Optimized DSP Software • Independent DSP Analysis

Audio Signal Processing Hardware Trends

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Outline

- Introduction
  - Key markets and motives
  - Processor options and trends
- General-purpose processors (GPPs), software dominate
  - PCs taking over the studio
  - Software is king for consumer audio
- Audio signal processing becoming ubiquitous
  - Consequences of convergence
- Higher volumes and the benefits of competition
- Connectivity becomes a key challenge
- Conclusions

Key Realities and Consequences

Realities:
- Audio processing needs becoming easier to meet
- Audio signal processing becoming quite inexpensive
- Applications evolving quickly
- Algorithms changing fast

Consequences:
- Programmable solutions win favor
- Audio processing becoming ubiquitous
  - Consumer audio dominates
  - Few special-purpose chips for pro audio
- Higher volumes
  - Increased competition, lower costs, faster innovation
- Connectivity becomes a (the?) key challenge

Key Markets and Motives

1. Pro audio (recording, post-production, performance, ...)
   - Support more formats, features, effects
   - Improve productivity, reduce cost
   - Ease of use, flexibility, quality

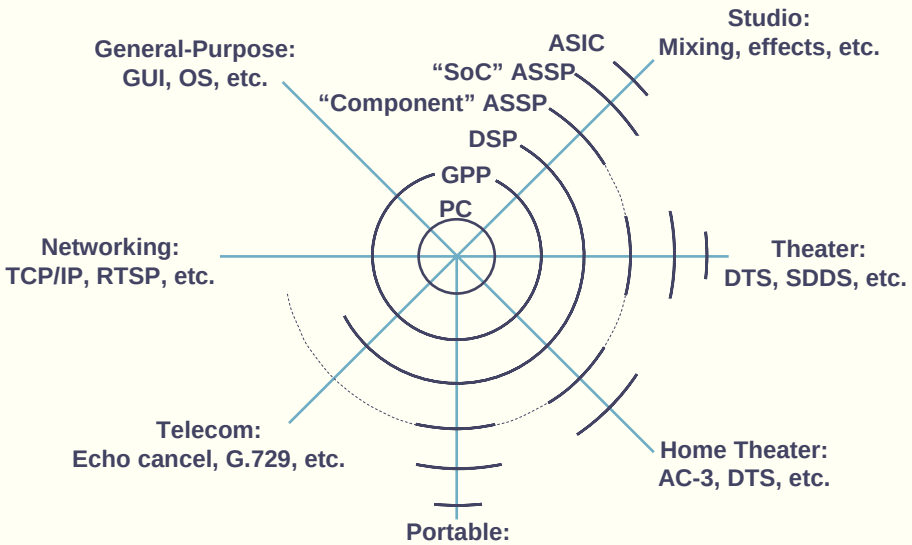

source: DigiDesign

2. "Convenience" consumer audio (mobile phone MP3 player, ...)
   - Basic audio support as a differentiator
     - Maximize convenience, but not necessarily audio quality
     - Combine with non-audio features
   - Minimize cost, time to market, engineering effort
   - Maximize flexibility

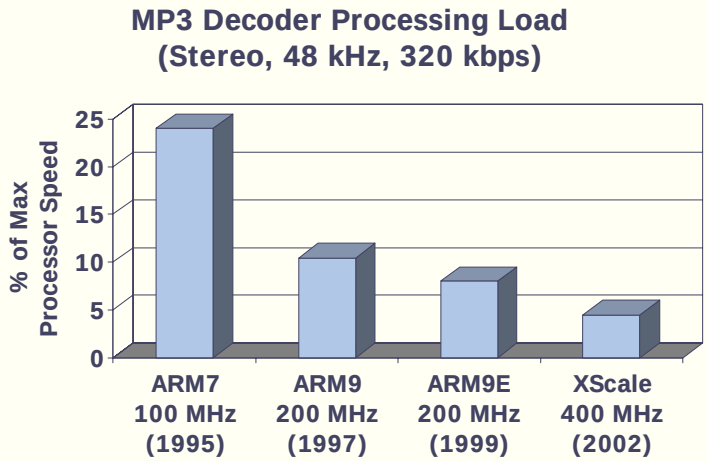
3. "Quality" consumer audio (home theater, ...)
   - Differentiate via audio features
   - High quality
   - Maximize flexibility


source: Hifi.com

Flexibility vs. Efficiency

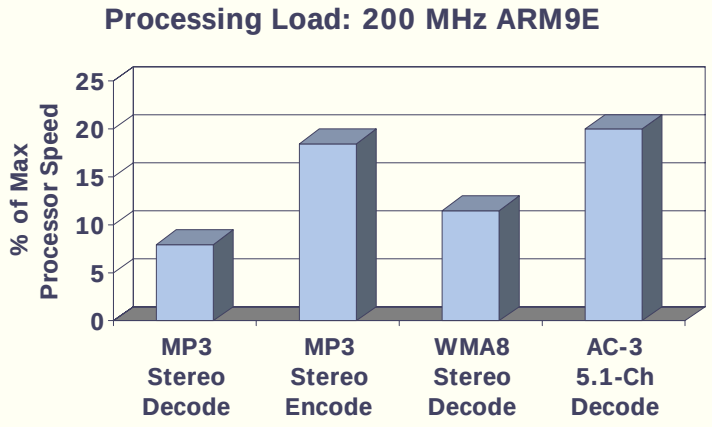


Audio Processing Gets Easier



Sources: *Digital Audio Codecs*, ARM Ltd. 2001
and BDTI estimates

Plenty of Headroom



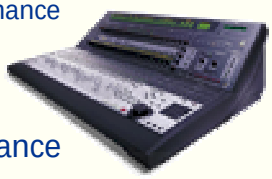
Source: *Digital Audio Codecs*, ARM Ltd. 2001

General-Purpose Processors, Software Ascendant

"Do I really need a shrimp peeler?"

PCs, CPUs Taking Over the Studio

As audio gets easier, less need for special hardware
- PC CPUs offer strong signal-processing performance
- Leverage PC performance increases, volume
- DSPs less important; little vendor focus
- Fewer custom processors



But PCs are not ideal for recording, performance
- "Blue screen of death" is unacceptable
- Latency is a problem
- Sound engineer's job doesn't necessarily become easier

Key consequences
- Studio gets cheaper, smaller
- More software, less hardware
- More machine, less man
- A new set of IT-like hassles for users

source: DigiDesign

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GPPs Rule "Convenience" Audio

Processors are cheap; why use special hardware?

Convergence drives GPP preference
- GPPs already present/preferred for other functionality
- System designers differentiate via non-audio features

Compression and numeric considerations favor GPPs

GPPs often encapsulated in an ASSP
- Stable, high-volume → "system-on-a-chip"
  - DANGER: New technology can upset stable applications
- ASSPs often contain multiple cores, accelerators, ...
- ASSP vs. "generic" processor boundary is blurring

Key drawback: dynamic features can cause problems

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Software Is King Everywhere

DSPs thrive in "quality" consumer audio
- Insufficient volume, stability to justify ASSPs or ASICs
- Differentiation achieved via custom algorithms
  - Need strong support for custom audio software development
  - Off-the-shelf implementations of required algorithms preferred

ASICs become less relevant
- ASIC design takes years; markets change in months
- Huge volumes needed to cover design, mask costs
  - Can one manufacturer sell 1-2 MM units?
  - Possible solution: the 486SX approach
    - Design chip for high-end apps; disable features for low-end apps
    - Transistors are cheap!

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Audio Signal Processing Becoming Ubiquitous

"Everywhere there's a pair of ears, there's an opportunity for digital audio."

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Convergence: More Than Buzzword

Faster processors enable inexpensive combination of audio capabilities with other functions

- Added to devices like phones, PDAs, and digital still cameras
- Enabling new products like A/V jukeboxes and media servers

"Personal content" changes everything

- Access audio anytime, anywhere, any way
- Content freed from hardware
- System model becomes more distributed, more complex
  - Transfer to portable device
  - Stream from content provider
  - Stream between devices

Consequences of Convergence

Algorithms, applications changing more rapidly

- Converged devices amplify instability problems
  - Example: unstable audio standards + unstable wireless standards
- Shift from mature to immature technology
  - Less predictability in evolution of the system
- Product design workload shifting to chip vendors

Conflicting system design goals

- Instability → flexible solutions (GPPs, DSPs, PC CPUs)
- High complexity → highly integrated, off-the-shelf solutions (ASSPs)
- Low prices → specialized solutions (ASICs, ASSPs)

What About "Quality" Audio?

High-end home theater and automotive audio applications

Moderate volumes → poor targets for ASSPs and ASICs

No graphical UI, OS, network stack, ... → less need for GPPs

Tough algorithms → DSP strengths

- Algorithms require much more power than those in "convenience" audio → DSP strengths
- Quiet environments → no fans → low power → DSP strength
- Differentiation in custom algorithms → DSP tools strengths
- Preference toward floating-point → DSP market position strength

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Higher Volumes and the Benefits of Competition

"Faster, better, *and* cheaper?"

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Lower Costs, Faster Innovation

Costs driven down, innovation accelerated due to volume and competition

- Inexpensive hardware, widely available software
  - Enable convergence of technologies
  - Enable acceptable prices
  - Enable easier entry into some markets
- Bigger, wider markets attract attention
  - Easier to get consumers interested
  - Easier to attract investment
- But litigation, regulation, and poor business models slow things down
  - Compression algorithm licensing structure is unwieldy
  - Legislation, industry back-room deals hinder innovation
  - Effective business models are essential but elusive

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Connectivity Becomes a Key Challenge

"It's not what you know, it's *who* you know."

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Expanding Options in Pro Audio…

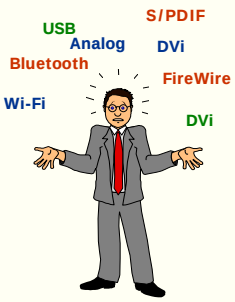
Many new options
- Riding the coat-tails of existing data standards like 1394, Ethernet, and ATM
- New standards and proprietary options
- Digital connections extend all the way to the mic!

Higher capacity
- Support new standards with higher data rates
- Fewer wires

Point-to-point wiring → audio networks
- Physical setup → virtual setup
- Solutions like mLAN key for managing the mess

…And in Consumer Audio

Connectivity trends mirror pro audio
- Many options
- Higher capacities
- Networked audio



Many issues remain unresolved
- Network topology is changing
  - Today: PC plays central role
  - Tomorrow: ???
- Network setup is too difficult for consumers
  - Device discovery and control not solved
- Digital rights management not solved

Home theater systems gain connections to other digital audio devices, PCs, and content providers

A New Set of Headaches

New options solve some problems, but introduce others
- Fewer wires, but more layers to worry about

Connectivity processing becomes increasingly important
- Sample rate conversion
  - Example: 44.1 kHz → 48 kHz
- Transcoding
  - Example: AAC → MP3
- Encryption and digital rights management
  - Example: WMA9 source encryption → 5C network encryption
- Where is all this decoding and decryption done?


source: DigiDesign

Resolving the confusion is crucial to many products
- Connectivity is crucial for personal-content model

Conclusions

"May you live in interesting times."

Conclusions

- We're entering a new era of ubiquitous digital audio!
  - Convergence is real and growing
  - Personal content will be a key driver
- Emphasis shifting from specialized hardware to software
  - PCs will dominate the studio... like it or not
  - Embedded GPPs will dominate convergence products
  - DSPs will thrive in some niches
- Connectivity enables new capabilities, but brings new challenges
  - Processor-based ASSPs help address integration challenges
- The "ecosystem" is all-important
  - A player without a content source is like a train without tracks
  - Business models and rights management present critical unsolved problems

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For More Information...
www.BDTI.com

- *DSP Insider* newsletter
- *Pocket Guide to Processors for DSP*
- White papers on processor architectures and benchmarking
- Audio compression algorithm implementation processor resource-use data
- BDTImark2000™ benchmark scores
- Article reprints on DSP-oriented processors and applications
- comp.dsp FAQ

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