# MAC Design: Standard Floating-Point vs. Hybrid Logarithmic 4-bit
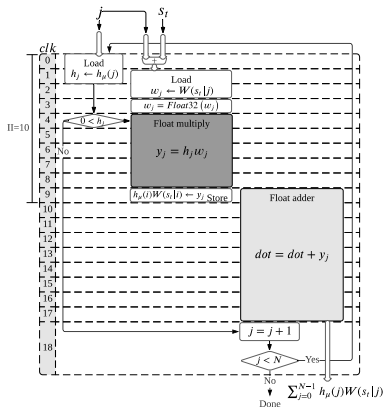
## Standard floating-point



$clk$

Load
$h_j \leftarrow h_\mu(j)$

Load
$w_j \leftarrow W(s_t|j)$
$w_j = Float32(w_j)$

$0 < h_j$

Float multiply
$y_j = h_j w_j$

$h_\mu(j)W(s_t|j) \leftarrow y_j$ Store

Float adder
$dot = dot + y_j$

$j = j + 1$

$j < N$ — Yes
No
$\sum_{j=0}^{N-1} h_\mu(j)W(s_t|j)$
Done

II=10

## Hybrid logarithmic 4-bit



$clk$

Load
$h_j \leftarrow h_\mu(j)$

Load
$w_j \leftarrow W(s_t|j)$

$h_m = Mant(h_j)$       $h_e = Exp(h_j)$

$0 < h_m$       $y_e = h_e + w_j$    Add exp

$y_j = Float32(0, y_e, h_m)$

$h_\mu(j)W(s_t|j) \leftarrow y_j$ Store

Pairwise product

Denormalize
$magn = BarrShift(h_m, y_e)$

$dot_m = dot_m + magn$
Accumulation

$j = j + 1$

$j < N$ — Yes
No

$threshold < dot_m$ — No

Yes

$dot = Normalize(dot_m)$

$\sum_{j=0}^{N-1} h_\mu(j)W(s_t|j)$       Skip IP update

II=2

Phase I

Phase II

Phase III