UNIVERSIDADE FEDERAL DO RIO GRANDE DO SUL
Instituto de Informática

Hardware Design for a Reference Frame Compression Technique for Multiview Video Coding

- **28th Southern Symposium on Microelectronics**

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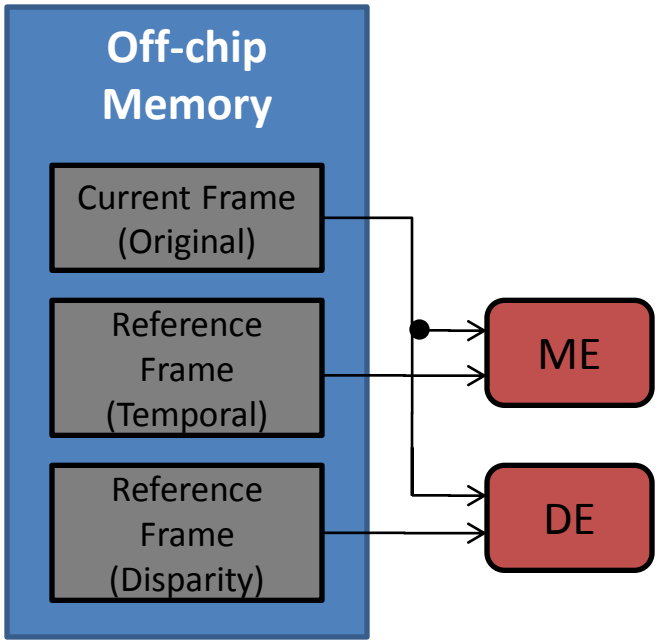
Introduction

- 3D Aplications
  - Multiple independent cameras record the same scene from different view points.
  - Same concept of multiview video coding.
- Multiview Video Coding Standardization
  - H.264/AVC Annex H (MVC Standard) in 2007
  - Provides 20-50% increased coding efficiency in comparison to the H.264/AVC.

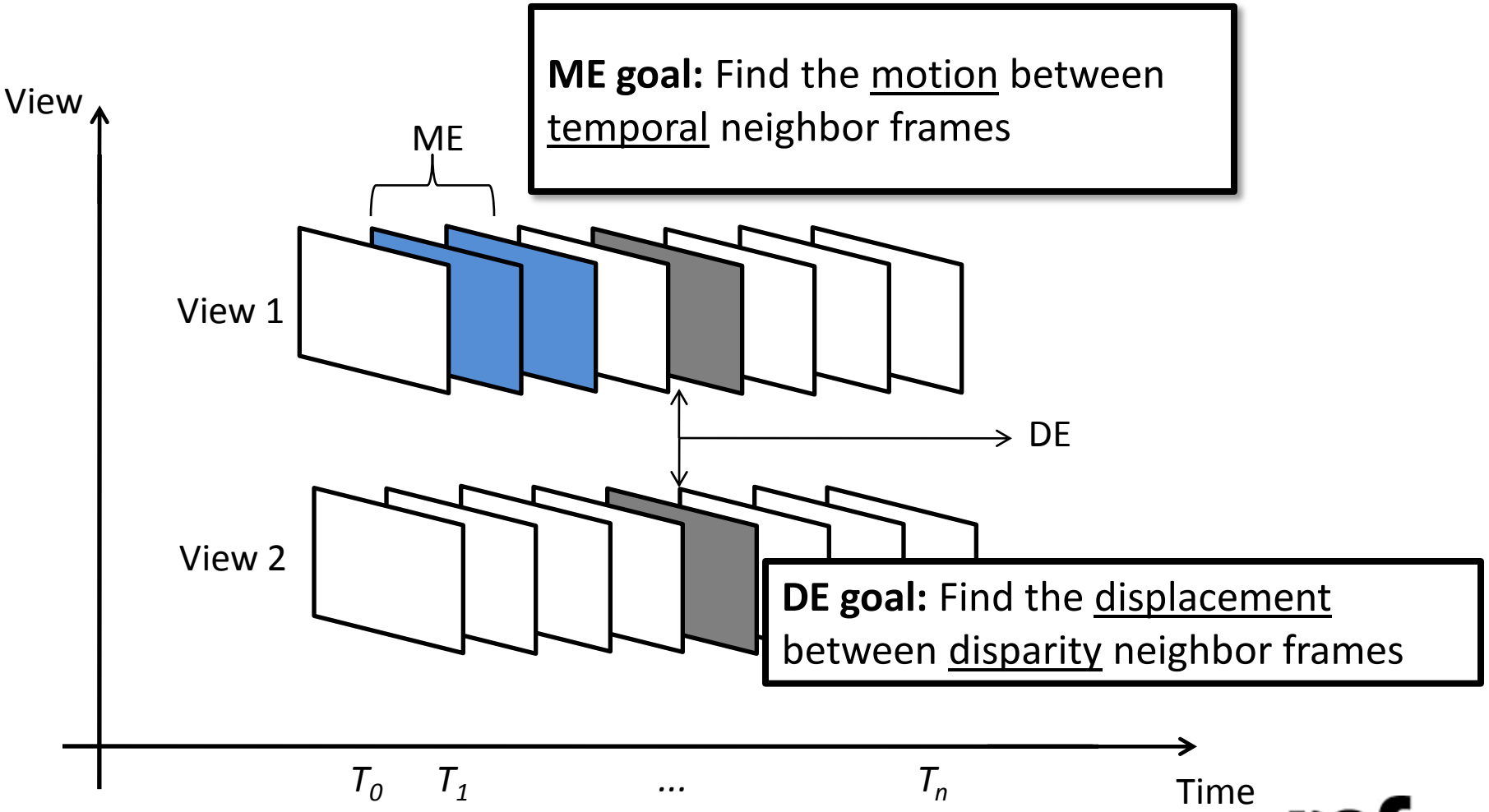
Problems

- **Off-chip Memory:** 90% of the ME/DE power consumption is related to the external and on-chip. (Zatt, 2011)



B. Zatt, M. Shafique, F. Sampaio, L. Agostini, S. Bampi, J. Henkel, "Run-time adaptive power-aware motion and disparity estimation in multiview video coding", **IEEE DAC**, pp. 1026-1031, 2011.

Motion and Disparity Estimation



Goals and Contributions

- **Goals:**
  - Design of an hardware architecture for a reference frame compression algorithm.
  - Reduce the memory traffic in the ME/DE on MVC encoders.
  - Evaluation of performance and hardware utilization.

Reference Frame Compression Technique

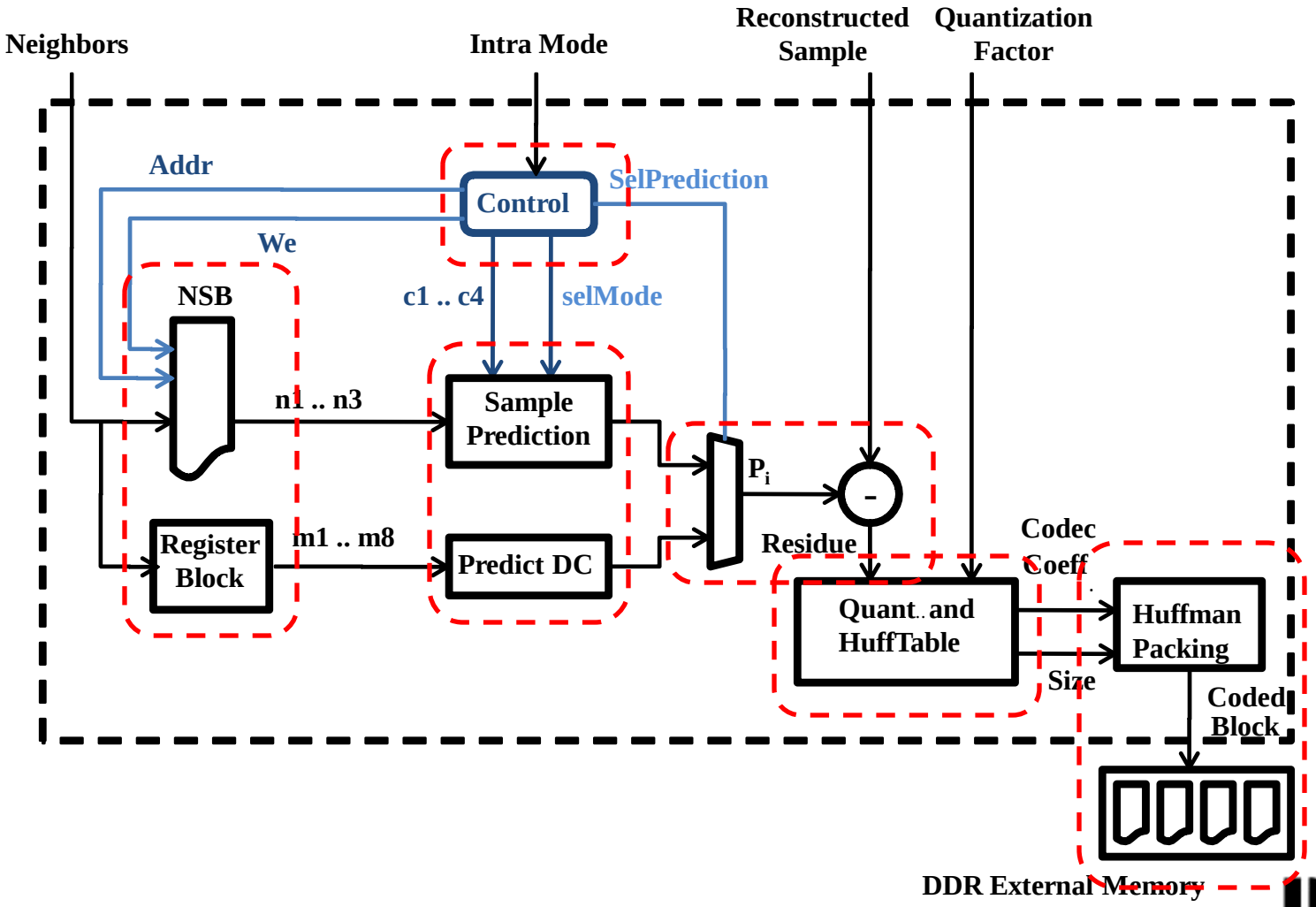
- The compression scheme is able to reduce the external memory accesses by up to 63%. (Sampaio, 2013)

Algorithm: Content-Adaptive Reference Frame Compression

```
1. // inputs: predModes[]: sixteen RDO MVC encoder intra prediction modes
2. //origBlock4x4[]: original 4x4 block samples
3. //reconBlock4x4[]: reconstructed 4x4 block samples
4. // outputs: codedBlock4x4[]: compressed bitstream to send to the DPB
5.function compressBlk4x4(predModes[ ], origBlock4x4[ ], reconBlock4x4[ ])
6.    codedBlock4x4 ← 0
7.    foreach reconSample, origSample in reconBlock4x4, origBlock4x4 loop
8.        predictSample ← intraPrediction(neighbors, predModes[reconSample])
9.        residueSample ← predictSample - reconSample
10.       quantizedSample ← quantization(residueSample)
11.       huffmanSample ← staticHuffman(quantizedSample, huffTable)
12.       codedSample ← packer(huffmanSample)
13.   end loop
14.   return codedBlock4x4
15.end function
```

Sampaio, F. "Energy-Efficient Memory Hierarchy for Motion and Disparity Estimation in Multiview Video Coding" **(Dissertação)**. Universidade Federal do Rio Grande do Sul, Porto Alegre, 15 fev. 2013

Hardware Architecture



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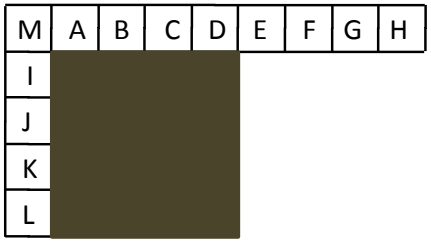
Neighbors Sample Buffer

- The thirteen neighbors required for the processing of one 4x4 block are stored in a memory.
- Each memory position is composed of three consecutive neighbors.
- Each memory position in the NSB occupies 24 bits (3 x 8bits).

NSB	
0 0 0 0	LKJ
0 0 0 1	KJI
0 0 1 0	JIM
0 0 1 1	IMA
0 1 0 0	MAB
0 1 0 1	ABC
0 1 1 0	BCD
0 1 1 1	CDE
1 0 0 0	DEF
1 0 0 1	EFG
1 0 1 0	FGH

Neighbors Sample



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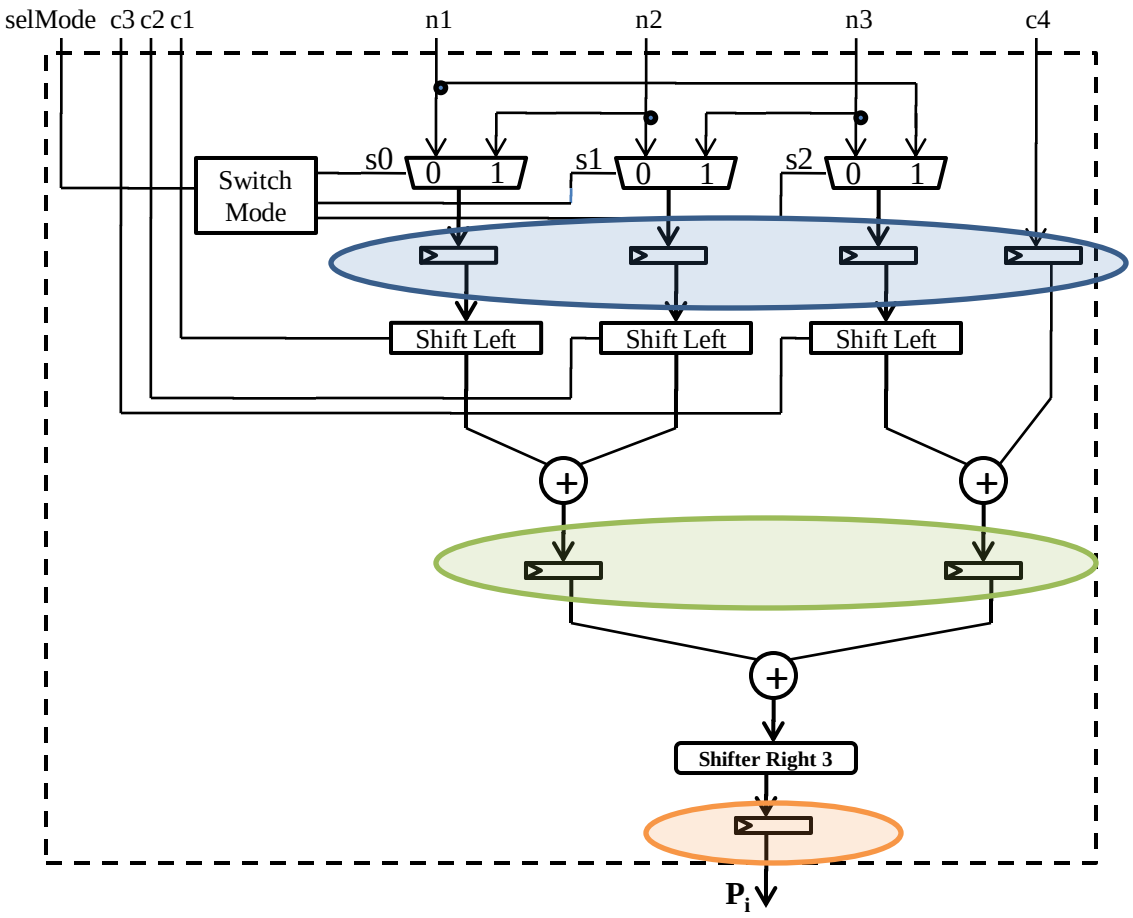
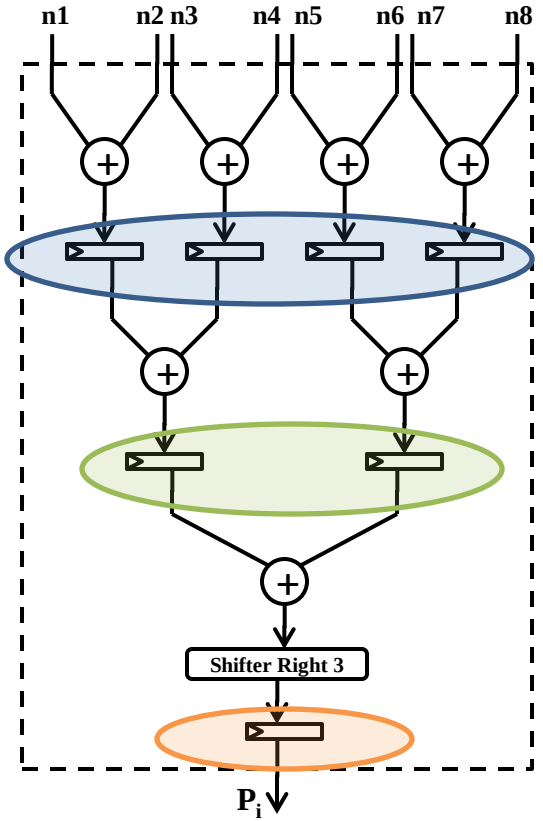
Sample Predictor

Sample Prediction



Prediction DC



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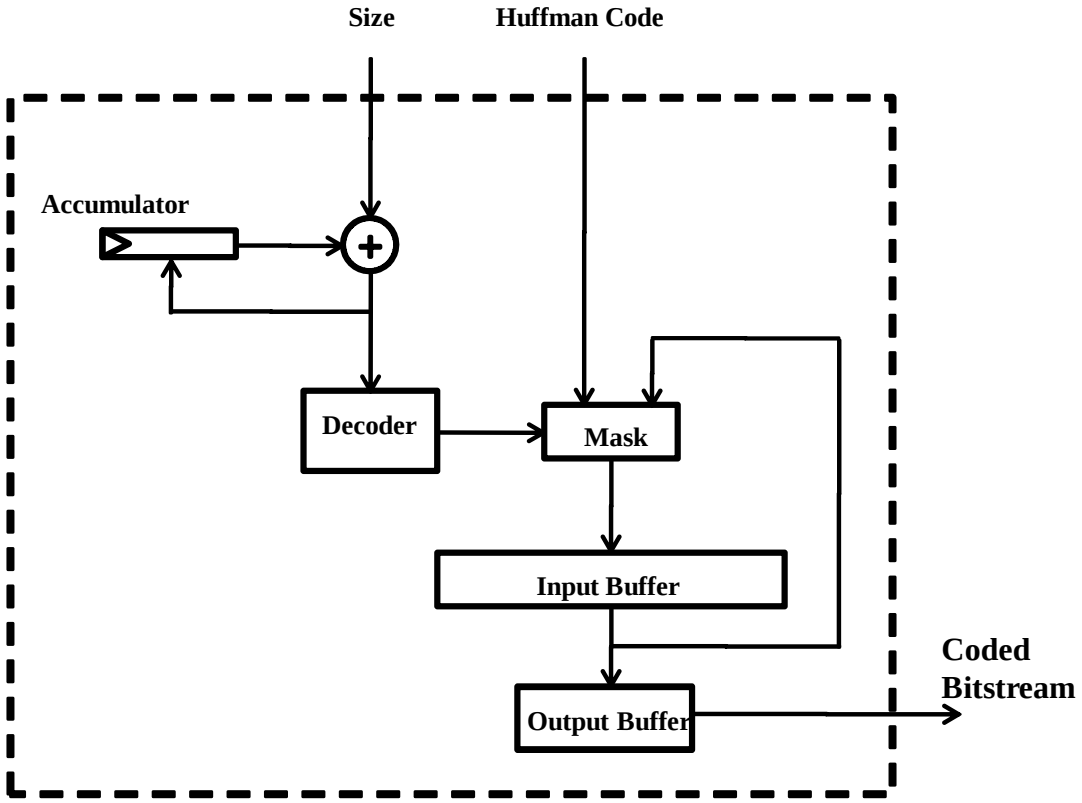
Quantize and Huffman Encoder

- Static Quantization and Huffman Encoder.
- The input code is relates with the fixed conversion table.
- The quantization and Huffman table was mapped to a memory.

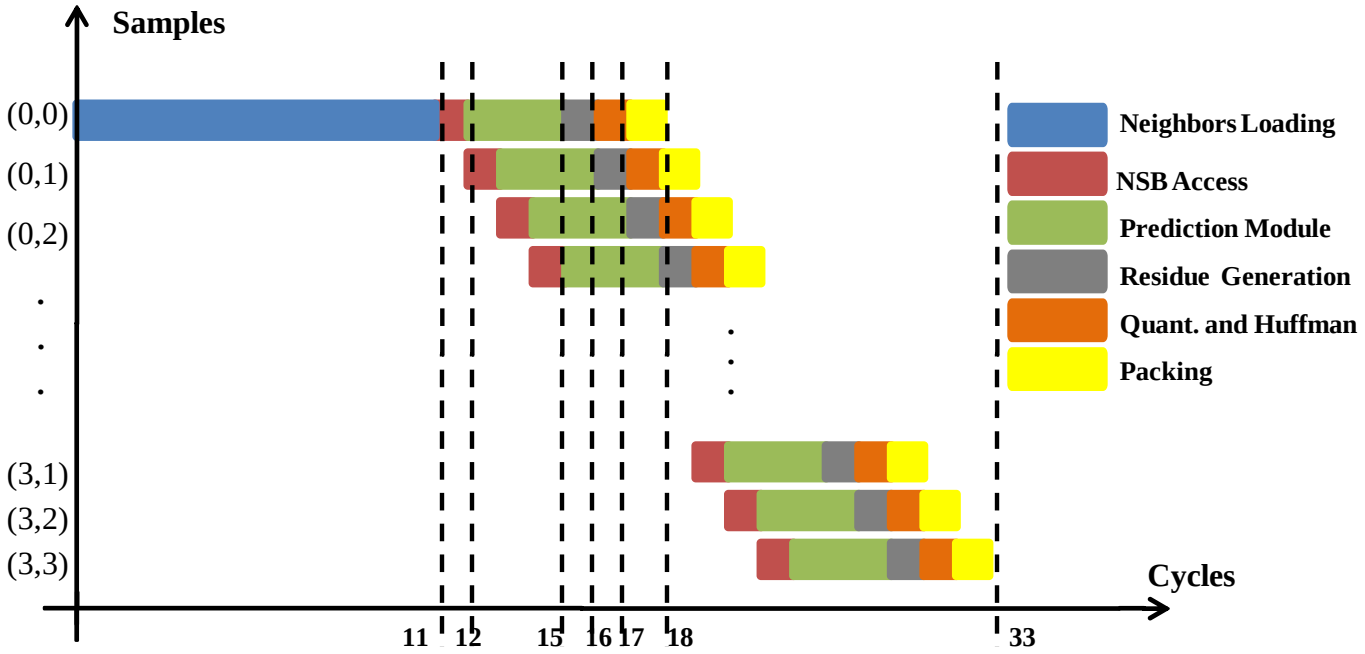
Packing

- Decoder module receives the number of valid bits on the Huffman code.
- The Mask module is responsible for packing these valid codes.
- The 16 most significant bits are sent to the output buffer.
- The rest of valid bits are sending to the Mask module and the process begins again.



Pipeline Schedule

- Pipeline schedule for the compression of one 4x4 block.



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Results

- Target Device (FPGA): Virtex 5 Xilinx FPGA (xc5vlx30)
- Maximum Frequency of Operation: 372 MHz

- Architecture Performance Evaluation:

Logic Utilization Summary	
#LUTs	98 (1%)
#FFs	89
#Slice FFs	89
#BRAMs	1
Frequency[MHz]	372

Resolution	Frequency [MHz] for 30fps			Throughput [fps] @max. freq.		
	2-view	4-view	8-view	2-view	4-view	8-view
VGA	38	76	152	293	146	73
XGA	97	194	389	114	57	28
HD1080	256	513	1026	43	21	10

Conclusions

- Hardware architecture design for a reference frame compression technique for Motion and Disparity Estimation (ME/DE) on MVC.

- Achievements:
  - 2-view 1080p processing in real time (@30 fps)
  - Reduced off-chip memory bandwidth
  - Low impact of hardware (1%)

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Thank You!

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