WHAT IS A REAL-TIME SYSTEM?

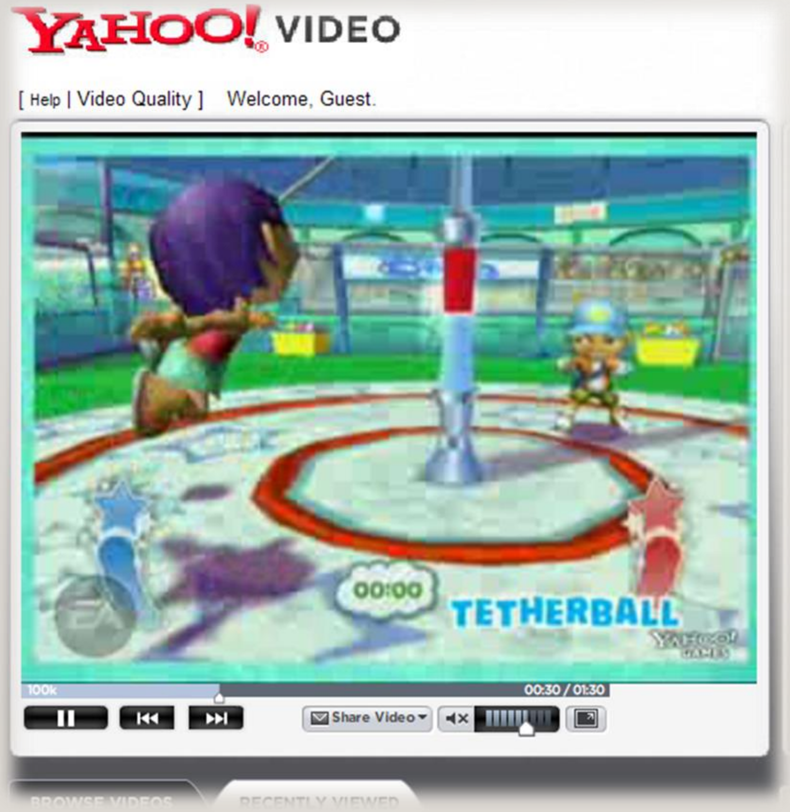
THE TERM “REAL-TIME SYSTEM” REFERS TO ANY INFORMATION PROCESSING SYSTEM WITH HARDWARE AND SOFTWARE COMPONENTS THAT PERFORM REAL-TIME APPLICATION FUNCTIONS AND CAN RESPOND TO EVENTS WITHIN PREDICTABLE AND SPECIFIC TIME CONSTRAINTS. COMMON EXAMPLES OF REAL-TIME SYSTEMS INCLUDE AIR TRAFFIC CONTROL SYSTEMS, PROCESS CONTROL SYSTEMS, AND AUTONOMOUS DRIVING SYSTEMS.

https://www.intel.com/content/www/us/en/robotics/real-time-systems.html

EXAMPLE REAL-TIME AND EMBEDDED SYSTEMS

Domain	**Application**
Avionics	Navigation; displays
Multimedia	Games; simulators
Medicine	Robot surgery; remote surgery; medical imaging
Industrial systems	Robot assembly lines; automated inspection
Civilian	Elevator control Automotive system; Global positioning system (GPS)

LETS DISCUSS SOME REAL TIME SYSTEM (RTS) CHARACTERISTICS

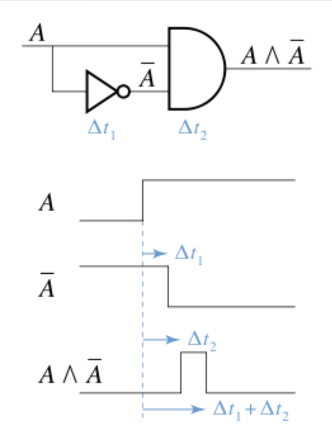


4 REALTIME CHARACTERISTICS

- RTS have to respond to events in a certain pre-detemined amount of time.
  - The time constraints have to be considered during planning, design, implementation and testing phases.
- Internal failures due to software and hardware fault have be handled satisfactorily.
  - You cannot simply pop-up a dialog error box that says "send report" or "don't send report".
  - Also external failures due to outside sources need to be handled.

5 REALTIME CHARACTERISTICS (CONTD.)

- Typical interaction in an RTS is asynchronous. Thus an RTS should have features to handle asynchronous events such as interrupt handlers and dispatcher and associated resources.
- Potential for race condition: when state of resources are timing dependent race condition may occur.
- Periodic tasks are common.



6 EMBEDDED SYSTEM

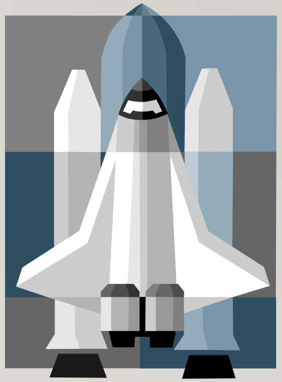
- Is a special purpose system designed to perform a few dedicated functions.
- Small foot prints (in memory)
- Highly optimized code
- Cell phones, mp3 players are examples.
- The components in an mp3 player are highly optimized for storage operations. (For example, no need to have a floating point operation on an mp3 player!)

7 REAL-TIME SYSTEM CONCEPTS

- A system is a mapping of a set of input into a set of outputs.
- A digital camera is an example of a realtime system: set of input including sensors and imaging devices producing control signals and display information.
- Realtime system can be viewed as a sequence of job to be scheduled.
- Time between presentation of a set of inputs to a system and the realization of the required behavior, including availability of all associated outputs, is called the response time of the system.

REAL-TIME SYSTEM CONCEPTS (CONTD.)

- Real-time system is the one in which logical correctness is based on both the correctness of the output as well as their timeliness.
- A soft real-time system is one in which performance is degraded by failure to meet response-time constraints.
- A hard real-time system is one in which failure to meet a single deadline may lead to complete and catastrophic failure.
- More examples:
  - Automatic teller: soft
  - Robot vacuum cleaner: firm
  - Missile delivery system: hard

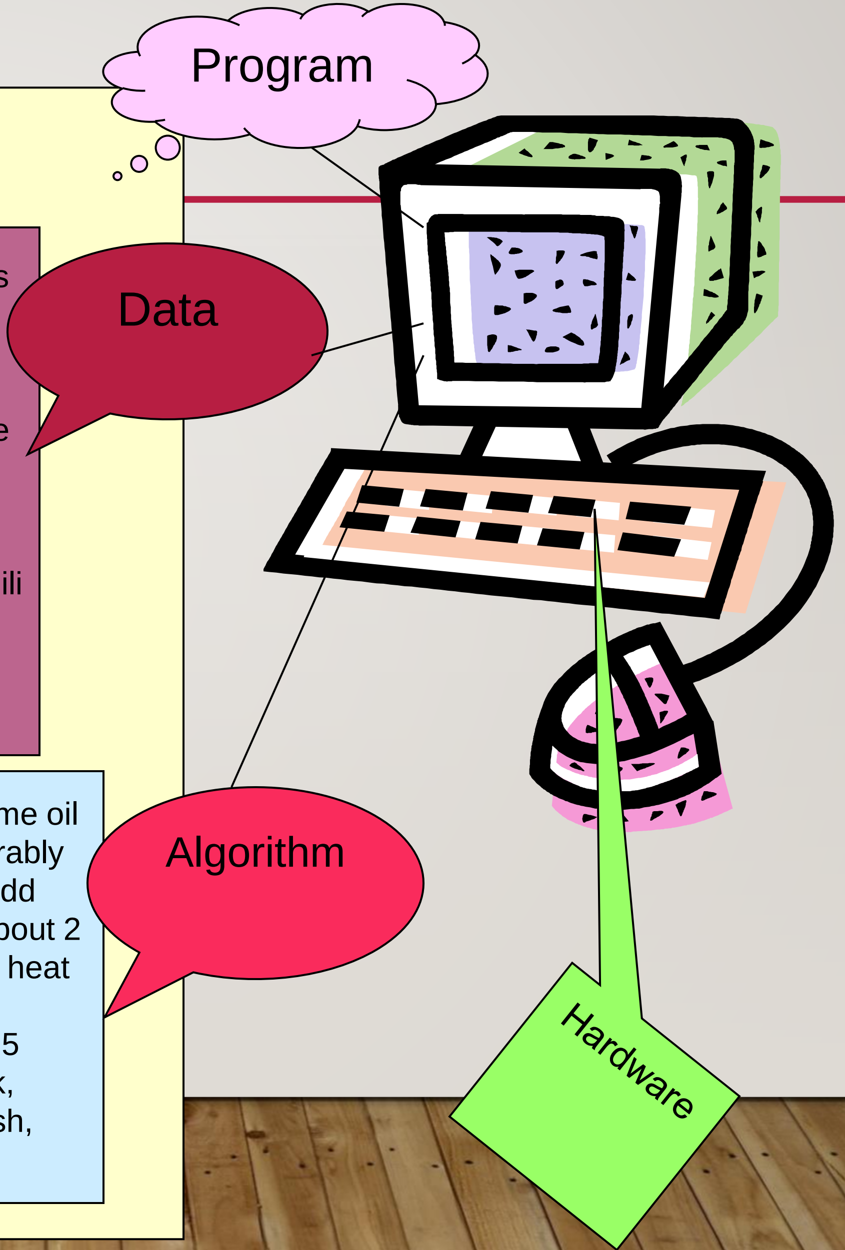


REGULAR COMPUTER SYSTEM

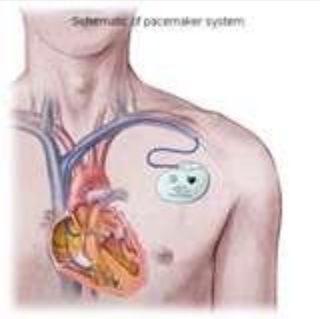
“From Minimalist”:
STIR-FRIED CHICKEN WITH CREAMED CORN
Time: 20 minutes

1 pound boneless chicken (breasts or thighs), in 1/2-inch chunks
2 tablespoons soy sauce
1 teaspoon sesame oil
1 tablespoon sherry, rice wine, sake or white wine
2 tablespoons peanut oil or another neutral oil, like corn or grape seed
1 tablespoon minced garlic
1 tablespoon minced ginger
1 small chili, seeds and stems removed, minced (or dried red chili flakes to taste)
1 15-ounce can creamed corn
1 cup corn kernels (fresh, frozen or canned)
Chopped cilantro leaves for garnish.

1. In a small bowl, mix the chicken with the soy sauce, the sesame oil and the wine. Put the peanut oil into a deep skillet or wok, preferably nonstick, and turn heat to high. Drain chicken. When oil is hot, add chicken to skillet, and cook, undisturbed, until bottom browns, about 2 minutes. Stir once or twice, and cook 2 minutes longer. Turn the heat down to medium-low.
2. Add the garlic, the ginger and the chili to the skillet, and stir; 15 seconds later, add the creamed corn and the corn kernels. Cook, stirring occasionally, until heated through, 3 or 4 minutes. Garnish, and serve over white rice.



EMBEDDED SYSTEMS









WHAT IS AN EMBEDDED SYSTEM?

DEFINITION:
AN EMBEDDED SYSTEM IS A DEDICATED COMPUTER SYSTEM DESIGNED FOR SPECIFIC FUNCTIONS OR APPLICATIONS WITHIN A LARGER MECHANICAL OR ELECTRICAL SYSTEM. IT INTEGRATES HARDWARE AND SOFTWARE TO PERFORM TASKS.

TYPES OF EMBEDDED SYSTEMS:

1. **Real-Time Systems**
2. **Standalone Systems**
3. **Networked Systems**
4. **Mobile Embedded Systems**

EMBEDDED SYSTEMS

- The use of electronics and software within a product
- Billions of computer systems are produced each year that are embedded within larger devices

- Today many devices that use electric power have an embedded computing system
- Often embedded systems are tightly coupled to their environment
    - This can give rise to real-time constraints imposed by the need to interact with the environment
        - Constraints such as required speeds of motion, required precision of measurement, and required time durations, dictate the timing of software operations
    - If multiple activities must be managed simultaneously this imposes more complex real-time constraints

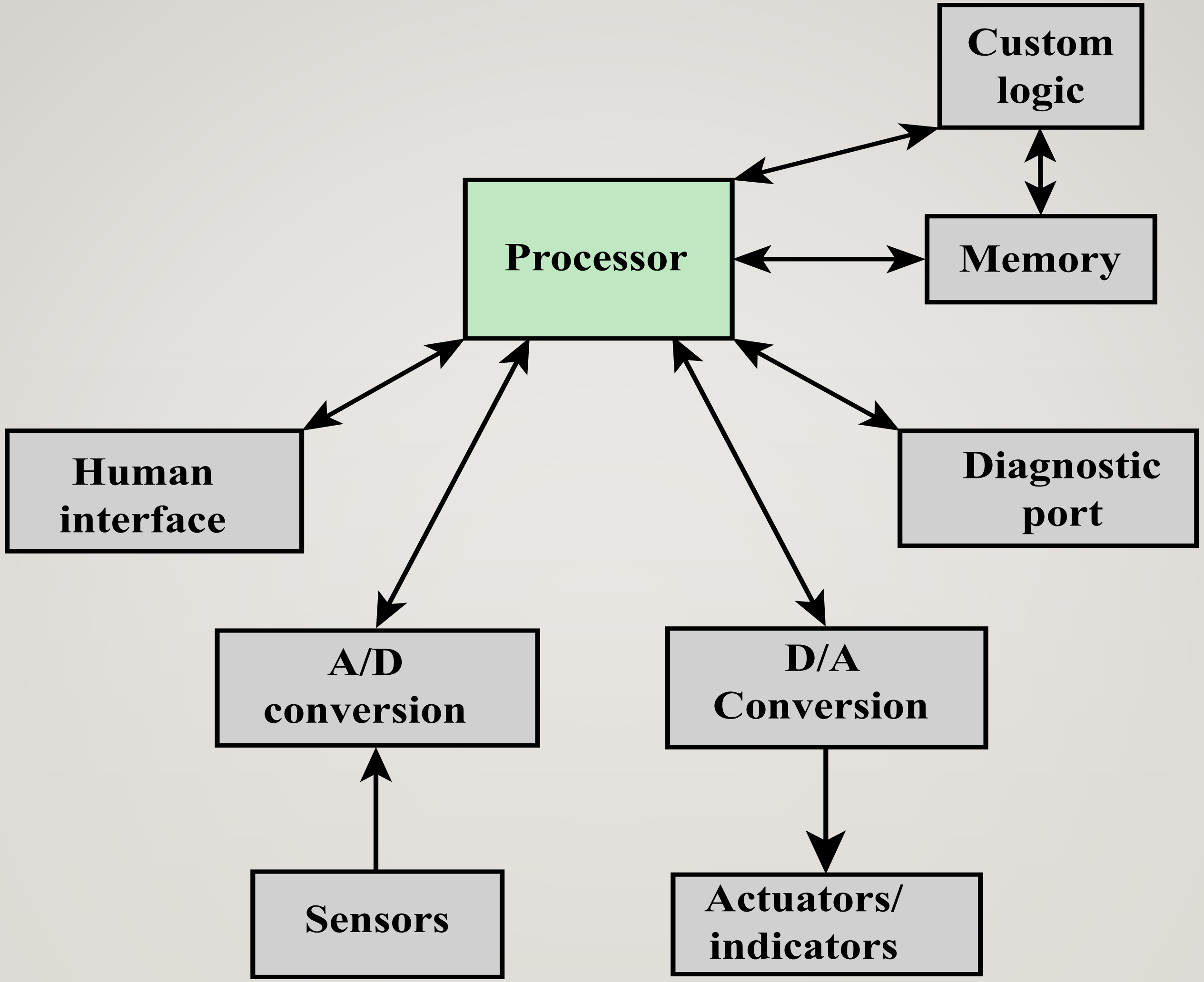


Figure 1.14 Possible Organization of an Embedded System

THE INTERNET OF THINGS (IOT)

- Term that refers to the expanding interconnection of smart devices, ranging from appliances to tiny sensors
- Is primarily driven by deeply embedded devices
- Generations of deployment culminating in the IoT:
  - Information technology (IT)
    - PCs, servers, routers, firewalls, and so on, bought as IT devices by enterprise IT people and primarily using wired connectivity
  - Operational technology (OT)
    - Machines/appliances with embedded IT built by non-IT companies, such as medical machinery, SCADA, process control, and kiosks, bought as appliances by enterprise OT people and primarily using wired connectivity
  - Personal technology
    - Smartphones, tablets, and eBook readers bought as IT devices by consumers exclusively using wireless connectivity and often multiple forms of wireless connectivity
  - Sensor/actuator technology
    - Single-purpose devices bought by consumers, IT, and OT people exclusively using wireless connectivity, generally of a single form, as part of larger systems
- It is the fourth generation that is usually thought of as the IoT and it is marked by the use of billions of embedded devices

APPLICATION PROCESSORS VERSUS DEDICATED PROCESSORS

EMBEDDED OPERATING SYSTEMS

- There are two general approaches to developing an embedded operating system (OS):
  - Take an existing OS and adapt it for the embedded application
  - Design and implement an OS intended solely for embedded use

- Application processors
  - Defined by the processor’s ability to execute complex operating systems
  - General-purpose in nature
  - An example is the smartphone – the embedded system is designed to support numerous apps and perform a wide variety of functions
- Dedicated processor
  - Is dedicated to one or a small number of specific tasks required by the host device
  - Because such an embedded system is dedicated to a specific task or tasks, the processor and associated components can be engineered to reduce size and cost

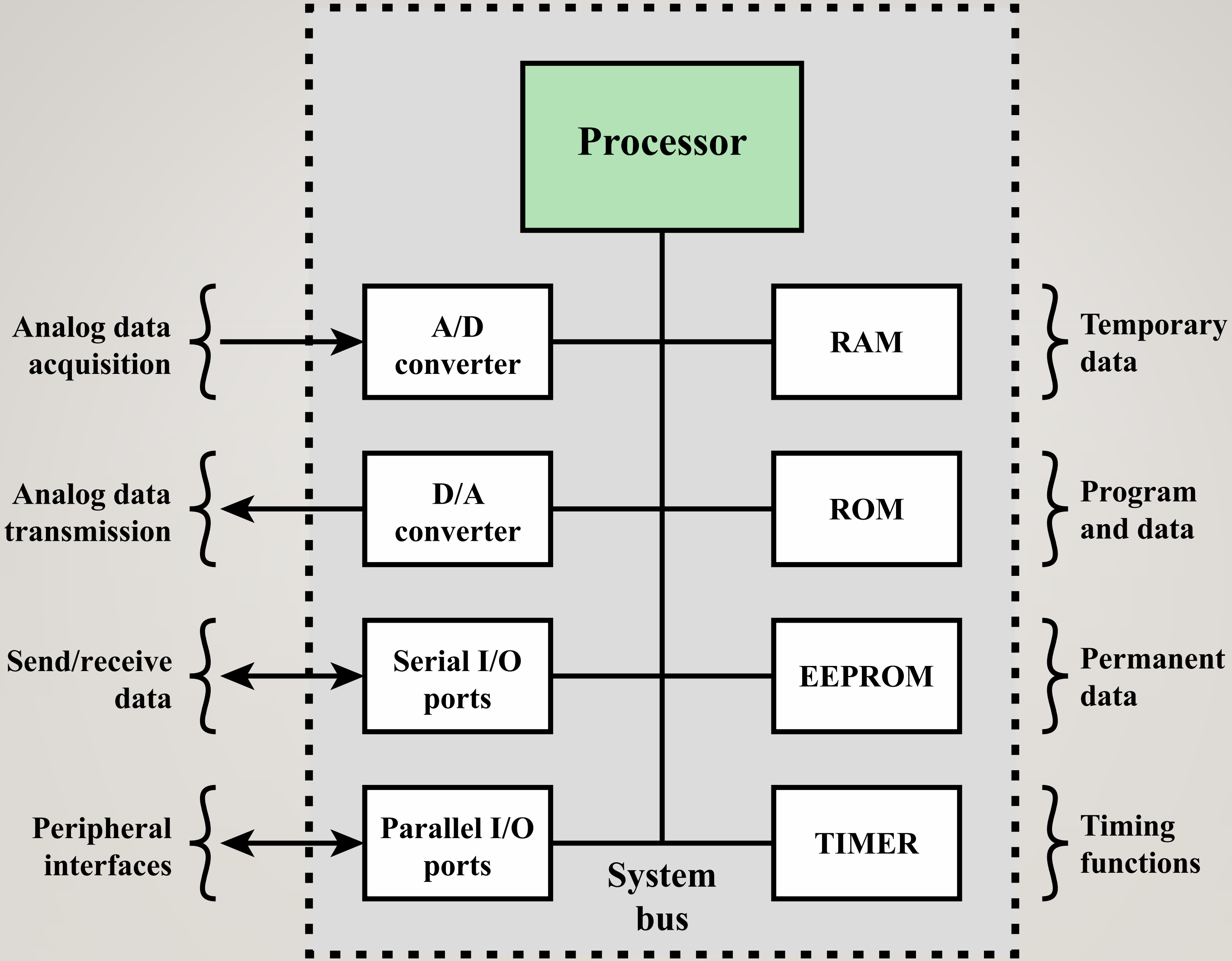


Figure 1.15 Typical Microcontroller Chip Elements

DEEPLY EMBEDDED SYSTEMS

- Subset of embedded systems
- Has a processor whose behavior is difficult to observe both by the programmer and the user
- Uses a microcontroller rather than a microprocessor
- Is not programmable once the program logic for the device has been burned into ROM
- Has no interaction with a user
- Dedicated, single-purpose devices that detect something in the environment, perform a basic level of processing, and then do something with the results
- Often have wireless capability and appear in networked configurations, such as networks of sensors deployed over a large area
- Typically have extreme resource constraints in terms of memory, processor size, time, and power consumption

ARM

Refers to a processor architecture that has evolved from RISC design principles and is used in embedded systems

Family of RISC-based microprocessors and microcontrollers designed by ARM Holdings, Cambridge, England

Chips are high-speed processors that are known for their small die size and low power requirements

Probably the most widely used embedded processor architecture and indeed the most widely used processor architecture of any kind in the world

Acorn RISC Machine/Advanced RISC Machine

ARM PRODUCTS

Cortex-A/Cortex-A50

Cortex-R

Cortex-M

- Cortex-M0
- Cortex-M0+
- Cortex-M3
- Cortex-M4

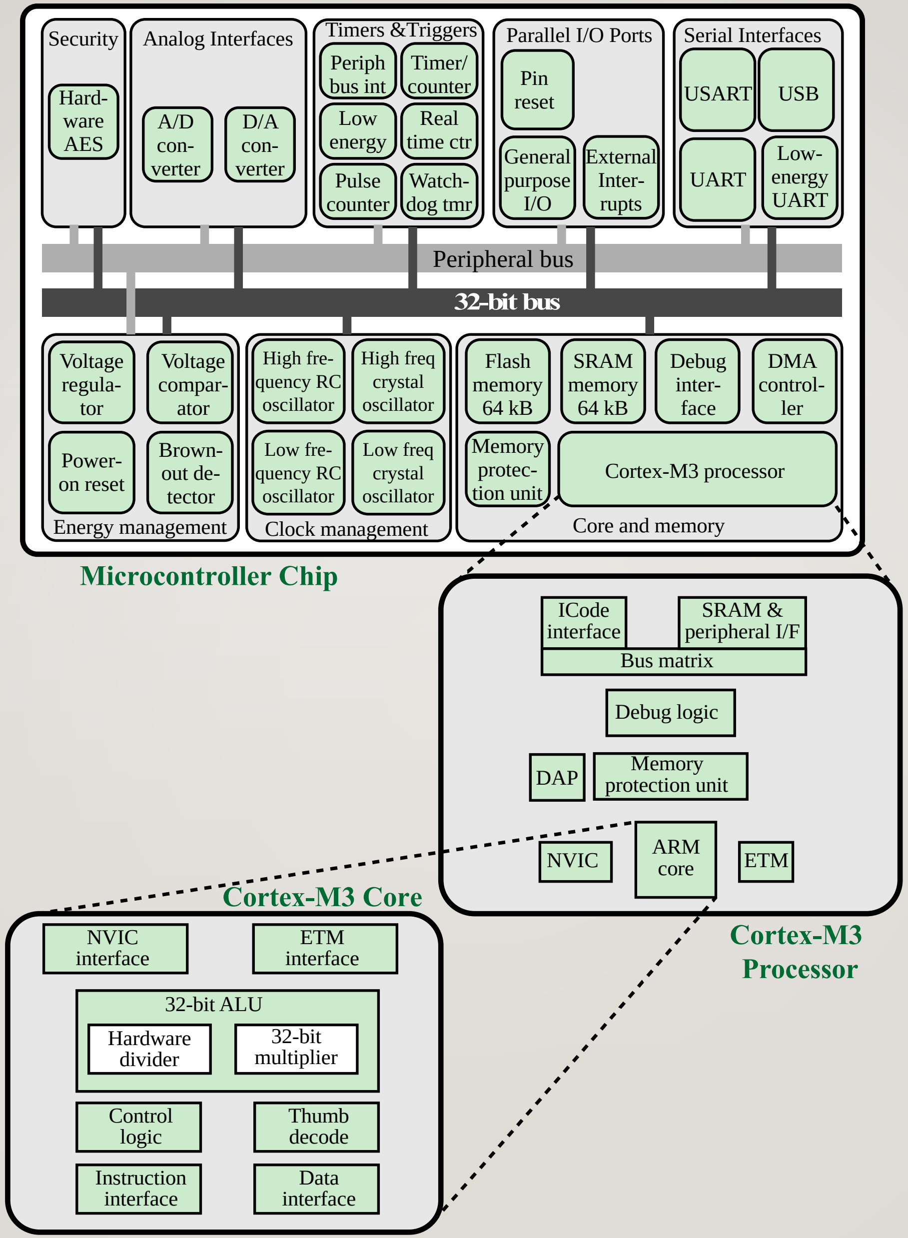


Figure 1.16 Typical Microcontroller Chip Based on Cortex-M3

CLOUD COMPUTING

- NIST defines cloud computing as:

“A model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources that can be rapidly provisioned and released with minimal management effort or service provider interaction.”

- You get economies of scale, professional network management, and professional security management
- The individual or company only needs to pay for the storage capacity and services they need
- Cloud provider takes care of security

CLOUD NETWORKING

- Refers to the networks and network management functionality that must be in place to enable cloud computing
- One example is the provisioning of high-performance and/or high-reliability networking between the provider and subscriber
- The collection of network capabilities required to access a cloud, including making use of specialized services over the Internet, linking enterprise data center to a cloud, and using firewalls and other network security devices at critical points to enforce access security policies

Cloud Storage

- Subset of cloud computing
- Consists of database storage and database applications hosted remotely on cloud servers
- Enables small businesses and individual users to take advantage of data storage that scales with their needs and to take advantage of a variety of database applications without having to buy, maintain, and manage the storage assets

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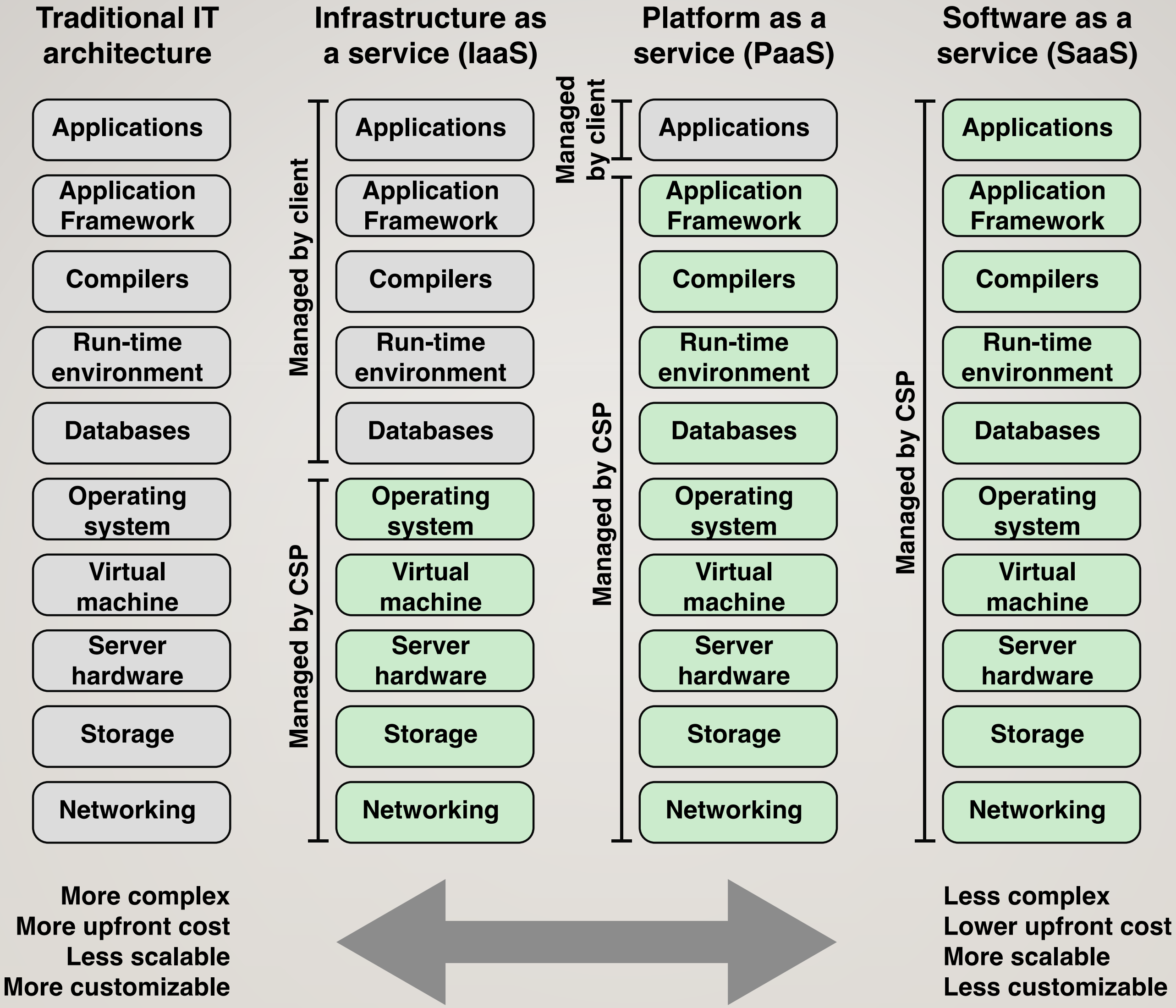

IT = information technology
CSP = cloud service provider

Figure 1.17 Alternative Information Technology Architectures

Summary

- What is an Embedded System?
  - Type of Embedded system
- Embedded systems
  - The Internet of things
  - Embedded operating systems
  - Application processors versus dedicated processors
  - Microprocessors versus microcontrollers
  - Embedded versus deeply embedded systems