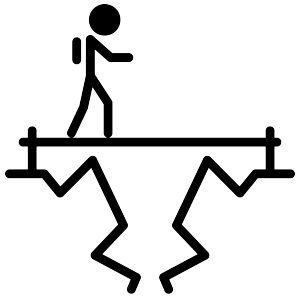
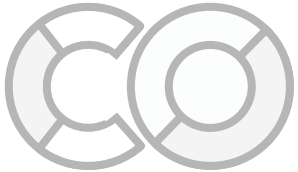
Keyword Spotting Challenges/Constraints

What are we going to learn?



Challenges with Keyword Spotting

The Keyword Spotting ML **Pipeline**



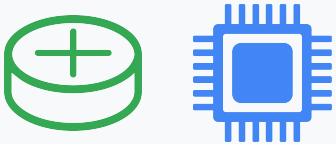
Hands-on training of a Keyword Spotting Model

Challenges and Constraints

Latency & Bandwidth

Accuracy & Personalization

Security & Privacy



Battery & Memory

Challenges and **Constraints**

Latency & Bandwidth

Accuracy & Personalization

Security & Privacy

Battery & Memory

LATENCY

Provide results quickly, respond in real-time to the user

Challenges and **Constraints**

Latency & Bandwidth

Accuracy & Personalization

Security & Privacy

Battery & Memory

BANDWIDTH

Minimize data sent over the network (slow and expensive)

Challenges and **Constraints**

Latency & Bandwidth

Accuracy & Personalization

Security & Privacy

Battery & Memory

ACCURACY

Listen continuously, but only trigger at the right time

Challenges and **Constraints**

Latency & Bandwidth

Accuracy & Personalization

Security & Privacy

Battery & Memory

PERSONALIZATION

Trigger for the user and **not** for background noise

Challenges and **Constraints**

Latency & Bandwidth

Accuracy & Personalization

Security & Privacy

Battery & Memory

SECURITY

Safeguarding the data that is being sent to the cloud

Challenges and **Constraints**

Latency & Bandwidth

Accuracy & Personalization

Security & Privacy

Battery & Memory

PRIVACY

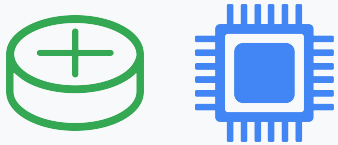
Safeguarding the data that is being sent to the cloud

Challenges and **Constraints**

Latency & Bandwidth

Accuracy & Personalization

Security & Privacy



Battery & Memory

BATTERY

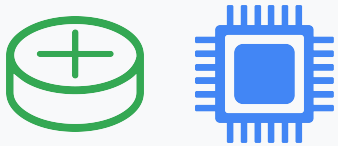
Limited energy, operate on coin-cell type batteries

Challenges and **Constraints**

Latency & Bandwidth

Accuracy & Personalization

Security & Privacy



Battery & Memory

MEMORY

Run on resource constrained devices

Challenges and **Constraints**

Latency & Bandwidth

Accuracy & Personalization

Security & Privacy

Battery & Memory

+ MORE

further constraints

Challenges and **Constraints**

Latency & Bandwidth

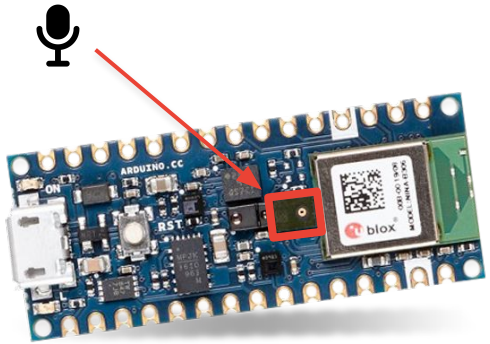
Accuracy & Personalization

Security & Privacy

Battery & Memory

So **how** do companies do ***Keyword Spotting*** today?

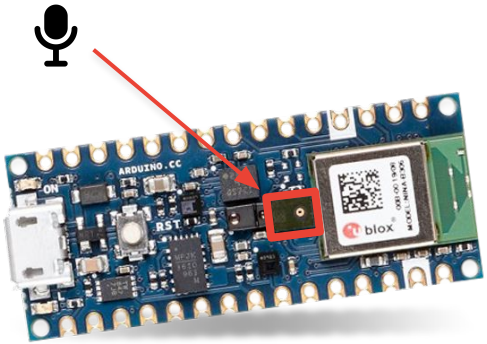
Anatomy of a Keyword Spotting Application

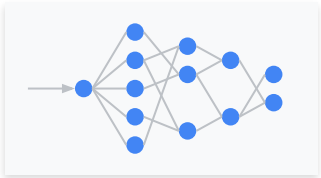


1 Continuously listen on the microcontroller

Anatomy of a Keyword Spotting Application

2 Process the data with **TinyML** at the edge





1 Continuously listen on the microcontroller

Anatomy of a Keyword Spotting Application

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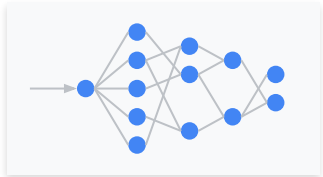
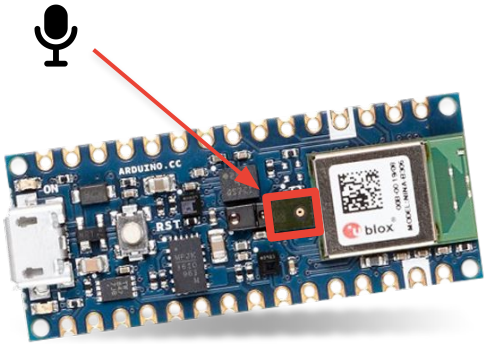


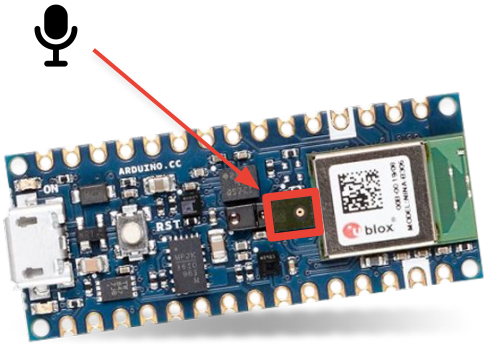


3 Send the data to the cloud when triggered

1 Continuously listen on the microcontroller

Anatomy of a Keyword Spotting Application

1 Continuously listen on the microcontroller



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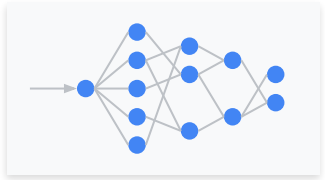
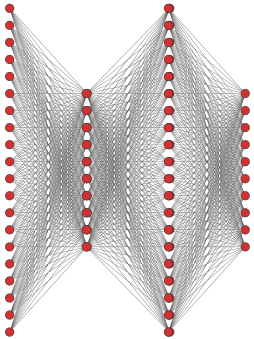
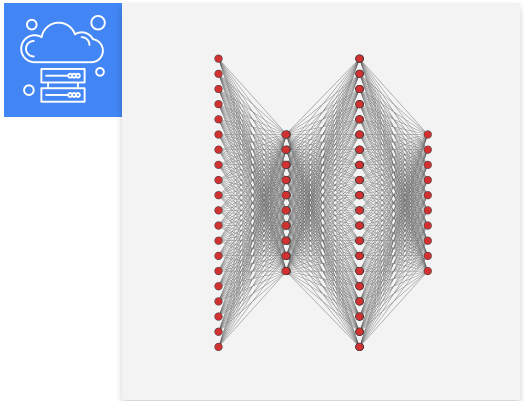


3 Send the data to the cloud when triggered

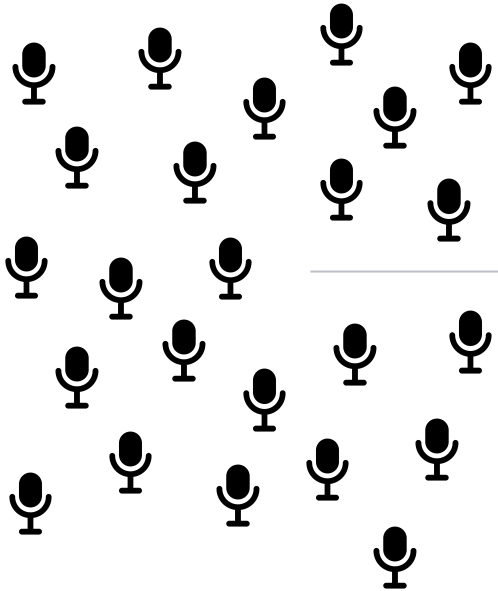
4 Process the full speech data with a large model in the cloud

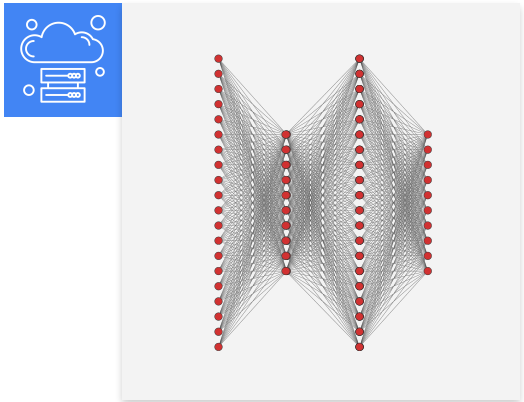


Anatomy of a Keyword Spotting Application

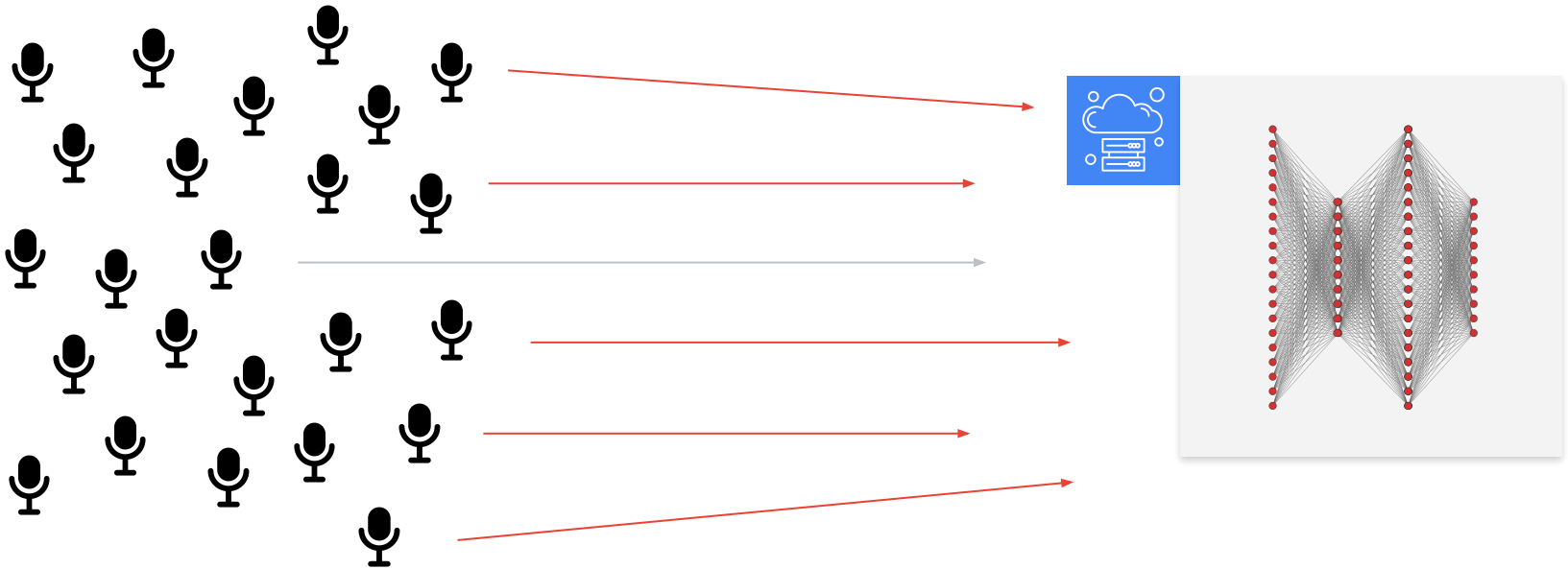


Anatomy of a Keyword Spotting Application





Anatomy of a Keyword Spotting Application



How do we scale to **billions** of users?

Source: Google

Cloud TPU

Source: Google

300 Watts

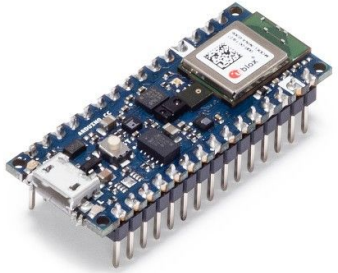
Source: Google

300 Watts

Cloud TPU

< 1 mWatt

TinyML



Anatomy of a Keyword Spotting Application