Insight, Analysis, and Advice on Signal Processing Technology

Processors for Consumer Video Applications

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Processor Selection Challenges

- The fundamental problem:
  - Lots of options—many types of processors available
  - Complex processors
    - E.g., heterogeneous multiprocessors
  - Complex applications
    - E.g., multiple standards to be supported
  - Demanding applications
    - Speed, cost, energy efficiency
  - Application requirements, processor options change quickly
  - Many important selection criteria to consider
  - Poor information
  - Complex analysis required…
  - But limited time and resources available
- The wrong choice can be fatal for a product development effort

Processor Selection Methodology

Use a hierarchical approach to make the problem manageable:

- Select appropriate categories (e.g., chip vs. core)
- Determine selection criteria
- Prioritize and assign weights to selection criteria
- Use critical criteria to eliminate unsuitable choices
  - Begin with classes of processors
- Evaluate and rank remaining candidates
- Weigh trade-offs among non-critical criteria
- Iterate as necessary
  - Refine criteria and analysis of candidates

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Processor Selection Criteria

Key Quantitative Factors

- Speed
  - Can the processor do the job?
  - How slow a clock rate can I use?
- Bill-of-materials cost
  - Processor cost
  - Supporting component cost
    - Integration: memory, peripherals, I/O interfaces, …
    - Memory usage
  - Royalties
- Energy consumption

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Assessing Application Speed

- Use relevant application or module speed data
  - More accurate than kernel benchmark mapping—if appropriate data is available
  - Use caution—data may be misleading or incomplete
- Augment with kernel benchmark results
  - Combined with application profile data
  - Useful when application data isn't available
  - Use kernel benchmark results to predict application module performance
- Use care with either approach…
  - Hazards include, e.g., data types, precision

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Assessing Speed, continued

- Processor core speed alone isn't enough
  - Must also consider memory sizes and bandwidths
  - I/O bandwidths and overheads
  - Multitasking effects
  - Impact of inter-processor synchronization and communication in multi-processor systems
    - Must define software architecture to predict performance
- Dynamic features complicate speed prediction
- Assessing energy efficiency can be very difficult

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Processor Selection Criteria

Development Factors

- Development effort, cost, risk
  - Breadth and quality of video-oriented tools, infrastructure
    - Application software components, OSs, drivers, players
    - Reference designs
    - Design services, support
  - Programming model complexity, familiarity
  - Language support
  - Pre-integrated subsystems
  - Start-up ("switching") costs
    - Compatibility; multi-vendor architecture
- Flexibility
- Roadmap risk

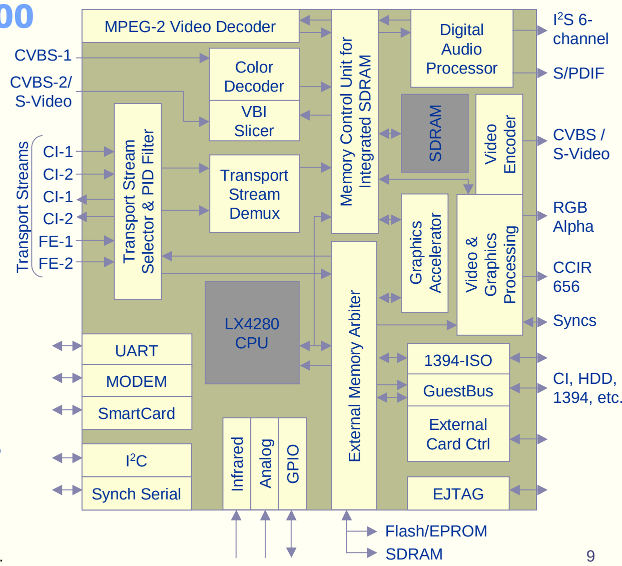
Video Processor Types

Processor Type	***Chips?***	***IP?***
PC CPU	✓	
RISC CPU	✓	✓
DSP (generic or specialized)	✓	✓
Media processor, heterogeneous multiprocessor	✓	✓
Customizable processor	✓	✓
ASIP		✓
Reconfigurable processor	✓	✓
FPGA	✓	✓
Fixed-function engines	✓	✓
ASSP (incorporating one or more processor types)	✓	

Example ASSP

Micronas MDE9500

- High-integration digital TV receiver
- Analog decode, DVB decryption, decode
- On-chip MPEG-2 video decoder (D1, 30 fps)
- Interfaces to other chips for, e.g., PVR functionality
- Customizable via software
  - MIPS-compatible CPU
  - Supports DVB-MHB
  - Supports Java
- Price $15-$30, qty 10k



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ASSPs

Strengths and Weaknesses

- ⬆ Ease of use
  - ⬆ Reduced system development costs
  - ⬆ Reduced required implementation expertise
- ⬆ Often very well matched to the application
  - ⬆ Architecture tuned for the application
  - ⬆ SoCs with extensive integration
  - ⬆ Can yield excellent performance, cost, energy efficiency
- ⬇ Often inflexible
- ⬇ Limited differentiation opportunities for system designer
- ⬇ Usually single-source
- ⬇ Roadmap often unclear

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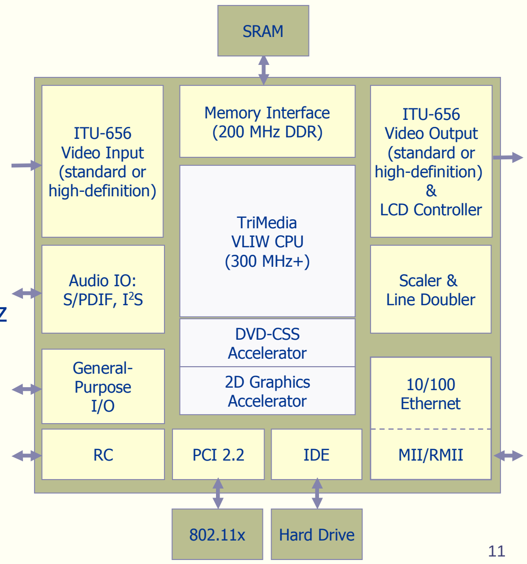
Example Media Processor

Philips PNX1500

- General-purpose 300 MHz five-way VLIW
- Media-specific interfaces, co-processors, instructions
- On-chip L1 data, instruction caches, and L2 data cache
- C/C++ programming model
- MPEG-4 decode (simple profile, CIF, 30 fps): 45 MHz
- MPEG-4 D1 video + audio encoding in real time
- Price <$20, qty >100k



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Media Processors

Strengths and Weaknesses

- ⬆ Higher performance than most DSPs, GPPs
  - ⬆ VLIW, huge register sets, wide SIMD typical
  - ⬆ High performance peripherals, co-processors
- ⬇ Very complex programming models
- ⬆ Better support for media processing in development tools and infrastructure, compared to GPPs
- ⬇ Application performance compiler-dependent
  - ⬇ Compilers can be poor quality
- ➡ Maturing technology—but roadmaps unclear
  - ⬇ 3rd party support weaker than other processor types
- ⬆ Development cost, risk, lower than ASIC, FPGA

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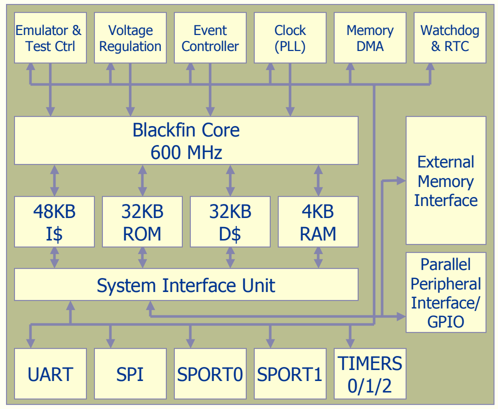
Example DSP Processor

Analog Devices ADSP-BF533

- 600 MHz, 16-bit fixed-point DSP with dual MAC units
  - 750 MHz also available
- Integrated peripherals target media apps (e.g., CCIR-656 port, I^2S ports)
- Good 3rd party software component support
- MPEG-4 decode, simple profile, CIF: 168 MHz
- ADSP-BF53x BDTImark2000™ score: 3,360 @ 600 MHz
- Price $16, qty 10k



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DSP Processors

Strengths and Weaknesses

- ⬆ Performance, efficiency on media applications strong compared to GPPs
- ⬇ But not as strong as customized solutions, and may not be adequate for demanding tasks
- ⬆ Media-oriented development tools, infrastructure
- ⬇ Overall tools not as sophisticated as those available for general-purpose processors
  - ⬇ Often, poor compiler quality
- ⬆ Third-party audio/video application software available
  - ⬇ Support for non-DSP software not as strong as, e.g., RISC
- ⬆ Mature technology
- ⬆ Relatively low development cost, risk

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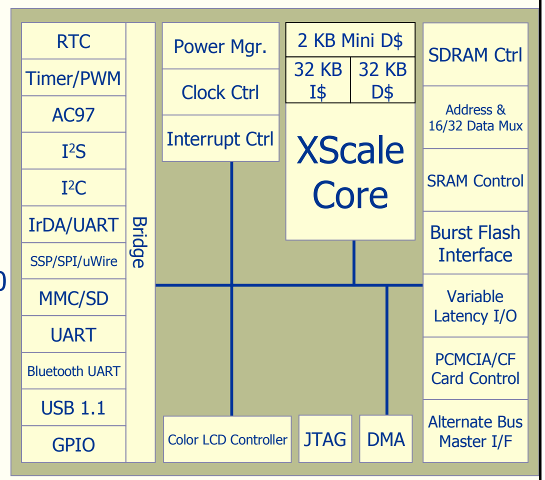
Example Embedded RISC CPU

Intel PXA255

- 400 MHz, 32-bit RISC with modest DSP extensions
- 16-bit SIMD, 32-bit data types benefit media apps
- Predicated instruction execution good for control
- MPEG-4 decode (simple profile, CIF @ 30 fps) 200 MHz
- BDTImark2000™ score: 930
- Good development tool support; optimized DSP software available (e.g., Intel IPP); good OS options
- Price $35, qty 10k



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Embedded RISC CPUs

Strengths and Weaknesses

- → Can have adequate performance on media applications
  - ↓ Often less efficient that DSPs and media processors
- ↓ Dynamic features complicate programming
  - ↓ Complicates optimization and ensuring real-time
- ↓ Sometimes, convoluted programming model
- ↑ 32-bit GPPs are more natural targets for non-media tasks
  - ↑ E.g., TCP/IP network stacks
- ↑ Multi-vendor architectures more common
- → Good tools overall, but generally weak on support for media application development
- ↑ Very good third-party OS, software component support
- ↑ Compatibility more common
- ↑ High integration parts increasingly common

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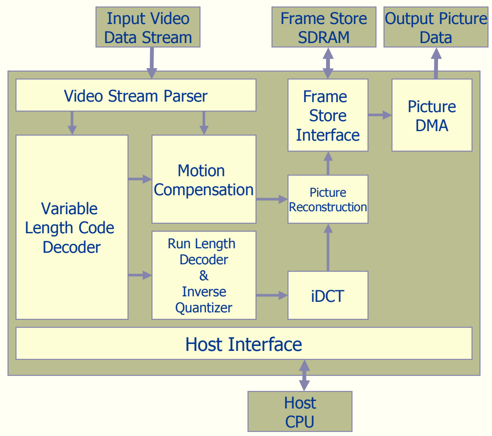
Example FPGA

Altera Stratix EP1S20

- Diverse on-chip hardware:
  - ~1.6 Mbits RAM
  - 18,460 logic elements
  - 80 embedded multipliers
  - 10 DSP blocks
  - 6 PLLs, 586 I/O pins
- Specialized high-speed I/O support
  - HyperTransport, PCI-X, SDRAM
- MPEG-2 HD decode
  - 4:2:0 at 108 MHz
  - 4:2:2 at 133 MHz
- Price $66 in qty 10k
  - ~65% cost reduction with "Hardcopy" structured ASIC port



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FPGAs

Strengths and Weaknesses

- ⬆ Massive performance gains on some algorithms
  - ⬆ ~50X throughput, cost/performance advantage over DSP/GPP processors in some applications
- ⬆ Architectural flexibility can yield efficiency
  - ⬆ Adjust data widths throughout algorithm
  - ⬆ Parallelism where you need it; distributed storage
- ⬆ Re-use hardware for diverse tasks
- ⬇ Slow time-to-market compared to, e.g., DSPs, GPPs
  - ⬇ Cumbersome design flow is unfamiliar to most signal-processing engineers
  - ⬇ Proprietary architectures
- ⬆ Suitability for single-channel, low-power, cost-sensitive signal-processing applications unclear

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Conclusions

- Lots of options, changing rapidly!
- Use a hierarchical approach
  - Develop a well-defined hierarchy of requirements
  - Start with the critical criteria and iteratively narrow the field
  - Expect to make trade-offs
- Assessing performance is a challenge
  - Resource-hungry algorithms, cost-constrained processors, many variables
- Appropriate integration is essential to low system cost
- Development-related considerations are key

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For More Information…

www.BDTI.com

Inside [DSP] newsletter and quarterly reports

Benchmark scores for dozens of processors

Pocket Guide to Processors for DSP

- Basic stats on over 40 processors

Articles, white papers, and presentation slides

- Processor architectures and performance
- Signal processing applications
- Signal processing software optimization

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