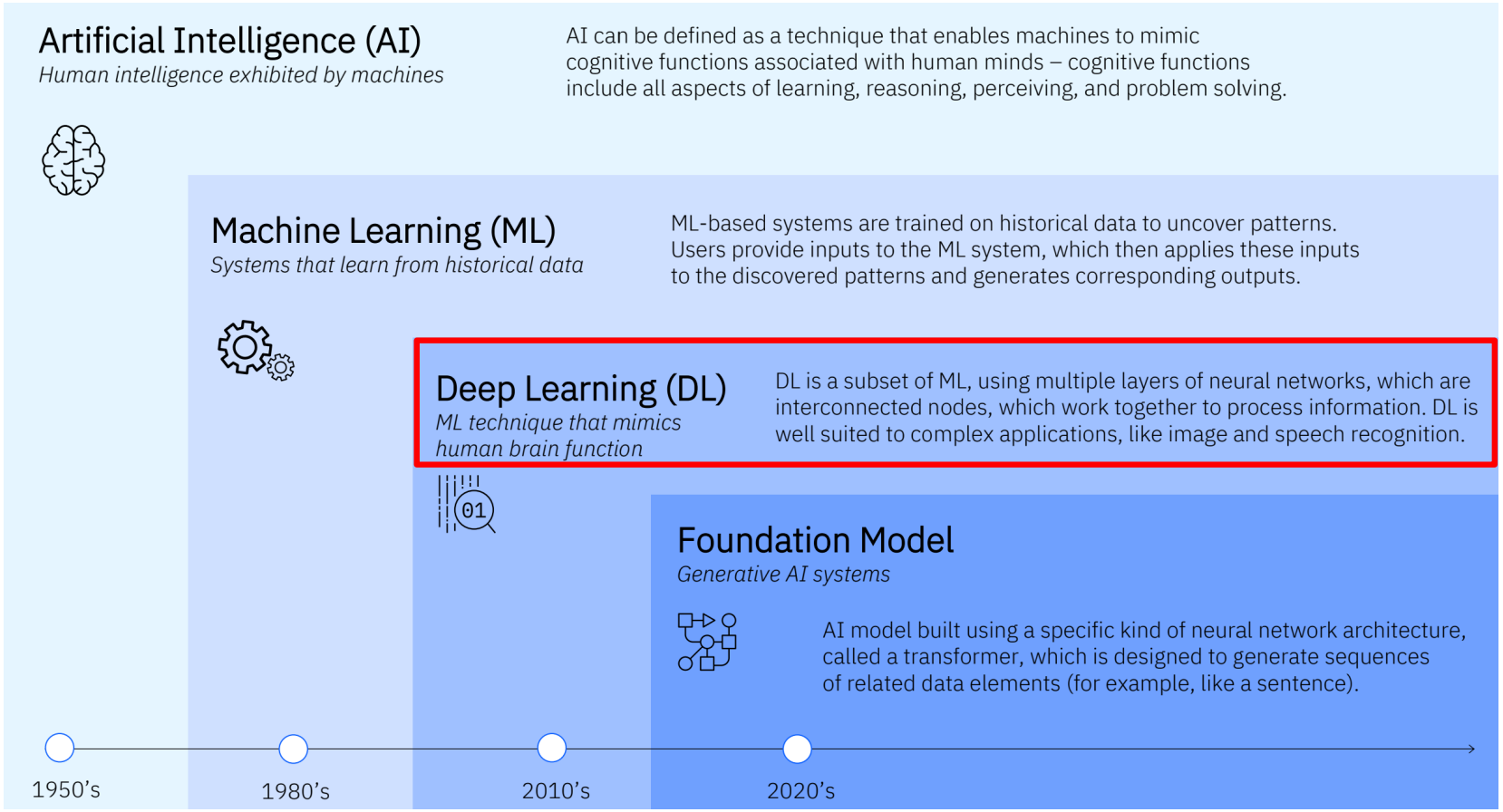
IBM z16
Integrated Accelerator for AI

Agenda

- AI introduction
- Integrated Accelerator for AI overview
- AI model scoring server options to leverage the Integrated Accelerator for AI
- Accelerated credit card fraud model demo

What is AI?

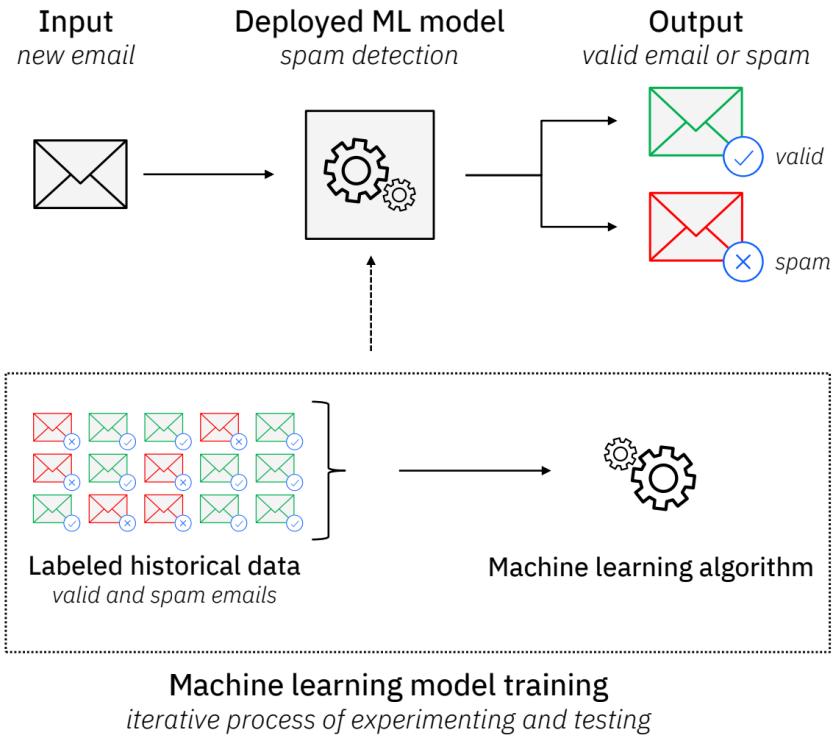


ML/DL Classification Models

Classification models assign labels to model inputs or assign them to specific categories. Common use cases include:

- Fraud detection
- Sentiment analysis
- Medical diagnosis
- Image recognition

Example: Spam detection for email



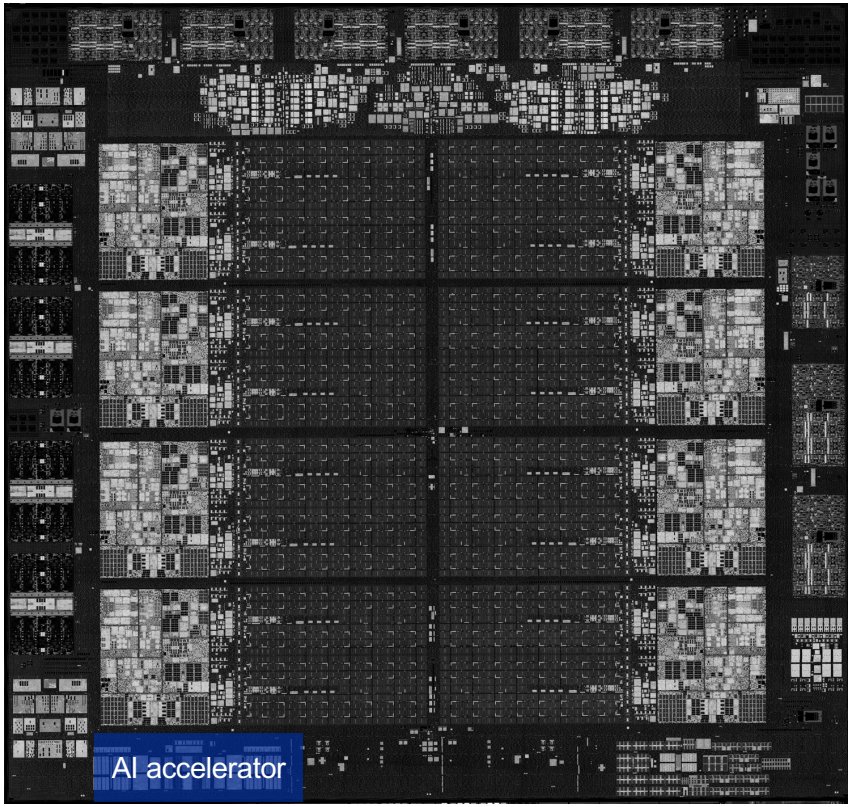
Machine learning model training
iterative process of experimenting and testing

IBM z16 Integrated Accelerator for AI Overview

IBM z16 Integrated Accelerator for AI

Centralized accelerator shared by all cores on-chip

- Very low and consistent inference latency
- Compute capacity for utilization at scale
- Designed for a variety of AI models ranging from traditional ML to RNNs and CNNs
- Security – provide enterprise-grade memory virtualization and protection



Integrated AI Accelerator – combining compute & data movers

On Chip AI Accelerator

Aggregate of >6 TFLOPS / chip

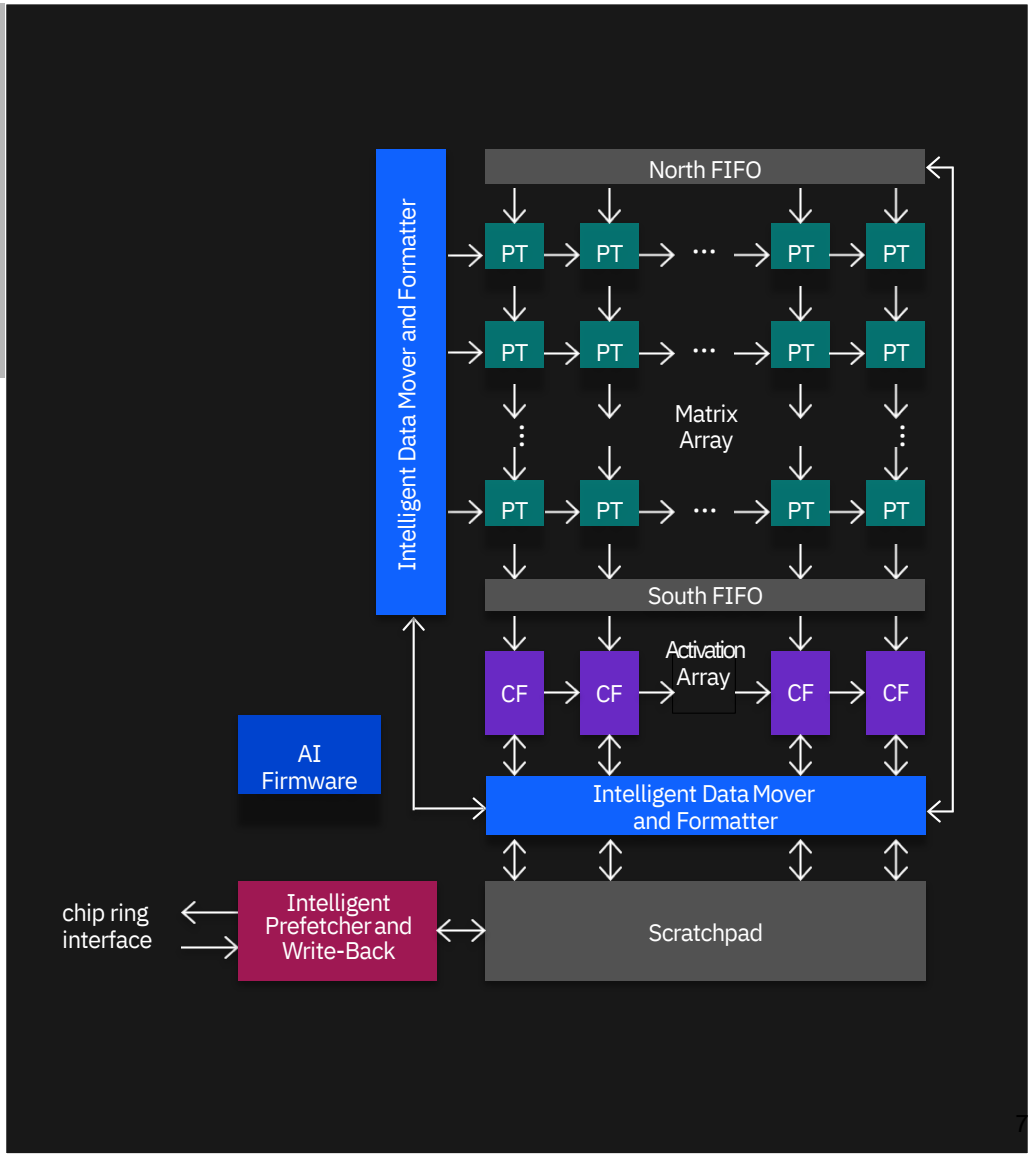
– Over 200 TFLOPS on 32-chip system

Compute Arrays

- 128 processor tiles with 8-way FP-16 FMA SIMD
  - Optimized for matrix multiplication and convolution
- 32 processor tiles with 8-way FP-16/FP-32 SIMD
  - Optimized for activation functions & complex operations

Intelligent Prefetcher and Data Movers

- 200+ GB/s read/store bandwidth from/to cache
- 600+ GB/s bandwidth between engines
- Multi-zone scratchpad for concurrent load, execution and store



Neural Network Processing Assist (NNPA) instruction on IBM z16

- New instruction provided to support the IBM z16 AIU
- AI Functions/Macros are abstracted via NNPA instructions. More than just matrix multiplication!
  - Elementwise, Activation
  - Normalization, Pooling
  - Matrix-multiplication
  - Convolution
  - Conv+Scale+Activate
  - MatMul+Compare/Activate
  - RNN activation
- Functions can be added per firmware update

Function group	#	Function support in GA1
Elementwise ops	0x10	NNPA_EL_ADD
	0x11	NNPA_EL_SUB
	0x12	NNPA_EL_MUL
	0x13	NNPA_EL_DIV
	0x14	NNPA_EL_MIN
	0x15	NNPA_EL_MAX
Activation ops	0x20	NNPA_LOG
	0x21	NNPA_EXP
	0x31	NNPA_RELU
	0x32	NNPA_TANH
	0x33	NNPA_SIGMOID
Norm op.	0x34	NNPA_SOFTMAX
	0x40	NNPA_BATCHNORM
Pooling	0x50	NNPA_AVGPOOL2D
	0x51	NNPA_MAXPOOL2D
Systolic ops	0x70	NNPA_CONVOLUTION
	0x71	NNPA_MATMUL_OP
	0x72	NNPA_MATMUL_OP_BCAST23
RNN	0x60	NNPA_LSTMACT
	0x61	NNPA_GRUACT
	0x00	NNPA_QAF

How can we leverage the Integrated Accelerator for AI?

- Deep Learning Frameworks:
  - ONNX (Open Neural Network Exchange)
  - TensorFlow
- Machine Learning Frameworks:
  - SnapML models
    - Random Forest, Extra Trees, and Gradient Boosting Machines models are accelerated

Model Serving 101

AI Lifecycle: Deploy Phase

Practical use of machine learning (ML) models for inference introduces a different set of requirements and tools than model training.

This is especially true when the insights generated will be consumed by an application.

Model inference servers are a critical component to enable AI in production.

At minimum, a model server provides for:

- Exposing endpoints (i.e., HTTP/REST, gRPC)
- Common API format
- Request management

Other important characteristics include:

Scalability/High Performance

Server-side micro-batching
- With IBM Integrated Accelerator for AI, this capability is critical for optimizing performance.

Support for multiple frameworks

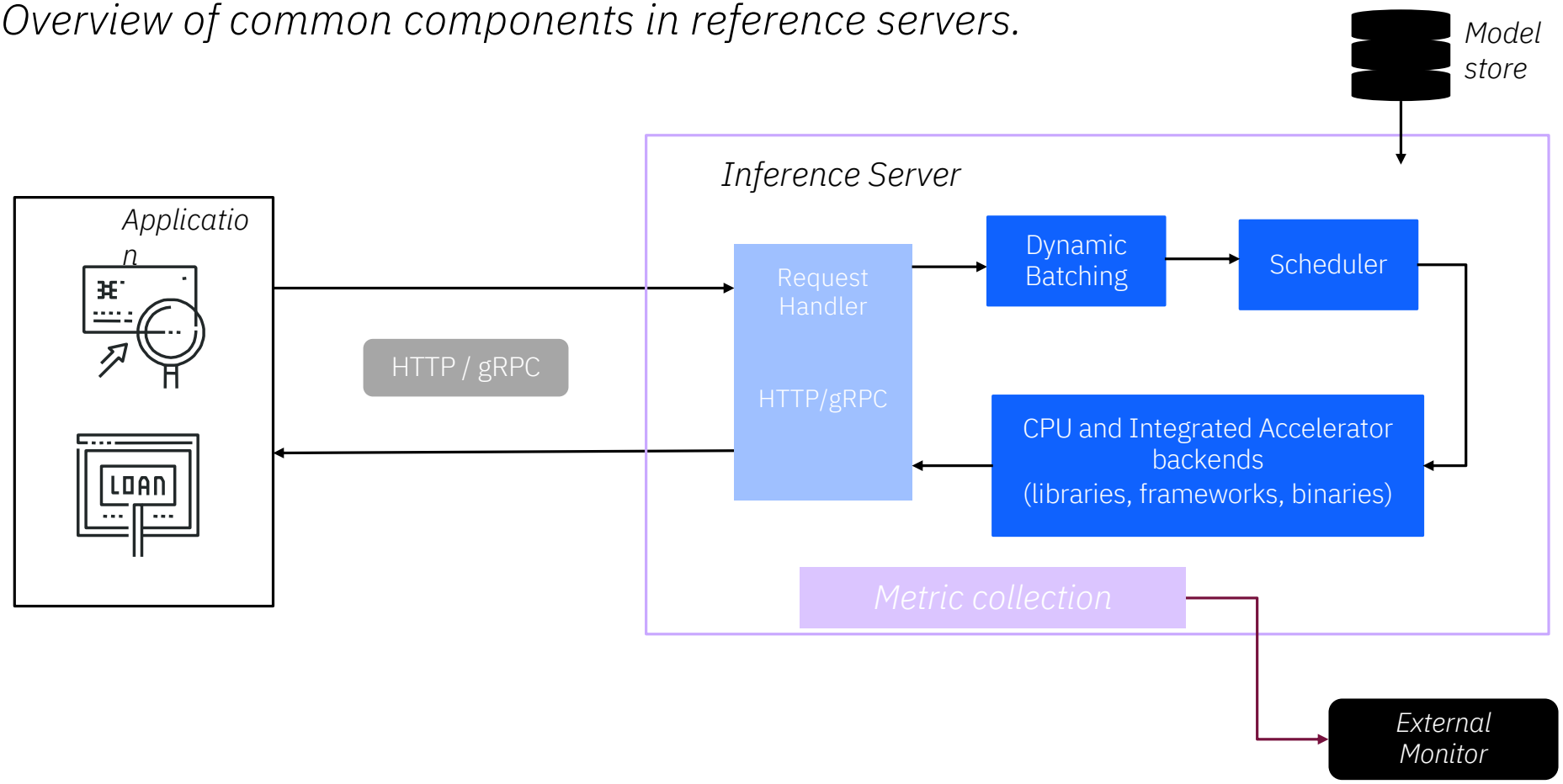
Version control

Metrics/Monitoring Integration

...and more

Inference Server Architecture

Overview of common components in reference servers.



Scoring Server Options*

IBM z/OS

Watson Machine Learning for z/OS

Accelerated Models:
- ONNX

Other Supported Models:
- Spark
- XGBoost
- PMML

Linux on Z

Triton Inferencing

Accelerated Models:
- ONNX
- SnapML

Other Supported Models:
- TensorFlow
- PyTorch
- PMML

TensorFlow Scoring Server

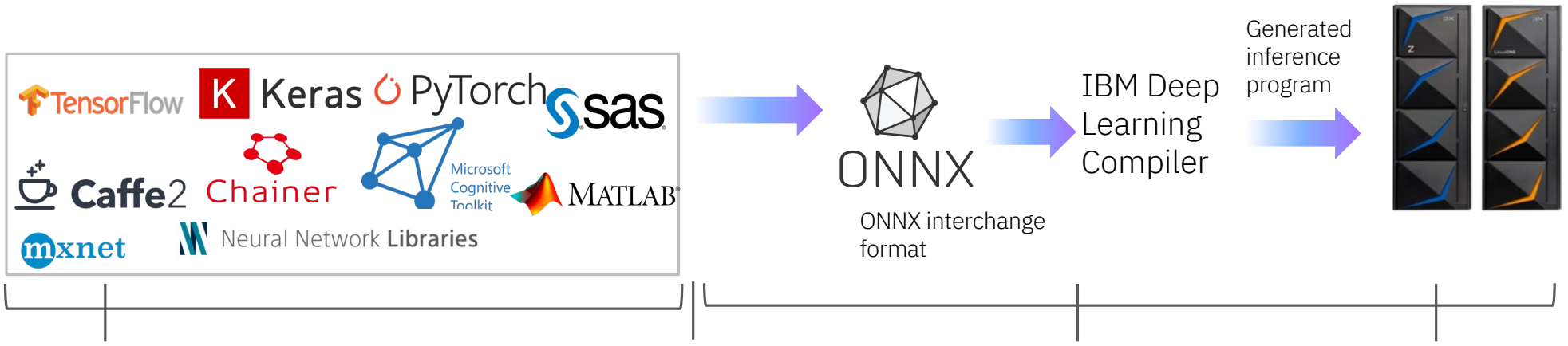
Accelerated Models:
- TensorFlow support under development

Supported Models:
- TensorFlow

* other scoring server options are available

AI Ecosystem:
Seamlessly leverage AI accelerator on IBM z16 with ONNX

- Bring machine learning & deep learning models to IBM z16 with ONNX/DLC
- Exploit IBM Integrated Accelerator for AI for best inference performance.
- Repeatable practice for different vendors to leverage IBM Z Integrated Accelerator for AI



Build and train model in any popular framework on any platform of your choice

Use ONNX, an opensource tool for framework interoperability

Models are converted to the ONNX interchange format

The IBM DLC (Deep Learning Compiler), generates a program from the model for execution on z/OS or Linux® on IBM z16

Deploy on IBM z16 and IBM LinuxONE and infuse model into workload application

Creating a Credit Card Fraud Model

How do we predict credit card fraud with AI?

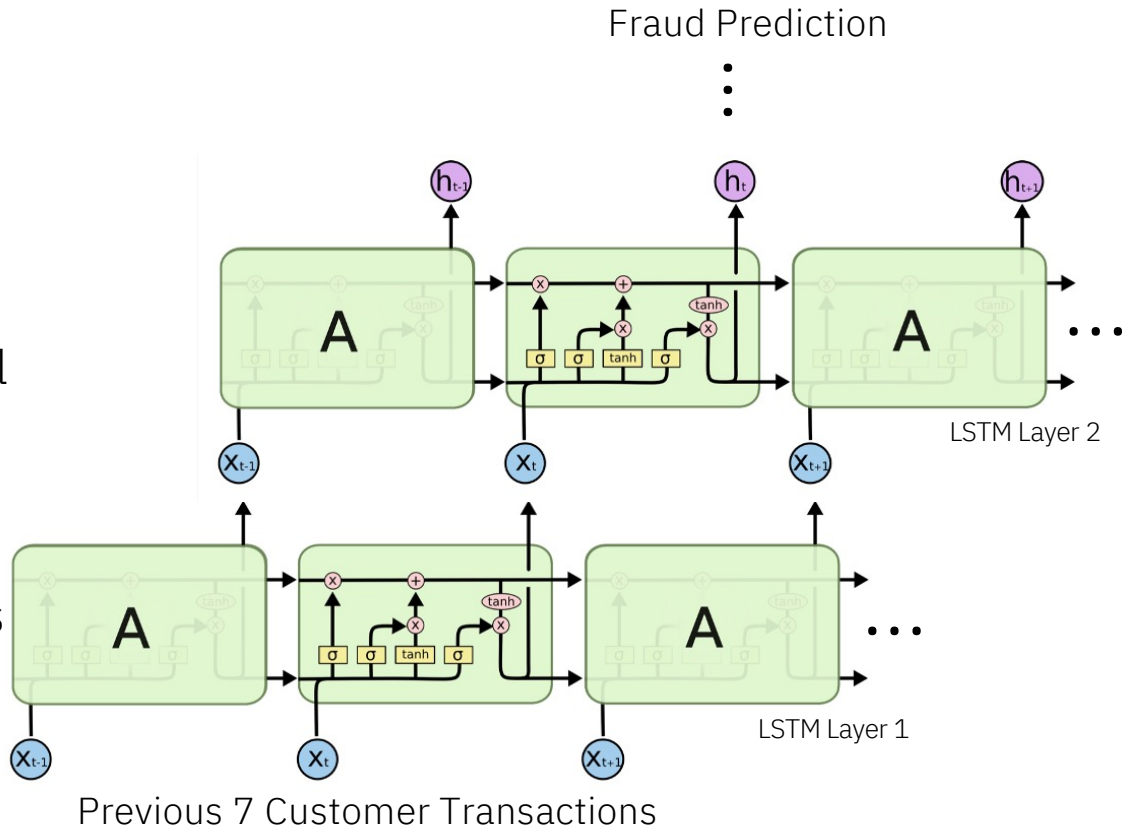
- Create a training dataset from previous customer transactions
  - We used an IBM Research synthetic dataset[1]
  - 2.4M samples with 29,342 labeled as fraudulent (1.22%)
- Label confirmed instances of fraud
- Train an AI model to predict whether a current transaction is likely fraudulent
- Evaluate model performance and deploy

Features Used for AI Training
User
Card
Year
Month
Day
Time
Amount
Use Chip?
Merchant Name
Merchant City
Merchant State
Zip
MCC
Errors?
Fraudster ID
Is Fraud?

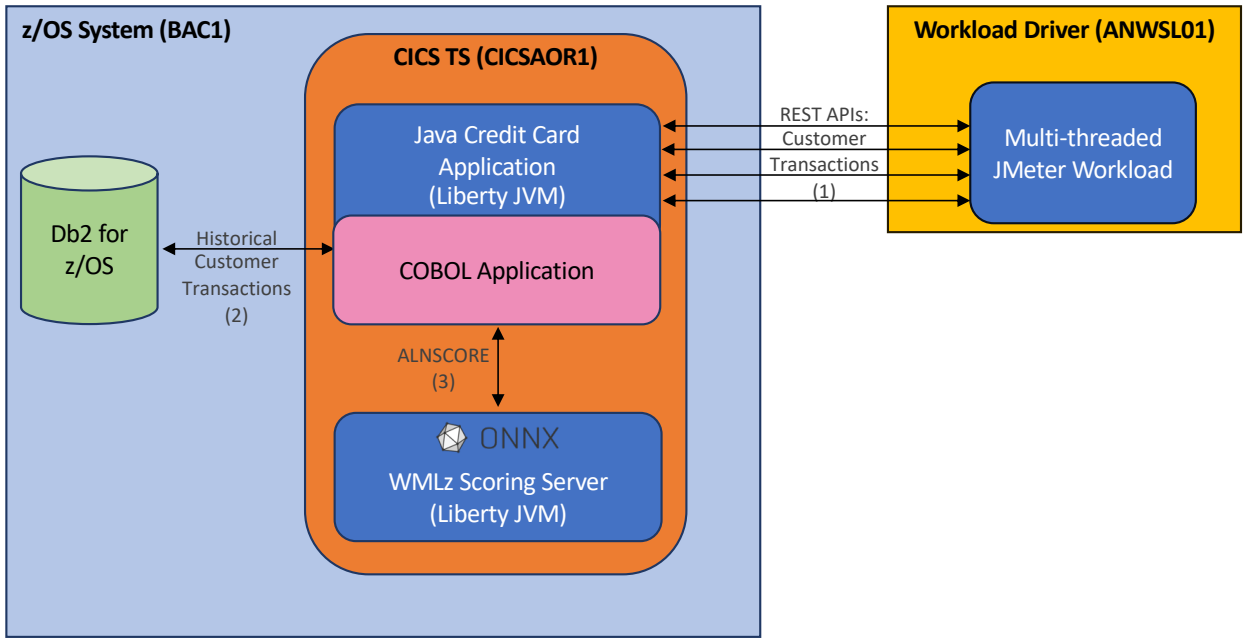
1. https://github.com/IBM/ai-on-z-fraud-detection

LSTM Credit Card Fraud Model

- Long Short-Term Memory model - specialized type of Recurrent Neural Network
- Incorporates feedback to efficiently process sequences of data
- Trained a 2-layer 200 cell LSTM model on ~800,000 customer credit card transaction sequences
- Classifies if the transaction is likely fraudulent or not based on a customer's 7 previous transactions



WSC CICS Transactional Workload Environment

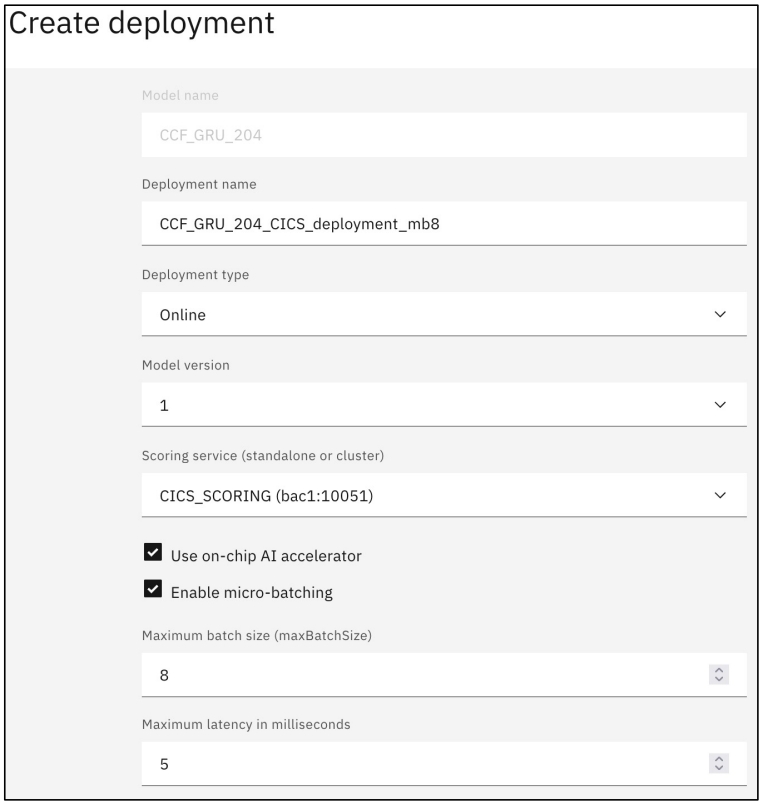


1. Simulated customer transactions are sent by JMeter to Java credit card application through a REST API call. Can control thread count.
2. A CICS transaction is initiated by the Java program, and the customers 7 previous credit card transactions are retrieved.
3. An AI prediction is performed using ALNSCORE to pass the previous transactions as input to the AI model
4. Prediction result is returned to Java application and then to JMeter

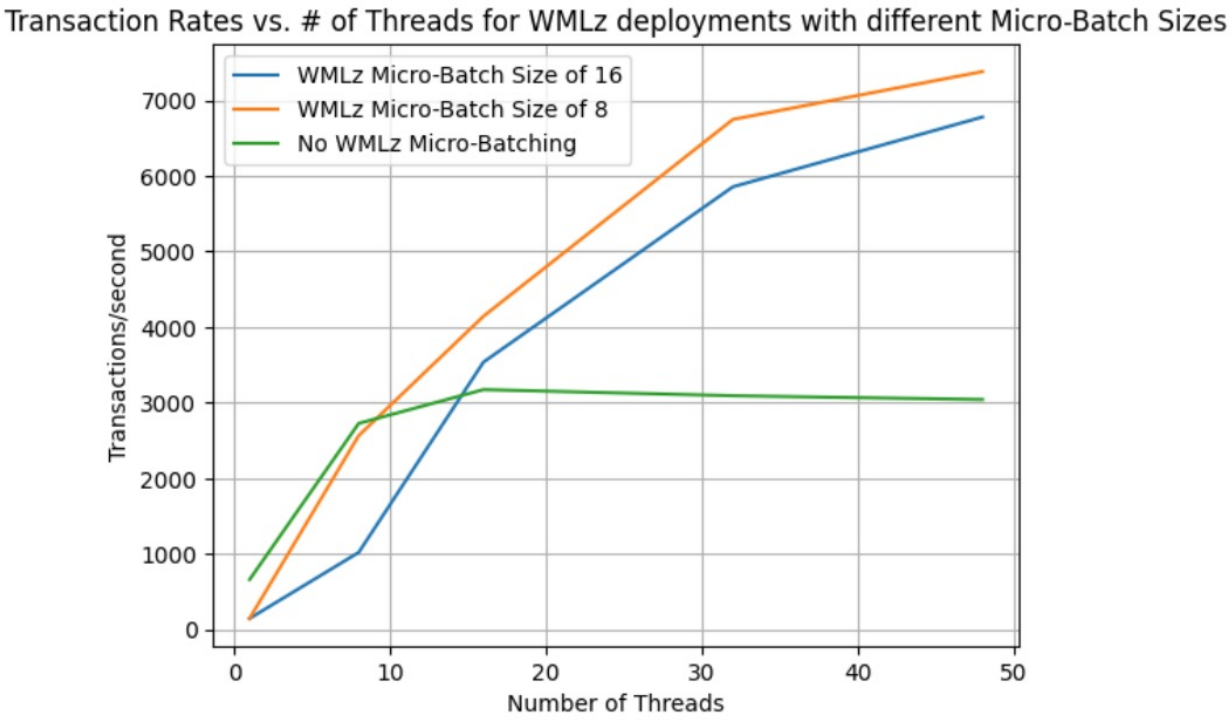
Accelerated Inferencing Demo

Deployment using Watson Machine Learning for z/OS (WMLz) and ALNSCORE

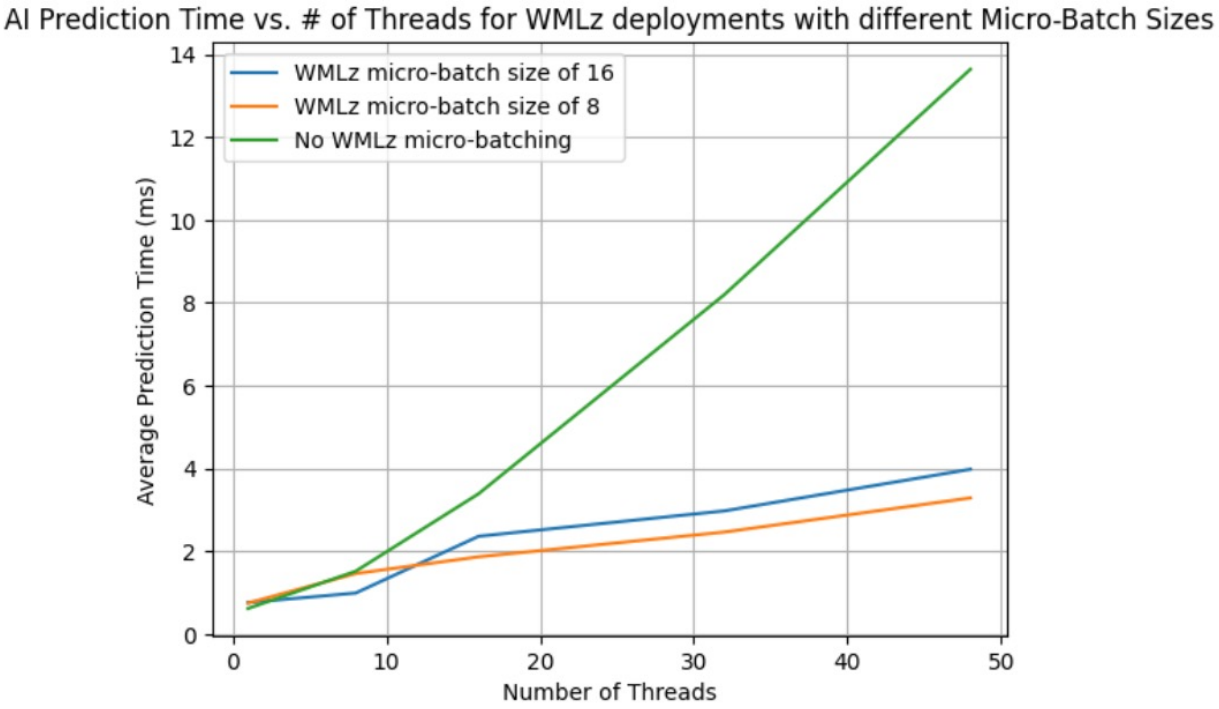
- First, model must be imported into WMLz
  - Deep Learning Compiler compiles model for efficient execution on the Integrated Accelerator for AI or CPU
- Can deploy to scoring server running in CICS region
- Can select whether deployment will use AI accelerator
- Specify deployment parameters to make online scoring more efficient
  - Micro-batch size: How many scoring requests to queue and send for processing simultaneously
  - Wait time: How long do I wait for the batch queue to fill up before processing scoring requests



Effect of WMLz Micro-Batching on Transaction Rates



Effect of WMLz Micro-Batching on Prediction Time



- Note: WMLz prediction times recorded by Java/COBOL application

Resources

- AI on IBM Z POCs
  - Contact aaminin@ibm.com
- AI on IBM Z 101
  - https://ibm.github.io/ai-on-z-101/
- IBM Z and LinuxONE Container Registry
  - https://ibm.github.io/ibm-z-oss-hub/main/main.html
- Watson Machine Learning for z/OS Overview
  - https://www.ibm.com/products/machine-learning-for-zos

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