Orchestrating a brighter world

NEC

Integration of NEC SX-Aurora into AI Frameworks (A SOL story)

Dr. Nicolas Weber (NEC Labs Europe)

Motivation

Obvious: Everyone does AI today!

- AI-optimized Fridges, Microwaves, Toasters, T-800 Terminators, …

But where to start?

Chainer

TensorFlow

theano

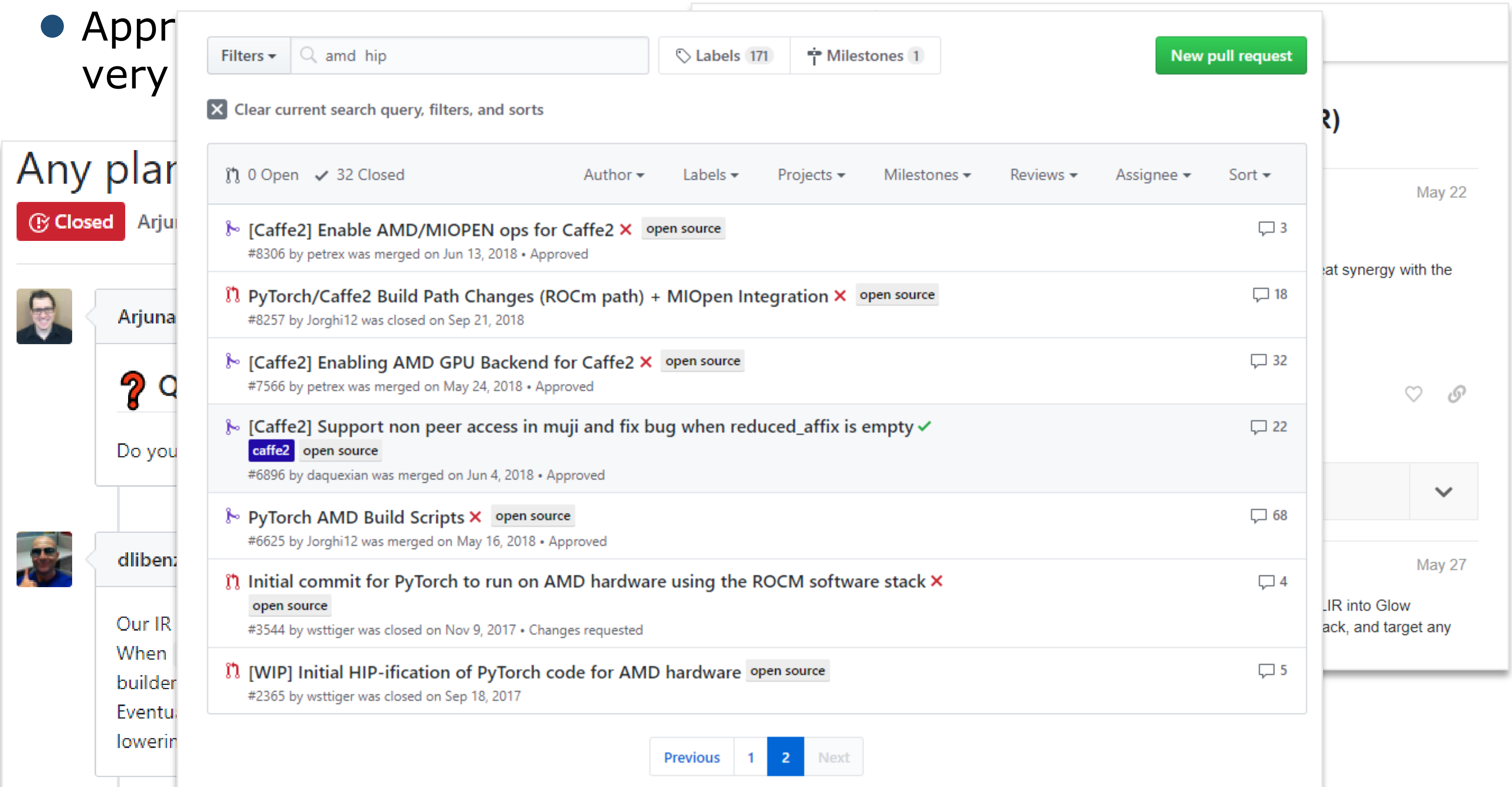
Caffe2

mxnet

PyTorch

Each framework has its own APIs

- Appr
  very



\Orchestrating a brighter world NEC

The SOL-Project

SOL is a full stack AI acceleration middleware

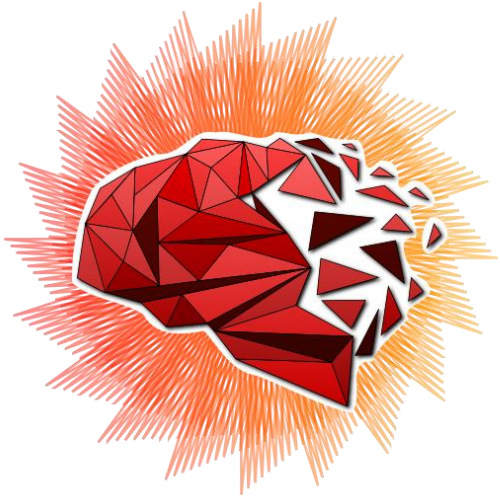
- Optimizations range from mathematical/algorithmic down to actual implementations/code generation
- Add-on to AI frameworks that does not require any code changes

Tightly integrates into existing frameworks

- PyTorch
- TensorFlow
- MxNet (in development)

Broad support for hardware architectures

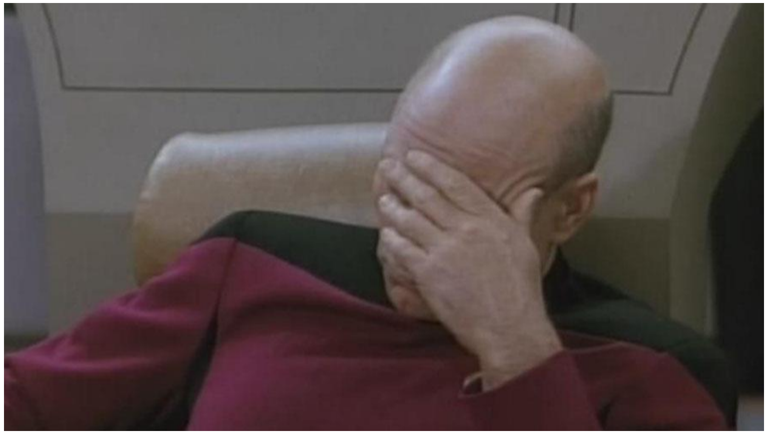
- X86 CPUs
- NVIDIA GPUs
- ARM64 CPUs
- **NEC SX-Aurora Tsubasa**



SOL in a nutshell

What data scientists see:

```
x = Conv(x, kernel=1x1, bias=True)
x = ReLU(x)
x = AvgPooling(x, kernel=13x13)
```



What HPC people see:

```
function(Conv):
    for(Batch, OutChannel, Y, X):
        for(InChannel, KernelY, KernelX):
            output[…] += input[…] * weight[…]
        output[…] += bias[…]

function(ReLU):
    for(Batch, OutChannel, Y, X):
        output[…] = max(0, input[…])

function(AvgPooling):
    for(Batch, OutChannel, Y, X):
        for(KernelY, KernelX):
            output[…] += input[…] / (13*13)
```

SOL in a nutshell (continued)

What we actually want:

```
function(FusedNetwork):
  for(Batch, OutChannel):
    float N[…]
    for(Y, X):
        for(InChannel, KernelY, KernelX):
            N[…] += input[…] * weight[…]
        N[…] += bias[…]
        N[…] = max(0, X)
    for(Y, X):
        for(KernelY, KernelX):
            output[…] += N[…] / (13*13)
```

SOL in a nutshell (more continued)

All layers merged into a single kernel function, using specialized hardware features

```
__global__ void F64486B08(...) {
  const int O0idx = blockIdx.x;
  const int O0 = O0idx / 256;
  const int O1 = O0idx % 256;
  __shared__ float T64[169];
  for(int O2idx = threadIdx.x; O2Idx < 169; O2Idx += 128) {
    float T63 = 0.0f;
    for(int I1 = 0; I1 < 512; I1++)         // #1 Convolution: 1x1 Pooling
      T63 += T61[O0 * 86528 + I1 * 169 + O2idx] * P63_weight[O1 * 512 + I1];
    T63 = (T63 + P63_bias[O1]);             // #1 Convolution: Bias
    T64[O2Idx] = fmaxf(T63, 0.0f);          // #2 ReLU
  }
  T66[O1] = REDUCE_ADD(T64);                // #3 AvgPooling: 13x13 Pooling
  T66[O1] = (T66[O1] / 169.0f);             // #3 AvgPooling: Normalization
}
```

CUDA blocks

shared memory

CUDA cores

Reduction

SOL Usage (Pytorch)

```
import torch
from torchvision import models
import sol.pytorch as sol

py_model  = models.__dict__["…"]()
input     = torch.rand(1, 32, 224, 224)
sol_model = sol.optimize(py_model, input.size())
sol_model.load_state_dict(py_model.state_dict())
sol.device.set(sol.device.ve, 0)
output = sol_model(input)
```

How to integrates SOL into the frameworks?

- SOL injects its optimized code as Custom Layer into the framework

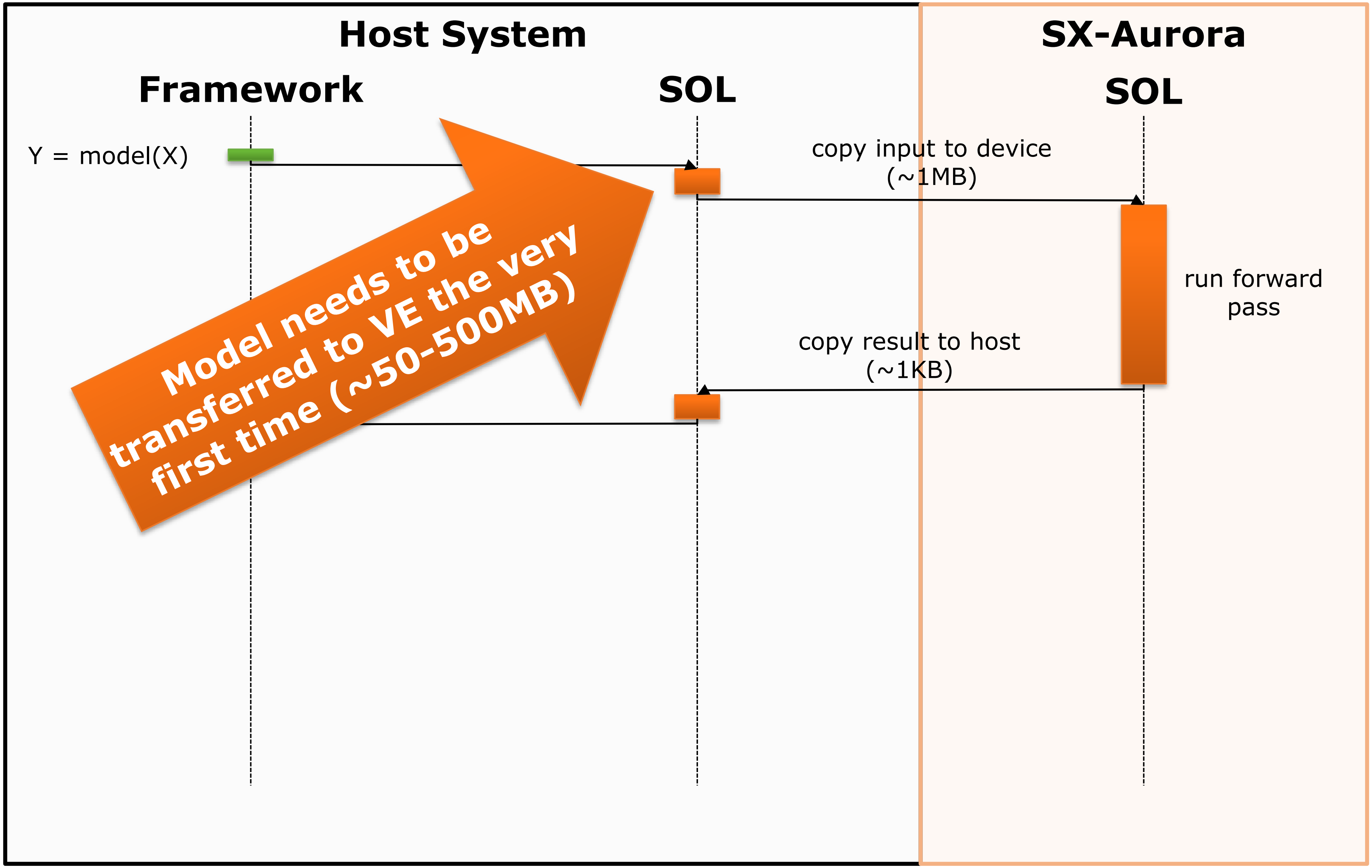
```
class SolLayer(torch.nn.Module):
      def  __init__(self):
            self.ParamA = …
            self.ParamB = …

      def forward(self, X):
            return sol.run(X, self.ParamA, self.ParamB)
```

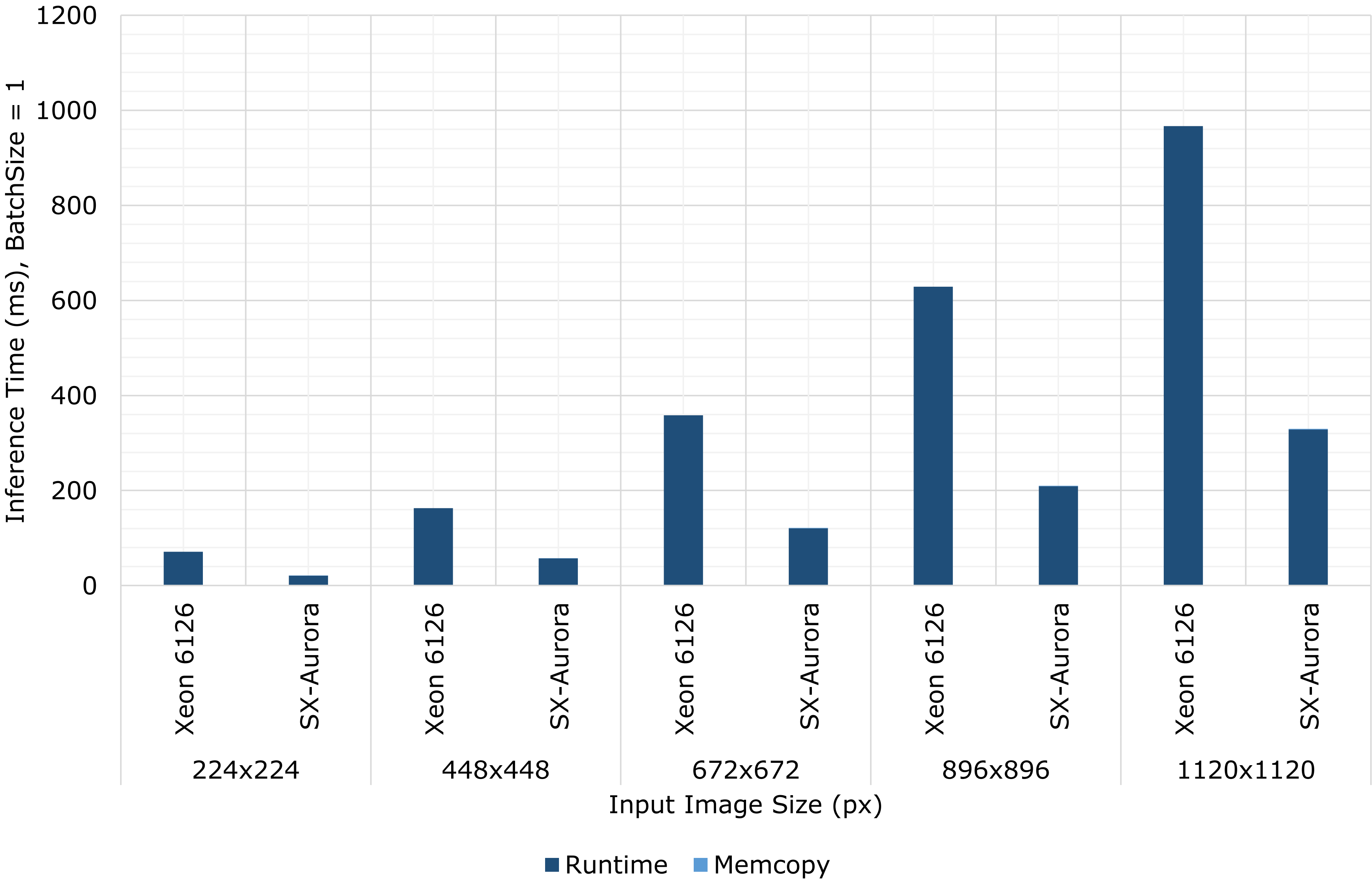
framework handles model parameters!

SOL handles execution

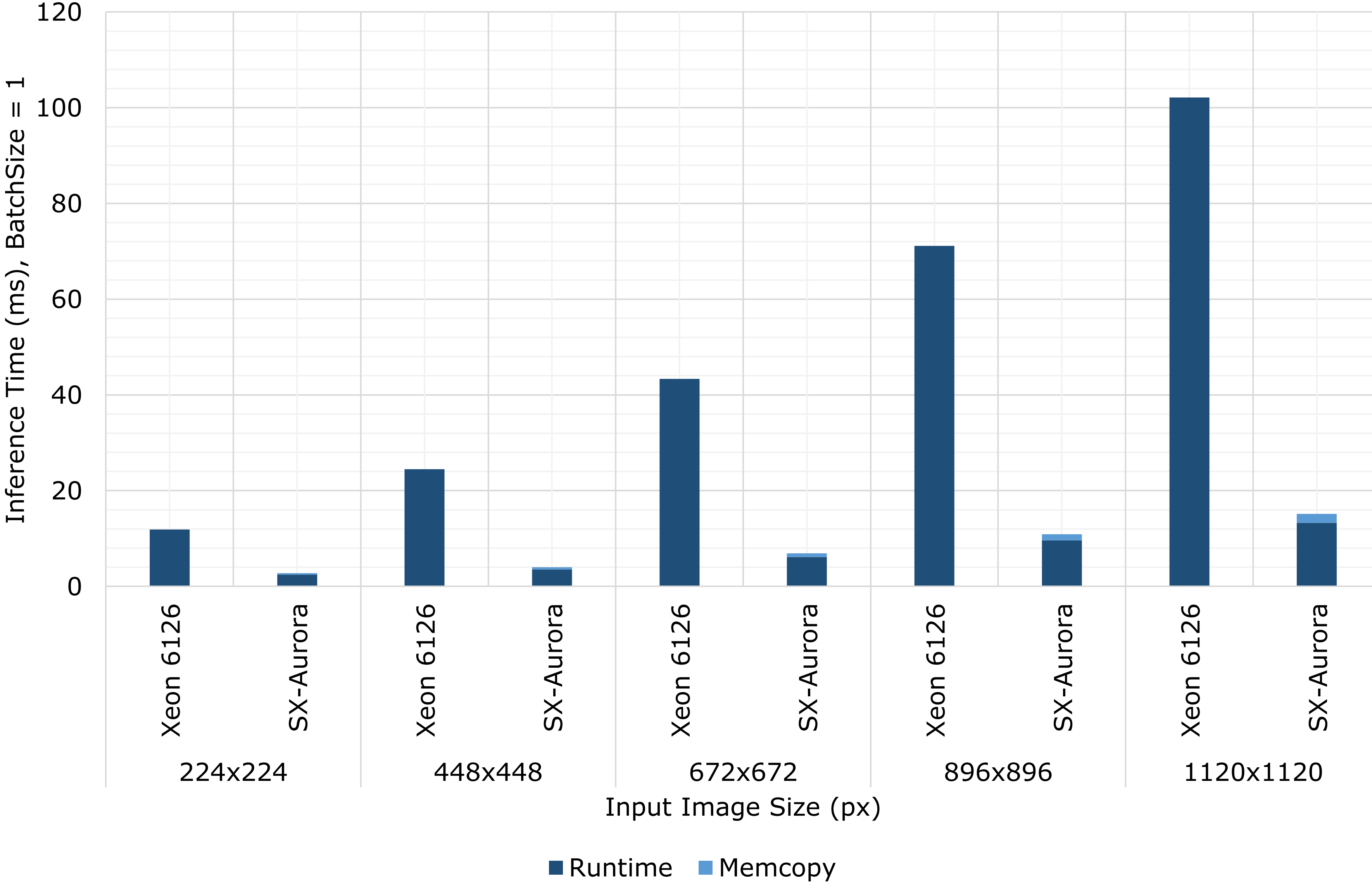
SOL SX-Aurora Inference



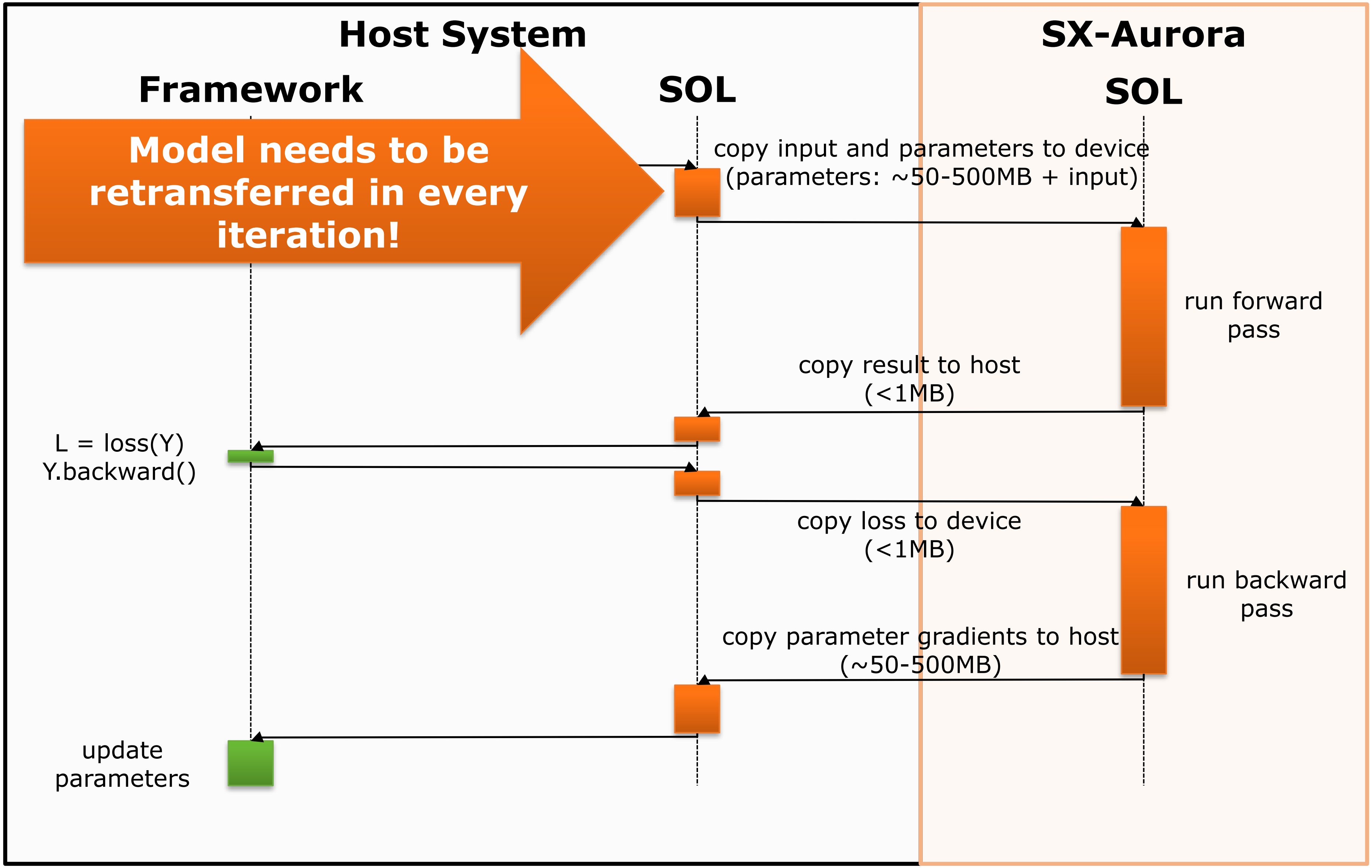
Inference on DenseNet 121



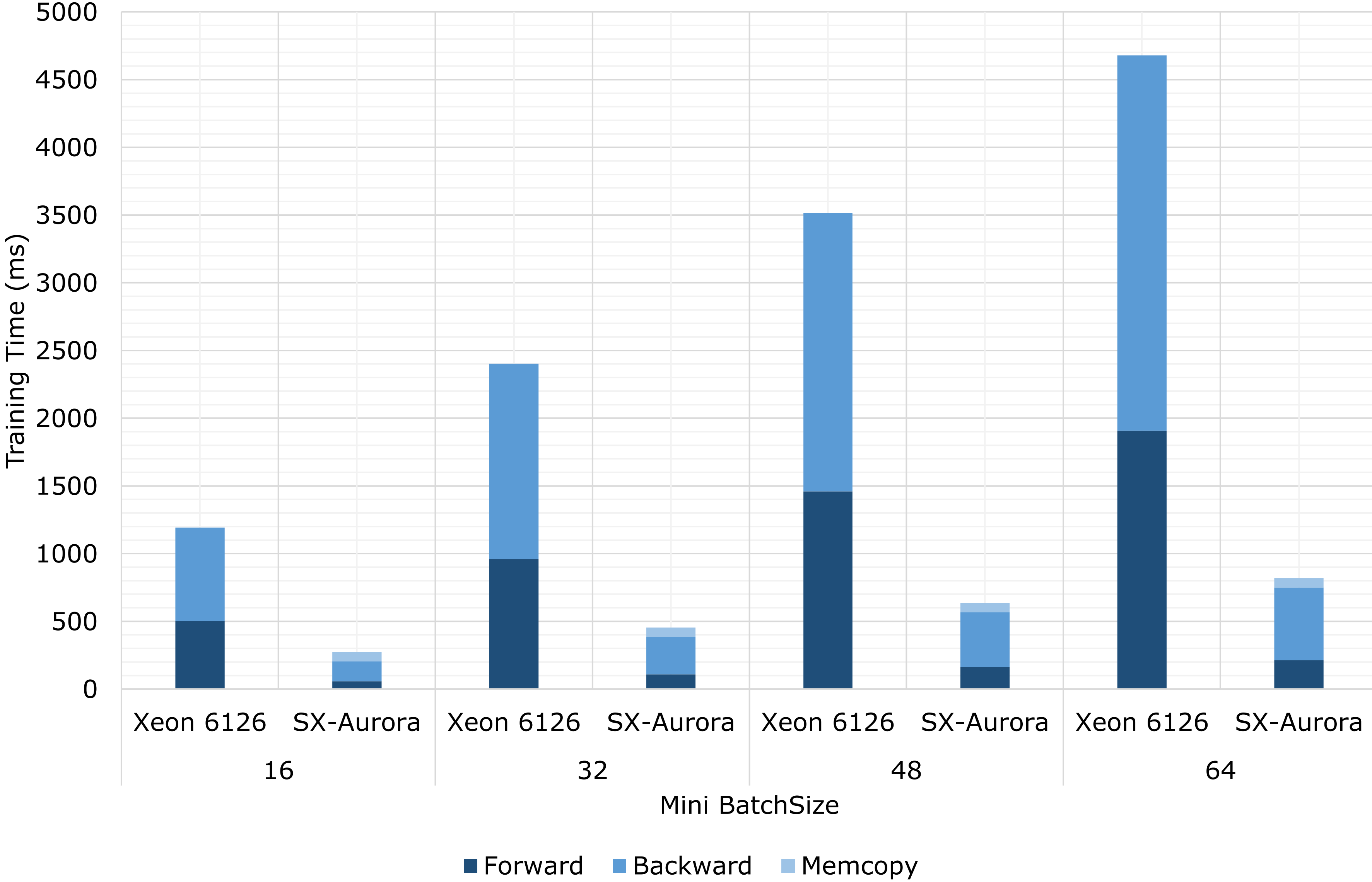
Inference ShuffleNet v2/0.5



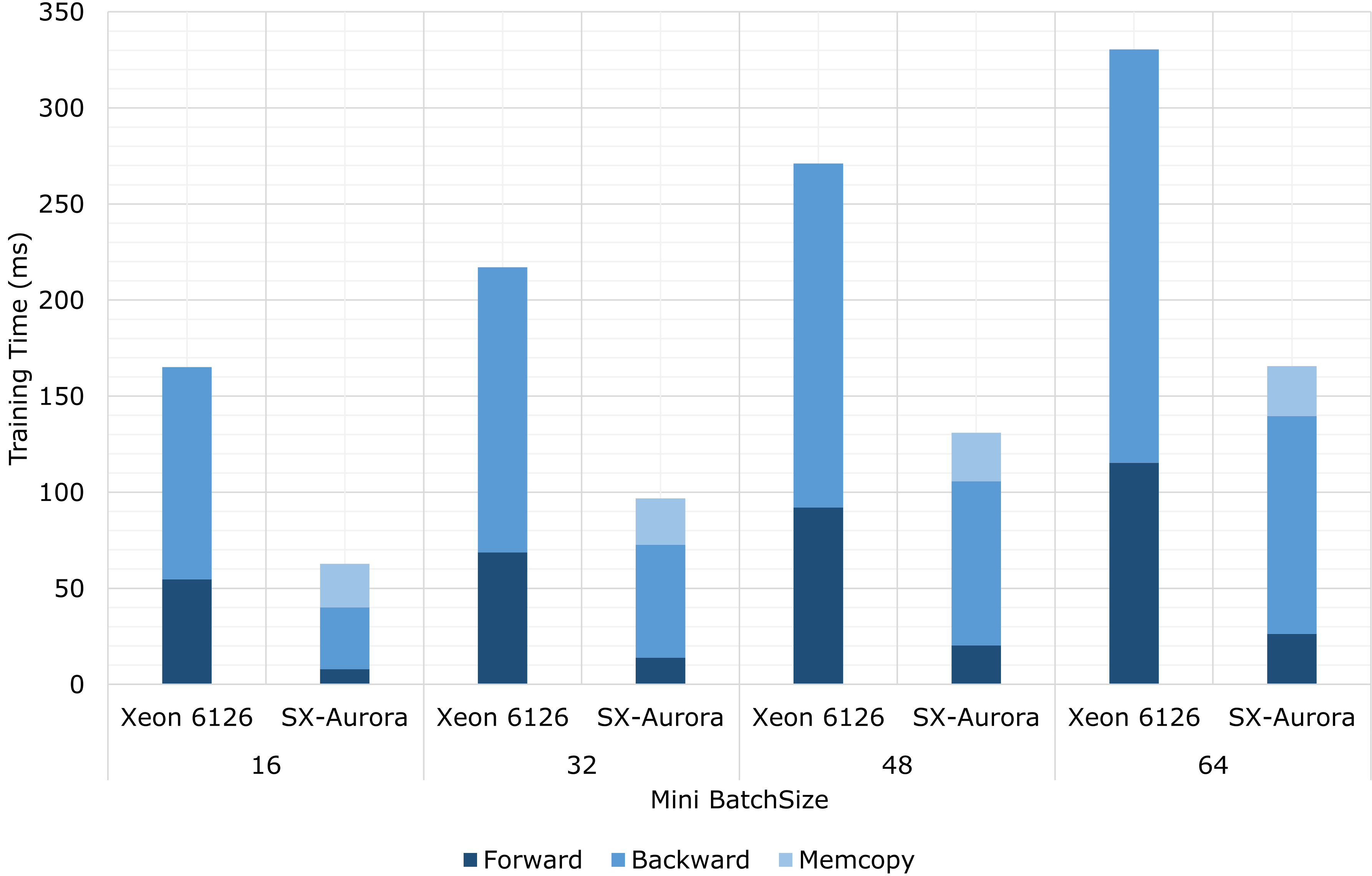
SOL SX-Aurora Training



Training on DenseNet 121



Training on ShuffleNet v2/0.5



Tested Neural Networks

Convolutional Neural Networks

- Alexnet
- SqueezeNet (1.0, 1.1)
- VGG + BN (11, 13, 16, 19)
- Resnet (18, 34, 50, 101, 152)
- Densenet (121, 161, 169, 201)
- Inception V3
- GoogleNet
- MobileNet (v1, v2)
- MNasNet (0.5, 0.75, 1.0, 1.3)
- ShuffleNet V2 (0.5, 1.0, 1.5, 2.0)
- ResNext (50, 101)
- WideResNet (50, 101)

Multi Layer Perceptron (MLP)

Linear/Logistic Regression

“How can the neural network be used in an application?”

SOL supports model deployment!

```
sol.deploy(trained_model, [1, 3, 224, 224],
target=sol.deployment.SharedLib, device=sol.device.ve,
lib_name=“MyNetwork”, func_name=“predict”, …)
```

```
#ifndef __MyNetwork__
#define __MyNetwork__

#ifdef __cplusplus
extern "C" {
#endif

void predict_init(const int deviceIdx);
int  predict_seed(const int seed);
void predict     (void* ctx, const float* input, float** output);

#ifdef __cplusplus
}
#endif
#endif
```

"How can I add new functionality, not supported by the framework?"

```
class MyLayer(torch.nn.Layer):
  def __init__(self, …):
    super().__init__()




    self.ParamA = torch.nn.Parameter(…)
    self.ParamB = torch.nn.Parameter(…)

  def forward(self, X):
    # … code that executes when PyTorch
    # executes the layer …
```

"How can I add new functionality, not supported by the framework?"

```
class MyLayer(sol.nn.CustomLayer):
   def __init__(self, …):
      super().__init__({
      sol.device.nvidia: ["libMyCUDA.so", "FwdCUDA",
"BwdCUDA"],
      sol.device.ve:     ["libMyVE.so", "FwdVE", "BwdVE"]
      })
      self.ParamA = torch.nn.Parameter(…)
      self.ParamB = torch.nn.Parameter(…)

   def forward(self, X):
      # … code that executes when PyTorch
      # executes the layer …
```

“How can I add new functionality, not supported by the framework?”

```
void FwdVE(void* ctx, const float* X, const float*
ParamA, const float* ParamB, float* Y) {
        /* YOUR CODE HERE */
}

void BwdVE(void* ...                              const float*
ParamA, const flo...                           float* dParamA,
float* dParamB) ...
        /* YOUR C...
}
```

coming in 2020

SOL Development Agenda 2020

Natural Language Processing:
- Recurrent Neural Networks (RNN)
- Transformers

Devices:
- AMD GPUs
- ARM Mali GPUs
- Intel Movidius Myriad

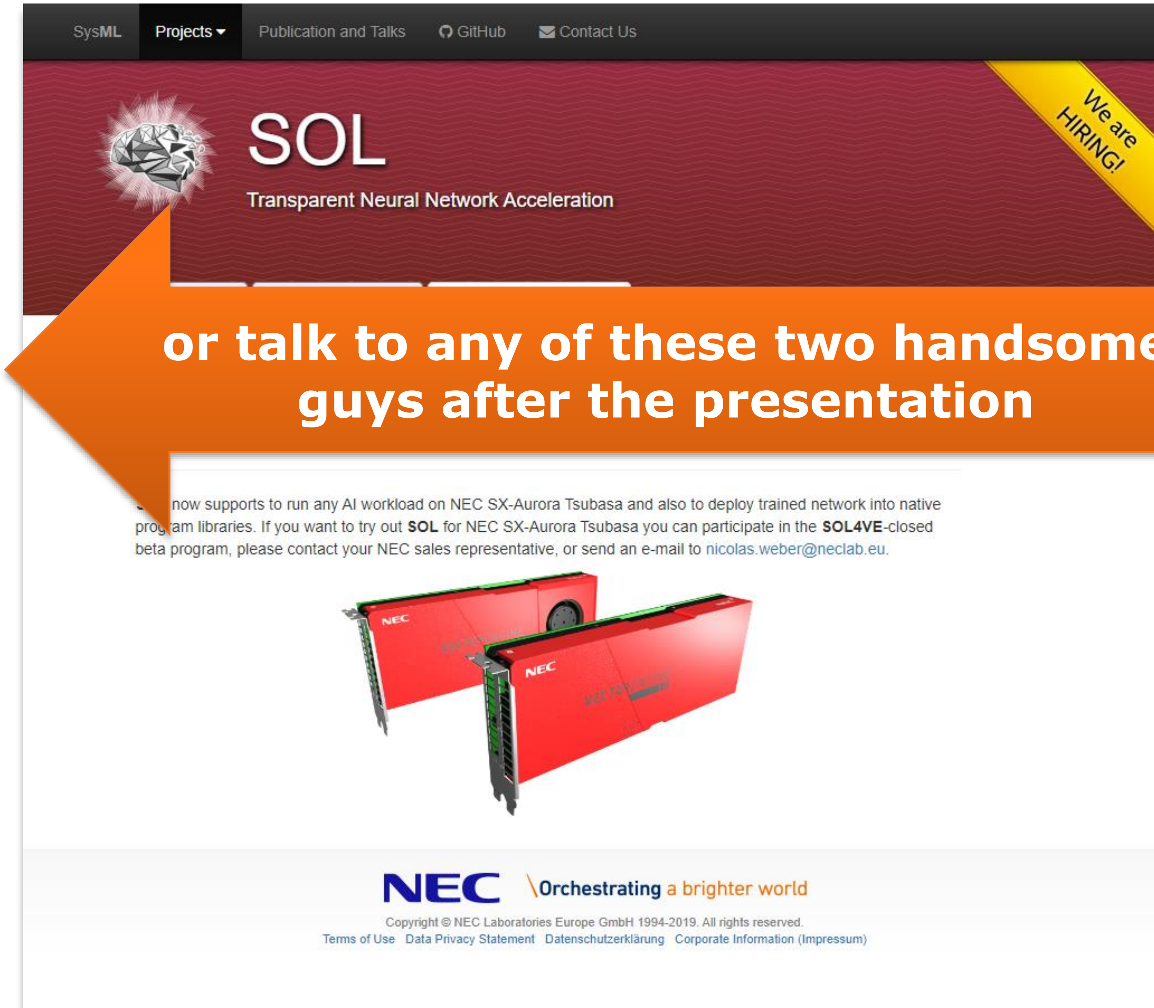
Frameworks:
- TensorFlow 2.0
- MxNet

Features:
- Custom Layer Support

…

“Can we try SOL4VE?”

Apply for the closed SOL4VE beta on:
www.sol-project.org



or talk to any of these two handsome guys after the presentation

\Orchestrating a brighter world

NEC

Dr. Nicolas Weber

Intelligent Software Systems Group

Senior Researcher

NEC Laboratories Europe

nicolas.weber@neclab.eu

www.sol-project.org

NEC HPC platform

Deep Learning

The last few years have seen a growing interest in Deep Learning techniques, thanks to the major breakthroughs achieved in the fields of computer vision and natural language processing. Complex problems, such as object detection, text translation and speech recognition, can now be solved with relatively small effort leveraging Deep Learning techniques.

These successes have encouraged researchers to explore many areas of application for such techniques. For example, even large computation tasks generally belonging to the high-performance computing domain, such as fluid mechanics, biology and astrophysics, may benefit from the application of Deep Learning to improve quality of simulations and increase computation performance.

Talk at NEC Booth

Thursday November, 21st 11:00am