Ascend Full-Stack AI

Software/Hardware Platform

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2. CANN: Compute Architecture for Neural Networks
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Towards an AI Era

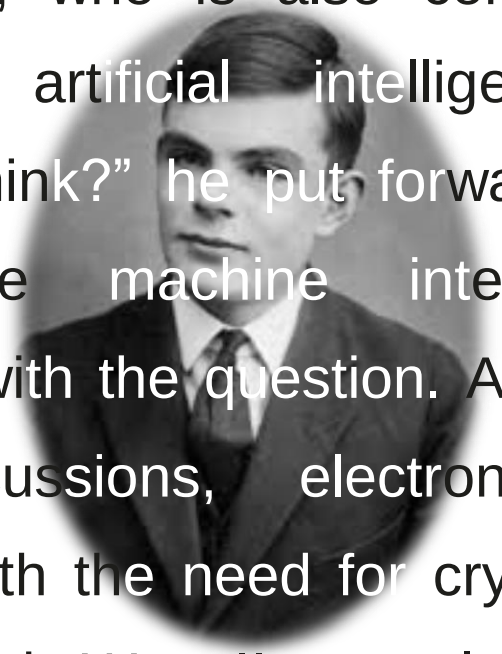
AI: The New Trend of the Industry

What is AI?

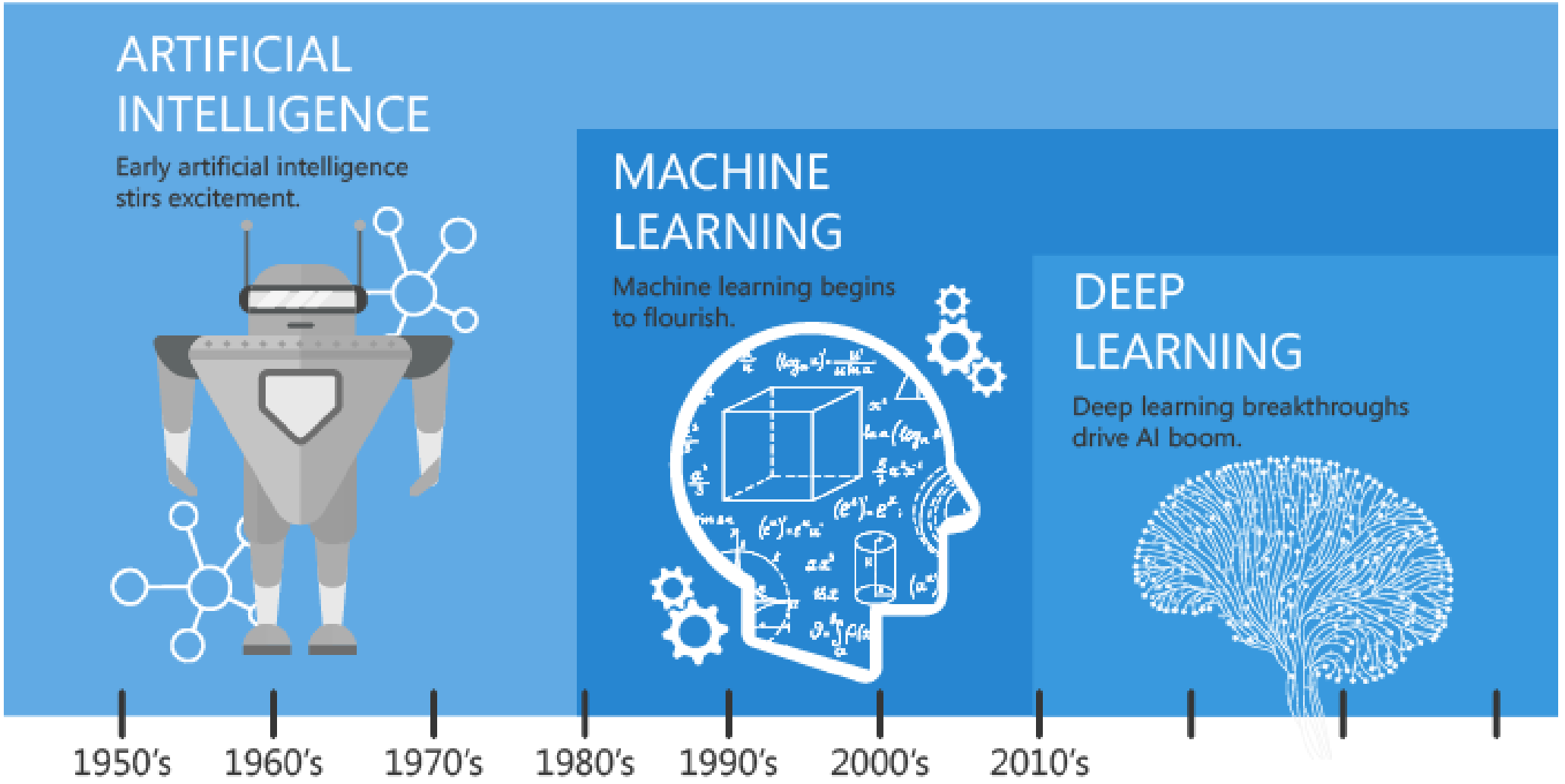
The AI is the invention that enables a computer or a robot connected to a computer system to perform certain actions similar to living things. AI aims to provide machines with skills that are human features such as knowledge, reasoning, perception, learning and managing textures .

Can AI think?

Alan Turing, who is also considered the father of artificial intelligence; “Can machines think?” he put forward in 1943. opened the machine intelligence to discussion with the question. As a result of these discussions, electronic devices produced with the need for crypto analysis during World War II revealed computer science and artificial intelligence technology.



Relationship between AI, ML and DL



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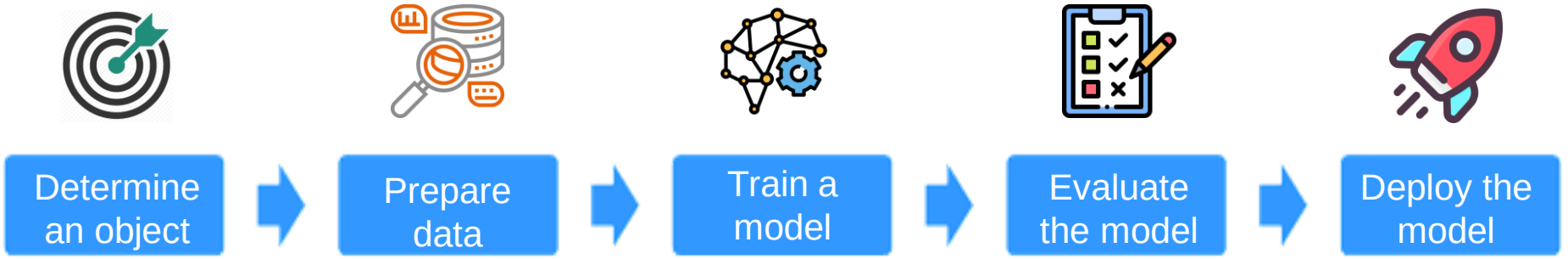
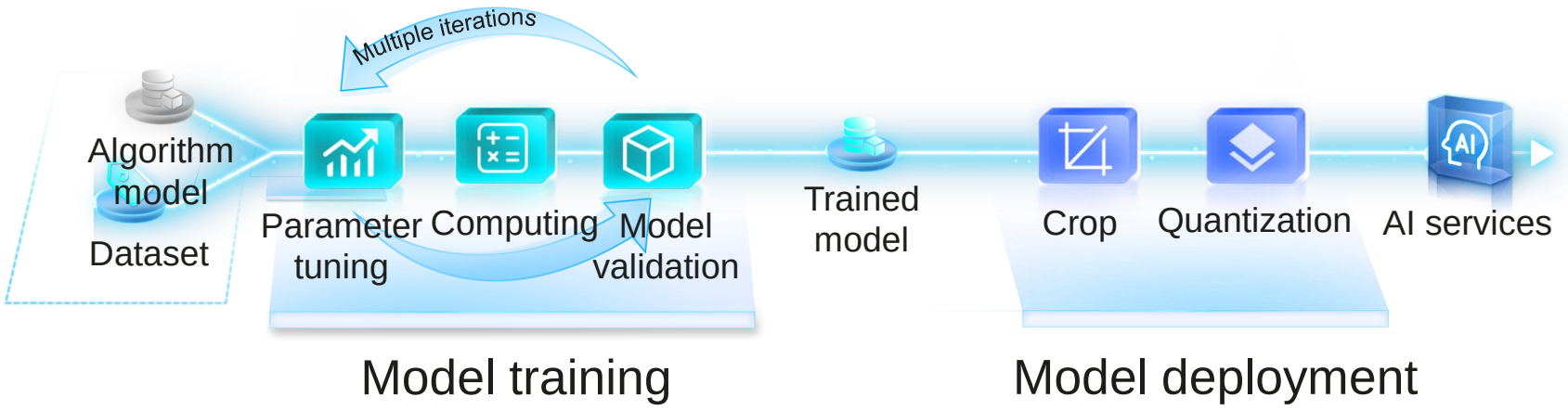
Basic Process of AI Development

The **AI development process** is as follows: determining an objective, preparing data, and training, evaluating, and deploying a model.



AI development process



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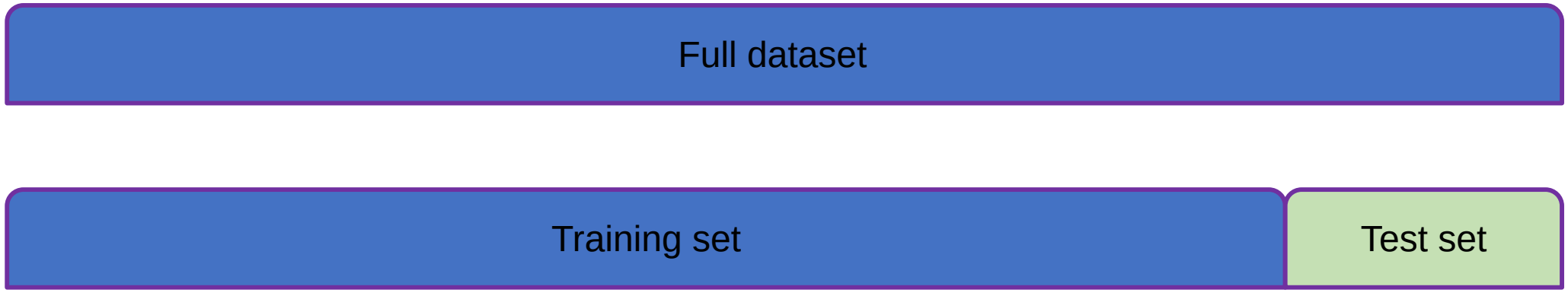
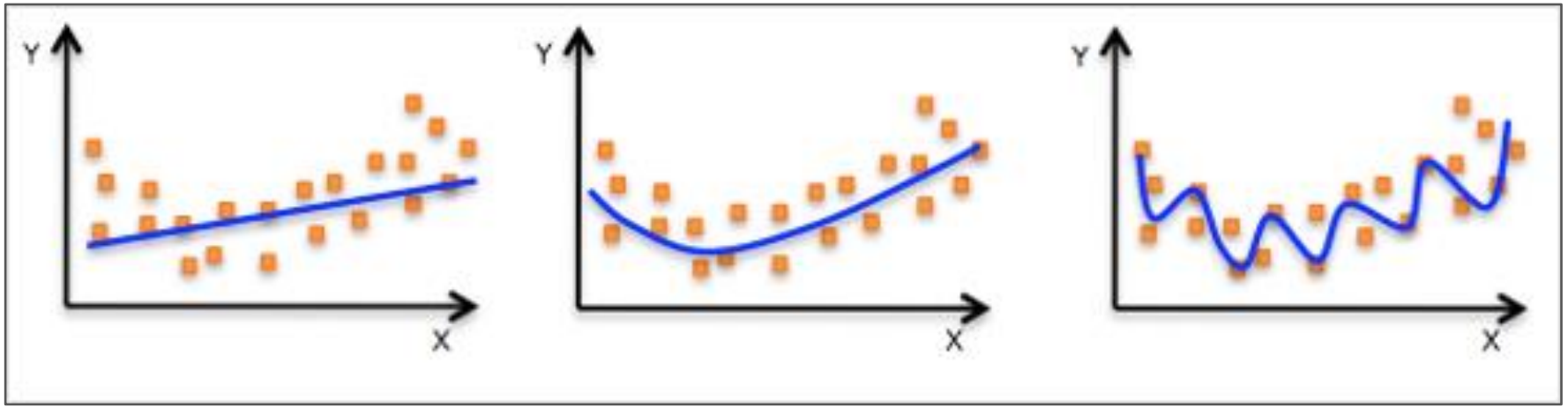
Training Set and Test Set

- **Training set:** dataset used in the training process, where each piece of training data is referred to as a training sample. Learning (or training) is the process of creating a model from data.
- **Test set:** dataset used for the testing process, where each sample is called a test sample. Testing refers to the process, during which the created model is used for prediction.



Underfitting and Overfitting

- **Underfitting:** The model is too simple. As a result, there are large training error and generalization error.
- **Overfitting:** The training error of a model obtained through training is very small, but the generalization capability is weak; that is, the generalization error is large.



Underfitting
No features are learned.

Good fitting

Overfitting
Noises are learned.

Huawei Ascend AI Solutions

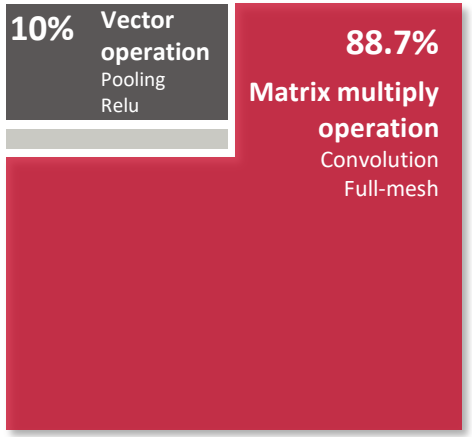
AI Unlocks Boundless Possibilities

Huawei Da Vinci Architecture Unlocks the Ultimate AI Computing Power

AI computing characteristics

~90% are matrix multiply operation

- AI computing is mainly based on the convolutional neural network (CNN) model.
- About 90% of the CNN model is based on matrix multiply operations.
- The **cube computing unit** is the most suitable.



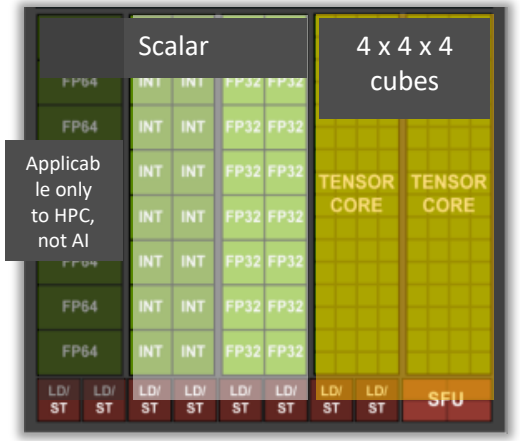
Da Vinci architecture: best-fit for AI computing

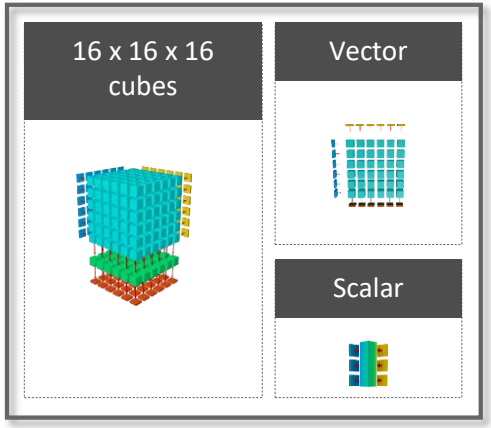
GPU

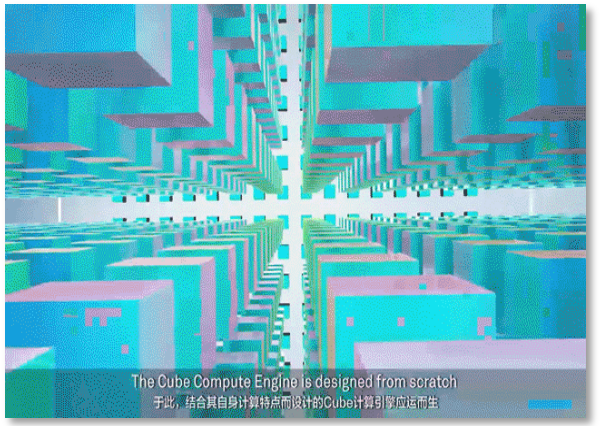
- **The GPU is not designed for AI computing.** Therefore, it is inefficient in matrix multiply computing.

NPU

- The Da Vinci architecture is **specially designed for AI computing.**
- Provides cube, vector, and scalar computing units for AI computing
- The Da Vinci architecture has a large proportion of cubes, enabling **high matrix multiply computing efficiency, and optimal area-to-efficiency ratio.**







2x area-to-efficiency ratio

On the same area, the Da Vinci architecture delivers 2x computing power.

	Other AI Chip Architectures	Da Vinci Architecture
Chip area (12nm)	5.x mm^2	13.x mm^2
Computing power	1.7 TOPS FP16	8 TOPS FP16
Area-to-efficiency ratio	**~0.3**	**~0.6**

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Ascend AI Processors Empower Superior Compute Intelligence

AI SoC with ultimate perf./watt

- Ascend-Mini
  Architecture: Da Vinci
- **Half precision (FP16): 11 TFLOPS**
  Integer precision (INT8): 22 TOPS
  16-channel full-HD video decoder: H.264/265
  Single-channel full-HD video encoder: H.264/265
  Max. power consumption: 8 W
- 12 nm

Most powerful AI processor

- Ascend-Max
  Architecture: Da Vinci
- **Half precision (FP16): 320 TFLOPS**
  Integer precision (INT8): 640 TOPS
  128-channel full-HD video decoder: H.264/265
- **Max. power consumption: 310 W**
- 7 nm

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Overview of The Huawei Ascend Full-Stack AI Platform

Industry applications

Smart city, manufacturing, energy, transportation, finance, carriers, education, and more

Application enablement

ModelArts

HiAI Service

Third-party platform

MindX

- **MindX DL** — Deep learning enablement
- **MindX Edge** — Intelligent edge enablement
- **ModelZoo** — Pre-trained model library
- **MindX SDK** — Industry SDKs

AI framework

MindSpore

An all-scenario deep learning framework for Ascend AI processors

Third-party frameworks such as TensorFlow and PyTorch

Supports secondary development, retraining and inference of models from third-party frameworks

Heterogeneous AI computing architecture

CANN

Unified heterogeneous computing architecture to unleash hardware computing potential

Full-pipeline development toolchain: MindStudio

O&M tools: FusionDirector/SmartKit

Ascend Community: hiascend.com

Full-series hardware

Atlas

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Ascend AI Processors Empower Superior Compute Intelligence

Based on the Ascend AI Processors and mainstream heterogeneous computing components in the industry, the Atlas series hardware products provide various product forms, such as modules, boards (inference and training cards based on application scenarios), edge stations, servers, and clusters, to build a cloud-edge-device AI infrastructure solution for all scenarios.

Ultimate computing power | **All-scenario deployment** | **Cloud-edge-device synergy**

Atlas 900 AI cluster

Atlas 800 AI server
Model: 9000/9010

Atlas 800 AI server
Model: 3000/3010

Atlas 300 AI accelerator card
Model: 3000/9000

Atlas 500 AI
edge station

Atlas 200 AI
accelerator module

Cloud — **Edge** — **Device**

Ascend 310
AI Processor

Ascend 910
AI Processor

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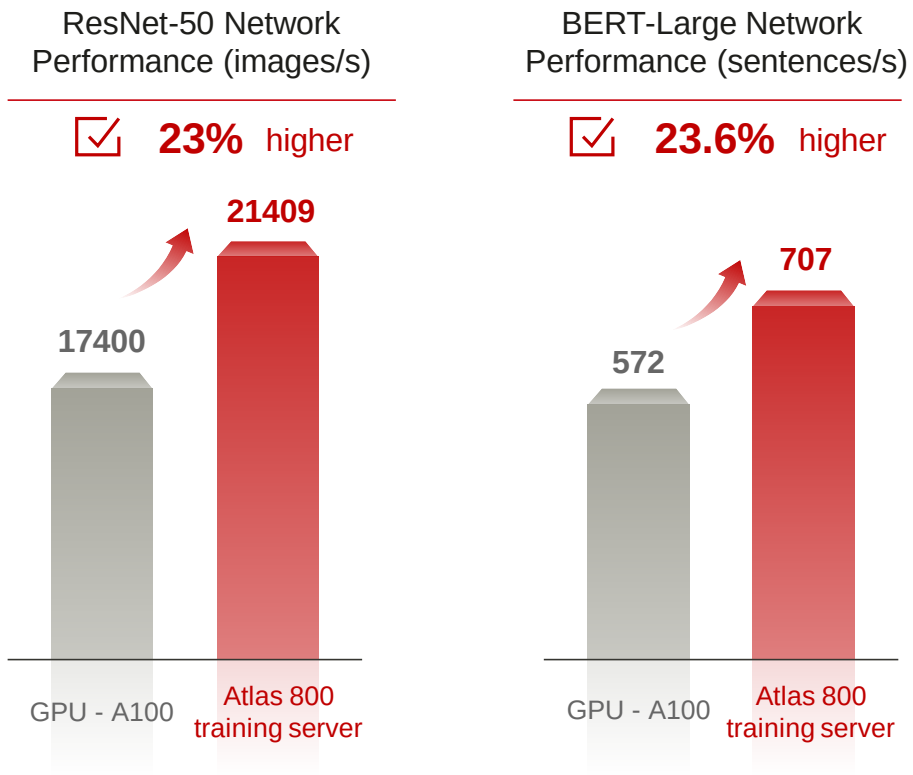
Software-Hardware Collaboration for Superior Computing in Model Training

Best-in-class training performance of mainstream models



Test benchmark: MindSpore tested on July 15, 2021

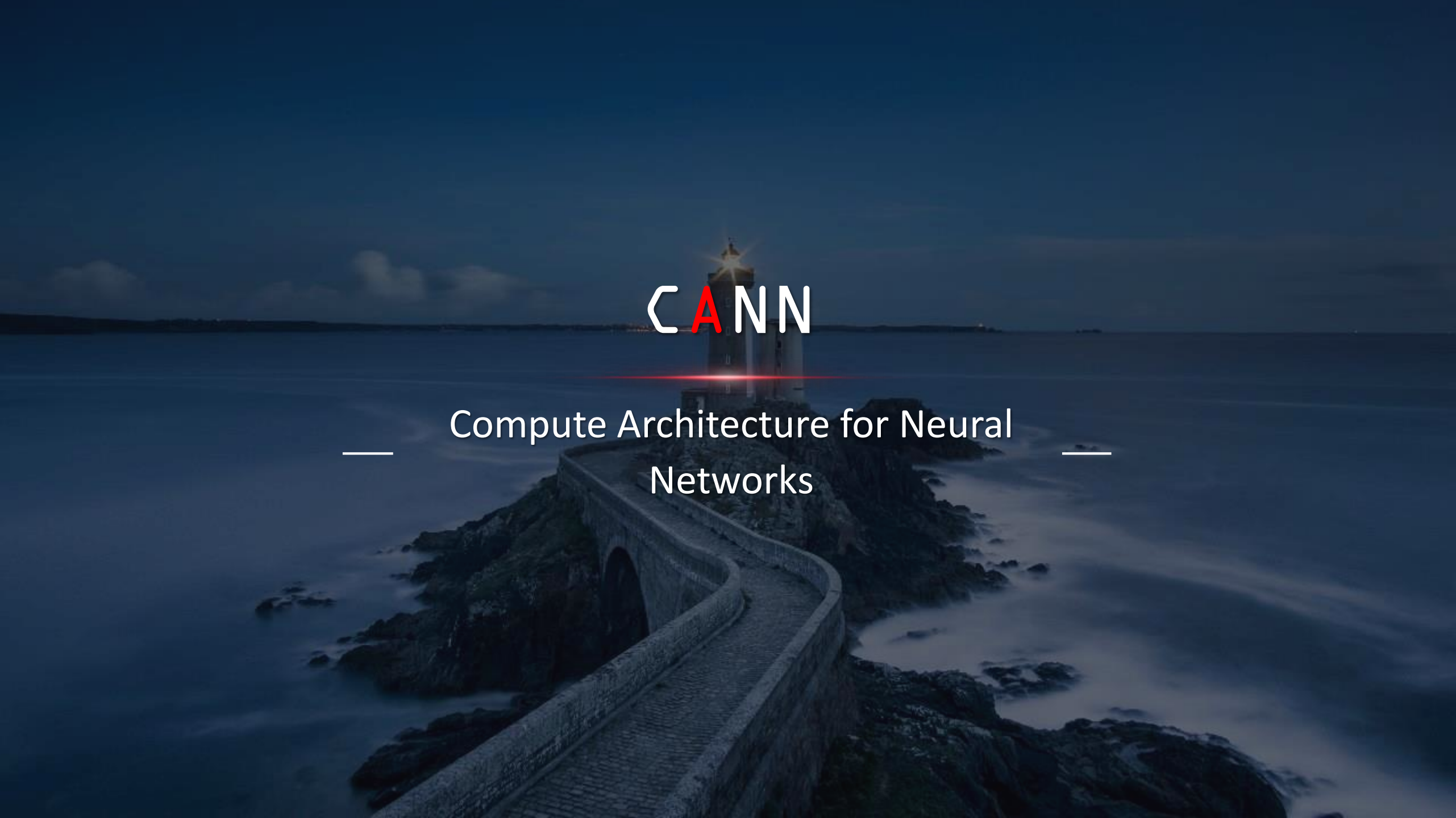
Better training performance of major models than that of NVIDIA

ResNet-50 (40% of ByteDance's computing power consumption)

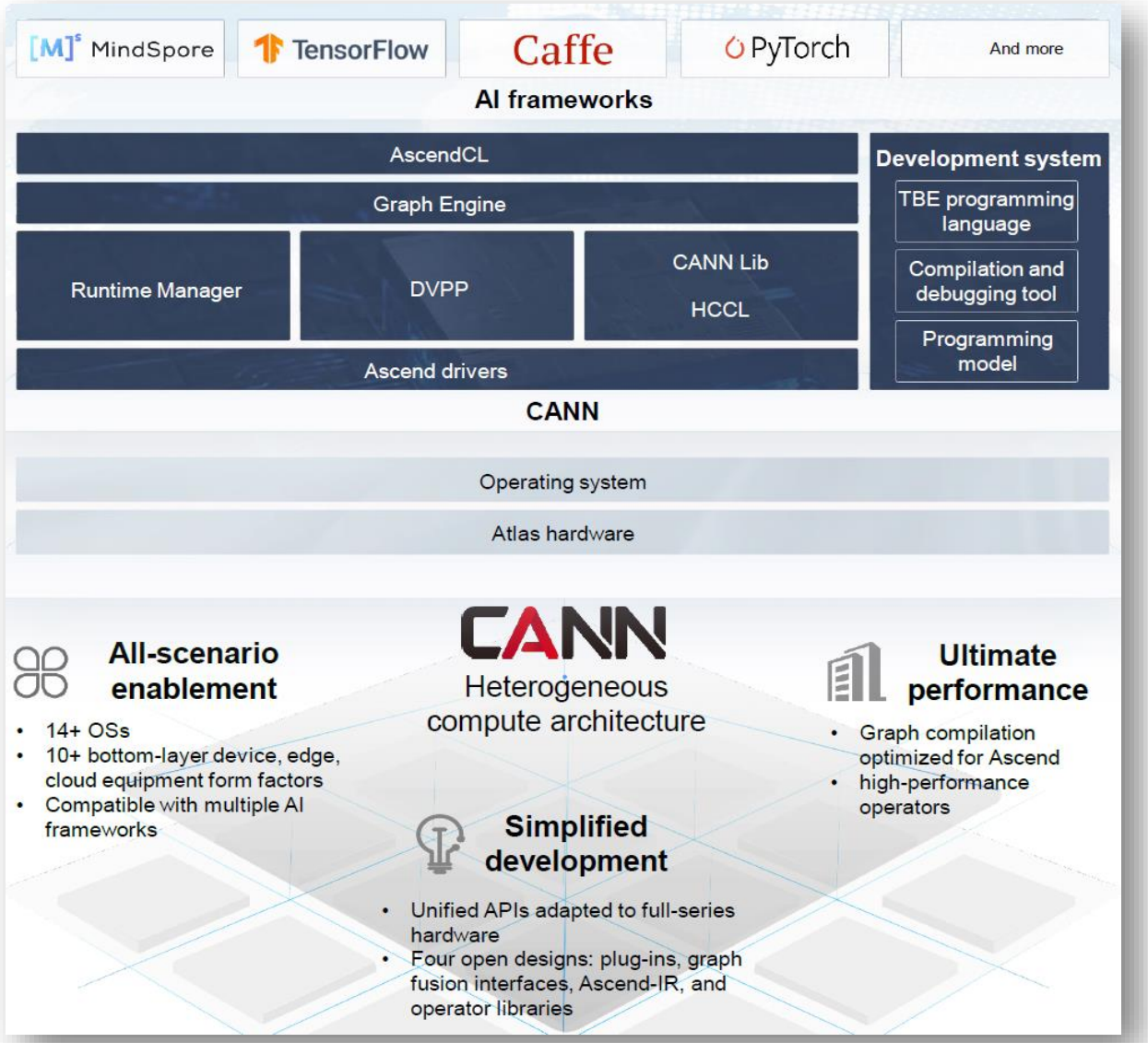
Test Scenario	NVIDIA V100	Ascend 910	Performance Comparison Ratio
Parallel Processors	FP16+XLA img/s	FP16 img/s	
1	1276	1846	145%
8	8675	14060	162%
16	13191	27731	210%
32	24302	54150	223%

BERT-Large (25% of ByteDance's computing power consumption)

Test Scenario	NVIDIA V100	Ascend 910	Performance Comparison Ratio
Parallel Processors	FP16+XLA sentences/s	FP16 sentences/s	
1	62	119	192%
8	445	861	193%
16	800	1643	205%
32	1360	3050	224%


CANN
Compute Architecture for Neural Networks

What is the CANN & ACL?



The Compute Architecture for Neural Networks (CANN) is a AI heterogeneous compute architecture designed for deep learning. It provides hierarchical APIs such as AscendCL, DVPP, and HCCL to help you quickly build AI applications and services based on the Ascend platform.

A Unified Heterogeneous Compute Architecture Unleashes Ultimate Hardware Compute Power

- Device-Edge-Cloud Synergy
- Efficient Development with AscendCL
- Unlimited Ascend Compute Power

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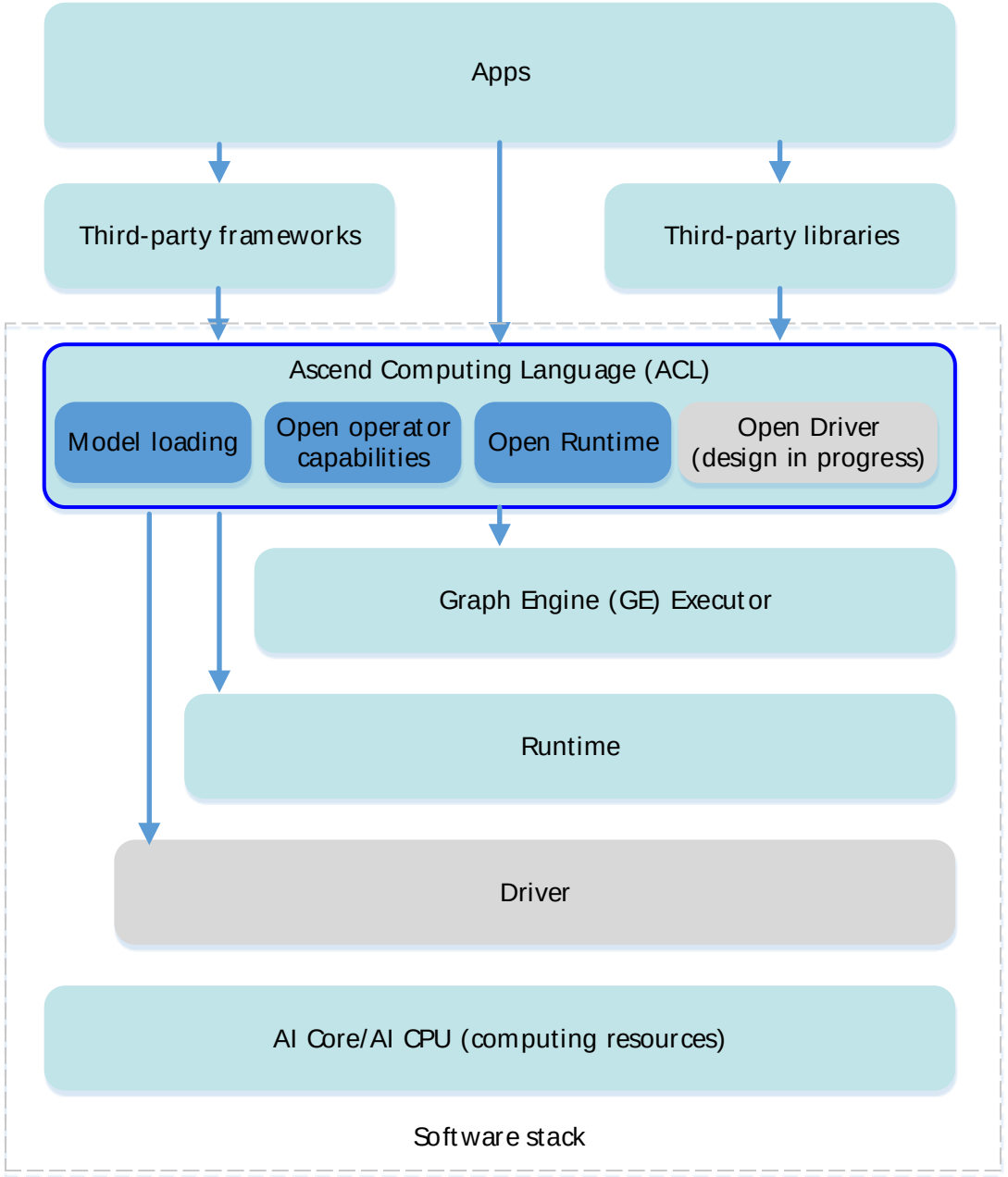
ACL Overview



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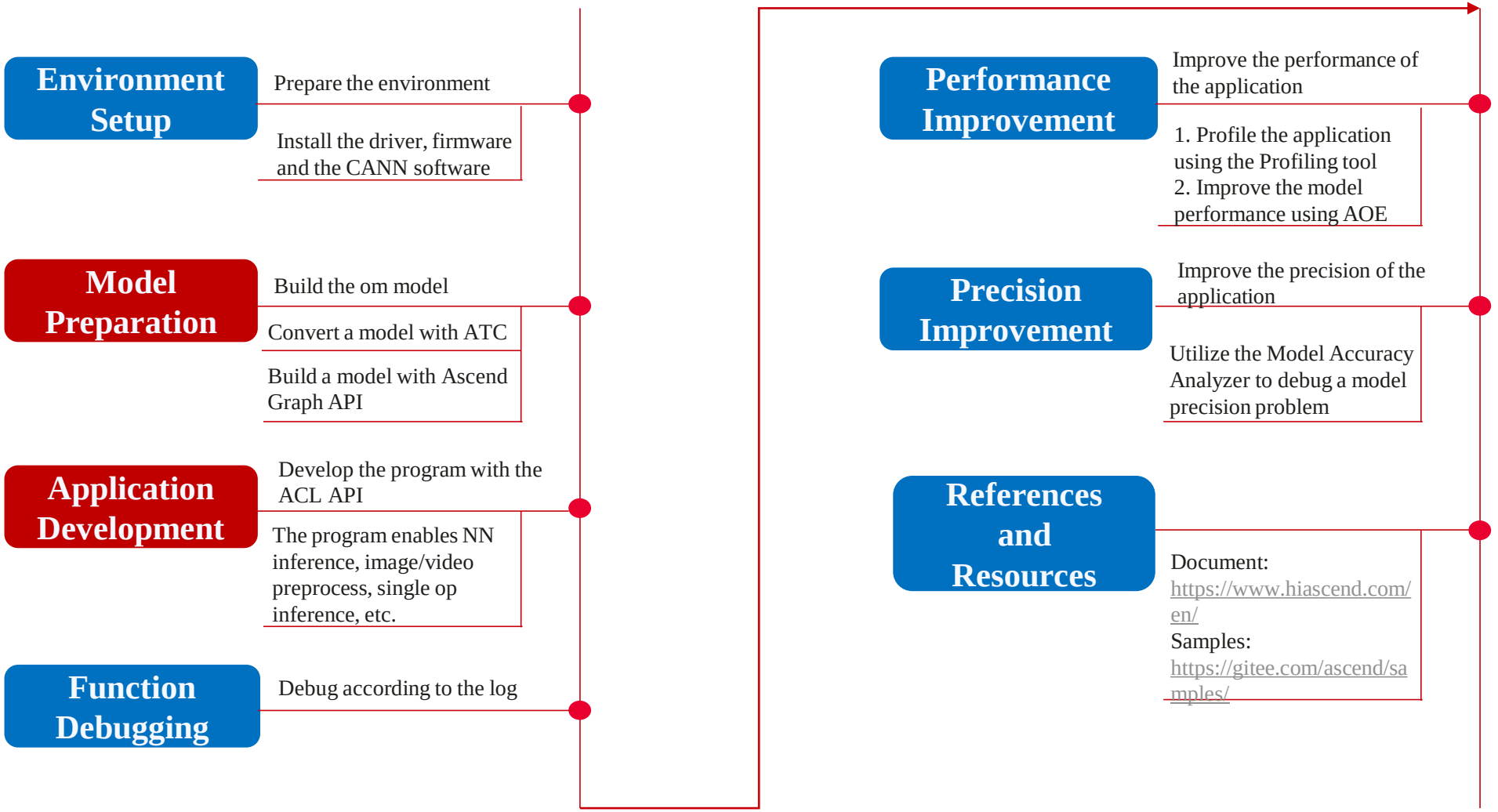
Step of Application Development on CANN



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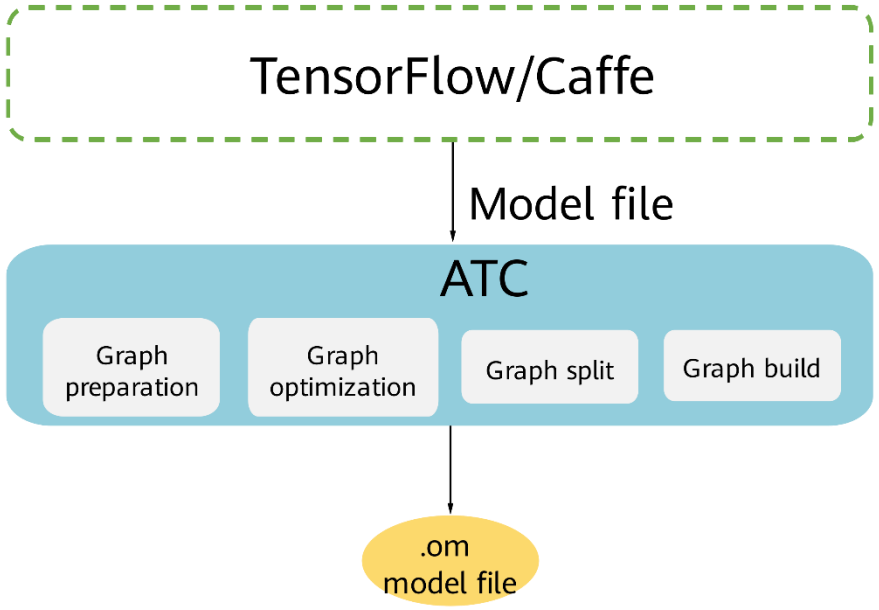
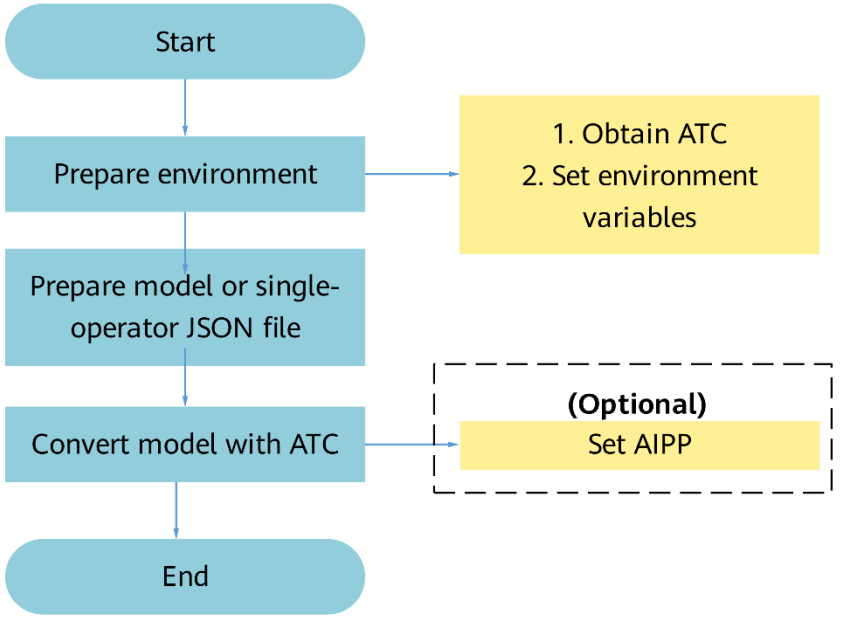
Model Preparation with ATC



ATC architecture

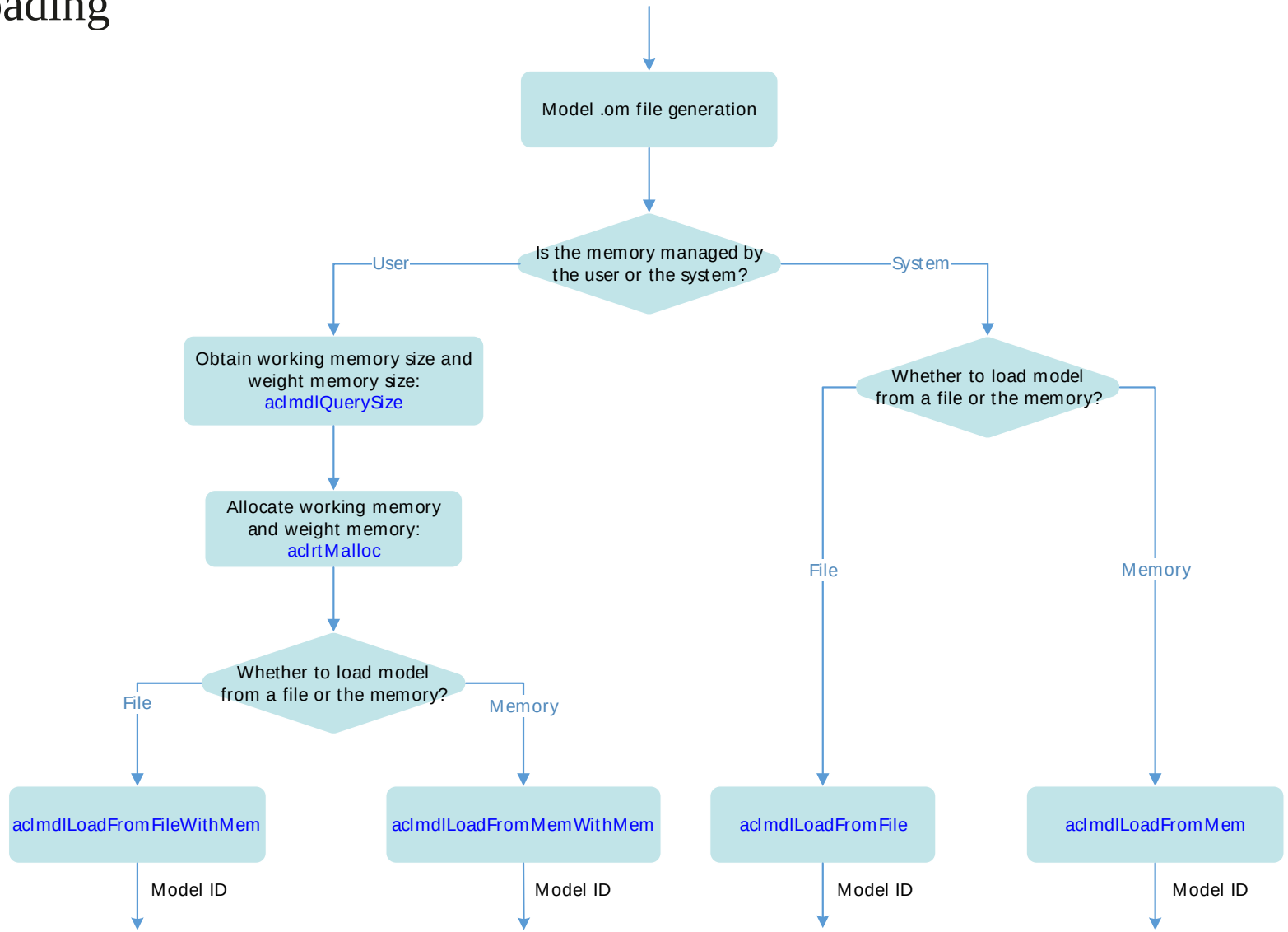


ATC workflow

```
atc --model=cafe_model/resnet50.prototxt \
    --weight= cafe_model/resnet50.cafemodel \
    --framework=0 \
    --output=model/resnet50 \
    --soc_version=Ascend310 \
    --input_format=NCHW \
    --output_type=FP32 \
    --out_nodes=prob:0
```

Typical APIs - Executing a Model

- Model Loading



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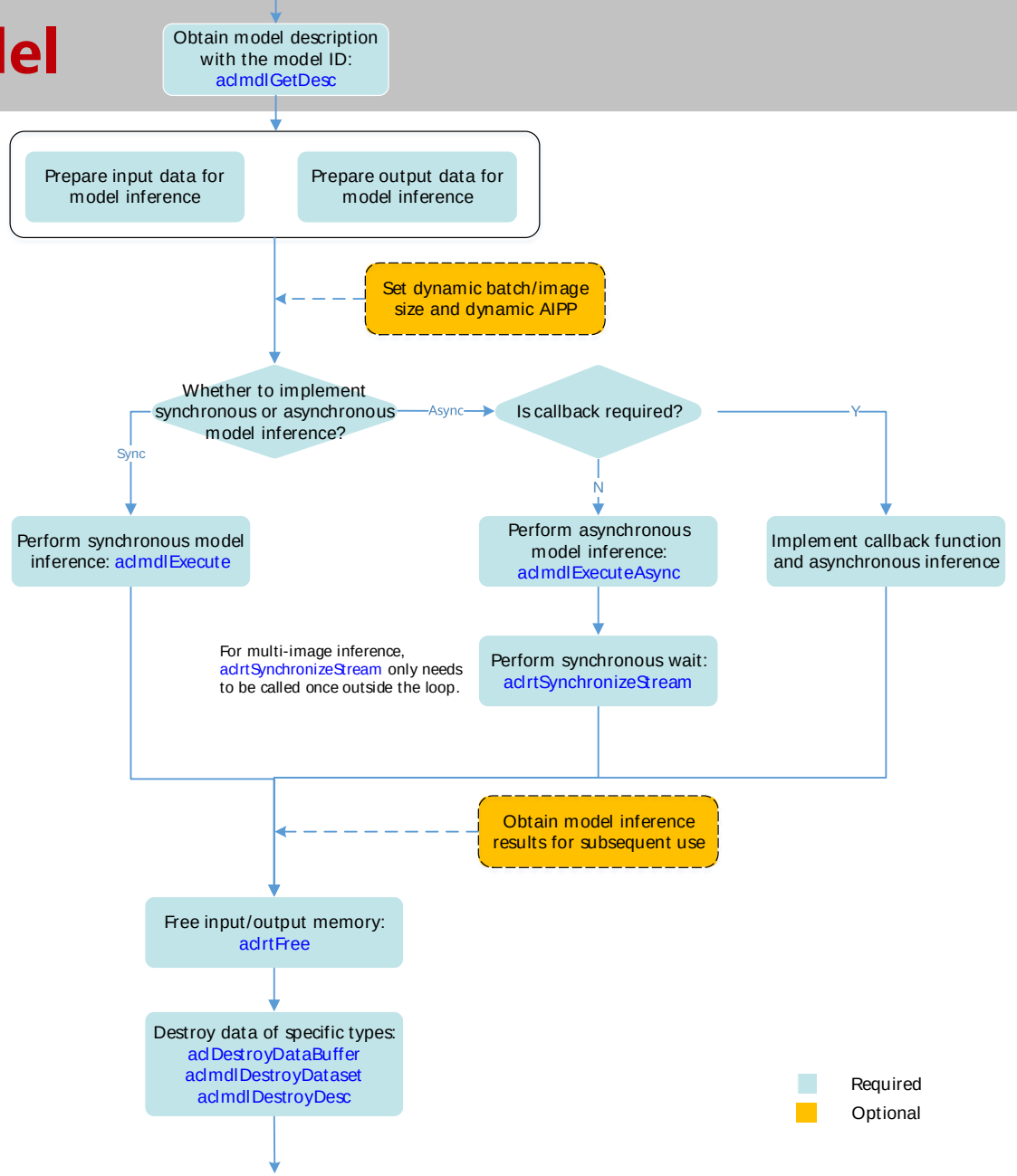
Typical APIs - Executing a Model

- Model Inference



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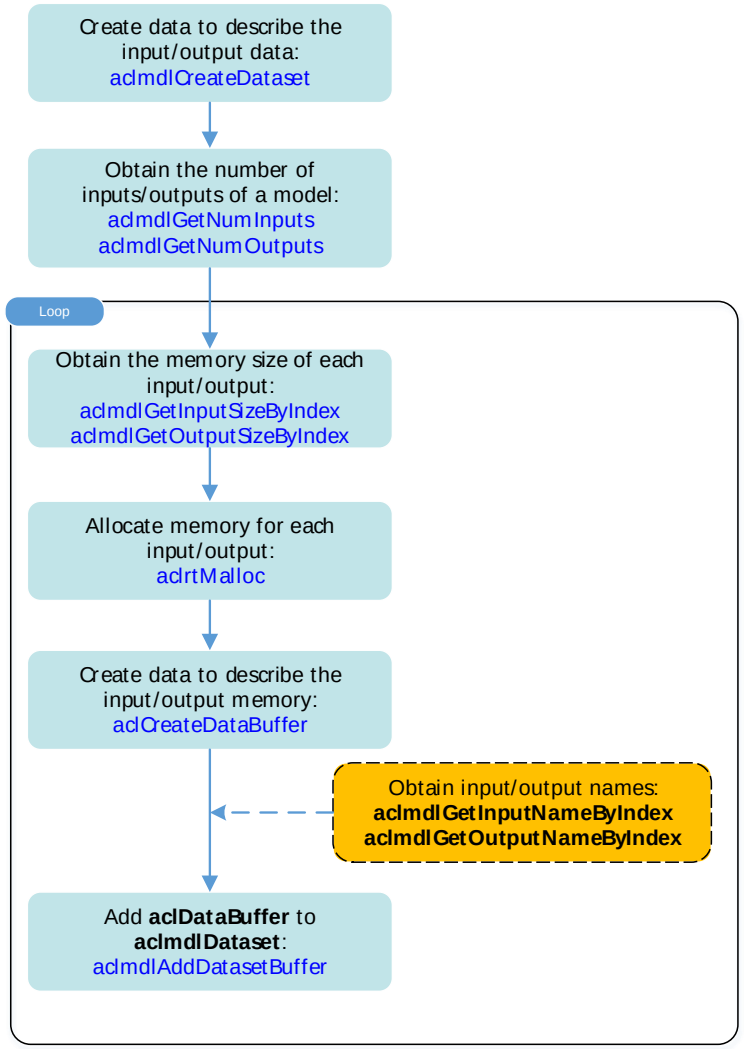
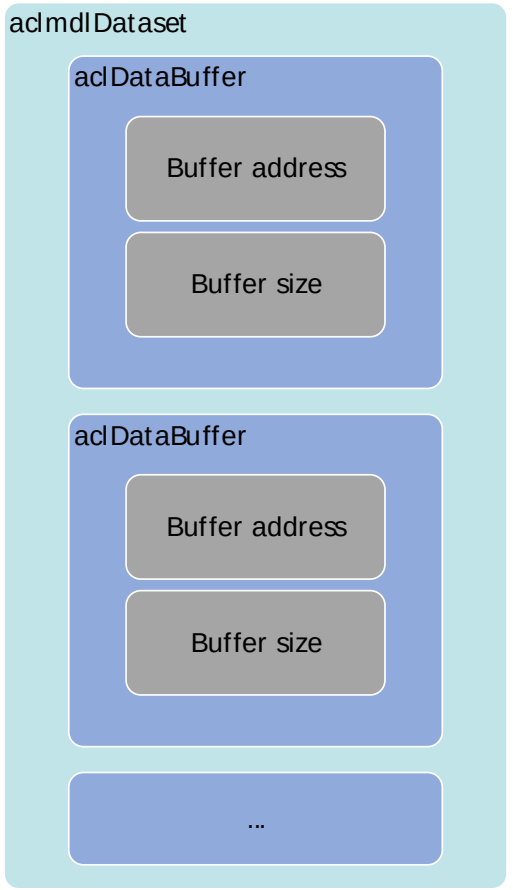
Typical APIs - Executing a Model

➢ Input and Output Data Preparation





aclmdlDataset and **aclDataBuffer**

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5. MindX: Ascend Computing Application Enablement Kit
6. Mindspore: Opensource AI Framework

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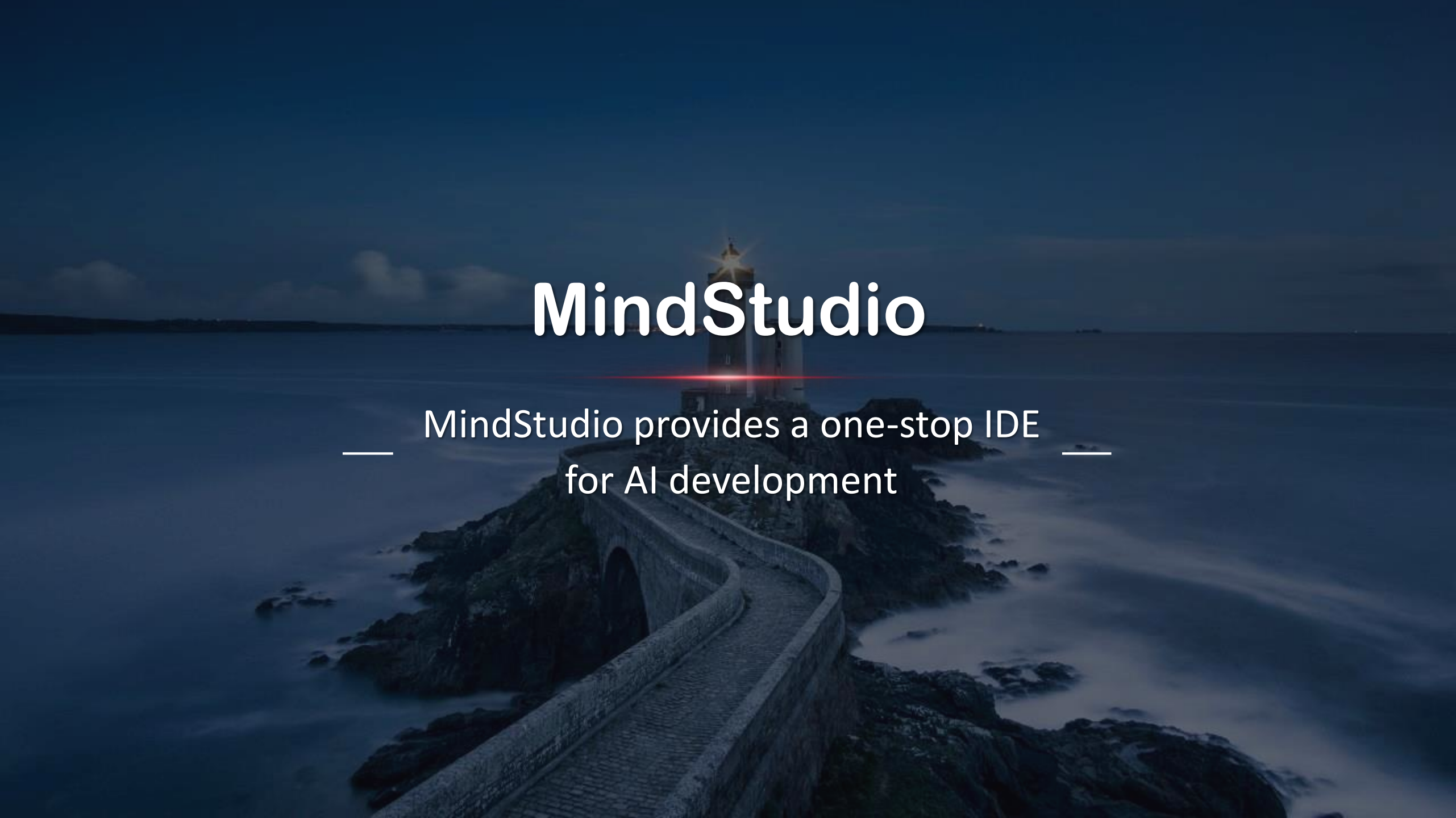
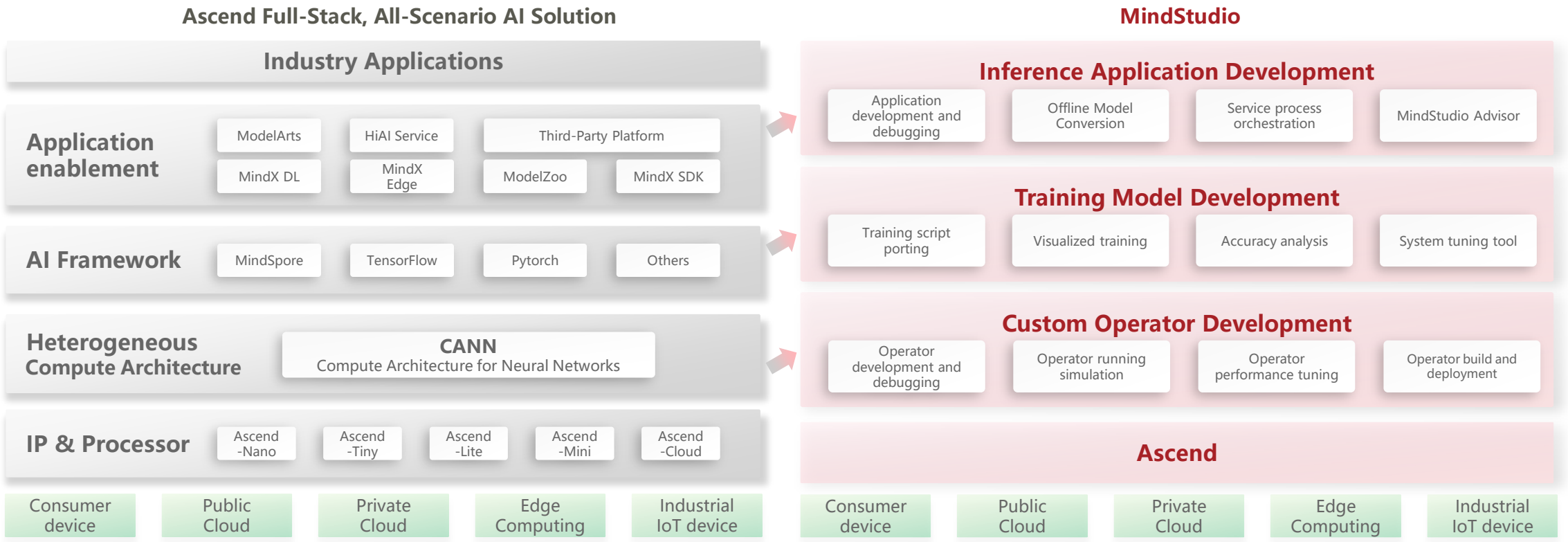

MindStudio
MindStudio provides a one-stop IDE
for AI development

MindStudio

MindStudio is an integrated development environment (IDE). It supports basic functions such as code development, build, debugging, and running in Python and C/C++. As a full-pipeline development toolchain in the Ascend AI full stack, MindStudio provides E2E tools for developing **training models**, **inference applications**, and **custom operators**, greatly improving the efficiency.



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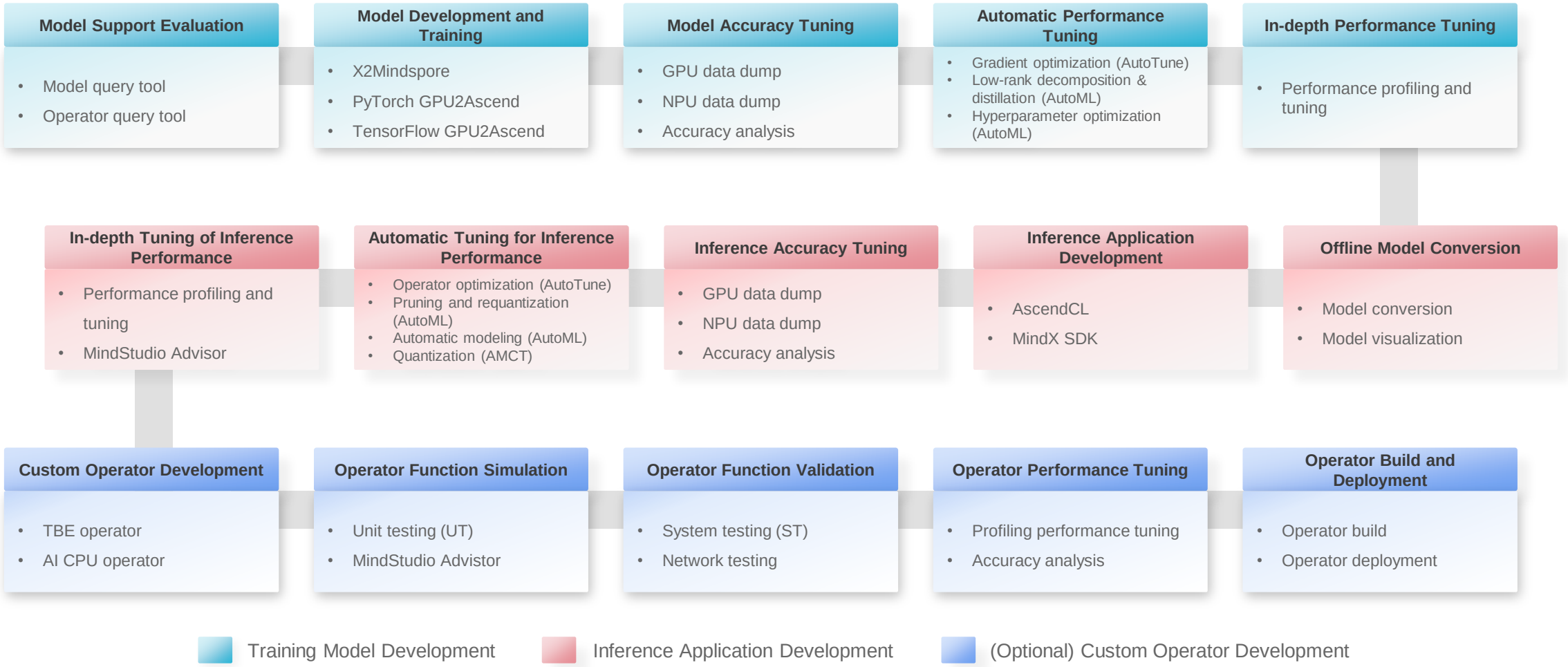
Functions of MindStudio



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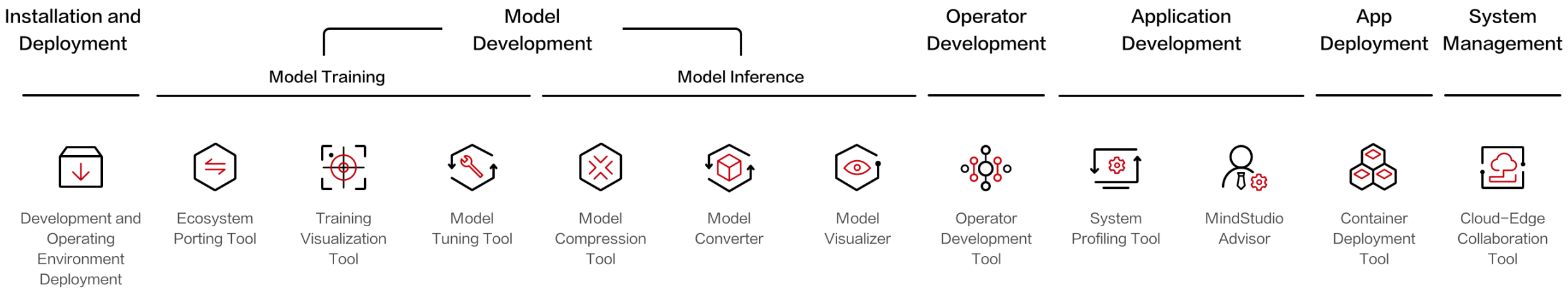
MindStudio

Model Development

Feature of MindStudio

Development Process



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Model Training on MindStudio

MindStudio support multiple AI frameworks. You can easily port your 3th party (**PyTorch, Tensorflow**) model with no or minimal changes to code.

Support for multiple AI frameworks

TensorFlow

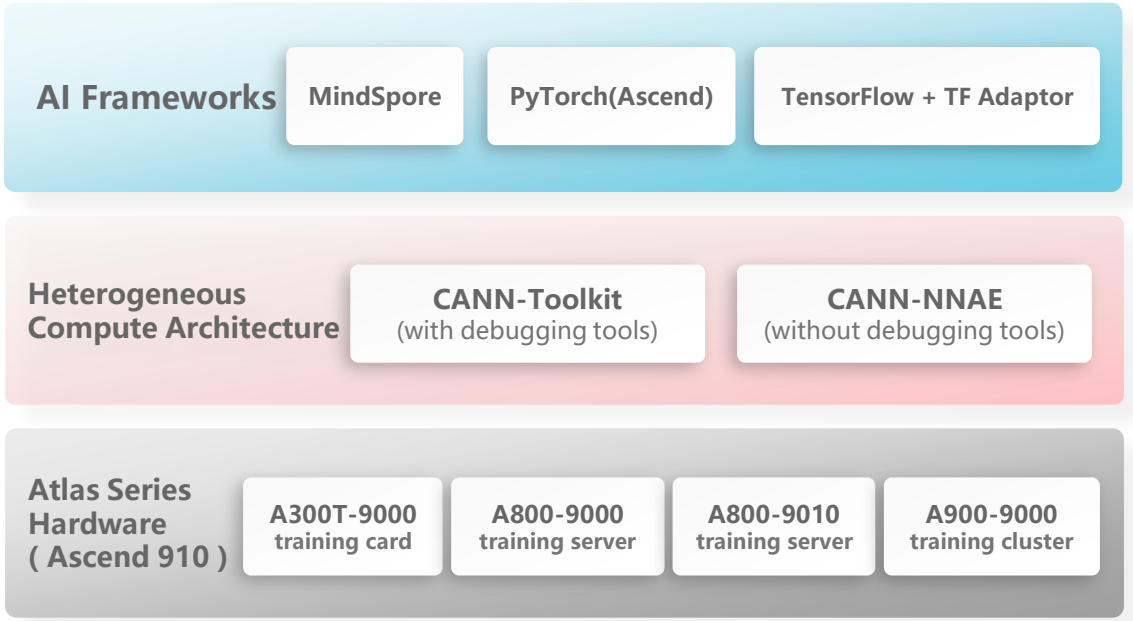
TensorFlow and TF Adapter are combined to support Ascend hardware version 1.15.

PyTorch

The PyTorch source code is modified to support Ascend hardware (NPU) versions 1.5 and 1.8.

MindSpore

The Huawei-developed AI framework that perfectly matches Ascend hardware.



Ascend full-stack AI software and hardware (training)

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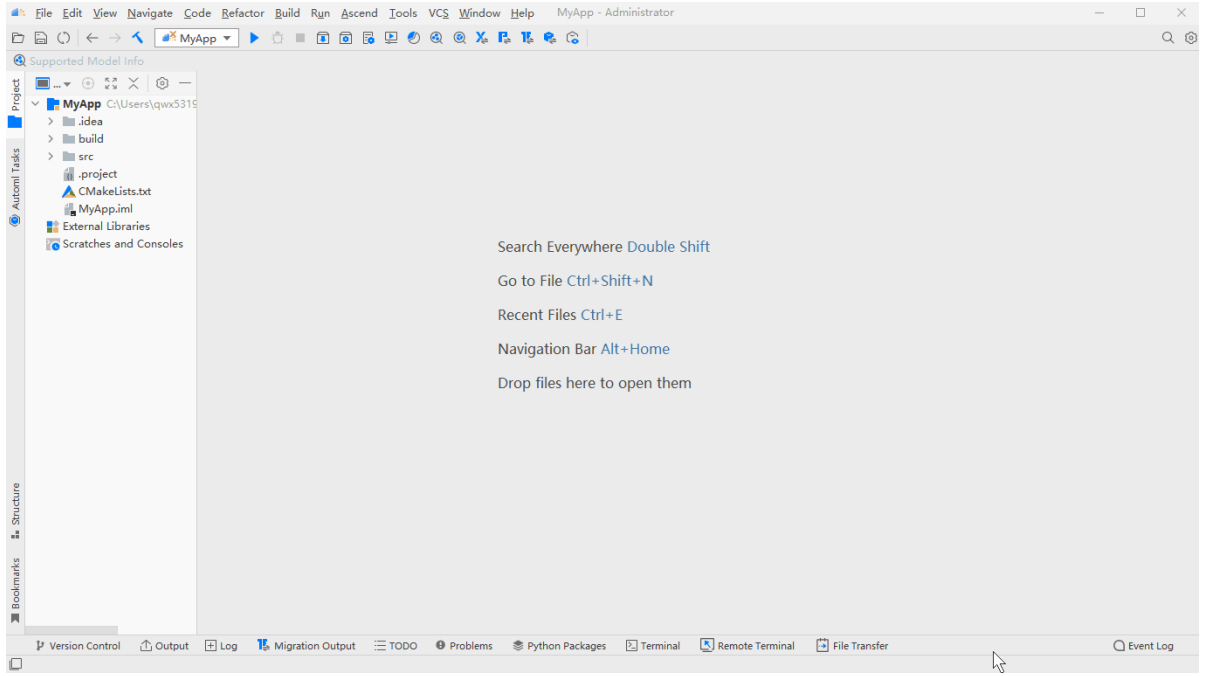
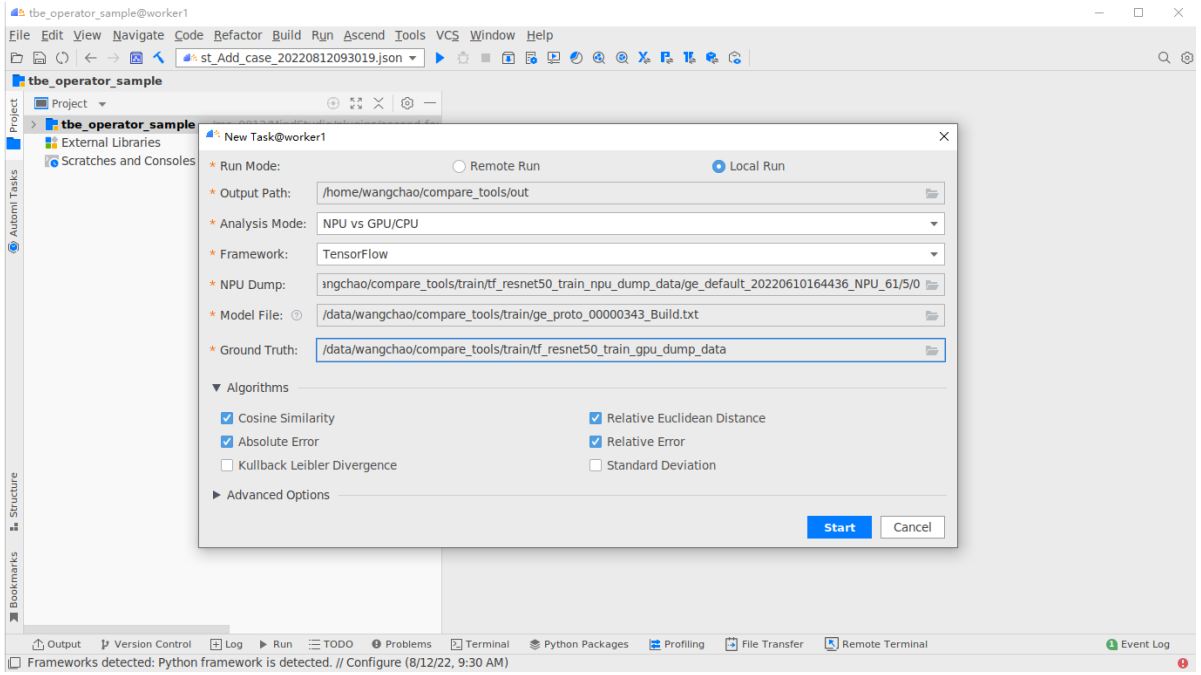
Model Training on MindStudio





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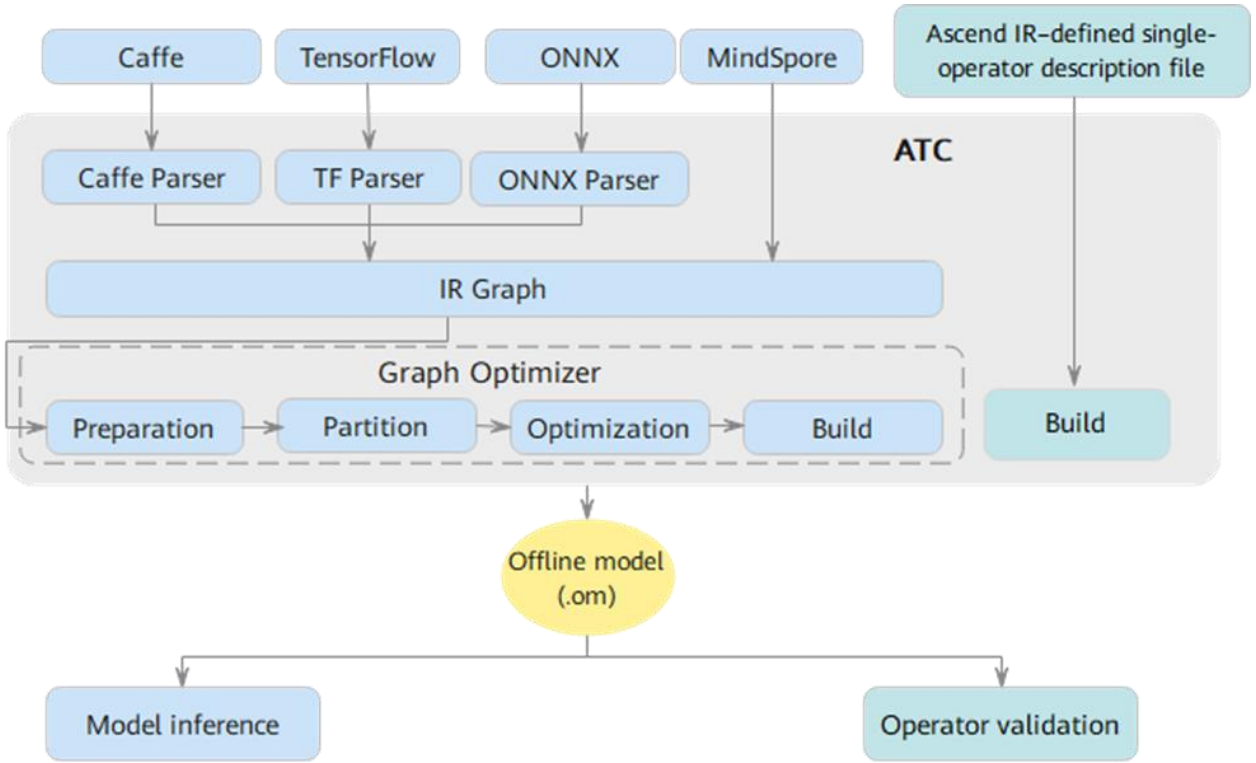
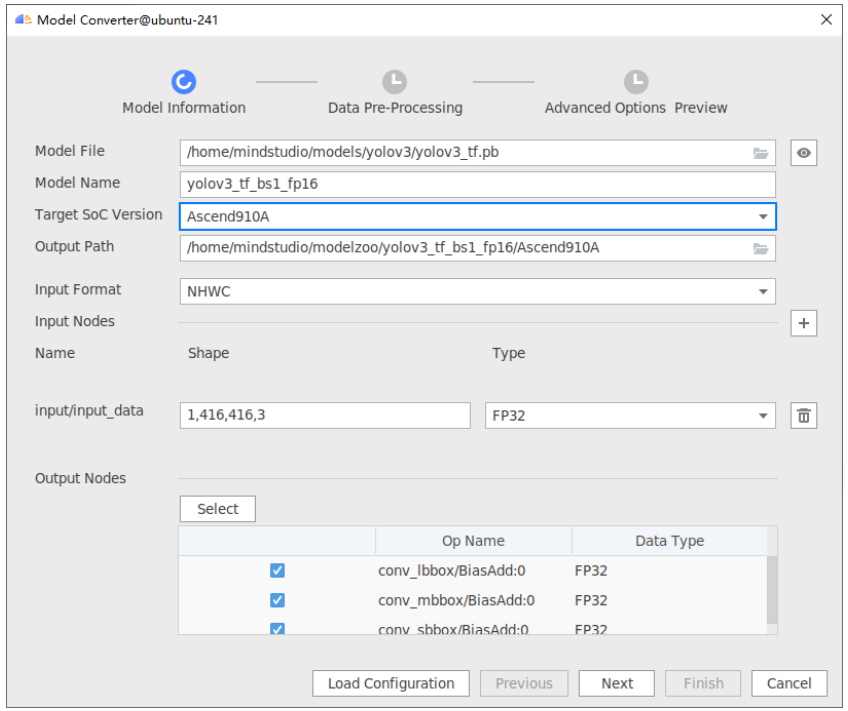
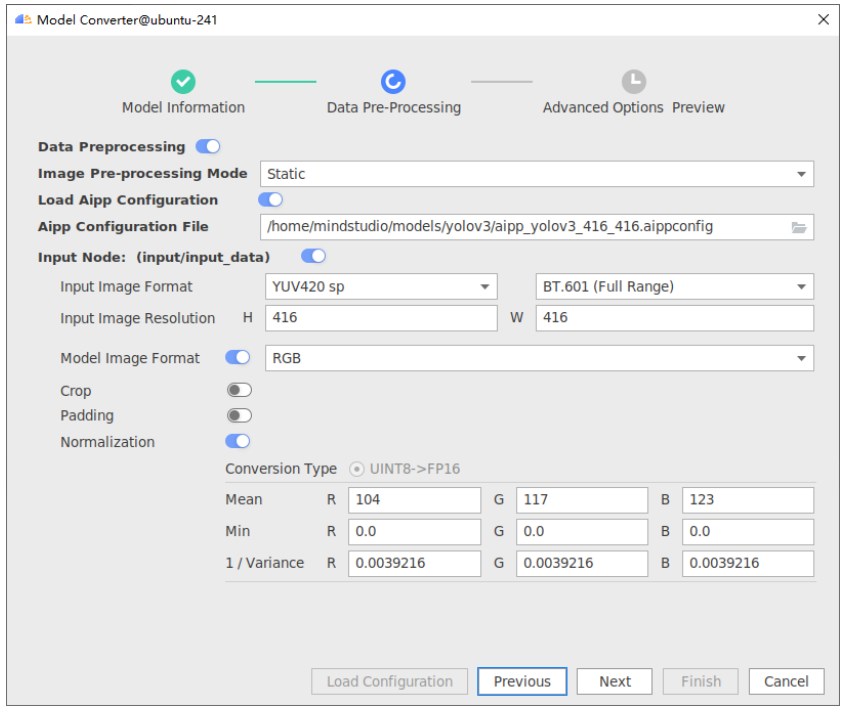
Model Inference on MindStudio

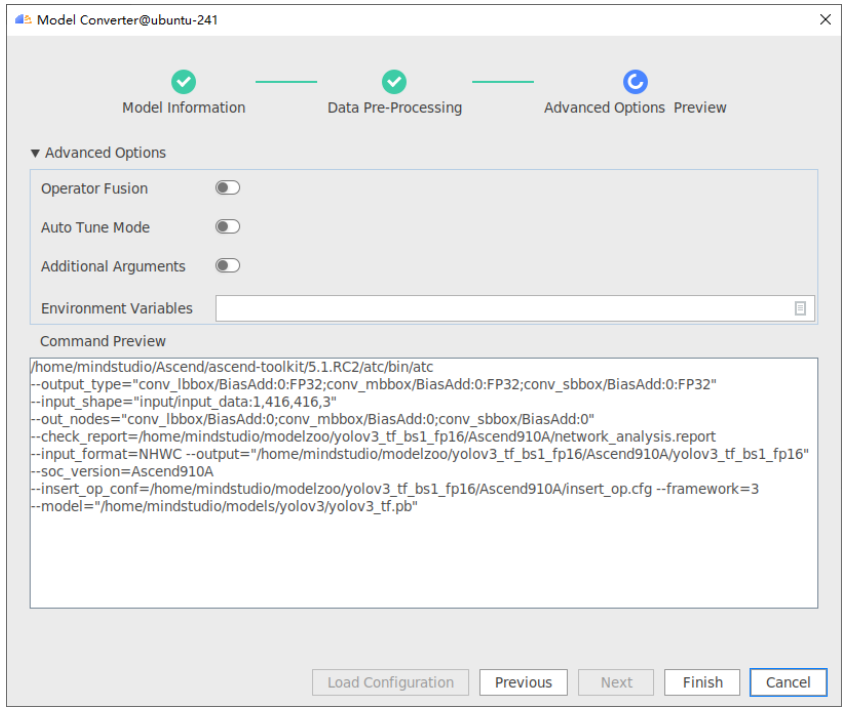
Inference application development more specifically based on offline models. Before inference execution, you need to use the **ATC** (Ascend Tensor Compiler) to convert the network model of the open-source framework into online model supported by the Ascend AI processor.



Model Inference on MindStudio







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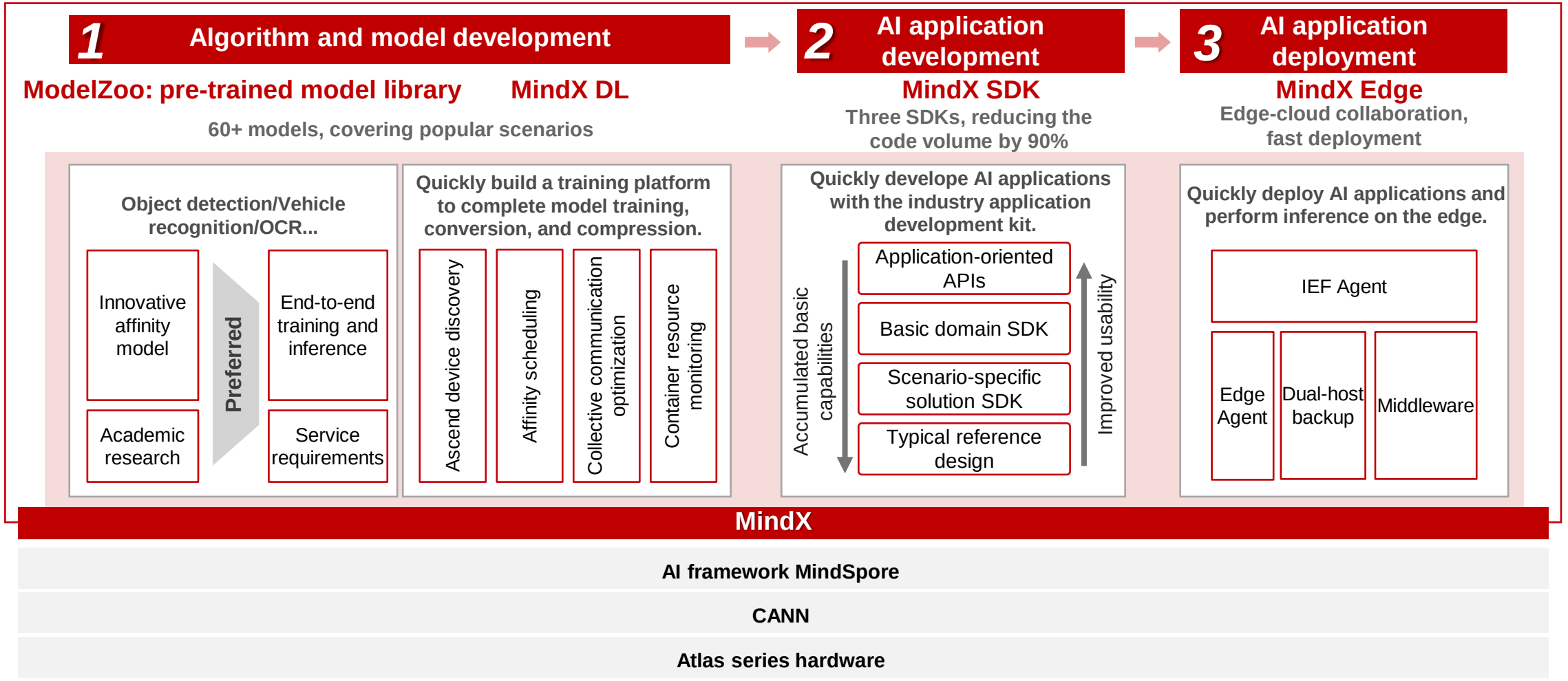
MindX

Bridging the Gap in AI Application Implementation and Enabling Quick Rollout of AI Applications

Overview of MindX

Huawei Ascend computing application enablement kit, bridges the gap in AI application implementation and enables quick rollout of AI applications.



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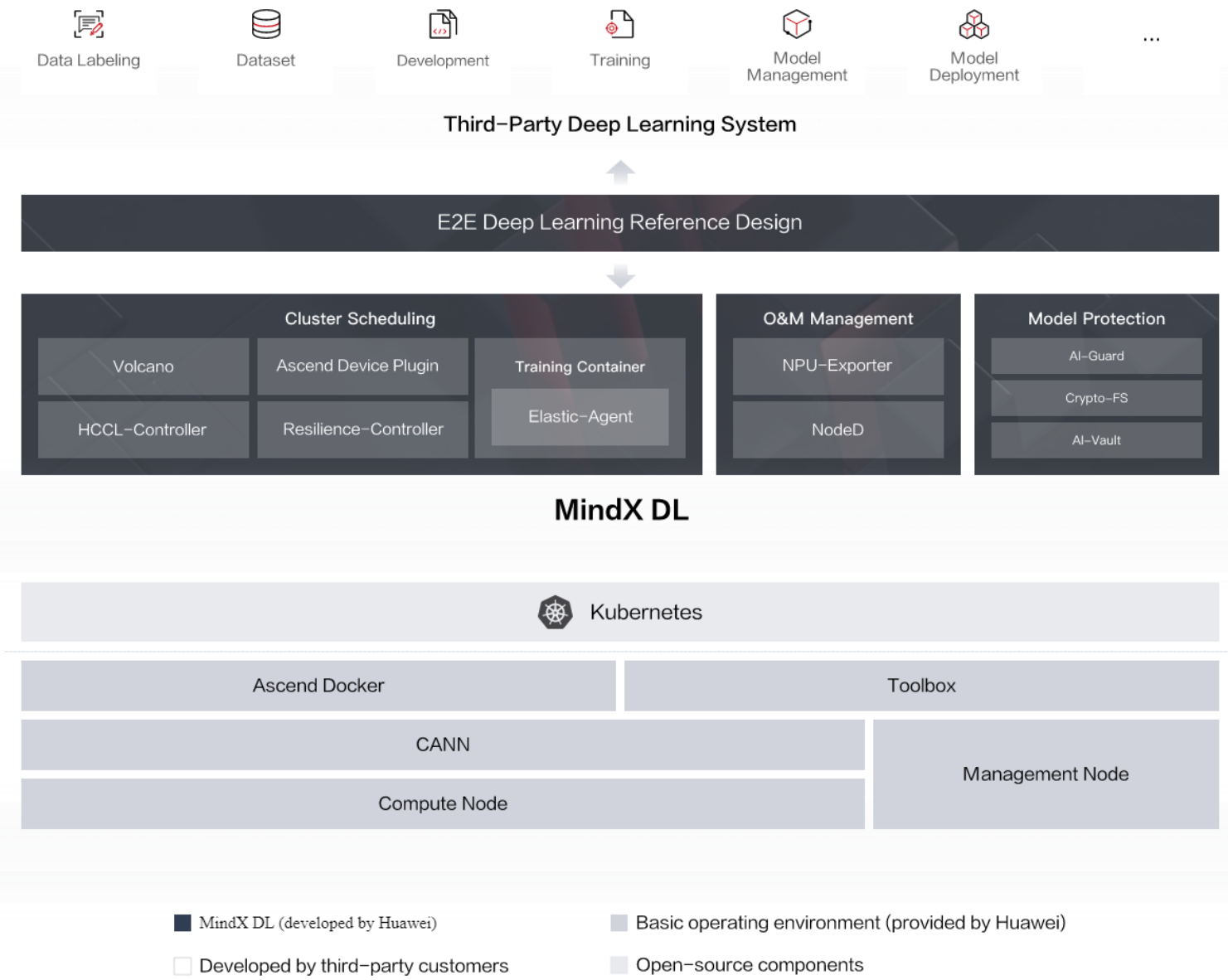
Overview of MindX DL



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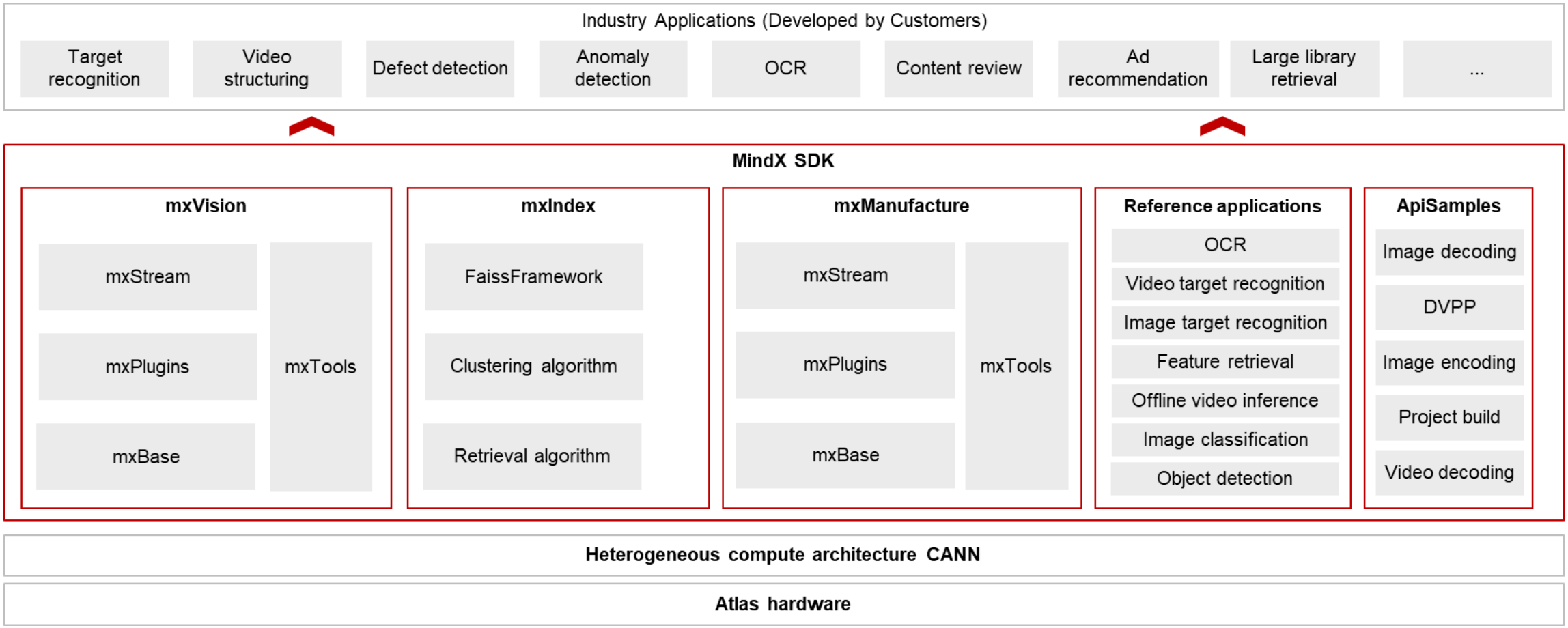
Overview of MindX SDK

MindX SDK accelerates high-performance AI application deployment and enables industries. It delivers various AI software development kits (SDKs) for Ascend AI Processor acceleration and provides simplified APIs to accelerate the development of high-performance AI applications for thousands of industries.



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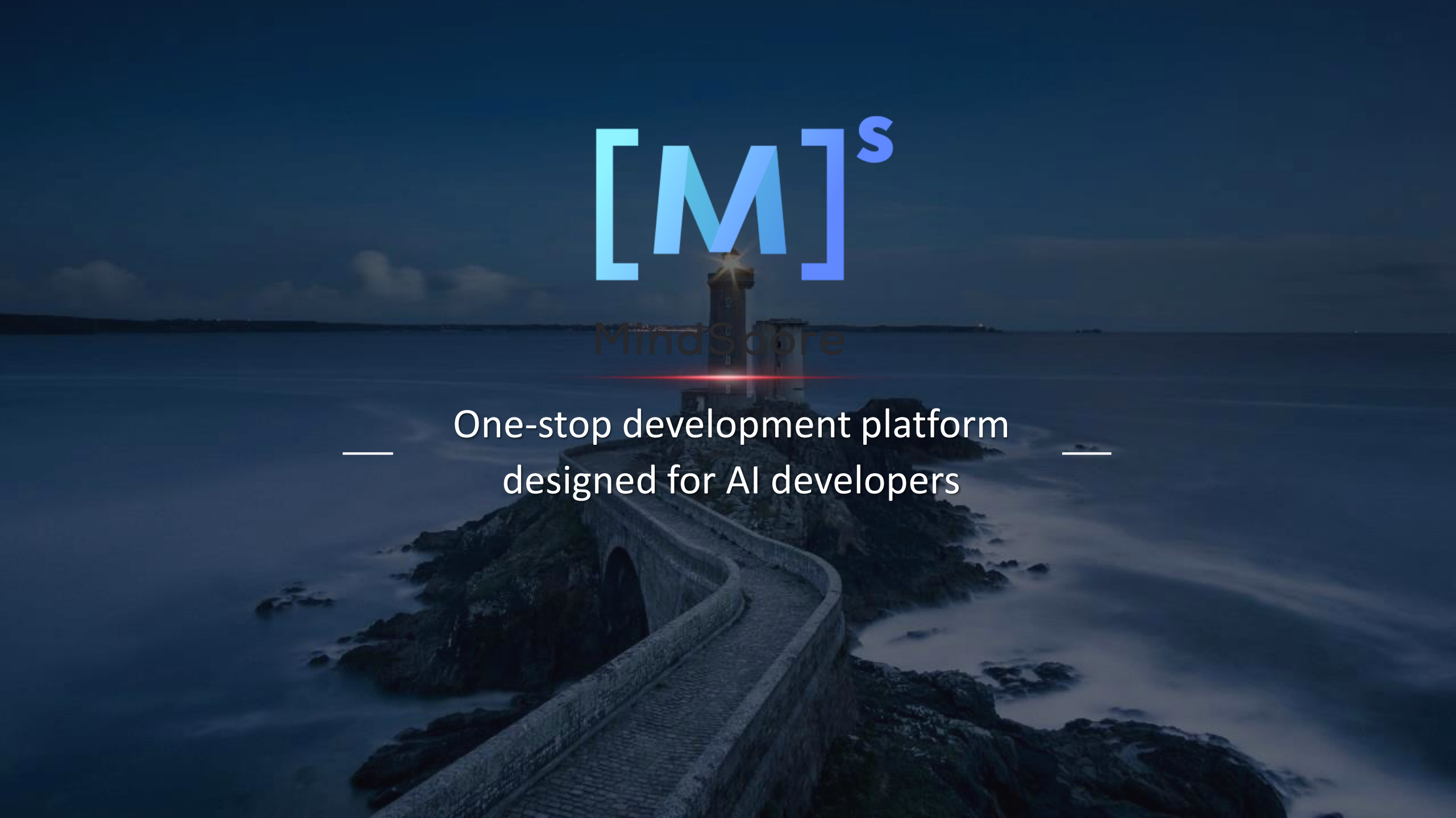
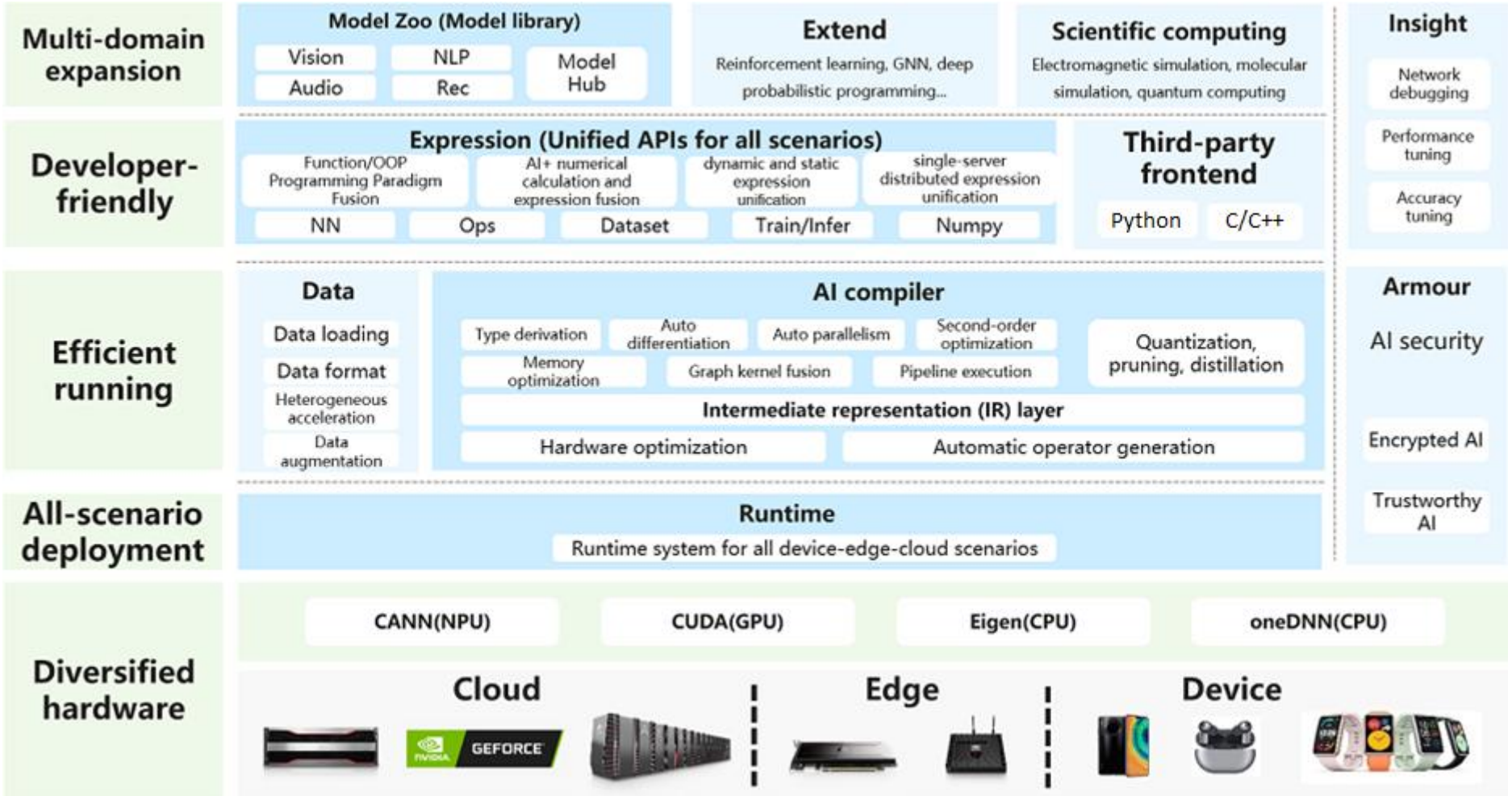


One-stop development platform
designed for AI developers

Overview of MindSpore

MindSpore is a deep learning framework in all scenarios, aiming to achieve easy development, efficient execution, and all-scenario coverage.



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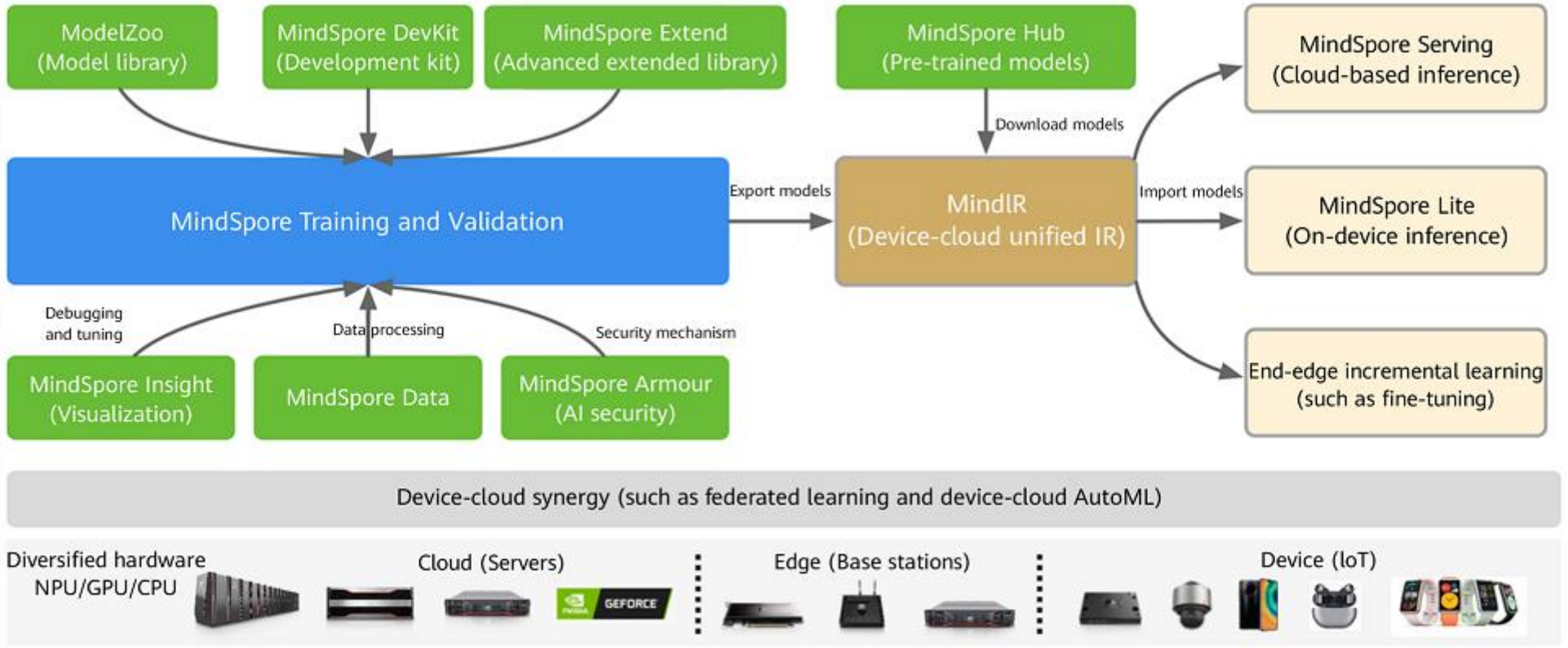
Executing Process of MindSpore

With an understanding of the overall architecture of MindSpore, we can look at the overall coordination relationship between the various modules, as shown in the figure:



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Open Source AI Framework MindSpore: All-Scenario AI Computing Framework

All-scenario AI application ecosystem

MindSpore

All-scenario unified APIs

Automatic differentiation	Automatic parallelism	Automatic optimization

MindSpore IR computational graph expression

On-device execution	Pipeline parallelism	Deep graph optimization

Device-edge-cloud, collaborative, distributed architecture (deployment, scheduling, communication, etc.)

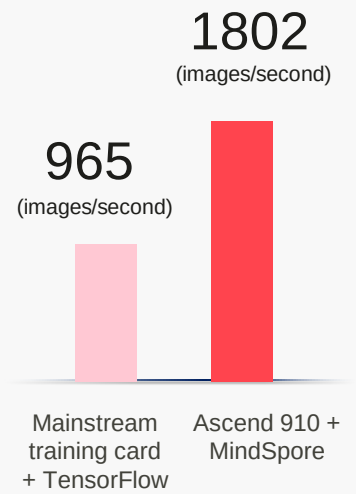
Processors: Ascend, GPU, and CPU

MindSpore

User-friendly development: AI algorithm as code

Runtime-efficient: optimized for Ascend and GPU

Flexible deployment: all-scenario on-demand collaboration



- ResNet 50 V1.5
- ImageNet 2012
- Based on the respective best batch size

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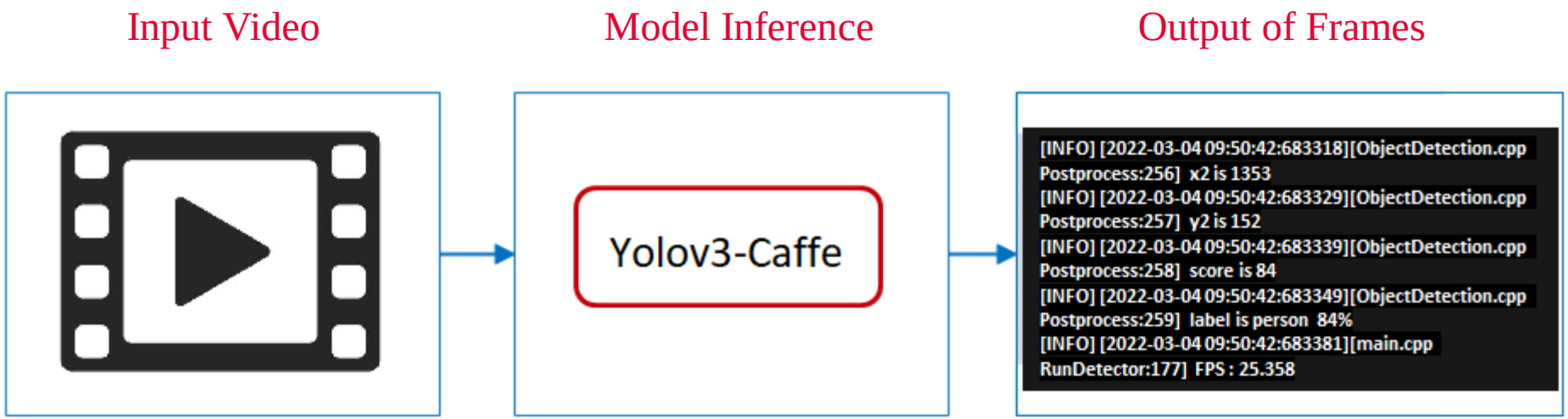
Time to Hands On

Ascend Turbocharges Intelligent Transformation

Overview of The ACL Single Stream Inference

- An application developed by ACL for single stream CV detection task using yolov3-caffe model.
- In this example, we will adapt a Caffe model to NPU infrastructure using ATC and then finally we will run this OM model using ACL.
- The throughput of model will be better than the original model, but there will be some tiny reduction (like 0.2) in accuracy.
- Thereby, we will able to run your models on GPUs with high performance and distribute it on edge and cloud devices.



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Preparing Code, Model and Video

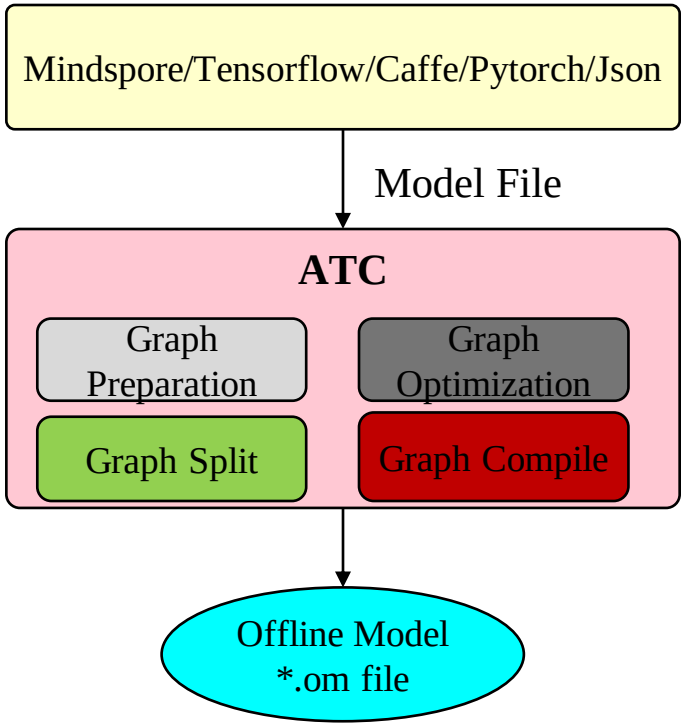
Step1： Get the source code model and video;

Source code：
https://gitee.com/ktuna/acl_multi_stream_inference

Caffe model：
https://modelzoo-train-atc.obs.cn-north-4.myhuaweicloud.com/003_Atc_Models/AE/ATC%20Model/Yolov3/yolov3.caffemodel

Video：
https://obs-9be7.obs.cn-east-2.myhuaweicloud.com/models/YOLOV4_coco_detection_car_video/test_video/test.mp4

Step2： Model conversion




```
atc --model=yolov3.prototxt \
--weight=yolov3.caffemodel \
--framework=0 \
--output==/data/model/yolov3 \
--soc_version=Ascend310 \
--insert_op_conf=./aipp_yolov3_416_no_csc.cfg
```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Run The Sample

Step3：Compile and execute the Demo

Compile

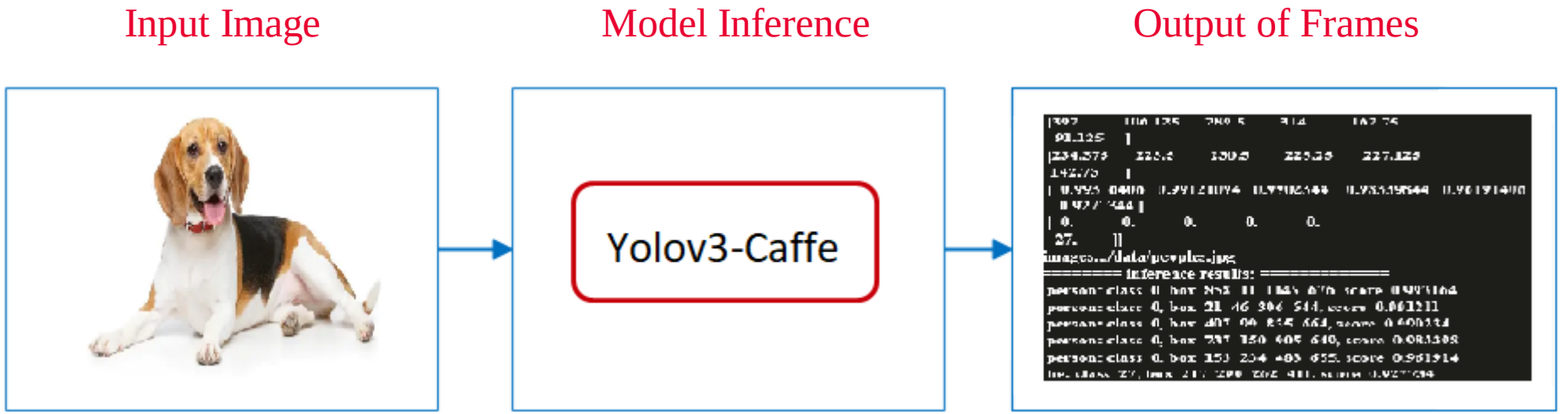
```
./build.sh
cd dist
./main
```

Execute

```
[INFO] [2022-03-04 09:50:42:683318][ObjectDetection.cpp Postprocess:256] x2 is 1353
[INFO] [2022-03-04 09:50:42:683329][ObjectDetection.cpp Postprocess:257] y2 is 152
[INFO] [2022-03-04 09:50:42:683339][ObjectDetection.cpp Postprocess:258] score is 84
[INFO] [2022-03-04 09:50:42:683349][ObjectDetection.cpp Postprocess:259] label is person 84%
[INFO] [2022-03-04 09:50:42:683381][main.cpp RunDetector:177] FPS : 25.358
[INFO] [2022-03-04 09:50:42:807613][ObjectDetection.cpp Postprocess:254] x1 is 1223
[INFO] [2022-03-04 09:50:42:807655][ObjectDetection.cpp Postprocess:255] y1 is 1
[INFO] [2022-03-04 09:50:42:807667][ObjectDetection.cpp Postprocess:256] x2 is 1351
[INFO] [2022-03-04 09:50:42:807677][ObjectDetection.cpp Postprocess:257] y2 is 152
```

Overview of The PyACL Object Detection Inference

- An application developed by PyACL for single stream CV detection task using yolov3-caffe model.
- In this example, we will adapt a Caffe model to NPU infrastructure using ATC and then finally we will run this OM model using PyACL.
- The throughput of model will be better than the original model, but there will be some tiny reduction (like 0.2) in accuracy.
- Thereby, we will able to run our models on GPUs with high performance and distribute it on edge and cloud devices.



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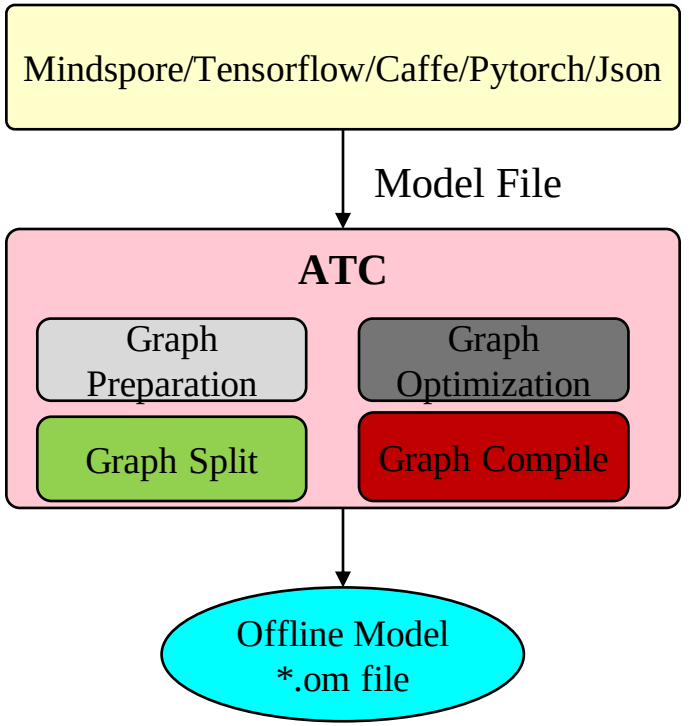
Preparing Code, Model and Video

Step1： Get the source code model;

Source code:
https://gitee.com/ktuna/acl_multi_stream_inference

Caffe model:
https://modelzoo-train-atc.obs.cn-north-4.myhuaweicloud.com/003_Atc_Models/AE/ATC%20Model/Yolov3/yolov3.caffemodel

Step2： Model conversion




```
atc --model=yolov3.prototxt \
--weight=yolov3.caffemodel \
--framework=0 \
--output==/data/model/yolov3 \
--soc_version=Ascend310 \
--insert_op_conf=./aipp_yolov3_416_no_csc.cfg
```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Run The Sample

Step3：Execute the Demo

Run

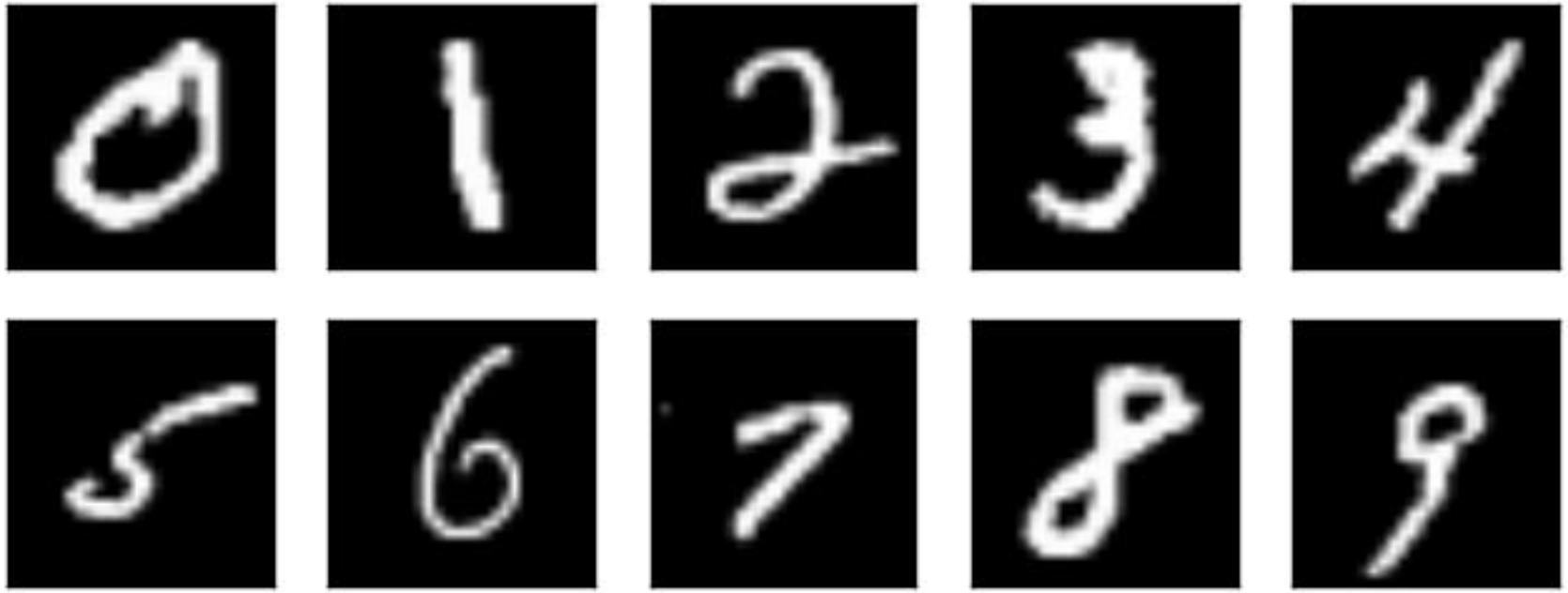
```
python3 object_detect.py ../data/
```

Execute

```
[397.        106.125     289.5       314.        167.75
  91.125    ]
[234.375     223.5       230.5       225.25      227.125
 142.75     ]
[  0.99316406   0.99121094   0.9902344    0.98339844   0.96191406
   0.9277344 ]
[  0.          0.          0.          0.          0.
  27.        ]]
images:../data/peoples.jpg
======== inference results: ============
person: class  0, box  858  11  1145  676, score  0.993164
person: class  0, box  21  46  306  644, score  0.991211
person: class  0, box  407  99  835  664, score  0.990234
person: class  0, box  737  150  905  649, score  0.983398
person: class  0, box  153  234  483  655, score  0.961914
tie: class  27, box  217  290  262  411, score  0.927734
```

Overview of The Sample

- The goal of this lab is to familiarize with the concepts of AI framework NPU training. For this purpose, a simple training example is considered. Here is the Tensorflow LeNet MNIST training example.



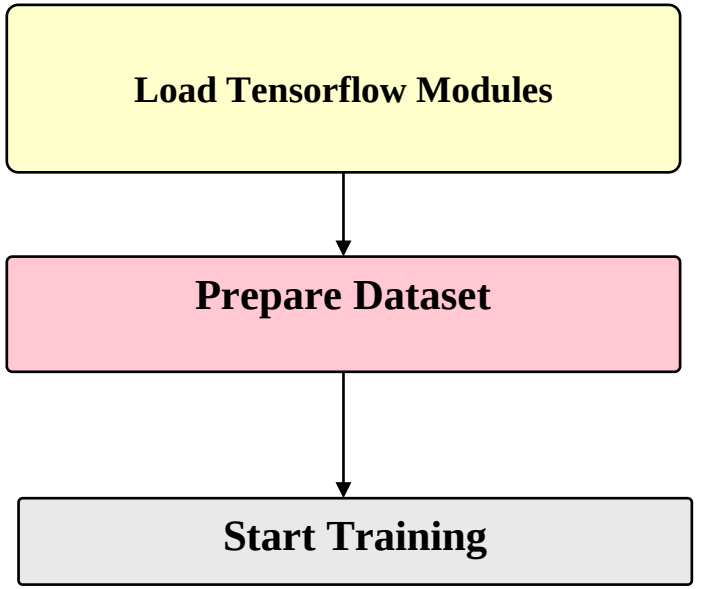
Run The Sample

Source code:
https://github.com/haicgu/training/tree/main/AI

```
module load GCC/9.5.0 OpenMPI TensorFlow-CANN/1.15.0
```

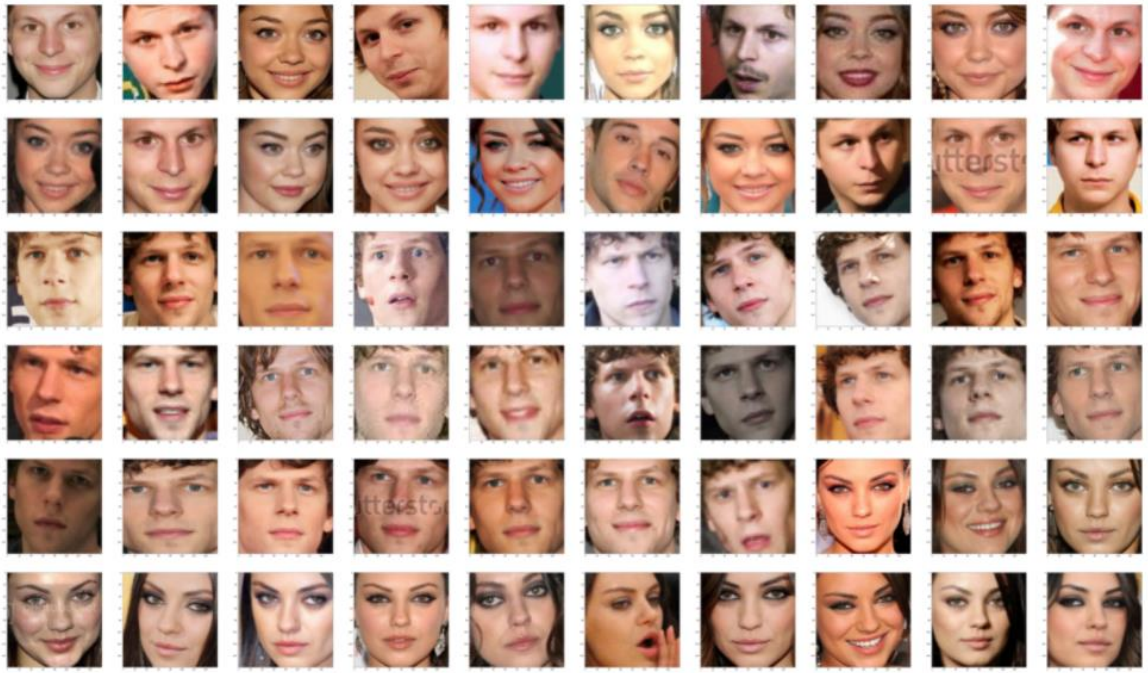
```
bash get_dataset.sh
```

```
#!/bin/bash
#SBATCH --partition=a800-9000
#SBATCH --time=00:10:00
#SBATCH --ntasks=1
#SBATCH --nodes=1
npu-smi info
python3 LeNet.py ---data_path ./MNIST
EOF
```



Overview of The Sample

- Creating face recognition is considered to be a very easy task in the field of computer vision, but it is extremely tough to have a pipeline that can predict faces with complex backgrounds when you have multiple faces, different lighting conditions, and different scales of images. . Here is the Tensorflow Facenet inference example.



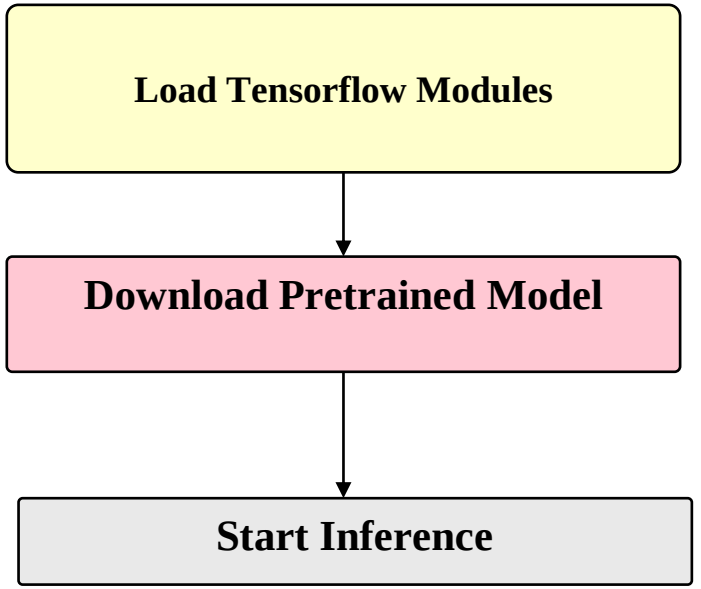
Run The Sample

Source code:
https://github.com/haicgu/training/tree/main/AI

```
module load GCC/9.5.0 OpenMPI TensorFlow-CANN/1.15.0
```

```
cd ./models
bash get_model.sh
```

```
#!/bin/bash
#SBATCH --partition=a800-3000
#SBATCH --time=00:10:00
#SBATCH --ntasks=1
#SBATCH --nodes=1
npu-smi info
python3 main.py --model_path ./models/facenet_tf.pb --input_tensor_name
input:0 --output_tensor_name embeddings:0 --image_path ./facenet_data
EOF
```



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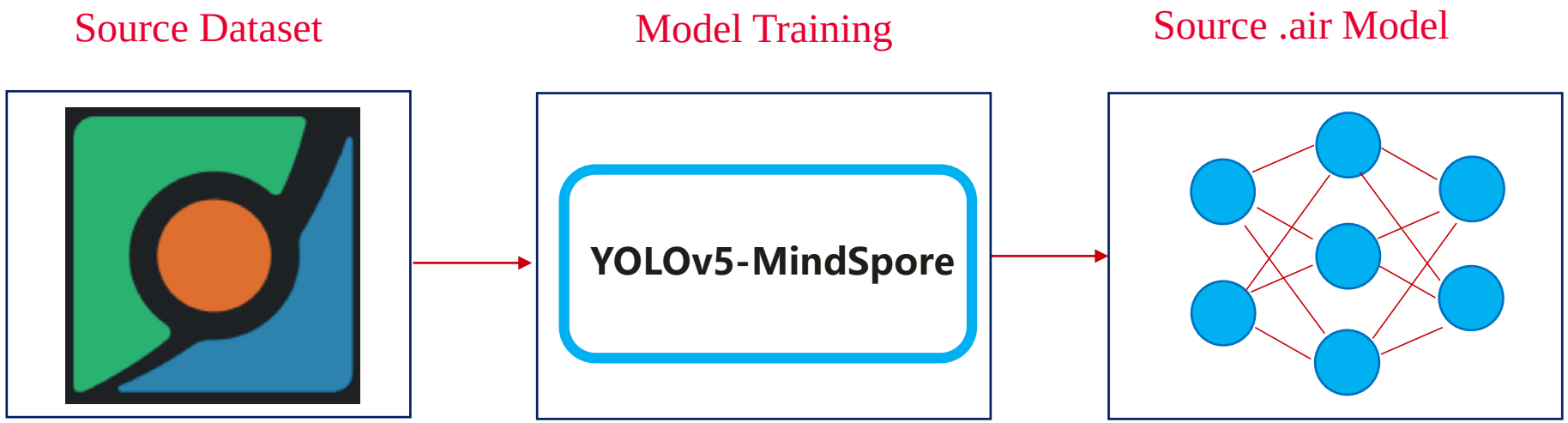
Overview of MindSpore YOLOv5 Training Sample

- In this example, we will train a MindSpore model on NPU.
- Before starting the training, we need to define the dataset path in the yaml configuration file. Then we will start the model training.
- After the training is completed, the trained model will be an .air model which is designed for MindSpore.



Run MindSpore YOLOv5 Training Sample

Step1： Get the source code and the dataset

Source code:
https://gitee.com/ktuna/mind-spore-yolov5 // DÜZENLENECEK PUSH SONRASI

COCO dataset:
https://cocodataset.org/#download
http://images.cocodataset.org/zips/train2017.zip
http://images.cocodataset.org/annotations/annotations_trainval2017.zip

Step2： Edit the configuration file

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Run The Sample

Step2：Execute the Demo

Execute

```
python3 train.py  \
    --device_target="Ascend" \
    --data_dir=/home/share/coco/ \
    --yolov5_version='yolov5s' \
    --is_distributed=0 \
    --lr=0.01 \
    --T_max=320 \
    --max_epoch=320 \
    --warmup_epochs=4 \
    --train_per_batch_size=32
```

Output

```
INFO:epoch[1], iter[1401], loss:235.398219, fps:122.95 imgs/sec, lr:0.0095592224708937109, per step time: 260.26368141174316ms
INFO:epoch[1], iter[1501], loss:230.998582, fps:120.20 imgs/sec, lr:0.0010241538984701037, per step time: 266.2326240539551ms
INFO:epoch[1], iter[1601], loss:228.316826, fps:109.34 imgs/sec, lr:0.0010923853842541575, per step time: 292.66693592071533ms
INFO:epoch[1], iter[1701], loss:225.158565, fps:114.16 imgs/sec, lr:0.0011606168700382113, per step time: 280.30664920806885ms
INFO:epoch[1], iter[1801], loss:220.219454, fps:115.76 imgs/sec, lr:0.0012288482394069433, per step time: 276.4246368408203ms
INFO:epoch[1], iter[1901], loss:236.302552, fps:113.82 imgs/sec, lr:0.0012970797251909971, per step time: 281.1565065383911ms
INFO:epoch[1], iter[2001], loss:230.399118, fps:109.73 imgs/sec, lr:0.0013653311094559729, per step time: 291.6242551803589ms
INFO:epoch[1], iter[2101], loss:225.763290, fps:112.56 imgs/sec, lr:0.0014335542580343783, per step time: 284.28987979888916ms
```

Thank you.

Atlas Details

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Discussion