Accelerating AI in Datacenters
Xilinx ML Suite

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Director, Data Center IP Solutions
2nd October 2018

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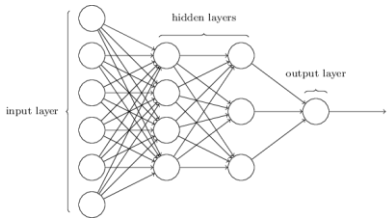
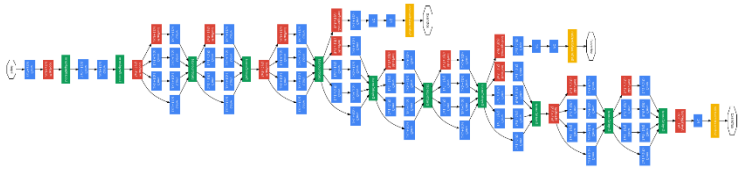
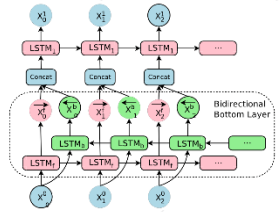
Deep Learning Models – A broad spectrum







Multi-Layer Perceptron

- Classification
- Universal Function Approximator
- Autoencoder

Convolutional Neural Network

- Feature Extraction
- Object Detection
- Image Segmentation

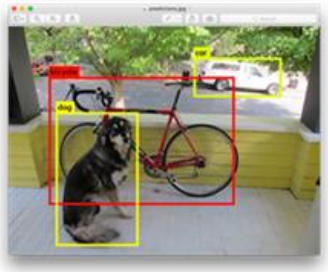
Recurrent Neural Network

- Sequence and Temporal Data
- Speech to Text
- Language Translation

Classification

“Dog”

Object Detection



Segmentation

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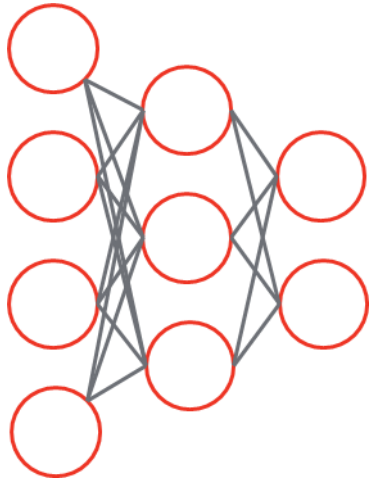
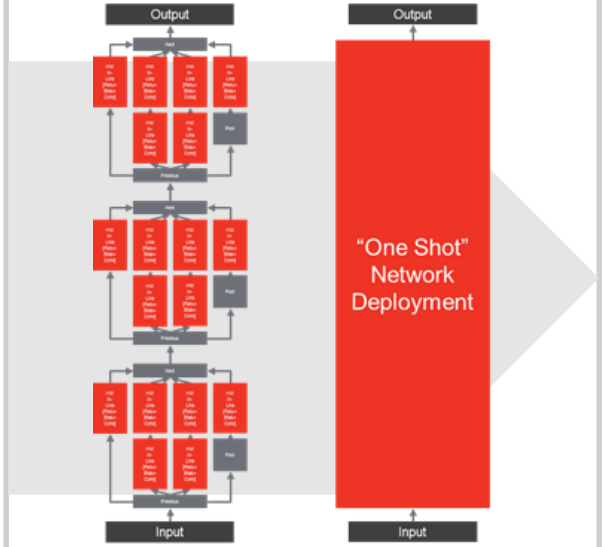
Xilinx ML Suite – DNN Processor + “Compiler, Quantizer, Runtime”

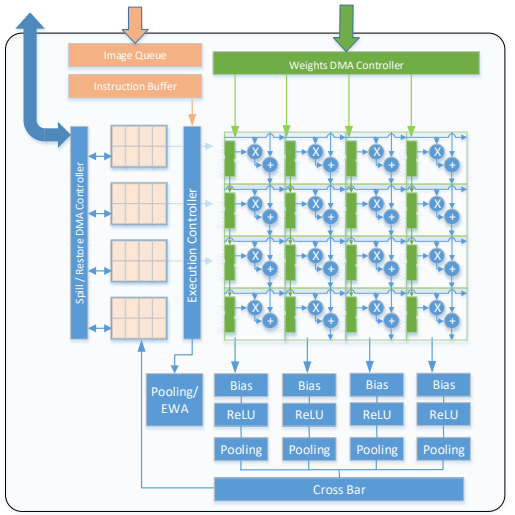
Trained Model



Compiler + Runtime



Xilinx DNN Processor



Low Latency, High Throughput – Batch 1

60-80% Efficiency

No FPGA Expertise Required

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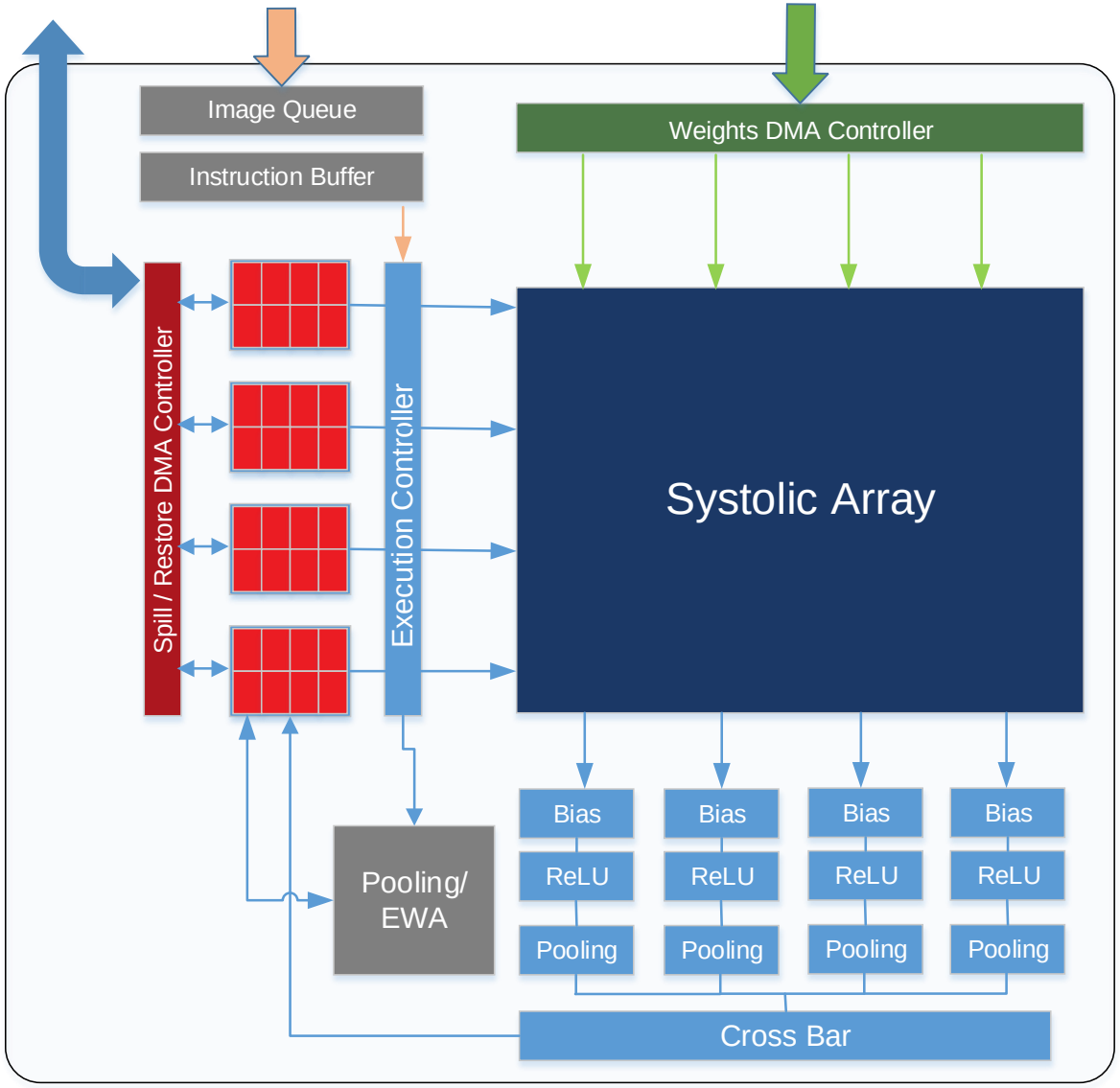
Xilinx DNN Processor (xDNN)



- Configurable Overlay Processor
- DNN Specific Instruction Set
  - Convolution, Max Pool etc.
- Any Network, Any Image Size
- High Frequency & High Compute Efficiency
- Compile and run new networks

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Rapid Feature and Performance Improvement

xDNN-v1 Q4CY17

- Array of Accumulator
- Int16 (Batch=1) and Int8 (Batch=2) support
- Instructions: Convolution, ReLU, Pool, Elementwise
- Flexible kernel size(square) and strides
- 500 MHz

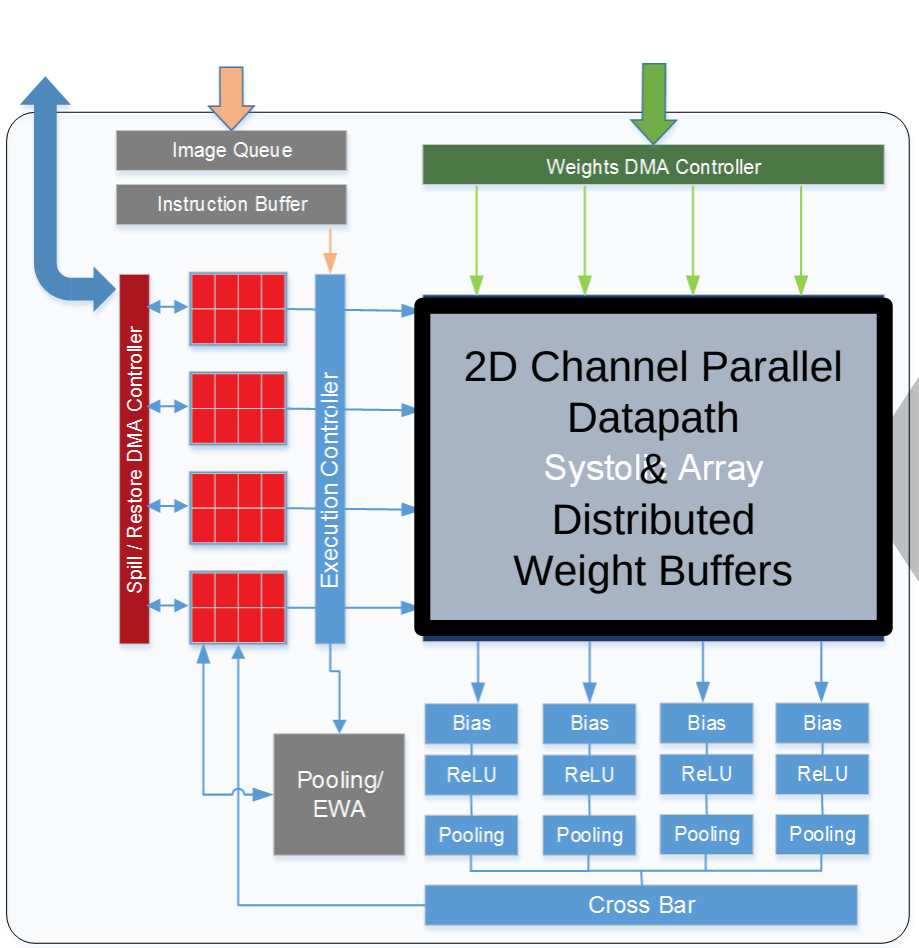
xDNN-v2 Q2CY18

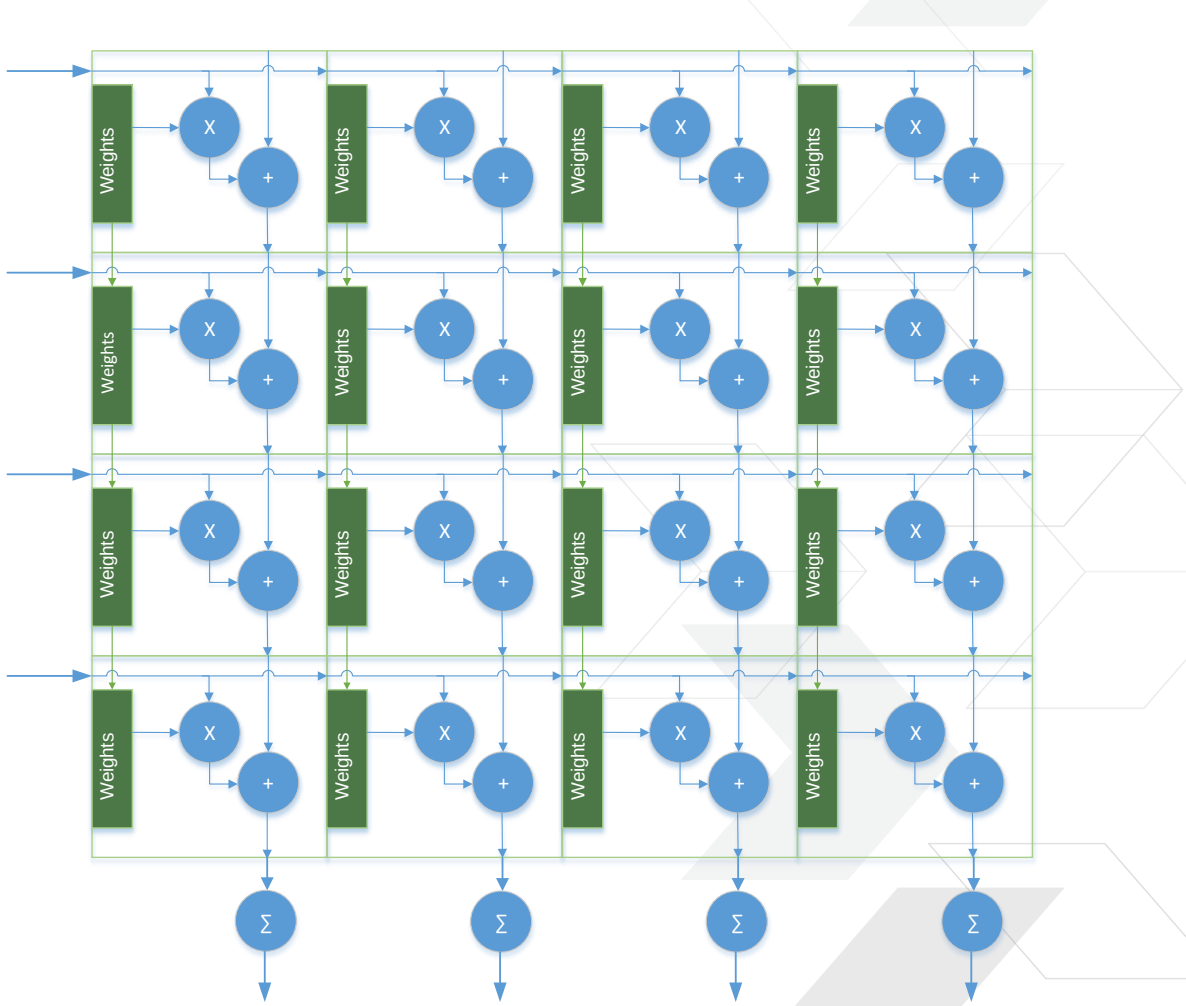
- All xDNN-v1 Features
- DDR Caching: Larger Image size
- New Instructions: Depth-wise Convolution, De-convolution, Up-sampling
- Rectangular Kernels
- 500 MHz

xDNN-v3 Q4CY18

- New Systolic Array Implementation: 2.2x lower latency
- Instruction Level Parallelism – non-blocking data movement
- Batch=1 for Int8 – lower latency
- Feature compatible with xDNN-v2
- 720+ MHz

xDNN – Channel Parallel Systolic Array





Micro-Architecture Optimized for underlying Ultrascale+ FPGA Fabric

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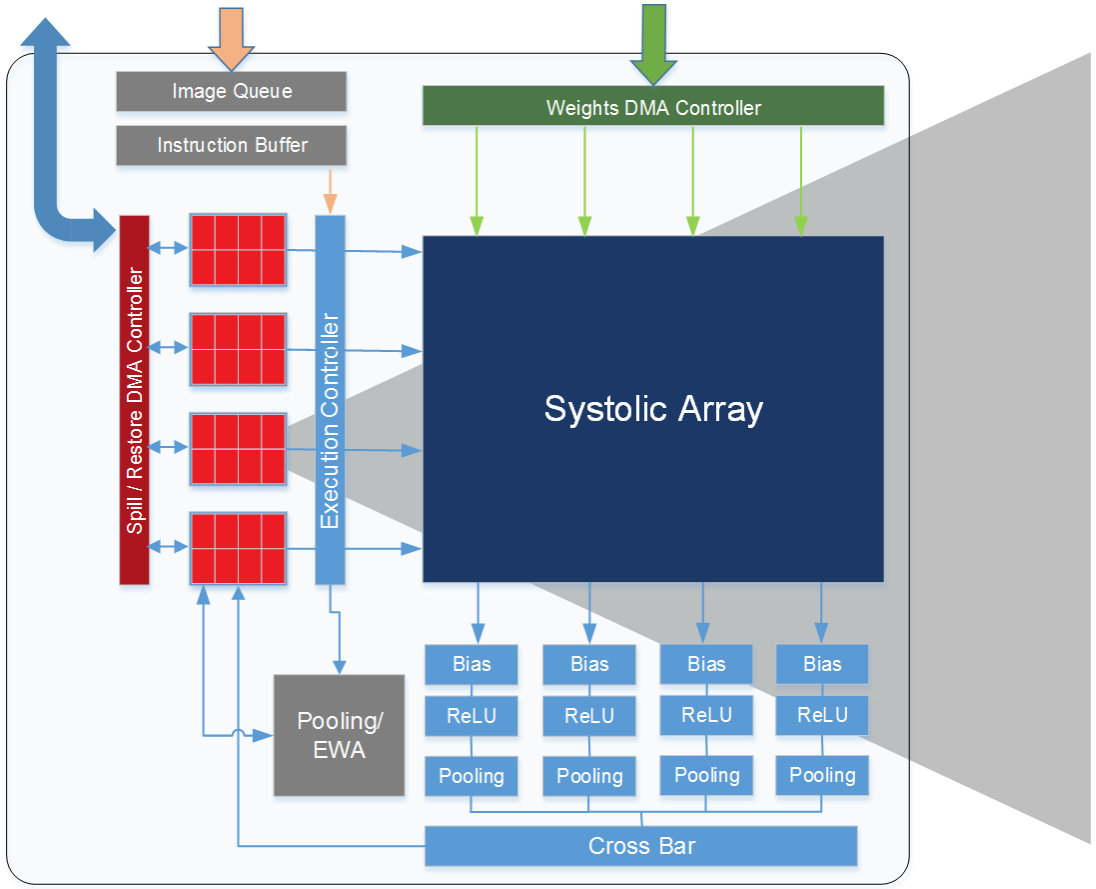
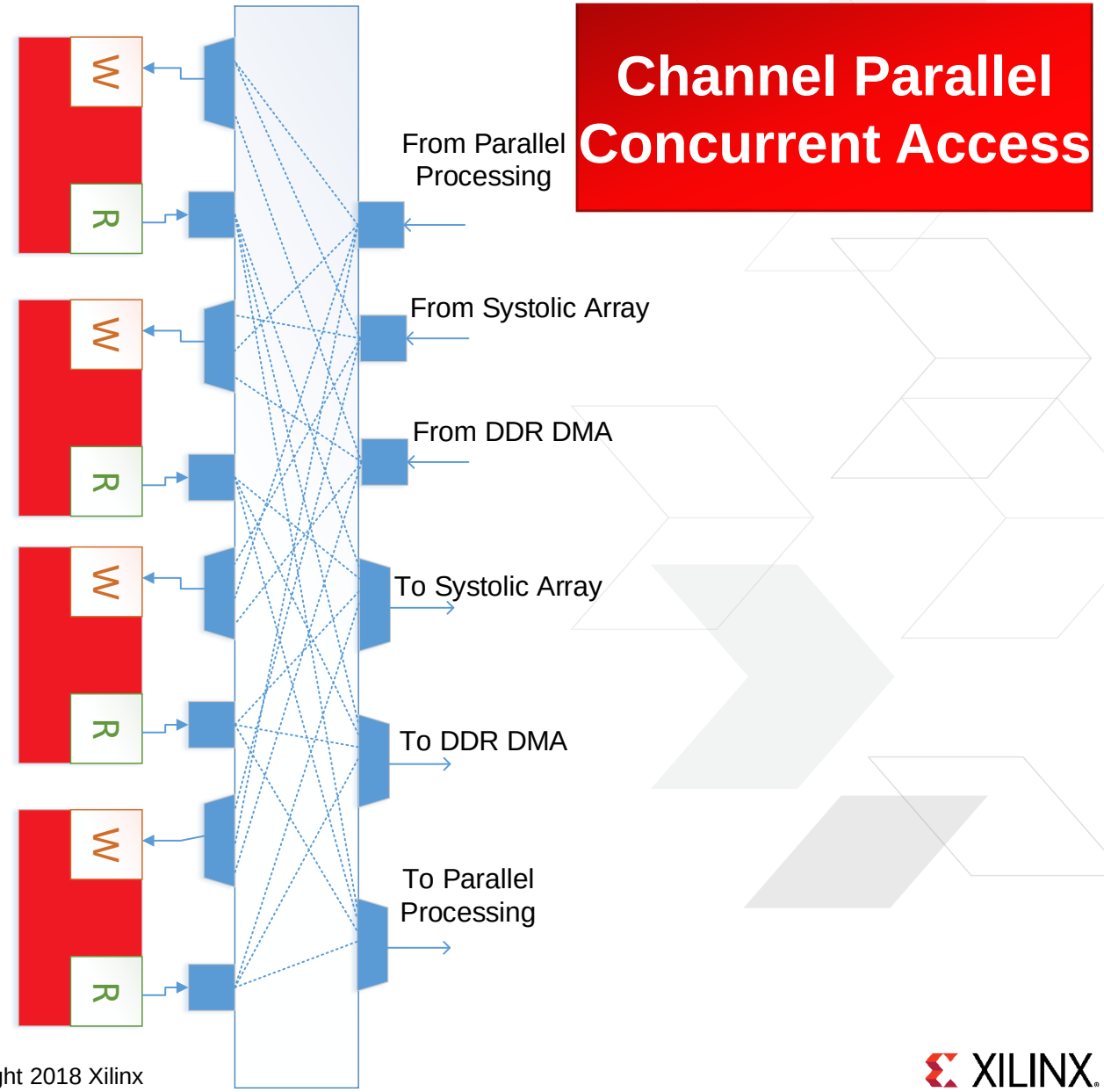
xDNN Processor – Tensor Memory





Channel Parallel Concurrent Access

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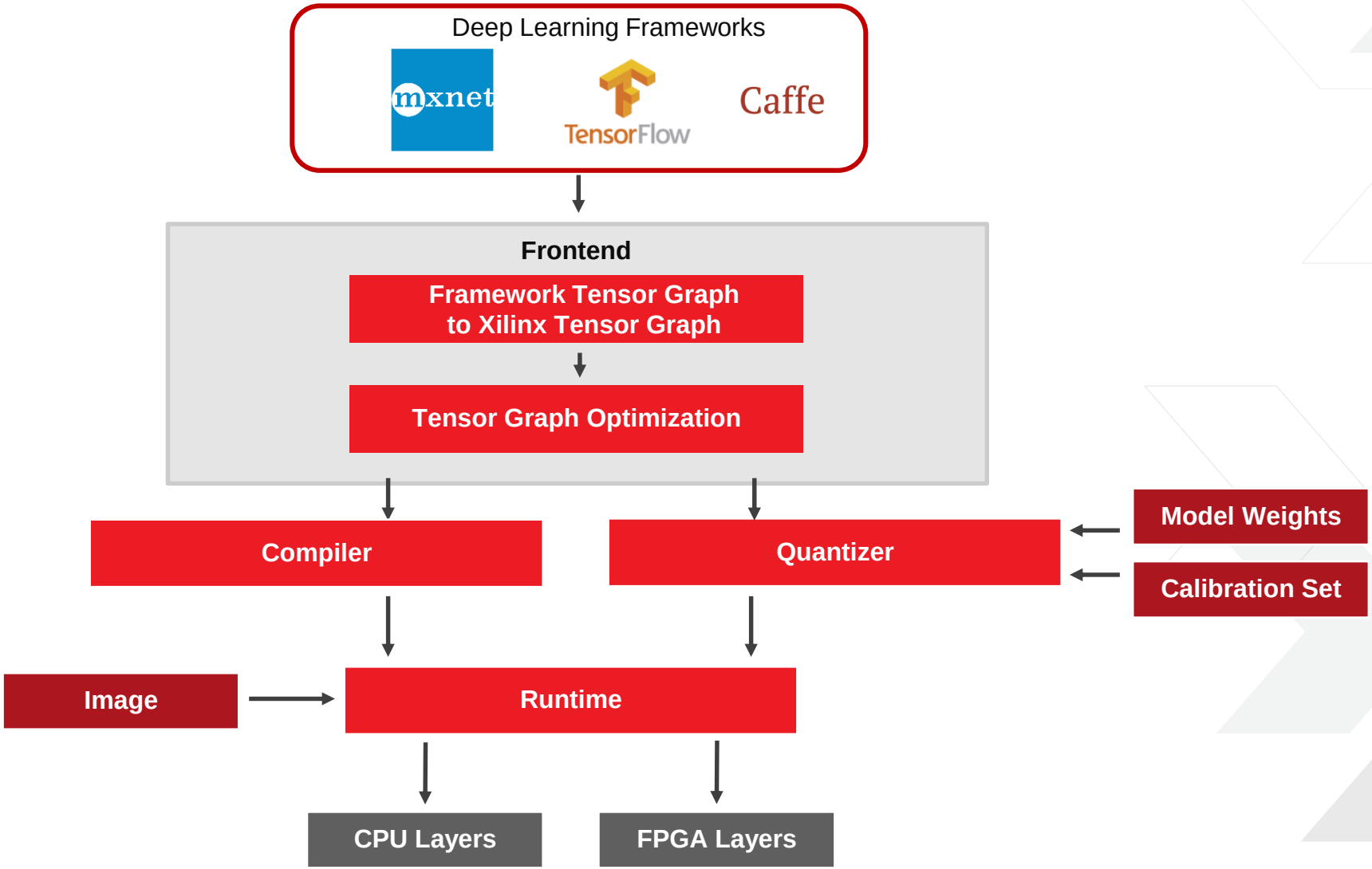
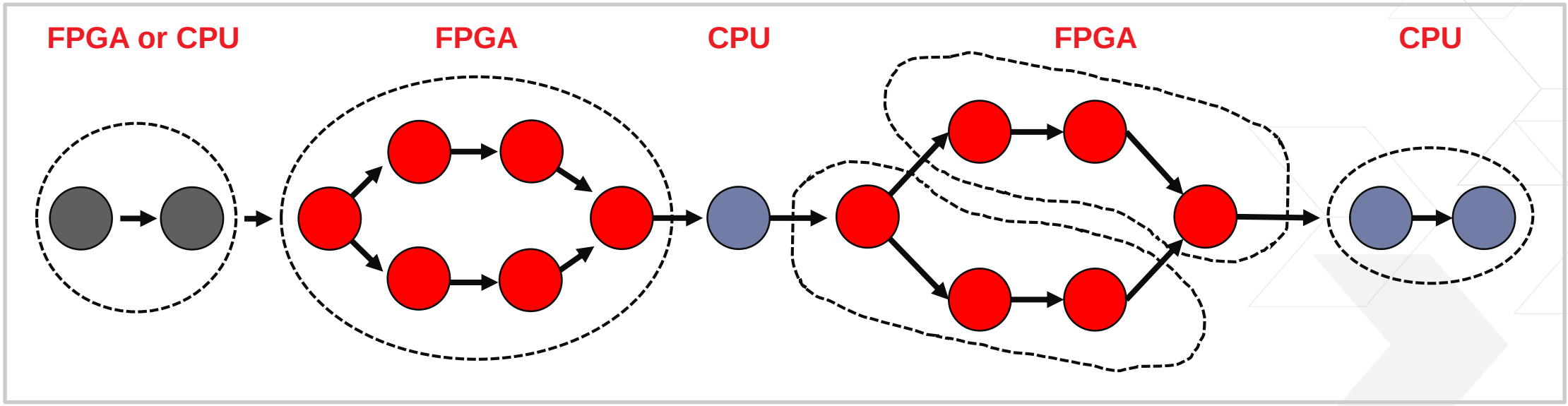
xDNN Compiler + Runtime



https://github.com/Xilinx/ml-suite

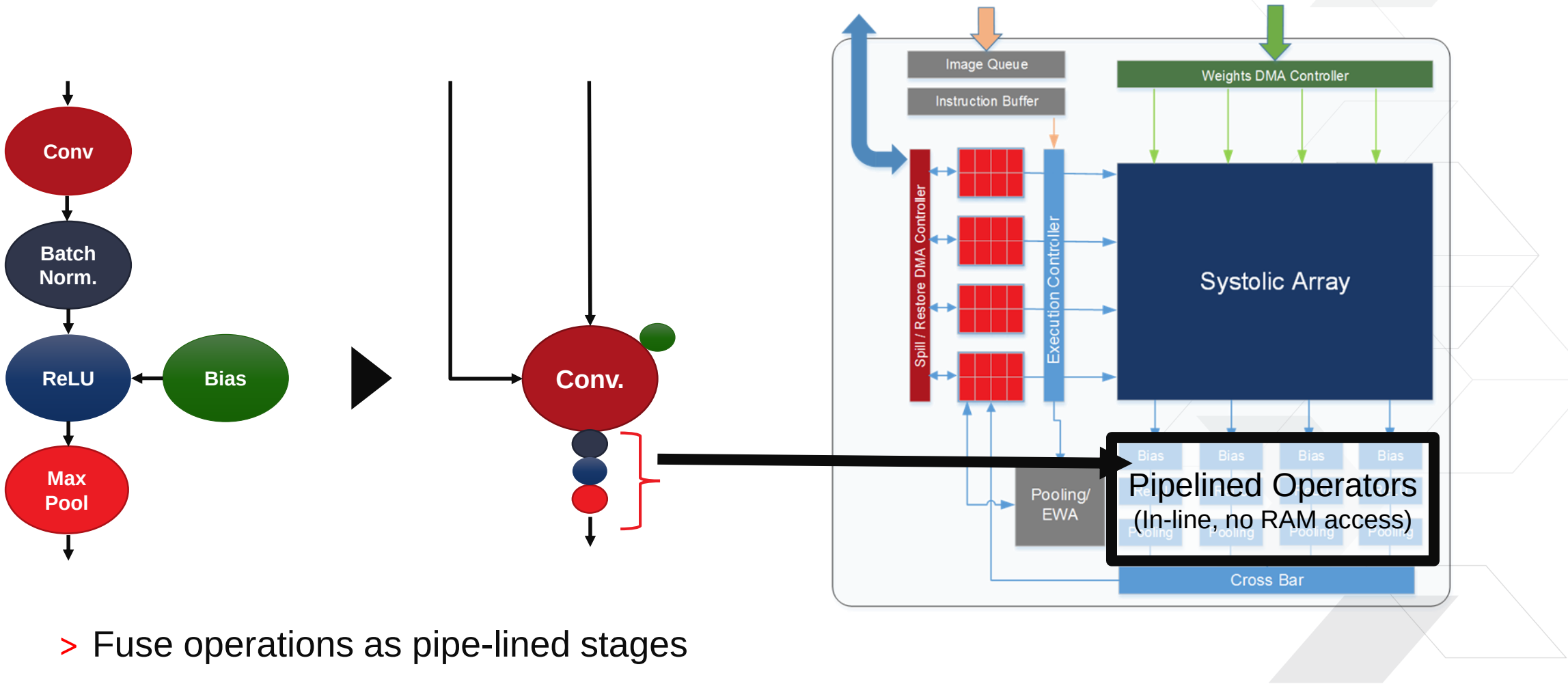
Graph Partitioning

- One time loading of sub-graph instructions
- Data Flow Execution



1 Core -> Multi-Core -> Multi-Chip

Fusing of Operations



- Fuse operations as pipe-lined stages
- Access activations only once

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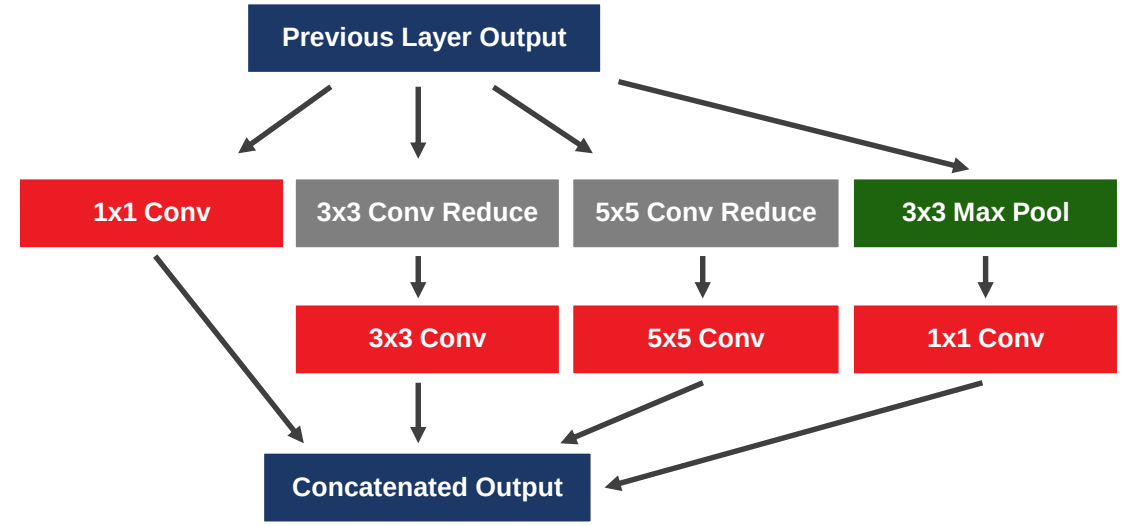
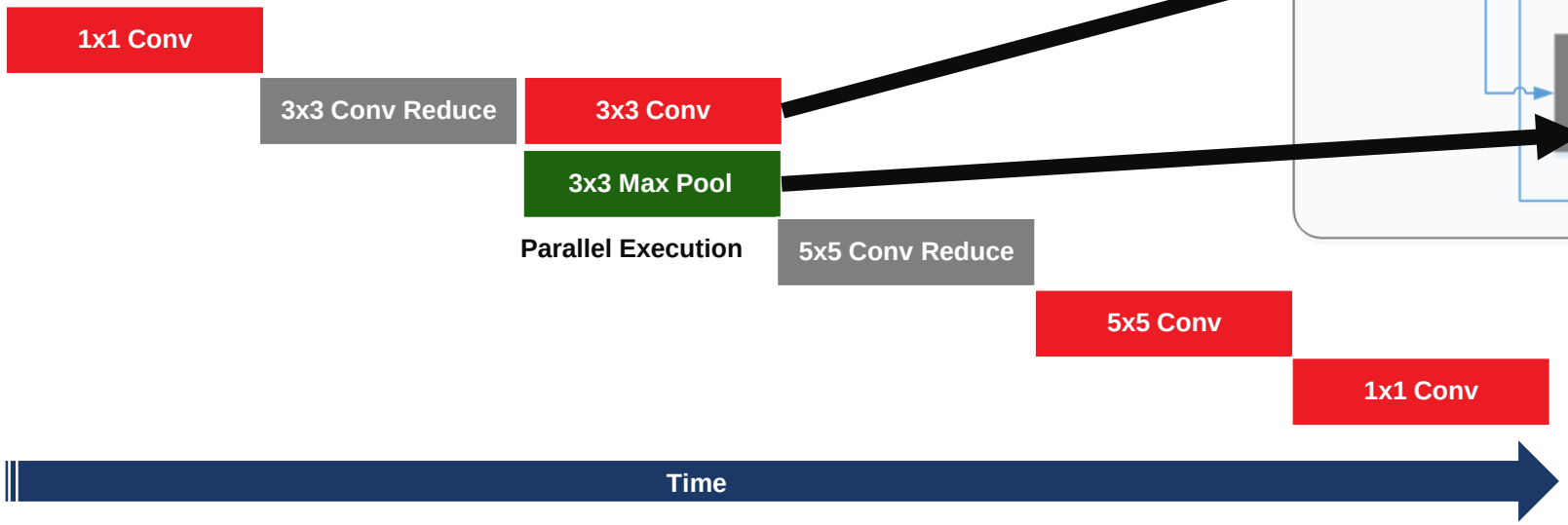
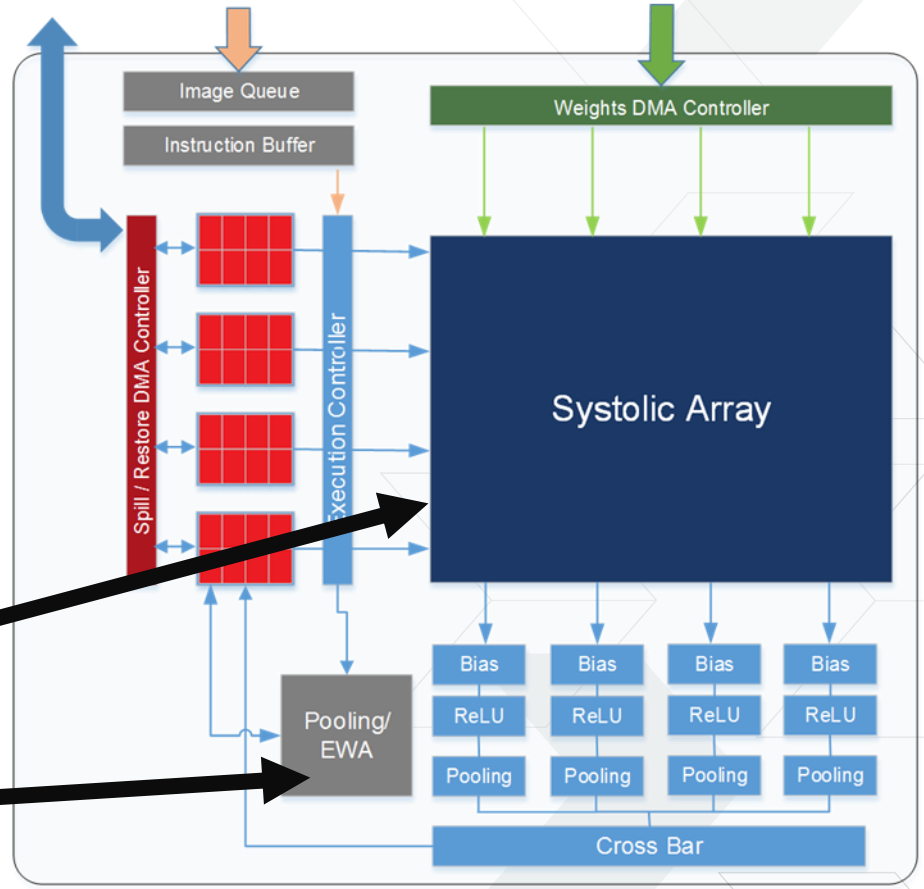
Instruction Level Parallelism







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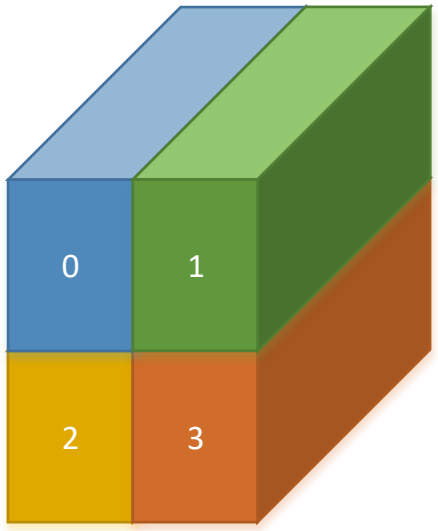
Automatic Intra Layer Tiling

- Tile when Feature Map size exceeds on-chip memory
- Work on full feature map depth

Any Feature Map Size



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xfDNN Runtime Engine

- ML specific engine built on top of SDx runtime
- Lightweight and portable with no dependency on ML frameworks
- Extensive C++/Python API with simplified use model
- Asynchronous XDNN execution
- Streaming/pipeline/Dataflow support for large imageset
- Multiple CNN models running on single FPGA
- Multiple FPGA support

Simple Usage

```
import xdnn, xdnn_io

args = xdnn_io.processCommandLine()
xdnn.createHandle(args['xclbin'], "kernelSxdnn_0", args['xlnxlib'])

(weightsBlob, fcWeight, fcBias) = xdnn_io.loadWeights(args)

(fpgaInputs, batch_sz) = xdnn_io.prepareInput(args)
fpgaOutput = xdnn_io.prepareOutput(args['fpgaoutsz'], batch_sz)

xdnn.execute(args['netcfg'],
  weightsBlob, fpgaInputs, fpgaOutput,
  batch_sz, args['quantizecfg'])

fcOut = xdnn.computeFC(fcWeight, fcBias, fpgaOutput)

softmaxOut = xdnn.computeSoftmax(fcOut)

xdnn_io.printClassification(softmaxOut, args);

xdnn.closeHandle()
```

Blocking

```
# exec_async() enqueues FPGA task and returns immediately
xdnn.exec_async(args['netcfg'],
  weightsBlob, fpgaInputs, fpgaOutput,
  batch_sz, args['quantizecfg'], args['PE'])

# get_result() blocks for FPGA result
xdnn.get_result(args['PE'])
```

Non-Blocking

```
numFPGAs = 8
args = xdnn_io.processCommandLine()
xdnn.createHandle(args['xclbin'], "kernelSxdnn_0", args['xlnxlib'], numFPGAs)

(weightsBlob, fcWeight, fcBias) = xdnn_io.loadWeights(args)
```

8-FPGA

https://github.com/Xilinx/ml-suite

Xilinx ML Suite

Tag: 1.1 | New pull request | Find file | Clone or download

kamranjk Update README.md — Latest commit 233b9ad 27 days ago

apps	Update README.md	a month ago
docs	Update README.md	27 days ago
examples	Update README.md	28 days ago
ext	Release 1.1 to master	a month ago
gemx	Doc updates, Notebook bug fix, Binary upgrade	a month ago
models	Delete yolo-xdnn-tend-20180206-bnremove.weights	28 days ago
notebooks	Doc updates, Notebook bug fix, Binary upgrade	a month ago
overlaybins	Add support for perpetual demo	a month ago
tests/gemx	Release 1.1 to master	a month ago
xfdnn	Add support for perpetual demo	a month ago

Server Platforms
Intel x86, AMD Epyc, Power9, ARM

FaaS
awsmarketplace, NIMBIX, Alibaba Cloud aliyun.com, HUAWEI*

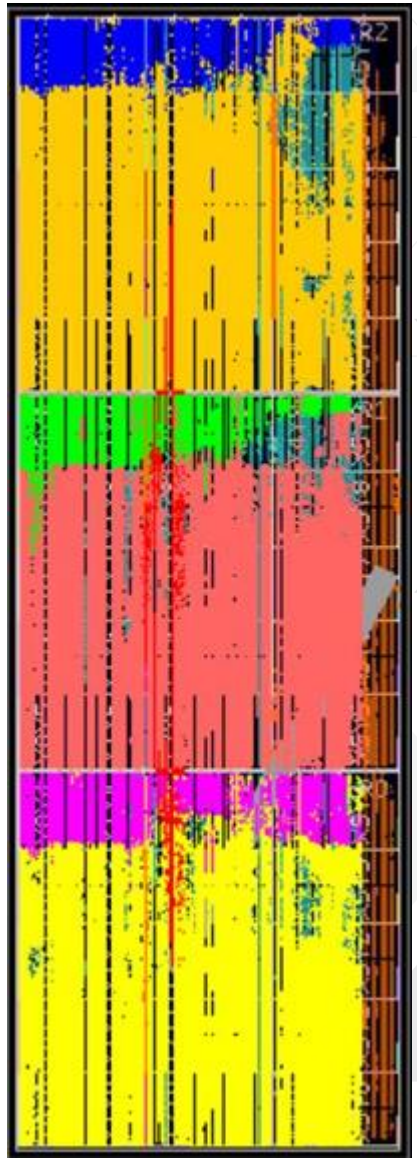
Xilinx Boards

*Under Development

xDNN v3 Implementation on Alveo U200

- 3 Large 96x16 PEs– 1 in each SLR – 5.2 ML Shell
- Kernels @ 720 MHz/360MHz

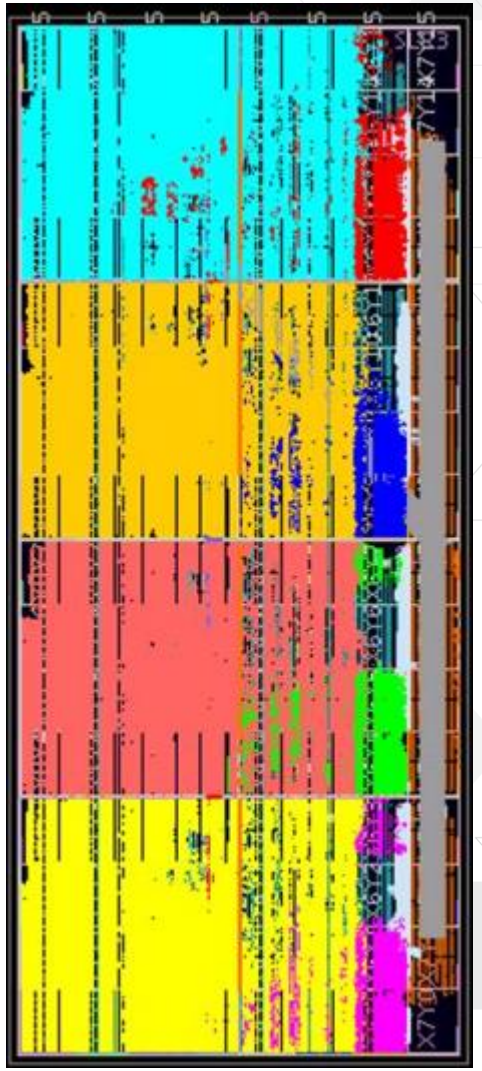
Resource	Count	Utilization
LUTs	658k	52%
DSPs	5661	80%
BRAM	1258	58%
URAM	864	92%



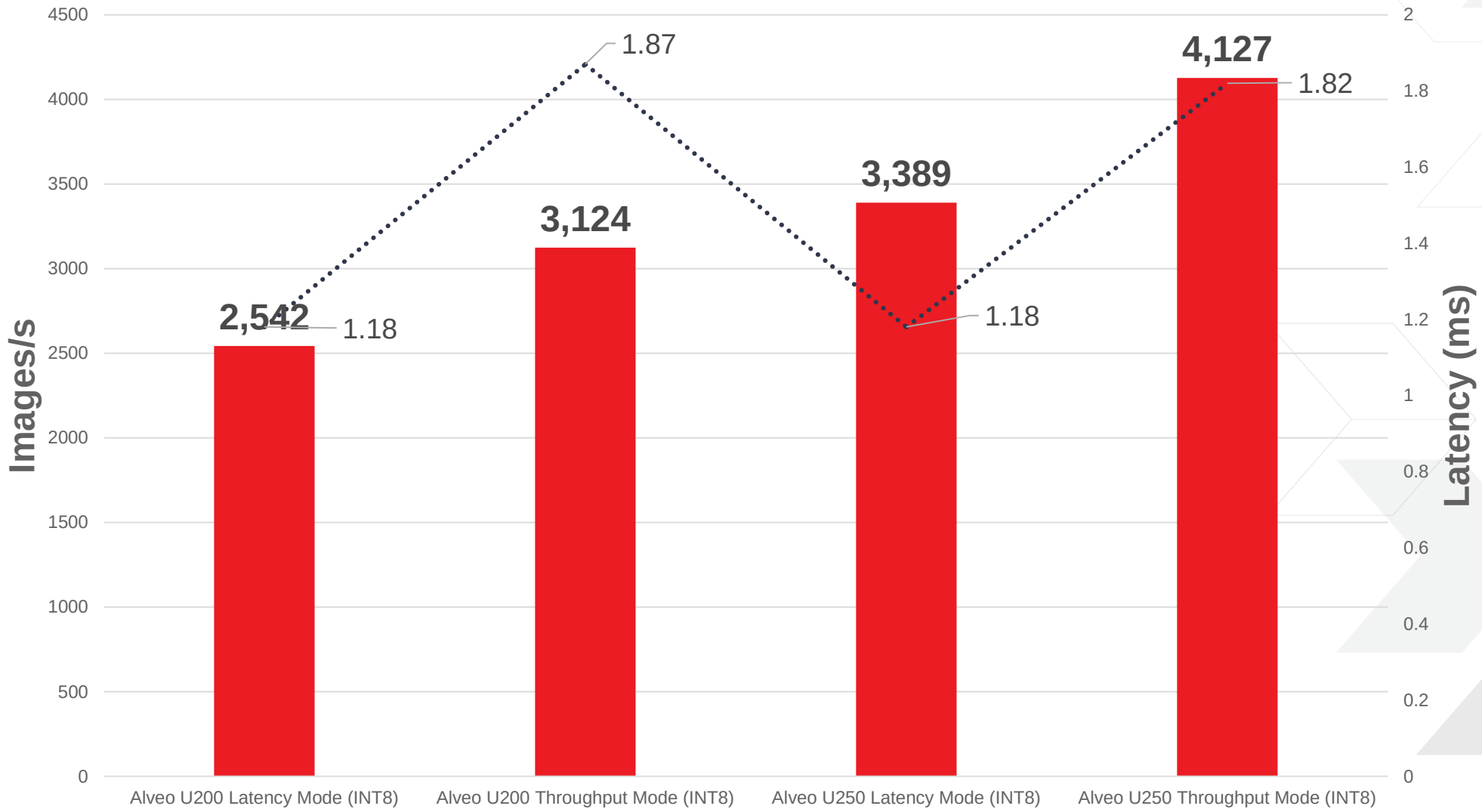
xDNN v3 Implementation on Alveo U250

- 4 Large 96x16 PEs– 1 in each SLR – standard 5.2 Shell
- Kernels at 700 MHz/350 MHz

Resource	Count	Utilization
LUTs	876k	51%
DSPs	7548	62%
BRAM	1632	61%
URAM	1152	90%



xDNN GoogLeNet v1 Performance – Image Size 224x224



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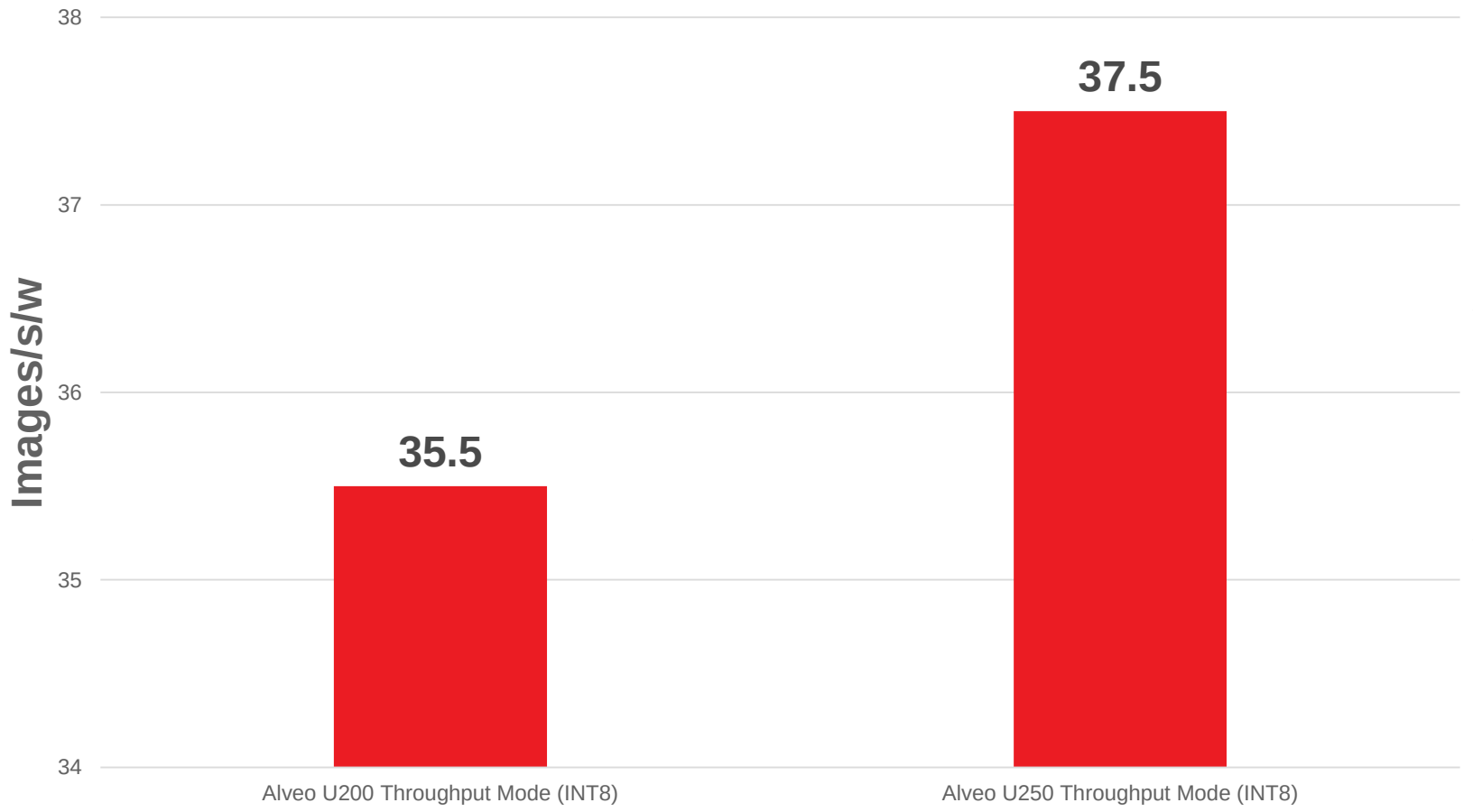
xDNN GoogLeNet v1 Energy Efficiency



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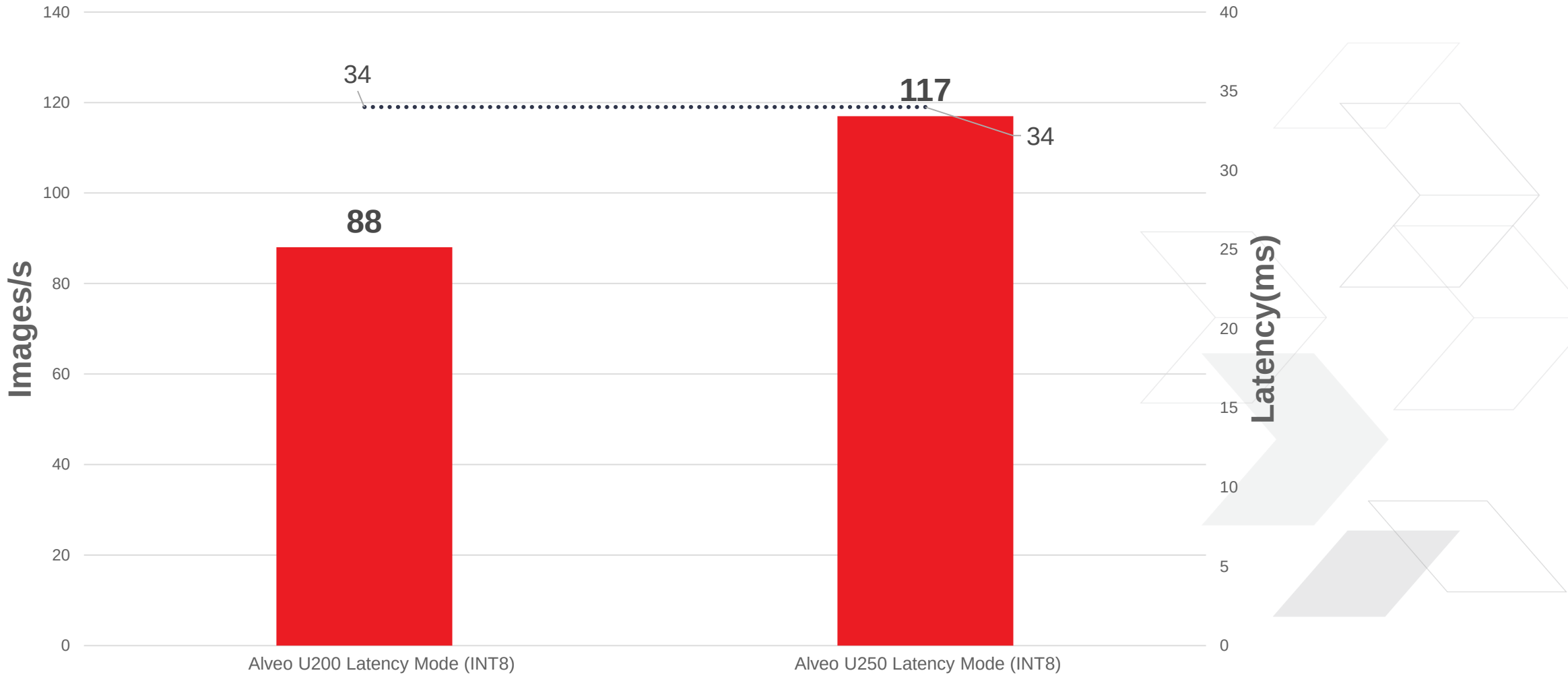
xDNN YOLO v2 Performance – Image Size 608x608



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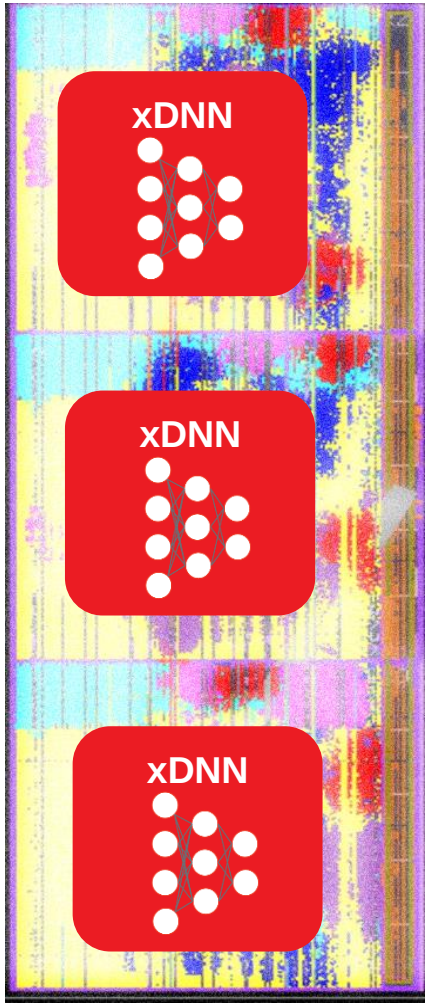
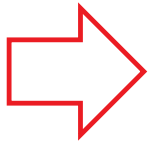
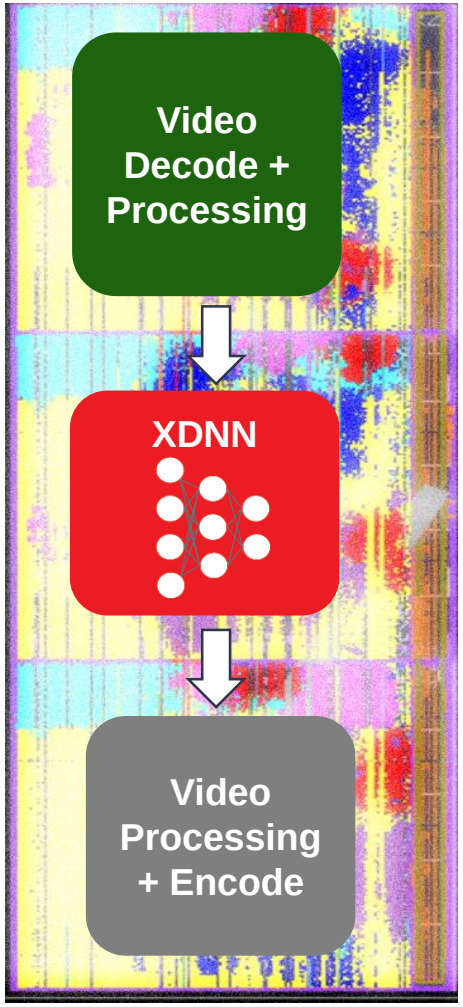
Custom Deep Learning Pipeline







- Video + ML
- Genomics + ML
- Risk Modelling + ML
- Database + ML
- Network IPS + ML
- Storage + ML

Integrate Custom Applications with xDNN. Lower end-to-end latency

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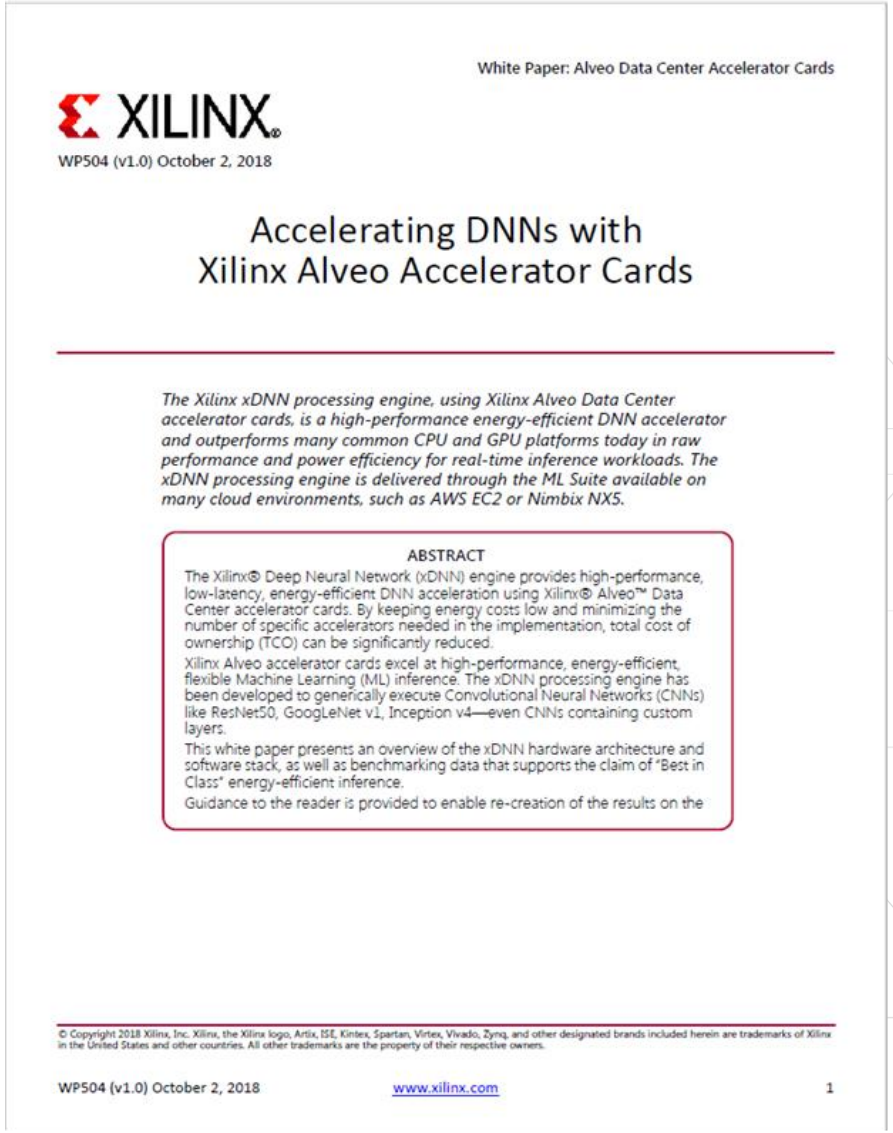
Additional Information

- Visit Alveo Demo Room
- Refer to White Paper WP504
  - "Accelerating DNNs with Xilinx Alveo Accelerator Cards"
- **https://www.xilinx.com/applications/megatrends/machine-learning.html**



White Paper: Alveo Data Center Accelerator Cards

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WP504 (v1.0) October 2, 2018

Accelerating DNNs with Xilinx Alveo Accelerator Cards

The Xilinx xDNN processing engine, using Xilinx Alveo Data Center accelerator cards, is a high-performance energy-efficient DNN accelerator and outperforms many common CPU and GPU platforms today in raw performance and power efficiency for real-time inference workloads. The xDNN processing engine is delivered through the ML Suite available on many cloud environments, such as AWS EC2 or Nimbix NX5.

ABSTRACT

The Xilinx® Deep Neural Network (xDNN) engine provides high-performance, low-latency, energy-efficient DNN acceleration using Xilinx® Alveo™ Data Center accelerator cards. By keeping energy costs low and minimizing the number of specific accelerators needed in the implementation, total cost of ownership (TCO) can be significantly reduced.

Xilinx Alveo accelerator cards excel at high-performance, energy-efficient, flexible Machine Learning (ML) inference. The xDNN processing engine has been developed to generically execute Convolutional Neural Networks (CNNs) like ResNet50, GoogLeNet v1, Inception v4—even CNNs containing custom layers.

This white paper presents an overview of the xDNN hardware architecture and software stack, as well as benchmarking data that supports the claim of "Best in Class" energy-efficient inference.

Guidance to the reader is provided to enable re-creation of the results on the

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