#RonDagdag

Making neural networks run in browser with ONNX

RON DAGDAG

Director of Software Engineering and Microsoft MVP

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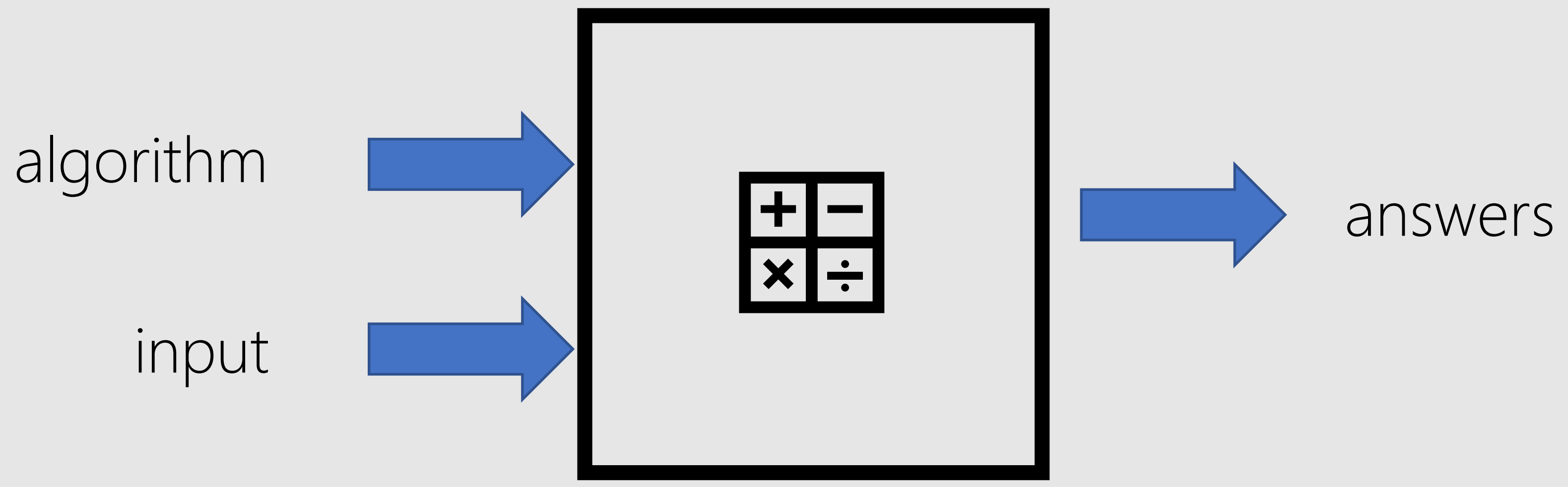
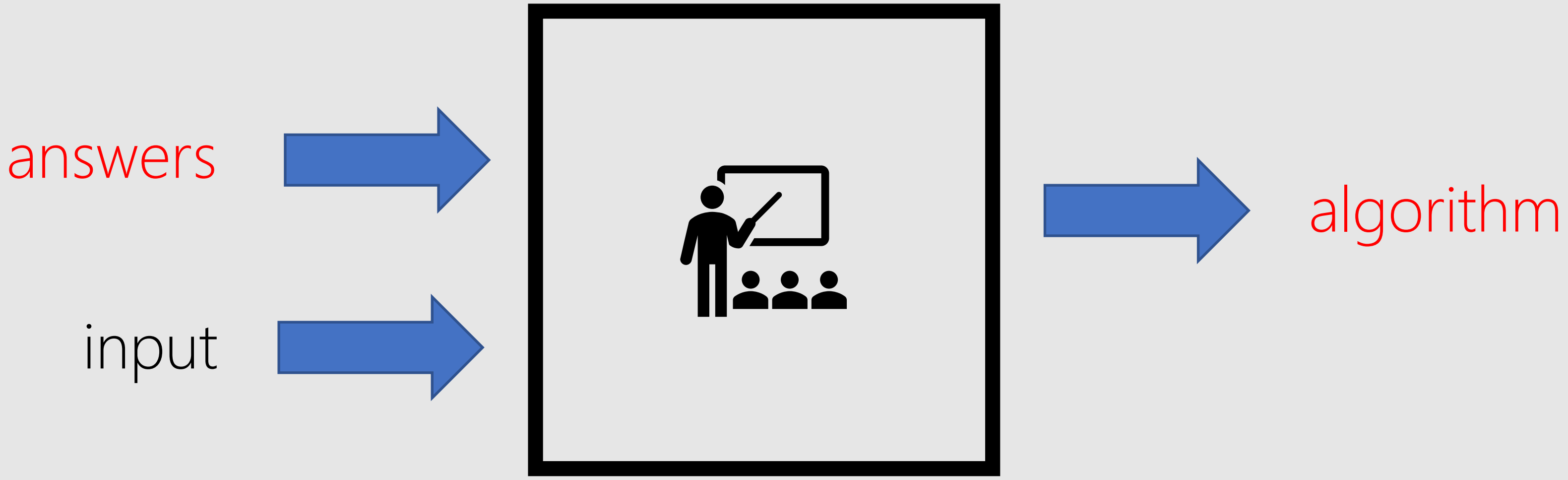
ONNX
Not ONIX
Not ONYX

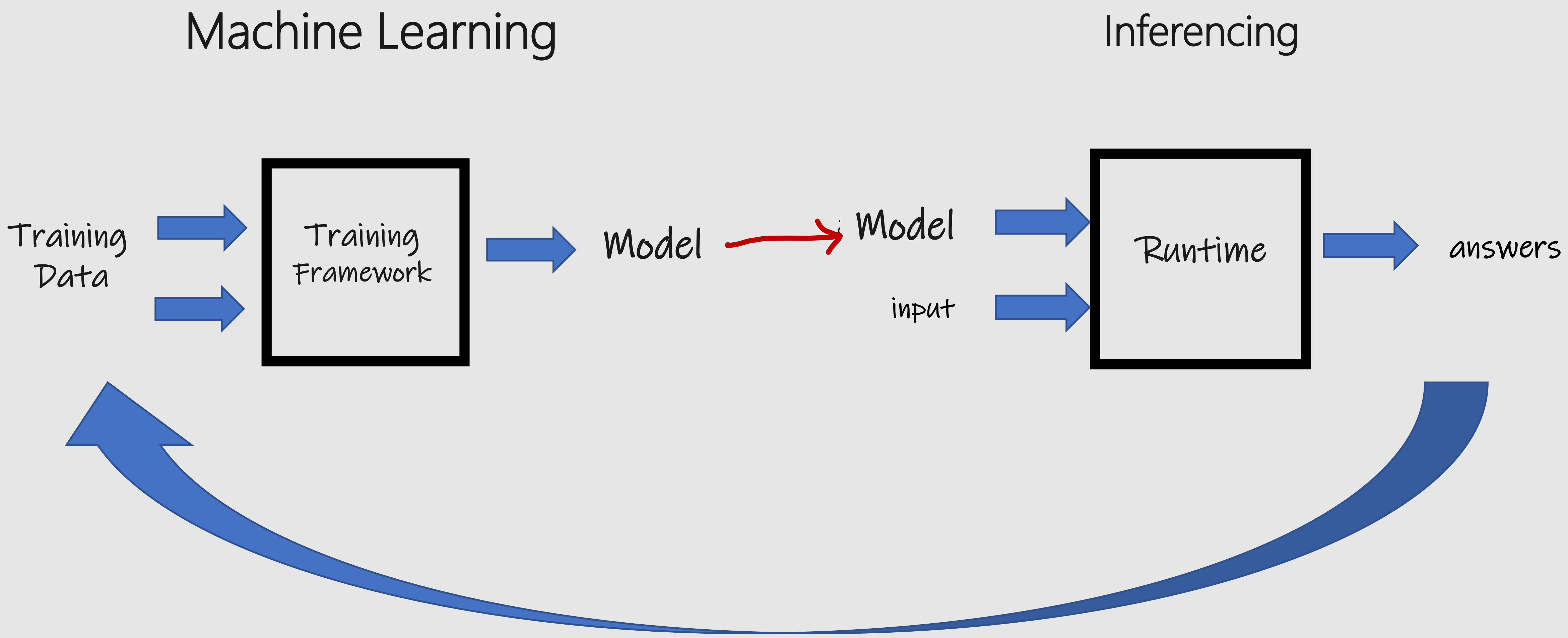
programming



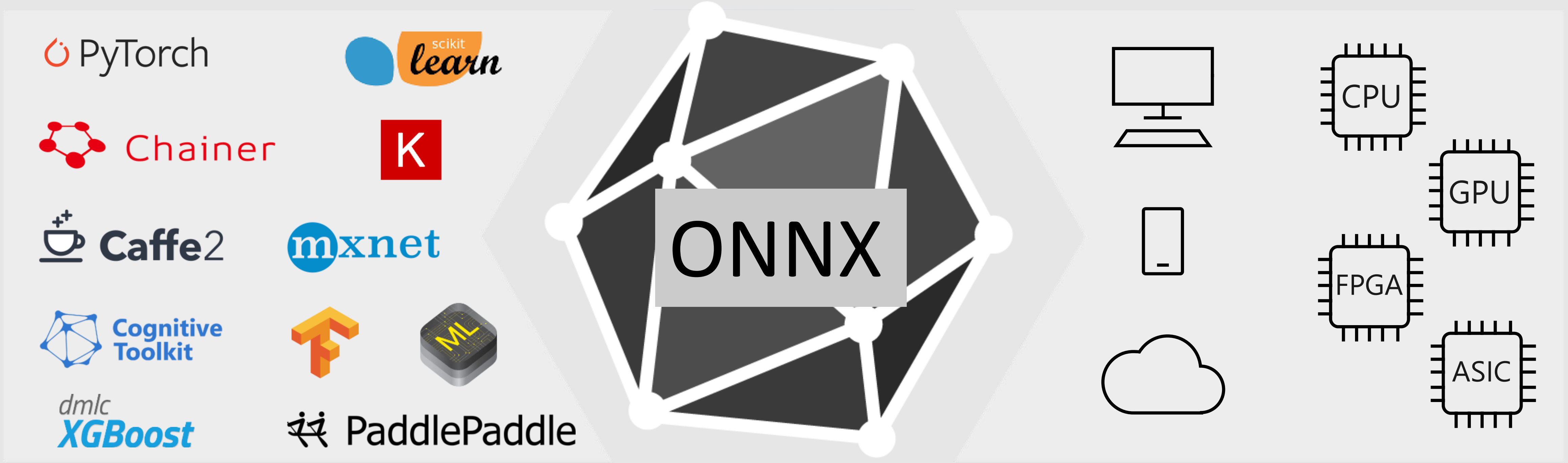
machine learning



ML Primer


Machine Learning
Inferencing
Training Data
Training Framework
Model
Model
input
Runtime
answers

Open and Interoperable AI



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ONNX

Open Neural Network Exchange

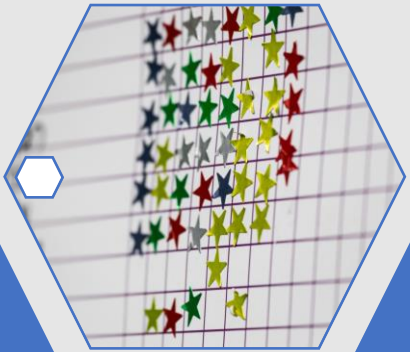
Open format for ML models

github.com/onnx

onnx.ai/

ONNX Partners

ABBYY	aizon	Alibaba Group 阿里巴巴集团	AMD	arm	aws	Baidu 百度
BECKHOFF	BITMAIN	cadence	CEVA	Facebook Open Source	GRAPHCORE	habana
HAILO	Hewlett Packard Enterprise	HUAWEI	IBM	Idein Inc	intel	MathWorks
MAXAR	MEDIATEK	mi	Microsoft	NVIDIA	NXP	OctoML
ORACLE	OPEN AI LAB 开 放 智 能	Preferred Networks	SIEMENS	SONY	Qualcomm	sas
商汤 sensetime	skymizer	SYNOPSYS	Tencent	unity	verizon media	vmware
WOLFRAM	Yandex	ZETANE				


12.5k
Github Stars

2100+
Pull
Requests

220+
Contributors

2.7k Github
Forks

40+ Model
Zoo

LF AI
GRADUATE
PROJECT

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When to use ONNX?

- Trained in Python or ML.NET - deploy into a C#/Java/Javascript app
- PyTorch docker image > 3.6 GB
- High Inferencing latency for production use
- Model to run resource on IoT/edge devices
- Model to run on different OS or Hardware
- Combine running models created from different frameworks
- Training takes too long (transformer models)

Agenda

- ✓ What is ONNX, When to use ONNX
- ❑ How to create ONNX models
- ❑ How to deploy ONNX models

Create

Frameworks

Caffe2 Chainer Cognitive Toolkit

mxnet PyTorch PaddlePaddle

ML.NET MathWorks dmlc XGBoost

scikit learn K

Services

Azure Custom Vision Service

Native support

Converters

Native support

ONNX Model

Native support

Converters

Deploy

Cloud Services

Azure Machine Learning services

Ubuntu VM

Windows VM

Windows Devices

IoT/Edge Devices

Web Browsers

Other Devices (iOS, Android, etc)

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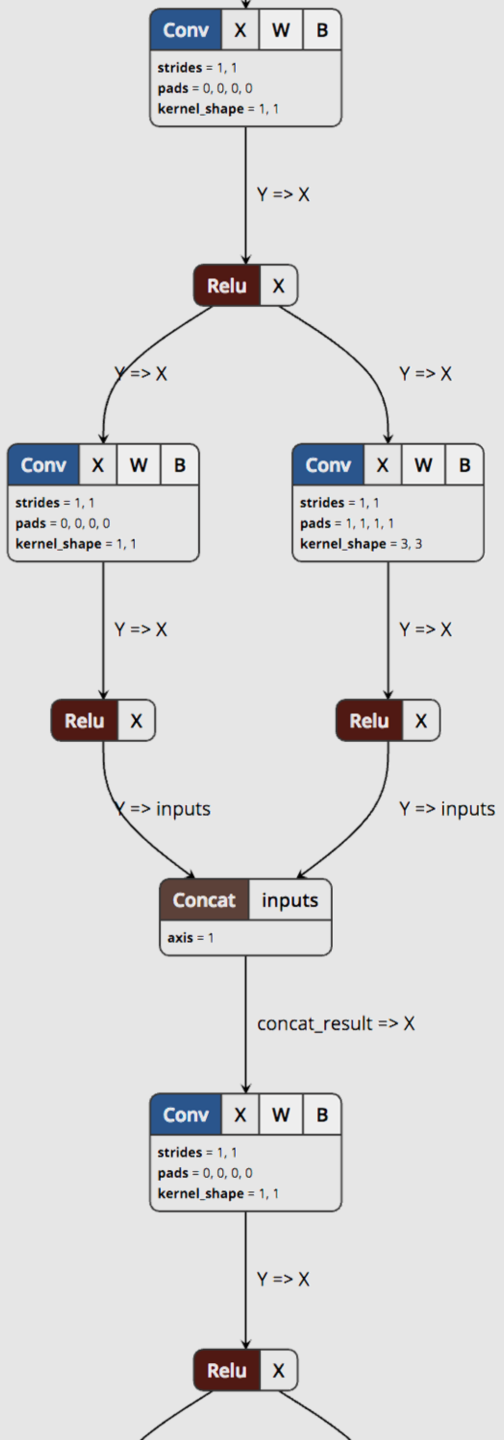
ONNX Models

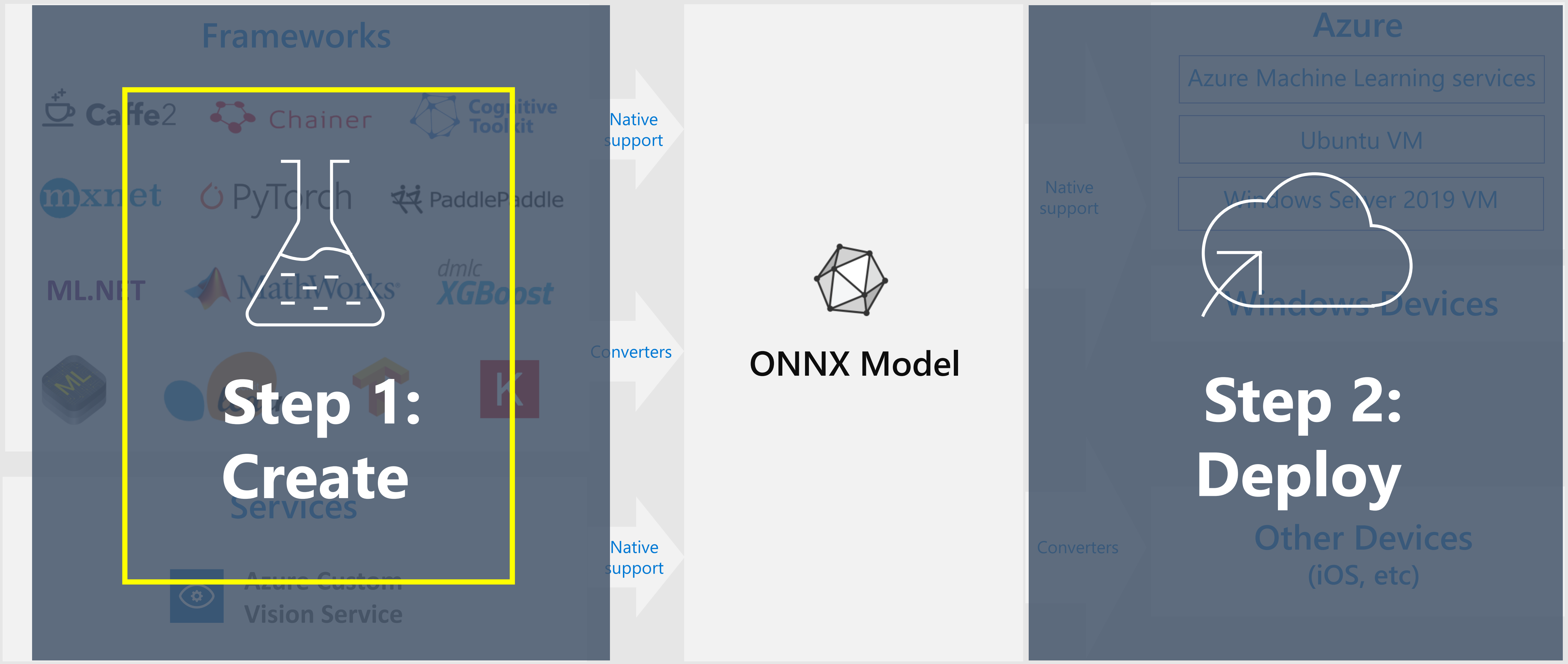
Graph of operations



Netron

https://netron.app/

https://lutzroeder.github.io/netron/


Frameworks
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Cognitive Toolkit
mxnet
PyTorch
PaddlePaddle
ML.NET
MathWorks
dmlc XGBoost
Services
Azure Custom Vision Service
Native support
Converters
Native support
ONNX Model
Azure
Azure Machine Learning services
Ubuntu VM
Windows Server 2019 VM
Native support
Windows Devices
Converters
Other Devices
(iOS, etc)
Step 1: Create
Step 2: Deploy

Secret Recipe

3 ways to get an ONNX model

- ONNX Model Zoo
- Azure Custom Vision Service
- Convert existing models

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ONNX Model Zoo: github.com/onnx/models

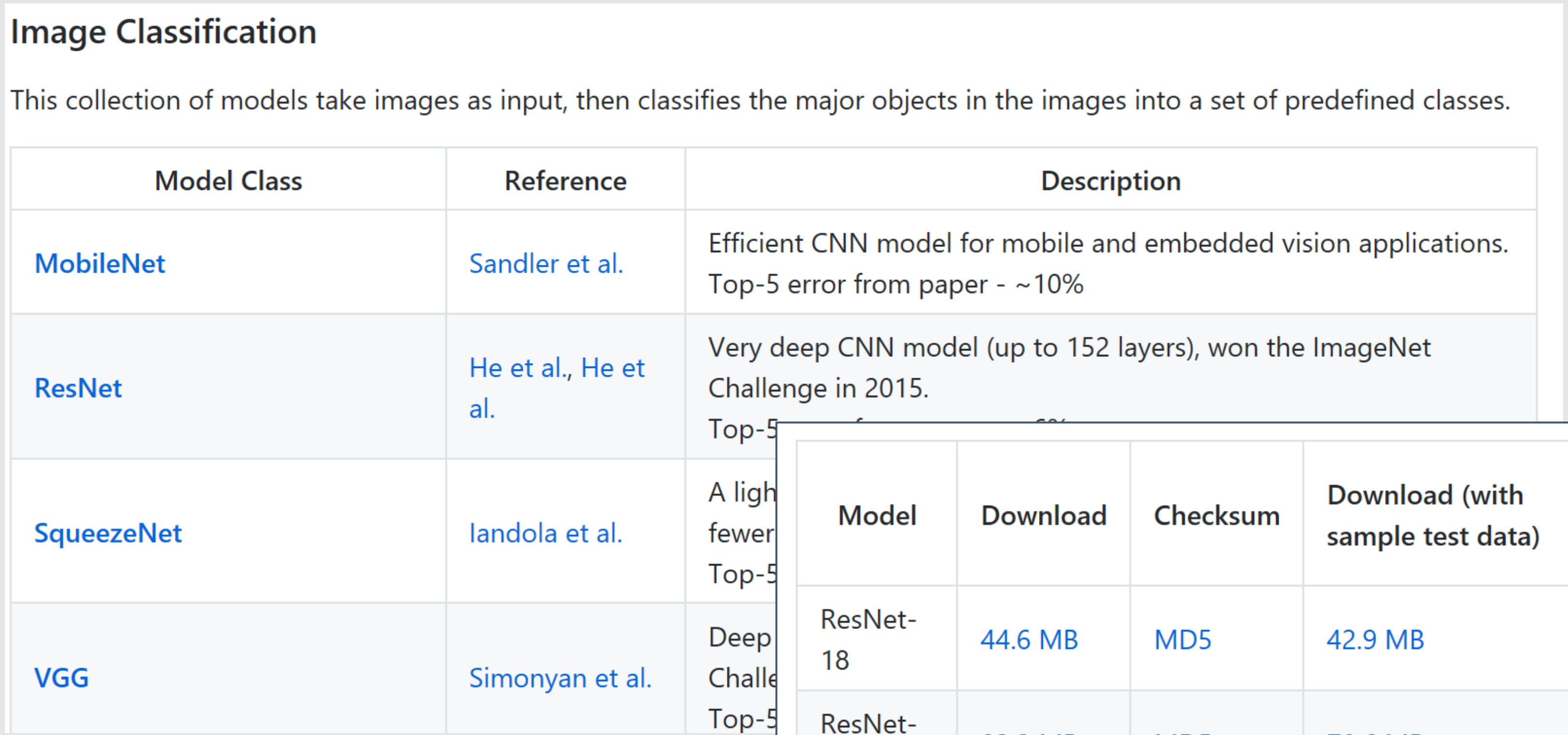
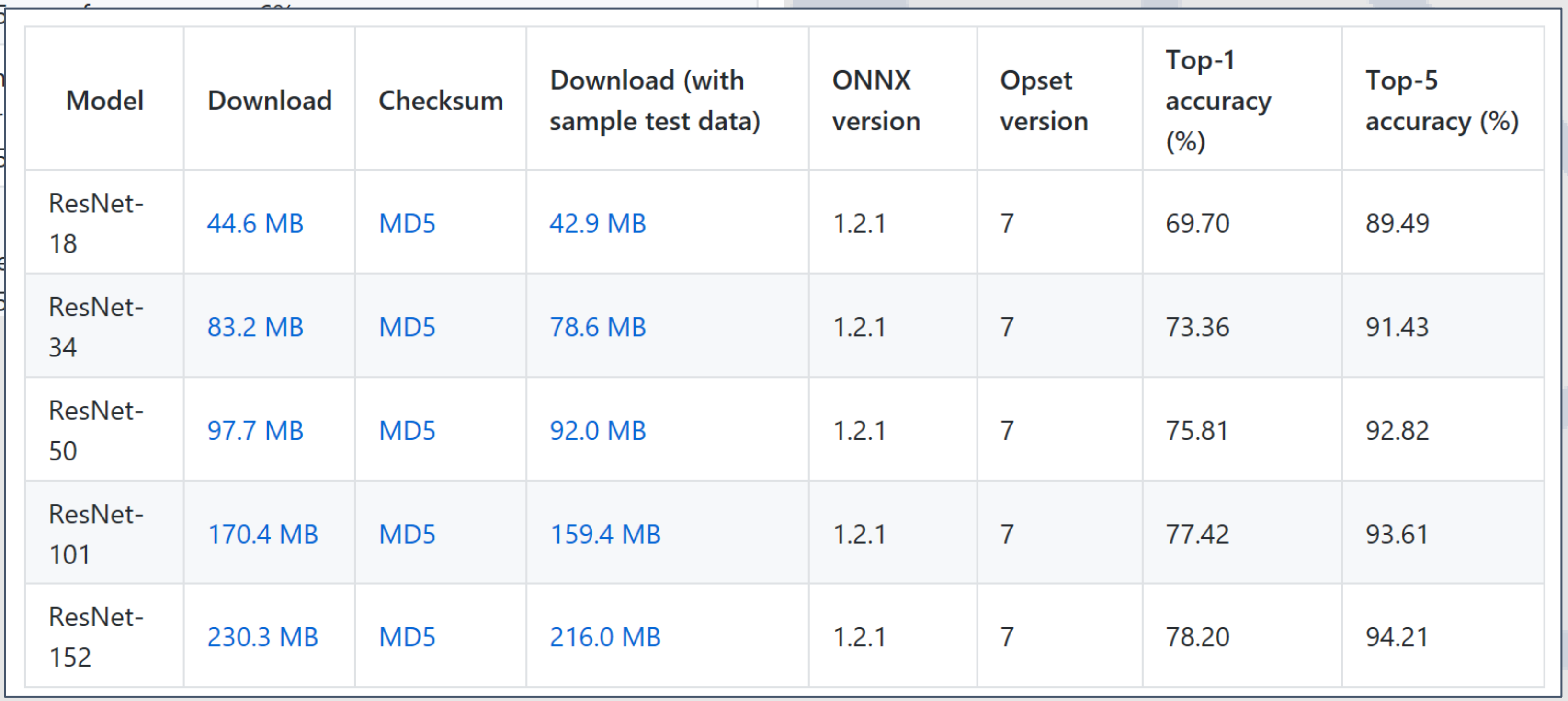


Image Classification

This collection of models take images as input, then classifies the major objects in the images into a set of predefined classes.

Model Class	Reference	Description
MobileNet	Sandler et al.	Efficient CNN model for mobile and embedded vision applications. Top-5 error from paper - ~10%
ResNet	He et al., He et al.	Very deep CNN model (up to 152 layers), won the ImageNet Challenge in 2015. Top-5
SqueezeNet	Iandola et al.	A ligh fewer Top-5
VGG	Simonyan et al.	Deep Challe Top-5



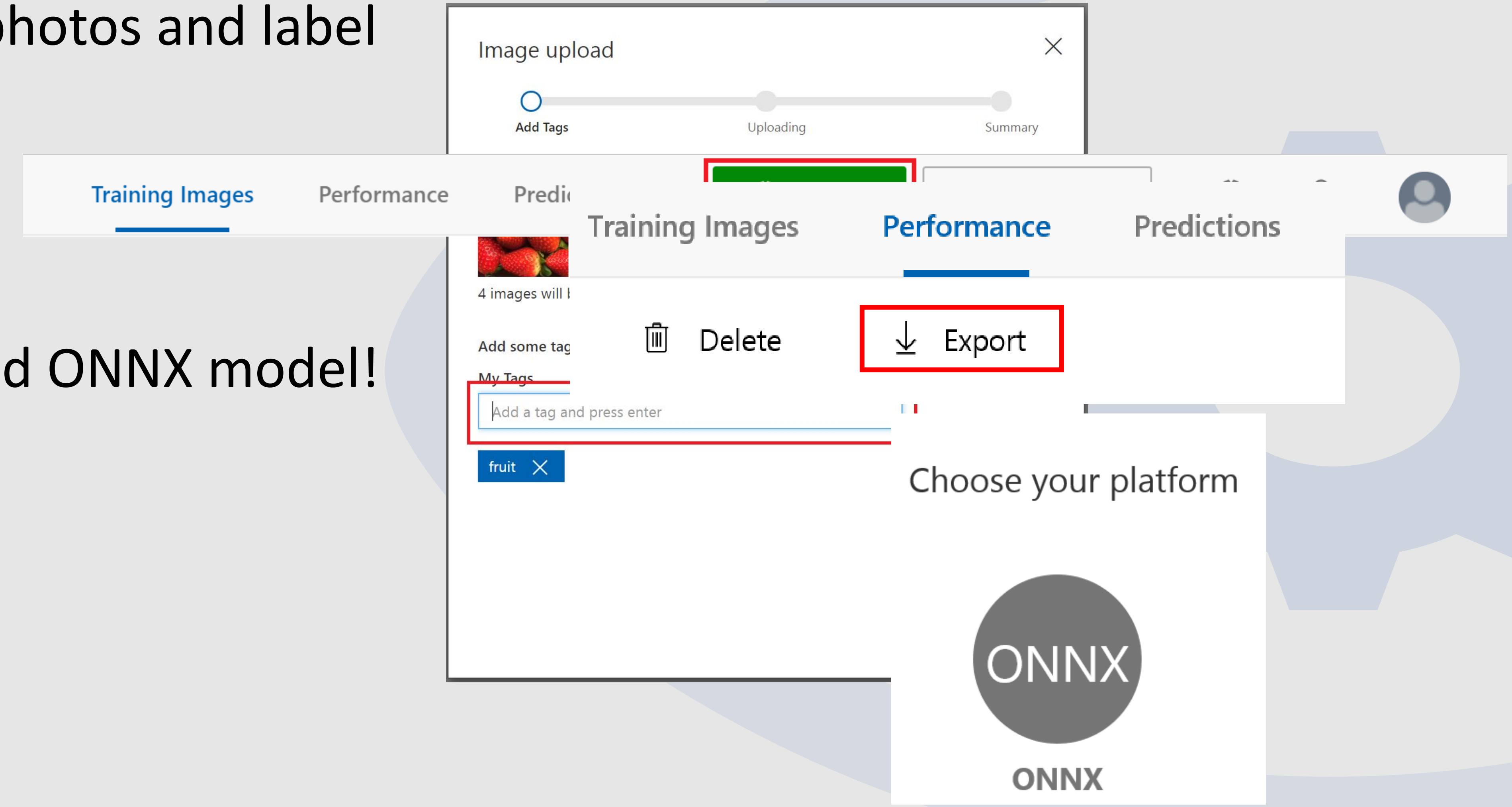
Model	Download	Checksum	Download (with sample test data)	ONNX version	Opset version	Top-1 accuracy (%)	Top-5 accuracy (%)
ResNet-18	44.6 MB	MD5	42.9 MB	1.2.1	7	69.70	89.49
ResNet-34	83.2 MB	MD5	78.6 MB	1.2.1	7	73.36	91.43
ResNet-50	97.7 MB	MD5	92.0 MB	1.2.1	7	75.81	92.82
ResNet-101	170.4 MB	MD5	159.4 MB	1.2.1	7	77.42	93.61
ResNet-152	230.3 MB	MD5	216.0 MB	1.2.1	7	78.20	94.21

Custom Vision Service: customvision.ai

1. Upload photos and label

2. Train

3. Download ONNX model!



Convert models

Caffe2
Yandex CatBoost
Chainer
Cognitive Toolkit
CoreML

Keras
LibSVM
MATLAB
MindSpore
mxnet

MyCaffe™
NCNN
NeoML
Neural Network Libraries
飞桨 PaddlePaddle
PaddlePaddle

PyTorch
sas
SIEMENS
Apache SINGA
scikit learn
SciKit Learn

Tengine
TensorFlow
dmlc XGBoost
WOLFRAM

Convert models

1. Load existing model

2. (Convert to ONNX)

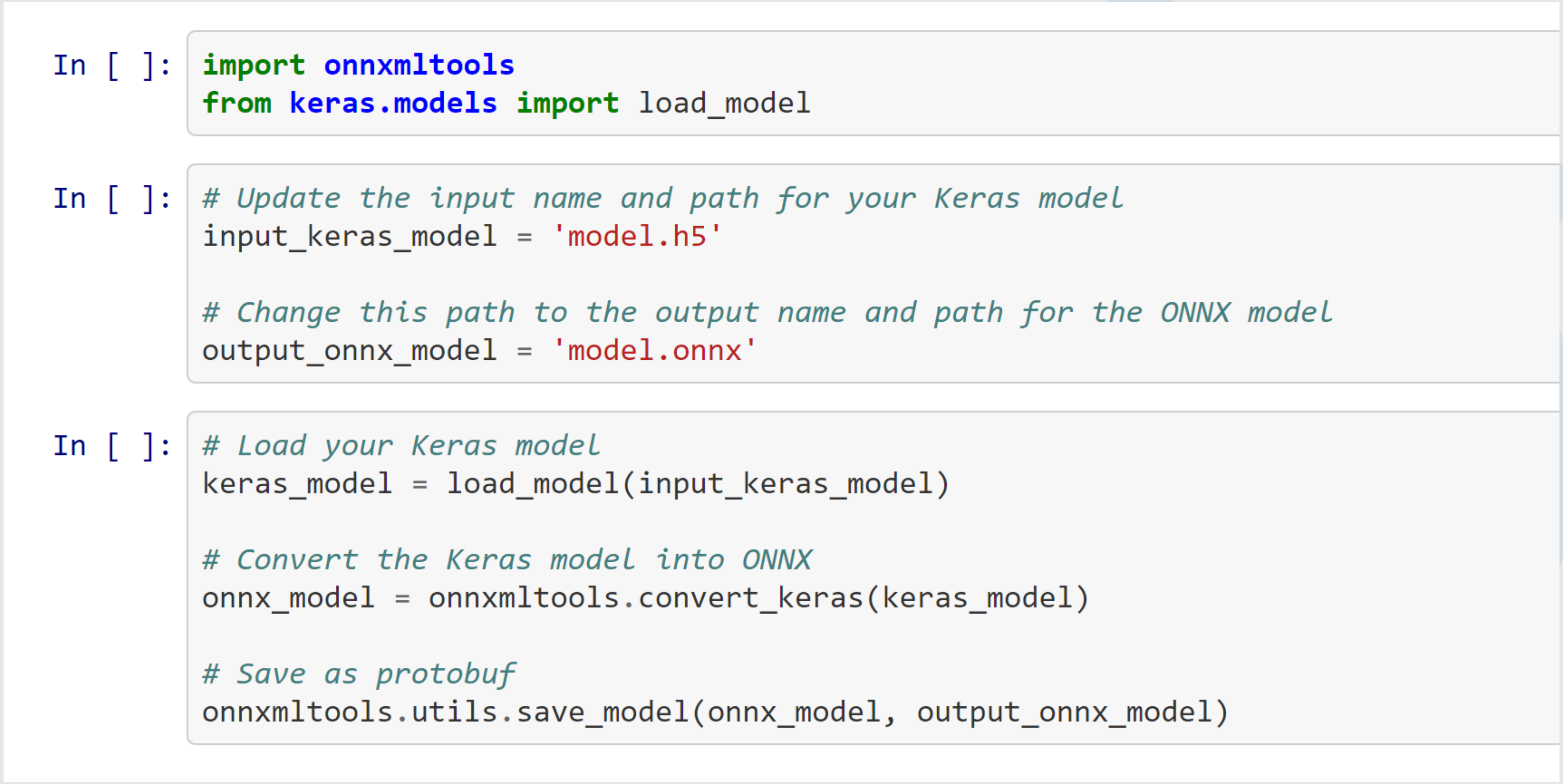
3. Save ONNX model

https://github.com/onnx/tutorials

Convert models: PyTorch

```
import torch
import torch.onnx

model = torch.load(“model.pt”)

sample_input = torch.randn(1, 3, 224, 224)

torch.onnx.export(model, sample_input, “model.onnx")
```

Convert models: Keras



```
In [ ]: import onnxmltools
        from keras.models import load_model
```

```
In [ ]: # Update the input name and path for your Keras model
        input_keras_model = 'model.h5'

        # Change this path to the output name and path for the ONNX model
        output_onnx_model = 'model.onnx'
```

```
In [ ]: # Load your Keras model
        keras_model = load_model(input_keras_model)

        # Convert the Keras model into ONNX
        onnx_model = onnxmltools.convert_keras(keras_model)

        # Save as protobuf
        onnxmltools.utils.save_model(onnx_model, output_onnx_model)
```

Convert models:

```
> python -m tf2onnx.convert
            --saved-model tensorflow-model-path
            --output model.onnx
```

https://github.com/onnx/tensorflow-onnx

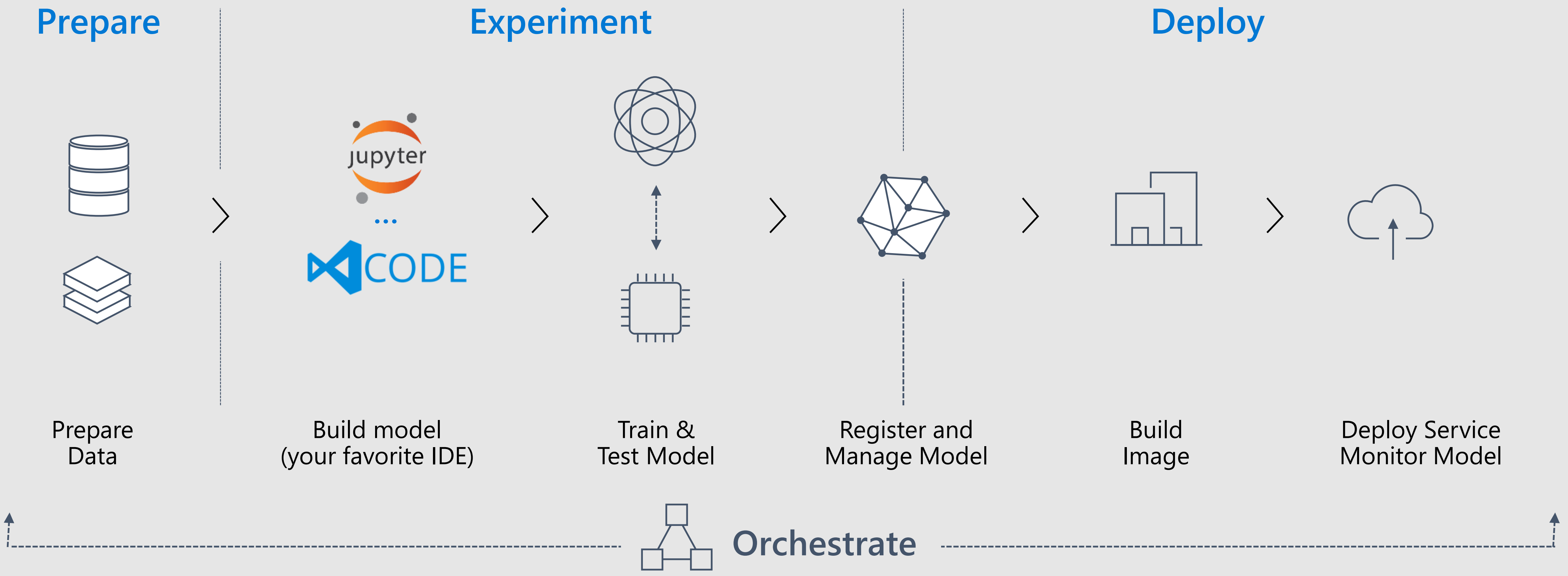
Convert models:

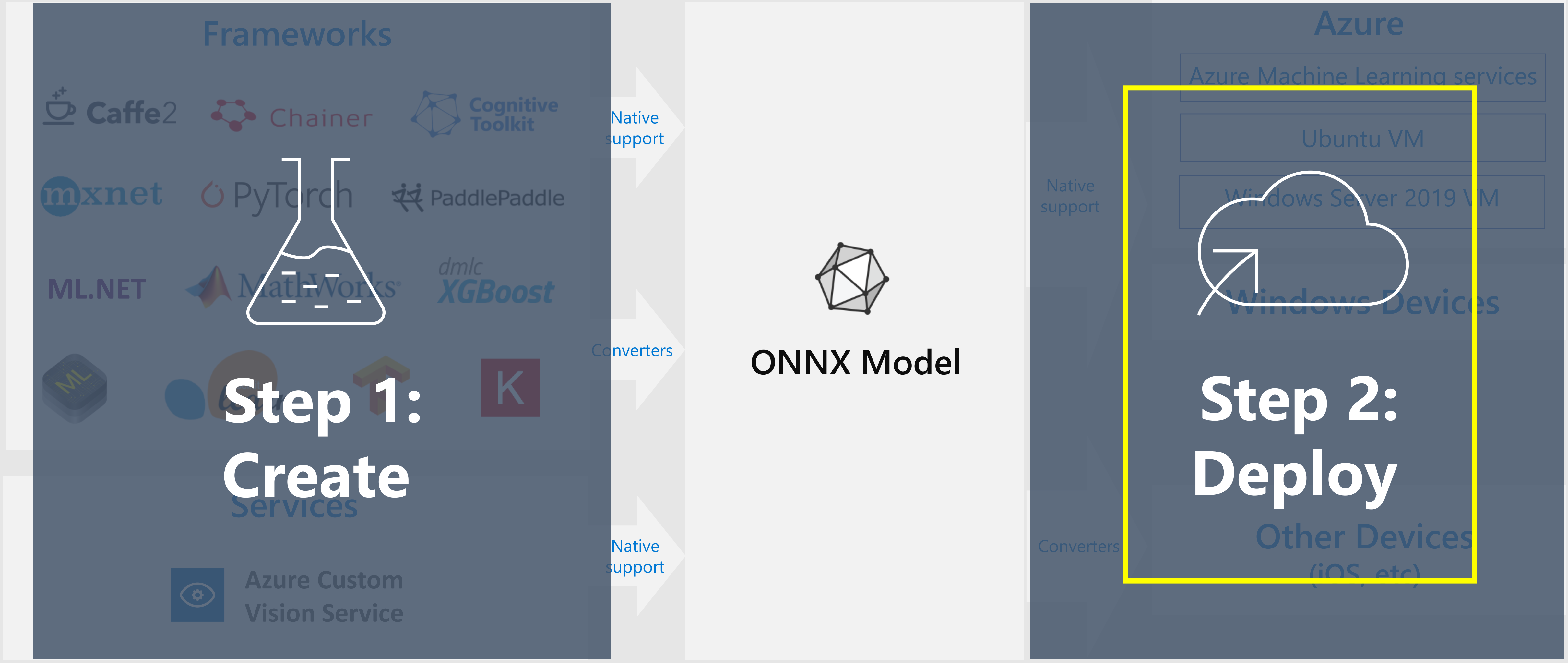
```python
# Train a model.
from sklearn.datasets import load_iris
from sklearn.model_selection import train_test_split
from sklearn.ensemble import RandomForestClassifier
iris = load_iris()
X, y = iris.data, iris.target
X_train, X_test, y_train, y_test = train_test_split(X, y)
clr = RandomForestClassifier()
clr.fit(X_train, y_train)

# Convert into ONNX format
from skl2onnx import convert_sklearn
from skl2onnx.common.data_types import FloatTensorType
initial_type = [('float_input', FloatTensorType([None, 4]))]
onx = convert_sklearn(clr, initial_types=initial_type)
with open("rf_iris.onnx", "wb") as f:
    f.write(onx.SerializeToString())
```

https://github.com/onnx/tutorials

Machine Learning

Typical E2E Process

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K
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Azure Custom Vision Service
Native support
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Native support
ONNX Model
Azure
Azure Machine Learning services
Ubuntu VM
Windows Server 2019 VM
Native support
Windows Devices
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Step 2: Deploy
Other Devices (iOS, etc)

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Baker
vs
Starting a Bakery

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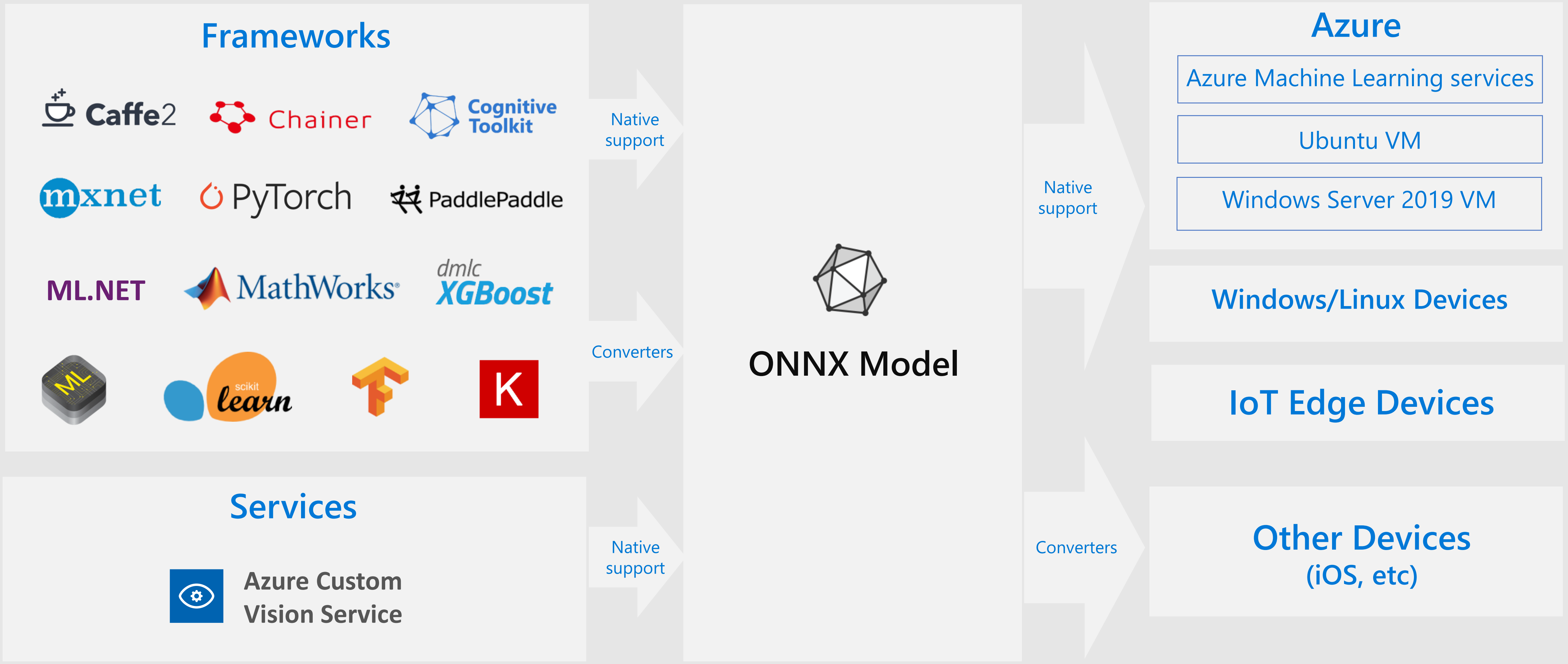
Create

Deploy



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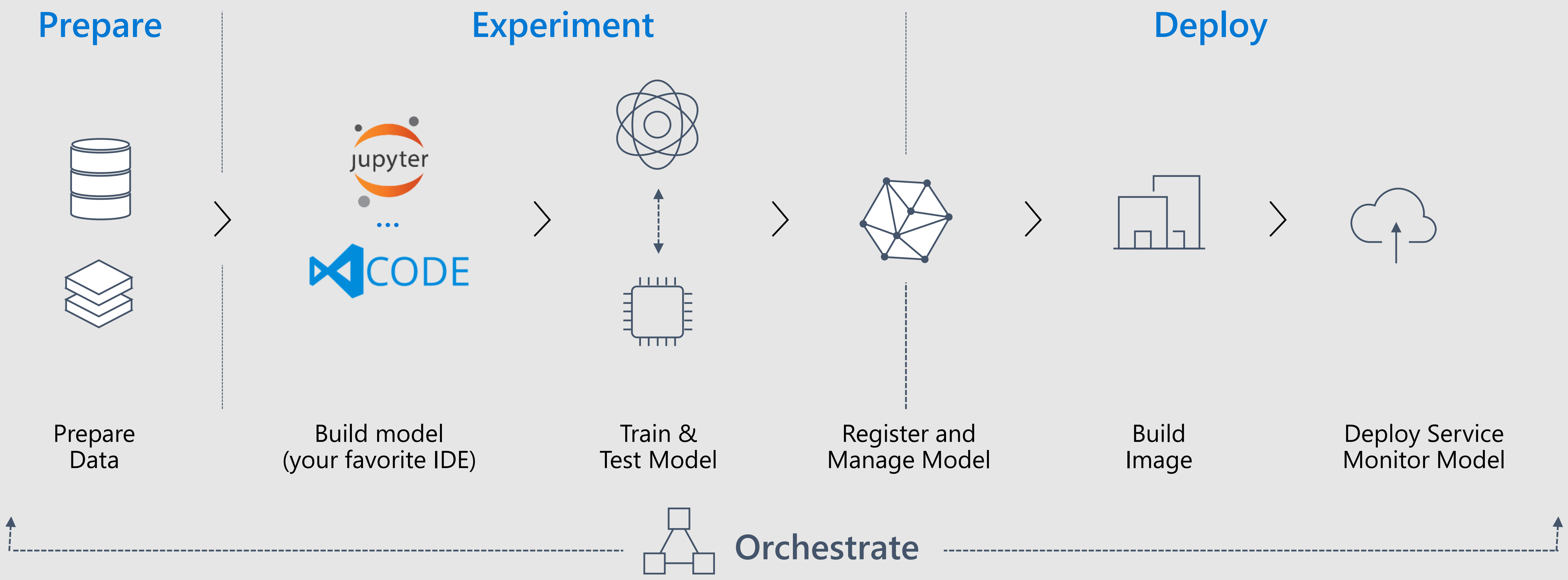
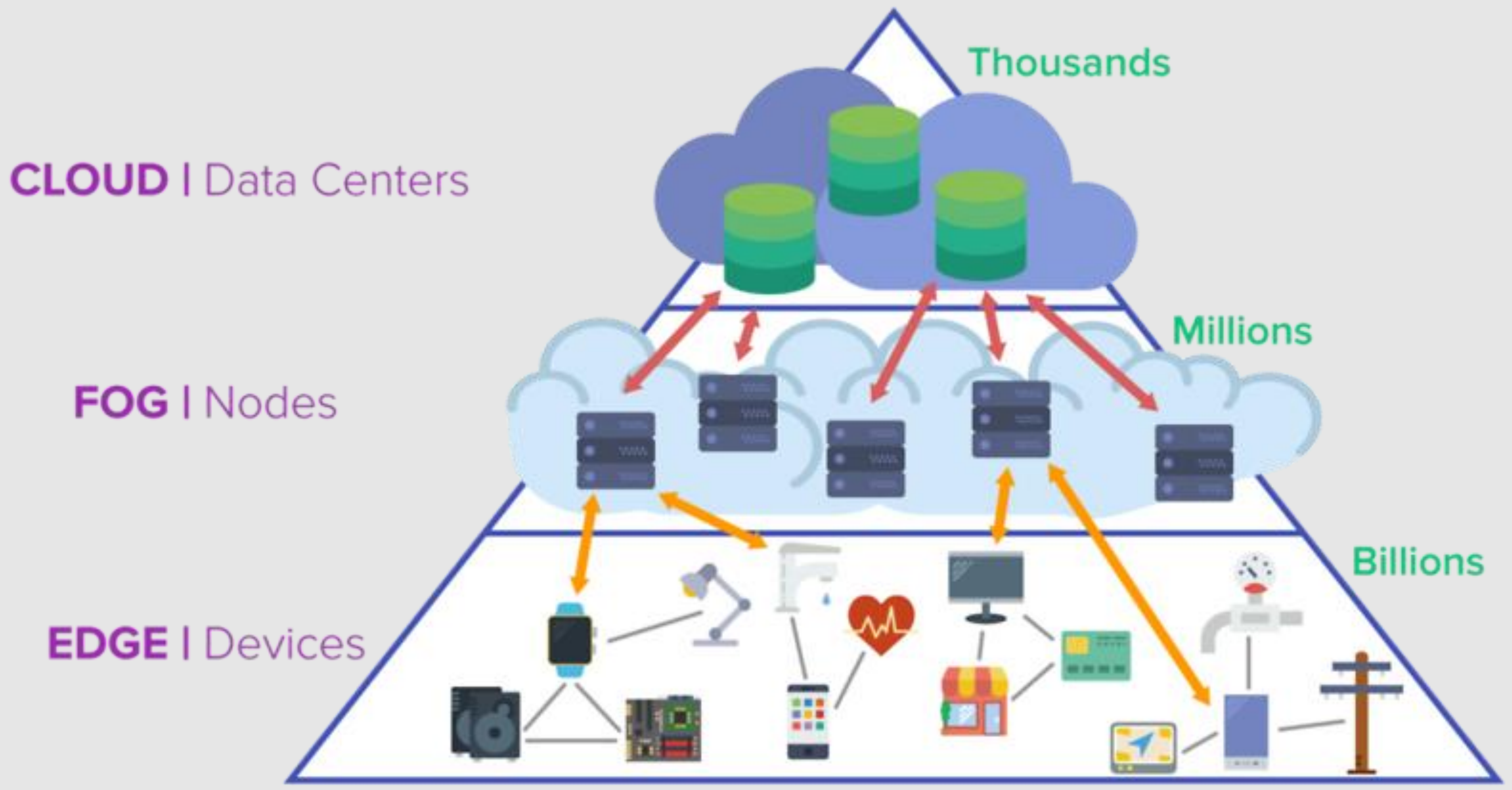
Machine Learning

Typical E2E Process



Cloud or Edge

What is the Edge?



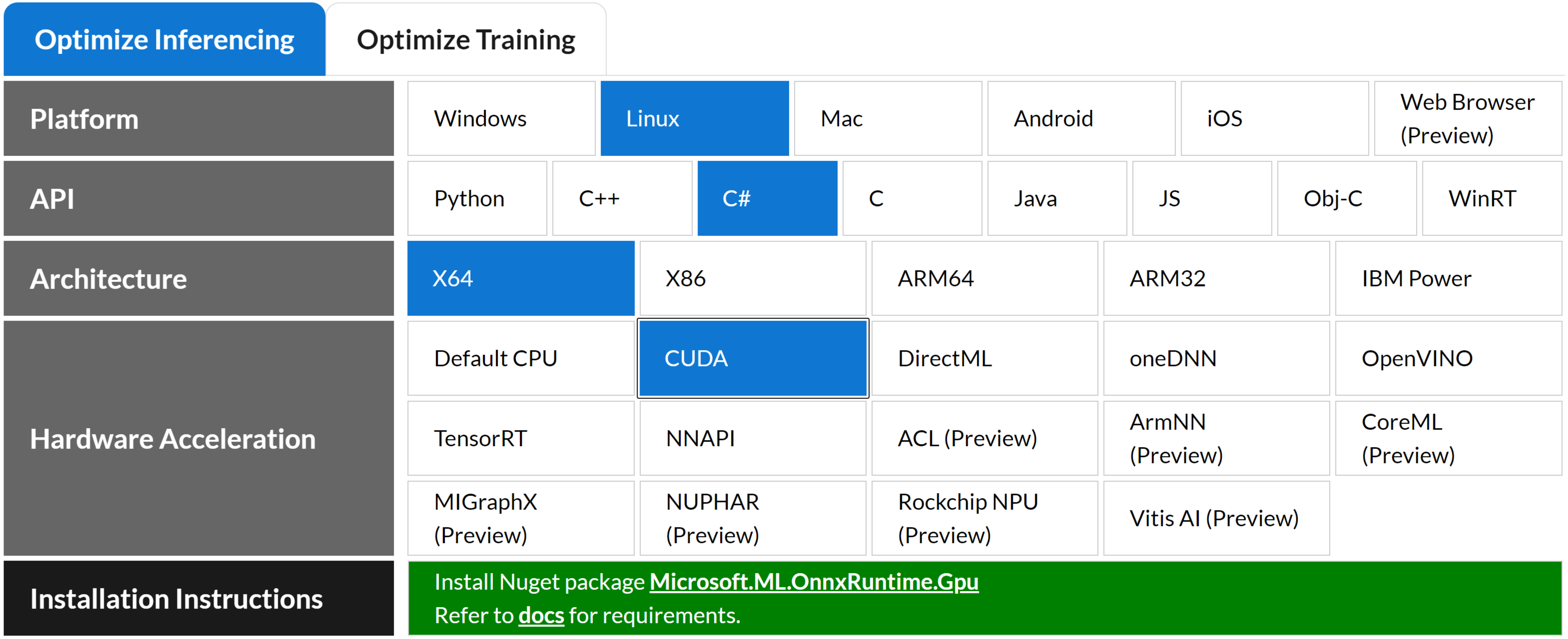
Imagimob AB

ONNX Runtime

- High performance inference engine for ONNX models
- Founded and Open Sourced by Microsoft under MIT License
- Supports full ONNX-ML spec
- Extensible architecture to plug-in hardware accelerators
- Ships with Windows 10 as WinML
- onnxruntime.ai

ONNX Runtime

Get Started Easily



[✓ Optimize Inferencing] Optimize Training

Platform	Windows	[✓ Linux]	Mac	Android	iOS	Web Browser (Preview)		
API	Python	C++	[✓ C#]	C	Java	JS	Obj-C	WinRT
Architecture	[✓ X64]	X86	ARM64	ARM32	IBM Power			
Hardware Acceleration	Default CPU	[✓ CUDA]	DirectML	oneDNN	OpenVINO			
	TensorRT	NNAPI	ACL (Preview)	ArmNN (Preview)	CoreML (Preview)			
	MIGraphX (Preview)	NUPHAR (Preview)	Rockchip NPU (Preview)	Vitis AI (Preview)				
Installation Instructions	Install Nuget package **Microsoft.ML.OnnxRuntime.Gpu** Refer to **docs** for requirements.							

ONNX Runtime JavaScript

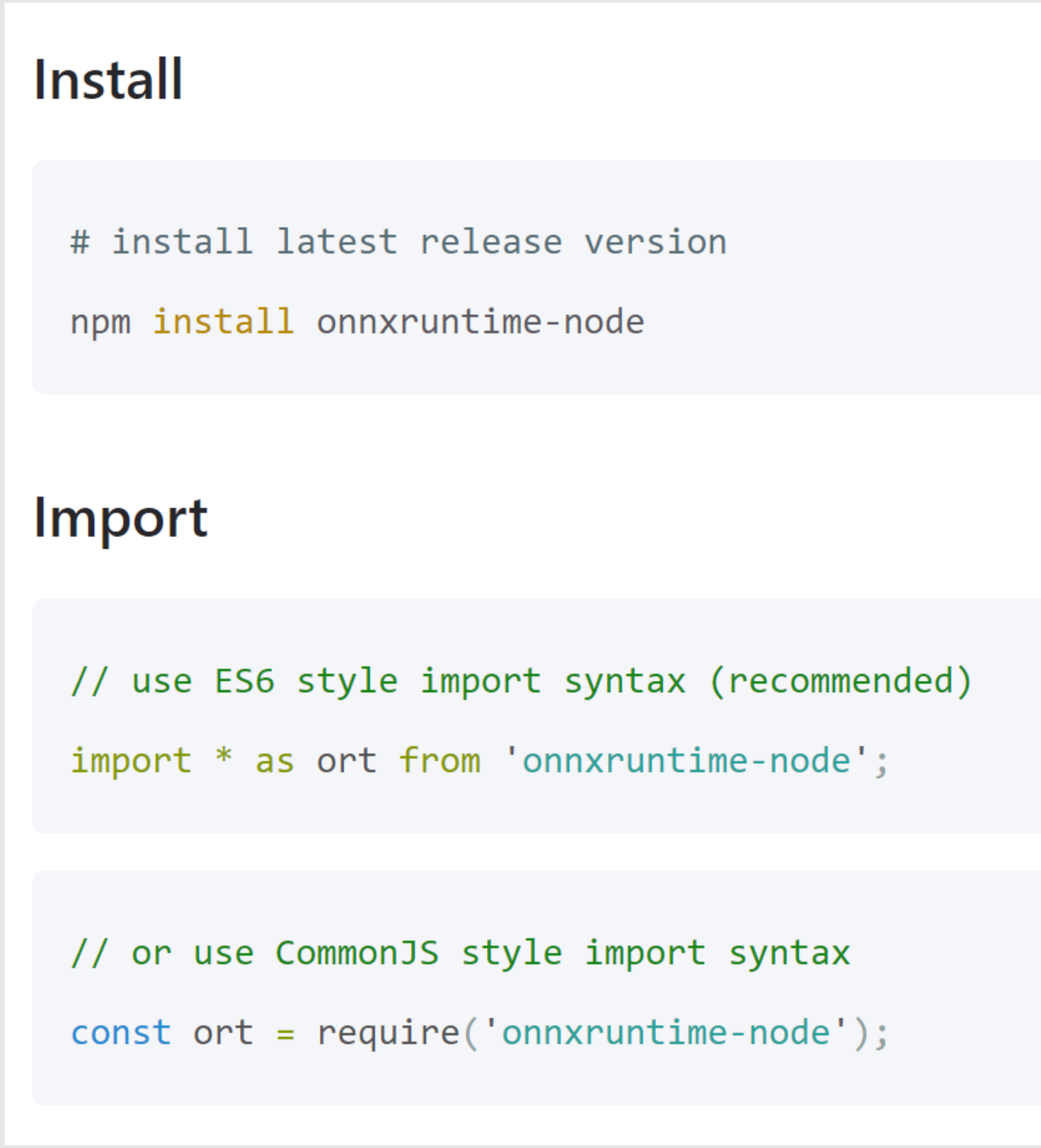
Node.js binding

Web

React Native

ONNX Runtime Node.js

- Node.js binding
- ONNX model inferencing
- Electron
- Uses web assembly



Install

```
# install latest release version
npm install onnxruntime-node
```

Import

```
// use ES6 style import syntax (recommended)
import * as ort from 'onnxruntime-node';
```

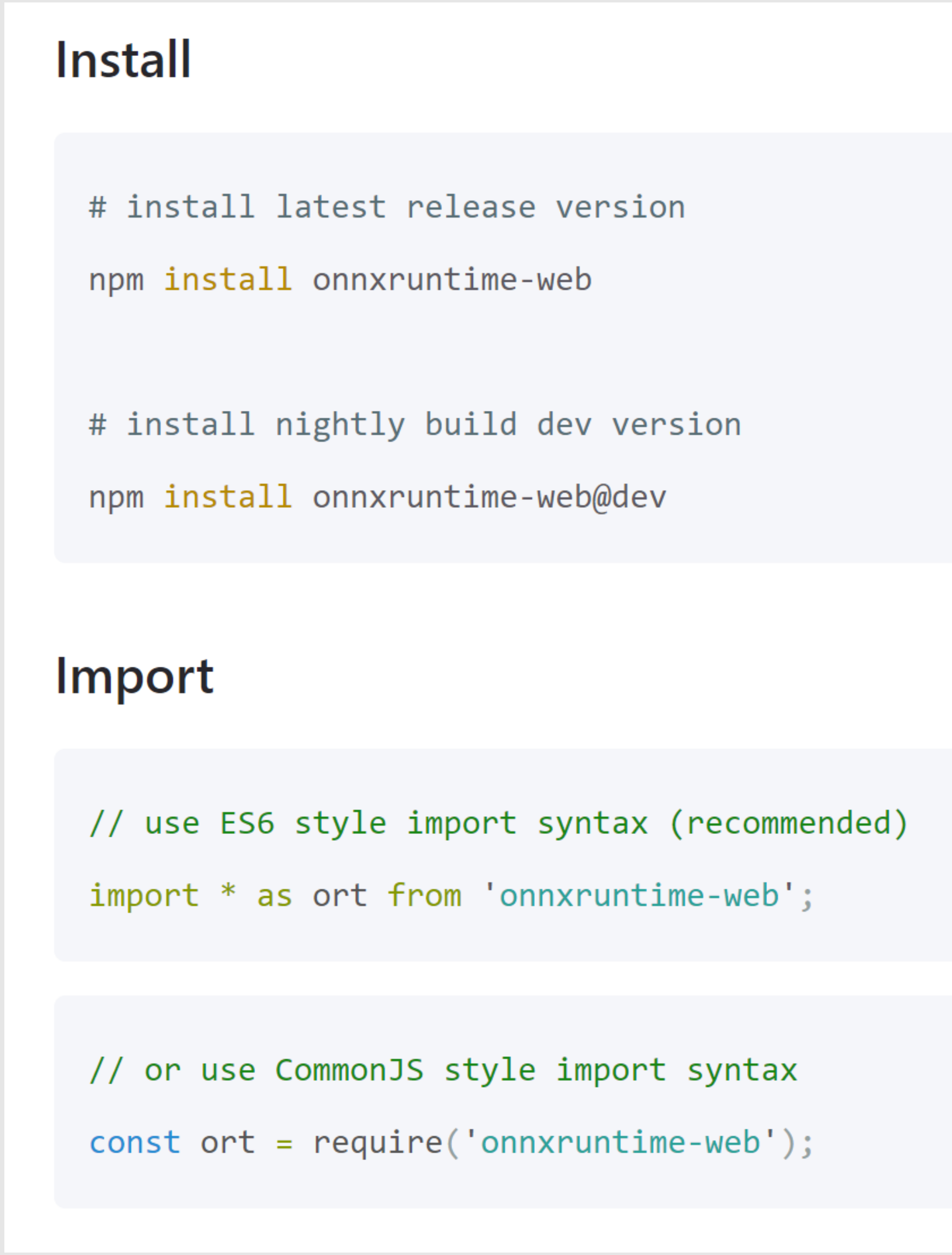
```
// or use CommonJS style import syntax
const ort = require('onnxruntime-node');
```

Node.js Demo

ONNX Runtime Web (ORT-Web)

- JavaScript library for running ONNX models on browsers
- adopted Web Assembly and WebGL technologies
- optimized ONNX model inference runtime for both CPUs and GPUs.

- React Template
  https://github.com/microsoft/onnxruntime-nextjs-template



Install

```
# install latest release version
npm install onnxruntime-web

# install nightly build dev version
npm install onnxruntime-web@dev
```

Import

```
// use ES6 style import syntax (recommended)
import * as ort from 'onnxruntime-web';
```

```
// or use CommonJS style import syntax
const ort = require('onnxruntime-web');
```

Why inference in the browser

It's faster

It's safer and helps with privacy

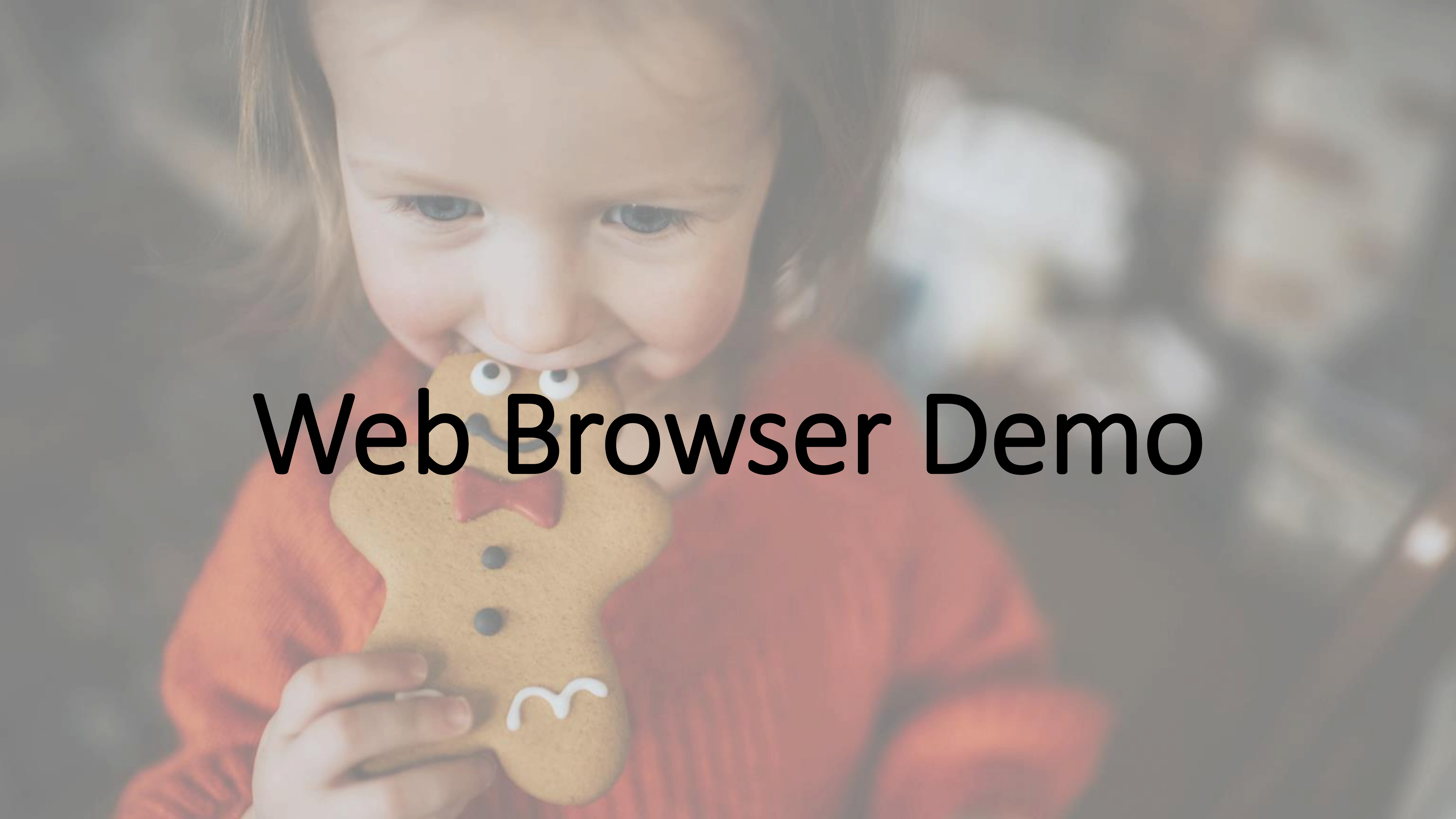
It works offline

It's cheaper

Why not in the browser?

THE MODEL IS TOO LARGE AND REQUIRES HIGHER HARDWARE SPECS.

DOWNLOADED ONTO THE DEVICE



Web Browser Demo

Resources

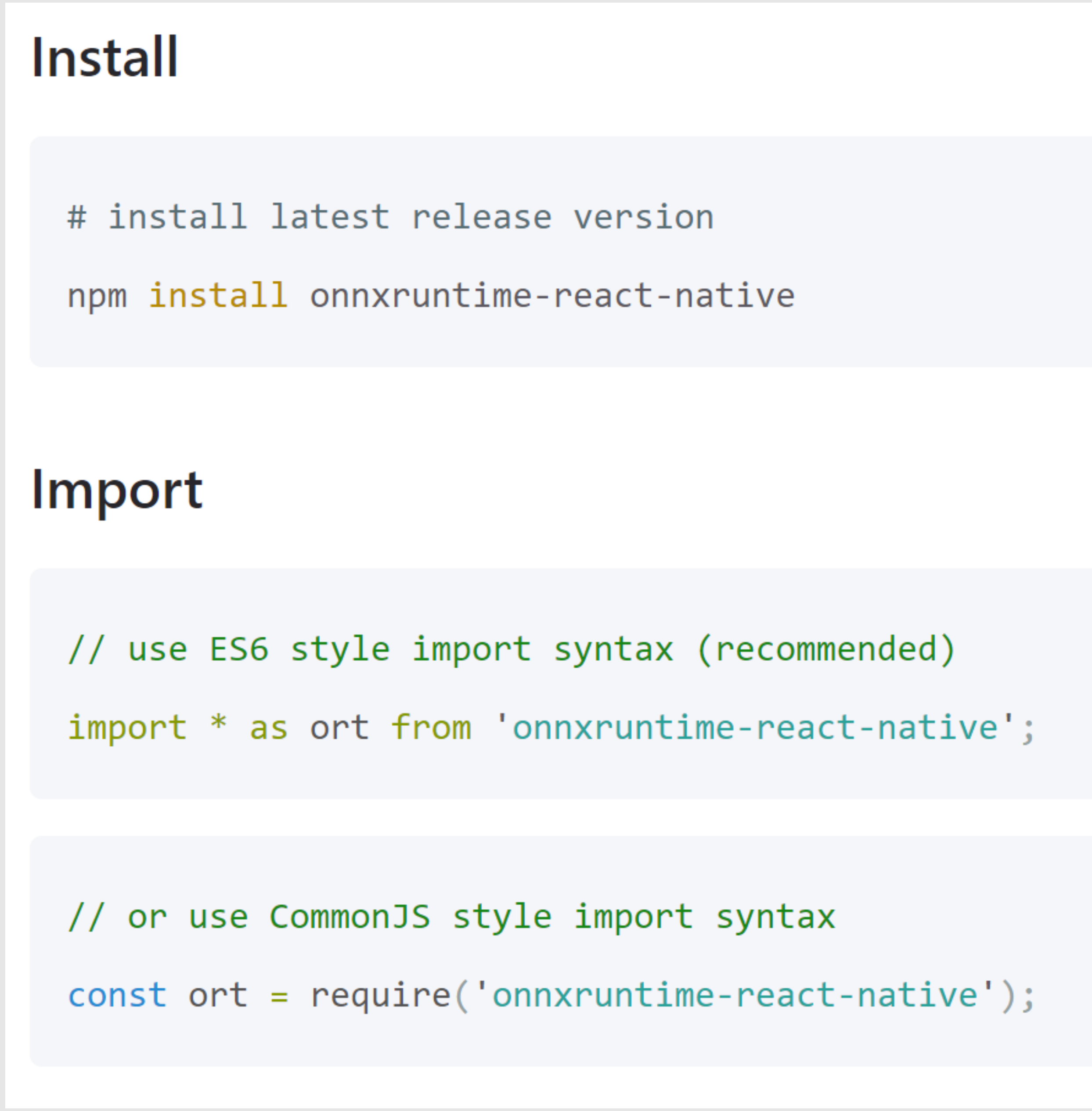
https://github.com/microsoft/onnxruntime-nextjs-template

https://github.com/microsoft/onnxruntime-web-demo

https://microsoft.github.io/onnxruntime-web-demo/#/

React Native

- score pre-trained ONNX models
- ONNX Runtime Mobile
- light-weight inference solution
- Android and iOS



Install

```
# install latest release version
npm install onnxruntime-react-native
```

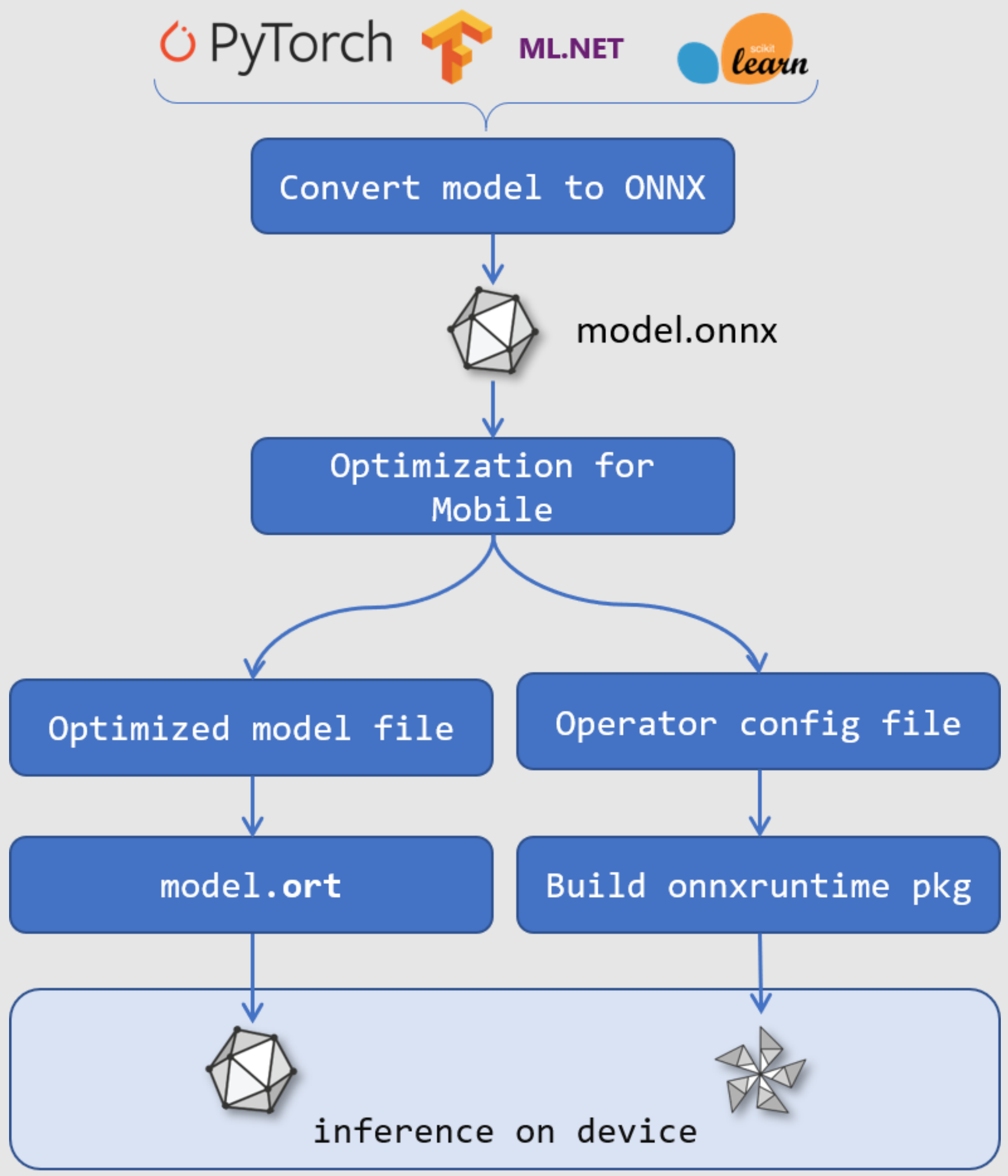
Import

```
// use ES6 style import syntax (recommended)
import * as ort from 'onnxruntime-react-native';
```

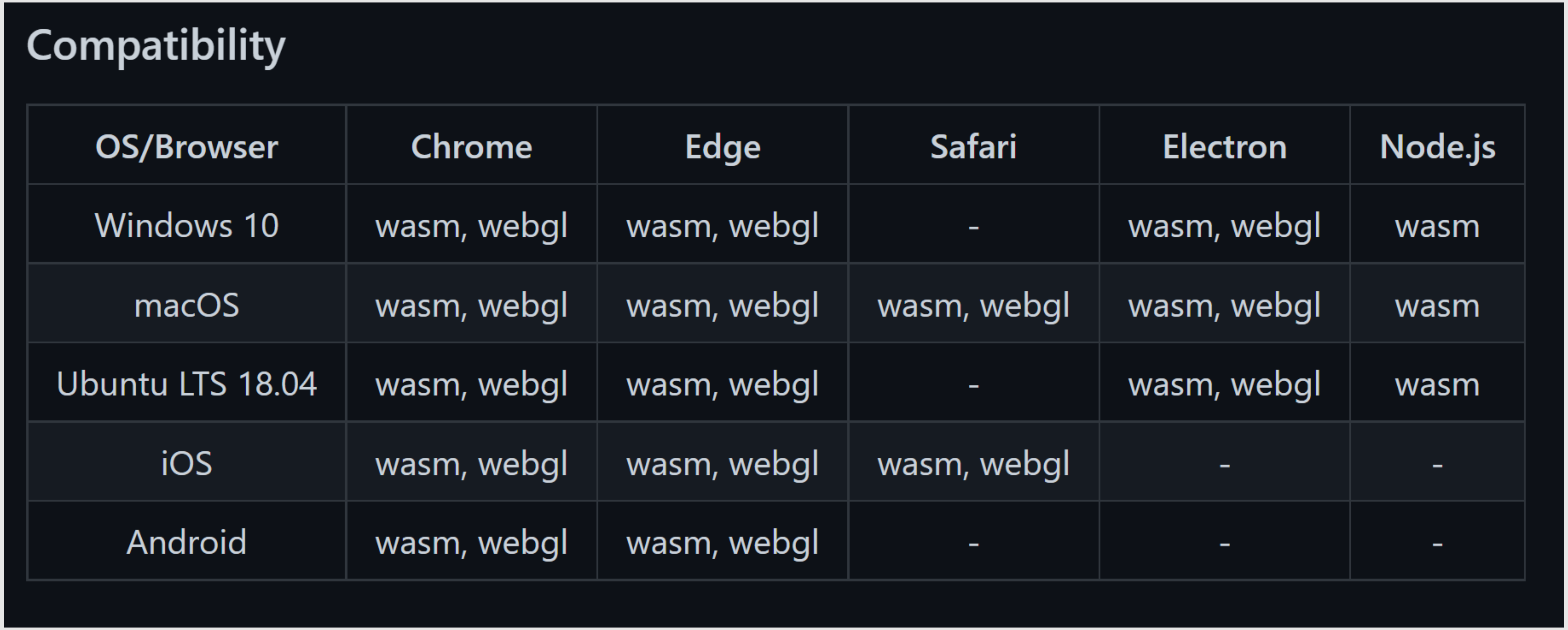
```
// or use CommonJS style import syntax
const ort = require('onnxruntime-react-native');
```

ONNX Runtime Mobile

- minimizes the binary size
- pre-optimized ONNX model to an internal format (‘ORT format model’)



Compatibility Chart



Compatibility

OS/Browser	Chrome	Edge	Safari	Electron	Node.js
Windows 10	wasm, webgl	wasm, webgl	-	wasm, webgl	wasm
macOS	wasm, webgl	wasm, webgl	wasm, webgl	wasm, webgl	wasm
Ubuntu LTS 18.04	wasm, webgl	wasm, webgl	-	wasm, webgl	wasm
iOS	wasm, webgl	wasm, webgl	wasm, webgl	-	-
Android	wasm, webgl	wasm, webgl	-	-	-

Recap

- ✓ What is ONNX

  ONNX is an open standard so you can use the right tools for the job and be confident your models will run efficiently on your target platforms

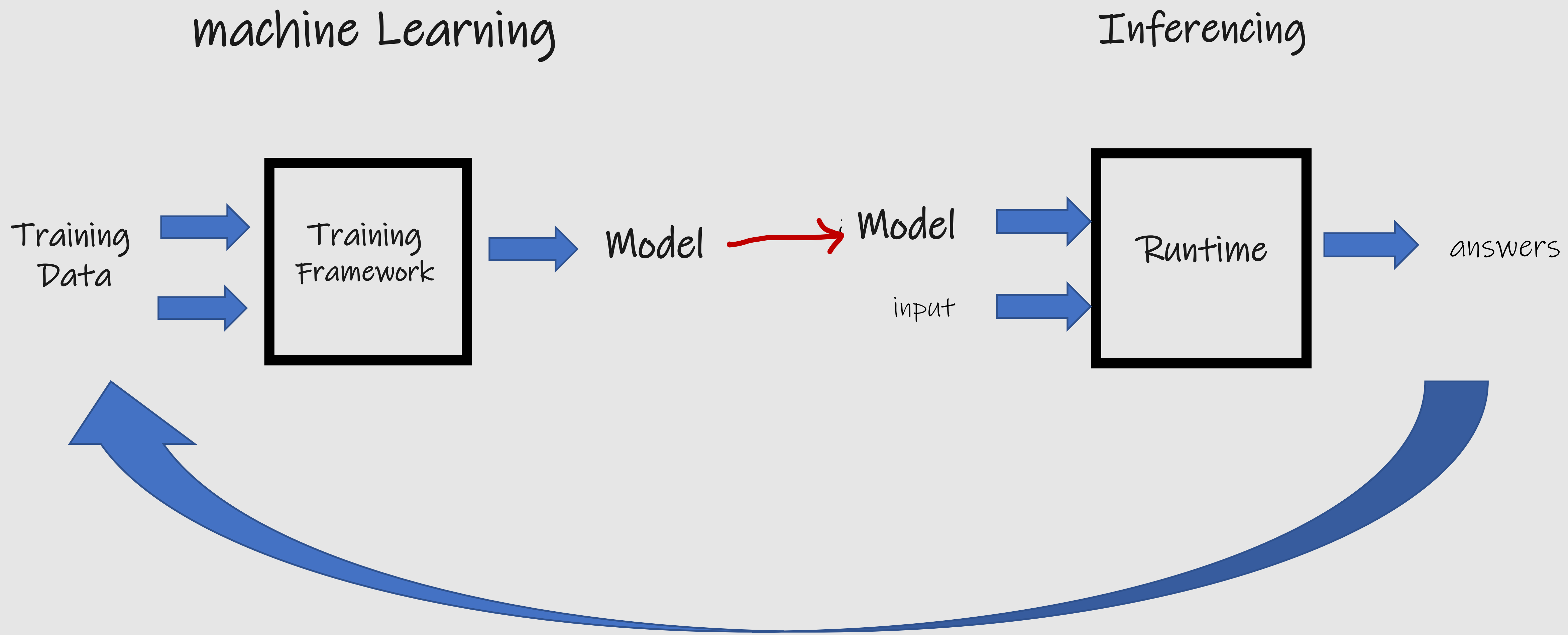
- ✓ How to create ONNX models

  ONNX models can be created from many frameworks

- ✓ How to deploy ONNX models

  ONNX models can be deployed with Windows ML, .NET/Javascript/Python and to the cloud with Azure ML and the high performance ONNX Runtime

ML Primer


machine Learning
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Training Data
Training Framework
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Model
input
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answers

https://github.com/rondagdag/onnx-web-presentation

About Me

Ron Dagdag

MVP Microsoft® Most Valuable Professional

https://linktr.ee/rondagdag

- Director of Software Engineering at Spacee
- 5th year Microsoft MVP awardee
- Personal Projects
  www.dagdag.net
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  Twitter @rondagdag
- Connect me via Linked In
  www.linkedin.com/in/rondagdag/
- Thanks for geeking out with me about ONNX