290T: The Business of Software: Creating a Sustained SW Business
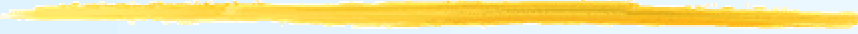
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Fall 2003
EECS
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So what should Palm have done?

- **Split into HW (PalmOne) and SW (PalmSource)?**
- **Or remain as a single company?**

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Outline

- **RTOS Technology Backgrounder**
- **RTOS Business Backgrounder**
- **Building a sustainable software business**
- **Challenges for WRS ahead**

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What does an operating system do?

- **You wish to run your application code on the hardware target of your choice**
- **Challenges:**
  - **It may be natural to organize your code as a series of interacting *processes* – but which process gets to run next?**
  - **Files**
  - **Memory**
  - **Peripherals (e.g. mouse, keyboard)**
 - **Processor interrupts**
  - **Networks**

application code

Target device
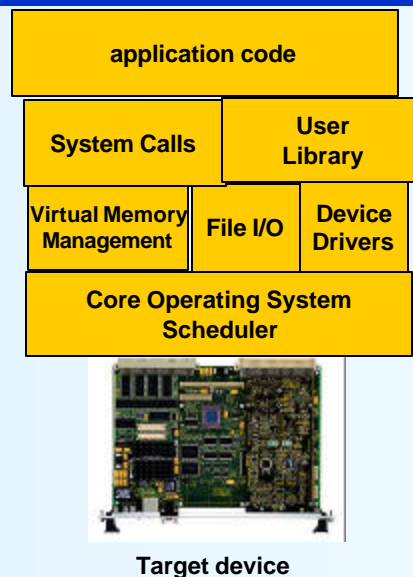
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What's wrong with that?

- **The injury: it will take a lot of tuning to get your software to run on a particular hardware target**
  - **Process scheduling**
  - **File management**
  - **Memory management**
  - **Peripherals (e.g. mouse, keyboard)**
  - **Processor interrupts**
  - **Network management**
- **The insult: once you do, it won't be able to run on anything else.**
- **It will take a lot of tuning/retuning to get the software to work on another piece of hardware**

application code

Target device
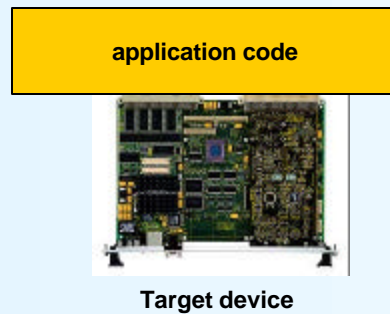
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Using an operating system

- **The solution is to provide a "layered software architecture" that provides a general application programmer interface**
- **This layered software architecture not only provides:**
  - **A programming abstraction of the underlying hardware**
  - **A set of standard software utilities**
  - **A scheduling algorithm to provide run-time support for scheduling the software processes**
  - **A portable environment that allows software to run on multiple hardware targets**

application code

System Calls	User Library

Virtual Memory Management	File I/O	Device Drivers

Core Operating System Scheduler

Target device

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What's "real time" about a RTOS?

- **What do all these applications have in common?**
  - **Anti-lock breaking system in a car**
  - **Flight-control system in a jet**
  - **Traffic-light control system**
  - **OS for a watch**

What's "real time" about a RTOS?

- **What do all these applications have in common?**
  - **Anti-lock breaking system in a car**
  - **Flight-control system in a jet**
  - **Traffic-light control system**
  - **OS for a watch**
- **Real-time operating systems must ensure that process meet "real time" constraints**

Additional RTOS Requirements

- **Small code size/footprint**
  - **On-chip silicon area is very expensive**
  - **Features must be there but code must be compact**
  - **No "one size fits all" solution**
- **Ability to handle "hard" and "soft" real time constraints**
  - **Hard constraints: "mission critical", anti-lock breaking**
  - **Soft constraints: video quality etc.**
- **Adaptable**
  - **Ability to adapt to addition of new devices**
- **Advanced power management**
  - **Embedded system developers look for RTOS to handle system-level power management of power sensitive devices**

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Importance of Compact RTOS

- **Embedded processors such as this Motorola Coldfire processor core have a wide variety of I/O support requirements but will typically be embedded with a modest amount of on-chip memory**
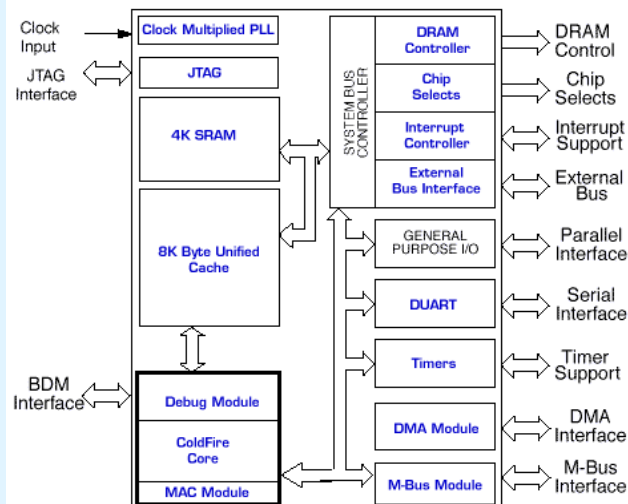
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Which of these are power sensitive?

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All of them

- **Of course portable devices are power sensitive but …**
- **Adding a fan *dramatically increases* the system cost of a laptop or printer**

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RTOS Important Features

Speed/Performance	42.1	21.6
Integration with other Tools	29.7	15.2
Price	29.7	15.2
Ease of Use	29.7	15.2
Code Size	28.7	14.7
Documentation	21.0	10.7
Standard API	19.5	10.0
Scalability	15.4	7.9
Support	15.4	7.9
Company Reputation	12.3	5.0
POSIX compatibility	9.2	4.7
CORBA compliance	2.6	1.3
Other	20.0	10.3

Source: Embedded Systems Programming 5/98

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Technical summary

- **An operating system provides a standard programming model that gives the programmer access to the underlying hardware capability**
- **A real time operating system is an operating system that also supports real-time requirements and may provide additional features more unique to embedded systems - such as power management**

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The Business of Operating Systems

- **General purpose operating systems:**
  - **OS/360 (IBM 360)**
  - **SUN UNIX**
- **Were closely linked to the hardware they run on.**
- **They were used to help "sell" the hardware – not as a revenue opportunity**
- **Microsoft managed to create a market for PC operating systems – a market that "belonged" to IBM – but that's not today's story**
- **Fiddler and WRS defined the 3rd party market for RTOS – let's review that history with Jerry's own slides**

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Embedded Development: Generation 1

- **Hardware: single board computer (SBC), minicomputer**
- **Development: Native (i.e. no support)**
- **Attributes:**
  - **Full-function OS**
    - **Non-Scalable**
    - **Non-Portable**
  - **Turnkey**
  - **Very primitive**

Jerry Fiddler, DAC Keynote 2002

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Embedded Development: Generation 2

- **Hardware: Embedded**
- **Development: Cross, serial line**
- **Attributes**
  - **Kernel**
  - **Originally no file sys, I/O, etc.**
  - **No development environment**
  - **No network**
  - **Non-portable, in assembly**

Jerry Fiddler, DAC Keynote 2002

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Embedded Development: Generation 3

- **Hardware: SBC, embedded**
- **Development: Cross, Ethernet**
  - **Integrated, text-based, Unix**
- **Attributes**
  - **Scalable, portable OS**
    - **Includes network, file & I/O sys, etc.**
  - **Tools on target**
    - **Network required**
    - **Heavy target required for development**
  - **Closed development environment (in other words, an "in house" environment)**

Jerry Fiddler, DAC Keynote 2002

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Embedded Development: Generation 4

- **Hardware: Embedded, SBC**
- **Development: Cross**
  - **Any tool - Any connection - Any target**
  - **Integrated GUI, Unix & PC**
- **Attributes**
  - **Tools on host**
    - **No target resources required**
    - **Far More Powerful Tools (WindView, CodeTest, …)**
  - **Open dev. environment, published API**
  - **Internet is part of dev. environment**
    - **Support, updates, manuals, etc.**

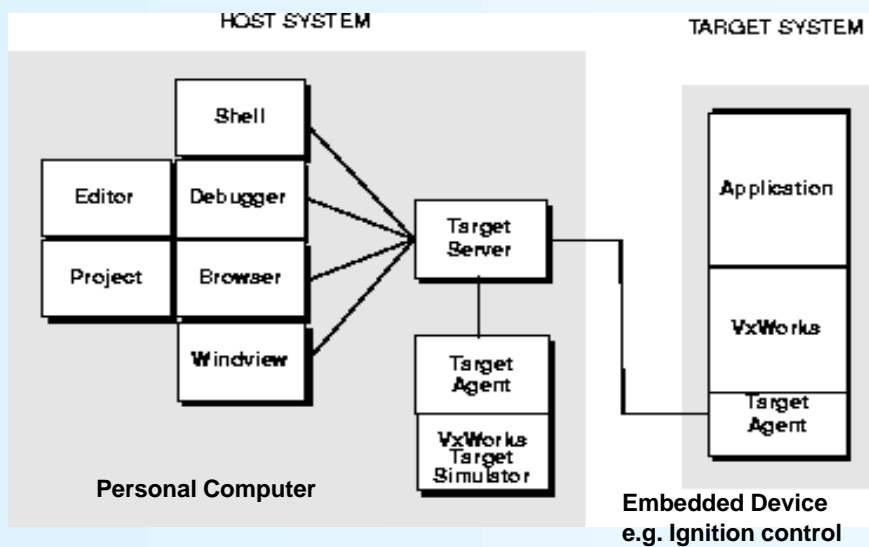**Jerry Fiddler, DAC Keynote 2002**

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WRS Offering, Tornado, comprises:

An Integrated Development Environment (IDE) to develop real-time and embedded applications with minimal intrusion on the target system.

- **VxWorks, a high-performance real-time operating system.**
- **Application-building tools (compilers and associated programs).**
- **IDE for managing projects, host-target communication, running, debugging, and monitoring VxWorks applications.**

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Overview of Tornado IDE

HOST SYSTEM

TARGET SYSTEM

Shell

Editor   Debugger

Project   Browser

Windview

Target Server

Target Agent

VxWorks Target Simulator

Personal Computer

Application

VxWorks

Target Agent

**Embedded Device
e.g. Ignition control**
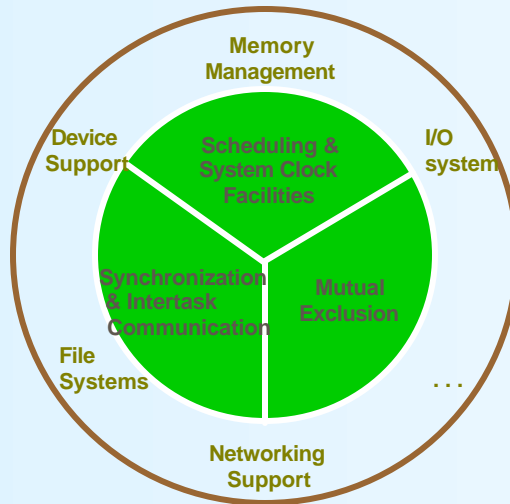
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Wind River Systems VxWorks RTOS

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WRS Success

- **Wind River Systems, founded in January 1981, by Jerry Fiddler and David Wilner**
- **Five years of consulting but in 1986 began to sell packages software in 1986**
- **Flagship produce, VXworks, first sold n 1987**
- **Basic business mode: per seat software license *and royalty on installations of embedded operating system***
- **At that time the majority of RTOS handcrafted by the hardware development group for particular applications**
- **WRS capitalized on the movement to outsource and standardize this effort**
- **Successful IPO on April 15, 1993**
- **Ron Abelmann (Vantage) becomes CEO in 1994**
- **40-45% growth rate continues until 1999**

- **WRS not only provided a key tool – the RTOS**
- **More importantly it "captured the source", "captured the desktop" for embedded system software design by providing an integrated design environment (IDE)**

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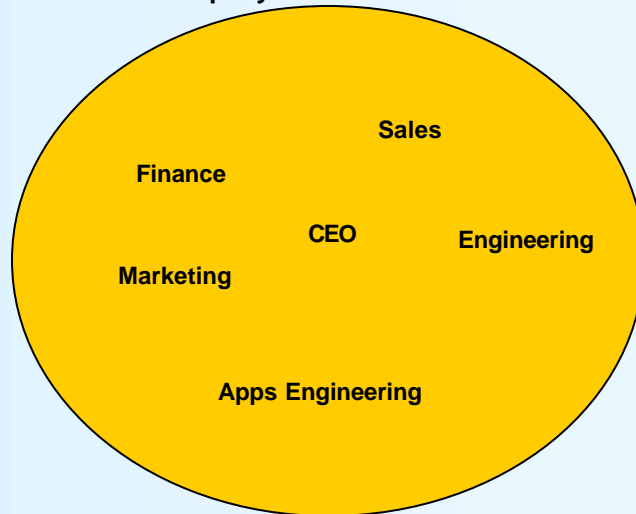- **Challenges for WRS ahead**

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Issues WRS Faced as they Grew

- **Evolving management and organizational structure**
- **Mergers and acquisitions**
- **Changing trends**
  - **End-customer requirements**
  - **Technology**
  - **Competitive environment**
  - **Wall street**

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Start-up Organizational Structure

- **In a start-up each individual must be prepared to do whatever is necessary to make the company successful**

Sales

Finance

CEO   Engineering

Marketing

Apps Engineering

Software "Functional" Organization

CEO

| VP Engineering | VP Applications Engineering | VP Marketing | VP/CFO Finance & Operations | VP Worldwide Sales |

- In time, the start-up structure is too chaotic
- It gets just too hard to get your own job done
- This organizational structure allows each functional unit to focus on their job

Business Unit Organization

```
                              ┌─────────┐
                              │   CEO   │
                              └────┬────┘
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   │   Of   │ │   Of   │ │   Of   │ │Operations│ │  Sales   │
   │Business│ │Business│ │Business│ │          │ │          │
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   └────────┘ └────────┘ └────────┘ └──────────┘ └──────────┘
```

•When your engineers have forgotten what a customer looks like, then it's time to change the organization again
•Business unit organization allows customer solution focus
•Each LOB/BU has engineering, marketing, application support

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Business Unit Organization

```
                                    ┌─────────┐
                                    │   CEO   │
                                    └────┬────┘
     ┌────────┬────────┬────────┬────────┴───┬───────────┬──────────┐
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                        │   R&D    │        │ Planning │
                        └──────────┘        └──────────┘
```

•After breaking into BU's it's often found that there is a lot of duplicate work and inconsistent customer messaging so add:
 • Corporate R&D
 • Strategic/Corporate planning and marketing

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Issues WRS Faced as they Grew

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- **Mergers and acquisitions**
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  - **End-customer requirements**
  - **Technology**
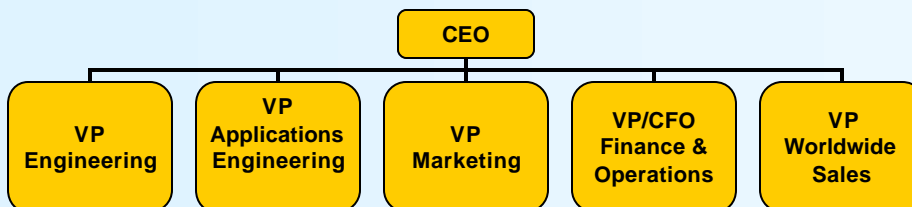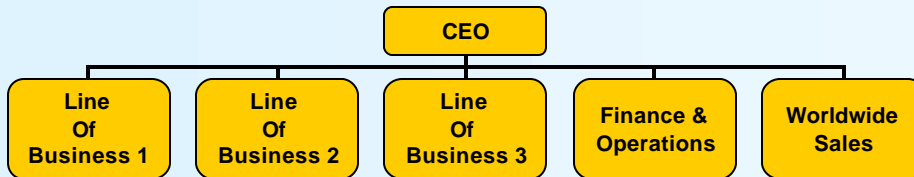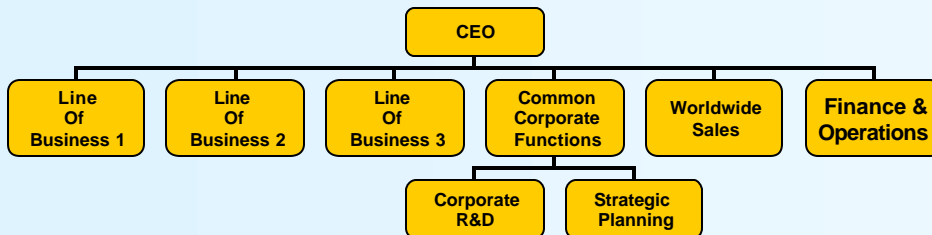 - **Competitive environment**
  - **Wall street**

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Mergers and Acquisitions

- **There are a number of factors that motivate a post-IPO company to engage in mergers (two companies of comparable size merging) and acquisitions (a larger company acquiring a smaller company for stock, cash, or mixture)**
- **Wall Street's means of valuation of high tech companies**
- **Strategic opportunities between the two companies**
- **Increasing economies of scale**
- **Increasing clout with:**
  - **Suppliers (not so relevant in software)**
  - **Distributors (or diminishing costs of distribution)**
  - **Customers – especially true if competitors are merging**
  - **Wall Street, stock holders – bigger companies get more notice**
- **"Buying" an installed customer base**

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Wall Street's System of valuation

- **Wall Street's System method of valuation of high tech companies:**
  - **Stock_price = earnings_per_share * %growth_rate *100**
  - **E.g. $1.00 eps * 30% growth rate = $30**
  - **Two (related) implications:**
    - **Difficult to spend on R&D to exploit new initiatives – the costs may reduce earnings and that will undermine the stock price**
    - **Earnings can't be spent on R&D but they can be spent to acquire other companies with comparable profit margins (non-dilutive)**
  - **I.e. performing acquisitions is just good business sense**
- **When you acquire technology and markets by acquisition then you have minimized market and technical risk**

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Summary

- **Review of RTOS**
- **Review of history of WRS and RTOS Market**
- **Focus on key issues in the growth of a software business**
  - **Mergers and acquisitions**
  - **Responding to changing trends:**
    - **Technology**
    - **Customer needs**
    - **Financial industry**
    - **Competition**
- **Going forward, hat is necessary for a company to gain a major market share in the RTOS market?**

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