Zephyr® Project

Developer Summit

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Management of IoT TinyML Devices

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@MMierunski

Agenda

- TinyML Introduction
- Anomaly Detection IoT device demo
- LwM2M overview
- Combining LwM2M with TinyML

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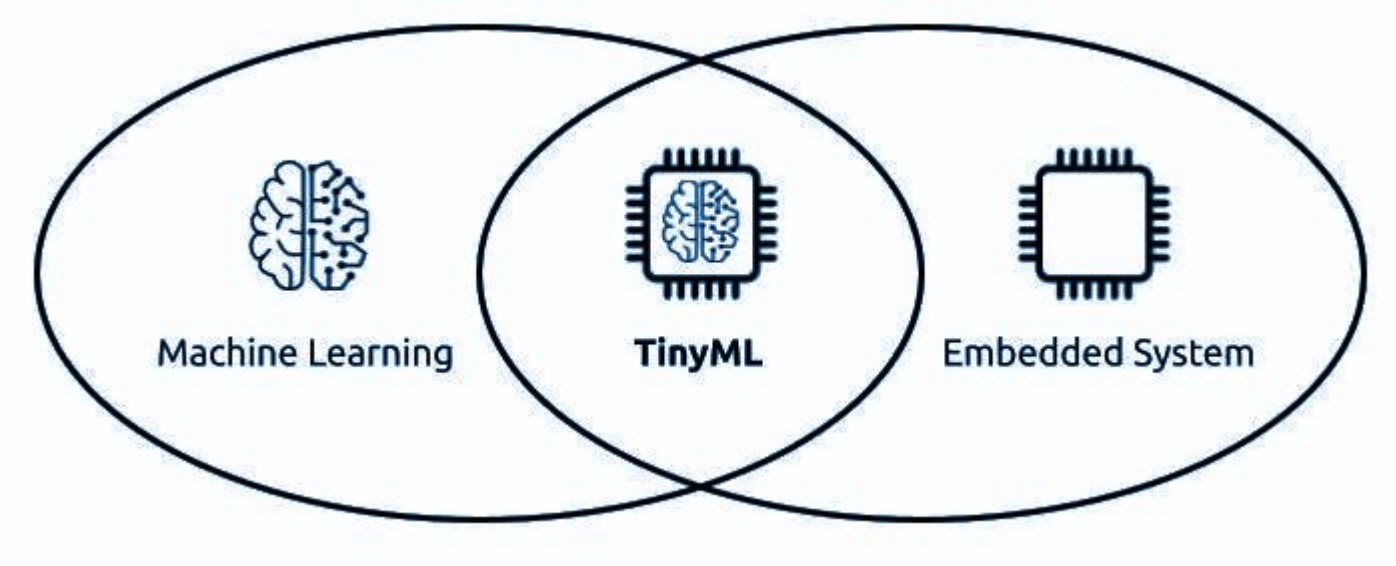
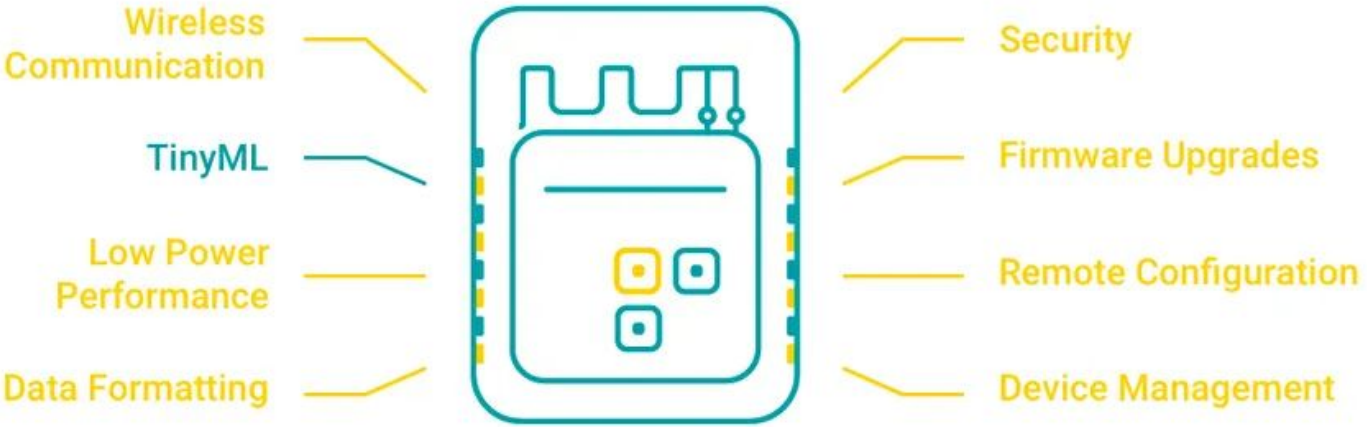
TinyML introduction

What is TinyML?



Elements of an Intelligent Device



Key Features

Low Latency

Power Efficiency

Privacy and security

Use cases

- Anomaly Detection
- Predictive Maintenance
- Energy Management
- Gesture Recognition
- Environmental Monitoring
- Health Monitoring and Wearables

TinyML

Continual Learning with LwM2M

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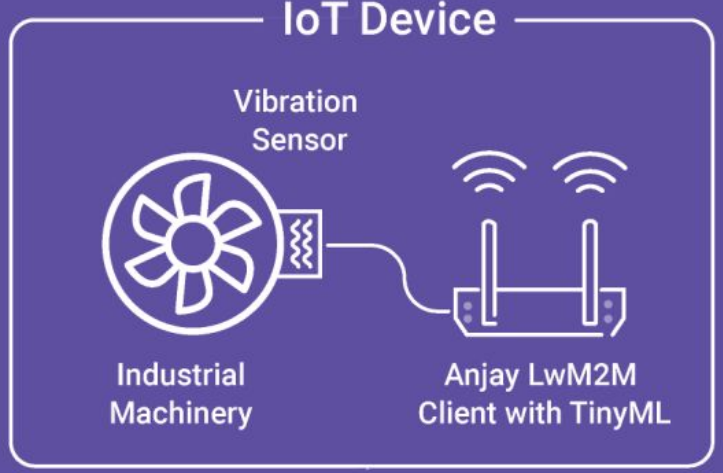
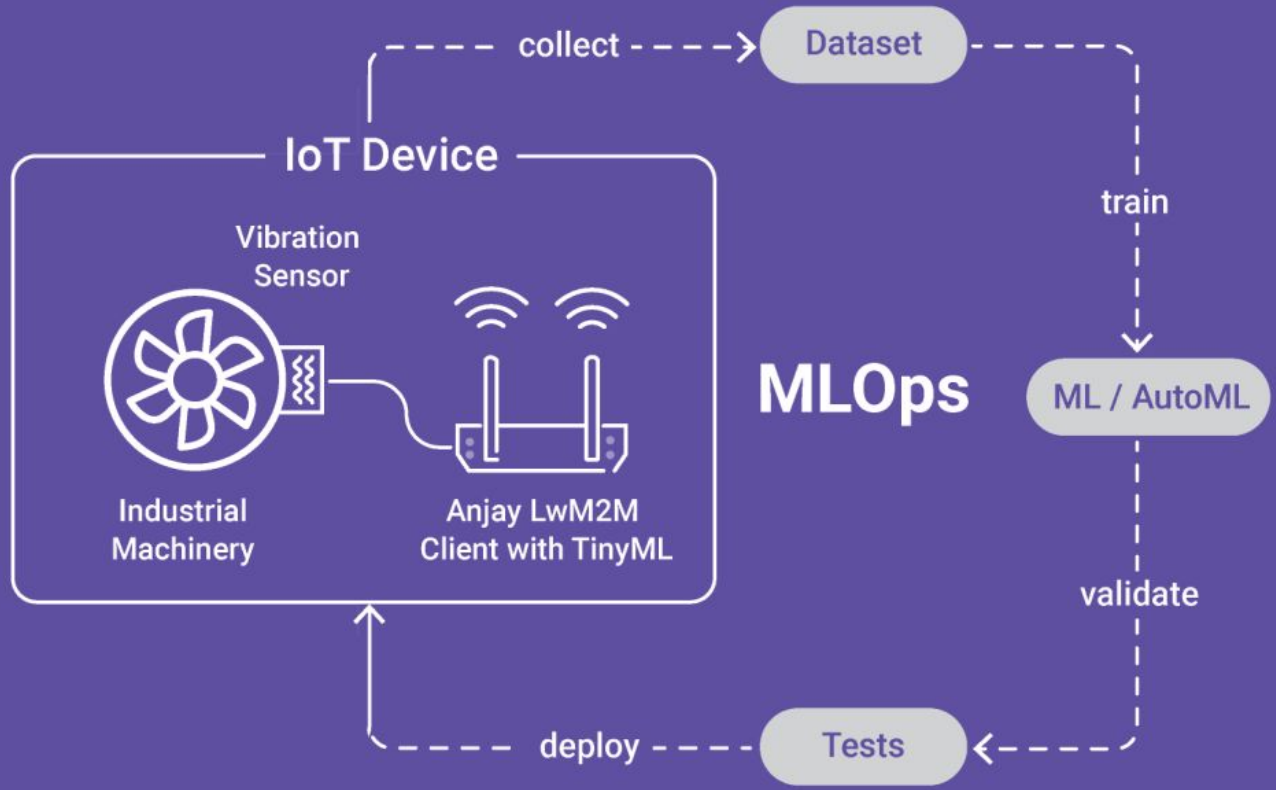
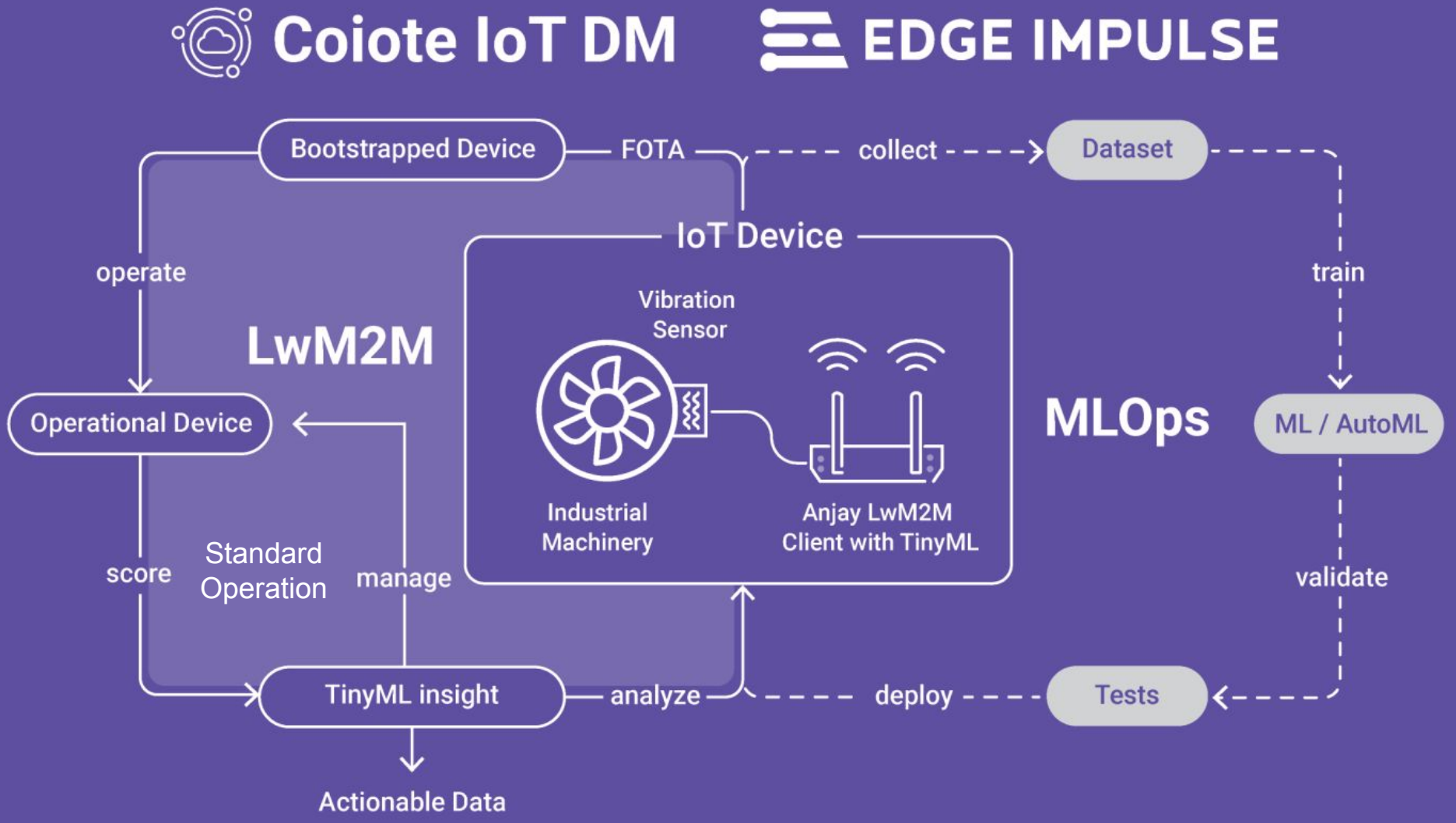
Anomaly Detection IoT demo


IoT Device
Vibration
Sensor
Industrial
Machinery
Anjay LwM2M
Client with TinyML

EDGE IMPULSE




Coiote IoT DM
EDGE IMPULSE
Bootstrapped Device
FOTA
collect
Dataset
IoT Device
operate
train
Vibration
Sensor
LwM2M
Operational Device
MLOps
ML / AutoML
Industrial
Machinery
Anjay LwM2M
Client with TinyML
score
Standard
Operation
manage
validate
TinyML insight
analyze
deploy
Tests
Actionable Data

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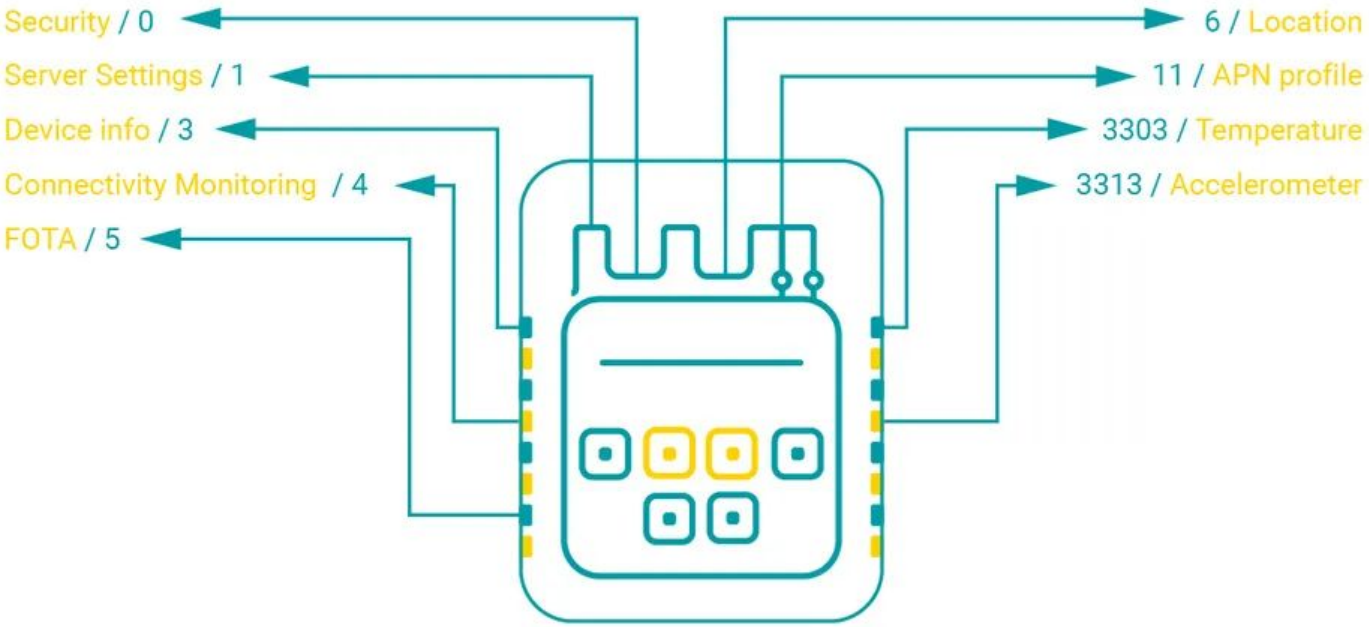
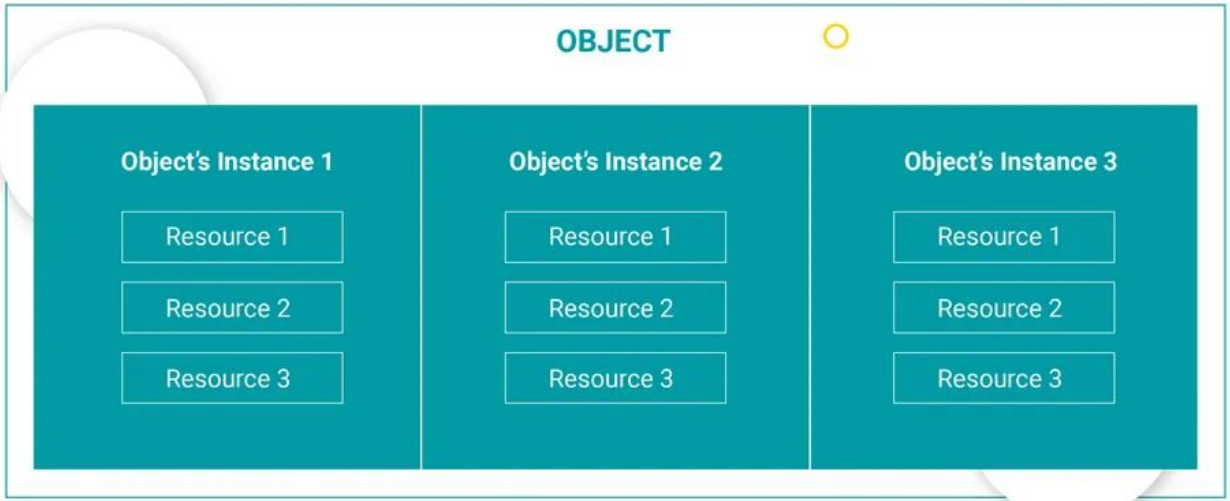
LwM2M Overview

LwM2M Architecture

Digital Representation using Smart Objects



LwM2M Data Model



LwM2M data format

Object ID / Object Instance ID / Resource ID = Data

Device Serial Number = 01234567	→	3/0/2 = 01234567
Location latitude = 52.0836007	→	6/0/0 = 52.0836007
Location longitude = 4.3181253	→	6/0/1 = 4.3181253
Temperature = 23.5	→	3303/0/5700 = 23.5
Air quality PM10 = 21.8	→	3428/0/1 = 21.8
Air quality PM2.5 = 18.3	→	3428/0/3 = 18.3

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LwM2M & TinyML

Accelerometer Object

Object definition

Name	Object ID	Object Version	LWM2M Version
Accelerometer	3313	1.0	1.0
Object URN		Instances	Mandatory
urn:oma:lwm2m:ext:3313		Multiple	Optional

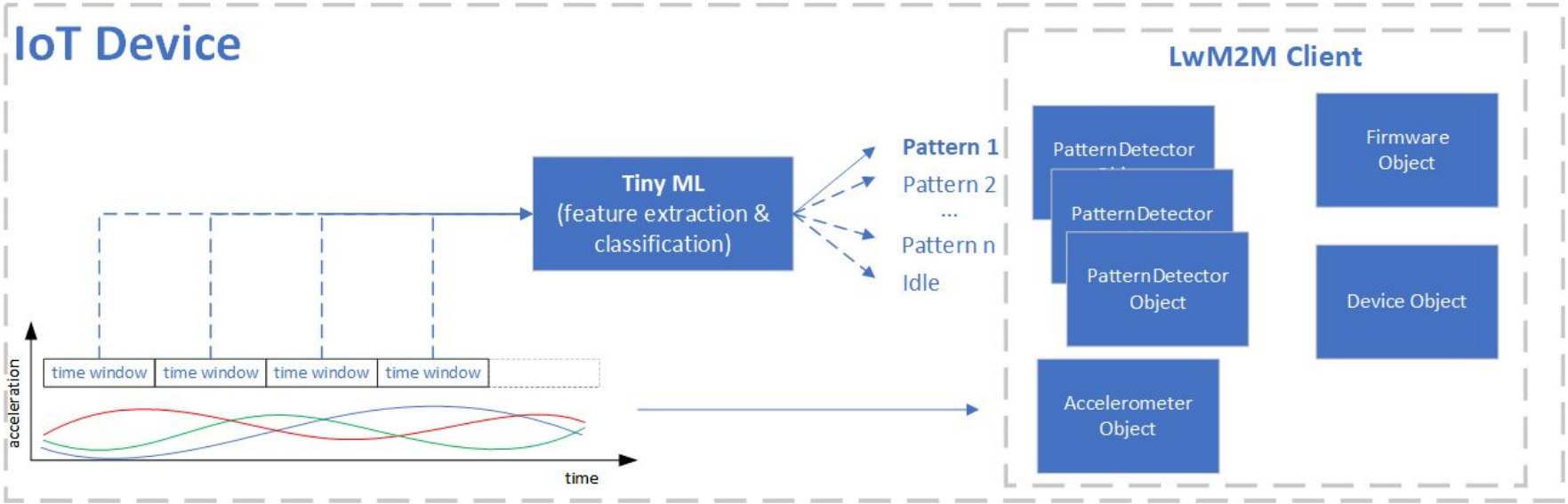
Resource Definitions

ID	Name	Operations	Instances	Mandatory	Type	Range or Enumeration	Units	Description
5702	X Value	R	Single	Mandatory	Float			The measured value along the X axis.
5703	Y Value	R	Single	Optional	Float			The measured value along the Y axis.
5704	Z Value	R	Single	Optional	Float			The measured value along the Z axis.
5701	Sensor Units	R	Single	Optional	String			Measurement Units Definition.
5603	Min Range Value	R	Single	Optional	Float			The minimum value that can be measured by the sensor.
5604	Max Range Value	R	Single	Optional	Float			The maximum value that can be measured by the sensor.

Interfaces
- Bootstrapping
- Registration
- Device Management
- Service Enablement
- Reporting

Stack
- Efficient Payload
- CoAP Protocol
- DTLS Security
- UDP/TCP/SMS Bearer

LwM2M Server



ML Model Object

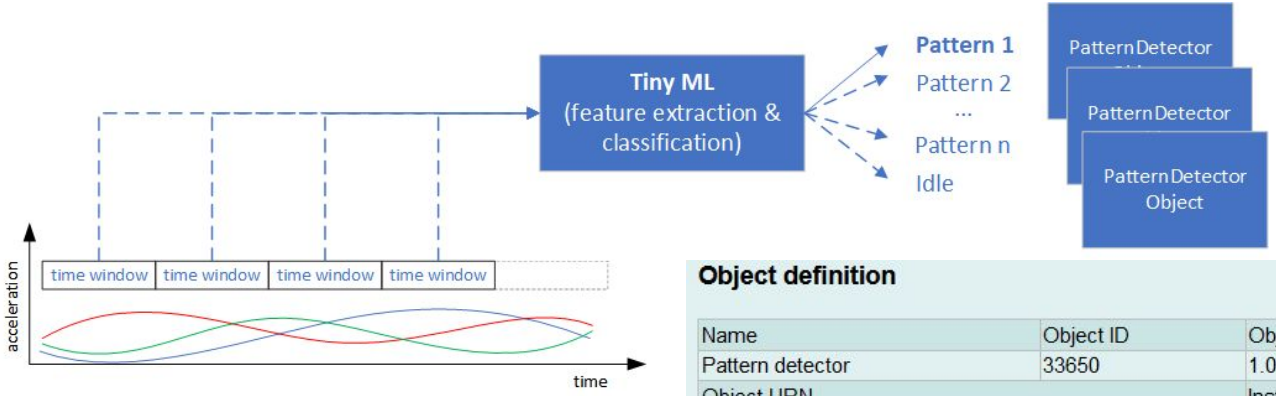
Object definition

Name	Object ID	Object Version	LWM2M Version
ML Model	33654	1.0	1.0
Object URN		Instances	Mandatory
urn:oma:lwm2m:ext:33654		Single	Optional

Resource Definitions

ID	Name	Operations	Instances	Mandatory	Type	Range or Enumeration	Units	Description
2000	Model Name	R	Single	Optional	String			ML model name.
2001	Model version	R	Single	Optional	Integer			ML model version.
2002	Learn	E	Single	Optional				Perform online learning.
2003	Knowledge	RW	Single	Optional	Opaque			Knowledge used by the model.

Pattern Detector Object



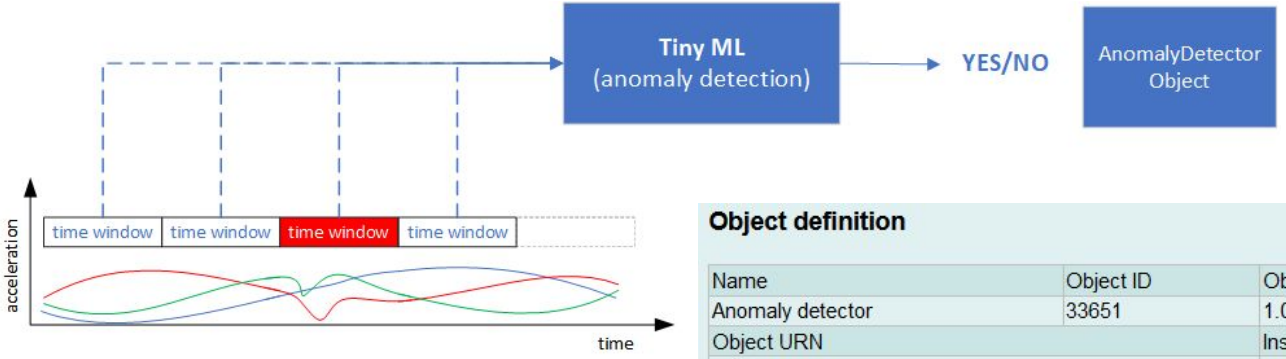
Object definition

Name	Object ID	Object Version	LWM2M Version
Pattern detector	33650	1.0	1.0
Object URN		Instances	Mandatory
urn:oma:lwm2m:ext:33650		Multiple	Optional

Resource Definitions

ID	Name	Operations	Instances	Mandatory	Type	Range or Enumeration	Units	Description
2000	Detector State	R	Single	Mandatory	Boolean			The current state of a detector.
2001	Detector Counter	R	Single	Mandatory	Integer			The cumulative value of patterns detected.
2002	Pattern Name	R	Single	Mandatory	String			Name of the pattern being detected.

Anomaly Detector Object



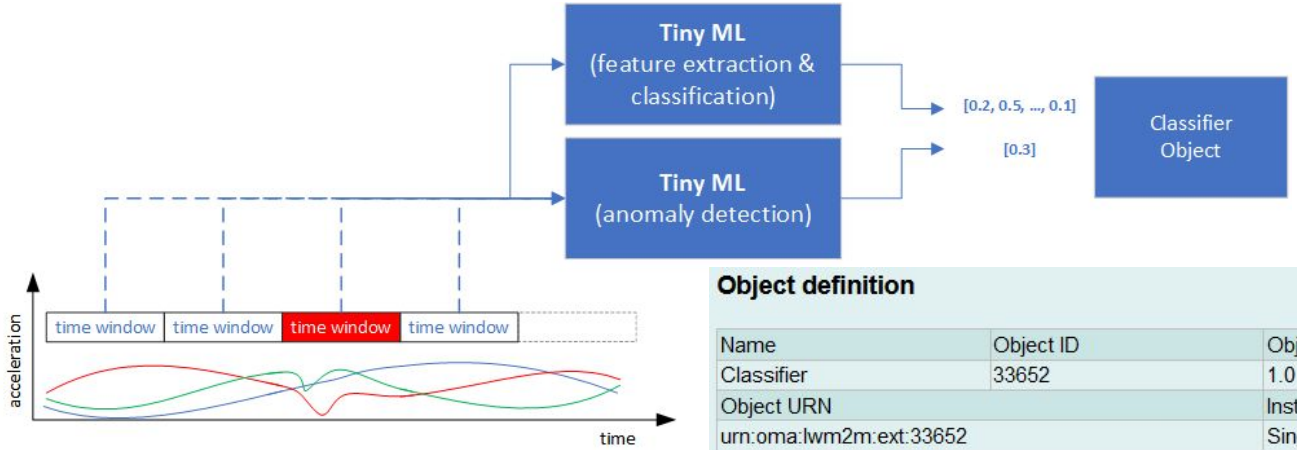
Object definition

Name	Object ID	Object Version	LWM2M Version
Anomaly detector	33651	1.0	1.0
Object URN		Instances	Mandatory
urn:oma:lwm2m:ext:33651		Single	Optional

Resource Definitions

ID	Name	Operations	Instances	Mandatory	Type	Range or Enumeration	Units	Description
2000	Anomaly State	R	Single	Mandatory	Boolean			The current state of a detector.
2001	Anomaly Counter	R	Single	Mandatory	Integer			The cumulative value of anomalies detected.
2002	Anomaly Treshold	RW	Single	Optional	Float			Input data is treated as anomaly if anomaly score is higher that threshold value.

Classifier Object



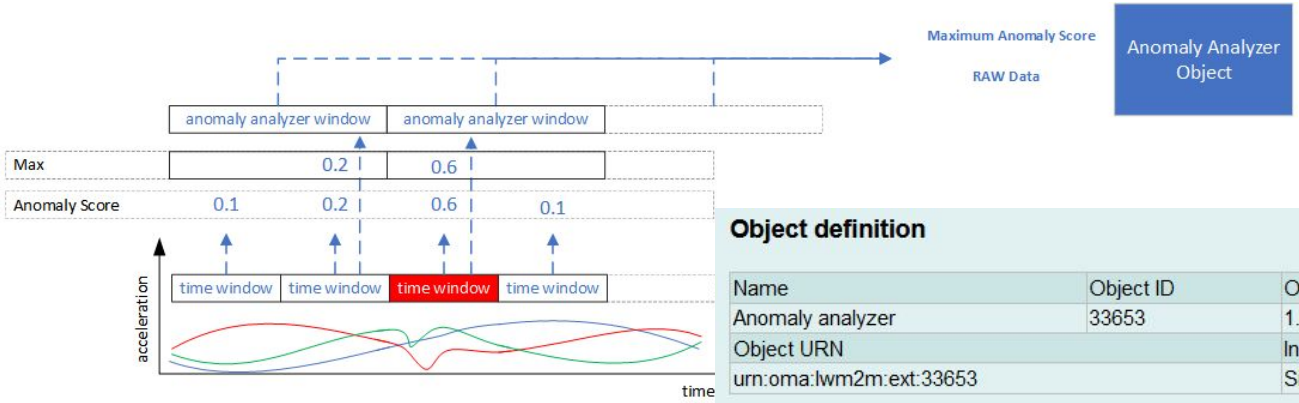
Object definition

Name	Object ID	Object Version	LWM2M Version
Classifier	33652	1.0	1.0
Object URN		Instances	Mandatory
urn:oma:lwm2m:ext:33652		Single	Optional

Resource Definitions

ID	Name	Operations	Instances	Mandatory	Type	Range or Enumeration	Units	Description
2000	Class Labels	R	Multiple	Mandatory	String			The labels of the classes that classifier is able to classify.
2001	Classification Output	R	Multiple	Mandatory	Float			The output of the classifier.
2002	Anomaly Output	R	Single	Optional	Float			Anomaly value of the classifier input data.

Anomaly Analyzer Object



Object definition

Name	Object ID	Object Version	LWM2M Version
Anomaly analyzer	33653	1.0	1.0
Object URN		Instances	Mandatory
urn:oma:lwm2m:ext:33653		Single	Optional

Resource Definitions

ID	Name	Operations	Instances	Mandatory	Type	Range or Enumeration	Units	Description
2000	Maximum Anomaly Score	R	Single	Mandatory	Float			Maximum value of the anomaly observed in the sensor data in a time window.
2001	RAW Data	R	Single	Optional	Opaque			The senor data for which maximum anomaly has been detected in the time window.
2002	Reset	E	Single	Mandatory				Action to reset stored data.

TinyML Objects - Summary

Object Name	ID	Description
Pattern Detector	33650	This object is used to report the pattern detected by the ML-based classification algorithms and to count the number of times it has been detected.
Anomaly Detector	33651	This object is used to report the anomaly detected by the ML-based algorithms and to count the number of times it has been detected.
Classifier	33652	This object is used to report the results of the ML-based classification algorithm.
Anomaly Analyzer	33653	This object is used to report the sensor data that are significantly different from the data in the training dataset.
ML Model	33654	This object is used to report the meta information of the ML model used by the device.

Summary and references

- https://www.wevolver.com/article/whats-this-lwm2m-standard-and-why-should-you-care
- https://www.wevolver.com/article/tinyml-continual-learning-with-lwm2m
- https://www.avsystem.com/blog/remote-firmware-updates-for-iot-devices/

Thank you for your attention!
Q&A

How to run FOTA updates using LwM2M & Zephyr

Time
05:00 PM Europe/Warsaw

Date
Wednesday, July 12, 2023