

THAT[®]

CONFERENCE

THANK YOU, THAT CONFERENCE PARTNERS!



CUNA
MUTUAL
GROUP

CORE**BTS**

Unspecified

SOFTWARE CO

Progress®

nvisia
connect. build. enable.

ionic

GrapeCity®

symplr

Google Cloud

TREK

Algorand

twilio



Justin Grammens
Founder + CEO | Lab651

TinyML : Let's Put Some Intelligence Into the Internet of Things!

LAB⁶⁵¹

We make new things possible™

lab651.com
connect@lab651.com

WHAT

WE WILL COVER

- Who am I
- Define IoT, Machine Learning and TinyML
- Discuss Common Use Cases
- Development - Arduino Nano BLE Sense 33
- Edge Impulse - Open Exercises & Hardware Exploration
- Feedback

Who

AM I?

- Founder, Lab651 & Recursive Awesome – Software Staffing & Project Outsourcing for Mobile, Cloud, IoT & Machine Learning
- Co-founder, Captovation – AI powered online presentation coaching platform
- Owner, IoT Weekly News – Publication covering trends in the AIoT
- Host of the “Conversations on Applied AI Podcast”
- Adjunct Professor – Teaching graduate level courses on IoT & ML
- Co-founder, Applied AI – 501(c)(3) non-profit: Monthly meetups & conferences on Artificial Intelligence & Machine Learning



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WHAT

IS IoT?

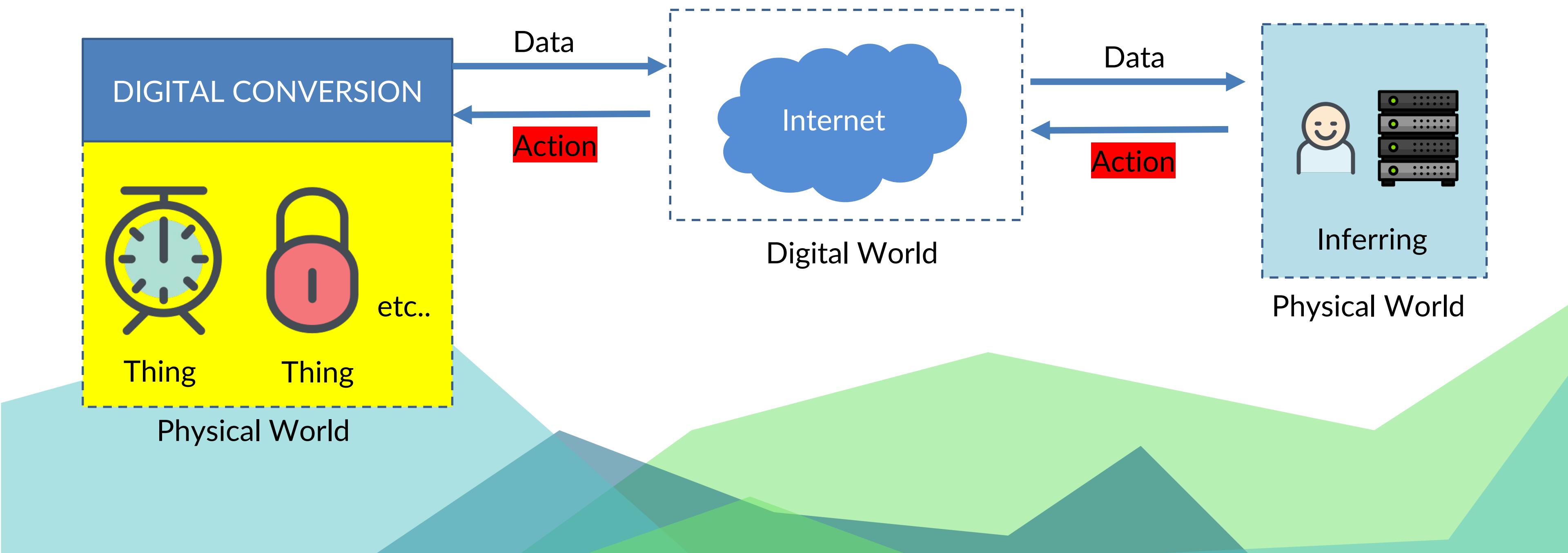
“IoT describes the network of physical objects—a.k.a. “things”—that are embedded with sensors, software, and other technologies for the purpose of connecting and exchanging data with other devices and systems over the Internet.”

Source: Wikipedia

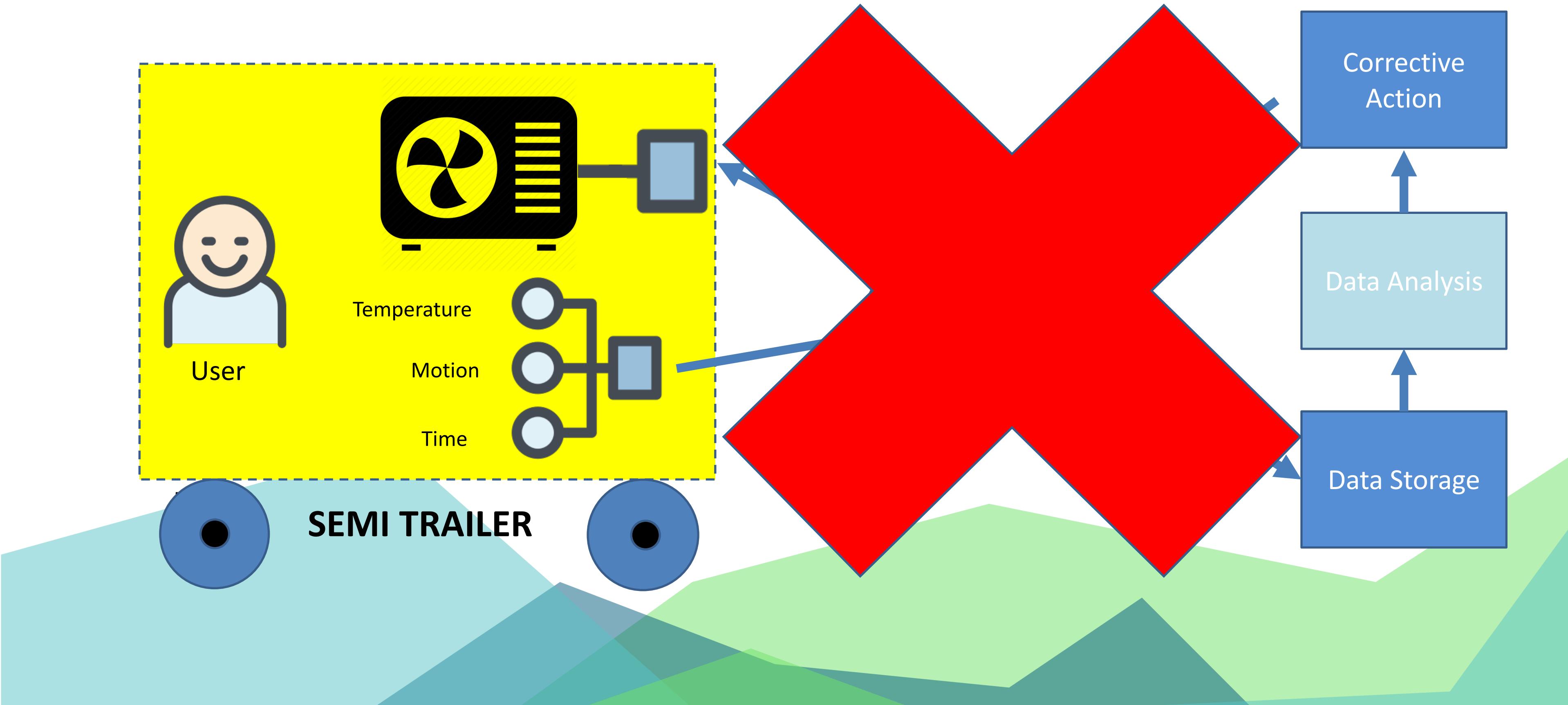
NOTE: The creator of the term (Kevin Ashton) prefers to now call it, “Things on the Internet”

WHAT IS IoT?

"The IoT is a set of technologies that allow **things** to become intelligent by **sensing**, **inferring** and **acting** to control the physical world using the **Internet**."



ENVIRONMENTAL CONTROL EXAMPLE





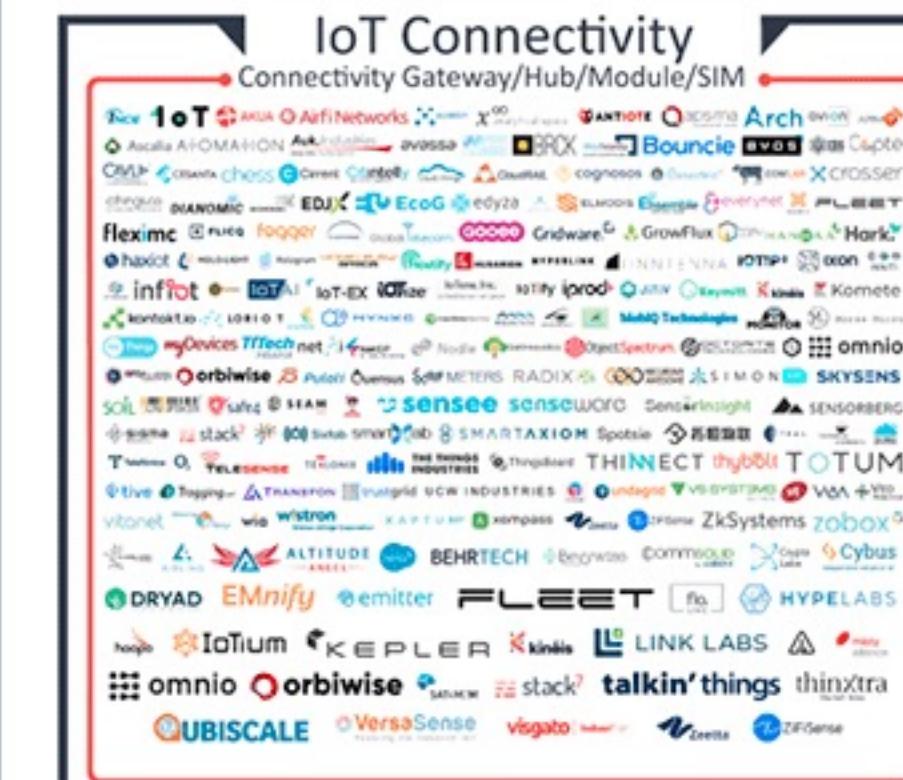
June 2021

IoT Startup Landscape 2021 – 1,200+ companies

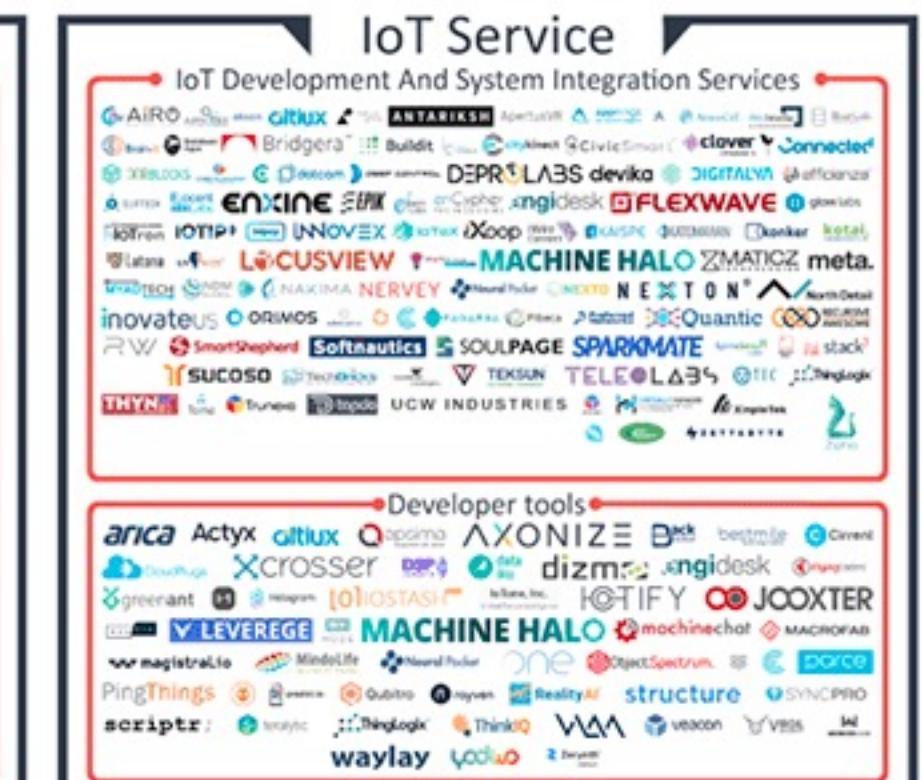
IoT Software



The image displays a grid of logos for numerous companies, categorized into two main sections: IoT Security and Database. The IoT Security section on the left includes logos for ArduCCTV, Airtivity, ANOKA, ARDEXA, Bantime, bluechip, CarX, CRYPTOME, CYDOME, DATAOS, DeCheck, Everdulf, FIREDOME, FirstPoint, Force, held, IANcore, GABC, HYPERLINK, IOTIP, WIFITIME, BOLT, IoTAJ, IoTDefense, IoTium, IXDen, JENBO, Lauretta, LOCH, MagicCube, magistralia, MobIQ Technologies, Momentum 2, Tiftech, NARIO, NIAGARA, openpath, PILOT SECURITY, Privafy, pipe, qbound, Qumranis, roping, SCLAK, scurid, SECURE, SECUREHOME, STERNUM, THINNECT, TOTBOT, SMARTAXION, STERNUM, ASTRALIA, VIVI, VIVIETTE, Video, VIVI, vitonet, WAKED, wility, wility, wility, wility, wility, wility, zymbit.



IoT Hardware

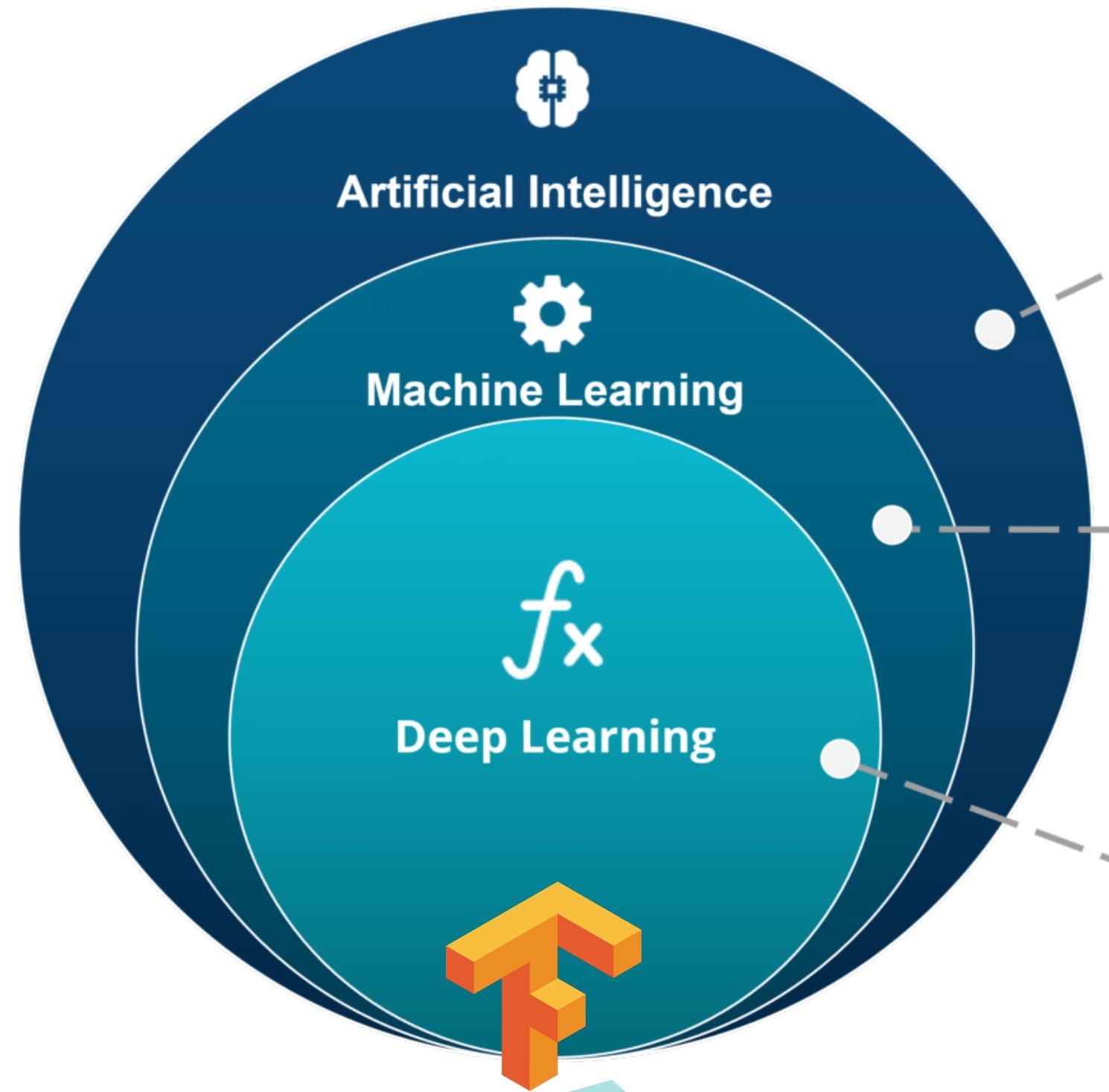


WHAT

IS MACHINE LEARNING?

Machine learning (ML) is a field of inquiry devoted to understanding and building methods that 'learn', that is, methods that leverage data to improve performance on some set of tasks.

Source: Wikipedia



ARTIFICIAL INTELLIGENCE

A technique which enables machines to mimic human behaviour

MACHINE LEARNING

Subset of AI technique which use statistical methods to enable machines to improve with experience

DEEP LEARNING

Subset of ML which make the computation of multi-layer neural network feasible

Source: Edureka.co



Activity Recognition



```
if(speed<4){  
    status=WALKING;  
}
```

```
if(speed<4){  
    status=WALKING;  
} else {  
    status=RUNNING;  
}
```

```
if(speed<4){  
    status=WALKING;  
} else if(speed<12){  
    status=RUNNING;  
} else {  
    status=BIKING;  
}
```

// Oh crap

Activity Recognition



0101001010100101010
1001010101001011101
0100101010010101001
0101001010100101010

Label = WALKING



1010100101001010101
0101010010010010001
0010011111010101111
1010100100111101011

Label = RUNNING



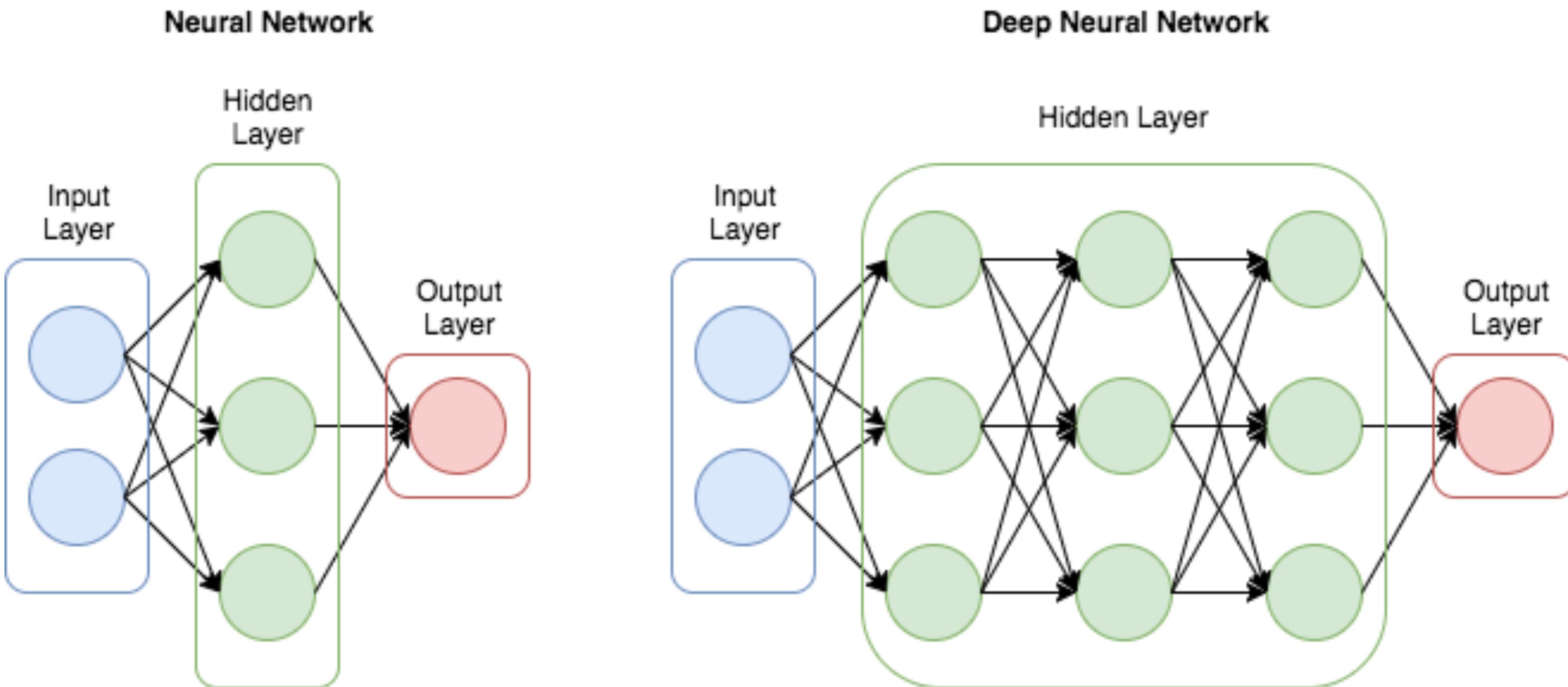
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1101010111010101110
1010101111010101011
1111110001111010101

Label = BIKING



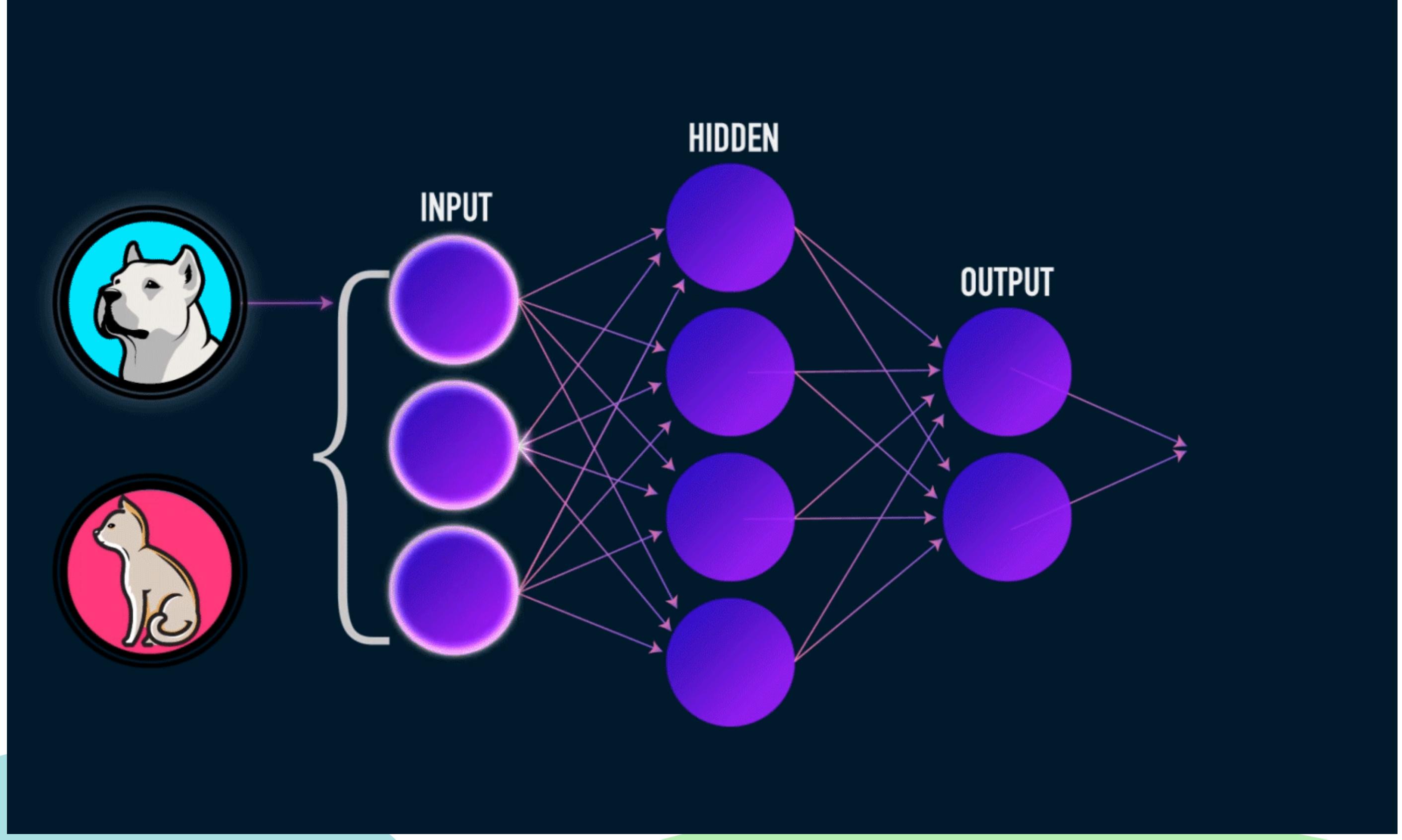
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0101110101010101110
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Label = GOLFING

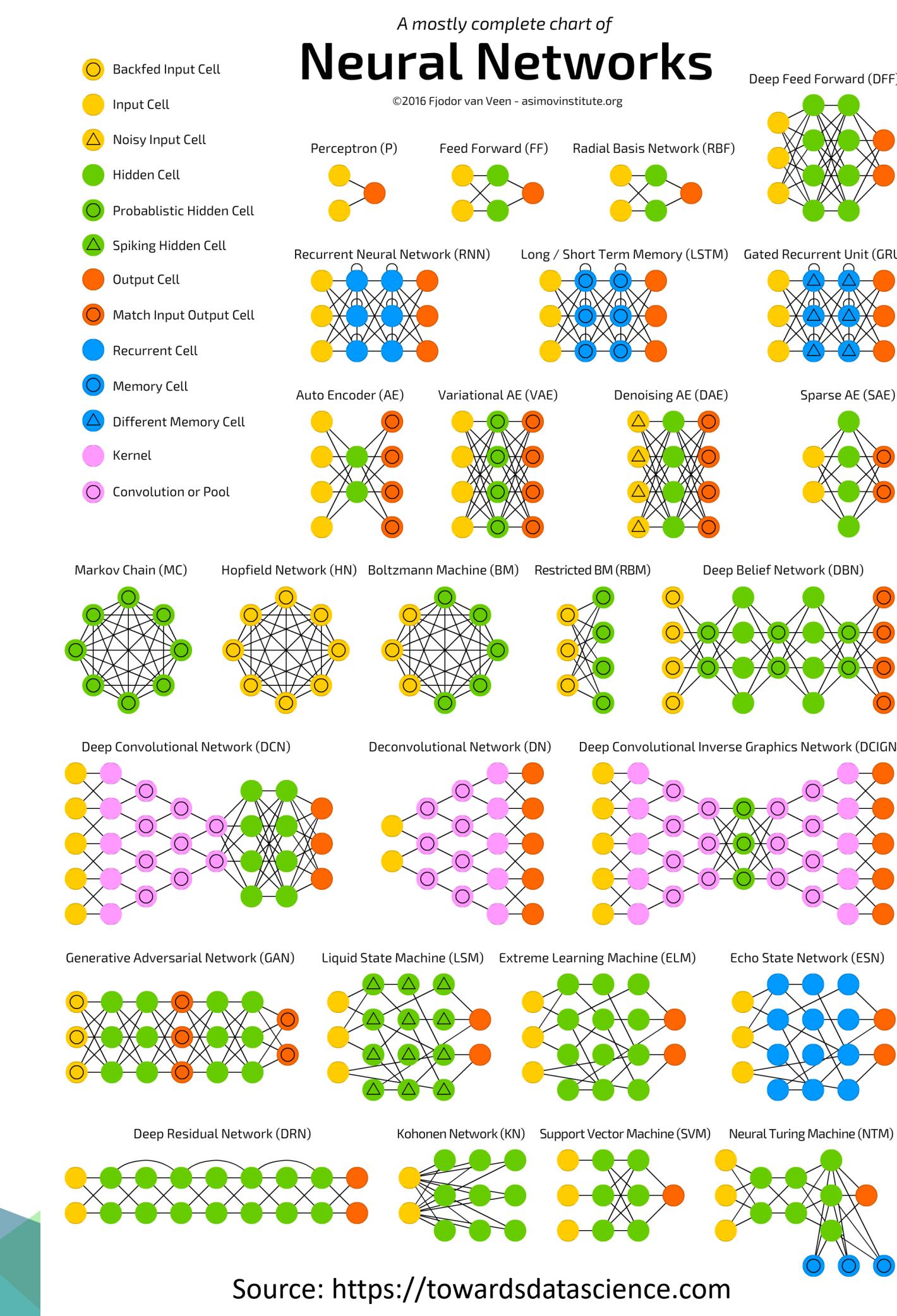


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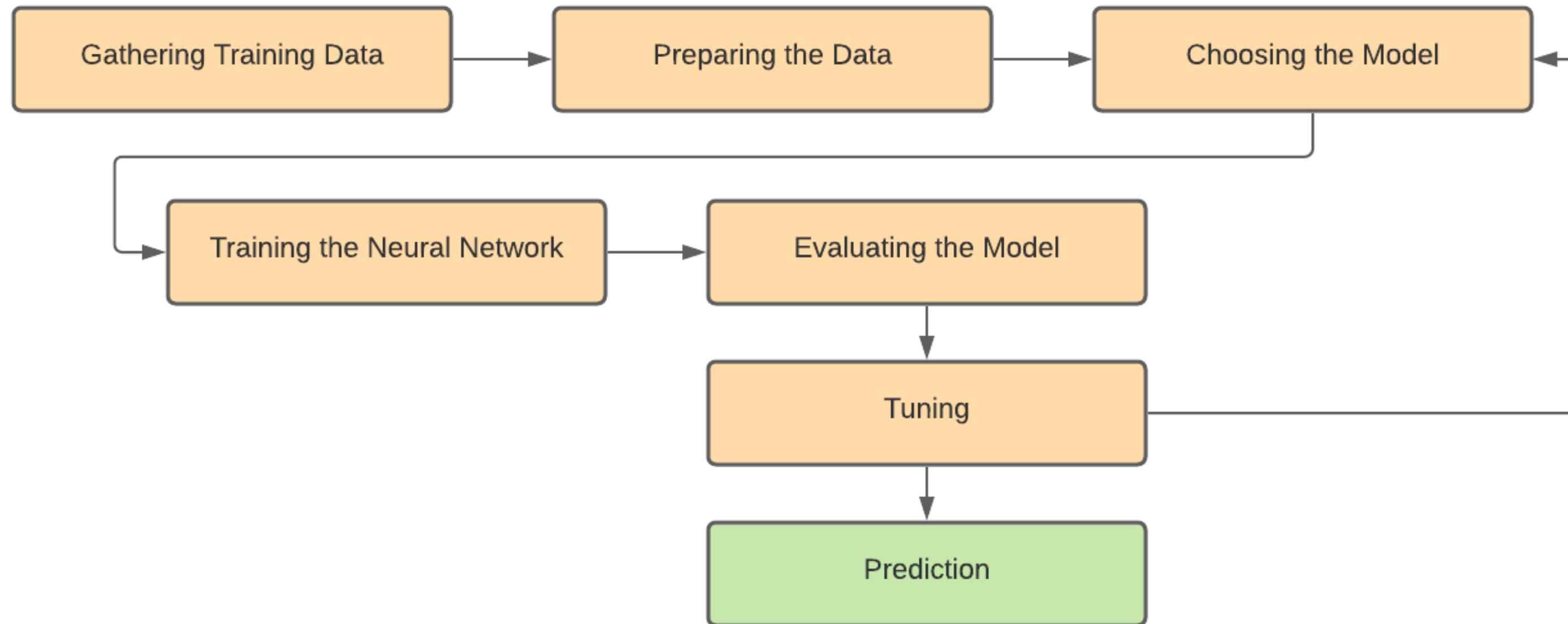
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It's a wild and
crazy world out
there....



Machine Learning Steps



WHAT

IS TinyML?

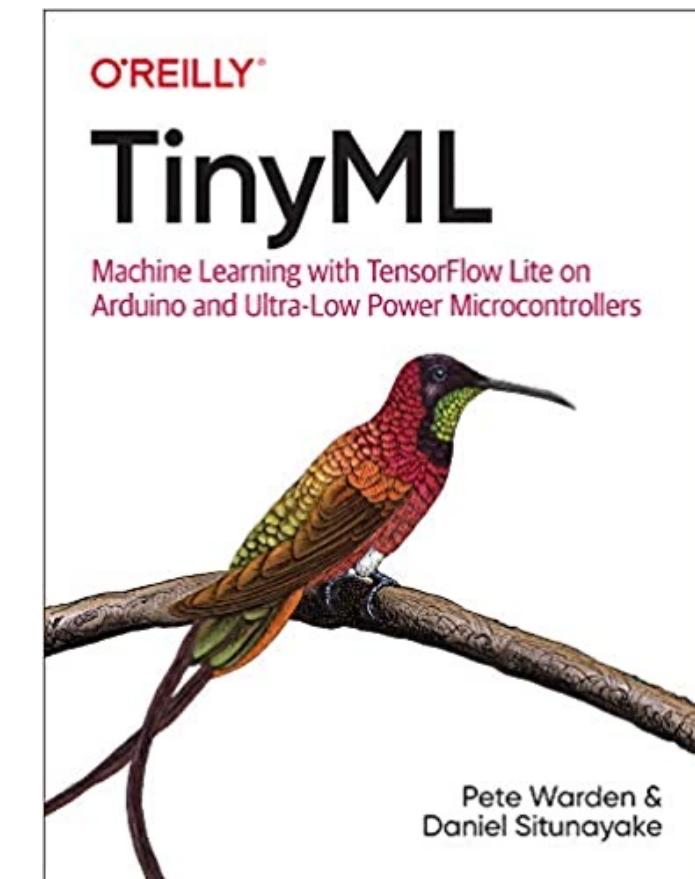
Tiny Machine Learning (TinyML) is broadly defined as applications including hardware, algorithms and software capable of performing on-device sensor data analytics at extremely low power, typically in the mW range and below, and hence enabling a variety of always-on use-cases and targeting battery operated devices.

Source: [TinyML.org](https://tinyml.org)

WHERE

DID IT COME FROM?

- Term coined by Pete Warden, TensorFlow Lite Engineering Lead at Google
- Pete & Daniel published a book on TinyML
- TinyML Foundation
 - Non-profit professional organization
 - Summits, Symposiums & Meetups



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HOW

IS IT DIFFERENT?

- Standard consumer CPUs consume 65 watts - 85 watts
- Standard consumer GPU consumes 200 watts- 500 watts
- A typical microcontroller consumes power in the order of milliwatts ($1/1,000$ W) or microwatts ($1/1,000,000$ W)
- Enables the TinyML devices to run unplugged on batteries for weeks, months, and in some cases, even years, while running ML applications on edge.

HOW

IS IT DIFFERENT?

- Low Footprint (small models)
- Low Power (< 1mW power)
- Low Latency (local inference)
- Low Bandwidth (internet not required)
- Privacy (no data being sent over the Internet)
- Low cost (32-bit microcontrollers < 50 cents)

USE CASE CATEGORIES FOR Ti nyML



Transportation



Healthcare



Agriculture



Security



Retail



Preventative
Maintenance

TinyML APPLICATIONS

Agriculture

TinyML can be used to detect diseases and pests in plants. As TinyML operates independently of an internet connection, it can perfectly implement automation and IoT in agricultural farms.



Healthcare

TinyML is already in use for the early detection of mosquito-borne diseases. It can also be used in fitness devices and healthcare equipment such as smart hearing aids



<https://www.azooptics.com/News.aspx?newsID=24900>

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TinyML APPLICATIONS

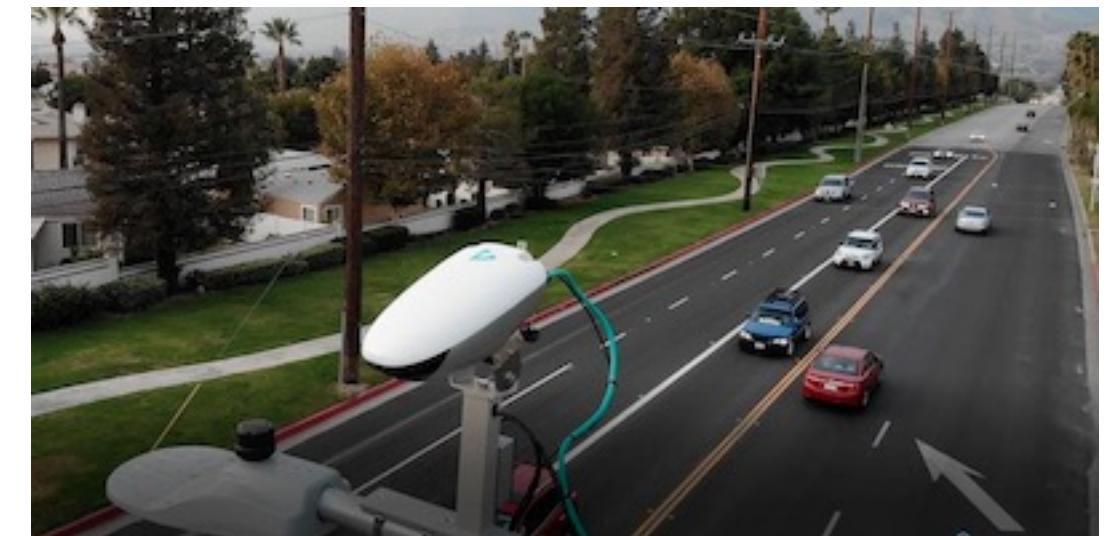
Retail

A TinyML application can track items on store shelves and send an alert before they get out of stock with AI-enabled cameras. It can also aid in deriving inferences about customer preferences in the retail sector.



Transportation

TinyML applications can be used to monitor traffic and detect traffic jams. Cities are integrating this data with traffic light management to optimize traffic in real-time. It can also be used for accident detection to make automatic alerts to the nearest trauma center.



TinyML APPLICATIONS

Law Enforcement

TinyML can be used to detect unlawful activities like riots and theft using machine learning and gesture recognition. A similar application can also be used for bank ATMs' security. A TinyML model can predict whether the user is a genuine customer making a transaction or an intruder trying to hack or break the ATM by monitoring user activity.



Ocean Life and Rainforest Conservation

TinyML applications are already in use for real-time monitoring of whales in the waterways of Vancouver and Seattle to avoid whales striking busy water lanes. Similar applications can monitor poaching, illegal mining, and deforestation. TinyML devices can also be deployed to monitor the well-being of coral reefs.



<https://blog.google/intl/en-ca/company-news/technology/ai-protecting-our-endangered-orca/>

BUSINESS APPLICATIONS

EATON

LifeSense system monitors and detects impending hydraulic hose failure and alerts operators and maintenance crews so they can schedule maintenance and plan downtime. Sells a proactive service, not just a hose.



USE CASE TYPES

- Preventative Maintenance

BENEFITS

- Predict and replace the hose before a failure*
- Avoids downtime
- Avoids environmental mess of hydraulic fluid
- Avoids injury to employees

BUSINESS APPLICATIONS

RADIA

Smart industrial grade paint mixer – installs at Lowe's and Home Depot.
Tracks vibration, voltage, error codes and intelligence, machine can shutdown or send a request for support.

USE CASE TYPES

- Preventative Maintenance

BENEFITS

- More efficient service calls (parts)
- Spot issues from runtime data before they occur*



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BUSINESS APPLICATIONS

XIRGOCAM

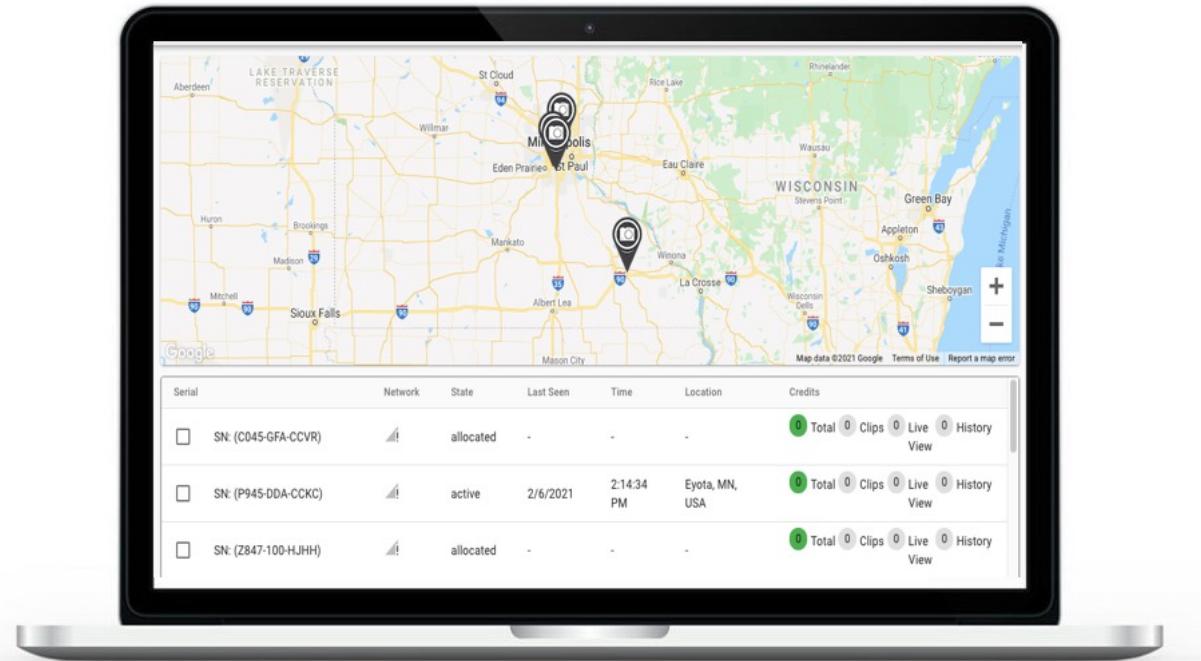
Intelligent Dashcam for drivers and fleet management. Track location, vehicle performance, risky driving and driver alertness.

USE CASE TYPES

- Asset Tracking
- Compliance
- Preventative Maintenance

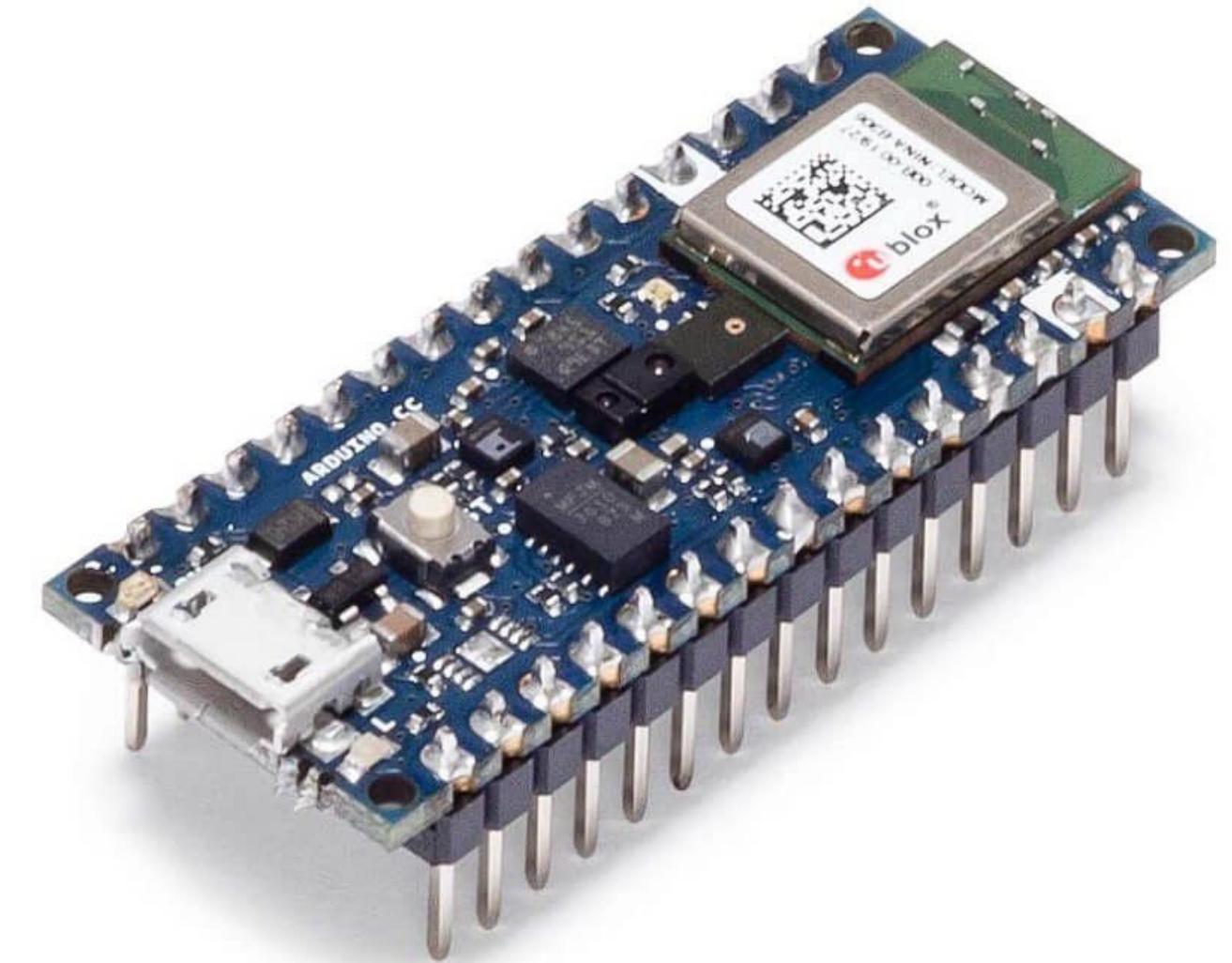
BENEFITS

- Alerts when drivers are distracted or drowsy*
- Remote video capture & security
- Engine performance & maintenance records



DEVELOPMENT HARDWARE

- nRF52840 - 64MHz
- 256 KB SRAM, 1MB flash
- Bluetooth Low Energy support
- 3D accelerometer, gyroscope and magnetometer
- Omnidirectional microphone
- Proximity & gesture detection
- Temperature & humidity detection



<https://docs.arduino.cc/hardware/nano-33-ble-sense>

TINYML

Workshop

- Let's jump into the workshop!
 - Source Code: <https://bit.ly/THAT-TinyML>
- Part 1: Local Development
 - Arduino Nano 33 BLE Sense
- Part 2: Edge Impulse
 - Arduino Nano 33 BLE Sense
 - Smartphone

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HOW TO GIVE ME FEEDBACK



Scan with your camera or QR code reader app

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HOW TO REACH ME

Justin Grammens
Founder + CEO | Lab651
justin@lab651.com



Meetup & Podcast - AppliedAI.MN
Newsletter: IoTWeeklyNews.com

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DAILY



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SEE YOU NEXT YEAR! JULY 2023

CALL FOR SPEAKERS STARTS JANUARY 1, 2023