Using Learning at the Edge to Deliver Business Value

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AGENDA:

01 GOALS
02 FIT
03 EXECUTION
DEFINITIONS:

**EDGE DEVICE** - a device whose compute, memory, and energy resources are constrained and cannot be easily changed.

**LEARNING AT THE EDGE** - training of a machine learning model on the edge device.
01 GOALS

- What is your objective?
Can learning at the edge help?
01 GOALS

02 FIT

- What are the benefits?

EDGE AI

- AUTONOMY
- ACCURACY
- PRIVACY
- SPEED
- SECURITY
- EVOLUTION

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01 GOALS

02 FIT

- What are the benefits?
01 GOALS

02 FIT

- What are the benefits?
01 GOALS

02 FIT

- What are the benefits?

Android 9 Pie

Source: https://www.android.com/versions/pie-9-0/
01 GOALS

02 FIT

- What are the benefits?
- What are the prerequisites?

FEASIBLE?
01 GOALS

02 FIT

- What are the benefits?
- What are the prerequisites?
01 GOALS

FIT

- What are the benefits?
- What are the prerequisites?

02 GOALS

FIT

- What are the benefits?
- What are the prerequisites?

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Model is only as good as the training data

- Anybody who has ever built a ML model
02 FIT

- What are the benefits?
- What are the prerequisites?
01 GOALS

02 FIT

- What are the benefits?
- What are the prerequisites?
01 GOALS

02 FIT

- What are the benefits?
- What are the prerequisites?

MINIMAL/ NO DATA PREPROCESSING
01 GOALS

02 FIT

- What are the benefits?
- What are the prerequisites?

LIMITED/NO LABELED DATA
01 GOALS

02 FIT

- What are the benefits?
- What are the prerequisites?
What are the benefits?

What are the prerequisites?

Scenario #1

Build a new product/device from scratch
01 GOALS

02 FIT

- What are the benefits?
- What are the prerequisites?

Scenario #1

Build a new product/device from scratch

Scenario #2

vs.

Improve an existing product/device
01 GOALS

02 FIT

- What are the benefits?
- What are the prerequisites?

Scenario #1

Build a new product/device from scratch

Scenario #2

Improve an existing product/device

YOU ARE SOMEWHERE HERE
01 02
GOALS  FIT
- What are the benefits?
- What are the prerequisites?
- What are the costs?

Scenario #1
Build a new product/device from scratch
- Bill of materials (BOM)
- Non-recurring engineering (NRE)
- User acquisition and retention, etc.

Scenario #2
Improve an existing product/device

VS.
01GOALS

- What are the benefits?
- What are the prerequisites?
- What are the costs?

02FIT

Scenario #1

- Build a new product/device from scratch
- Bill of materials (BOM)
- Non-recurring engineering (NRE)
- User acquisition and retention, etc.

Scenario #2

- Improve an existing product/device
- Non-recurring engineering (NRE)
- Product redesign-related NRE
- Feature introduction, etc.
01 GOALS

FIT

- What are the benefits?
- What are the prerequisites?
- What are the costs?
- Does it make sense?

BOTTOM LINE
GOALS

FIT

EXECUTION
01 GOALS

02 FIT

03 EXECUTION

- Where do I start? Data.

LIMITED & MINIMALLY PREPRORESSED DATA
- Where do I start? Data.
Where do I start? Data.
- Where do I start? Data.
- How does learning happen?
01 GOALS

02 FIT

03 EXECUTION

- Where do I start? Data.
- How does learning happen?

LEARNING AT THE EDGE: APPROACHES

GENERIC MODEL TRAINED ON CLOUD/ PREM
+ MODEL REFINED ON-DEVICE

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Where do I start? Data.

- How does learning happen?

Where do I start? Data.
- How does learning happen?
LEARNING AT THE EDGE: APPROACHES

- Where do I start? Data.
- How does learning happen?

| GENERIC MODEL TRAINED ON CLOUD/PREM + MODEL REFINED ON-DEVICE |
| COLLABORATIVE LEARNING (E.G. FEDERATED LEARNING) |
01 GOALS

Where do I start? Data.

02 FIT

How does learning happen?

03 EXECUTION

Source: https://ai.googleblog.com/2017/04/federated-learning-collaborative.html
Where do I start? Data.

How does learning happen?

LEARNING AT THE EDGE: APPROACHES

- **GENERIC MODEL TRAINED ON CLOUD/ PREM + MODEL REFINED ON-DEVICE**

- **COLLABORATIVE LEARNING (E.G. FEDERATED LEARNING)**

- **MODEL TRAINED FROM SCRATCH + POTENTIALLY RETRAINED ON-DEVICE ONLY**
- Where do I start? Data.
- How does learning happen?
- Where do I start? Data.
- How does learning happen?
- What else shall I take into account?
01 GOALS
- Where do I start? Data.
- How does learning happen?
- What else shall I take into account?

02 FIT

03 EXECUTION

MODEL LOSS
**01 GOALS**

- Where do I start? Data.
- How does learning happen?
- What else shall I take into account?

**02 FIT**

**03 EXECUTION**

EXPERIENCE CONSISTENCY
Where do I start? Data.
- How does learning happen?
- What else shall I take into account?
Where do I start? Data.
How does learning happen?
What else shall I take into account?

FUN? YES!
TRIVIAL? NO!
RESOURCES:

Publications
On-Device Machine Learning: An Algorithms and Learning Theory Perspective
https://arxiv.org/abs/1911.00623

On-device Learning: Examples
Android 9 Pie, Adaptive Battery and Brightness
https://www.android.com/versions/pie-9-0/

Core ML 3, On-device Training

Federated Learning: Collaborative Machine Learning without Centralized Training Data
https://ai.googleblog.com/2017/04/federated-learning-collaborative.html
THANK YOU