Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

ALMA MATER STUDIORUM
UNIVERSITÀ DI BOLOGNA

# *The scary relationship between AI and Energy (footprint)*

Luca Benini

PULP
Parallel Ultra Low Power

erc
European Research Council

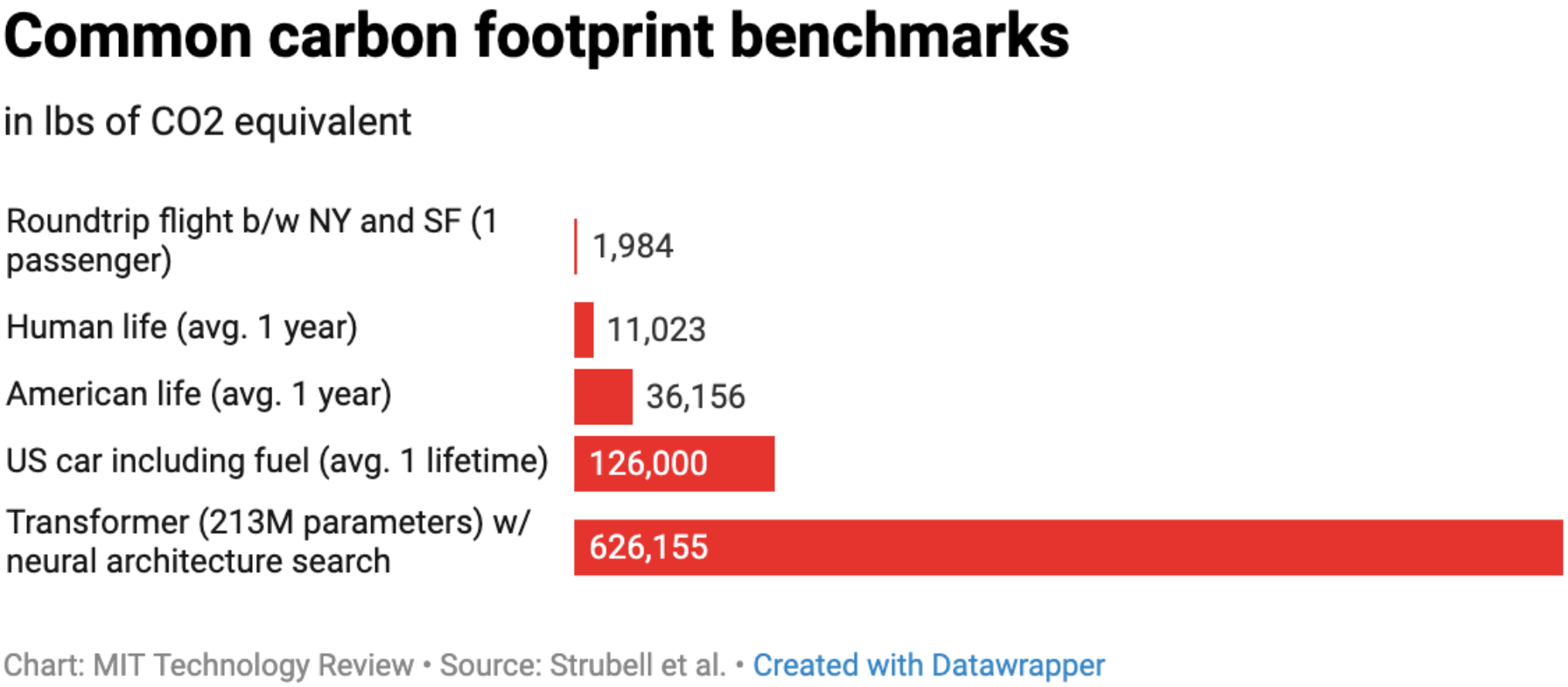
European Commission
Horizon 2020
European Union funding
for Research & Innovation

nano-tera.ch

FNSNF
Fonds national suisse
Schweizerischer Nationalfonds
Fondo nazionale svizzero
Swiss National Science Foundation

# Deep Learning Sustainability?

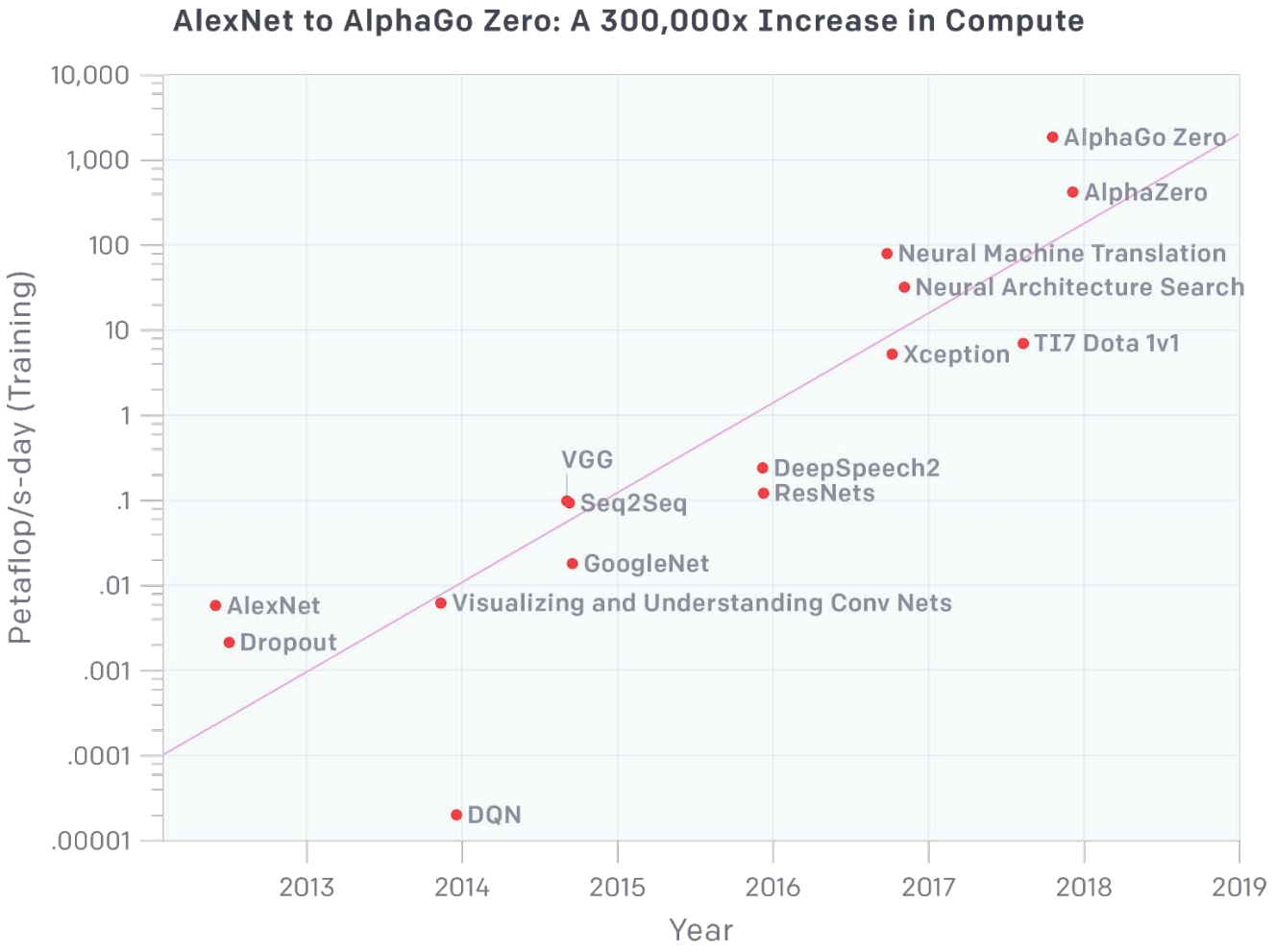





Model training is probably not a significant source of carbon emissions today, **but it is increasing exponentially**

# Exponential Problem





# What can we do about it?

Network Architecture

Specialized hardware

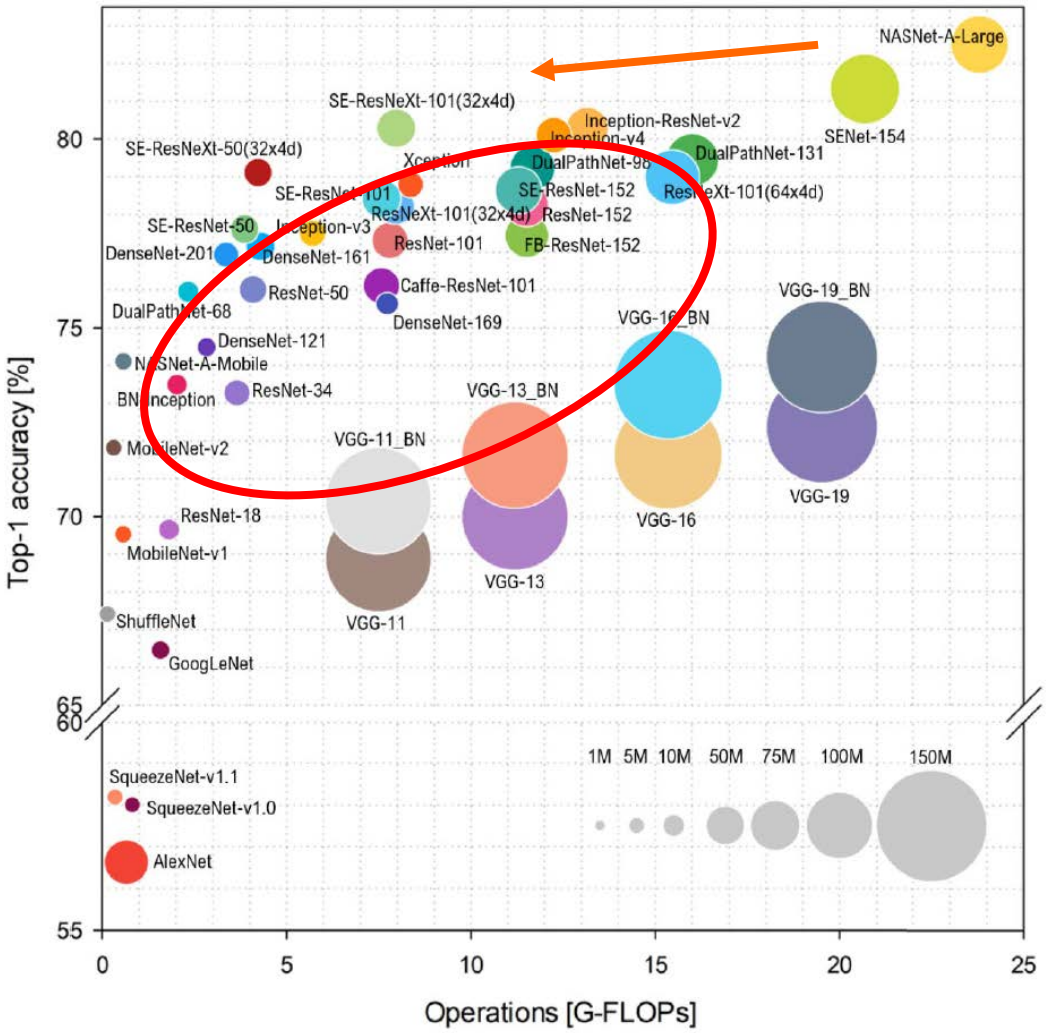
Transprecision HW+SW

Edge AI

…Neuromorphic??

# Network Architecure





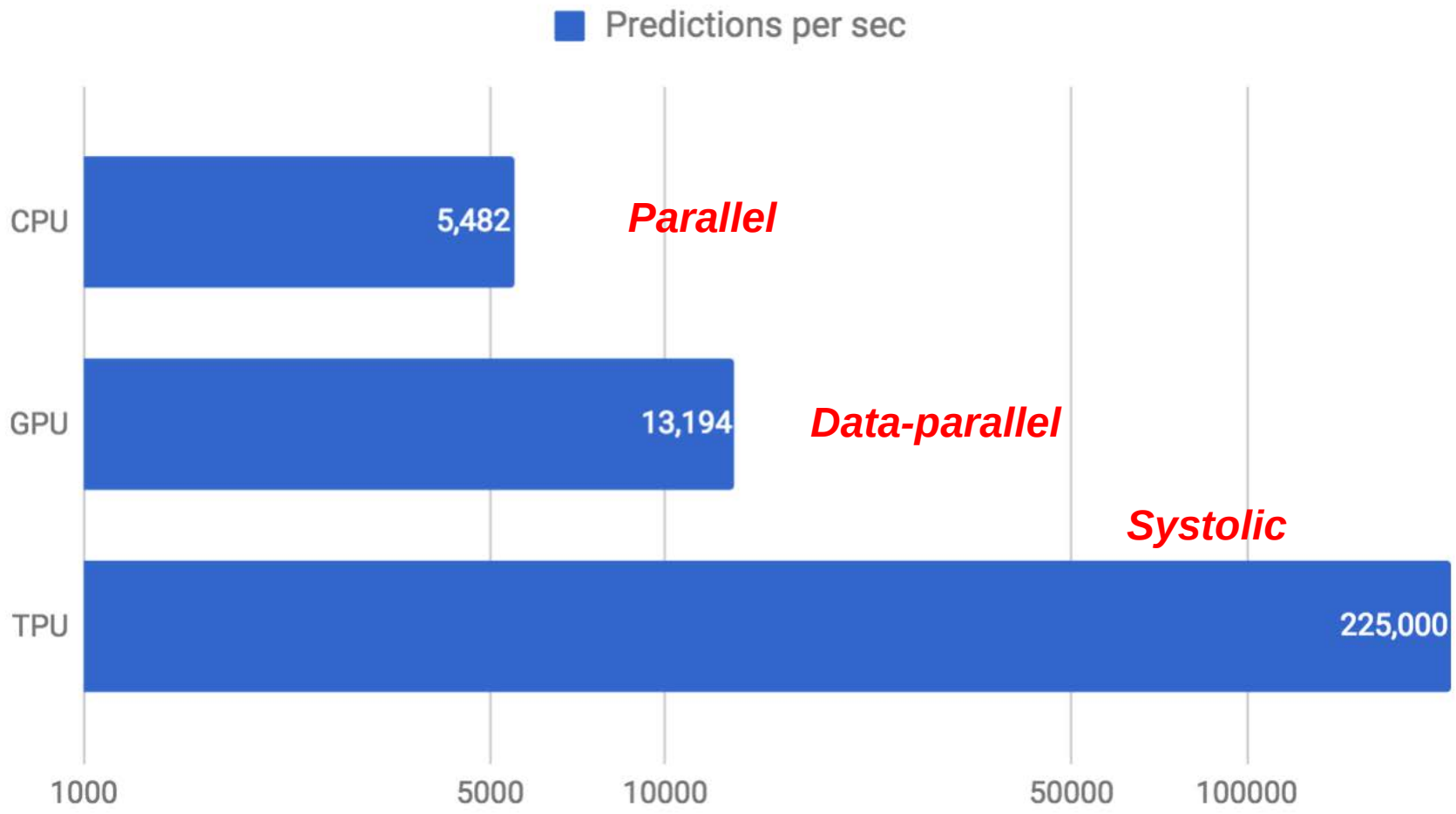

**Flat Pareto frontier @ high accuracy**

**Many non-Pareto points (SOA is still evolving very rapidly**

MLbench ISCA20

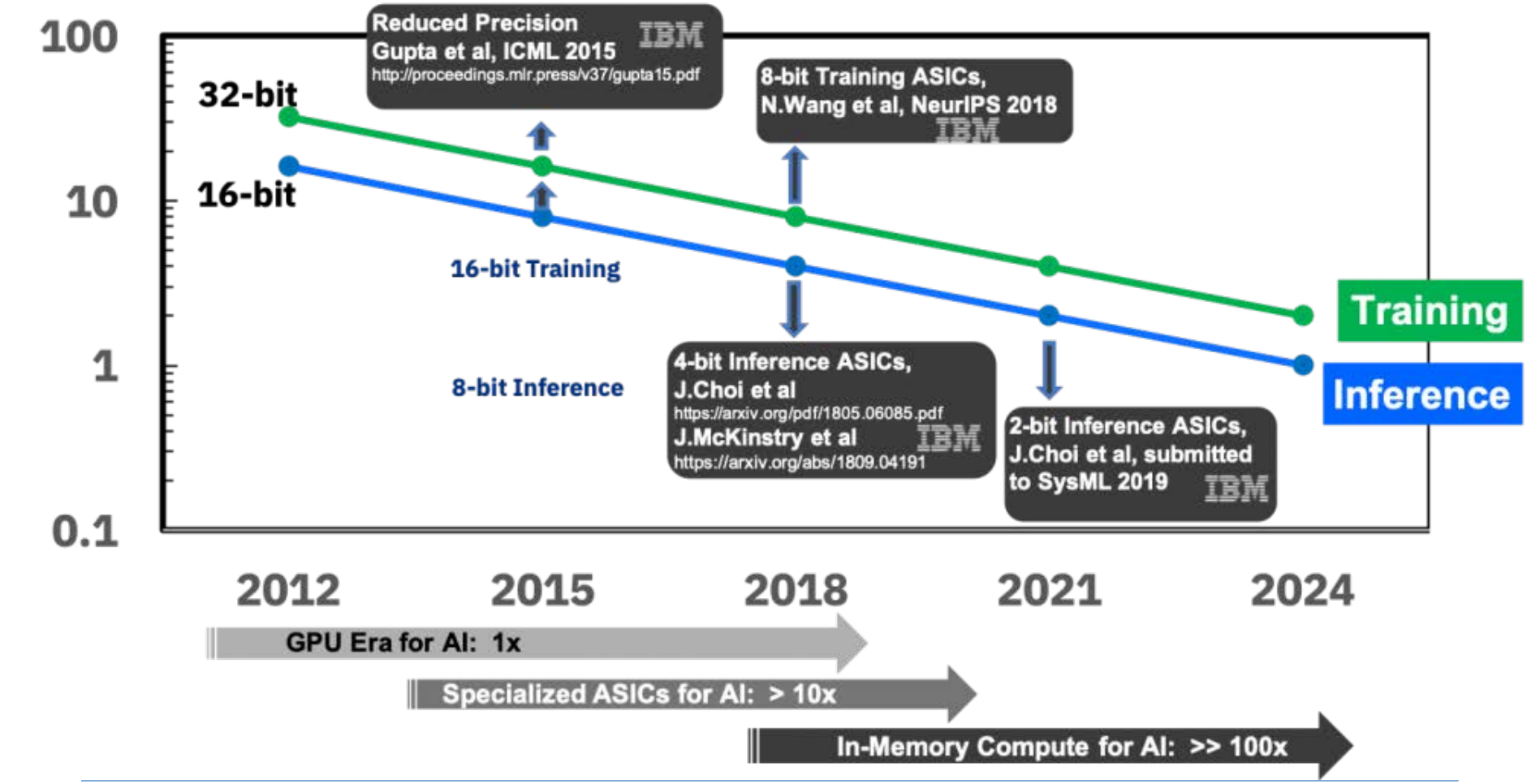
# Specialized Hardware





# Transprecision HW+SW



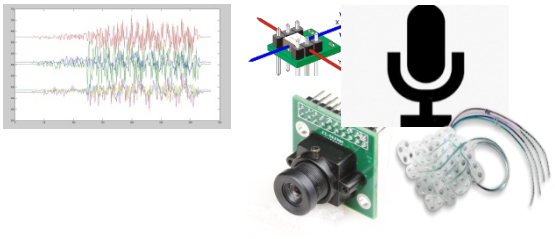


# Edge AI!



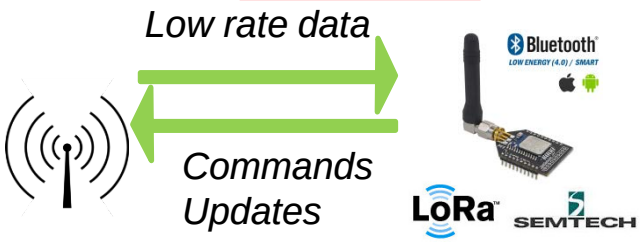
**Sense**

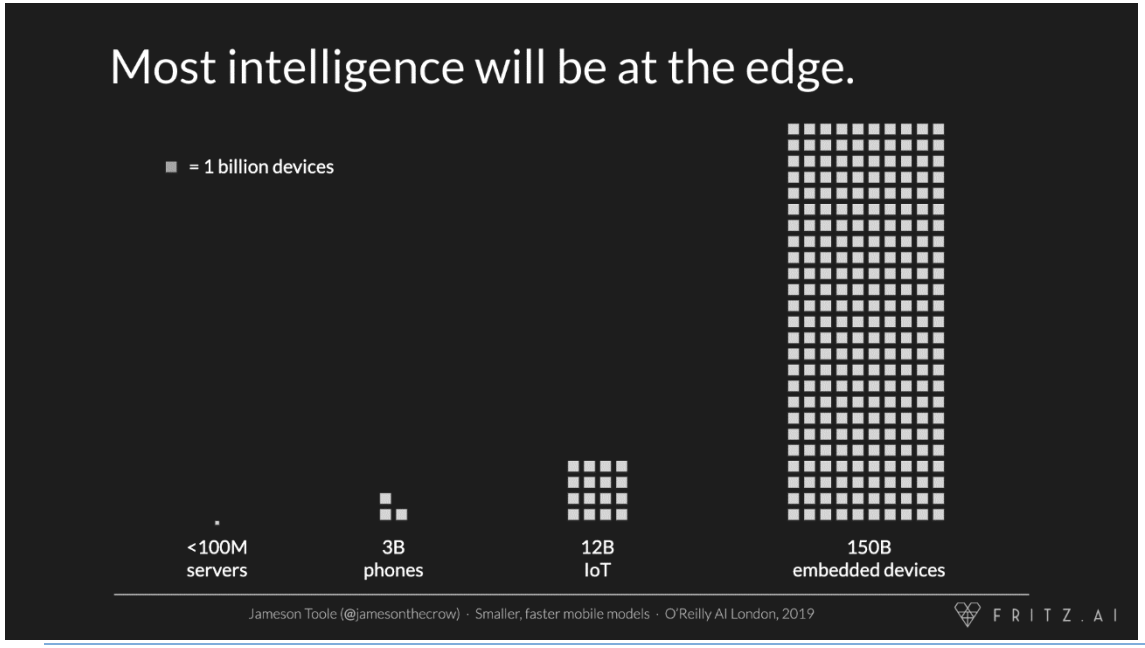
IMU, MIC, ImG, ExG



**Analyze and Classify**


**Transmit**

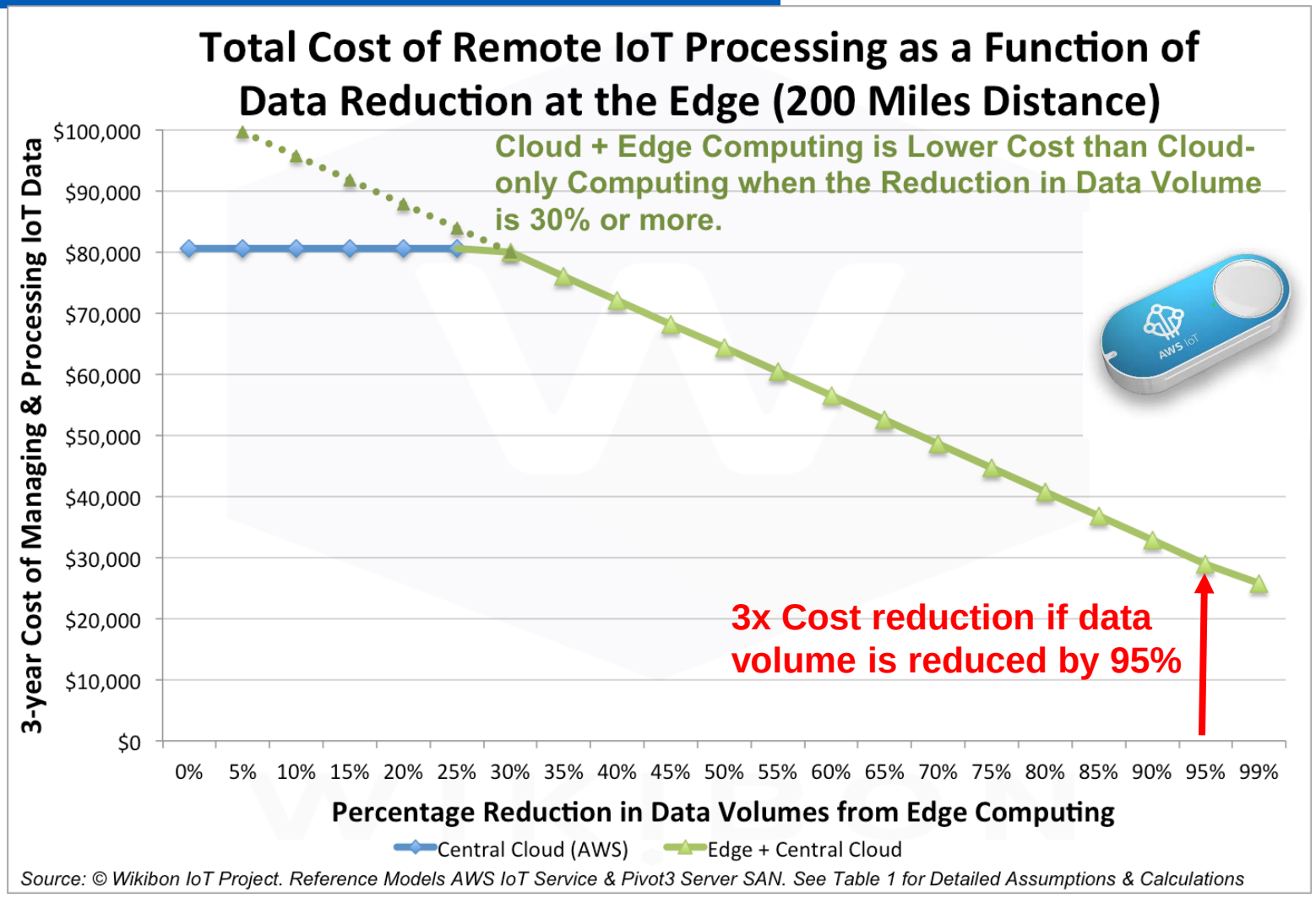




# Does it Matter?





# Neuromorphic?



Our neurons are super slow and not MAC-based…

We do not learn by backpropagation…

We do not need millions of examples…

**But today's neuromorphic approaches are vastly inferior to DL in terms of quality (and efficiency)**