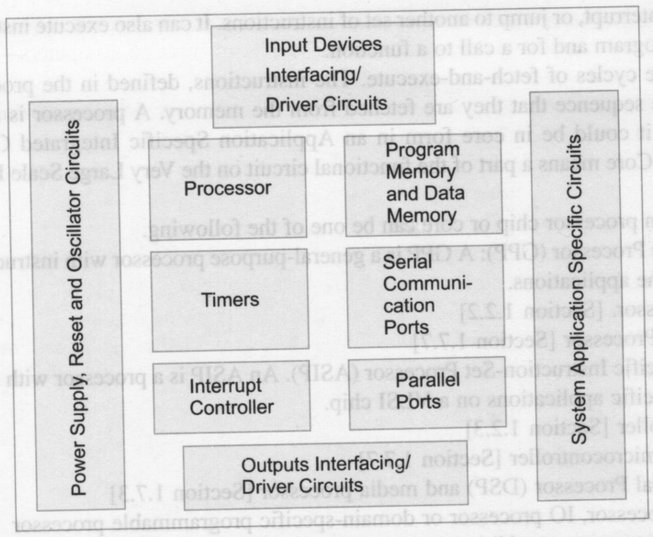

Fig. 1.1 The components of embedded system hardware

distinct rates. For example, audio, video, data, network stream and events have different rates and time constraints. (2) Complex algorithms. (3) Complex graphic user interfaces (GUIs) and other user interfaces. (4) Dedicated functions.

Constraints An embedded system is designed keeping in view three constraints: (1) available system-memory, (2) available processor speed, (3) the need to limit power dissipation when running the system continuously in cycles of 'wait for events', 'run', 'stop', 'wake-up' and 'sleep'.

The system design or an embedded system has constraints with regard to performance, power, size and design and manufacturing costs.

1.2 PROCESSOR EMBEDDED INTO A SYSTEM

A processor is an important unit in the embedded system hardware. It is the heart of the embedded system. Knowledge of basic concept of microprocessors and microcontrollers is must for an embedded system designer. A reader may refer to a standard text or the texts listed in the 'References' at the end of this book for an in-depth understanding of microprocessors, microcontrollers and DSPs that are incorporated in embedded system design. Chapter 2 will explain 8051 and a few processors.

1.2.1 Embedded Processors in a System

A processor has two essential units: Program Flow Control Unit (CU) and Execution Unit (EU). The CU includes a fetch unit for fetching instructions from the memory. The EU has circuits that implement the instructions pertaining to data transfer operations and data conversion from one form to another. The EU includes the Arithmetic and Logical Unit (ALU) and also the circuits that execute instructions for a program

control task, say, halt, interrupt, or jump to another set of instructions. It can also execute instructions for a call or branch to another program and for a call to a function.

A processor runs the cycles of fetch-and-execute. The instructions, defined in the processor instruction set, are executed in the sequence that they are fetched from the memory. A processor is in the form of an IC chip; alternatively, it could be in core form in an Application Specific Integrated Circuit (ASIC) or System on Chip (SoC). Core means a part of the functional circuit on the Very Large Scale Integrated (VLSI) chip.

An embedded system processor chip or core can be one of the following.

1. General Purpose Processor (GPP): A GPP is a general-purpose processor with instruction set designed not specific to the applications.
   (a) Microprocessor. [Section 1.2.2]
   (b) Embedded Processor [Section 1.7.7]
2. Application Specific Instruction-Set Processor (ASIP). An ASIP is a processor with an instruction set designed for specific applications on a VLSI chip.
   (a) Microcontroller [Section 1.2.3]
   (b) Embedded microcontroller [Section 1.7.7]
   (c) Digital Signal Processor (DSP) and media processor [Section 1.7.3]
   (d) Network processor, IO processor or domain-specific programmable processor
3. Single Purpose Processors as additional processors: Single purpose processor examples are as follows: (1) Coprocessor (e.g., as used for graphic processing, floating point processing, encrypting, deciphering, discrete cosine transformation and inverse transformation or TCP/IP protocol stacking and network connecting functions). (2) Accelerator (e.g., Java codes accelerator). (3) Controllers (e.g., for peripherals, direct memory accesses and buses). [Section 1.7.7]
4. GPP or ASIP cores integrated into either an ASIC or a VLSI circuit or a Field Programmable Gate Array (FPGA) core integrated with processor units in a VLSI (ASIC) chip. [Sections 1.6 and 1.7]
5. Application Specific System Processor (ASSP). [Section 1.7.9]
6. Multicore processors or multiprocessor [Section 1.7]

For a system designer, the following are important considerations when selecting a processor:

1. Instruction set
2. Maximum bits in an operand (8 or 16 or 32) in a single arithmetic or logical operation
3. Clock frequency in MHz and processing speed in Million Instructions Per Second (MIPS) or in an alternate metric *Dhrystone* for measuring processing performance [Section 2.6]
4. Processor ability to solve complex algorithms while meeting deadlines for their processing

A microprocessor or GPP is used because: (i) processing based on the instructions available in a predefined general purpose instruction set results in quick system development. (ii) Once the board and I/O interfaces are designed for a GPP, these can be used for a new system by just changing the embedded software in the ROM. (iii) Ready availability of a compiler faciiitates embedded software development in high-level languages. (iv) Ready availability of well-tested and debugged processor-specific APIs (Application Program Interfaces) and codes previously designed for other applications results in new systems developed quickly.

1.2.2 Microprocessor

The CPU is a unit that centrally fetches and processes a set of general-purpose instructions. The CPU instruction set includes instructions for data transfer operations, ALU operations, stack operations, IO operations and