DSP Processors, Embodiments, and Alternatives

DSP Processors

- DSP systems and, in particular, real-time DSP systems contain mainly repetitious application of data-driven behaviours defined by mathematical algorithms under strict timing constraints
- DSP processors are designed for repetitive, numerically intensive tasks
- DSP applications define two main requirements:
  - timing
    - sequence of operations must be performed in a given time
  - error
    - accuracy of results must be less than specified
- DSP processors contain features to improve the accuracy and performance of computations

DSP Processors: The Most Important Features

- Fast multiply-accumulate
  - single-instruction cycle MAC
  - multiplier and accumulator integrated into main arithmetic unit (data path)
- Multiple-access memory architecture
  - parallel instruction fetch and operand accesses
- Specialized addressing modes
  - dedicated address generation units
- Specialized execution control
  - efficient looping capabilities
- Specialized features to improve numerical accuracy
- Peripherals and input/output interfaces

Embodiments (1)

- DSP found in new application areas with new requirements
  - No single processor can fulfill all the requirements
  - Increase of integration levels
  - New packaging techniques
- Single-chip processor
- Multi-chip modules (MCM)
  - multiple dies combined into a single package
  - higher packaging density
  - higher operation speed
  - reduced power dissipation
- Multiple processors on a chip
- Microprocessor or -controller and DSP processor are integrated into a single chip
  - increased performance
  - reduced power consumption
- TI: two TMS320C40 processors with 128k*32 SRAM
- Motorola: M86356 contains M68000 and DSP 56000
**Embodiments (#2)**

- **Chip sets**
  - Processor is divided into several packages
  - Processor is complex or requires large number of I/O pins
    - Separate packages allow use of smaller and cheaper package
  - Increased flexibility

- **Multiprocessors**
  - High-performance systems requiring programmability
  - Some DSP’s have been designed especially for multiprocessor systems
    - TMS320C4X and ADSP-2106X have dedicated communication ports for inter-processor communications.
    - TMS320C8X contains four DSP processors and a RISC processor in a single chip.

- **Butterfly DSP: LH9124 processor and LH9320 address generator are separate components. Several address generators can be used with a single processor.**

**DSP Cores**

- **Final chip is combination of**
  - DSP processor
    - Programmability
    - Existing development tools
    - Existing SW libraries
  - User defined custom logic
    - Low production cost
    - Small size
    - Low power consumption

- **Used in high-volume designs**

**DSP Core Based ASICs**

- **Custom HW**
  - Final chip is combination of:
    - DSP processor
    - Programmability
    - Existing development tools
    - Existing SW libraries
    - User defined custom logic
      - Low production cost
      - Small size
      - Low power consumption
  - Used in high-volume designs

**DSP Core Based ASICs**

- **Foundry-Captive Cores**
  - Core vendor provides also the foundry services for ASIC fabrication
  - TI: standard DSP processors are macrocells which are surrounded by full-custom layouts, standard cells, or gate arrays or mixture of these.
  - SGS-Thompson: D950-CORE is offered as macrocell in standard ASIC library.

- **Licensable Cores**
  - Core vendor licenses the core design to the customer, who selects an appropriate foundry
  - Typically optimized full-custom layout compatible with fabrication process of a particular foundry
  - Also synthesizable HDL designs
    - Modifications possible
    - Foundry selected freely
Customizable DSP Processors

- Modification of the core itself rather than including additional surrounding circuitry
  - DSP processor, which may be extended or modified
  - additional functional units in data path
    - error coding unit
    - bit manipulation unit
- Modifications in core must be reflected also to the development tools
  - AT&T Microelectronics: DSP1600 was designed for easy attachment of extra execution units into the data path and the development tools support new units.
  - Philips: EPICS core has been demonstrated with different word widths.

Alternatives to Commercial DSP Processors (1)

- General-Purpose Microprocessors in Embedded Systems
  - for less-demanding DSP applications
  - compared to DSP processors
    - more cost effective
    - development tools more sophisticated and powerful
  - RISCs have features to support multimedia applications
    - single instruction cycle MAC (under certain circumstances)

- PCs and Workstations
  - software-only DSP with loose requirements
  - scientific and engineering DSP simulations (no real-time requirements)
  - cost effective (no extra hardware required)
  - DSP capabilities can be extended with add-on boards
    - on-board DSP processors
    - A/D and D/A converters
    - telephone line interfaces

Alternatives to Commercial DSP Processors (2)

- Custom Hardware
  - the best performance
  - the lowest production cost
  - board level realization the most common
    - standard logic devices
    - FPGA's
    - fixed-function or configurable arithmetic units
    - application-specific processors
  - development may be time-consuming
  - difficult to modify (fixed nature)

- Implementation options are not mutually exclusive
- In reality, DSP systems are designed with different technologies for different parts of the system