Multicore and Digital Signal Processing (DSP)

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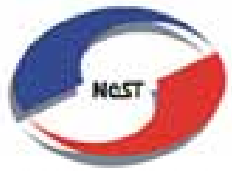


Outline

- A quick look at the embedded market
- Overview of DSP applications and market trends
- Multi core benefits and challenges
- Architecture approaches
- Case studies

Quick look at the market

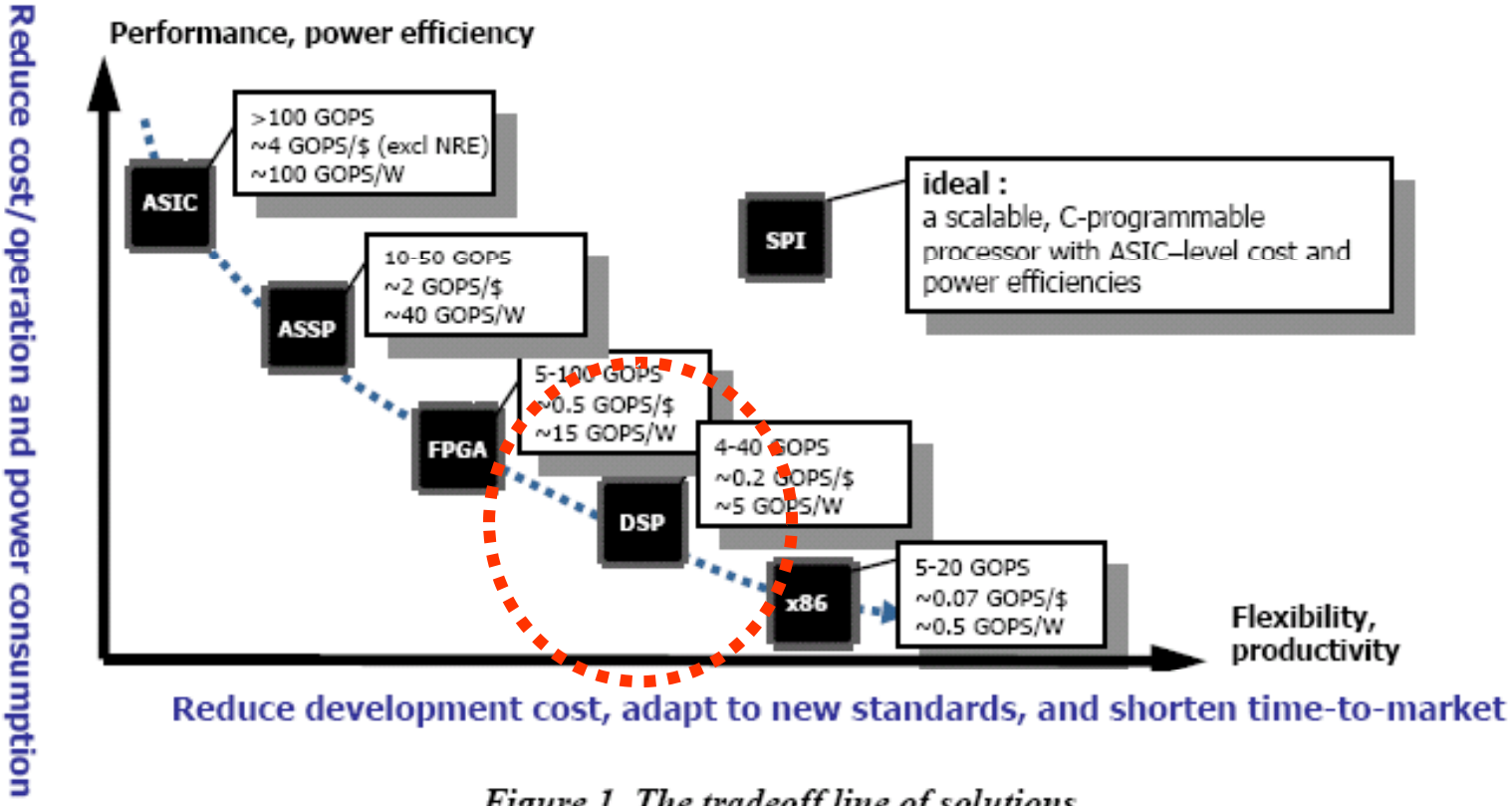


Figure 1. The tradeoff line of solutions

* *Courtesy – Stream Processors Inc.*

Why DSPs ?

- ASICs provide great performance but application bounded and very high development costs
- ASSPs can’t benefit from algorithmic improvements and new standards
- FPGS requires complex hardware oriented programming
- DSP’s provide flexible programmability with high performance
  - The question is “Is that enough ?”

DSP Applications

- Market demand for DSP based products are exploding
- DSP Applications are traditionally notorious for CPU intensive operations
- Video, Audio, Speech being major applications in the consumer world
- Market trend show high integration of multimedia capabilities to every consumer device
  - Medial players, cell phones etc.
- Performance, power efficiency being the major concerns

DSP Redefined !

- DSP is not Digital Signal Processing, it is more like programming the DSP Processors !

- There is a shift in the market from considering the high-performance, low power to enable scalable, programmable and configurable DSP cores

DSPs - Market

- In 2006 , General purpose DSP market is US$ 7.6 billion and Embedded DSP market is US$ 14.3 billion
- General purpose DSP market is lead by major players like TI, Analog Devices and Freescale
  - Dominated by communication applications with cellular being the biggest
- Embedded DSP market is served by more than 100 chip vendors
  - Major players are Qualcomm, Broadcom, Infineon and Marvell
  - Solutions in the form of ASSPs, ASICs, FPGAs, RISC/DSP combos, DSP Enhanced processors etc.
  - Major applications are set top boxes, DVD players, A/V receivers, MP3 players and digital still cameras.
- Market shows steady growth with applciations in GbE LAN PHYs, WLAN, WiMAX and Bluetooth basebands, as well as DSL and cable modems.
- New DSP-centric markets like DAB and HDTV is emerging

Demanding applications – Example 1

- Video surveillance
  - Driven to provide better actionable information at lower total costs, physical security companies are deploying new technology in the areas of content analysis and management. With the acceptance of IP, managing bandwidth and storage resources have become key, while the digital networked formats provide much greater degrees of freedom than was possible with the previous generation of analog CCTV-based solutions.

- Features:
  - Multi-codec / multi-stream / multi-format, e.g. simultaneous MJPEG, MPEG-4, H.264 in arbitrary resolutions, framerates and quality levels – also dynamically adjusted based on classification
  - Preprocessing, e.g. de-interlacing and image stabilization
  - Display processing, e.g. scaling, tiling and OSD
  - Event-based actions, e.g. robust motion detection based on classification
  - Authentication and encryption, watermarking
  - Intelligent video content analysis, e.g. tracking and classification

Demanding applications – Example 2

- HD Video conferencing
  - Manufacturers of video conferencing equipment have traditionally used DSPs since much of the secret sauce is in the encoder and rate control mechanisms. With the introduction of high-definition, H.264, and an emerging array of more advanced techniques to deliver a lifelike experience, processing requirements are skyrocketing.

- Features:
  - increasing resolution and framerate, e.g. 1920x1080p or 1280x720p
  - Content-adaptive compression, e.g. spending more bits on faces, gestures
  - Virtual camera/eye viewpoints
  - Advanced rate control mechanisms
  - I/O processing, e.g. alpha blending, high-quality scaling, and presentation transitions

Why Multi core ?

- Modern day media, imaging and signal processing applications insatiable appetite for computing power
- Increase in processor performance due to increase in clock frequency is coming to a halt
- Only choice of new processor designs is to incorporate multiple cores to facilitate parallel processing

Mult icore benefits

- Scalable performance and power
  - High performance for peak computing loads
  - Low active and leakage power with light computing loads
  - Turn off cores not needed at any moment
- Multiple loosely-related or independent tasks for highly parallelizable execution
  - Specialized functional cores optimized for maximum performance at lower power
- Several simple cores much less design effort than complex, high performance uni-processor
- System hierarchy keeps most communication local
  - Reduces routing congestion and power

Challenges of Multi core design

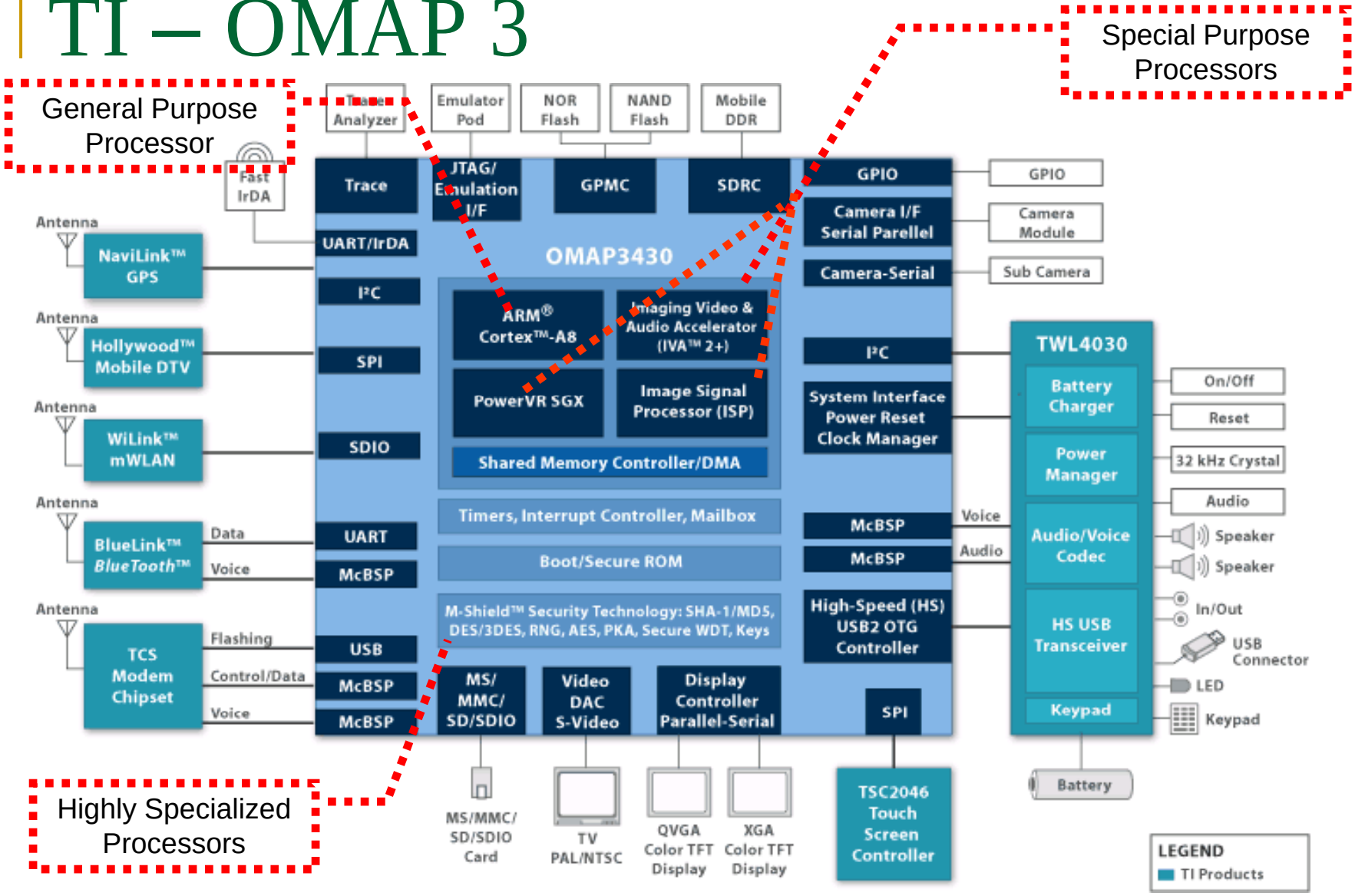
- Application efficiency may suffer when dividing one problem across processors
- OS changes required to schedule processors and manage power states
- Complexity & cost of memory system: If memory can't keep up, under utilizing the multiple cores
  - Large caches and on-board memories
  - High-bandwidth, low latency main memory
  - Extra bus protocol and traffic for maintaining cache coherence
- Complexity & cost of software development
  - Parallel applications and operating systems are more difficult to program
  - Software development tools are lacking for parallel programming

Multicore Architecture approaches

- Heterogeneous architecture
  - Different tasks running on each core (E.g. RTOS on one core, where audio processing on other core)
  - Each core may be optimized for specific applications
  - E.g. TI OMAP, DaVinci
- Homogeneous model
  - Identical cores and only data processed by each core is different
  - Much suitable for a multi-channel application
  - E.g. Analog Devices ADSP-BF561

Case studies

TI – OMAP 3

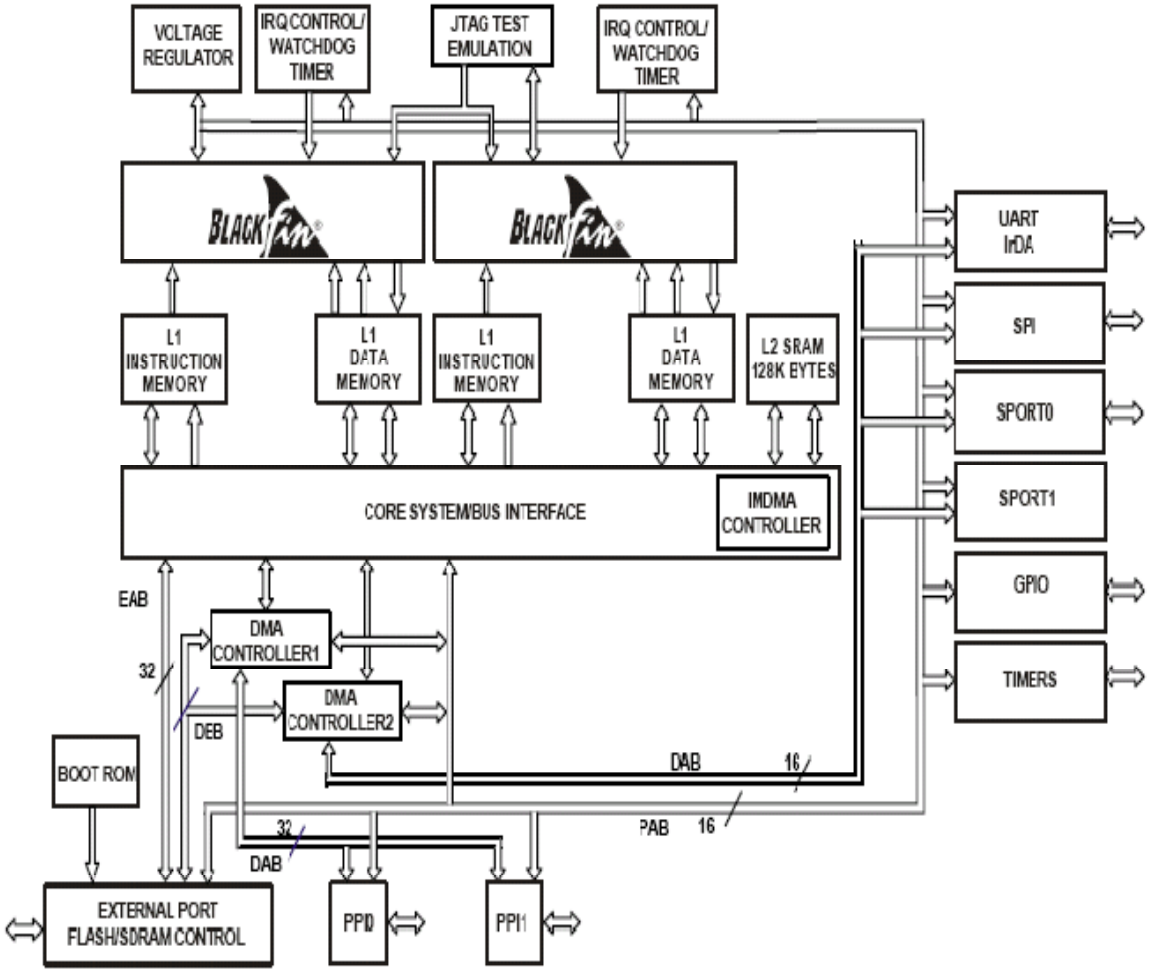


Optimal processing core for each task

OMAP Architecture benefits

- Simultaneous parallel processing at lower power
- Specialized cores for efficient processing
  - HSPs are 10 ~ 20 x more energy efficient than GPPs for many algorithms
  - SPPs fill gap in power and performance between HSPs and GPPs
  - Cores can be powered off when usage is not required
- Flicker free video and click-free audio during multi tasking

Analog Devices – BF561



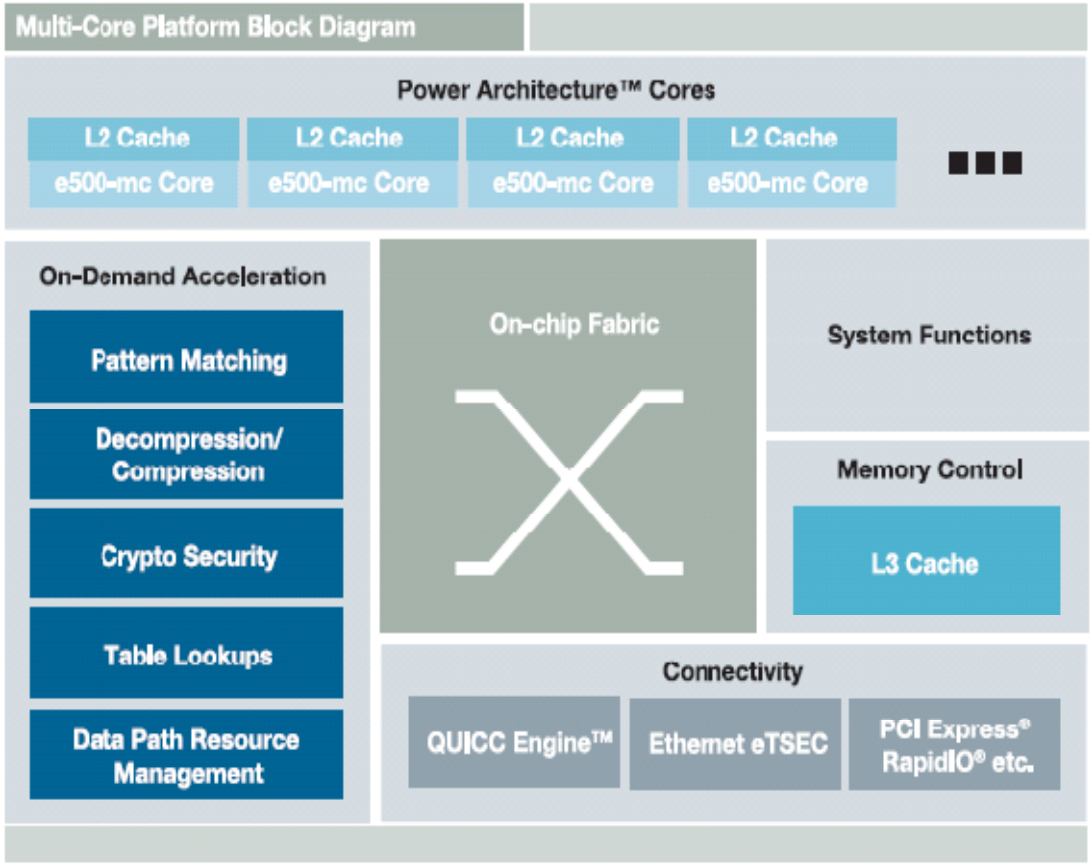
Features

- Dual Blackfin cores with each core capable of 600MHz
- Large On-Chip Memory of 328 KBytes – arranged as individual L1 memory systems for each core plus a shared L2 memory space.
- Application Tuned Peripherals provide glueless connectivity to a variety of audio/video converters and general-purpose ADCs/DACs.

Target applications

- Digital Still Cameras
- Digital Video Cameras
- Portable Media Players
- Digital Video Recorders
- Set Top Boxes
- Consumer Multimedia
- Automotive Vision Systems
- Broadband Wireless Systems

Freescale – Multi core platform

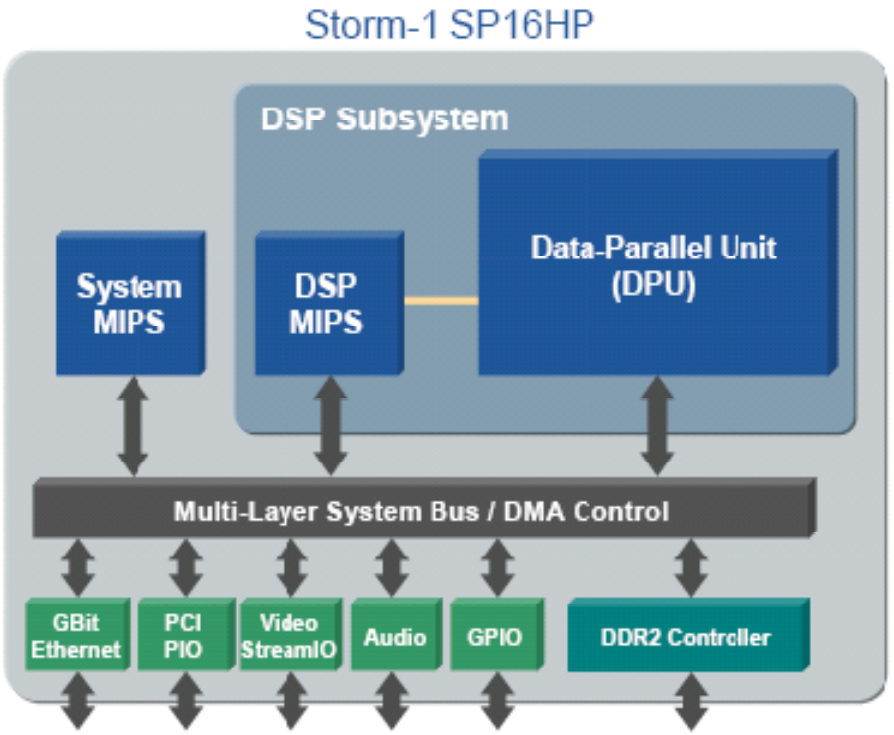


- Features
  - Scalable on-chip fabric for connectivity among cores (up to 32 cores)
  - Enhanced power architecture
  - High performance acceleration blocks
  - Cache hierarchy

- Products are expected based on this platform by late 2008

Emerging players – E.g. SPI

- System MIPS core
  - Manages I/O, runs OS (e.g. Linux)
- DSP MIPS core
  - Runs main DSP application threads, runs RTOS (e.g. Nucleus)
  - Makes kernel function calls to the DPU
- Data-Parallel Unit (DPU)
  - Processes kernels
  - Stream Processor execution model
  - Scales with number of lanes
- Memory and I/O Subsystem



Conclusion

- Industry is entering a new era of ubiquitous media availability
- Real time media applications are computationally demanding requiring billions of operations per second
- Traditional processors can not meet the challenge
- Fixed function hardware is also insufficient due to their inflexibility and high cost

- The industry agrees on :
  - Only viable way is parallel processing
  - Multi core processors will dominate the scene
  - Bandwidth challenges and programming easiness still remains as challenges

Thank you…