Emerging Trends in Embedded Processors

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ABSTRACT
An Embedded Processor is simply a µProcessors that has been “Embedded” into a device. Embedded systems are important part of human life. For illustration, one cannot visualize life without mobile phones for personal communication. Embedded systems are used in many places like healthcare, automotive, daily life, and in different offices and industries. Embedded Processors develop new research area in the field of hardware designing.

Keywords—Embedded Processor, ARM, AVR, PIC, processors today

I. INTRODUCTION
This Paper provides a brief introduction to embedded systems, including their main components and application areas. It also provides an overview of the emerging trends and the related implications in the design and development of these systems.

An Embedded Processor is simply a µProcessors that has been “Embedded” into a device. It is software programmable but interacts with different pieces of hardware. It performs both control and computation, more performance than a µController but not as much as a general purpose processor.

The main reason for using embedded processors is their cost and size, so they don’t take up much die area and thus they are cheap to fabricate. Embedded processors are verified systems. Embedded processors run software, the key part of that is the SOFT – deal with changing specs. The three most important design criteria are power, performance, and cost.

II. MARKET OF EMBEDDED PROCESSOR
Embedded systems are important part of human life. For illustration, one cannot visualize life without mobile phones for personal communication. Its presence is practically unavoidable in almost all facets of human endeavor. While we search on configurations in each of these application spaces, we can clearly recognize the trend as to where the future of embedded systems is heading. [5]

1. Automotive
Embedded systems are clearly the ways and means of achieving multiple objectives from infotainment systems, engine control unit, fuel management, car-area-network, safety systems. Traffic management and prediction systems are being developed for big cities. The media oriented systems transport (MOST) is one of the technologies being deployed by OEMs for multimedia and infotainment networking.

2. Healthcare
Electronic medical device and other technological innovations with the convergence of nanotech, biotech, communication tech and device, manufacturing tech, sensor technologies are making breathtaking transformations in healthcare delivery. Interestingly the convergence of wireless communication with the sensors created the BAN – body area network which is today used to monitor, heart pulse rate, ECG, temperature, oxygen, blood pressure etc., sleep disorders can also be monitored using a clip device fixed to head band. Wireless cardiovascular solutions offer unprecedented visibility into a patient’s health status – anytime, anywhere across the world.

3. Consumer Electronics
While, mobiles, iPods, handhelds, etc., have changed the landscape of the personal entertainment in the world in the contemporary past, the emerging trend is adding more intellect in the communication devices by converging the social networks, personal entertainment, location based services and choices city information, and profile of the users. Nowadays set-top boxes used in television are also using microprocessors.

4. Industrial Control
Mostly industries are working on embedded systems, some of the examples are, Control Systems,
various cards, Artificial Satellites, Missiles, Space stations, Nuclear reactors and shuttles.

III. PROCESSORS TODAY

1. ARM (Advanced RISC Machine)

The ARM architecture has evolved a lot from its first version ARM1 to the latest ARM11. Some ARM processors are compared in terms of their features. [1]

Table 1: Key Features of ARM family

<table>
<thead>
<tr>
<th>Key Features</th>
<th>ARM 7</th>
<th>ARM 9</th>
<th>ARM 10</th>
<th>ARM 11</th>
</tr>
</thead>
<tbody>
<tr>
<td>Core</td>
<td>32-bit RISC</td>
<td>32-bit RISC</td>
<td>32-bit RISC</td>
<td>32-bit RISC</td>
</tr>
<tr>
<td>Pipelining Stages</td>
<td>3</td>
<td>5</td>
<td>6</td>
<td>8</td>
</tr>
<tr>
<td>Architecture</td>
<td>Von-Neumann</td>
<td>Harvard</td>
<td>Harvard</td>
<td>Harvard</td>
</tr>
<tr>
<td>Code Density</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Die Size</td>
<td>Small</td>
<td>Small</td>
<td>Small</td>
<td>Small</td>
</tr>
<tr>
<td>Max. Operating Frequency (in MHz)</td>
<td>80</td>
<td>150</td>
<td>260</td>
<td>335</td>
</tr>
<tr>
<td>MIPS/MHz</td>
<td>0.97</td>
<td>1.1</td>
<td>1.3</td>
<td>1.2</td>
</tr>
<tr>
<td>mW/MHz</td>
<td>0.06</td>
<td>0.19 + cache</td>
<td>0.5 + cache</td>
<td>0.4 + cache</td>
</tr>
<tr>
<td>Buses</td>
<td>AHB</td>
<td>AMBA</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Multiplier</td>
<td>8X32</td>
<td>8X32</td>
<td>16X32</td>
<td>16X32</td>
</tr>
<tr>
<td>Memory Coupling</td>
<td>No tight coupling</td>
<td>No tight coupling</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Power Performance</td>
<td>Very low</td>
<td>Very low</td>
<td>Medium</td>
<td>Optimu m</td>
</tr>
</tbody>
</table>

2. AVR

These are microcontrollers designed by ATMEL with modified Harvard architecture. Some of the variants of AVR used nowadays are:[4]

- Tiny AVR – ATtiny Series
  16KB Program Memory
  6-32 Pin package
  Limited peripheral set

- Mega AVR – ATmega
  512KB Program Memory
  28–100 Pin package
  Extended instruction set (multiply instructions and instructions for handling larger program memories)

- Application specific AVR
  512KB Program Memory
  28-100 Pin package
  LCD Controller
  USB Controller
  Advanced PWM
  CAN

- FPSLIC - (AVR with FPGA)
  FPGA 5K to 40K gates
  SRAM for the AVR program code, unlike all other AVRs
  AVR core can run at up to 50 MHz

- 32 bit AVR
  This includes DSP and SIMD instructions, along with other video and audio processing features. This 32-bit family of devices is projected to compete with the ARM based processors. It is not compatible with the original AVR or any of the various ARM cores, but the instruction set is similar to other RISC cores.

3. PIC (Peripheral Interface Controller)

The first generation of PICs with EPROM storage is almost totally replaced by chips with Flash memory. Similarly, the original 12-bit instruction set of the PIC1650 and its direct descendants has been old-fashioned by 14-bit and 16-bit instruction sets. Microchip still trades OTP (one-time-programmable) and windowed (UV-erasable) versions of some of its EPROM based PICs for volume orders or legacy support.

- Baseline core devices (12 bit)
  These are characterized by the PIC10 series, as well as by some PIC16 and PIC12 devices.
  - 12-bit wide code memory
  - 32-byte register file
  - Twotinylevel deep call stack
  - 6-pin to 40-pin packages

- ELAN Microelectronics clones (13 bit)
  ELAN Microelectronics Corp. makes a series of PICmicro-like microcontrollers with a 13-bit instruction word. The instructions are limited to a 6-bit register address and a 10-bit (1024 word) program space, but mostly compatible with the mid-range 14-bit instruction set.
- Mid-range core devices (14 bit)
  The mid-range core is presented in the majority of devices labeled PIC16 and PIC12.
  14-bit wide code memory
  Improved 8 level deep call stack
  Instruction set differs very slightly from the baseline devices
  2 additional op-code bits allow 128 registers
  2048 words of code to be addressed directly
  Two additional 8-bit literal instructions and subtract.

- Enhanced mid-range core devices (14 bit)
  These devices introduce additional reset methods, deeper hardware stack, ‘C’ programming language optimizations and 14 additional instructions.

- PIC17 high end core devices (16 bit)
  The 17 series never became popular and has been superseded by the PIC18 architecture.
  Memory mapped accumulator
  Read access to code memory
  Direct register to register moves External program memory interface
  8-bit × 8-bit hardware multiplier
  Second indirect register pair
  Auto-increment/decrement

- PIC18 high end core devices (16 bit)
  Call stack is 21 bits wide and considerably deeper
  Call stack may be written and read conditional branch instructions
  Indexed addressing mode
  Extending the FSR registers to 12 bits
  Addition of another FSR register

- dsPIC16 and PIC 24-bit microcontrollers
  Hardware MAC (multiply–accumulate)
  Barrel shifting
  Bit reversal
  (16x16)-bit single-cycle multiplication and other DSP operations
  Hardware divide assist (19 cycles for 16/32-bit divide)
  Hardware support for loop indexing
  Direct memory access

- PIC32 32-bit microcontrollers
  The highest execution speed 80 MIPS Flash memory: 512 kByte
  One instruction/clock cycle execution
  First cached processor
  Allows execution from RAM
  Full Speed Host/Dual Role
  OTG USB capabilities

Full JTAG
2-wire programming and debugging
Real-time trace

4. Arduino
It is a single-board microcontroller, proposed to make the application of interactive objects or environments more manageable. The hardware consists of an open-source hardware board designed around a 32-bit Atmel ARM or an 8-bit Atmel AVR microcontroller. Current models an 8-bit Atmel AVR microcontroller, a USB interface, as well as 14 digital I/O pins which allow the user to attach numerous extension boards. [3]

Various processors for different fields are also available in the market,
- DSP Processors
- Media Processor
- Graphic Processor Unit
- Application Specific Instruction Processors (ASIPs)
- Multiprocessor Systems using GPPs
- Customizable Processors
- System-on-a-Chip (SoC)

IV. FURTHER ENHANCEMENT
The requirement of embedded processors are grooving rapidly due to its use in our day today life. Thus a lot of variants of microprocessors and microcontrollers are so frequently available. Some of embedded processors further enhancements are: VLIW processors which consist of features like multiple issue machines and Scheduling done by the compiler, Customized Processors which allows more cost effective design as we now pick, Instruction Compaction with Thumb is good, but we need to do better as more and more functionality moves to software. Pipeline lengths are starting to get very long and Intel’s XScale has branch prediction tables with an estimated growth on Embedded Processors.

V. CONCLUSION
Embedded Processors are available with the ease of use. Now many Embedded Software’s are also available, which make easier to work on it. The uses of microcontrollers or microprocessors are expanding very fast all over the World. Thus we conclude that a lot of variants and different processors for many different fields will take their place in the upcoming phase.

REFERENCES