

tinyML[®] Talks

Enabling Ultra-low Power Machine Learning at the Edge

“TinyML 101 - the new area of AI inside the IoT”

Abraham Arce - Cloud Software Engineer, Intel

Sheratan Arevalo - SAP Team Lead, Global Company

February 24, 2022



www.tinyML.org

tinyML Talks Strategic Partners

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SYNTIANT

Additional Sponsorships available – contact Olga@tinyML.org for info

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Powering tinyML Innovation

Arm AI Virtual Tech Talks

The latest in AI trends, technologies & best practices from Arm and our Ecosystem Partners.

Demos, code examples, workshops, panel sessions and much more!

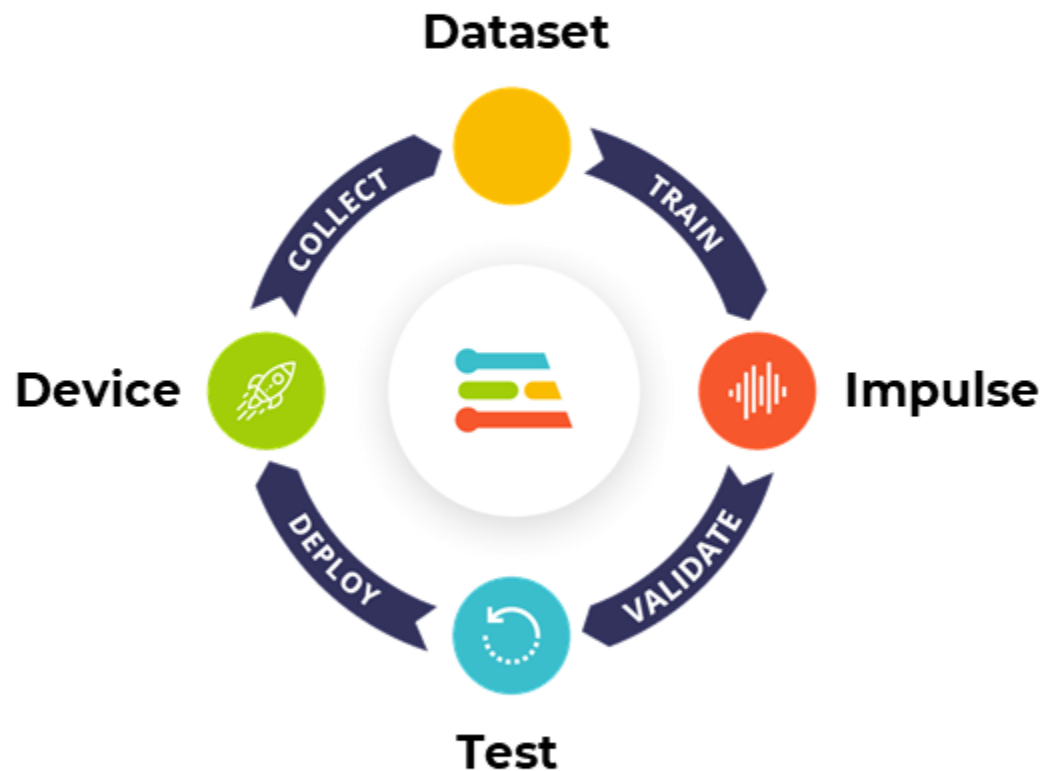
Fortnightly Tuesday @ 4pm GMT/8am PT

Find out more:

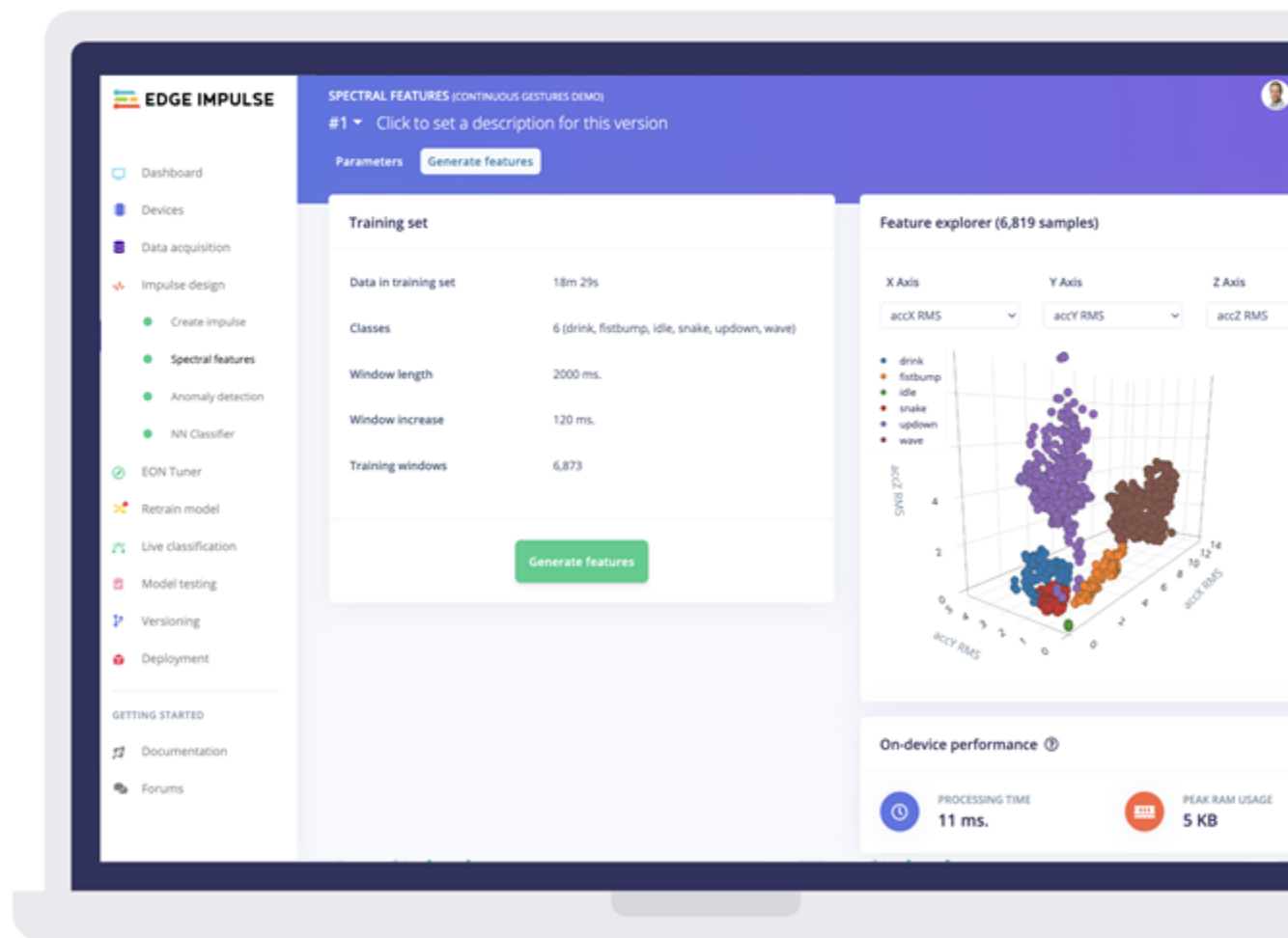
www.arm.com/techtalks



EDGE IMPULSE The leading edge ML platform



www.edgeimpulse.com



Advancing AI research to make efficient AI ubiquitous

Power efficiency

Model design,
compression, quantization,
algorithms, efficient
hardware, software tool

Personalization

Continuous learning,
contextual, always-on,
privacy-preserved,
distributed learning

Efficient learning

Robust learning
through minimal data,
unsupervised learning,
on-device learning

A platform to scale AI across the industry



Perception

Object detection, speech
recognition, contextual fusion



Reasoning

Scene understanding, language
understanding, behavior prediction



Action

Reinforcement learning
for decision making



Edge cloud



Cloud



IoT/IIoT



Automotive



Mobile

SYNTIANT



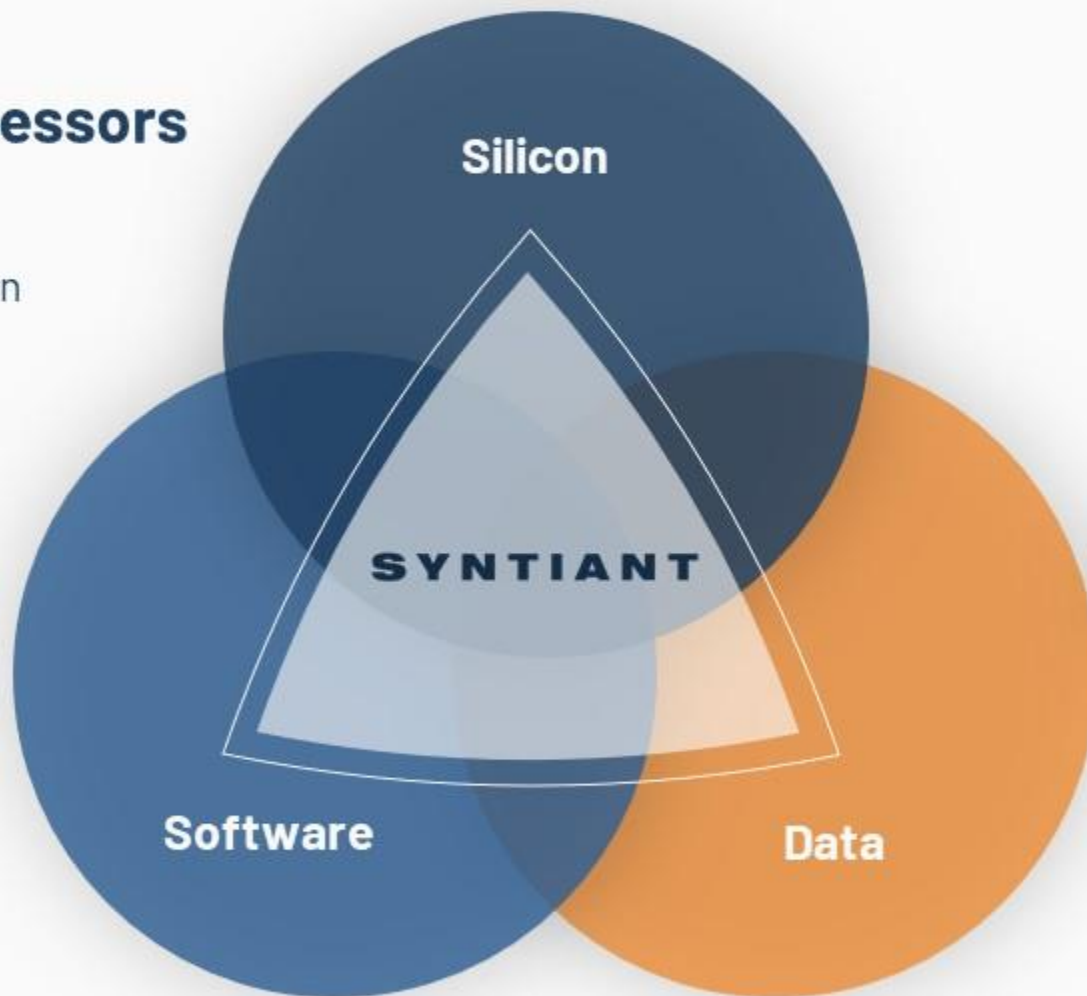
Neural Decision Processors

- At-Memory Compute
- Sustained High MAC Utilization
- Native Neural Network Processing



ML Training Pipeline

- Enables Production Quality Deep Learning Deployments



**End-to-End
Deep Learning
Solutions
for
TinyML & Edge AI**



Data Platform

- Reduces Data Collection Time and Cost
- Increases Model Performance



Platinum Strategic Partners



WE USE AI TO MAKE OTHER AI FASTER, SMALLER AND MORE POWER EFFICIENT



Automatically compress SOTA models like MobileNet to <200KB with **little to no drop in accuracy** for inference on resource-limited MCUs



Reduce model optimization trial & error from weeks to days using Deeplite's **design space exploration**



Deploy more models to your device without sacrificing performance or battery life with our **easy-to-use software**

BECOME BETA USER bit.ly/testdeeplite

mobilityXlab

arm





KLIKA·TECH

GLOBAL IOT SOLUTIONS



Reality AI[®]

Add Advanced Sensing to your Product with Edge AI / TinyML

<https://reality.ai>



info@reality.ai



[@SensorAI](https://twitter.com/SensorAI)



[Reality AI](#)

Pre-built Edge AI sensing modules, plus tools to build your own

Reality AI solutions

Prebuilt sound recognition models for
indoor and outdoor use cases

Solution for industrial anomaly detection

Pre-built automotive solution that lets cars
“see with sound”

Reality AI Tools[®] software

Build prototypes, then turn them into
real products

Explain ML models and relate the function
to the physics

Optimize the hardware, including
sensor selection and placement

BROAD AND SCALABLE EDGE COMPUTING PORTFOLIO

Microcontrollers & Microprocessors

Arm® Core



Arm® Cortex®-M 32-bit MCUs
Arm ecosystem, Advanced security, Intelligent IoT



Arm®-based High-end 32 & 64-bit MPUs
High-resolution HMI, Industrial network & real-time control



Arm® Cortex®-M0+ Ultra-low Power 32-bit MCUs
Innovative process tech (SOTB), Energy harvesting

Renesas Synergy™ Arm®-based 32-bit MCUs for Qualified Platform
Qualified software and tools

Renesas Core



Ultra-low Energy 8 & 16-bit MCUs
Bluetooth® Low Energy, SubGHz, LoRa®-based Solutions



High Power Efficiently 32-bit MCUs
Motor control, Capacitive touch, Functional safety, GUI



40nm/28nm process Automotive 32-bit MCUs
Rich functional safety and embedded security features

Core technologies

AI

A broad set of high-power and
energy-efficient embedded processors

Security & Safety

Comprehensive technology and support
that meet the industry's stringent standards



Digital & Analog & Power Solution

Winning Combinations that combine our
complementary product portfolios

Cloud Native

Cross-platforms working with partners
in different verticals and organizations

Gold Strategic Partners

T I N Y



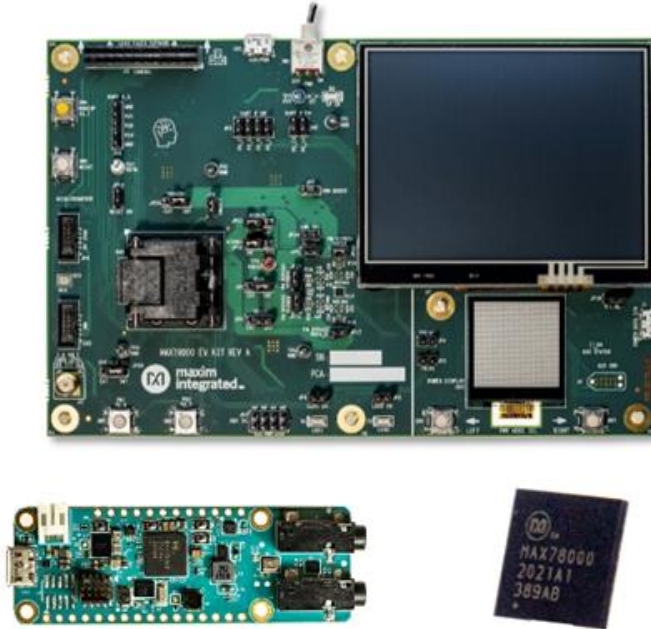
TALKS
webcast



FotaHub

Maxim Integrated: Enabling Edge Intelligence

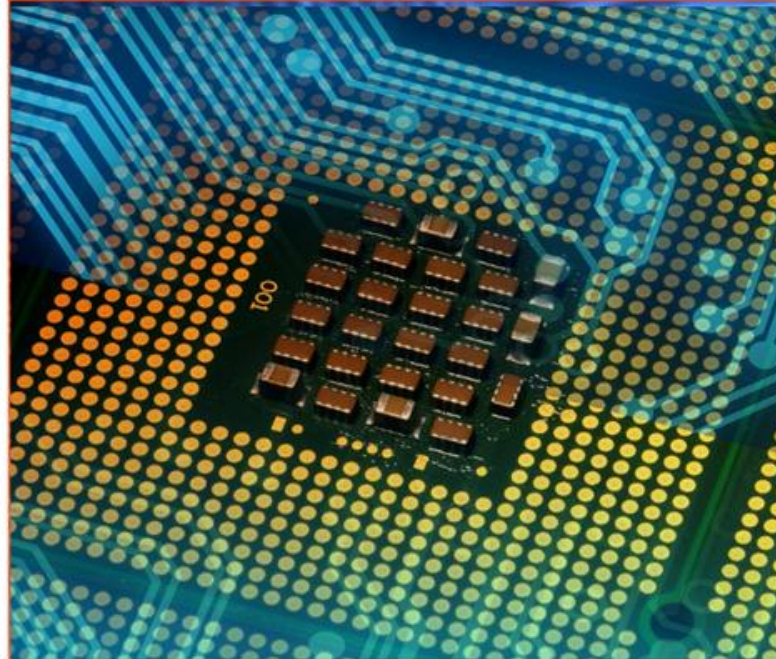
Advanced AI Acceleration IC



The new MAX78000 implements AI inferences at low energy levels, enabling complex audio and video inferencing to run on small batteries. Now the edge can see and hear like never before.

www.maximintegrated.com/MAX78000

Low Power Cortex M4 Micros



Large (3MB flash + 1MB SRAM) and small (256KB flash + 96KB SRAM, 1.6mm x 1.6mm) Cortex M4 microcontrollers enable algorithms and neural networks to run at wearable power levels.

www.maximintegrated.com/microcontrollers

Sensors and Signal Conditioning



Health sensors measure PPG and ECG signals critical to understanding vital signs. Signal chain products enable measuring even the most sensitive signals.

www.maximintegrated.com/sensors



LatentAI

Adaptive AI for the Intelligent Edge

[Latentai.com](https://latent.ai)



Micr.ai



NXP



seed studio

The IoT Hardware Enabler



Build Smart IoT Sensor Devices From Data

SensiML pioneered TinyML software tools that auto generate AI code for the intelligent edge.

- End-to-end AI workflow
- Multi-user auto-labeling of time-series data
- Code transparency and customization at each step in the pipeline

We enable the creation of production-grade smart sensor devices.



sensiml.com



life.augmented



SynSense

SynSense builds **sensing and inference** hardware for **ultra-low-power** (sub-mW) **embedded, mobile and edge** devices. We design systems for **real-time always-on smart sensing**, for audio, vision, IMUs, bio-signals and more.

<https://SynSense.ai>



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AONdevices



The logo for Grovety Inc. features a green stylized leaf icon followed by the text "Grovety Inc." in a green sans-serif font.





tinyML Summit 2022

Miniature dreams can come true...

March 28-30, 2022

Hyatt Regency San Francisco Airport

<https://www.tinymml.org/event/summit-2022/>



*The Best Product of the Year and the Best Innovation of the Year awards are open for nominations between **November 15** and **February 28**.*

tinyML Research Symposium 2022

March 28, 2022

<https://www.tinymml.org/event/research-symposium-2022>

More sponsorships are available: sponsorships@tinyML.org



tinyML Trailblazers Series

Success Stories with Marian Verhelst
(Professor, EE Department of KU Leuven)

LIVE ONLINE March 2nd, 2022 at 8 am PST



Register now!





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8.3k members in
43 Groups in 34 Countries

tinyML - Enabling ultra-low Power ML at the Edge

<https://www.meetup.com/tinyML-Enabling-ultra-low-Power-ML-at-the-Edge/>



2.6k members
&
5.1k followers

The tinyML Community

<https://www.linkedin.com/groups/13694488/>





Subscribe to
tinyML YouTube Channel
for updates and notifications
(including this video)
www.youtube.com/tinyML





Next tinyML Talks

Date	Presenter	Topic / Title
Friday, February 25	MB Jallow, MarsCrowd	Application of ultra-low-power and resource-constrained devices to improve health care delivery in resource-constrained communities

Webcast start time is 4:30 am Pacific time

Please contact talks@tinymml.org if you are interested in presenting

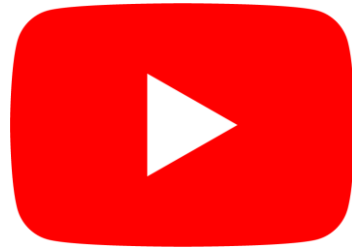


Reminders

Slides & Videos will be posted tomorrow



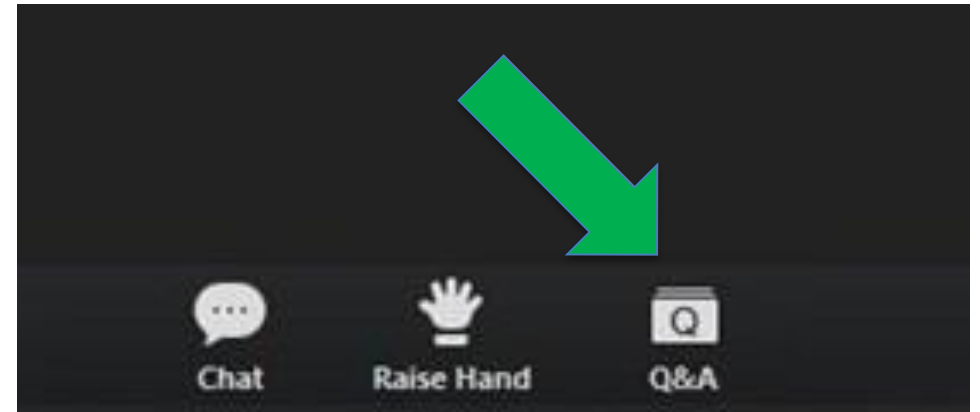
tinyml.org/forums



youtube.com/tinyml



Please use the Q&A window for your questions





Sheratan Arevalo



Sheratan Arevalo leads SAP Support and Functional Operation for a Global Company. He also has experience as software developer and hardware enthusiastic for more than 14 years. He has a passion for mentoring and coaching young people.



Abraham Arce



Abraham works at Intel as Cloud Software Engineer, contributing to GNU/Linux since 1996, HAM Amateur Radio operator, trainer and consultant in the Internet of Things space.





Code | Learn | Contribute

What will you create?

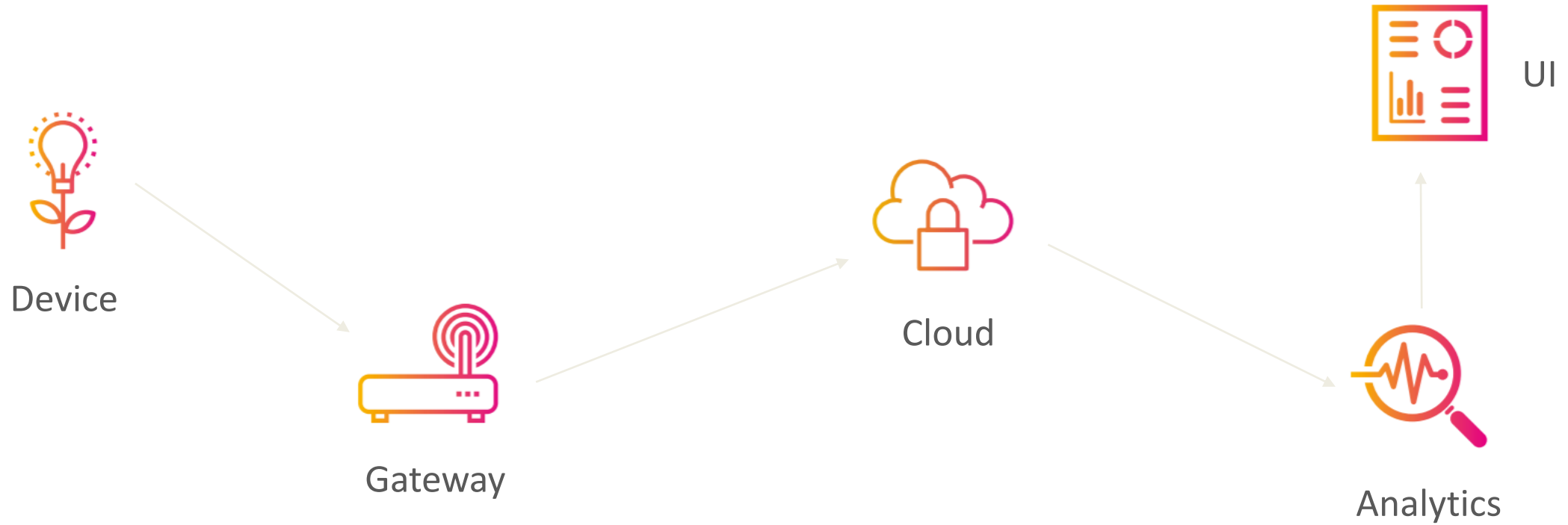


The Internet of Things - IoT

Network of physical objects—"things"—that are embedded with sensors, software, and other technologies for the purpose of connecting and exchanging data with other devices and systems over the internet.



IoT – High Level Architecture



IoT – High Level Architecture - Health



Device



Gateway

fitbit

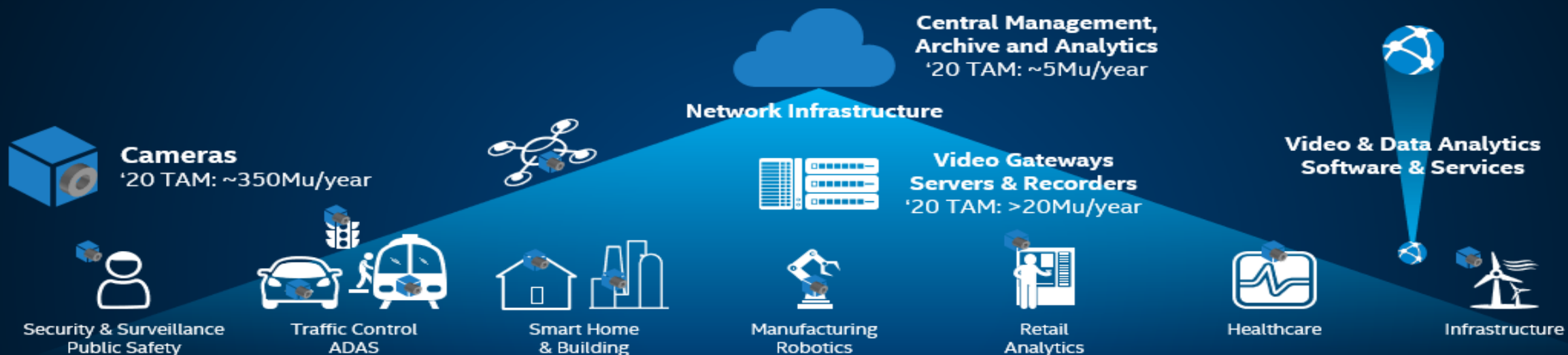
Cloud



Analytics

IoT - End to End Solution

EYE OF THE IOT



**VIDEO IS A PILLAR
OF THE IOT**

**MASSIVE MARKET
OPPORTUNITY**

**A MARKET IN NEED
OF A LEADER**

IoT - End to End Solution – Bacab Home Personal Project

Activities Firefox Web Browser sáb 16:38

Overview - Home Assistant - Mozilla Firefox

Overview - Home Assistant x Groups - Bosques Urbanos x +

192.168.192.202:8123/lovelace/home 60%

Welcome to Bacab Home!
Bacab? Old god of the interior of the earth and of thunder, sky-carrier, fourfold. Today? a Smart Home!

Birthdays

Princess	Polito	Maca	Balam
105 days	182 days	174 days	218 days

Lights

All	Downstairs	Upstairs
Off	Off	Off

Shopping List

- + Add item
- ☐ Vacations View
- ☐ Front Door Out Of Home w Lights +
- ☐ User Add Altitude
- ☐ Add Views To Telegram
- ☐ Magnet On Status?
- ☐ Move the alarm action sections to scripts

Holidays

New Year	Holy Kings
174 days	179 days

Family

Commute

Home To School	Home To Work
11 min	60 min

Mode

Vacation	Street
<input type="checkbox"/>	<input type="checkbox"/>

Alarm

ARM HOME ARM AWAY ARM NIGHT

Alarm Code

1	2	3
4	5	6
7	8	9
0	CLEAR	

Summary

Environment

Dark Sky Hourly Summary Rain starting tomorrow morning.

Home Mean Temperature	Home Mean Humidity
27.93 °C	Unknown

Motion On Today

Now	Hours
Clear	1.19 h

All Lights On

Today	Yesterday
0.39 h	1.03 h

Users Week

Balam Home	Balam Not Home
0.0 h	136.64 h

Battery Levels

Home Mean Battery Levels
78.67 %



IoT - End to End Solution – Bacab Home Personal Project

Activities Firefox Web Browser sáb 16:41

Overview - Home Assistant - Mozilla Firefox

Overview - Home Assistant Groups - Bosques Urbanos

192.168.192.202:8123/lovelace/cameras 60%

Bacab Home

Motion

- Hue Outdoor Motion Sensor 01 Clear
- Amcrest Camera 01 Motion Clear
- Application Restricted Zone Notifier Python Clear

Ffmpeg Camera 01 2020-07-11 16:38:32

Amcrest Camera 01

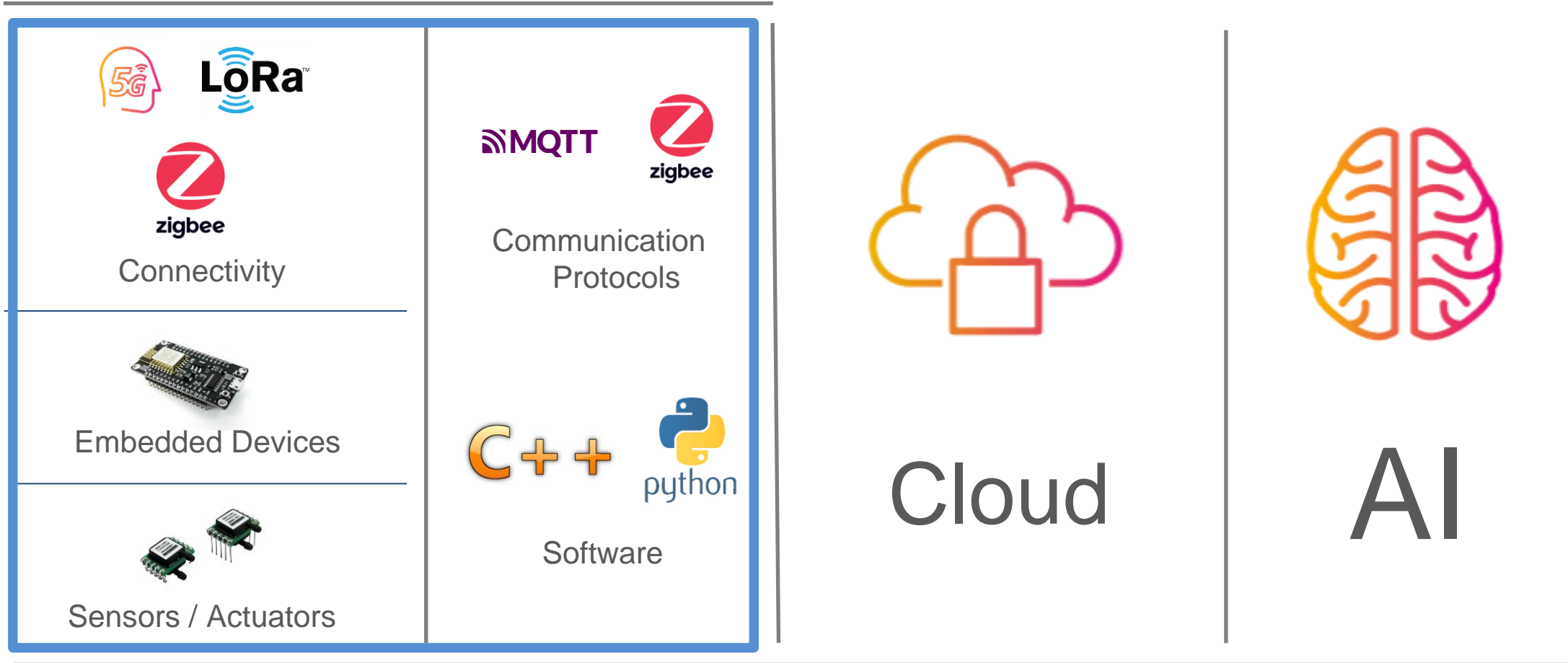
Last Picture Amcrest Camera 01

Last Picture Ffmpeg Camera 01 2020-07-11 16:40:25

IoT – Inside the Architecture



Edge Computing



Security



Edge Computing

IoT – Inside the Architecture



Connectivity



Embedded Devices



Sensors / Actuators



Communication
Protocols



Software



Cloud



AI

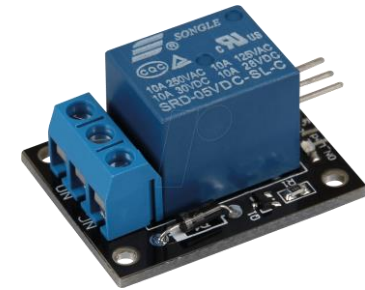
Security

IoT – Sensors & Actuators

▼ Sensor Categories	Sensors grouped by category
▶ Accelerometer	Measure acceleration & tilt or collision detection
▶ Analog Inputs	Sensors with a variable voltage output
▶ Atmospheric Pressure	Measure pressure and atmospheric conditions
▶ Button	Button, Switch or Toggle
▶ Color Sensor	Light sensors with special function: Color recognition
▶ Compass/Magnetometers	Measure magnetic field to give rotation or heading
▶ Digital Potentiometer	Resistive digital to analog converters (DAC)
▶ Displays	TFT, LCD, LED display elements
▶ Electricity	Measure electric current and ADC converters
▶ Flex/Force	Measure bending or detect vibration
▶ Gas	Measure substance concentrations in gases
▶ GPS	Provide positioning capabilities
▶ Gyroscopes	Measure rotation rate in one or more axes
▶ LEDs	LEDs, LED strips, LED matrix displays & controllers
▶ Light/Proximity/IR	Measure light intensity or distances
▶ Liquid Flow	Measure liquid flow rates or levels
▶ Medical	Sensors with specific medical application
▶ Motor	Various motors & controllers to get things moving
▶ Other	Other types of supported sensors
▶ Relay	Different low and high power relays
▶ RFID	Wireless sensors using RFID tags
▶ Serial	Sensors using serial communication
▶ Servo	Various servo motors & controllers
▶ Sound	Provide sound recording or playback
▶ Temperature/Humidity	Measure temperature & humidity
▶ Time	Real time clocks & time measurement
▶ Touch Sensor	Capacitive touch sensors
▶ Video	Provide video or video camera access
▶ Wireless Communication	Provide WiFi, Bluetooth, RF communication



Sensor



Actuator



Sensor framework
for IoT developers



Edge Computing

IoT – Inside the Architecture



Connectivity



Communication
 Protocols



Cloud



AI



Embedded Devices



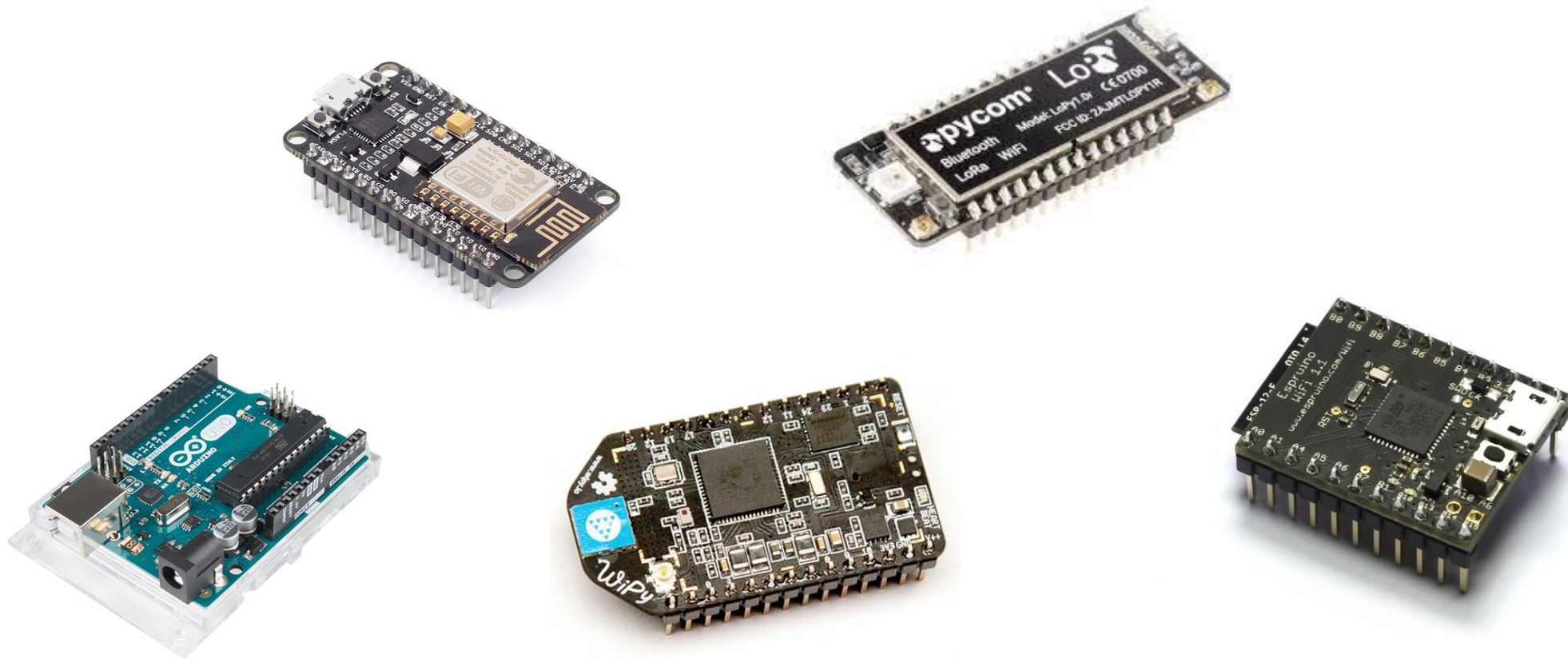
Software



Sensors / Actuators

Security

IoT – Embedded Devices





Edge Computing

IoT – Inside the Architecture





zigbee

Connectivity




zigbee

Communication
 Protocols




python

Software



Cloud



AI



Embedded Devices



Sensors / Actuators

Security



IoT – Connectivity

WiFi

Bluetooth

Zigbee

Lower Power Area Network (LPWAN)

- LTE-M
- NB-IoT
- LoRa

Cellular

- LTE
- 2G
- 3G
- 4G
- 5G





Edge Computing

IoT – Inside the Architecture



Connectivity



Embedded Devices



Sensors / Actuators



Communication
Protocols



Software



Cloud



AI

Security

IoT - Communication Protocols

Some Popular Protocols

- MQTT – Message Queue Telemetry Transport Protocol
- COAP – Constrained Application Protocol
- AMQP – Advance Message Queuing Protocol
- DDS – Data Distribution Service



Edge Computing

IoT – Inside the Architecture



Connectivity



Communication
Protocols



Embedded Devices



Sensors / Actuators



Software



Cloud



AI

Security

IoT – Software

1



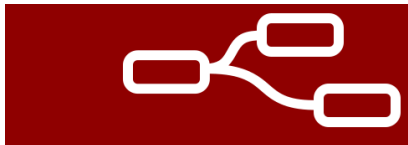
Arduino is a simple-to-use IoT platform, operates through an array of hardware specifications that can be given to interactive electronics.

2



IoT Platform based on Node.js. It is considered a complete toolkit to make HTTP API for devices. Zetta combines Rest API, websockets.

3



Node-RED

Visual tool for lining the Internet of Things, i.e., wiring together hardware devices, APIs, and online services in new way.



IoT – Inside the Architecture



Edge Computing



Connectivity



Embedded Devices



Sensors / Actuators



Communication
Protocols



Software



Cloud



AI

Security

The Internet of Things (IoT) has been associated with major cyberattacks, often involving the abuse of vulnerable connected devices, such as surveillance cameras, to facilitate malicious activities.



Edge Computing

IoT – Inside the Architecture



Connectivity



Embedded Devices



Sensors / Actuators



Communication
Protocols



Software



Cloud

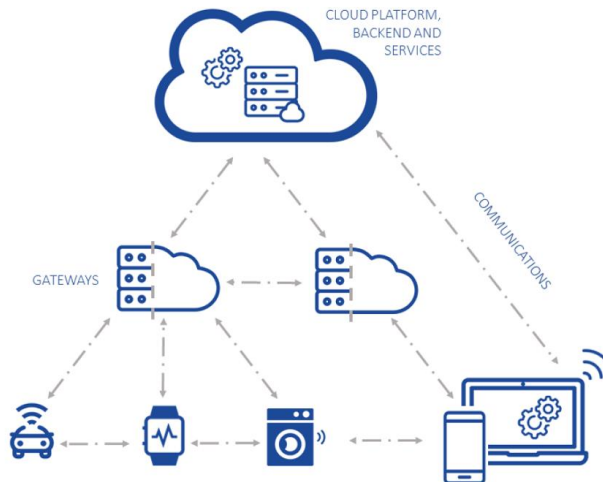
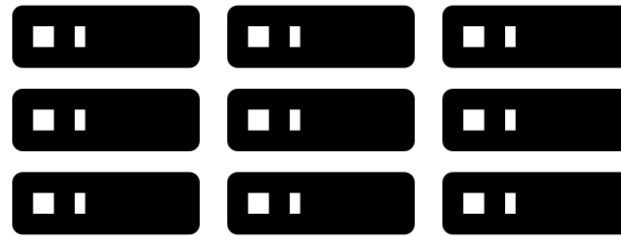


AI

Security

IoT - Cloud

- **Google** Cloud Platform
- **IBM** Watson IoT
- **Amazon** AWS IoT Core
- **Digital Ocean**



- **Microsoft** Azure IoT Suite
- **Oracle** IoT
- **Cisco** IoT Cloud Connected

IoT – Inside the Architecture



Edge Computing



zigbee

Connectivity

MQTT



zigbee

Communication
Protocols



Cloud



AI



Embedded Devices

C++



python

Software



Sensors / Actuators

Security



IoT – Edge Computing





Edge Computing

IoT – Inside the Architecture



Connectivity



Embedded Devices



Sensors / Actuators



Communication
Protocols



Software



Cloud



AI

Security



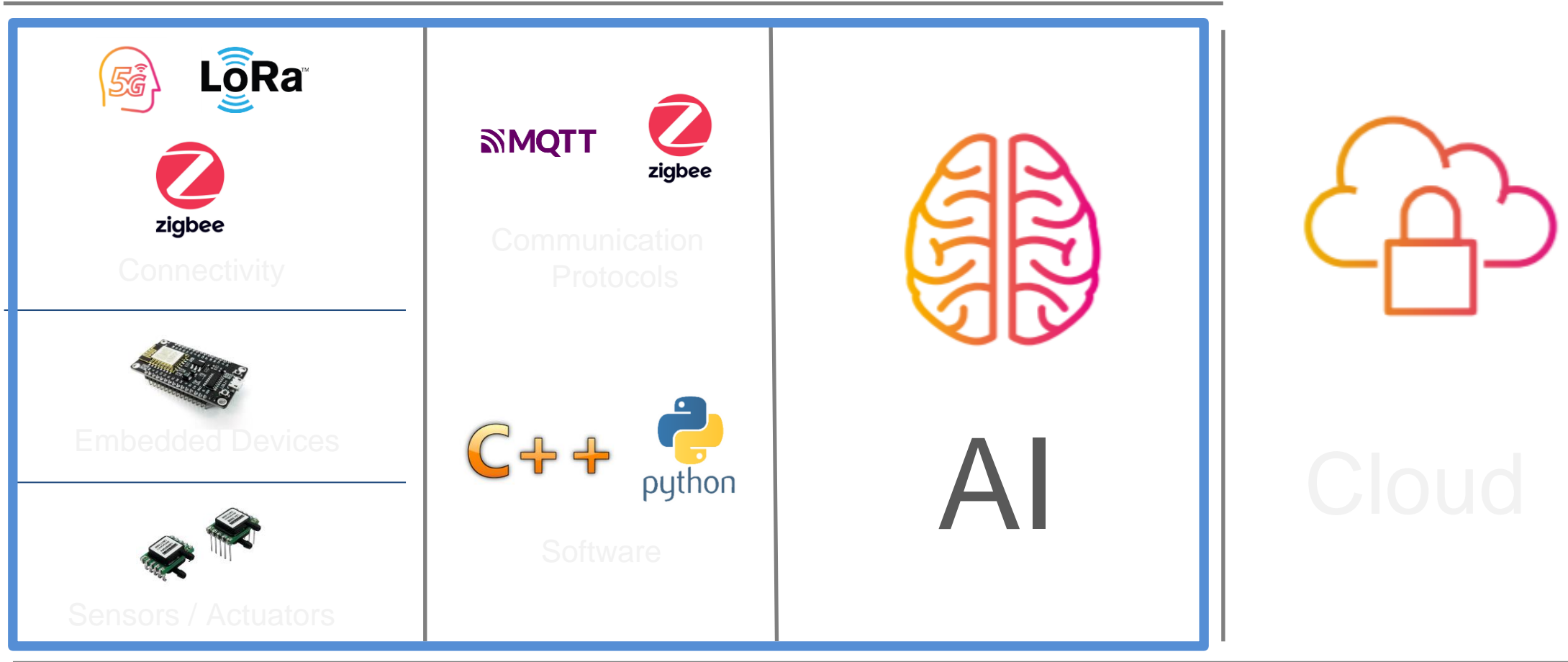
IoT – AI



IoT – Inside the Architecture



Edge Computing



Security



IoT - End to End Solution – Bacab Home

Integrate tinyML

Activities Firefox Web Browser sáb 16:41

Overview - Home Assistant - Mozilla Firefox

Overview - Home Assistant x Groups - Bosques Urbanos x +

192.168.192.202:8123/lovelace/cameras 60%

Bacab Home

Motion

- Hue Outdoor Motion Sensor 01 Clear
- Amcrest Camera 01 Motion Clear
- Application Restricted Zone Notifier Python Clear

Ffmpeg Camera 01 2020-07-11 16:38:32

Amcrest Camera 01

Last Picture Amcrest Camera 01

Last Picture Ffmpeg Camera 01 2020-07-11 16:40:25

T I N Y

The screenshot shows a web browser window displaying the Home Assistant Lovelace interface. The top bar is blue with the "Bacab Home" title and a row of icons for home, light, motion, camera, power, and other functions. The main content area is divided into several panels. On the left, there's a "Motion" panel listing three sensors: "Hue Outdoor Motion Sensor 01", "Amcrest Camera 01 Motion", and "Application Restricted Zone Notifier Python", each with a "Clear" button. Below this is a large video feed labeled "Ffmpeg Camera 01" showing a street scene with a white car. To the right of the motion panel is another video feed labeled "Amcrest Camera 01" showing the same street scene. Below the "Amcrest Camera 01" feed is a smaller thumbnail labeled "Last Picture Amcrest Camera 01". At the bottom left, there's a large "T I N Y" logo with a stylized building graphic. The browser's address bar shows the URL "192.168.192.202:8123/lovelace/cameras" and the page is zoomed to 60%.



IoT – Call to Action

#tinyML #Latam

Edge Computing

Connectivity

Communication
Protocols

Embedded Devices

Software

Sensors / Actuators

Cloud

AI

Security



TinyML / AIoT

Internet of Things + Machine Learning

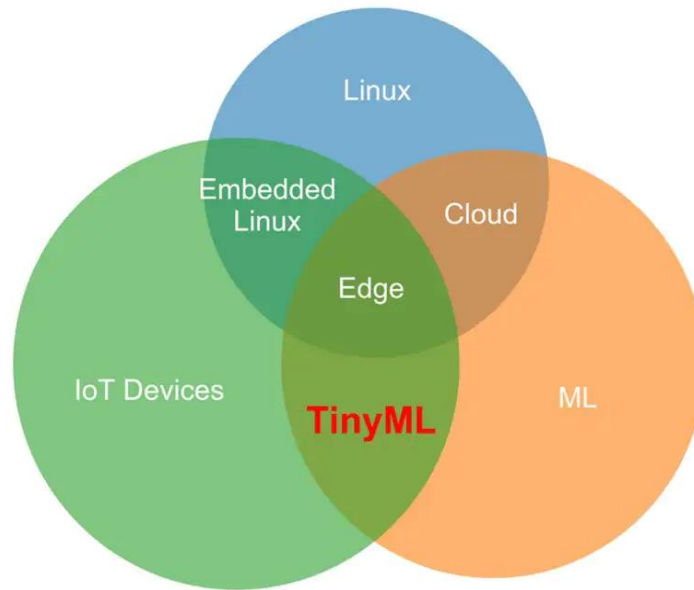


What is TinyML?

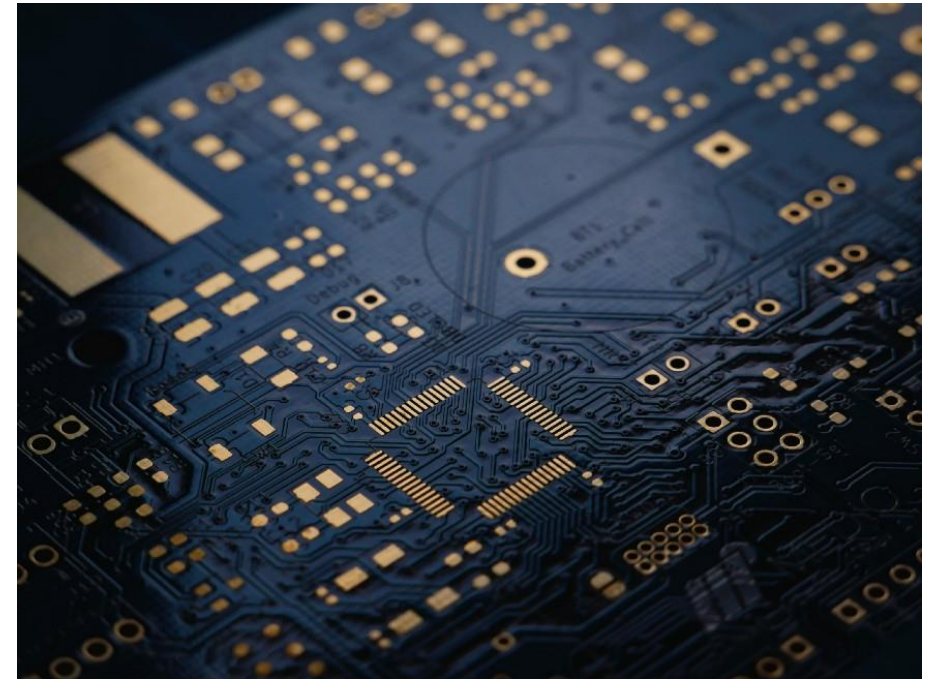
Tiny Machine Learning (or TinyML) is a [machine learning](#) technique that integrates reduced and [optimized machine learning](#) applications that require “**full-stack**” (hardware, system, software, and applications) solutions, including machine learning architectures, techniques, tools, and approaches capable of performing on-device analytics at the very edge of the cloud.

TinyML can be implemented in low energy systems, such as sensors or [microcontrollers](#), to perform automated tasks.

With TinyML, we can do more with less. The technique is still ML, but with less energy, costs, and without an internet connection.



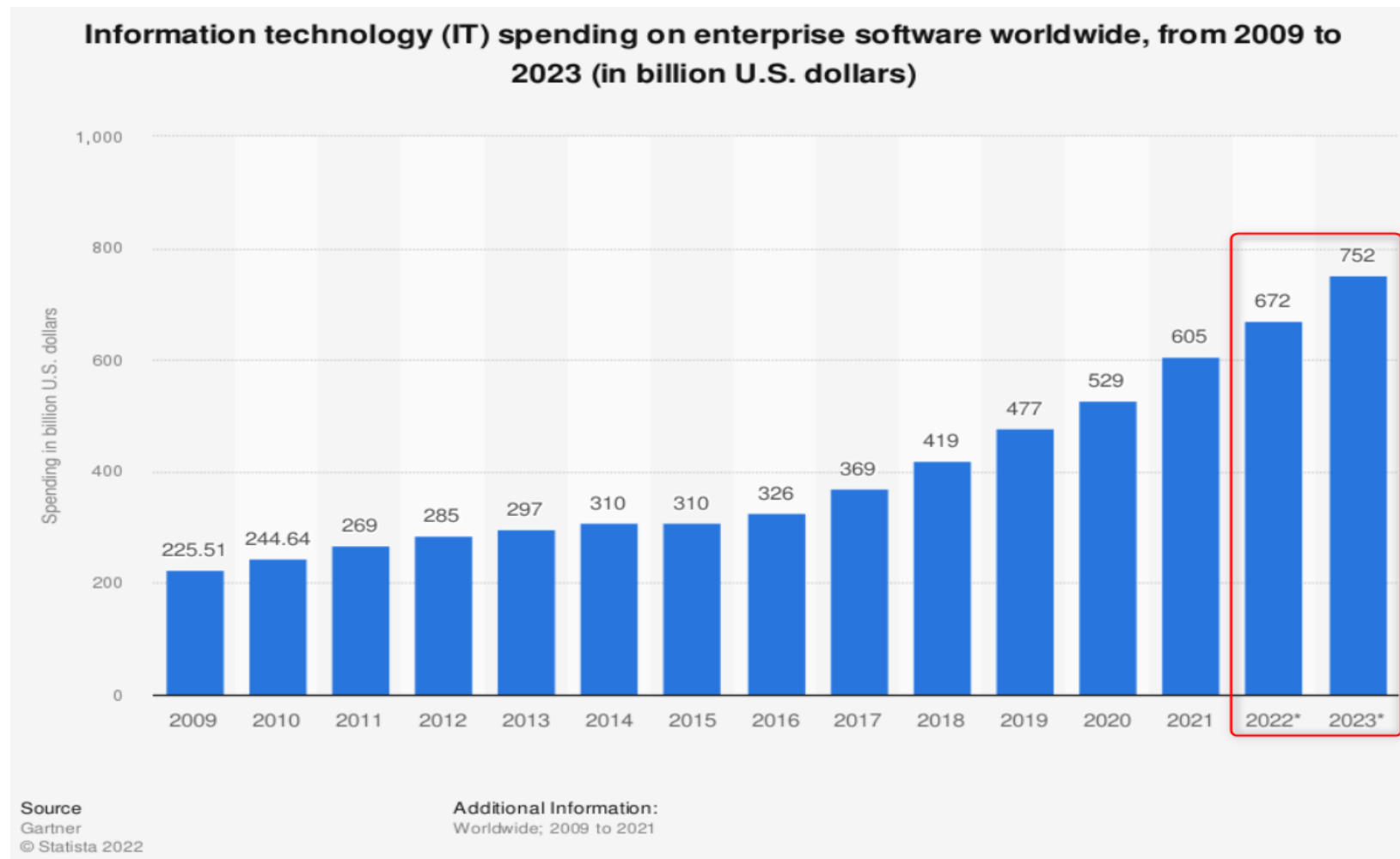
What is TinyML?



TinyML - My Point of View

Supply Chain Visibility – ERP Systems

- **Warehousing** : Opportunities to leverage TinyML in warehousing range from monitoring dock bottlenecks to identifying safety issues in the warehouse.
- **Inventory Management** : While smart edge devices that monitor and flag storage conditions are already being used on shop floors of many warehouses, opportunities to expand usage of TinyML are plenty.
- **Transportation** : Pattern recognition and incident detection are among the capabilities ML algorithms can help build and these can be leveraged in TinyML powered edge devices, can help study traffic patterns to optimize and plan routes based on peak traffic hours.



In 2022, IT spending on enterprise software is expected to amount to around 672 billion U.S. dollars worldwide, a growth of 11 percent from the previous year. Like nearly all sub-segments of the IT services industry, the enterprise software market has experienced high levels of growth in recent years, with market revenues more than doubling in the decade between 2010 and 2020.

Published by Lionel Sujay Vailshery Feb 21, 2022

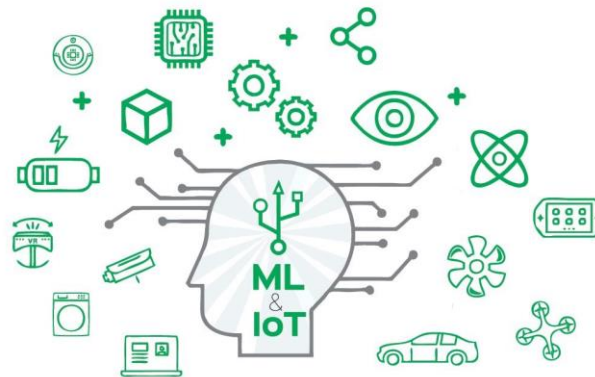
Advantages

Low Latency: Since the model runs on the edge, the data doesn't have to be sent to a server to run inference. This reduces the latency of the output.

Low Power Consumption: As we discussed before, microcontrollers consume very little power. This enables them to run without being charged for a really long time.

Low Bandwidth: As the data doesn't have to be sent to the server constantly, less internet bandwidth is used.

Privacy: Since the model is running on the edge, your data is not stored in any servers.





The future of ML is tiny and Bright.

Thank you



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www.tinyml.org



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