RVBAP = reverberated VBAP

VBAP - the vector base amplitude panning developed by Ville Pulkki – allows to pan signals in a two or three dimensional acoustical space using any arbitrary setup of loudspeakers. However, it is only possible to pan the signal which appear at a fixed distance to the listener. This distance is usually the real distance speaker – listener. To extend the virtual acoustical room beyond the speakers (and thus beyond the borders of the real space) a portion of reverberated signal can be added.
RVABP – i.e. reverberated VBAP – tries to implement the usage of reverb to create a more realistic sense of acoustical space.

How it works:

To add a feeling of 'distance' to amplitude panned signals a certain amount of reverb has to be added. There has to be one reverb per speaker / output channel. The final output signal consists of the following components:

- the 'normal' VBAP signals representing the 'dry part' of the signal with levels corresponding to the position in the room
- a 'global reverb' part, i.e. reverb on all channels
- a 'local reverb' part, i.e. reverb with different levels on different channels depending on position in room

As outlined above, the reverberated signal is split into two parts: *global* and *local*. The global part represents the reflected sound coming from all directions (equally distributed). For signals close to the listener the global reverb part has a rather high level.
The local part is reverb coming from the same direction the signal source is located at (thus using the VBAP amplification levels, among others).
To simulate a more 'remote' signal source, the reverb has to come from the same direction as the signal itself. Second, the amount of reverb – compared to the direct signal – increases with distance giving a 'far away' sound. Sound sources close to the listener have a higher amount of direct sound (i.e. global reverb part).
Moving a signal source away from the listener has the following effects:
- the direct level decreases by a certain amount and
- the level of the reverberated part decreases as well, but with a smaller amount.

If (D) is the distance (with D = 1 being the distance between listener and the speakers), the amplification (a) looks like this:

direct sound: $a_d = 1/D$
reverberated sound: $a_r = 1/\sqrt{D}$

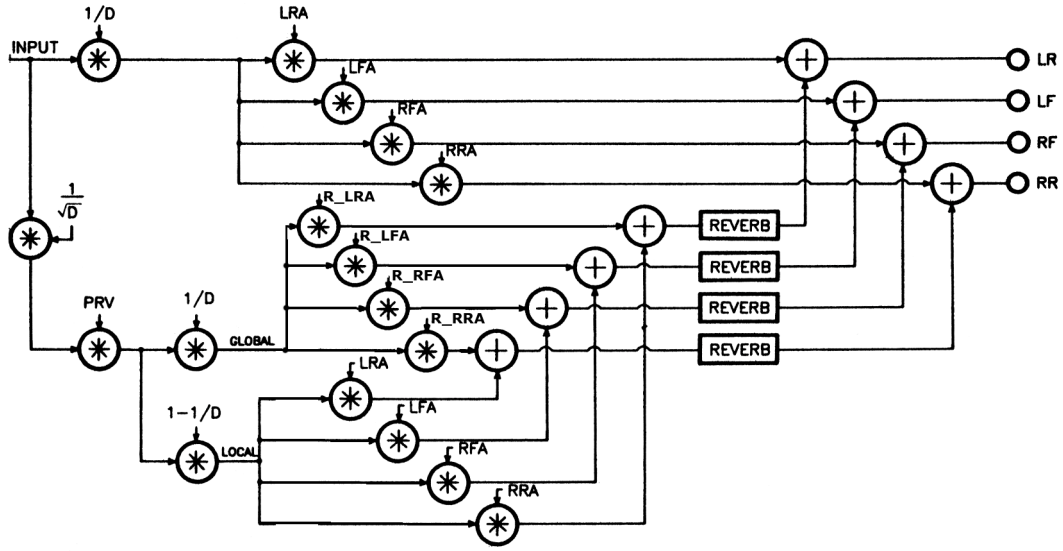
The reverberated part is split into global and local part giving the following amplification factors:

global: $a_{rg} = 1 / D$
local: $a_{rl} = 1 - (1 / D) = 1 - a_{rg}$

All this applies to distances greater than 1. In other words, the distance of the sound sources to be simulated is at least the distance listener – speaker. It is not possible to simulate shorter distances!

To get a natural sounding reverb the reverbs used should have slightly different parameter for each channel. This would simulate the fact that every room has a different reflected 'sound' at different directions (because of different wall materials, uneven sound distribution due to windows, stairs and the like).

To calculate the global reverb part some tricks are necessary. We assume that a signal that is output with equal level on all speakers appears to be 'in the middle of the room' or without any special direction. This is what we need for the global reverb part since a nearby sound source will result in reflections from all walls at about the same level.
In case there are more speakers on one side of the listener the signals there would add and thus disturb the above assumption. To solve this problem additional amplification has to be added to individual channels (only in the global reverb part!) to compensate for these effects.



overview of the internal signal flow (using 4 speakers)

LRA, LFA, RRA, RFA are the amplification factors coming from VBAP, PRV is the percentage of reverberation which determines the character of the room to be simulated.
R_LRA, R_LFA, R_RRA, R_RFA are the gains for the global reverb part. These stay unchanged regardless the signal direction!

The 'rvbap' object for Max/MSP:

An external for Max/MSP (OS X / WinXP) is available to allow easy implementation of RVBAP. It includes all necessary calculations. Thus, only a few other objects are needed.
Basically, the output of 'rvbap' is fed into a matrix~ object that does all the signal calculations. The number of outputs of matrix~ has to be twice the number of speakers used. The first half of outlets is connected to the dac~ directly, the second half carries the signals that need reverberation. In the supplied help patch monoverb~ is used for reverberating the signal. It's output is simply added to the corresponding output channels as well.