Linux as the Conductor: Driving Pre-Compiled Audio DSP Kernels on C7x for Real-Time Processing

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Agenda

- Problem Statement
- Proposed Solution
- Software Architecture
- Linux-Controlled Multi-channel Audio Offload Example
- ARM vs C7x + ARM: Real-Time Performance Comparison
- Current Status and Next Steps
- Q&A

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Problem Statement

❖ **Inefficient CPU Usage**
ARM (Linux) struggles with compute-heavy real-time workloads, leading to high CPU load.

❖ **Complex Linux ↔ DSP Integration**
Interfacing between Linux and DSP involves custom IPC, memory handling, and synchronization complexity.

❖ **Poor Scalability**
Systems become CPU-bound, limiting support for multi-channel and advanced processing pipelines.

❖ **Inefficient Data Movement**
Multiple memory copies and unmanaged buffers increase latency and overhead.

❖ **Underutilization of DSP Resources**
DSP cores exist but remain underused due to integration difficulty and lack of simple workflows.s

Existing solutions usually trade Simplicity for performance; The problem is not is dsp availability for compute – It's making DSP compute usable for Linux in simpler way.

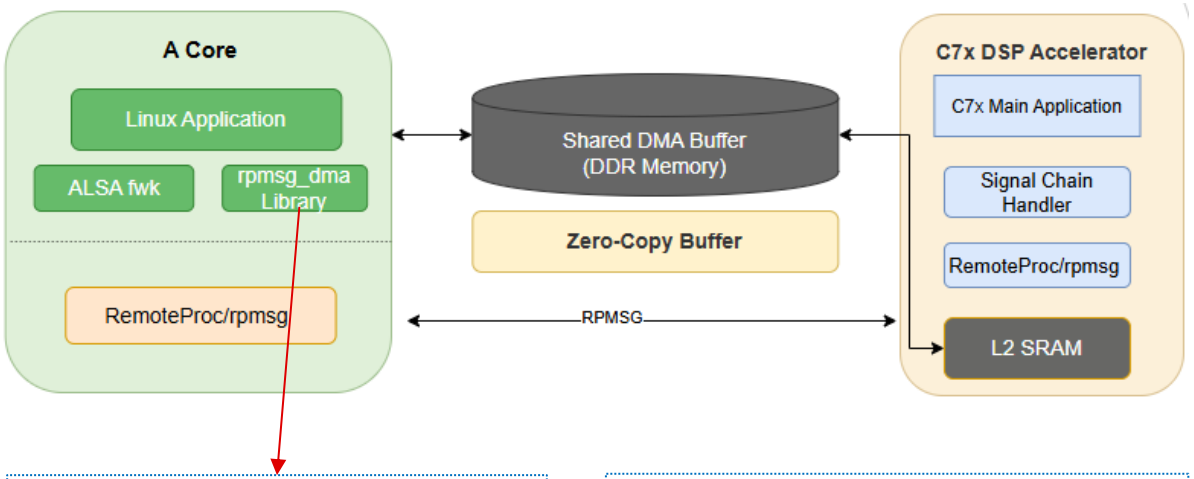
Proposed Solution: Linux Controls, DSP accelerates

Core Idea

- Keep Linux as the system orchestrator
- Use DSP as a compute accelerator
- Separate control plans(Linux) and data plane (shared memory)

Key Advantage

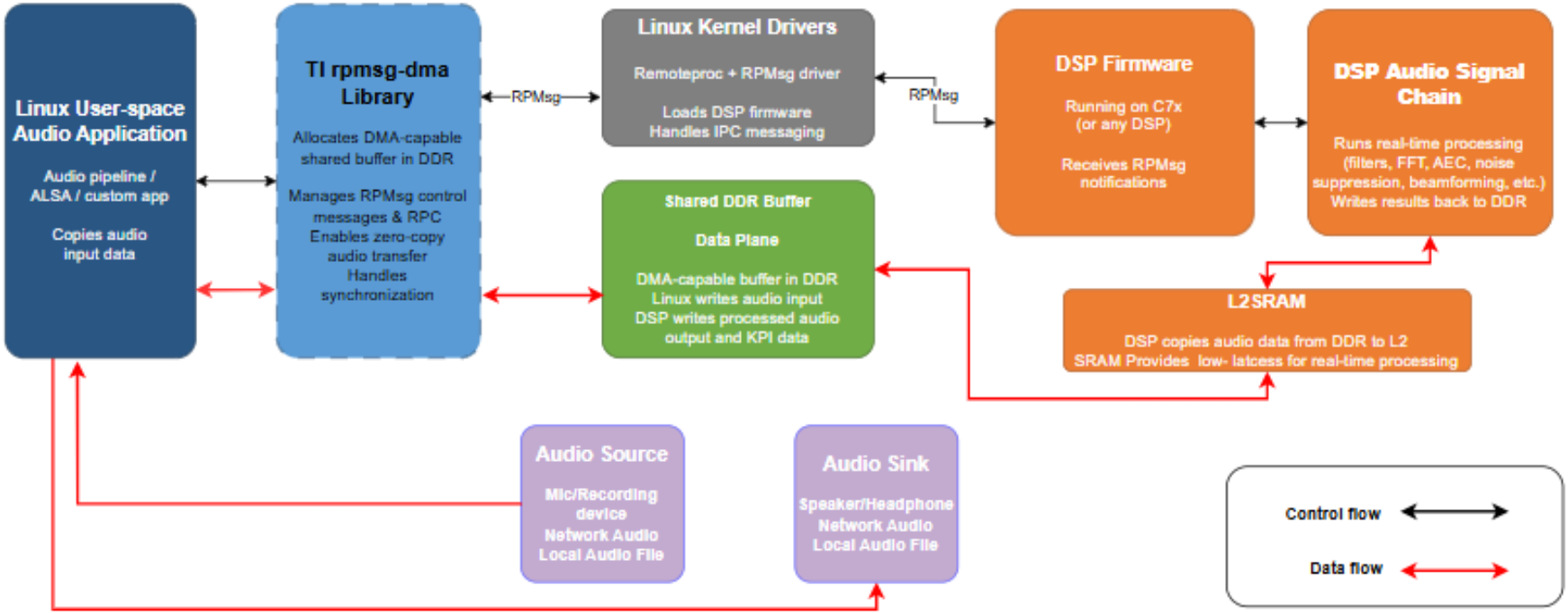
- No need to move application logic from Linux
- Reuse pre-built DSP kernels
- Zero-copy buffer model (no redundant ARM+DSP copies)
- Deterministic, low-latency processing
- Clean, reusable heterogeneous compute pattern



- Manages ARM → DSP communication (RPMsg/RPC)
- Allocates and manages shared DMA buffers (DDR)
- Handles synchronization & low-latency messaging

- Linux writes data → shared DMA buffer (DDR)
- Notifies DSP via RPMsg
- DSP copies data → L2 SRAM
- DSP executes signal chain
- Results/KPI written back → shared buffer
- DSP notifies Linux

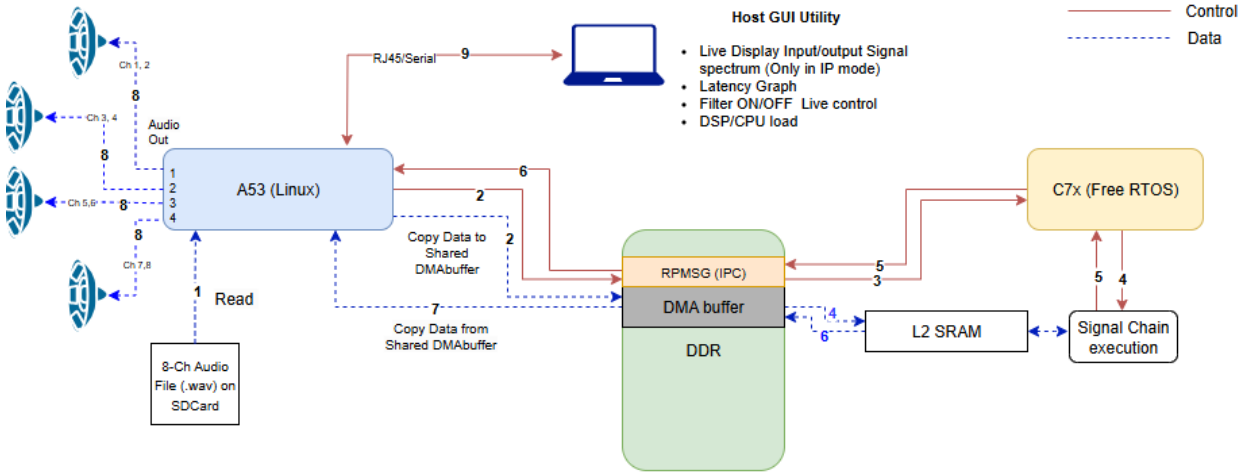
Software Architecture



Linux-Controlled Multi-channel Audio Offload Example

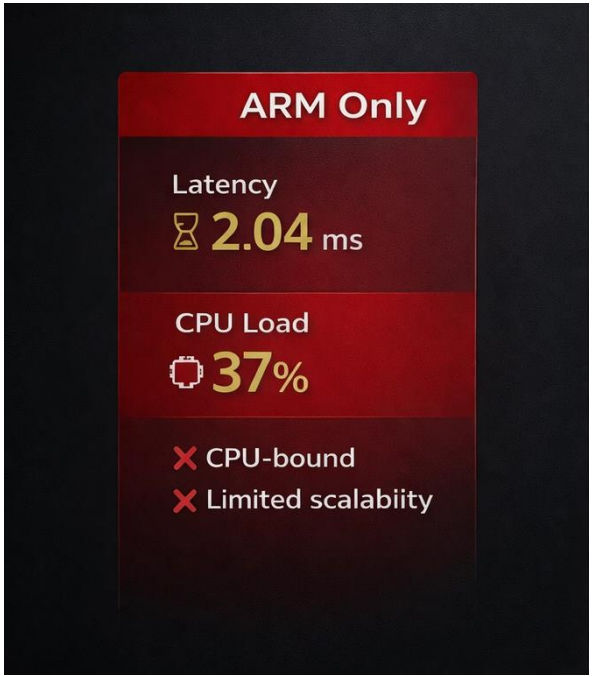
What is AM62D?

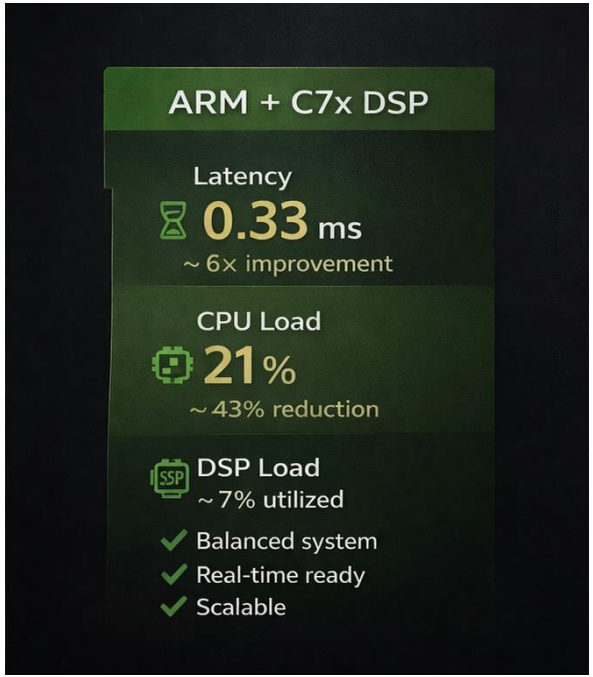
- Sitara AM62D Audio & Signal Processing SoC
- Expandable hardware for premium audio
- Quad Cortex-A53 running Linux
- C7x vector DSP for signal processing
- R5F cores for real-time control
- McASP interfaces for multichannel audio

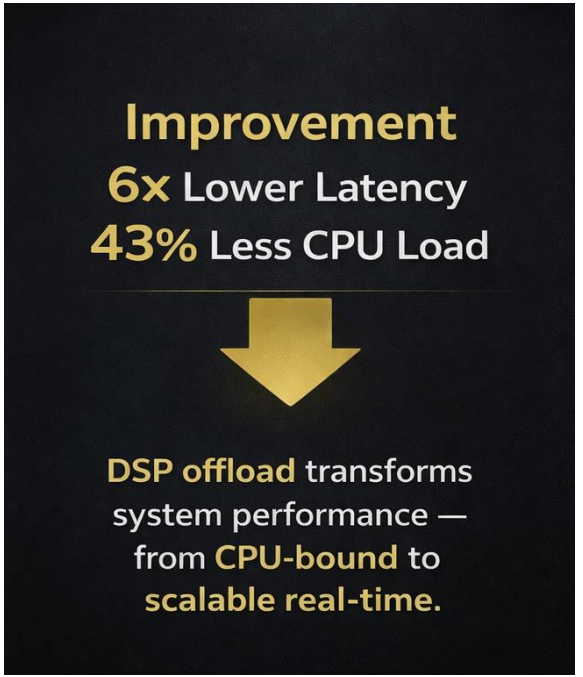


Signal chain execution on DSP

ARM vs C7x + ARM: Real-Time Performance Comparison







Signal chains are not strictly identical; results reflect practical system-level improvements with DSP offload.
Illustrative visuals generated using AI tools; performance data is based on measured results.

Current Status and Plan Ahead

Current Status

- Established Linux ↔ DSP offload architecture (ARM + C7x)
- Developed rpmsg-dma based communication framework
- Implemented shared DDR buffer model with zero-copy data flow
- Integrated with ALSA (Linux audio pipeline support)
- Achieved end-to-end real-time multichannel processing pipeline
- DSP execution optimized using L2 SRAM (low latency, deterministic)
- Validated with streaming and compute workloads

Next Steps

- Integrate with PipeWire (modern Linux audio stack)
- Extend to DSP + AI hybrid pipelines (feature extraction + inference)
- Enhance scalability (higher channels, bandwidth, workloads)
- Improve buffering & scheduling (multi-buffering, pipelining)
- Add profiling, tracing, and latency measurement tools

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Q&A

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