

CHAPTER 1

INTRODUCTION

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What is an Embedded System?

- Electronic devices that incorporate a computer (usually a microprocessor) within their implementation.
- A computer is used in such devices primarily as a means to simplify the system design and to provide flexibility.
- Often the user of the device is not even aware that a computer is present.

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Aerospace	Navigation systems, automatic landing systems, flight attitude controls, engine controls, space exploration (e.g., the Mars Pathfinder).
Automotive	Fuel injection control, passenger environmental controls, anti-lock braking systems, air bag controls, GPS mapping.
Children's Toys	Nintendo's "Game Boy", Mattel's "My Interactive Pooh", Tiger Electronic's "Furby".
Communications	Satellites; network routers, switches, hubs.

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Computer Peripherals	Printers, scanners, keyboards, displays, modems, hard disk drives, CD-ROM drives.
Home	Dishwashers, microwave ovens, VCRs, televisions, stereos, fire/security alarm systems, lawn sprinkler controls, thermostats, cameras, clock radios, answering machines.
Industrial	Elevator controls, surveillance systems, robots.
Instrumentation	Data collection, oscilloscopes, signal generators, signal analyzers, power supplies.

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Medical	Imaging systems (e.g., XRAY, MRI, and ultrasound), patient monitors, heart pacers.
Office Automation	FAX machines, copiers, telephones, cash registers.
Personal	Personal Digital Assistants (PDAs), pagers, cell phones, wrist watches, video games, portable MP3 players, GPS.

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Embedded Rules!

- Embedded processors account for 100% of worldwide microprocessor production!
- Embedded:desktop = 100:1
- 1999: #embedded processors in the home estimated at 40-50.

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Design Goal: Reliability

- Mission Critical
- Life-Threatening
- 24/7/365
- Can't reboot!

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Design Goal: Performance

- Multitasking and Scheduling
- Optimized I/O → Assembly Language
- Limits, Inaccuracies of Fixed Precision

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Design Goal: Cost

- Consumer Market: Minimize Manufacturing Cost.
- Fast Time to Market Required
- No chance for future modification.

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What is a Real-Time System?

- Real-time systems process events.
- Events occurring on external inputs cause other events to occur as outputs.
- Minimizing response time is usually a primary objective, or otherwise the entire system may fail to operate properly.

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Hard/Soft Real-Time Systems

- Soft Real-Time System
 - Compute output response as fast as possible, but no specific deadlines that must be met.
- Hard Real-Time System
 - Output response must be computed by specified deadline or system fails.

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Multi-Tasking and Concurrency

- Most real-time systems are also embedded systems w/several inputs and outputs and multiple events occurring independently.
- Separating tasks simplifies programming, but requires somehow switching back and forth among the three task (*multi-tasking*).
- *Concurrency* is the appearance of simultaneous execution of multiple tasks.

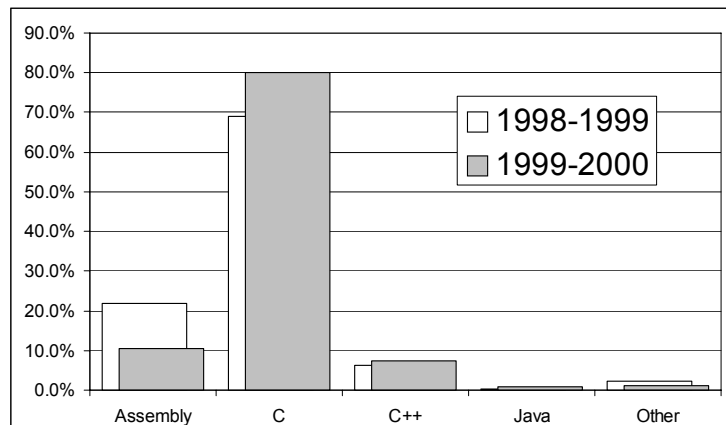
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Three Concurrent Tasks Within a Programmable Thermostat

<pre> /* Monitor Temperature */ do forever { measure temp ; if (temp < setting) start furnace ; else if (temp > setting + delta) stop furnace ; } </pre>	<pre> /* Monitor Time of Day */ do forever { measure time ; if (6:00am) setting = 72°F ; else if (11:00pm) setting = 60°F ; } </pre>	<pre> /* Monitor Keypad */ do forever { check keypad ; if (raise temp) setting++ ; else if (lower temp) setting-- ; } </pre>
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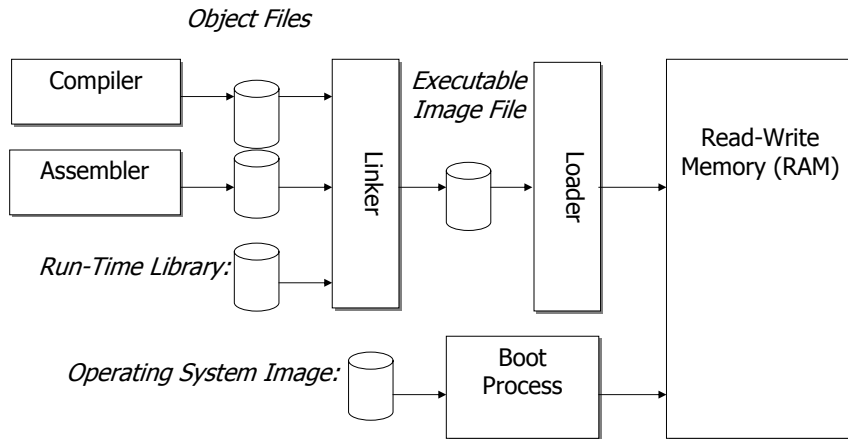
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Programming Languages Used in New Embedded Designs



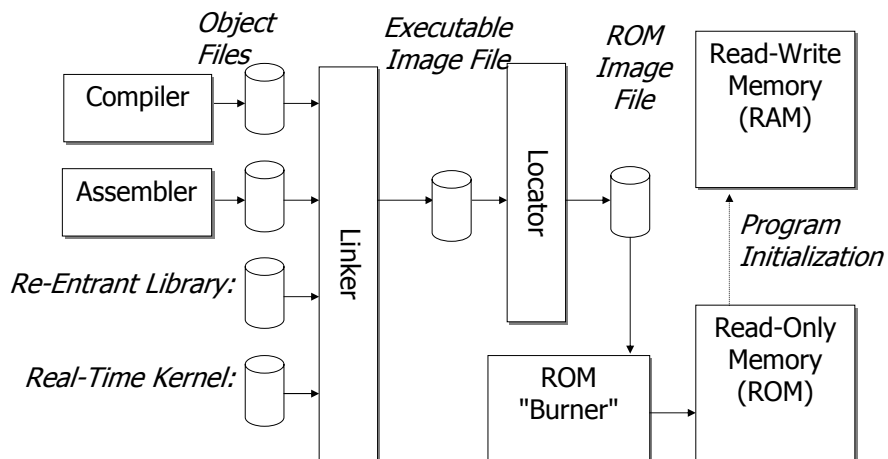
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The build and load process for desktop application programs.



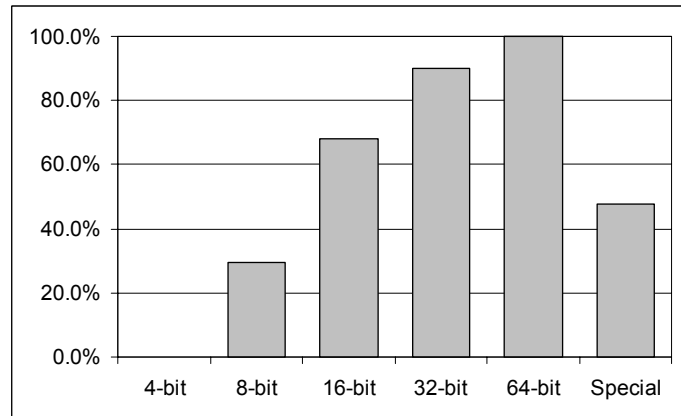
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The build and load process for embedded application programs.



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Use of Real-Time Kernels in New Embedded Designs.



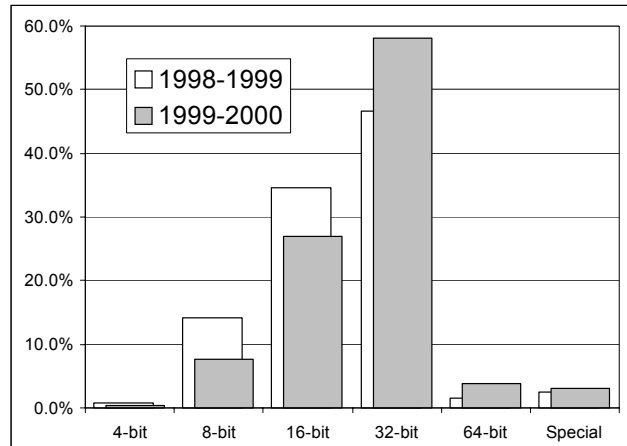
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Examples of Embedded Real-Time Software.

<i>Property</i>	<i>FAX Machine</i>	<i>CD Player</i>
Microprocessor:	16-bit	8-bit
Number of Threads:	6	9
Read-Write Memory (RAM):	2048 Bytes	512 Bytes
<i>Total RAM Actually Used:</i>	1346 Bytes (66%)	384 Bytes (75%)
<i>Amount Used by Kernel:</i>	250 Bytes (19%)	146 Bytes (38%)
Read-Only Memory (ROM):	32.0 KB	32.0 KB
<i>Total ROM Actually Used:</i>	28.8 KB (90%)	17.8 KB (56%)
<i>Amount Used by Kernel:</i>	2.5 KB (8.7%)	2.3 KB (13%)

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Processor Types Used in New Embedded Designs



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Product: Hunter Programmable Digital Thermostat.

Microprocessor: 4-bit

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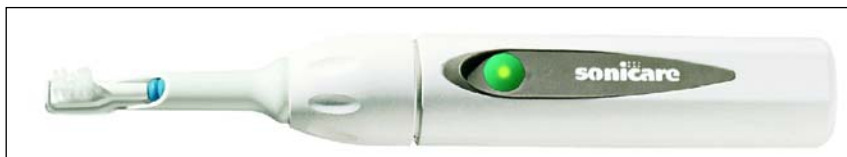
Product:Vendo V-
MAX 720 vending
machine.

Microprocessor:
8-bit Motorola
68HC11.

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Product: Sonicare Plus toothbrush.

Microprocessor: 8-bit Zilog Z8.



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Product: Miele dishwashers.

Microprocessor: 8-bit Motorola 68HC05.

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Product: NASA's Mars Sojourner Rover.

Microprocessor: 8-bit Intel 80C85.

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Product: CoinCo
USQ-712 coin
changer.

Microprocessor:
8-bit Motorola
68HC912.

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Product: Garmin
StreetPilot GPS
Receiver.

Microprocessor: 16-
bit.

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**Product: TIQIT
Computer's
"Matchbox PC".**

**Microprocessor:
32-bit AMD Elan
SC410.**

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**Product: Palm Vx
handheld.**

**Microprocessor:
32-bit Motorola
Dragonball EZ.**

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Product: Motorola
i1000plus iDEN Multi-
Service Digital Phone.

Microprocessor: Motorola
32-bit MCORE.

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Product: Rio 800
MP3 Player.

Microprocessor: 32-
bit RISC.

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Product: RCA
RC5400P DVD
player.

Microprocessor: 32-
bit RISC.

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Product: IBM
Research's Linux
wrist watch
prototype.

Microprocessor:
32-bit ARM RISC.

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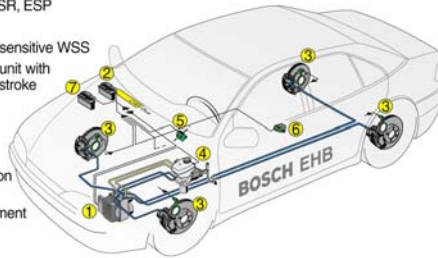
Product: Sony Aibo
ERS-110 Robotic
Dog.

Microprocessor: 64-
bit MIPS RISC.

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Bosch Electrohydraulic Brake EHB

- 1 Electrohydraulic actuator for EHB, ABS, ASR, ESP
- 2 EHB - ECU
- 3 Active, direction-sensitive WSS
- 4 Brake operation unit with integrated pedal stroke sensor
- 5 Steering wheel angle sensor
- 6 Yaw rate and lateral acceleration sensor
- 7 Engine management ECU



BOSCH 

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