  - GPS
  - Triangulation
- Component placement affects quality

Hardware Platform - Expansion

- Standard connectors are flexible, but drive device size
- Daughtercard connectors provide optional follow-on development

- Make sure peripheral power is off when not in use

System Software

- Power Modes
- Frequency/Voltage Adjustment
- Interrupt Reduction
- Intelligent Waiting

System Software

Power Modes

- CPU Power Modes
  - Run, Idle, Doze, Sleep, Off
  - Prepare memory for battery backup
  - Allow instant-on
  - Set I/O pins properly in Sleep
- Peripheral Power Modes
  - Many peripherals have them
  - Usage can double or triple battery life

System Software

Frequency/Voltage Adjustment

- Power consumption linearly proportional to CPU core frequency
- Power consumption proportional to square of CPU core voltage
- Analyze your software for periods when performance is independent of CPU core frequency and adjust accordingly

System Software

Interrupt Reduction

- Make interrupt buffers larger
- Use DMA whenever possible
  - Allows CPU to remain in Idle
  - Reduces interrupt count
  - Reduces computational bandwidth requirements

System Software

Intelligent Waiting

- Avoid "spinning" - try to go to Idle
- If "spinning" is unavoidable, can clock frequency and voltage be reduced?

Summary

- Hardware, software, & mechanical design teams must interact
  - mechanical, electrical, and software engineering matters are highly intertwined
- Design challenges
  - Form factor
  - Battery life