

Digital Signal Processing for Music

Part 20: Reverb

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Intro

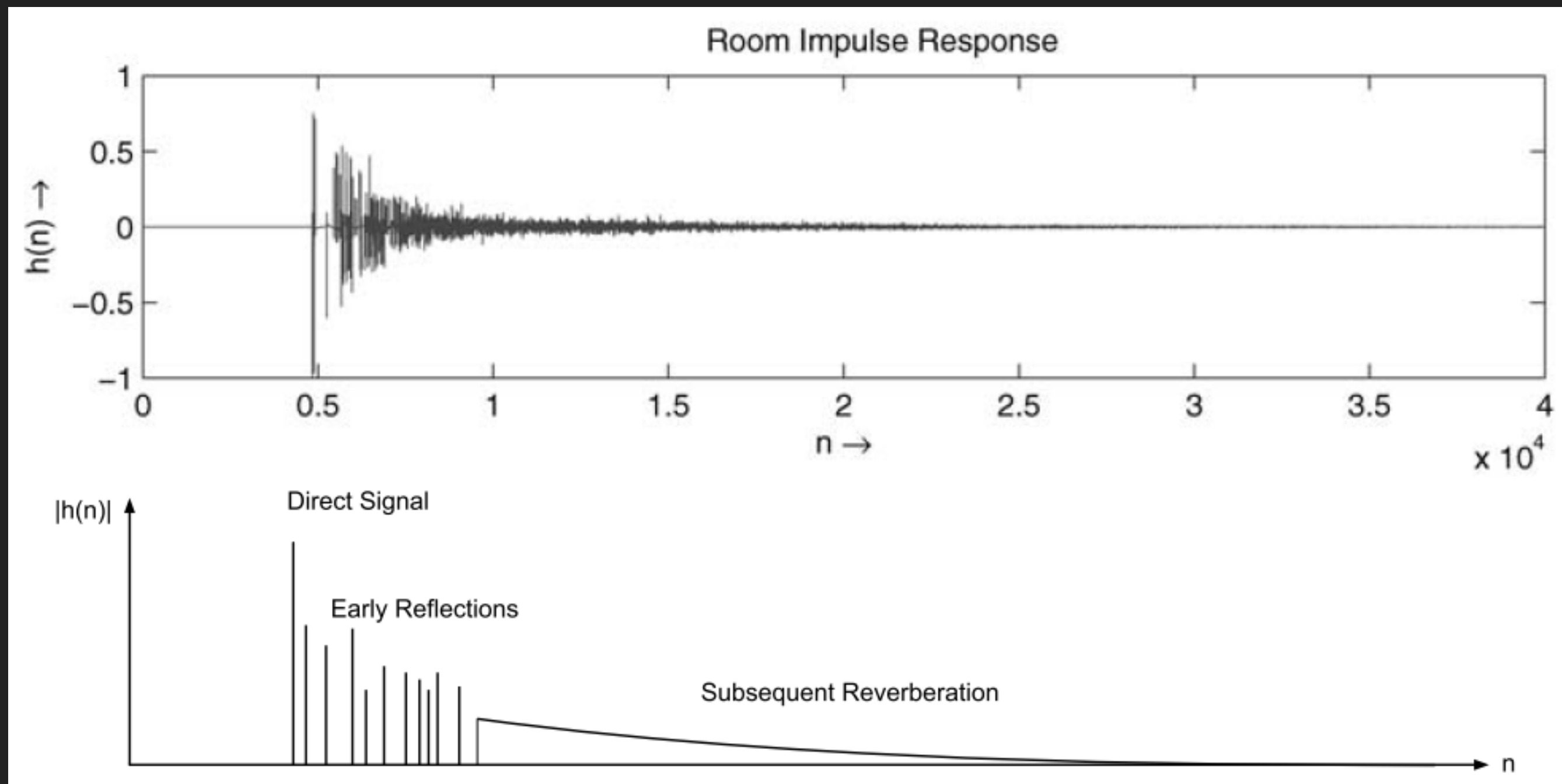
»» Idea:

- »» Artificially generate the impression of envelopment and reverberation
- »» Possibly allow to modify specific characteristics of the "modeled" room

»» Approaches

- »» (Digital) parametric reverberation (predecessors: spring, plate, room, ...)
- »» Fast convolution

Artificial Reverberation: Room Impulse Response



Room Impulse Response: Properties

Room impulse response is sum of (filtered and delayed) reflections

»» Properties

- »» Level decrease is approximately linear
- »» Density of reflections increases

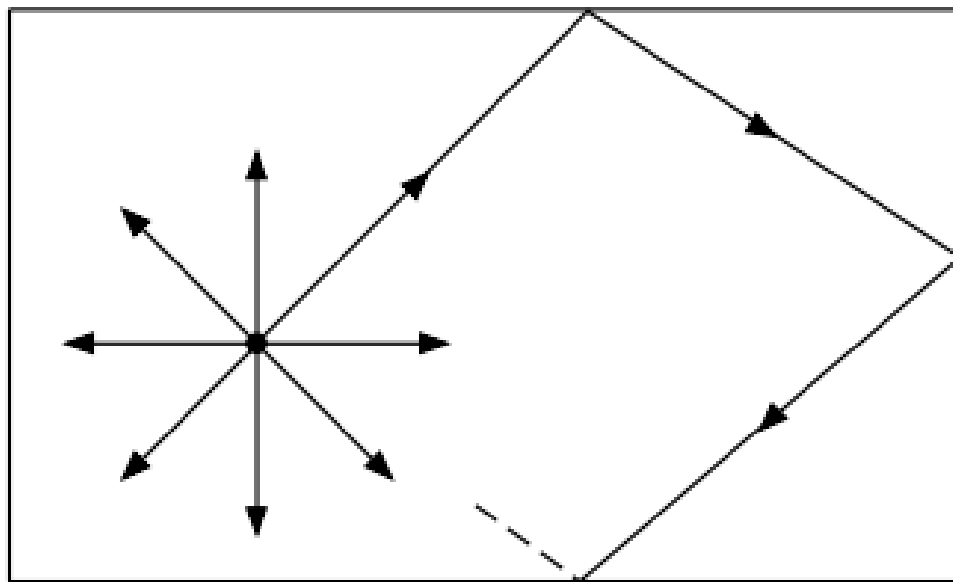
»» Description

- »» Reverberation time: time in seconds for a level decrease of 60 dB
- »» Depends mainly on
 - »» Room *volume*
 - »» Surface *area*
 - »» Surface *absorption*
- »» Sabine:

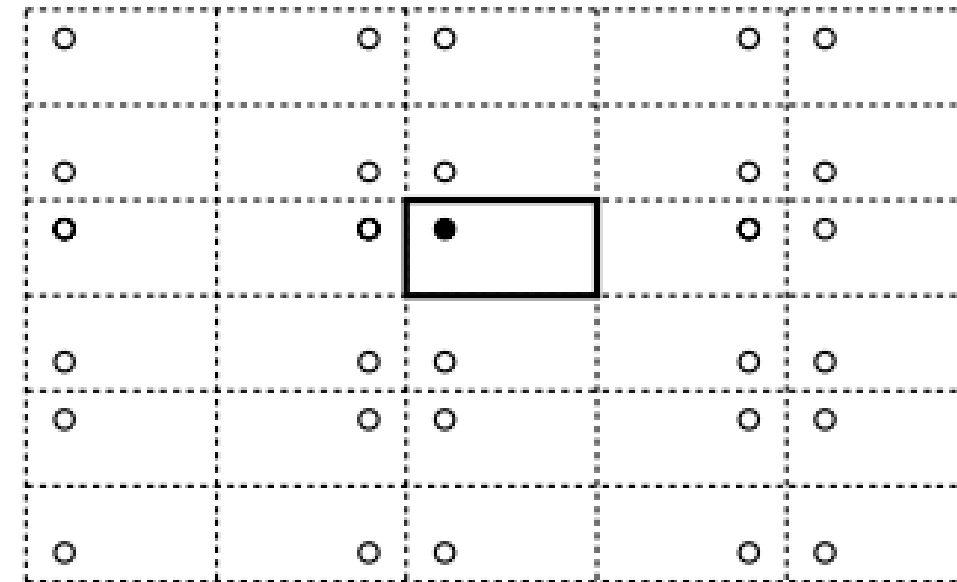
$$T_{RT} = 0.163\text{m}^{-1} \frac{V}{\sum \alpha_n \cdot S_n}$$

Room Simulation

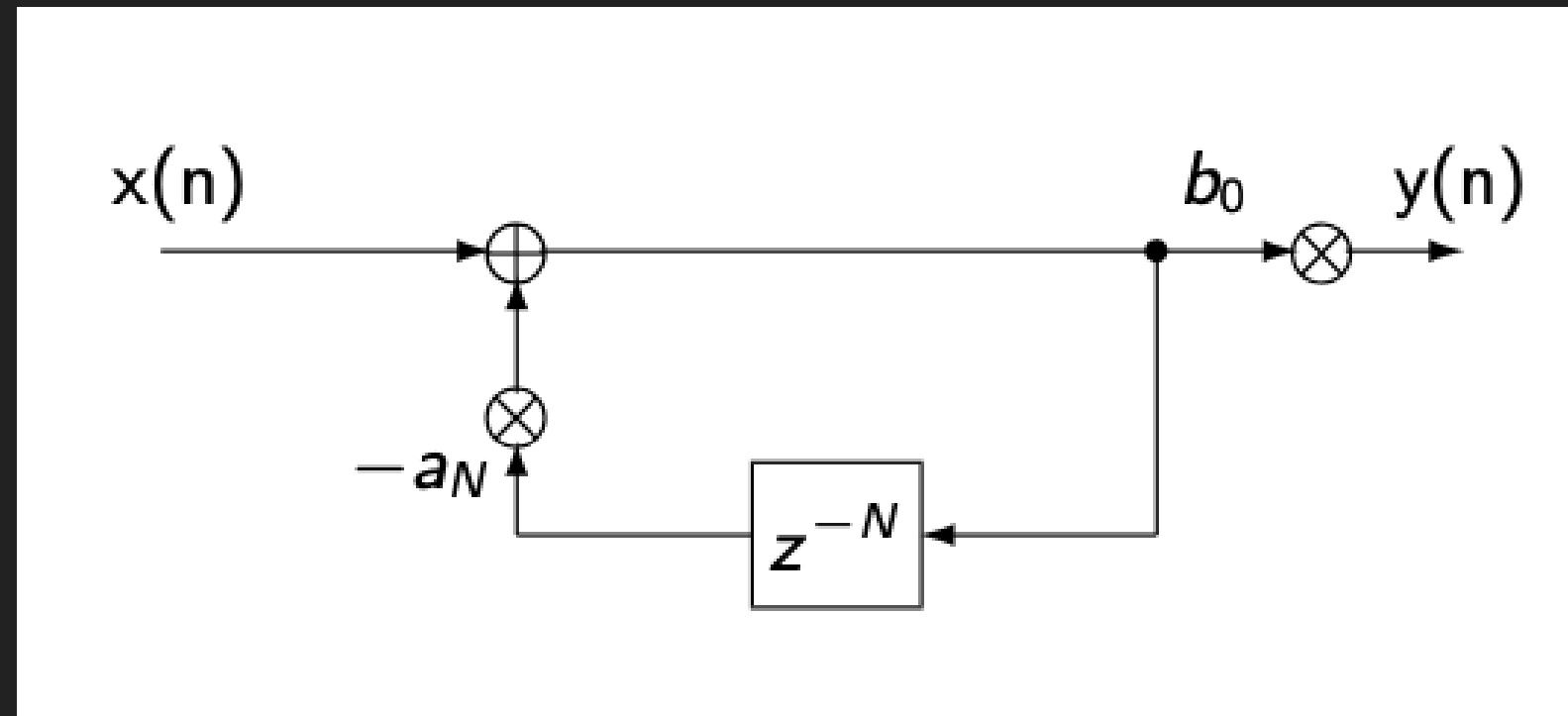
a) Ray Tracing



b) Virtual Image Sources



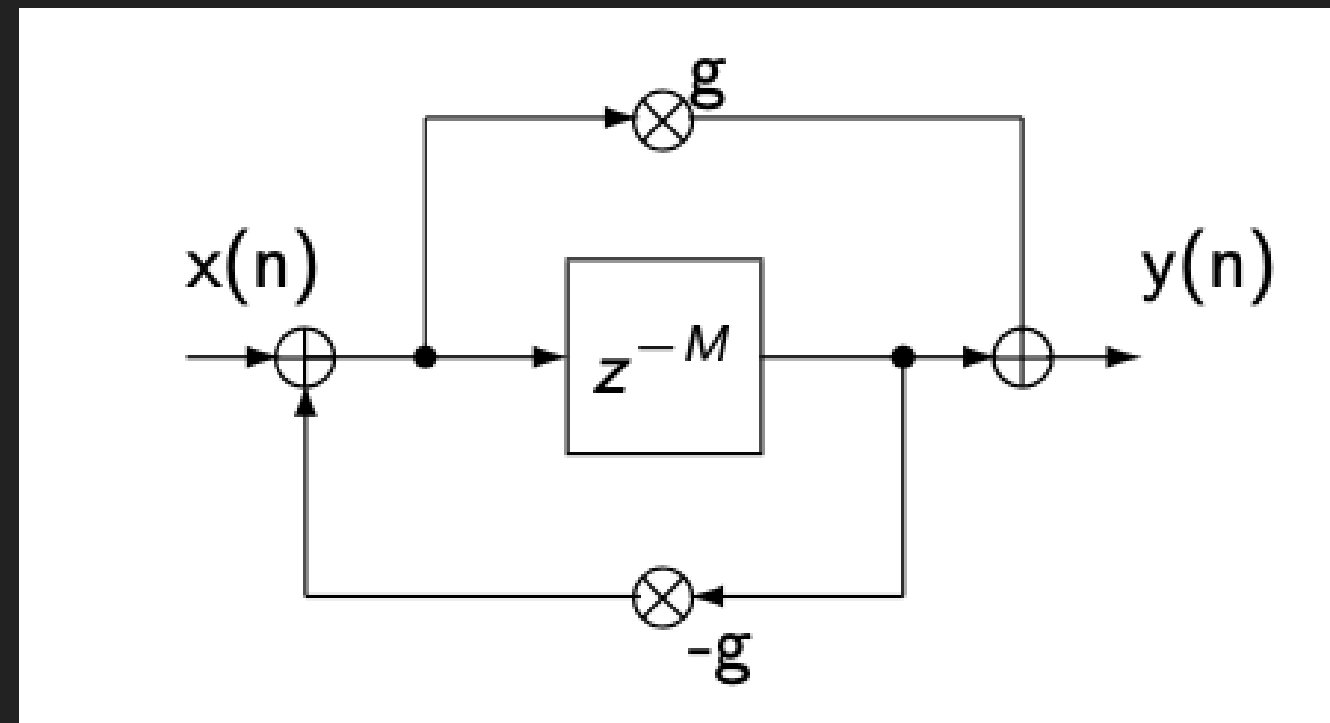
Traditionally Used Filters: Comb Filter



$$y(n) = b_0 \cdot x(n) - a_N \cdot y(n - N)$$

$$H(z) = \frac{b_0}{1 - a_N \cdot z^{-N}}$$

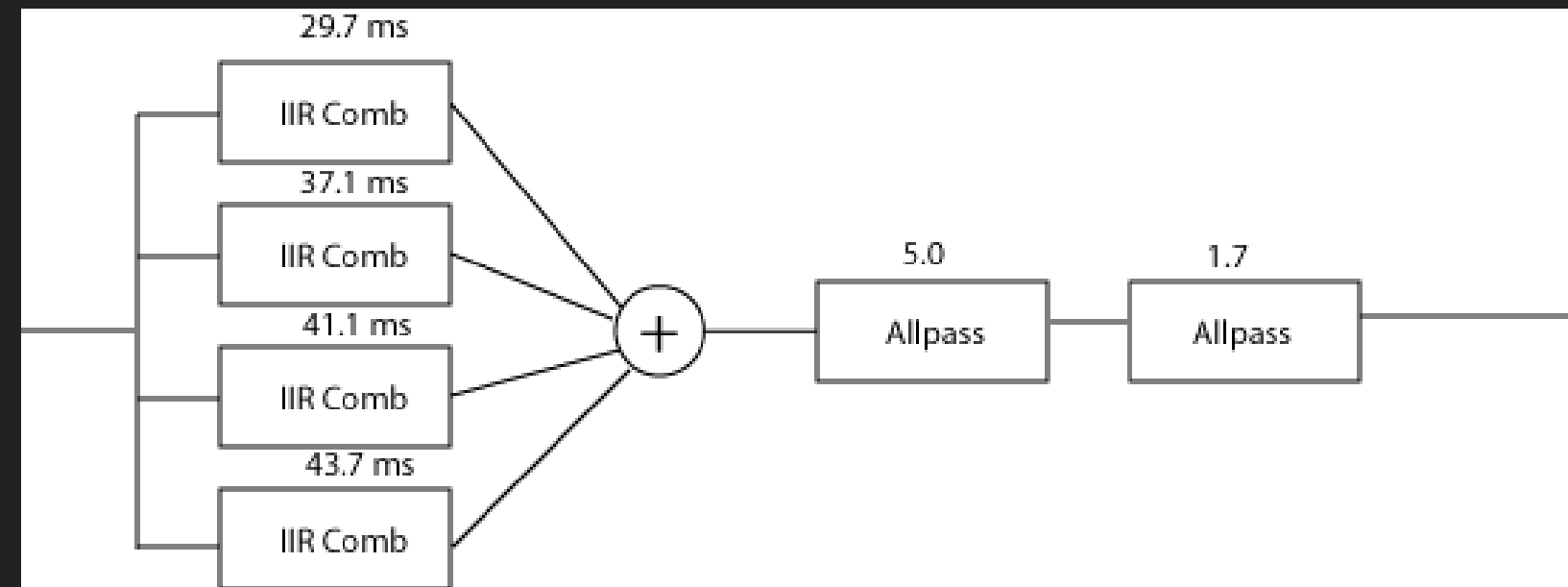
Traditionally Used Filters: All Pass Filter



$$y(n) = g \cdot x(n) + x(n - M) - g \cdot y(n - M)$$

$$H(z) = \frac{z^{-M} + g}{1 + g \cdot z^{-M}}$$

Reverberation: Schroeder



Questions:

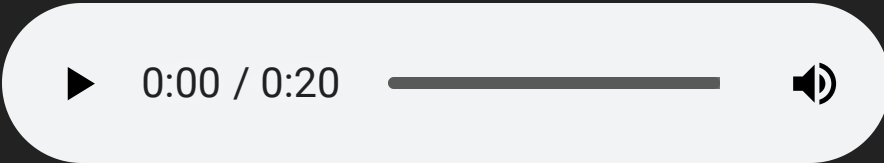
- » How to change the reverberation time?
- » How to change the density?

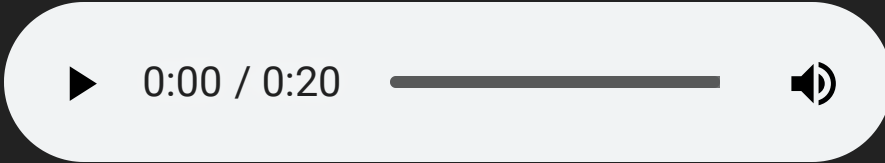
Reverberation: Schroeder

» Problems


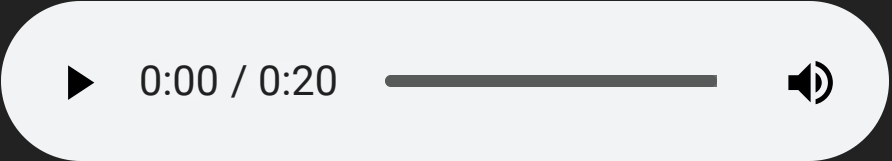
- » sound coloring (→ prime numbers)
- » Periodicity

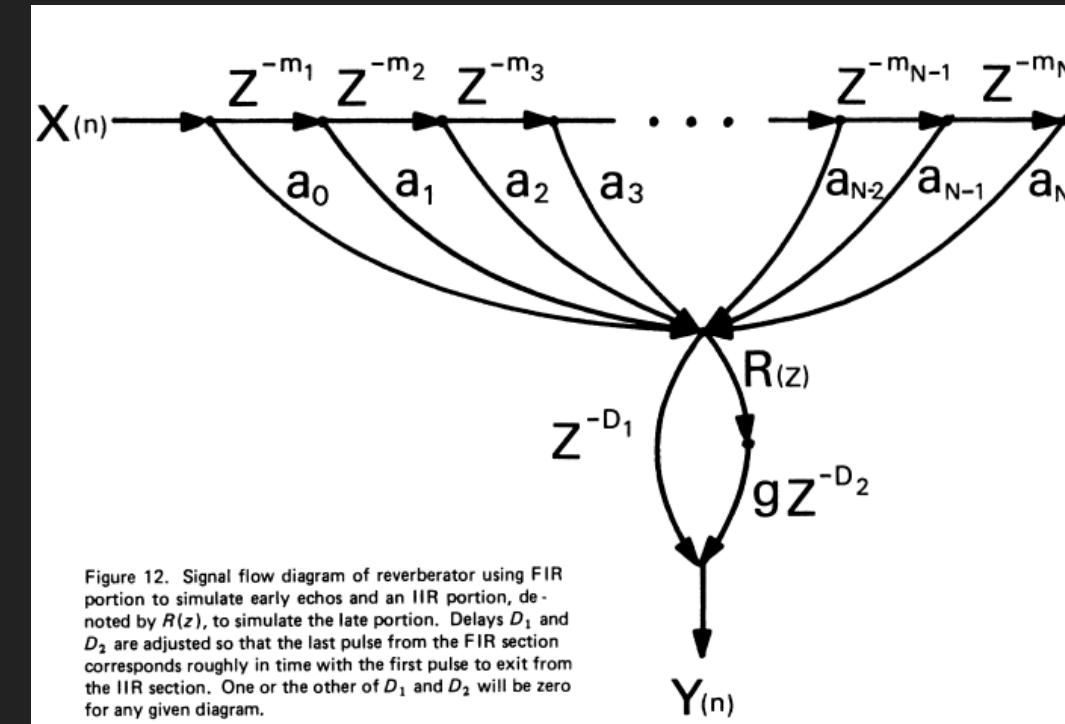
» Audio

» Original: 

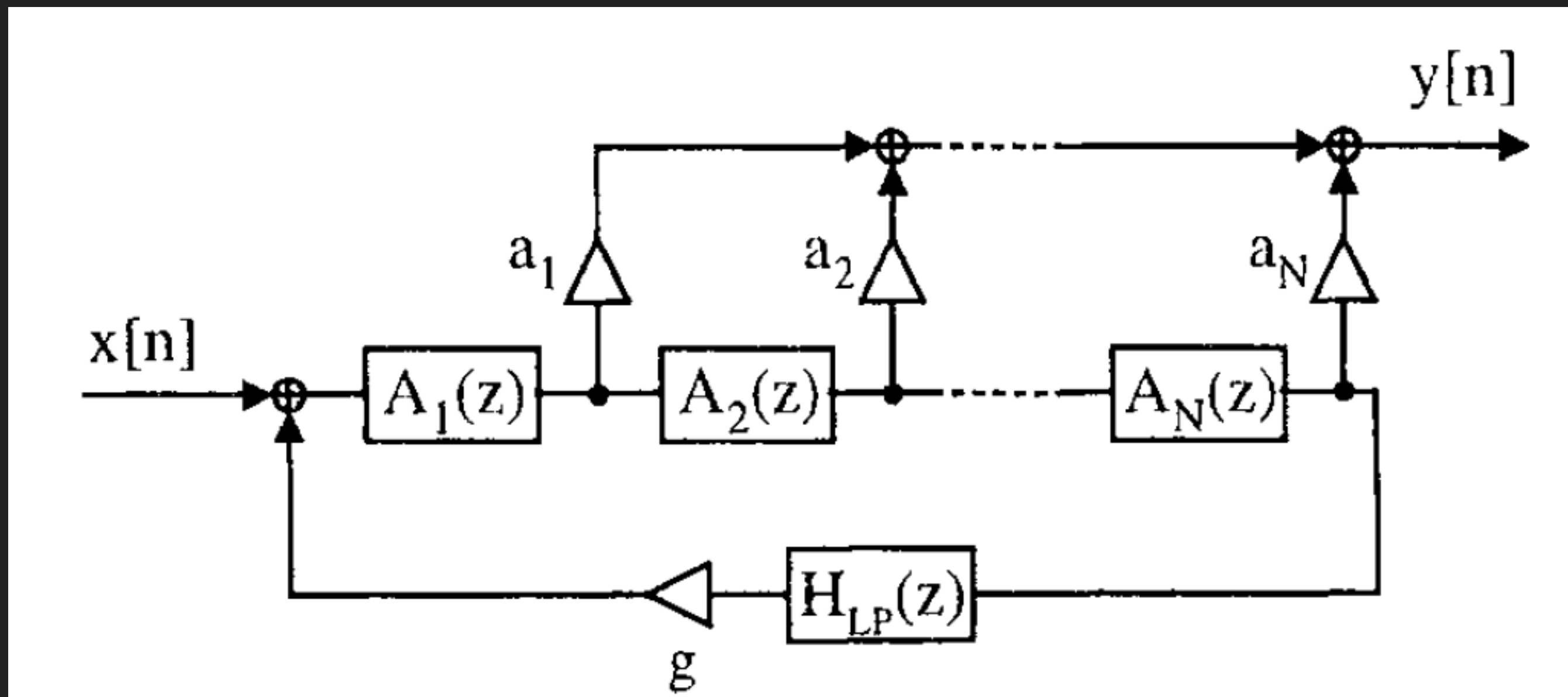
» Wet: 

Reverberation: Moorer

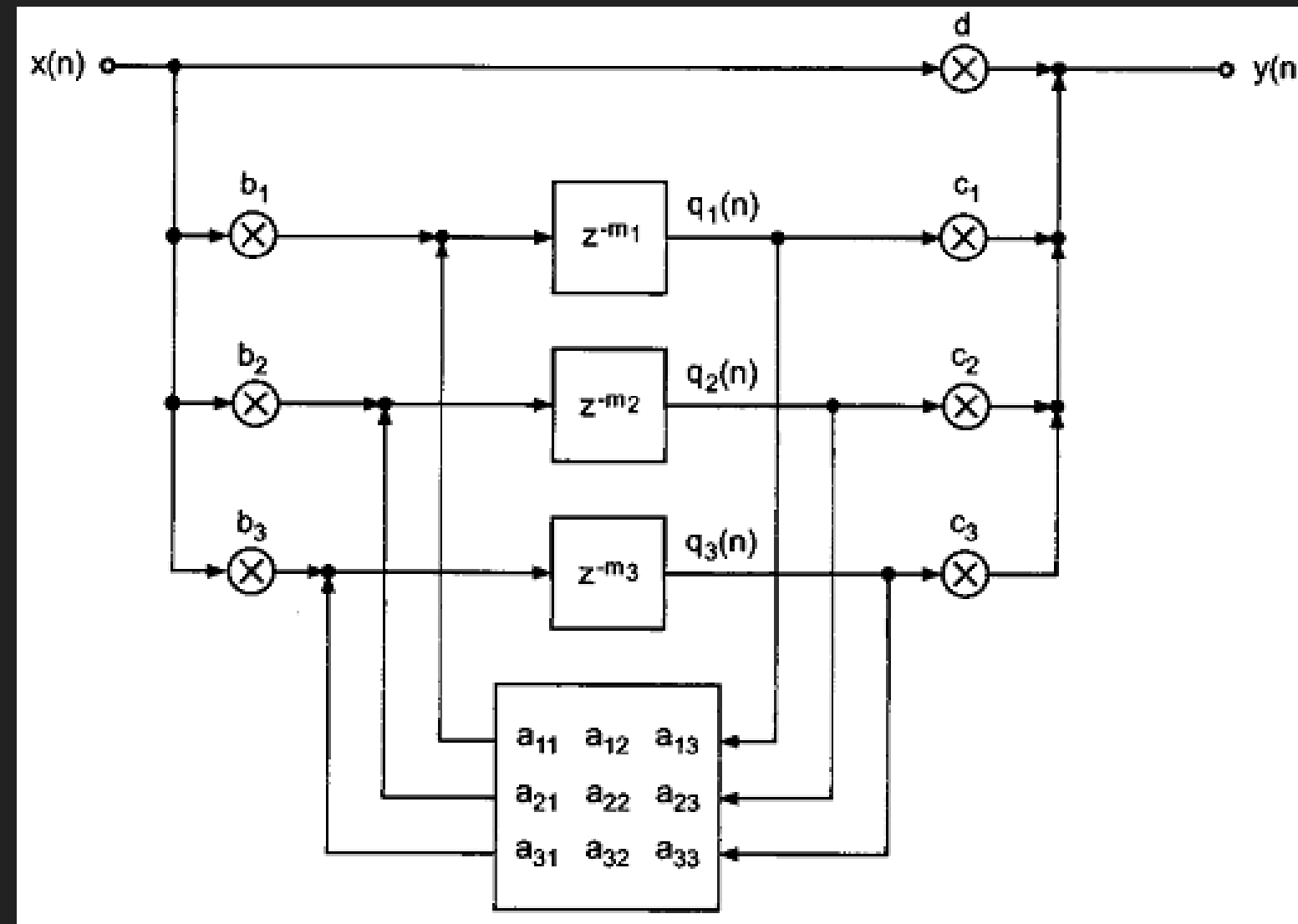
- » Similar to Schroeder's model
 - » More comb filters
 - » Low pass in feedback paths
 - » Simple FIR model for early reflections
-
- » Original: 
 - » Wet: 



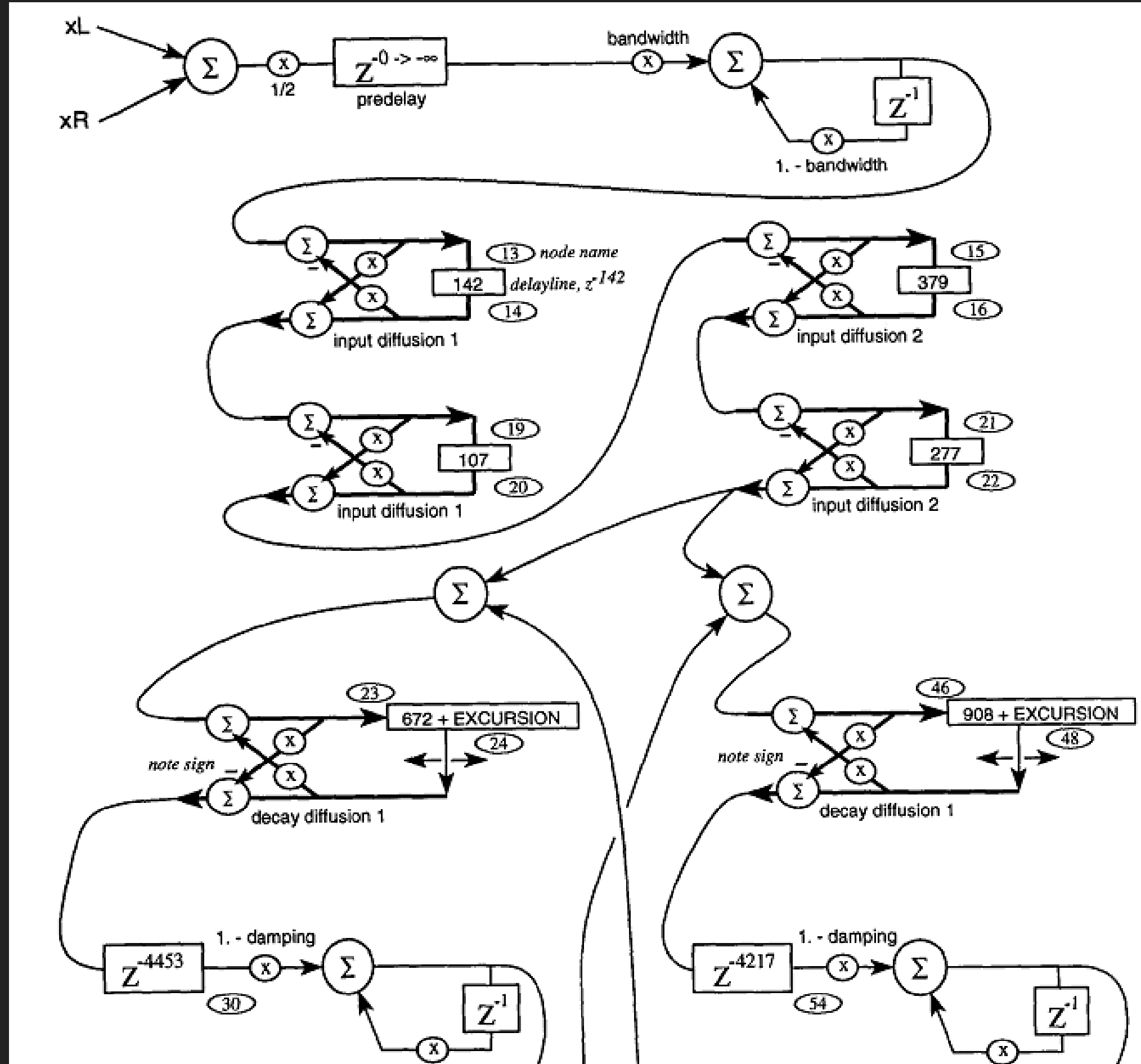
Other Reverberation Approaches: Gardner



Other Reverberation Approaches: Jot (Feedback Delay Network)

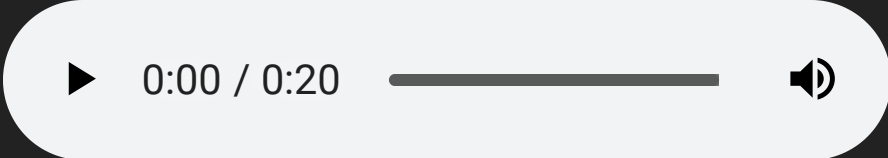



Dattorro



Dattorro Examples

Intention: Plate Reverb Model (Dense, Bright, Fast Build-Up Time)

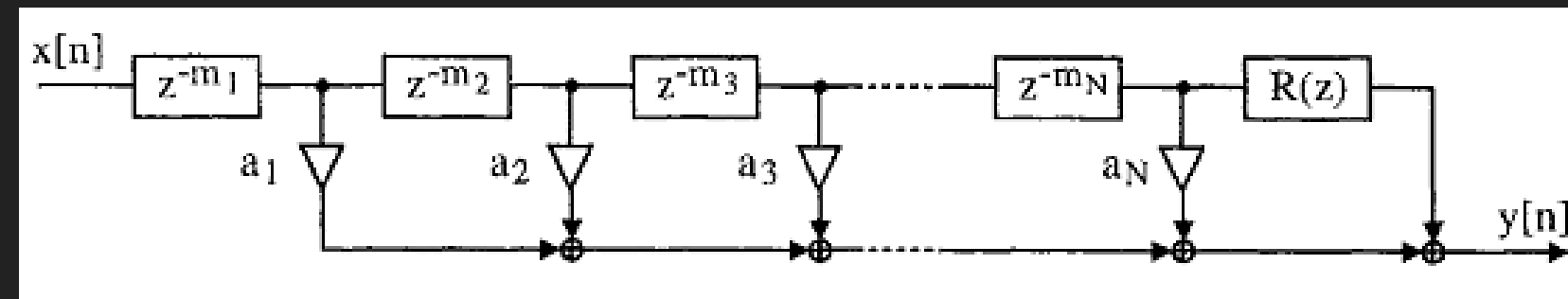
»» Original: 

»» Wet (Plate): 

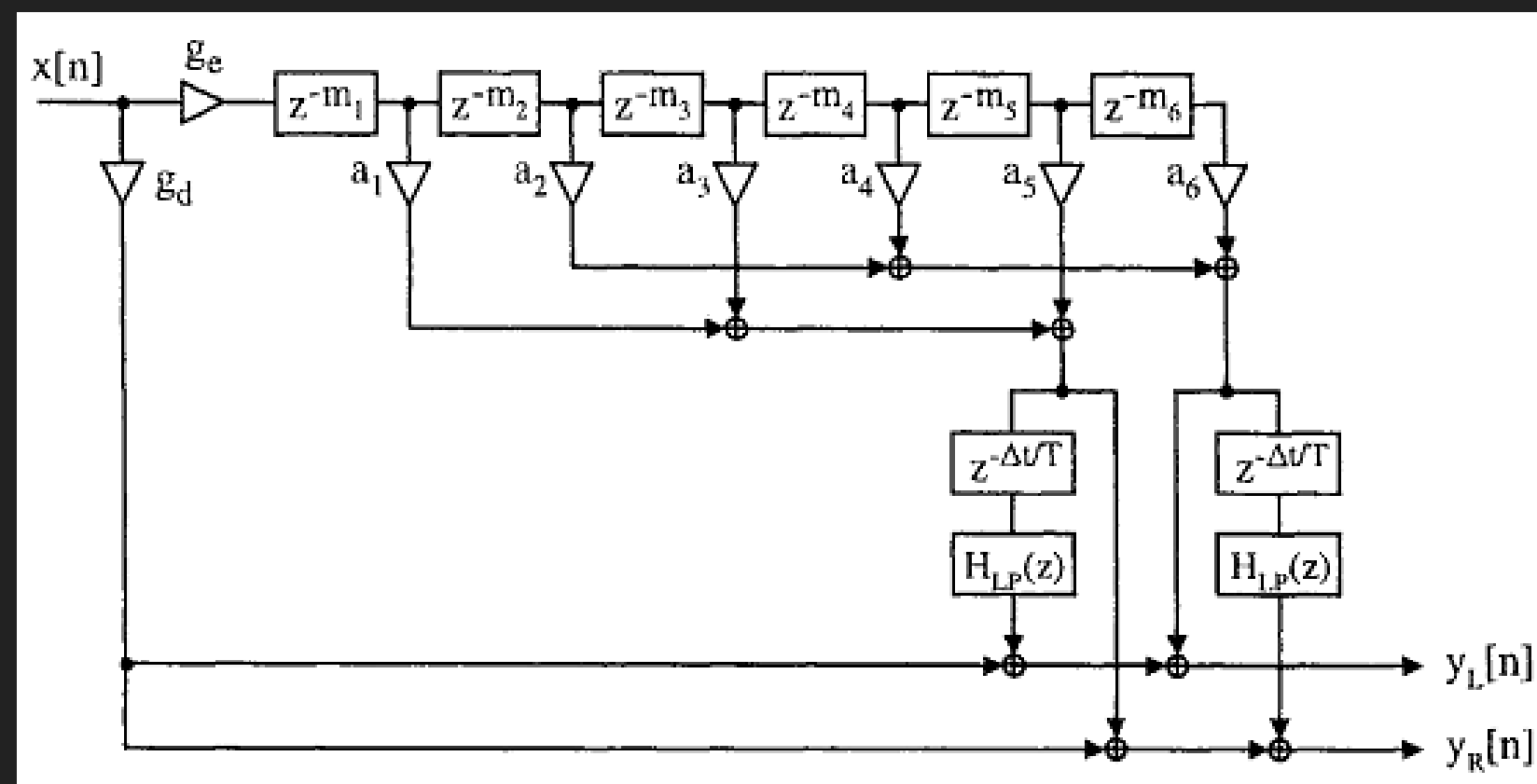
»» Wet (Medium Hall): 

»» Wet (Cathedral): 

Early Reflections: Models



Early Reflections: Models



Quality Enhancements

»» **Multi-Channel Processing**

»» Mono In → Mono Out

»» Mono In → Stereo Out

»» Stereo In → Stereo Out

»» **Delay Modulation**

»» Increase "diffusivity" and "liveliness"

Common Parameters

- » Wetness
- » Reverberation Time
- » Pre-Delay
- » Low Pass Cutoff
- » Low Pass Slope
- » Bass Boost
- » Ratio of Early Reflection / Late Reverberation
- » Diffusion, Liveliness, etc

Summary

- » **Advantages** over convolution reverbs
 - » Fully parametrizable - not restricted to predefined IR library
 - » Works well with already somewhat reverberated recordings
 - » Lower workload (IIR vs. FIR)
- » **Disadvantages** over convolution reverbs
 - » Less realistic, no real-world IRs