Extracting Posteriors from a Gaussian Mixture Model

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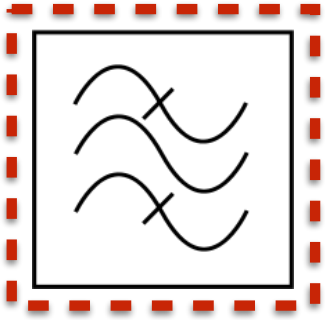
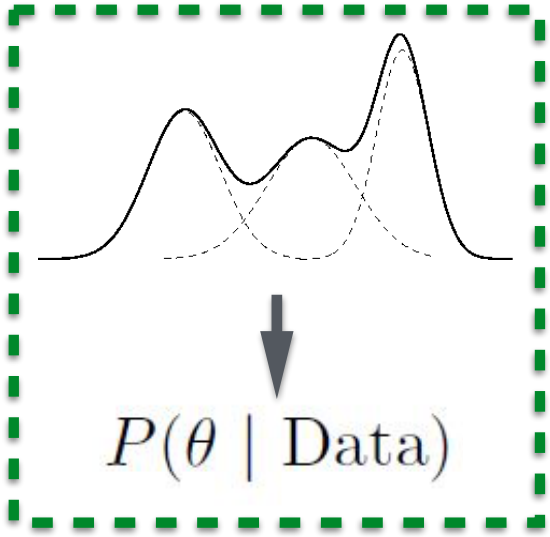
6.375 Final Project

May 11, 2016

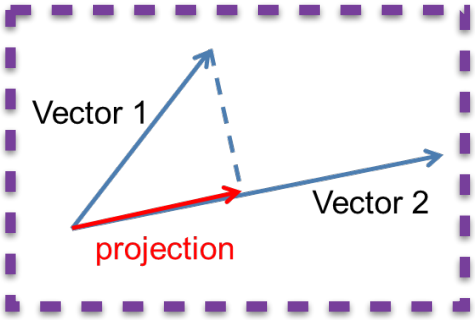
Introduction



Voice Activity Detection



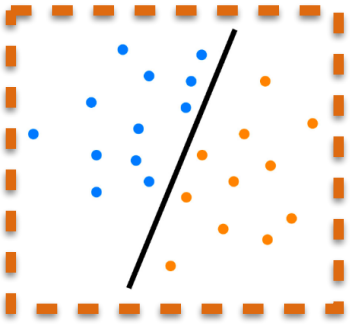
Posterior Extraction from GMMs



Dimensionality Reduction

Raw Speech Vectors

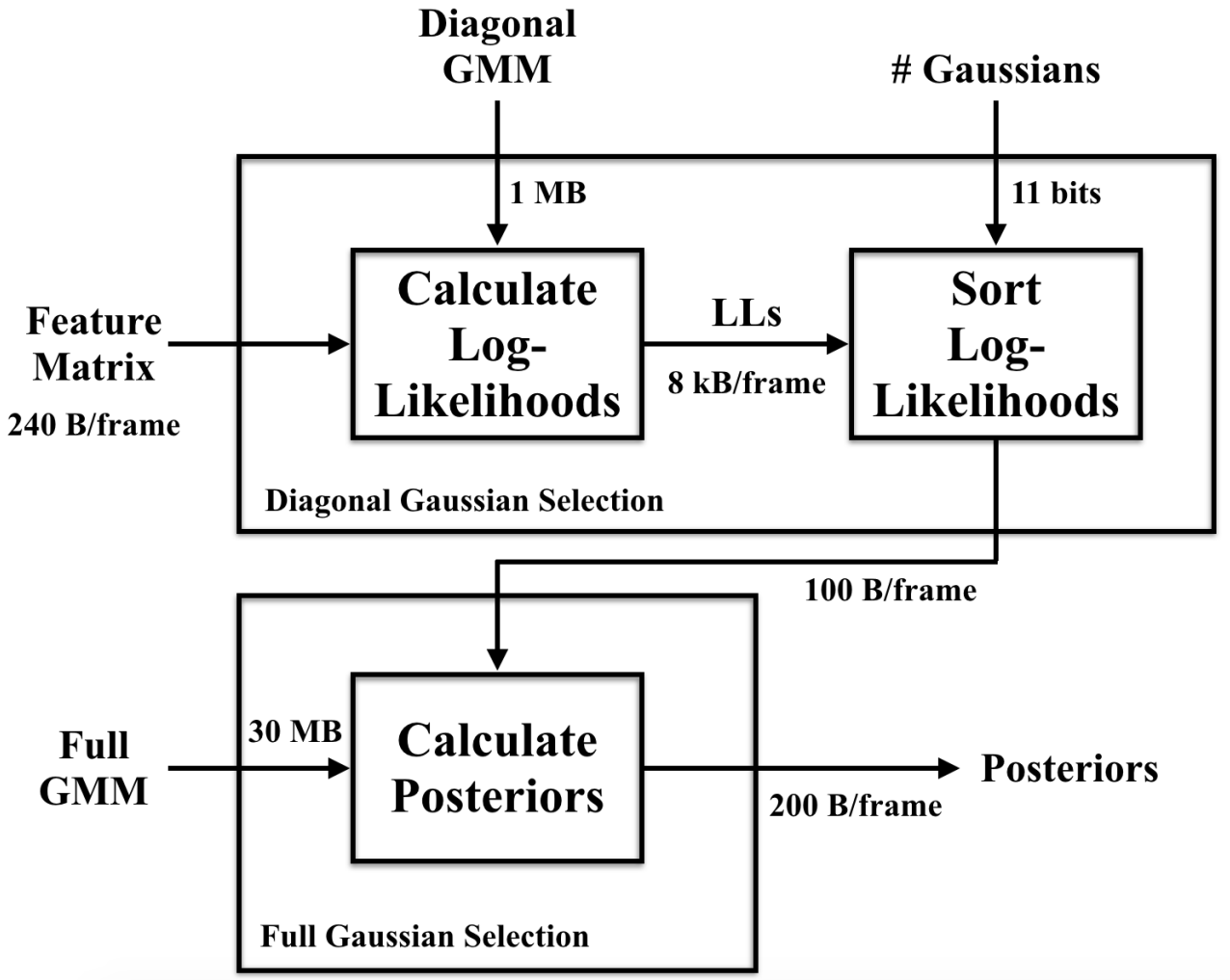
Applications



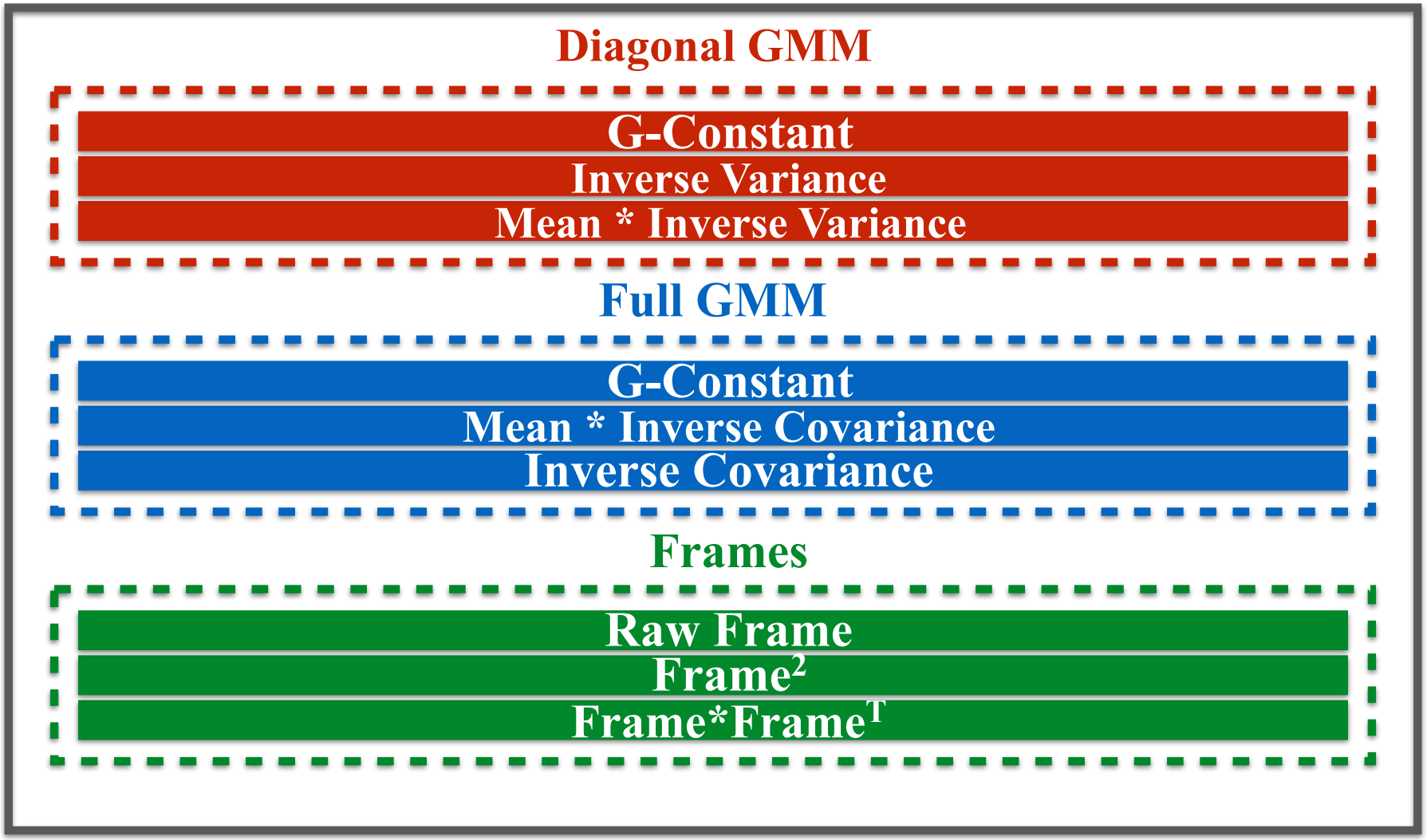
Classification

System Overview

- All computations are performed on 32-bit fixed-point numbers
- GMMs and frame matrix are stored in DRAM

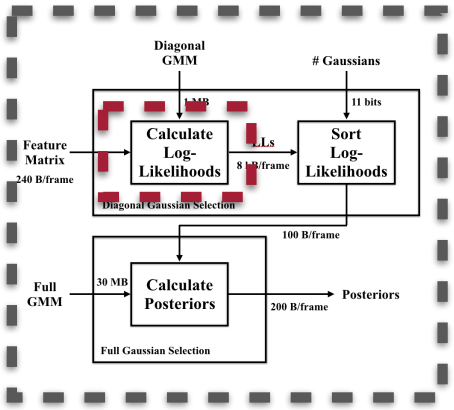


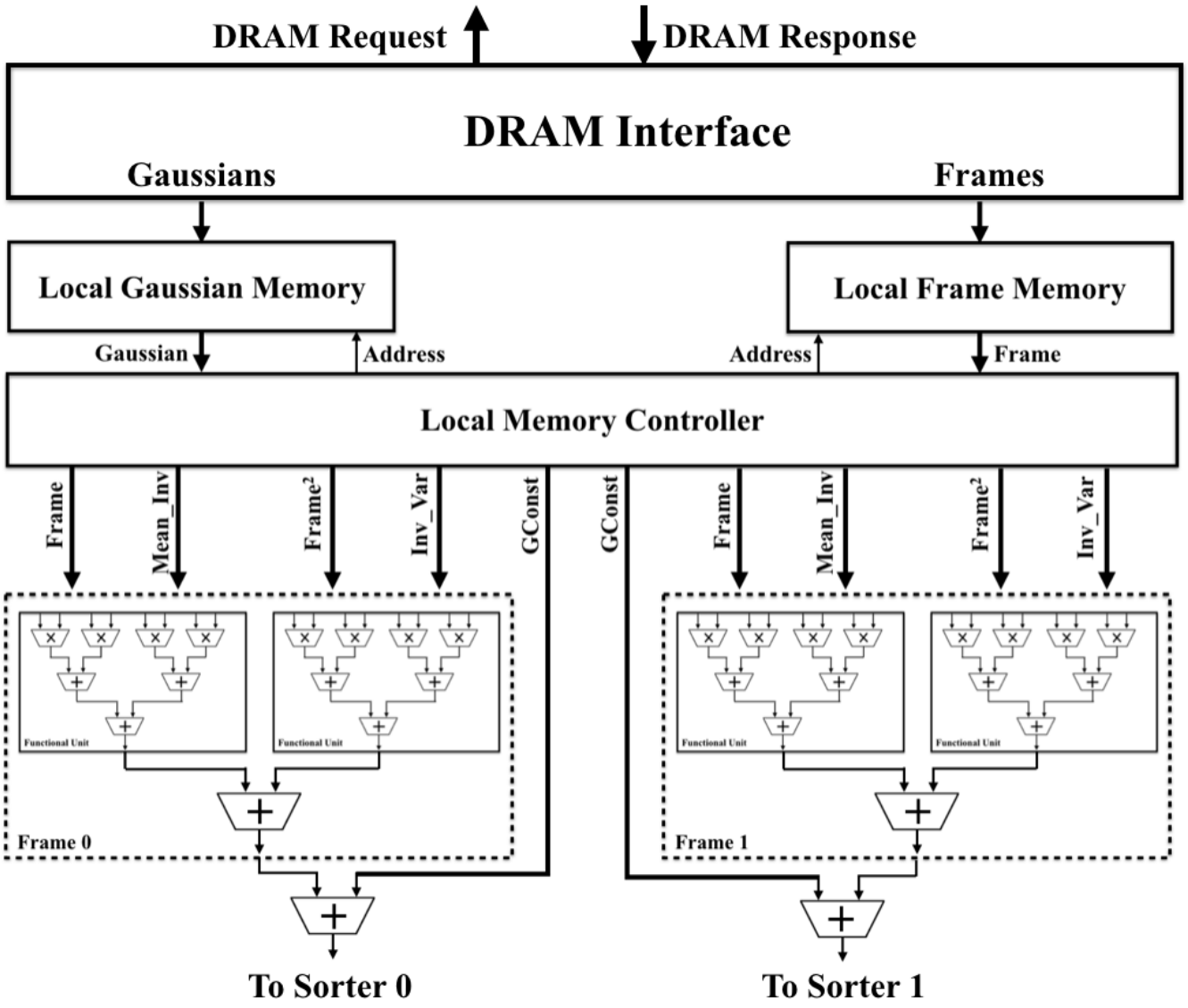
Memory Layout



Diagonal GMM Selection Module

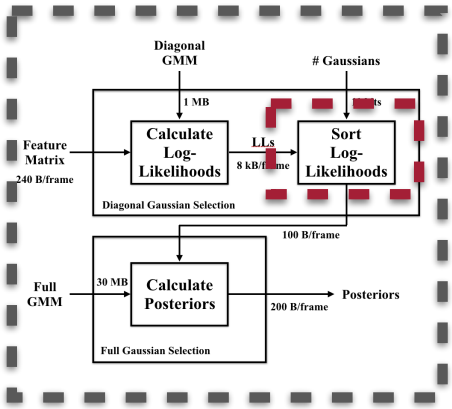
- Computes two dot products
- 60 elements, 32 bits

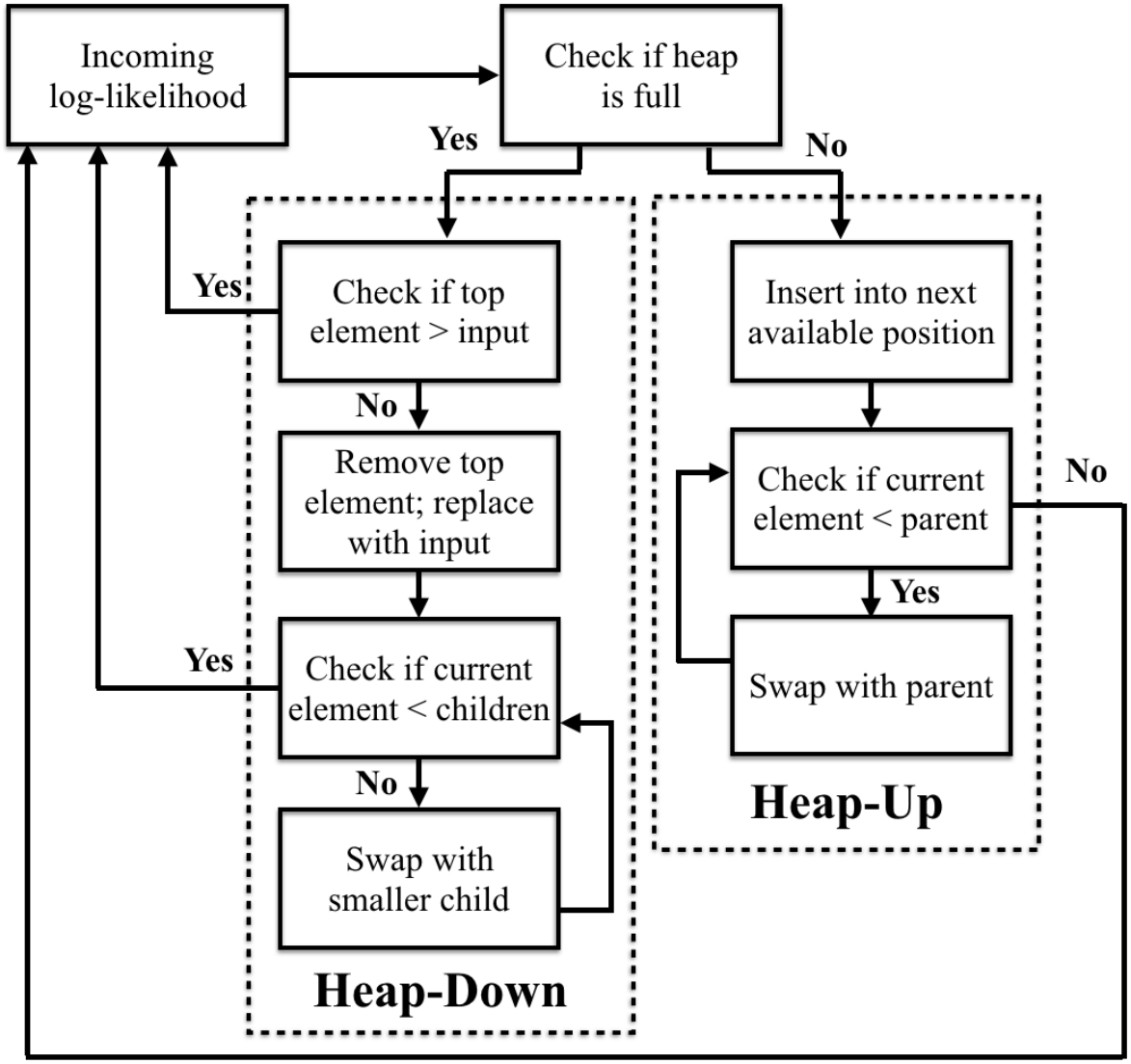




Sorting Module

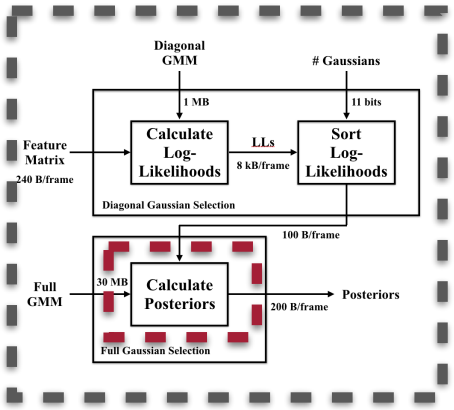
- Chooses *K* largest log-likelihoods

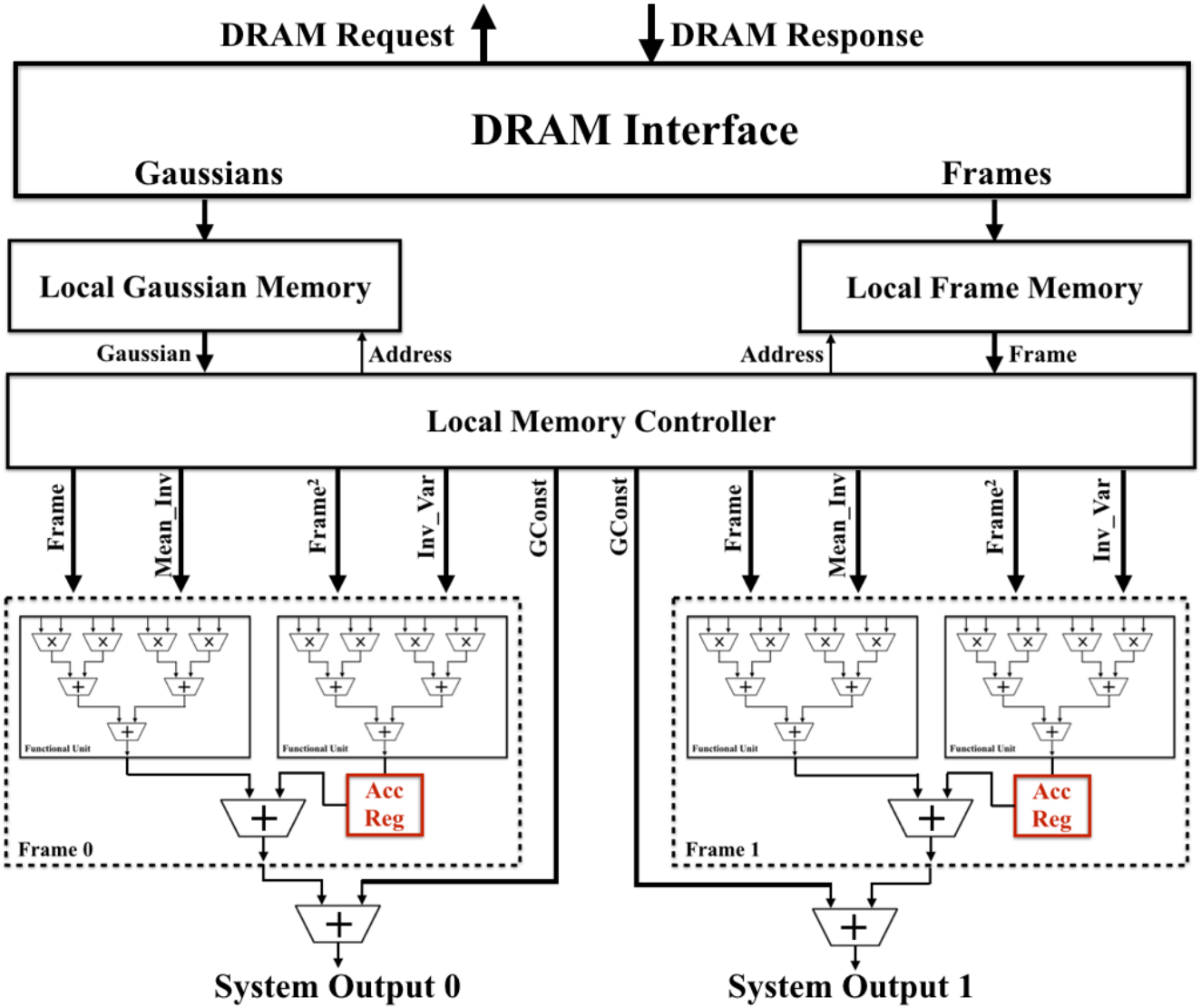




Full GMM Selection Module

- Computes two dot products
- 60 elements, 32 bits
- 1830 elements, 32 bits





Simulation Results

Gaussian ID	Hardware Value	Software Value	Error
0	-156.495	-156.5087	0.00875
4	-161.275	-161.2985	0.0145
5	-195.919	-195.9338	0.00755
6	-181.110	-181.1254	0.00850
8	-192.481	-192.4866	0.00290

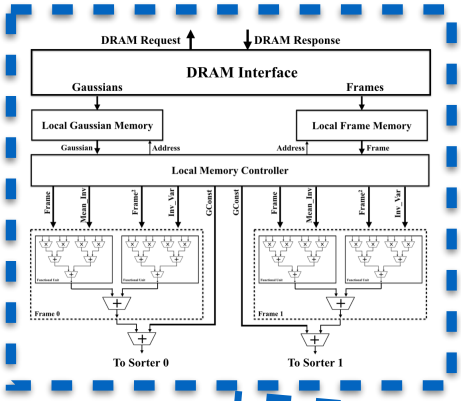
- Setup: 10 Gaussians, 2 frames, 5 selected
- Average error for the frame shown is 0.0085%

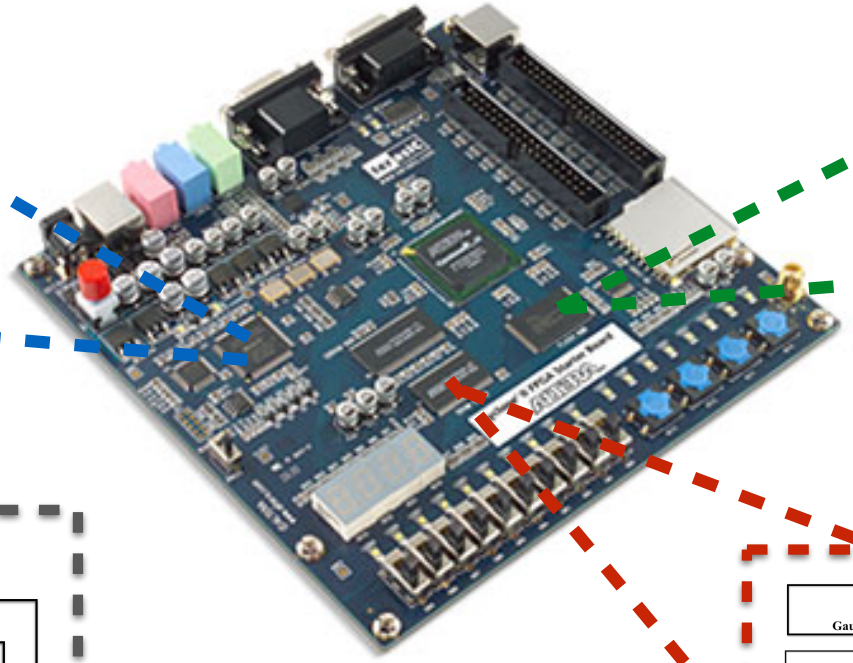
Synthesis Results

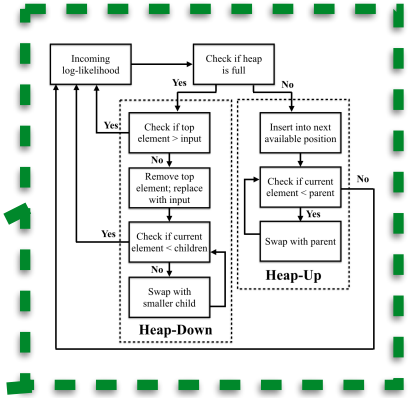
Parameter	Value
Slice LUTs	295450 (97.31% utilization)
Slice Registers	260133 (42.84% utilization)
Block RAM Tiles	354 (34.36% utilization)
DSP Blocks	1920 (68.57% utilization)
Clock Frequency	20 MHz
Critical Path	33.405 ns (In DRAM Control)
Total Negative Slack	0.000 ns
Total Negative Slack Failing Endpoints	277973
Worst Negative Slack	0.077 ns

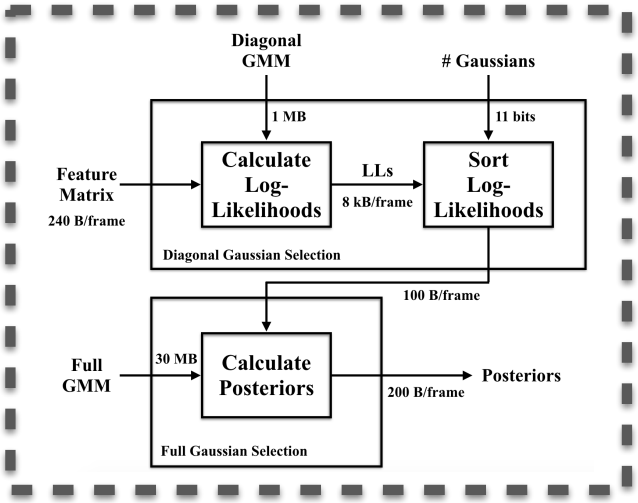
- Area was a significant concern
- Routing difficulties may have led to timing violations
- Could have increased BRAM utilization

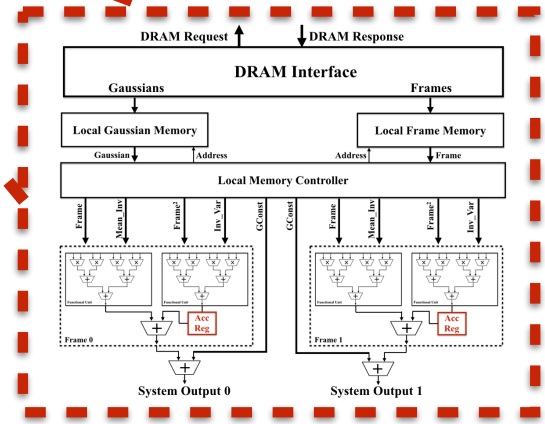
Questions?


DRAM Request
DRAM Response
DRAM Interface
Gaussians
Frames
Local Gaussian Memory
Local Frame Memory
Gaussian
Address
Address
Frame
Local Memory Controller
Frame
Mean_Inv
Frame²
Inv_Var
GConst
Frame 0
Frame 1
To Sorter 0
To Sorter 1




Incoming log-likelihood
Check if heap is full
Yes
No
Check if top element > input
Yes
No
Remove top element; replace with input
Check if current element < children
Yes
No
Swap with smaller child
Heap-Down
Insert into next available position
Check if current element < parent
No
Yes
Swap with parent
Heap-Up


Diagonal GMM
Gaussians
1 MB
11 bits
Feature Matrix
240 B/frame
Calculate Log-Likelihoods
LLs
8 kB/frame
Sort Log-Likelihoods
Diagonal Gaussian Selection
100 B/frame
Full GMM
30 MB
Calculate Posteriors
Posteriors
200 B/frame
Full Gaussian Selection


DRAM Request
DRAM Response
DRAM Interface
Gaussians
Frames
Local Gaussian Memory
Local Frame Memory
Gaussian
Address
Address
Frame
Local Memory Controller
Frame
Mean_Inv
Frame²
Inv_Var
GConst
Acc Reg
Frame 0
Frame 1
System Output 0
System Output 1