

TOM ERBE - UC SAN DIEGO

REVERB TOPOLOGIES AND DESIGN

TEXT

RESOURCES:

- ▶ Manfred Schroeder, "Natural Sounding Artificial Reverb," 1962.
- ▶ Michael Gerzon, "Synthetic Stereo Reverberation," 1971.
- ▶ James (Andy) Moorer, "About This Reverberation Business," 1979.
- ▶ Christopher Moore, "Time-Modulated Delay System and Improved Reverberation Using Same," 1979.
- ▶ John Stautner and Miller Puckette, "Designing Multichannel Reverberators," 1982.
- ▶ Jon Dattorro, "Effect Design - Part 1: Reverberator and Other Filters," 1997.
- ▶ Jean-Marc Jot, "Efficient models for reverberation and distance rendering in computer music and virtual audio reality," 1997.
- ▶ D. Rochetto, "Reverberation," *DAFX - Digital Audio Effects*, Udo Zölzer, 2002.

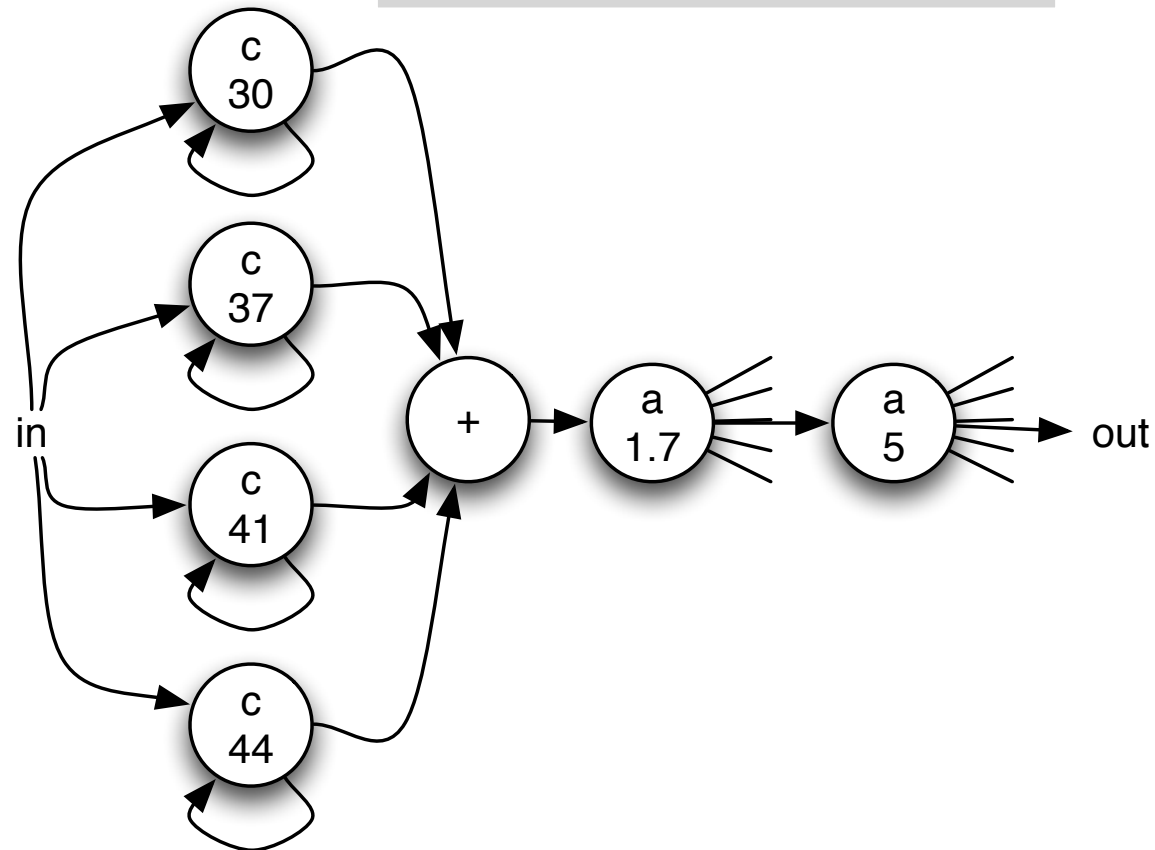
DOWNLOAD PD & MAX/MSP REVERB PATCHES FROM

[HTTP://TRE.UCSD.EDU/WORDPRESS/?CAT=17](http://tre.ucsd.edu/wordpress/?cat=17)

TOPOLOGIES AND HIGHLIGHTED IDEAS

- ▶ Manfred Schroeder - Network of allpass and comb filters.
- ▶ James Moorer - Filtered comb filters.
- ▶ Christopher Moore - Time modulated delay in feedback. Multi-tap output for early reflection modeling.
- ▶ William Martens and Gary Kendall - Spatialized early reflections.
- ▶ Michael Gerzon/John Stautner & Miller Puckette - Feedback delay network using a matrix mixer for feedback.
- ▶ David Griesinger - Single feedback loop, using alternating delays and allpass filters. Time modulated allpass filters.

"Natural sounding artificial reverb"
1962 - Manfred Schroeder



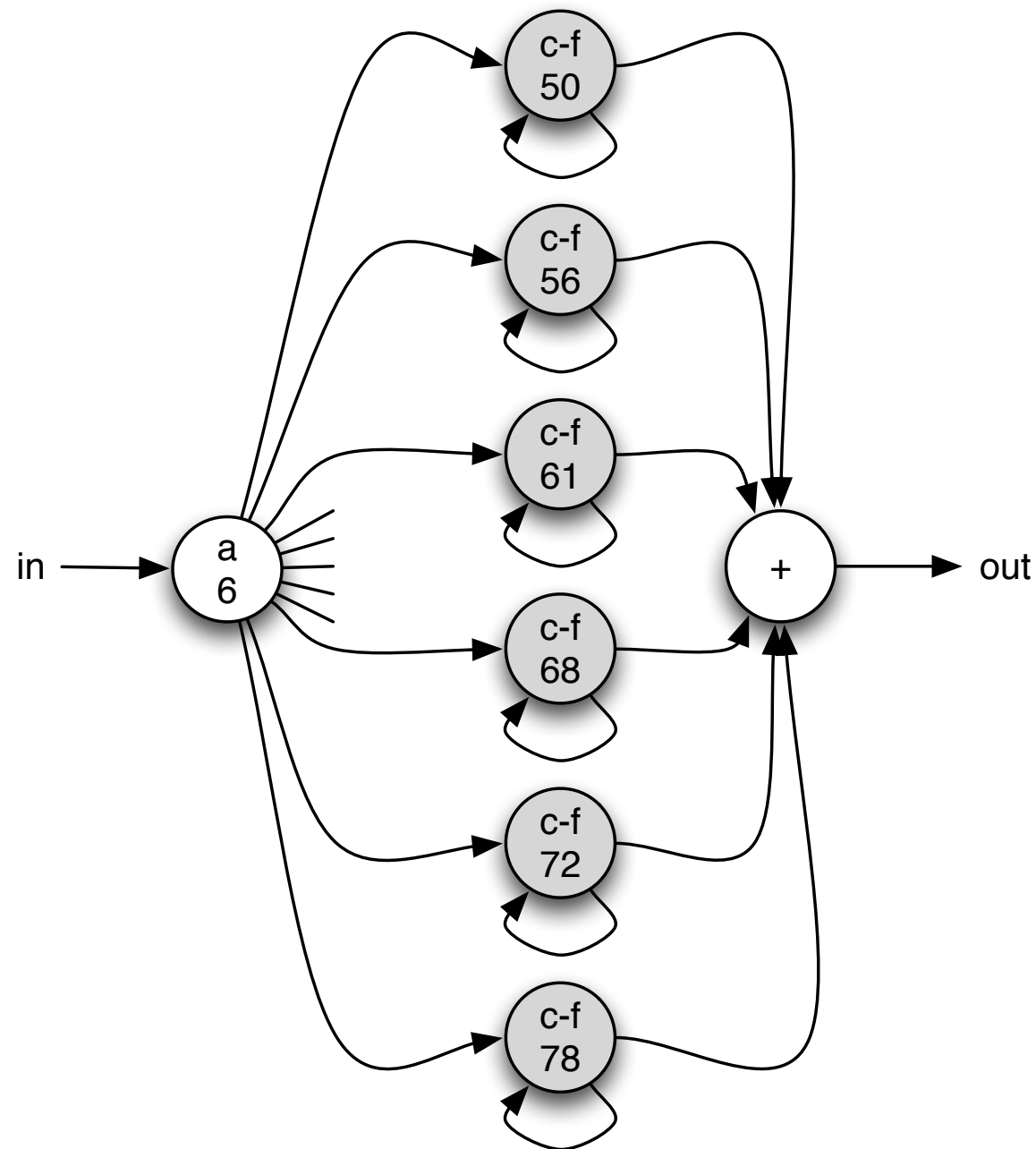
Four comb filters in parallel sent into two series allpass filters.

The comb filter gain is $\text{comb_time/reverb_time} \times -60\text{dB}$. This insures that all combs decay at same time.

The independent comb filters will give this reverb prominent resonances.

Comb and allpass sections may be reversed, allowing stereo output from combinations of combs.

"About this reverberation business"
1979 - James Moorer



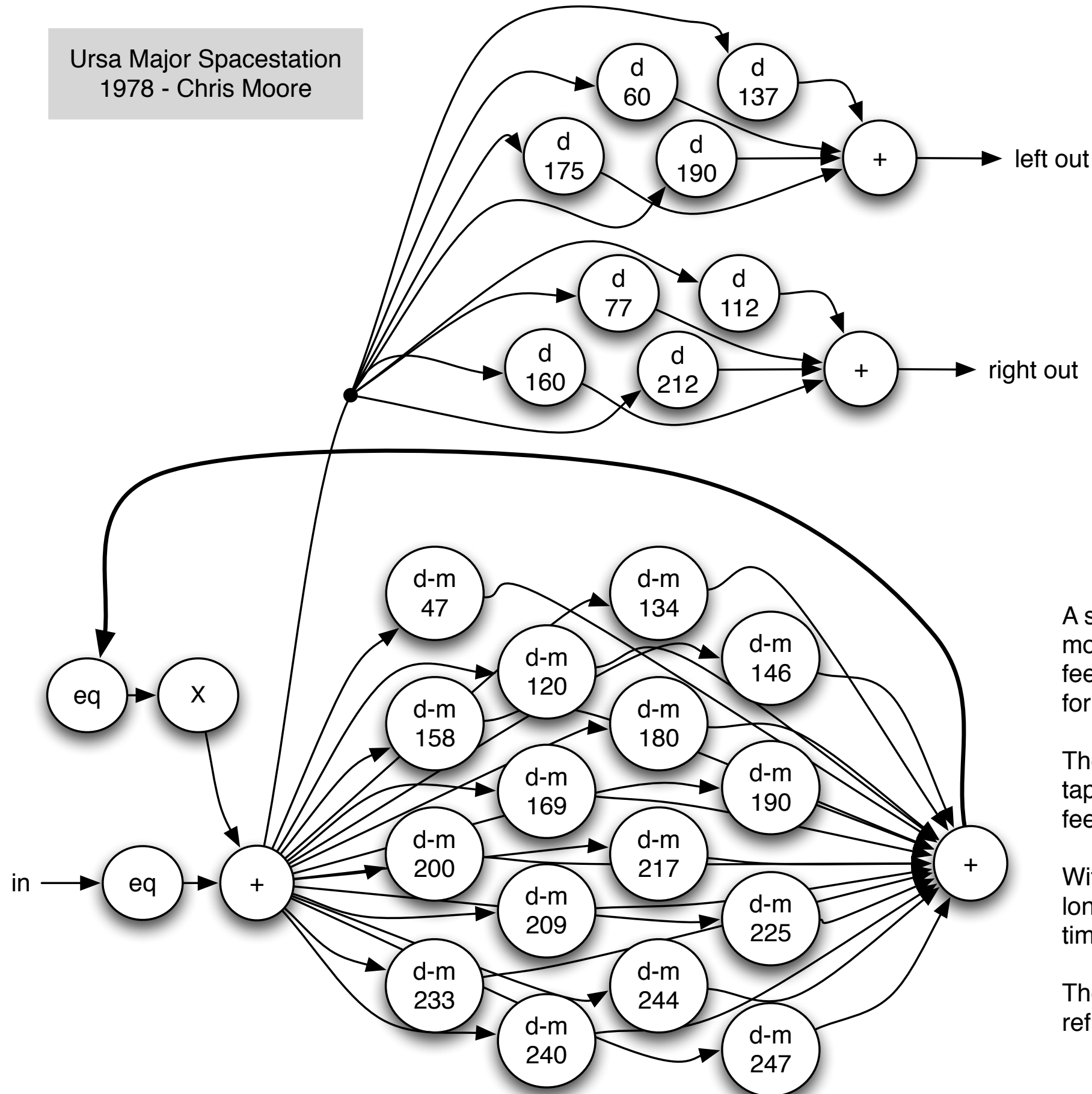
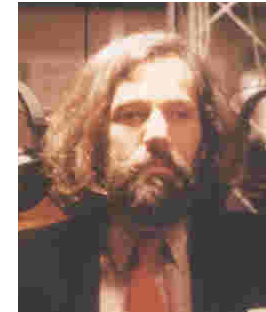
One allpass filter sent into six parallel low pass comb filters.

The single pole low pass filter in the feedback loop of each comb causes each repetition to be darker.

The comb gain is $\text{comb_time}/\text{reverb_time} \times -60\text{dB}$. This again insures that all combs decay at same time.

A stereo output made from varying combinations of comb outputs.

Ursa Major Spacestation
1978 - Chris Moore



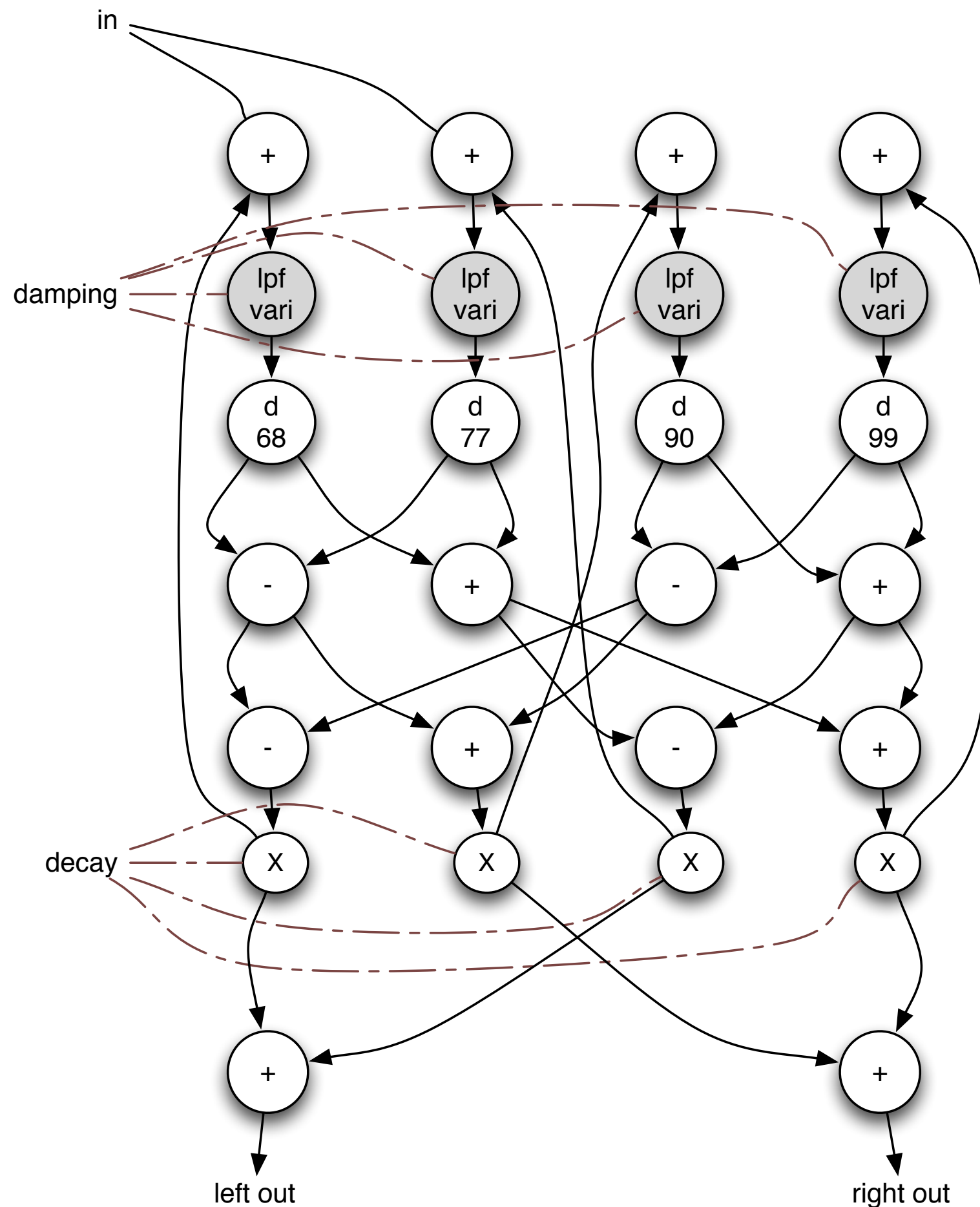
A single delay with sixteen modulated delay taps for the feedback loop and four delay taps for each output channel.

The modulated delay time on each tap allows for more gain without feedback.

With a single feedback path and long initial delays. It takes some time to build up density.

The output taps allow early reflections to be modeled.

NxN FDN
1971 - Michael Gerzon
1982 - John Stautner/Miller Puckette

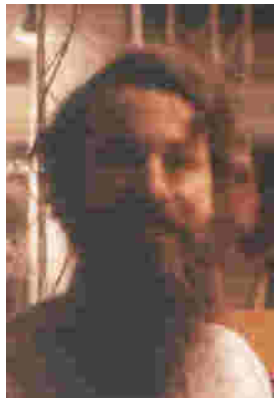


This is a 4x4 example of the general design proposed independently by Gerzon, then Puckette and Stautner.

The key characteristic is N delay lines which are sent into a NxN unitary gain matrix which then feedback into the delay lines. In this case all gain multipliers are 1 (and aren't shown), a Hadamard matrix.

Other sizes and other unitary gain matrices are possible.

Lexicon 480L
1986 - David Greisinger

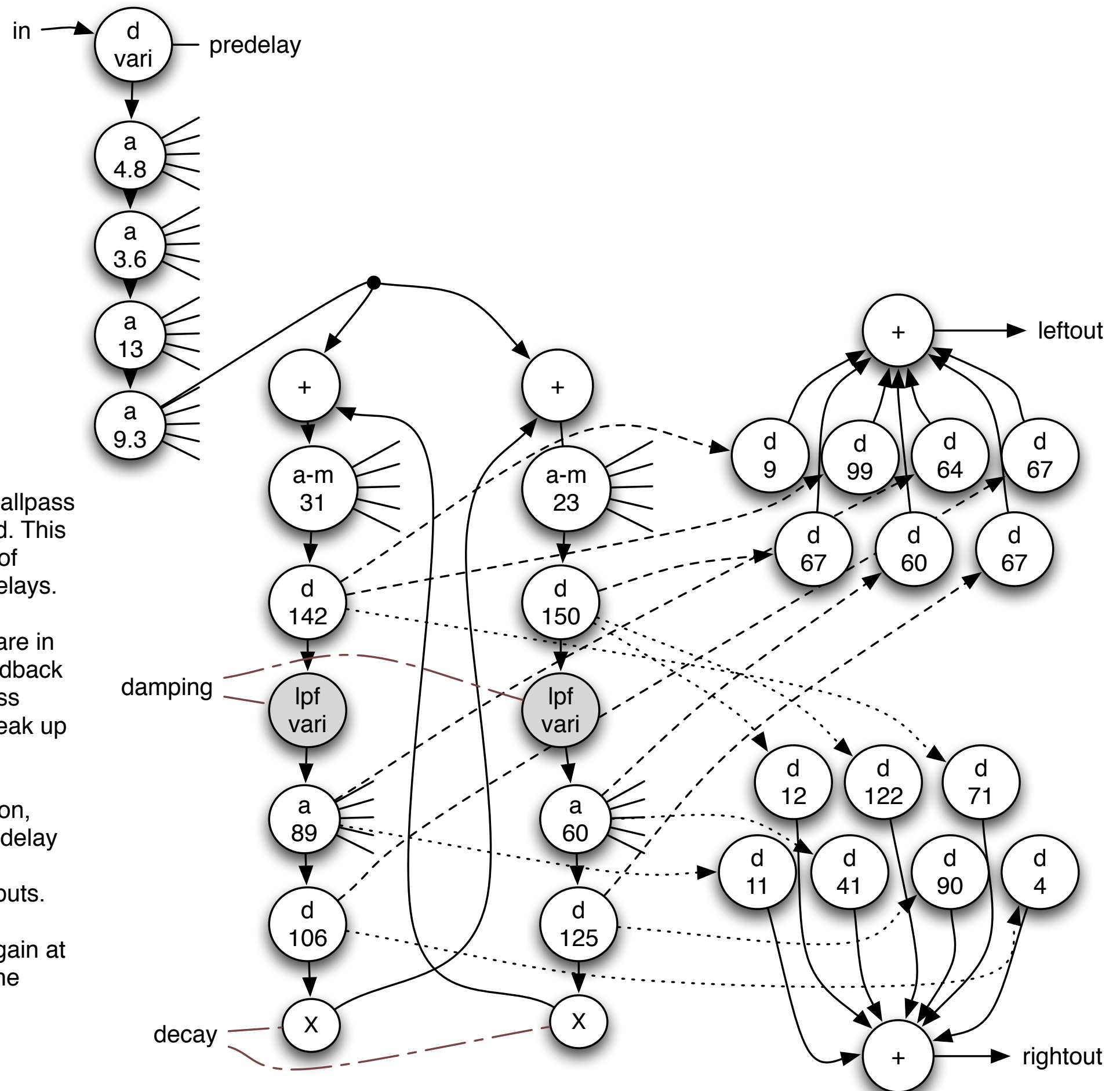


A pre delay feeding a series of allpass filters, providing a diffuse sound. This is sent into two sides of a loop of alternating allpass filters and delays.

Two lowpass "damping" filters are in the loop, as are two decay (feedback gain) controls. Two of the allpass filters are time modulated to break up repetition.

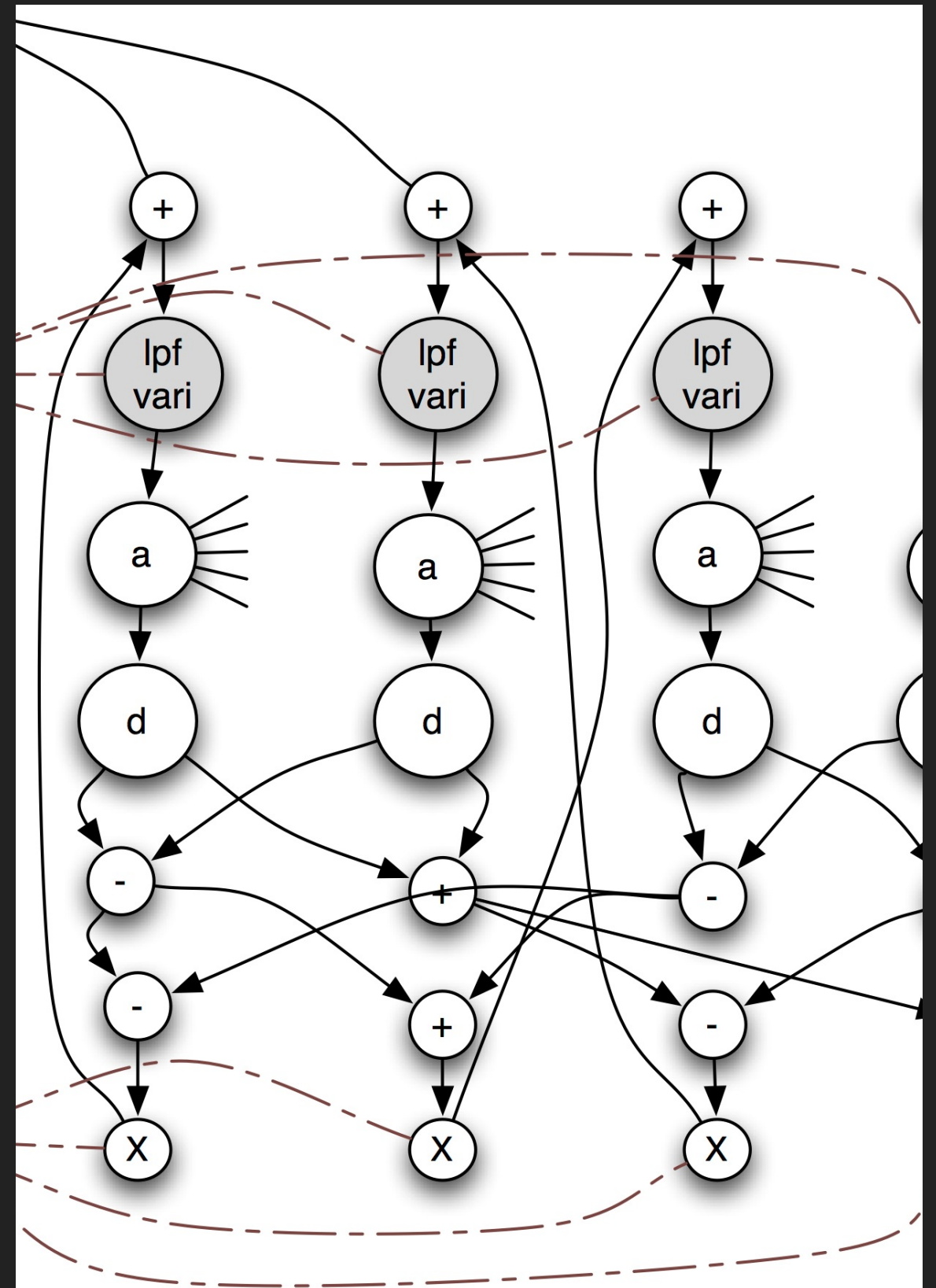
Like the Ursa Major Spacestation, there are multiple taps into the delay loop to provide separate early reflections for left and right outputs.

One thing to note. With decay gain at unity, this network can freeze the sound for infinite reverb.



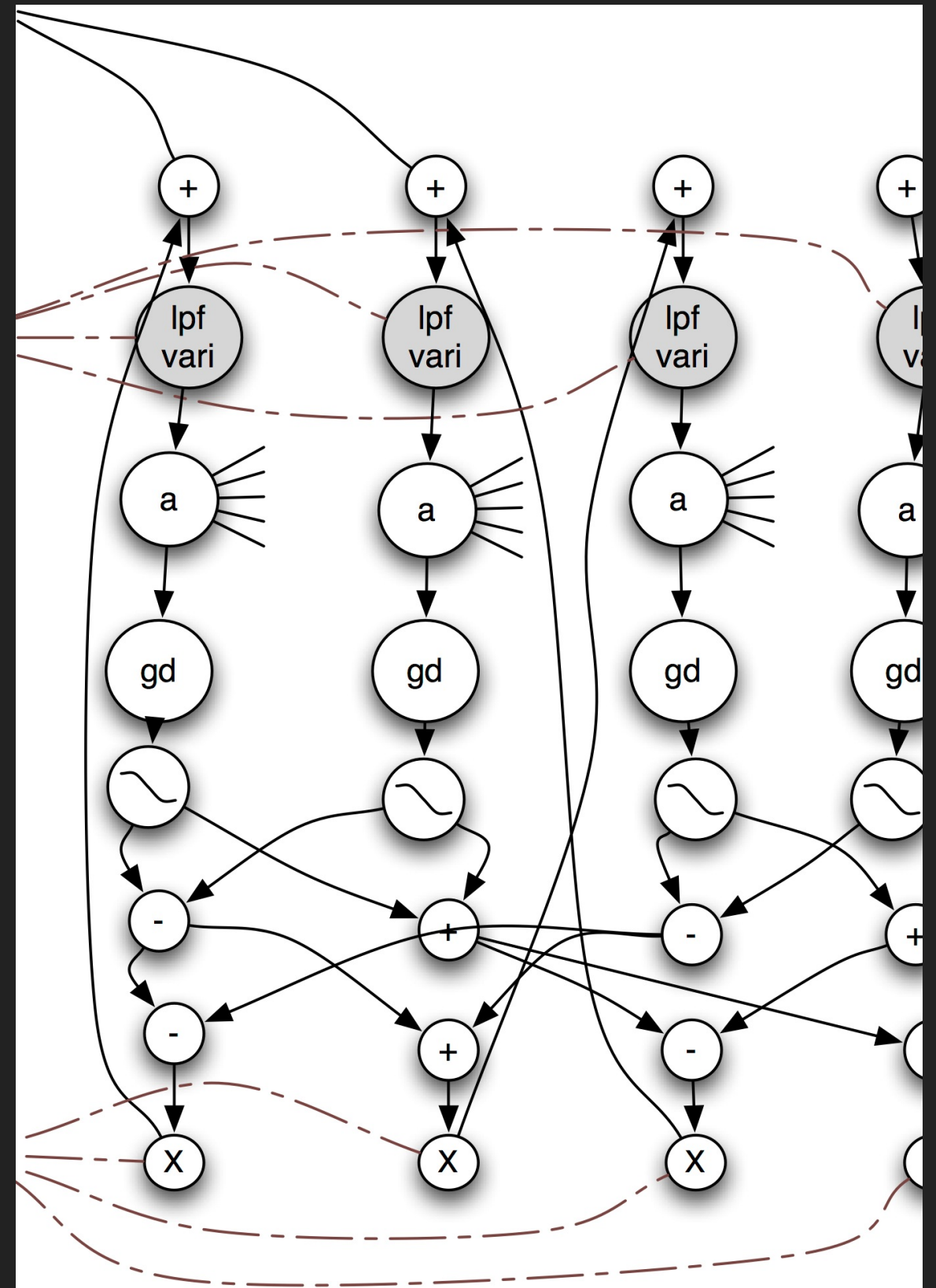
THE ERBE-VERB: EXTENDING THE REVERB

- ▶ Start with an FDN reverb, but precede each delay with an allpass filter for much higher echo density.
- ▶ Allow adjustable gain on allpass to lower this density buildup.
- ▶ Make all delay times globally variable, so that size can quickly be adjusted and modulated.
- ▶ Room size should go beyond reasonable sizes.



THE ERBE-VERB: EXTENDING THE REVERB

- ▶ Replace each delay with a granular variable delay. The room size and shape can morph randomly (as suggested by Gordon Mumma's piece, "Stressed Space Palindromes").
- ▶ Add a saturation polynomial after each granular delay. Now decay can be less than zero, and the room can freely resonate, pushing against the saturation limit.



OTHER REVERB IDEAS

- ▶ Spatialized early reflections (binaural, ambisonic, multiple speaker).
- ▶ Other processing in feedback loop to minimize repetition or to color reverb (e.g. frequency shifting, pitch shifting, modal filters).
- ▶ Gain normalization of feedback loop processing so that unity gain can be preserved.
- ▶ Connection of multiple reverberators.
- ▶ Integration of convolution techniques.

QUESTIONS?