Multi-Channel Noise/Echo Reduction in PulseAudio on Embedded Linux

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May 2013

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Outline

- Communication device
- Echo cancellation
- Multi-channel noise/echo reduction
- PulseAudio architecture
- Results

- TI OMAP3 based (DM3730)
  ARM Cortex-A8, 1 GHz, 512 MB RAM
- < 10W, Power over Ethernet (PoE)

- Two audio codecs
  - 4-channel mic array
  - handset, headset

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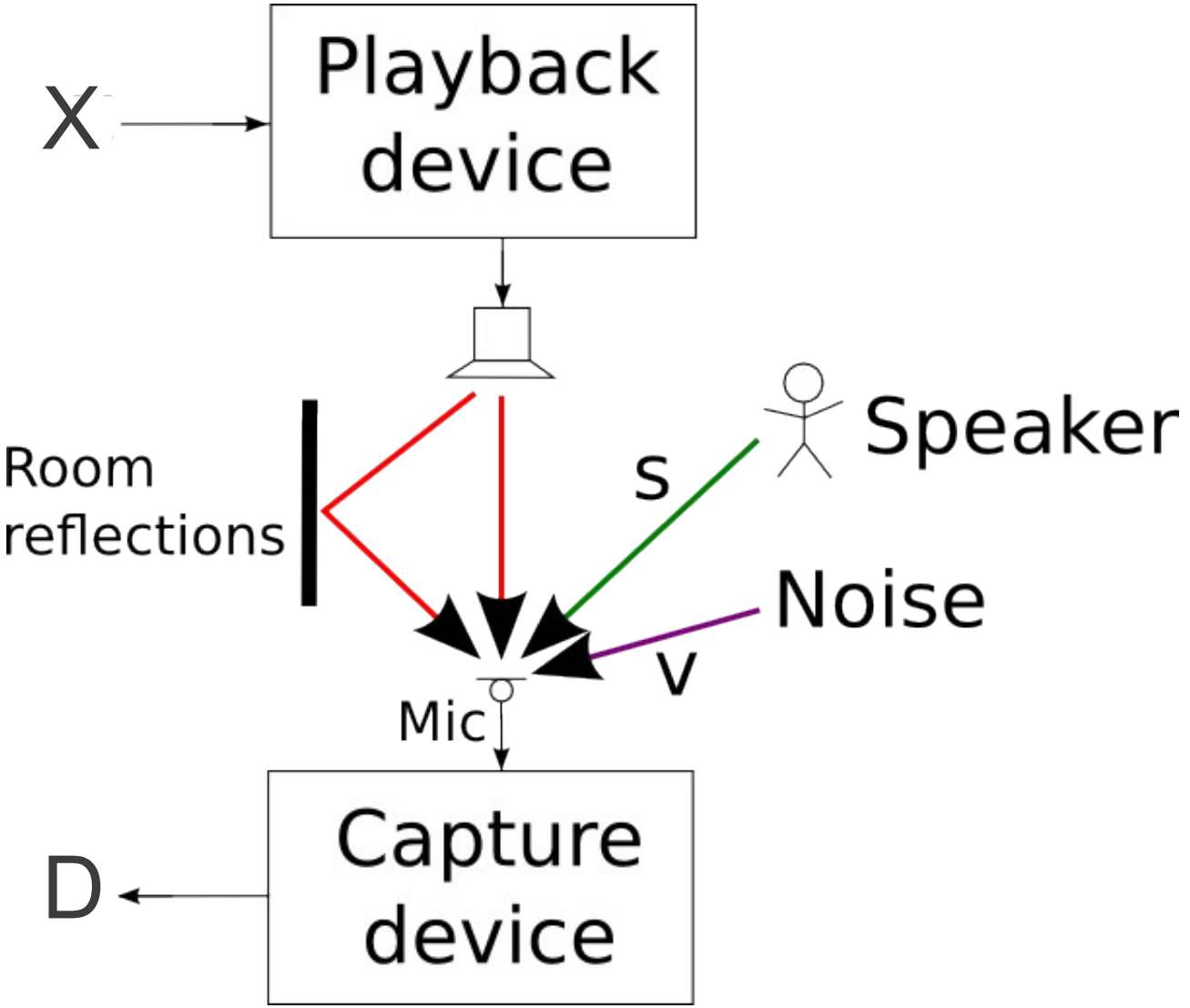
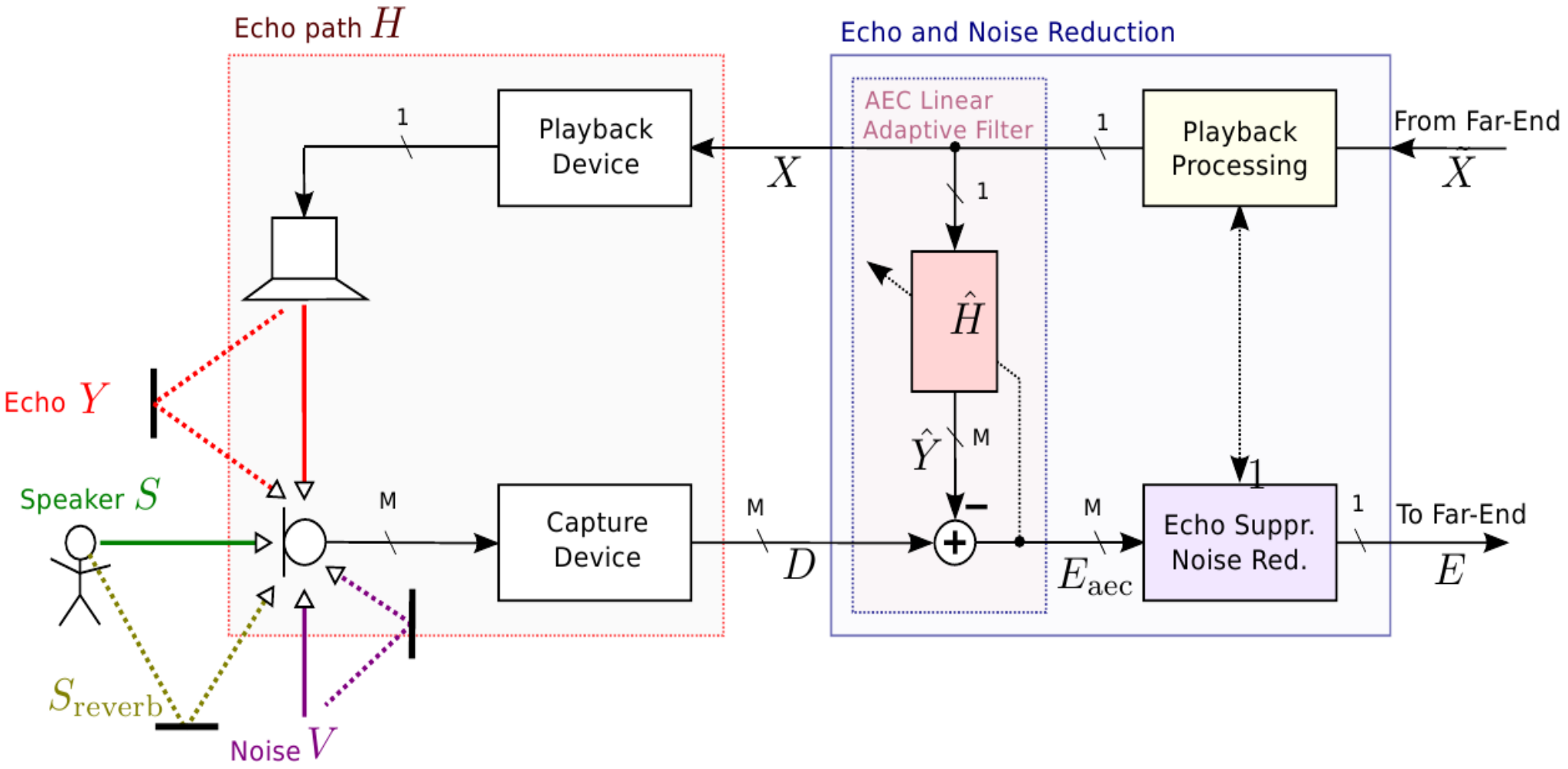
Digital MEMS Microphones

Problem: Mic = Target Speaker + Echo + Noise



Acoustic Echo and Noise Reduction



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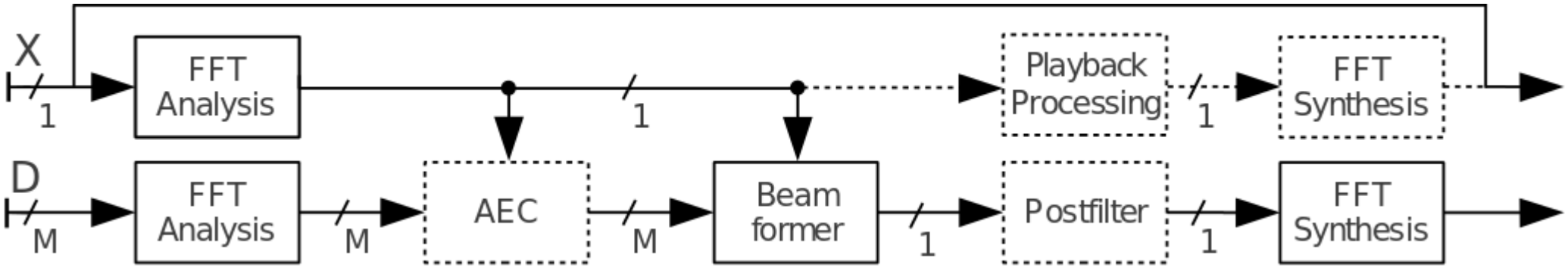
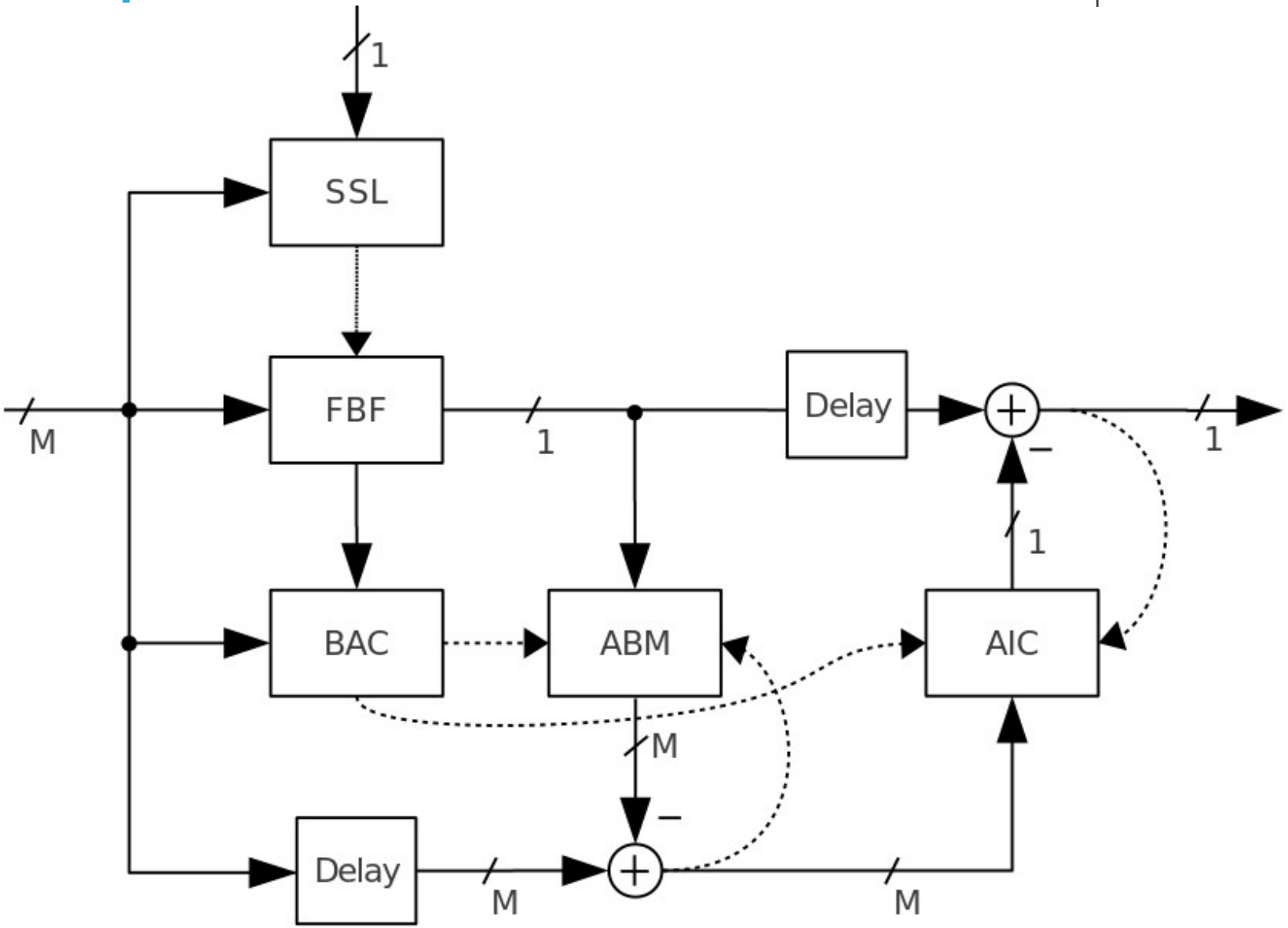
Multi-Channel Audio Processing



M=4 ... # Microphones
D ... Microphone Signal
X ... Playback Signal

Adaptive Beamformer

BAC ... Beamformer Adaption Control
ABM ... Adaptive Blocking Matrix
AIC ... Adaptive Interference Canceller



SSL ... Sound Source Localization
FBF ... Fixed Beam Former

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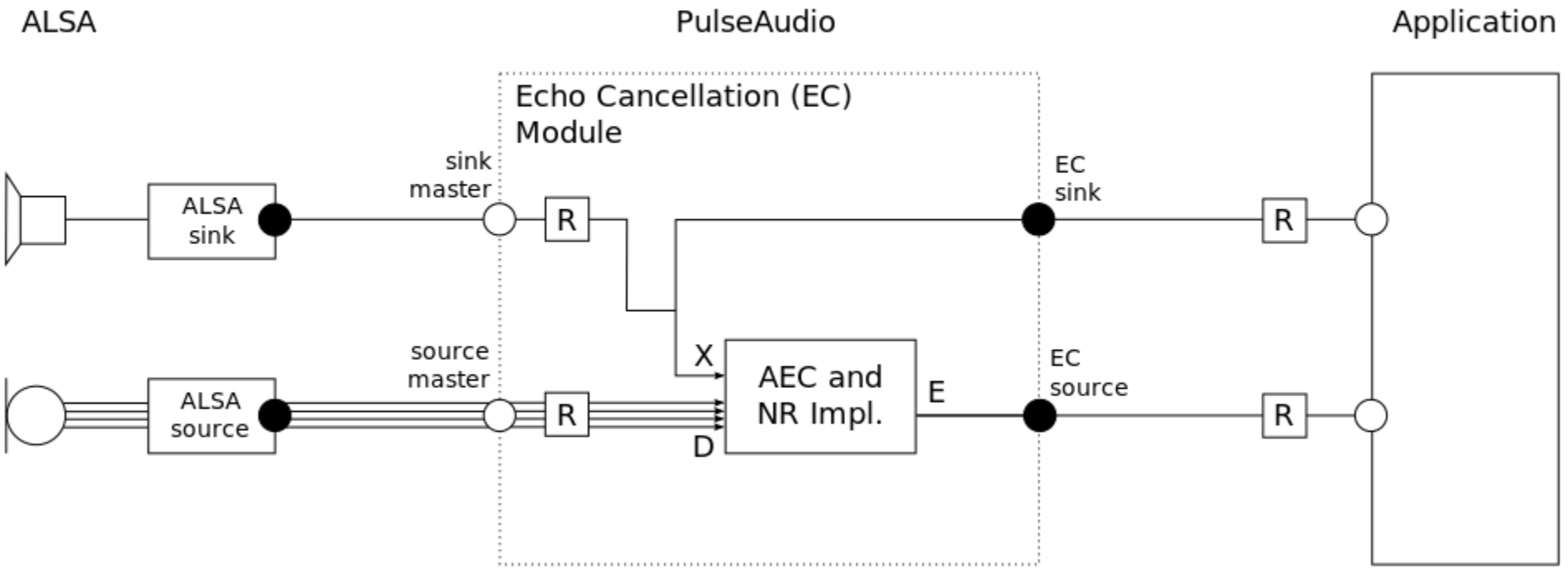
PulseAudio Echo Cancellation



R ... Resampling
NR ... Noise Reduction

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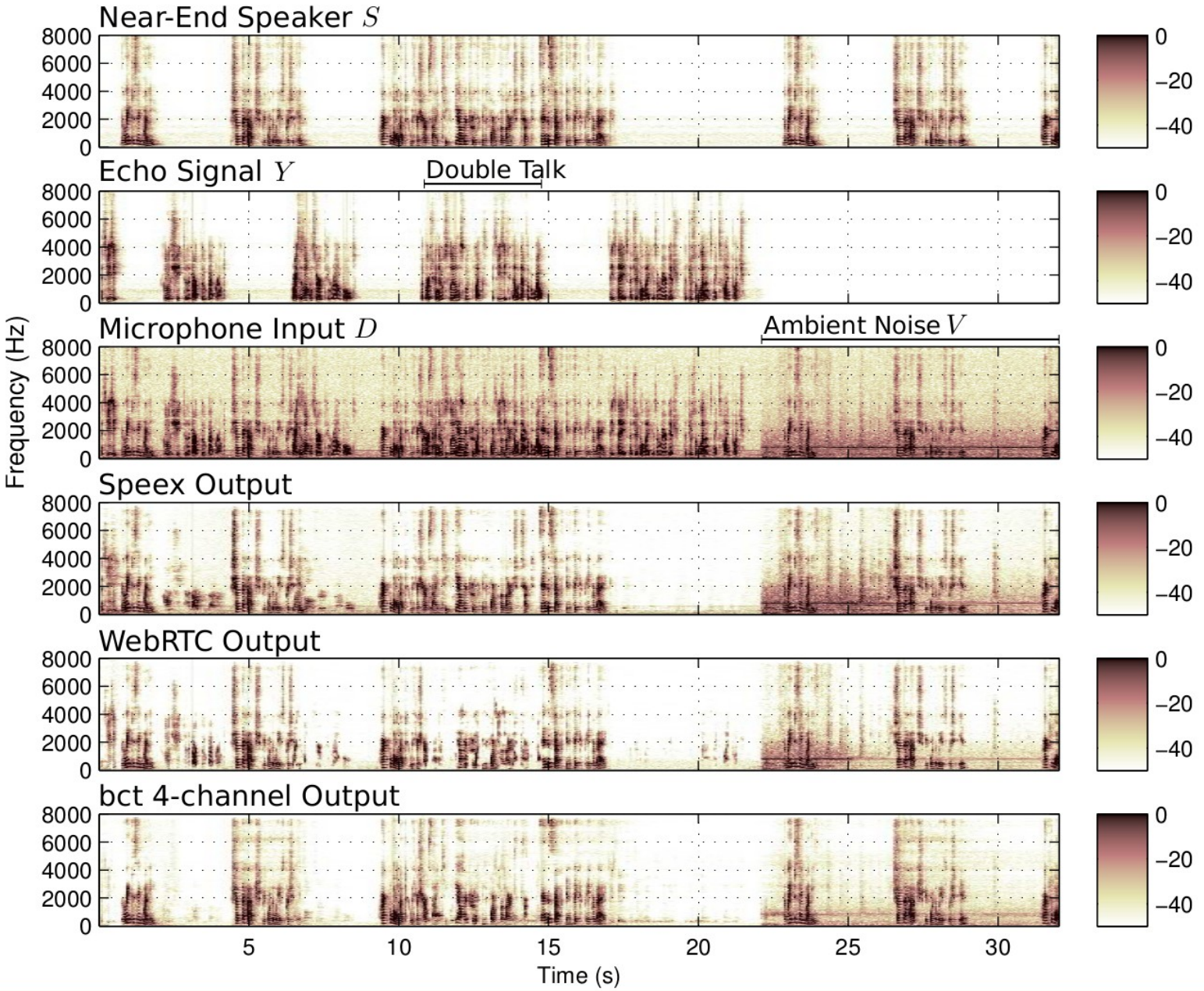
PulseAudio Contributions

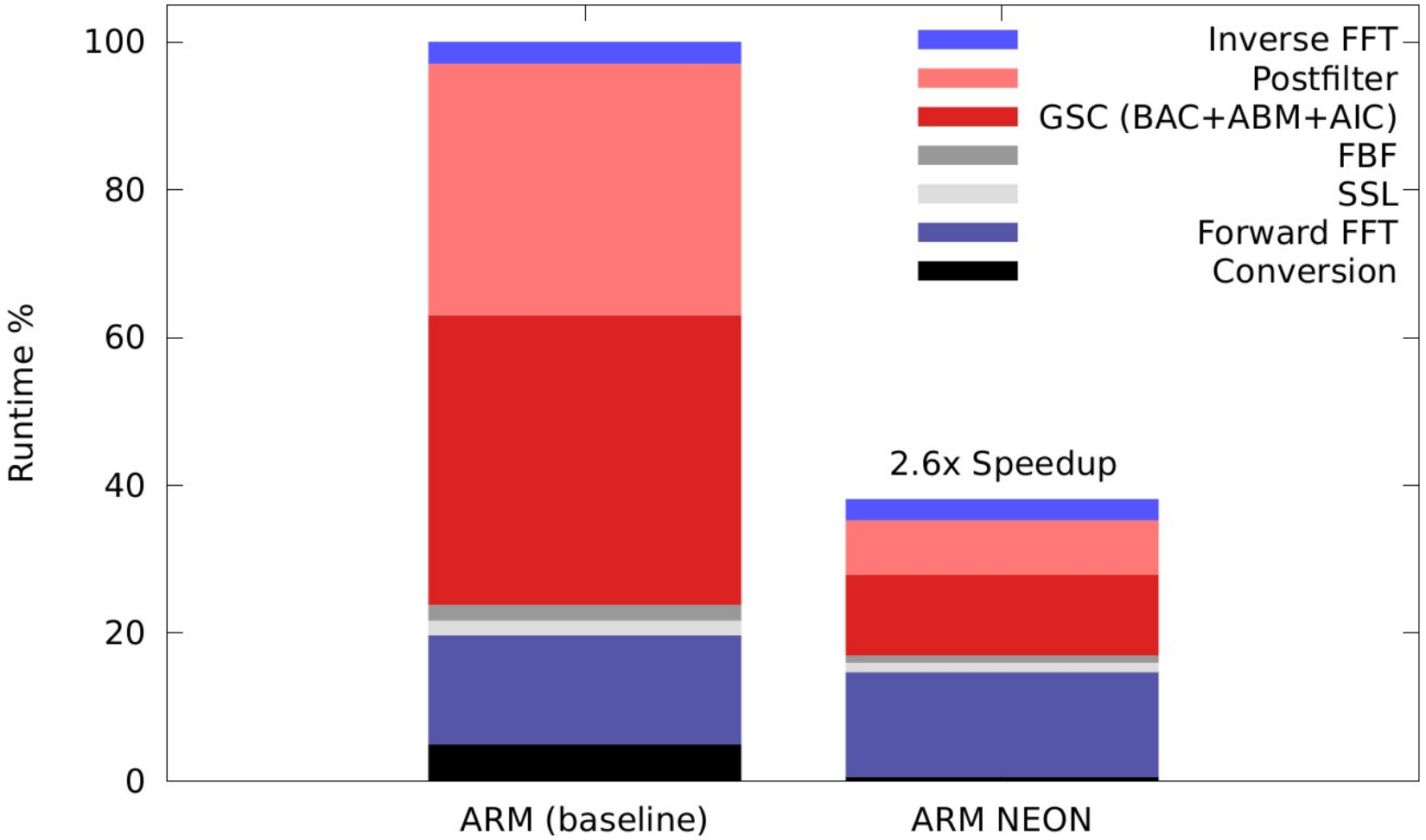
During 3.0 and 4.0 development cycle

- ARM NEON optimizations (remapping, sample conversion, mixing)
- Resampling improvements
- Support for multi-channel EC with different input/output sample specs
- module-remap-source
- Single and multi-channel AEC Implementations (not yet public)

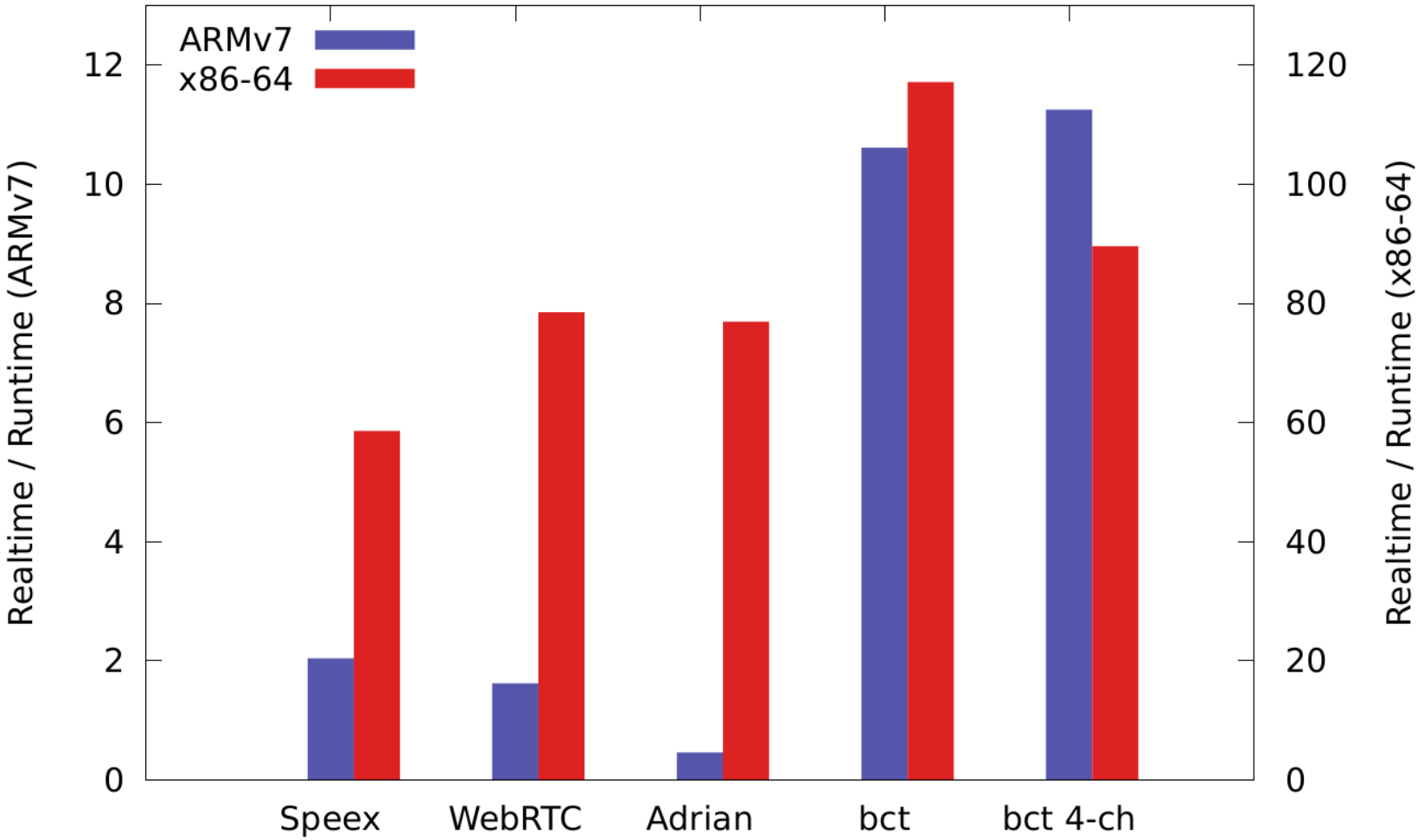
Noise/Echo Reduction Results



Runtime Components and Optimization



Runtime Comparison



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Summary

- Multi-channel audio processing on embedded Linux
- PulseAudio provides noise/echo reduction to application
- Separation of concerns:
  Hardware abstraction, signal processing, application
- Optimization required (algorithm design, implementation layer)

Questions?

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