CHAPTER 1

INTRODUCTION

What is an Embedded System?

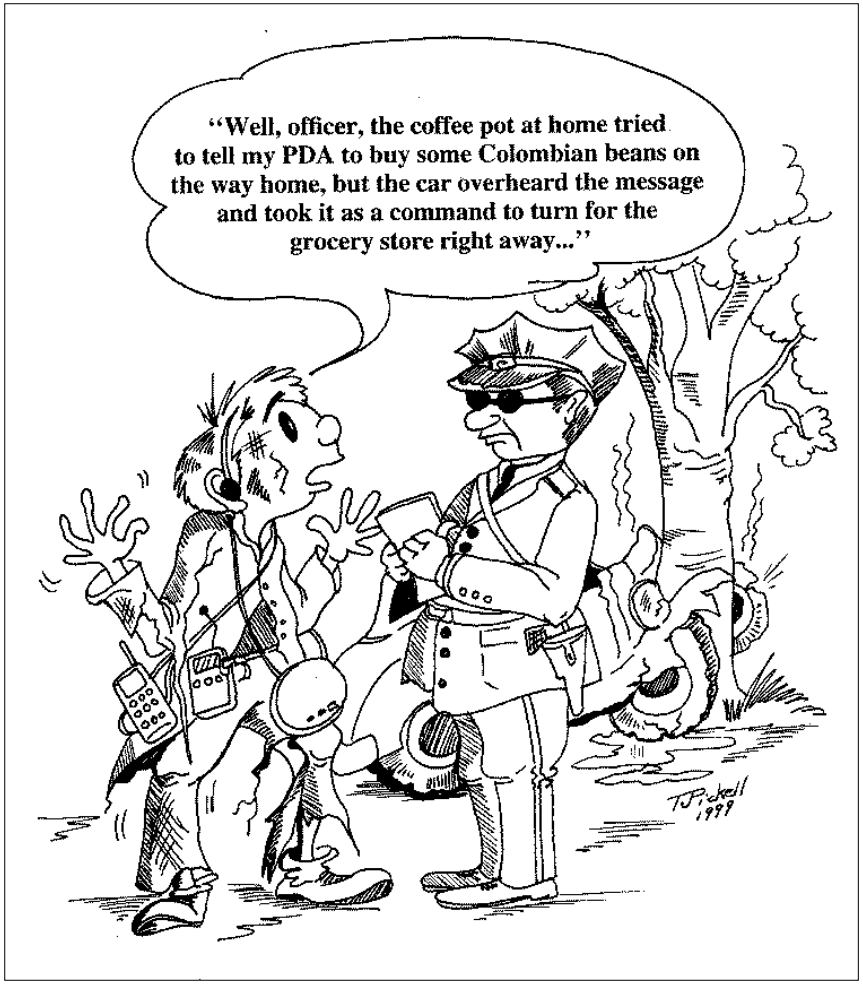
- An electronic device that incorporates a microprocessor.
- The microprocessor simplifies system design and provides flexibility.
- The user may not be aware that a microprocessor is inside.

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.

Design Goal: Reliability

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



Design Goal: Performance

- Multitasking and Scheduling
- Optimized input/output strategies
- Assembly Language where appropriate
- Limits, Inaccuracies of Fixed Precision

Design Goal: Cost

- Consumer Market
  - Minimize Manufacturing Cost
- Fast Time to Market
  - Minimize Design Time
- No customer upgrades

What is a Real-Time System?

- Real-time systems process events.
- Output in response to input events.
- Primary objective: Minimize response time

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.

Multi-Tasking and Concurrency

- Real-time systems are embedded systems w/multiple inputs and outputs and multiple events occurring independently.

- Separating tasks simplifies programming, but requires switching back and forth among the different threads of computation (*multi-tasking*).

- *Concurrency* is the appearance of simultaneous execution of multiple tasks.

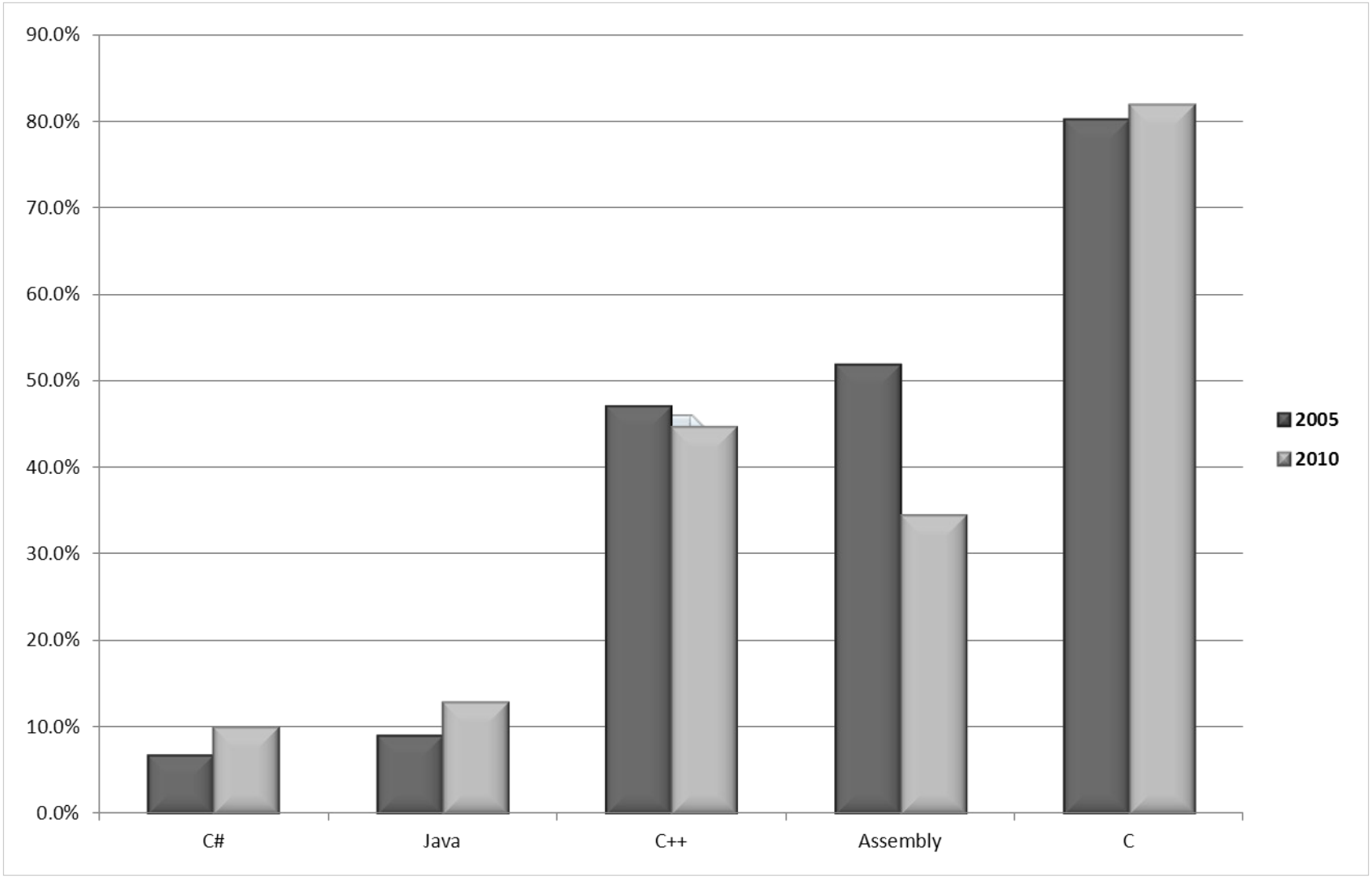
Three Concurrent Tasks Within a Programmable Thermostat

```
/* Monitor Temperature */
do forever {
        measure temp ;
        if (temp < setting)
                start furnace ;
        else if (temp >
                setting + delta)
                stop furnace ;
}
```

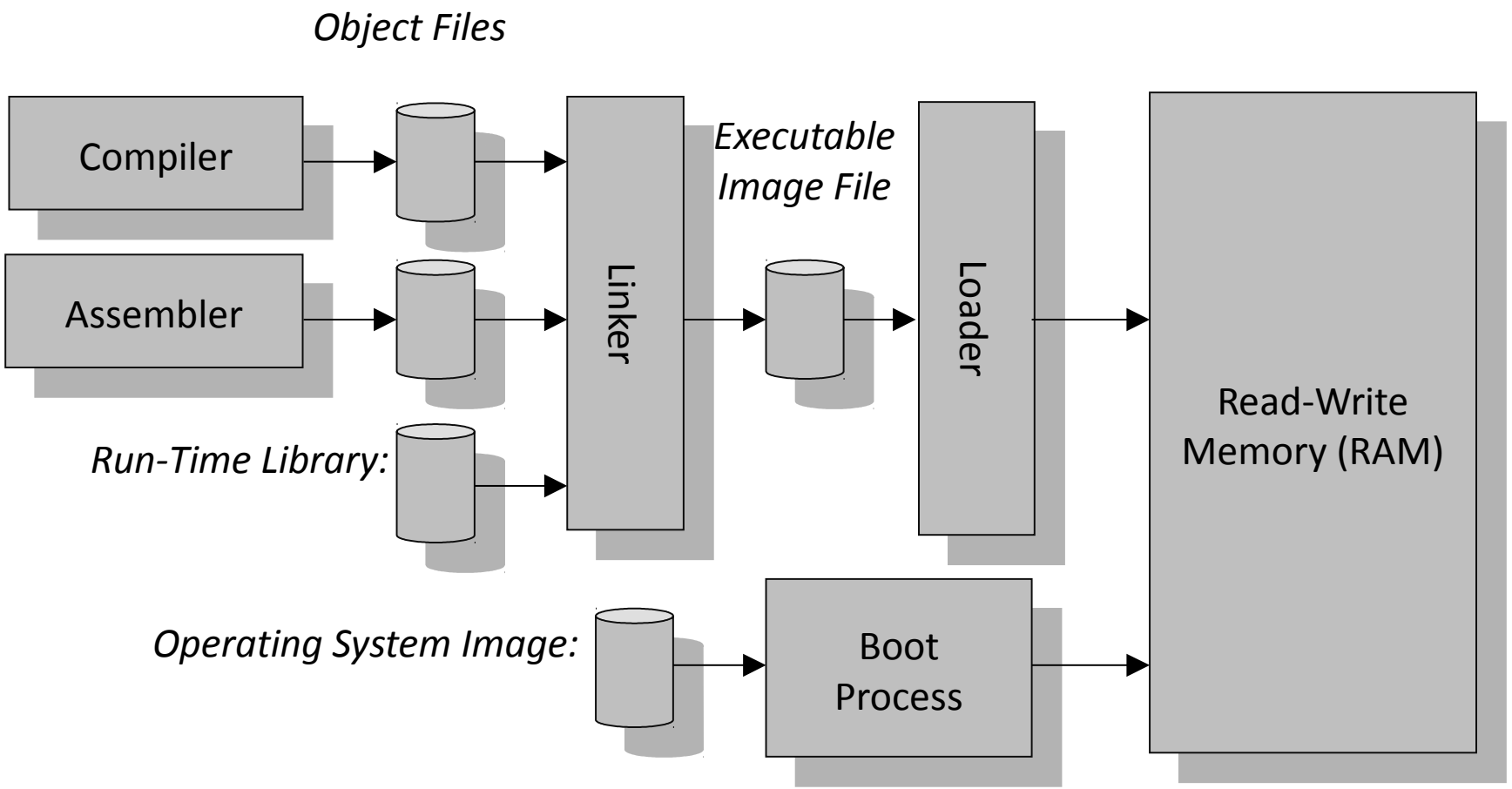
```
/* Monitor Time of Day */
do forever {
        measure time ;
        if (6:00am)
                setting = 72°F ;
        else if (11:00pm)
                setting = 60°F ;
}
```

```
/* Monitor Keypad */
do forever {
        check keypad ;
        if (raise temp)
                setting++ ;
        else if (lower temp)
                setting-- ;
}
```

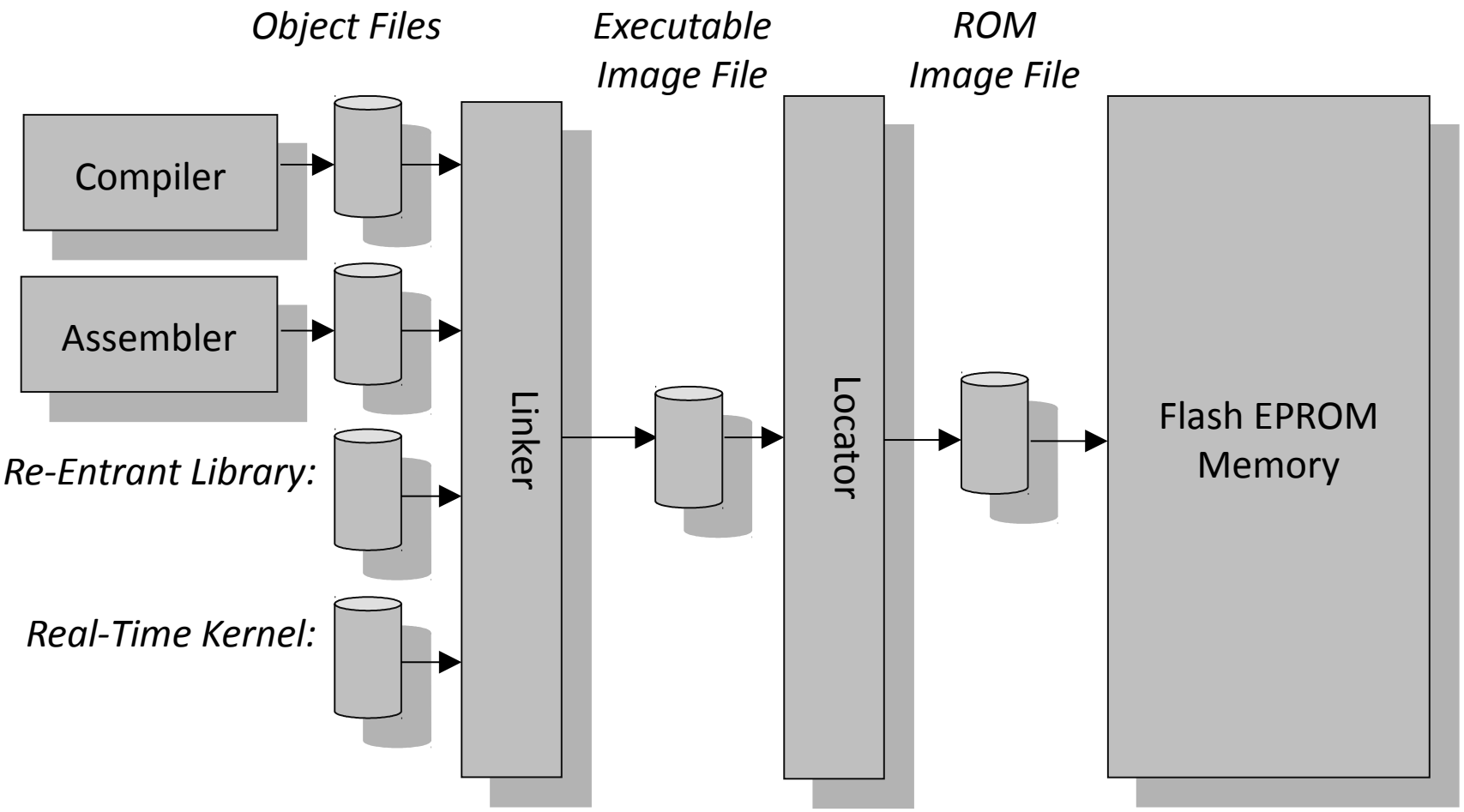
Programming Language Use in Embedded Designs



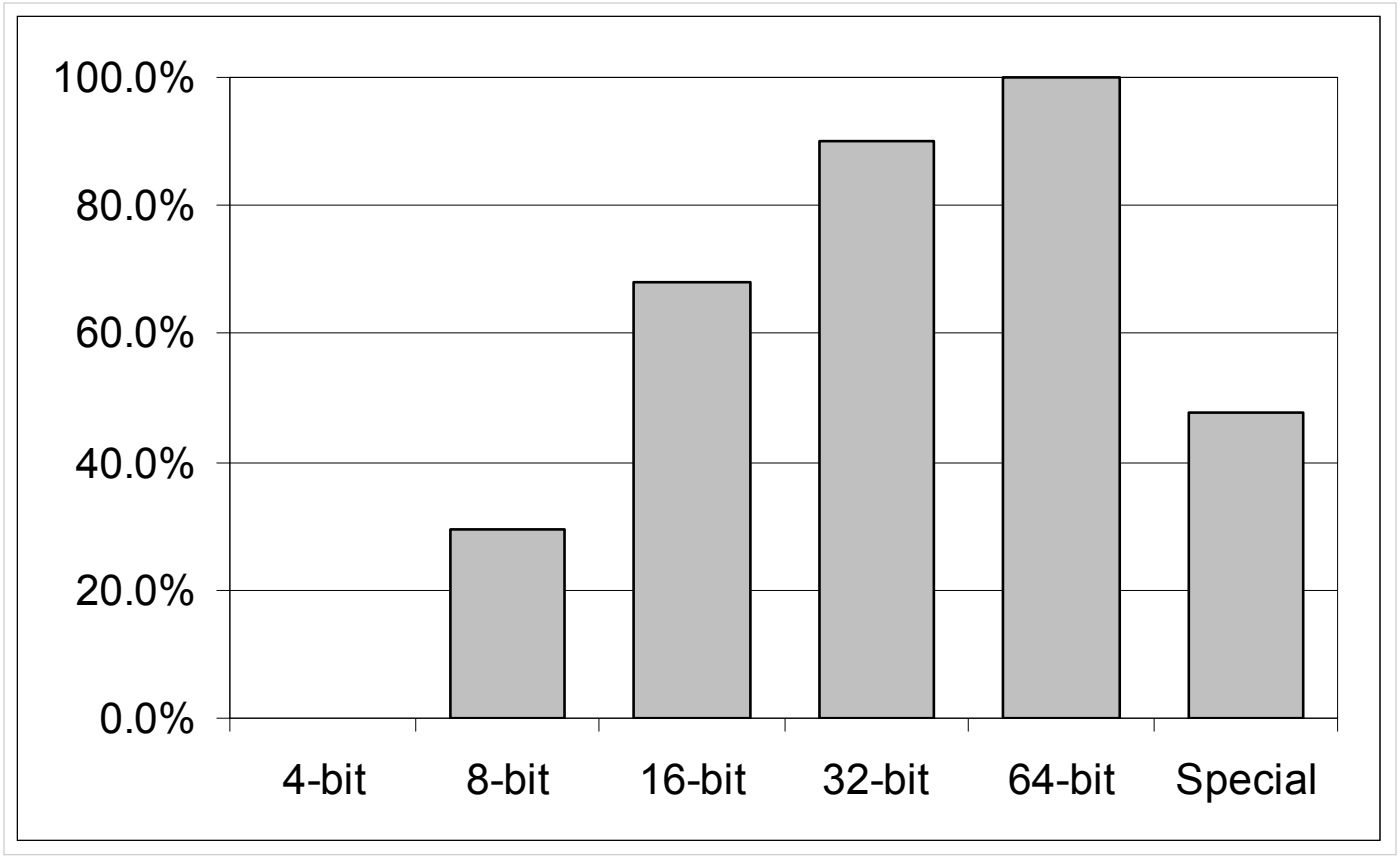
Desktop Application Development



Embedded Application Development



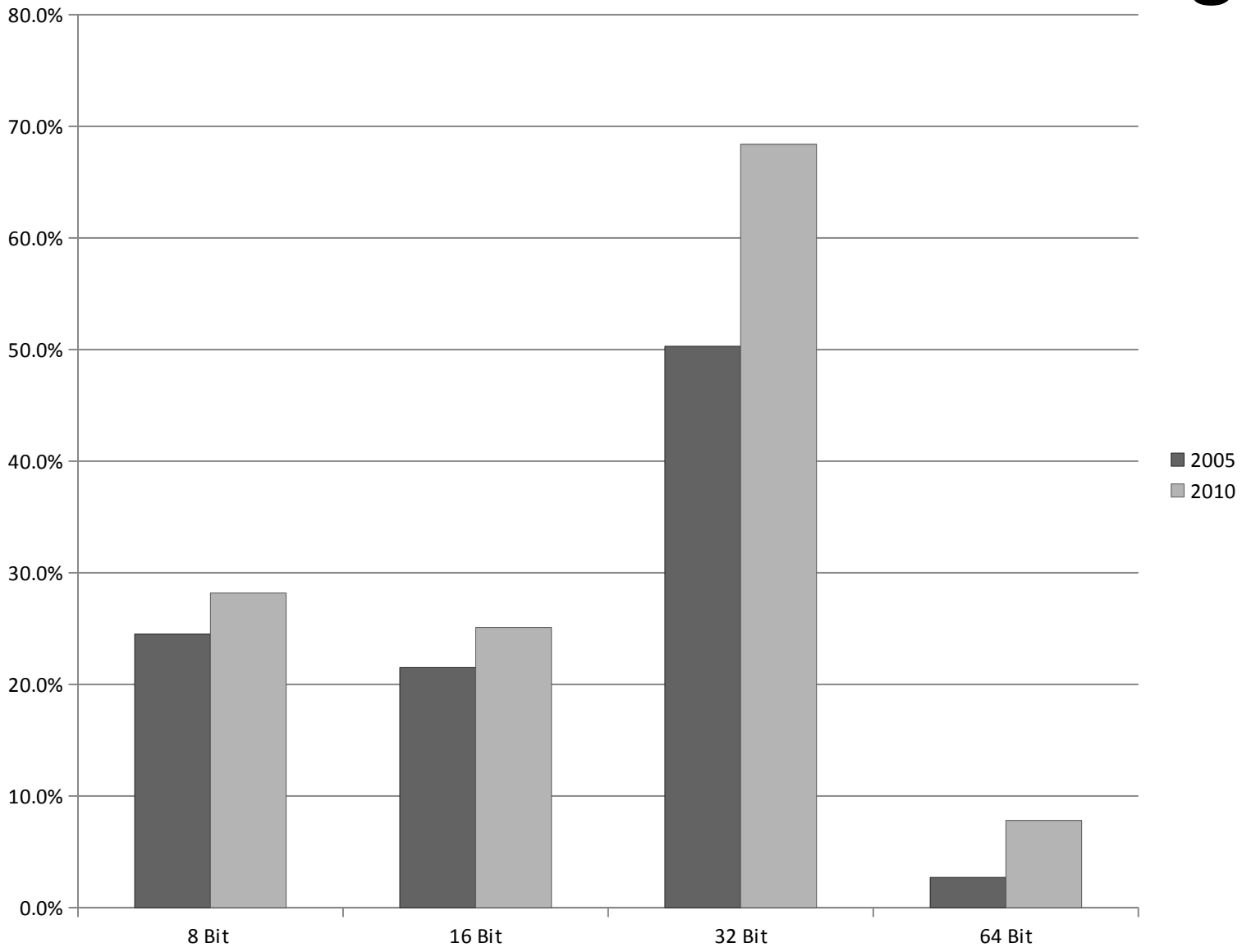
Use of Real-Time Kernels in New Embedded Designs.



Examples of Embedded Real-Time Software.

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

Processor Use in Embedded Designs



Product: Hunter Programmable Digital Thermostat.

Microprocessor: 4-bit

The tiny ATMEL 8-bit picoPower AVR processor in Vitality's GlowCap™ helps people remember to take their medication on time. It can sense when the bottle is opened, transmit that information wirelessly to a Vitality server, flash its LED, and play a ring-tone.

The Vendo Vue40 vending machine uses a 16-bit Hitachi H8/3007 processor.

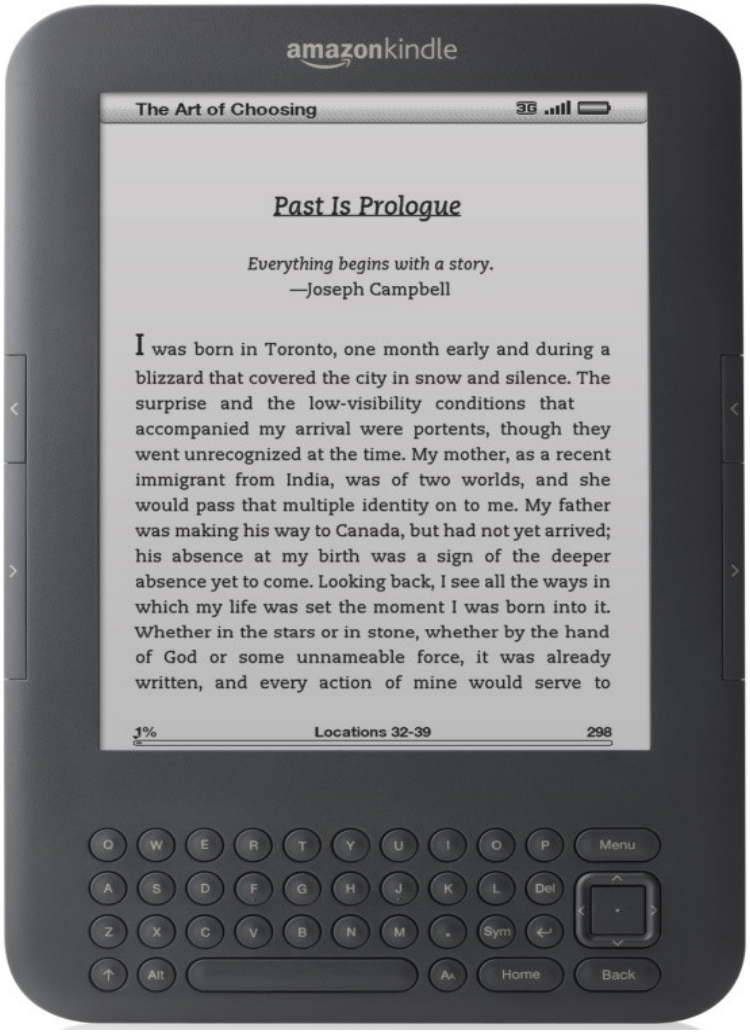
The Sonicare DiamondClean toothbrush uses an 8-bit PIC microprocessor.

Product: Miele dishwashers.

Microprocessor: 8-bit Motorola 68HC05.

NASA's 2003 Mars Exploration Rover used an BAE Systems RAD6000 32-bit RISC cpu and Wind River Systems' VxWorks embedded real-time operating system

The Seagate Barracuda XT disk drive incorporates two ARM Cortex-R4 processors – one to control the servos, and another to handle the command and data flow.



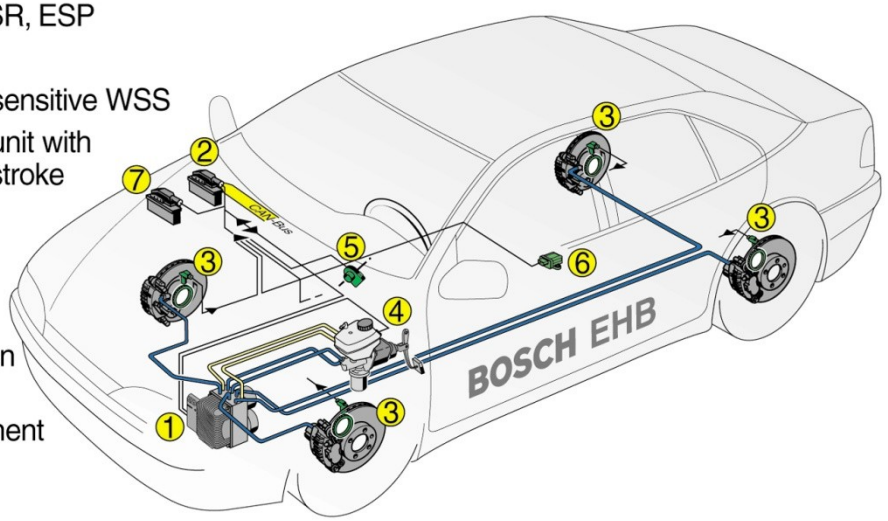
The Amazon Kindle 2 uses a 32-bit ARM processor.

Product: Sony Aibo ERS-110 Robotic Dog.

Microprocessor: 64-bit MIPS RISC.

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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ARM Powered Products