Algorithmic Intuition

AI at the Edge: Bringing Intelligence to Small Devices at the Network Edge

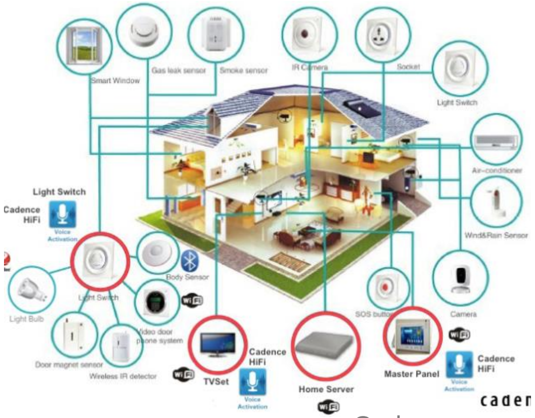
Kevin A. Shaw, Ph.D.
Chief Technology Officer / Cofounder

Intuition for Sensors

Technology Revolution: The Drive for Ubiquity

First Wave: Resources shared by many.

Second Wave: One-to-one.



Cadence.com

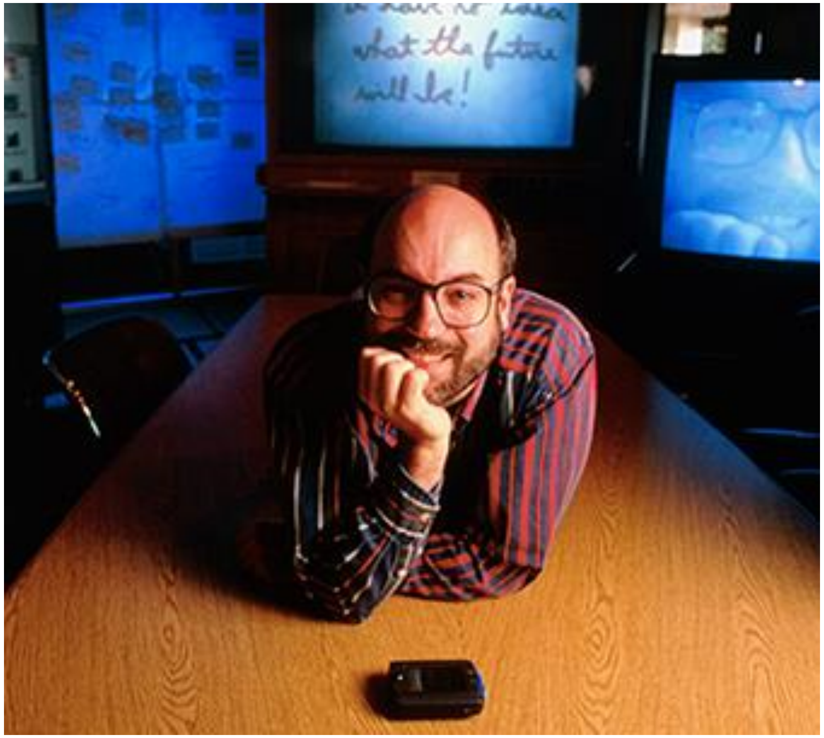
Third Wave: Many to Many.

Technology

Ubiquity: Computing Everywhere

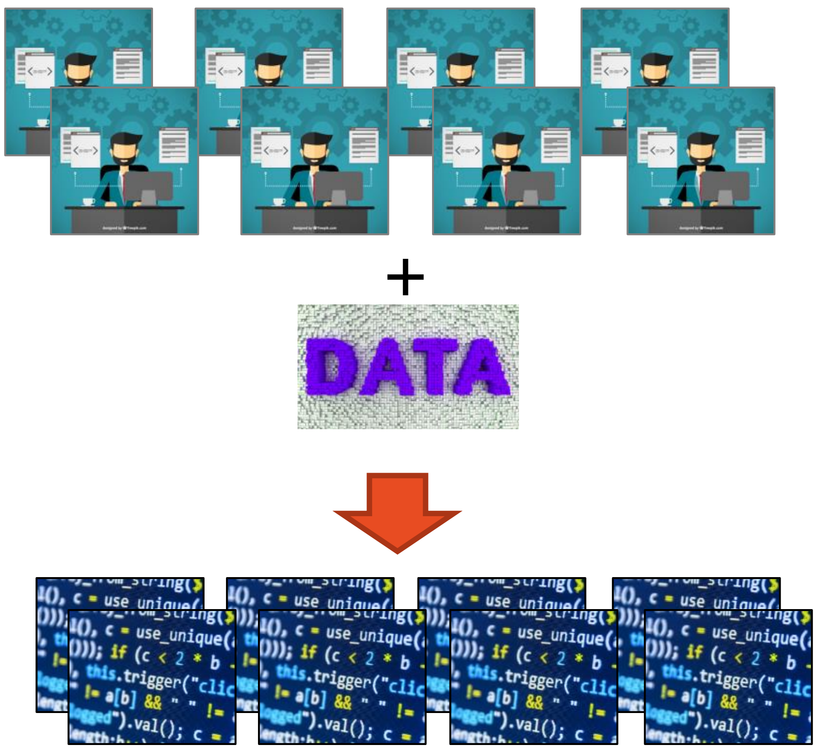
"The most profound technologies are those that disappear. They weave themselves into the fabric of everyday life until they are indistinguishable from it."

-- Mark Weiser, 1991, Scientific American

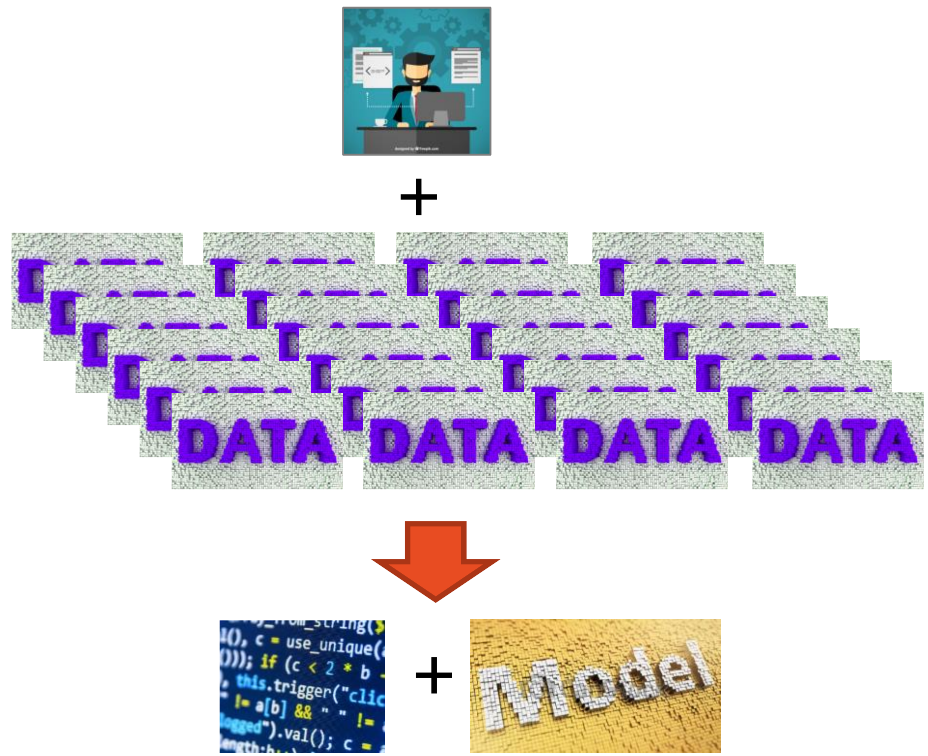


Mark Weiser, CTO at Xerox PARC, 1990

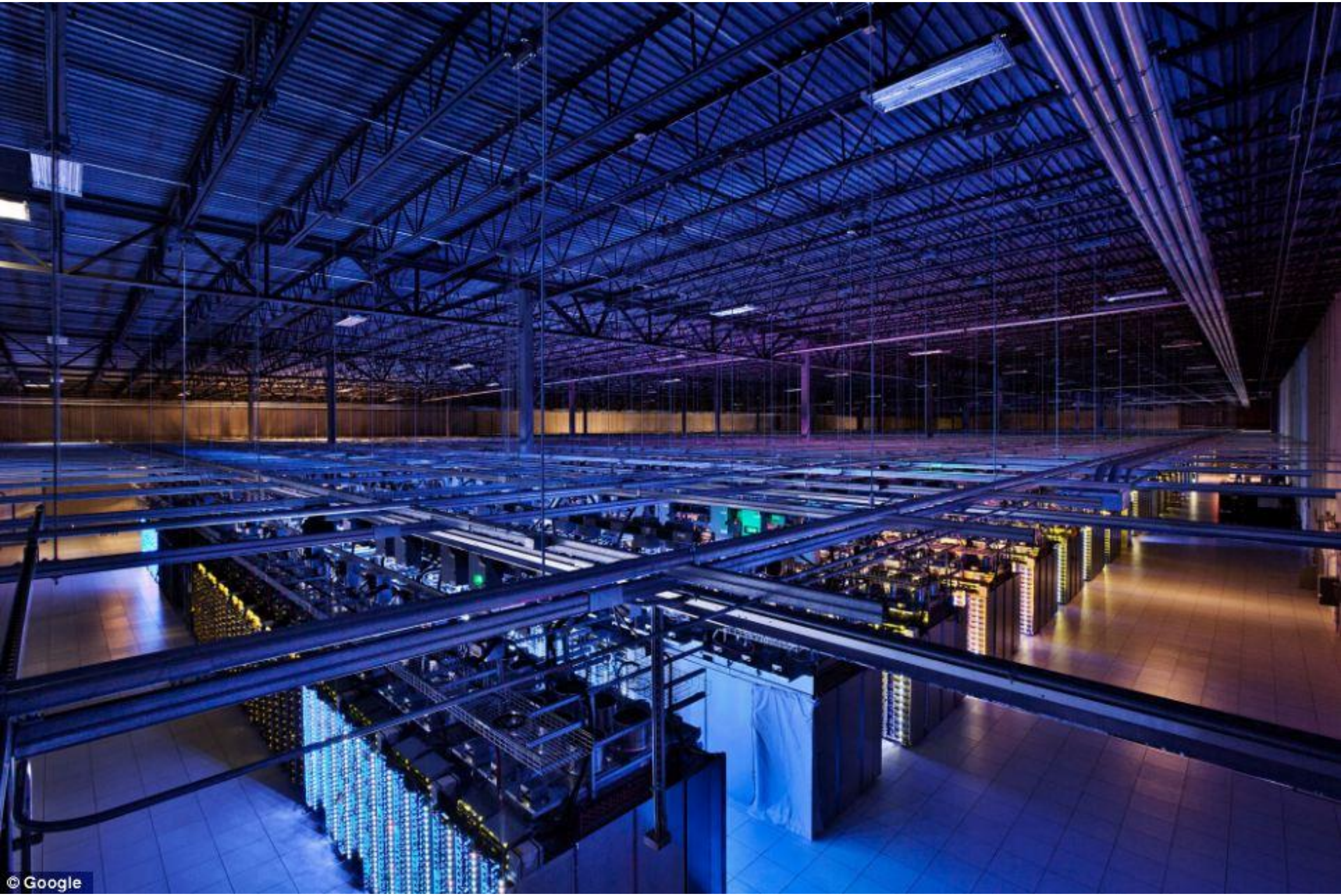
Algorithmic Revolution



Traditional Programming Methodology



Machine Learning Methodology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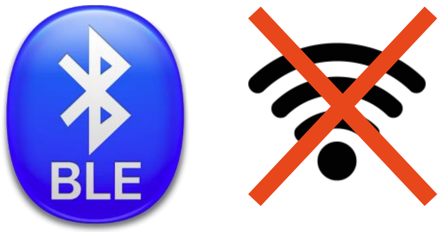
Devices at the Edge

Devices at the Edge

Battery powered

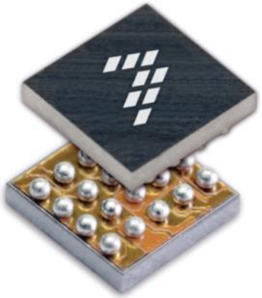
Low maintenance



Limited or No Network

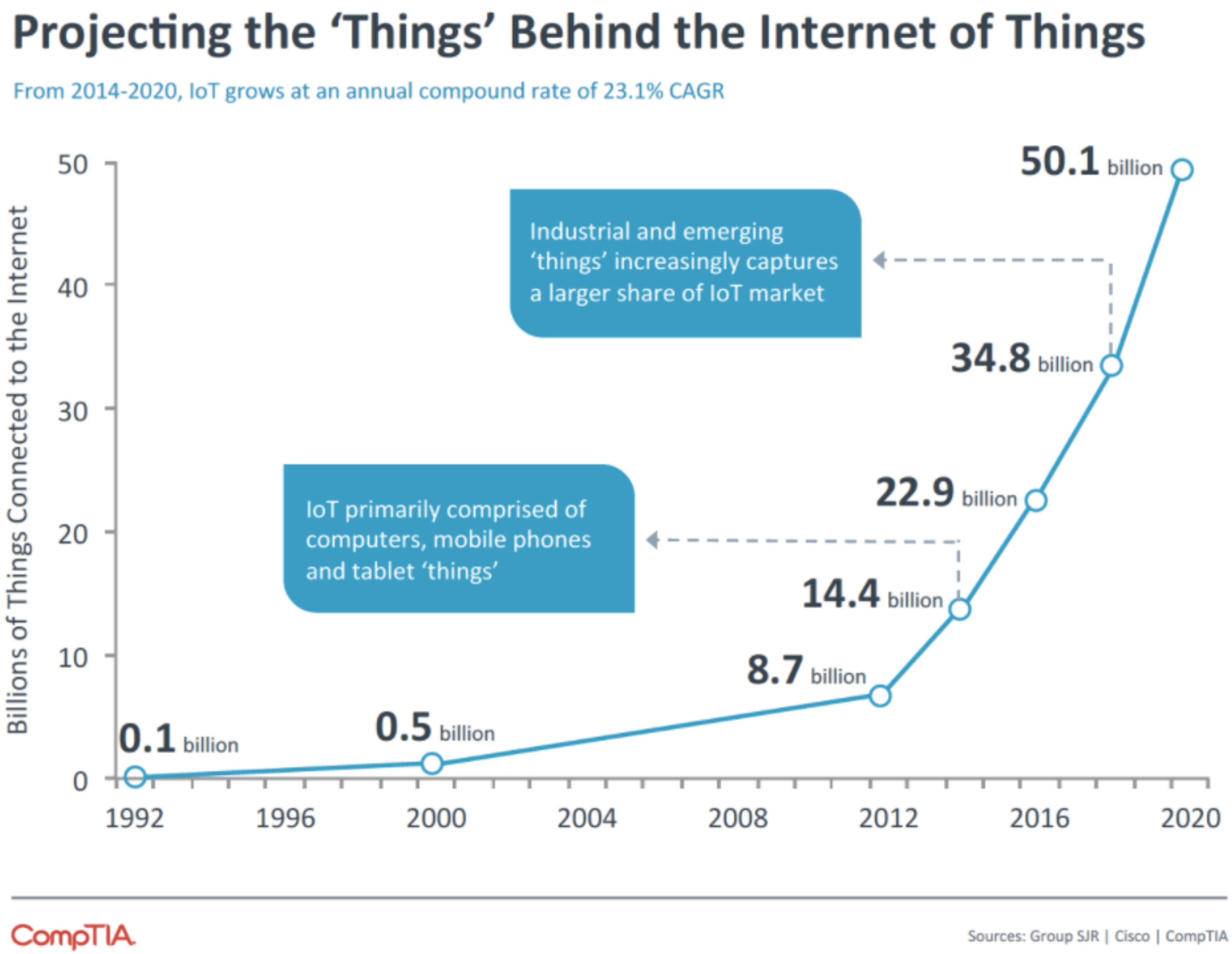
Limited Memory

No display



Limited compute

Devices at the Edge

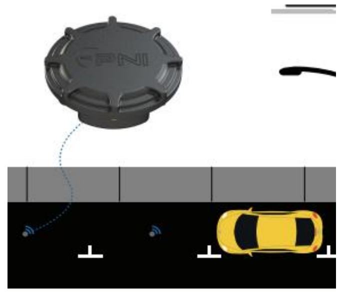


Example: Kitchen Faucet

The World of IoT

Door Knob

Gas Meter



Parking Sensor

Thermostat

Doorbell

LED Lighting

Smoke Detectors

Waste Bins

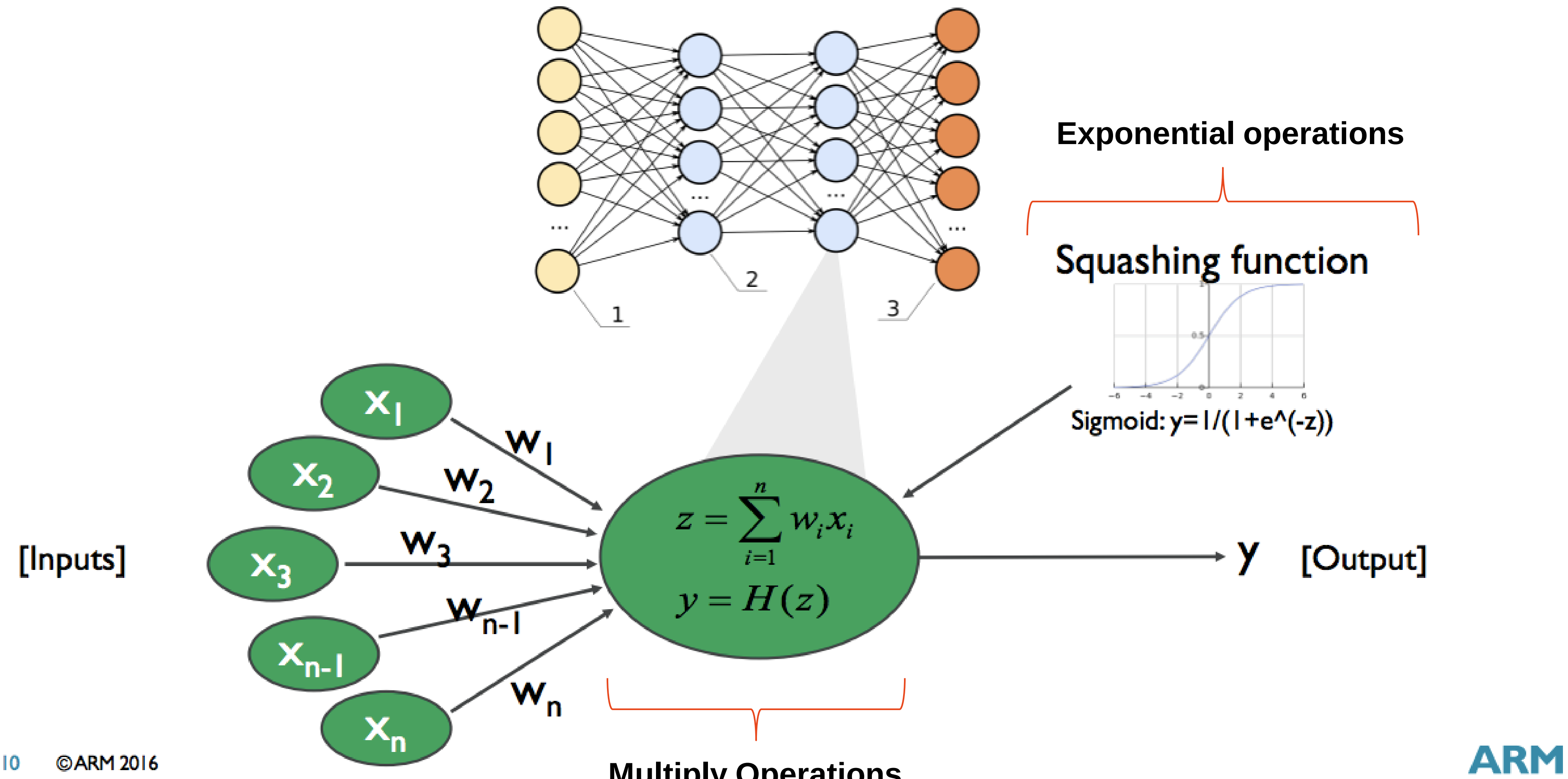
Fitness Bands

Appliances

Compute and Sensing Requirements

- High Compute
  - Vision/Camera images: Face detection; object detection
  - Acoustic Processing: voice detection (Alexa, Siri)
  - Requirements: GPU or dedicated Vision Processor
- Low Compute
  - Motion: Steps and Activity
  - Environmental: humidity, temperature, gasses, particulates
  - Pressure: elevation
  - Location/Proximity: Beacons
  - Requirements: ARM Cortex M-class or similar

Basic Neural Network



Jem Davies, “ARM and Machine Learning”

Challenges: Hardware

- Memory Limitations
  - Memory is 64K to 512K in most MCU cores
- Power Limitations
  - Can’t send raw data for processing
  - Network transport is very costly:
    - Compute often; transport rarely
- Math Operations
  - FPU (Floating Point Unit)
- Processor design
  - 32bit
  - Low power designs; peripherals can dominate power profile

Challenges: Software

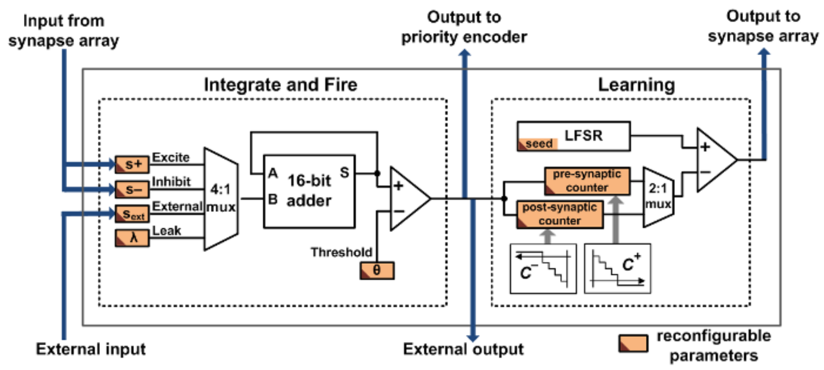
- Software frameworks for DNN
  - Many available, but not for embedded
- DNN Training
  - Typically running on large machines with GPU support
  - Generates a model file for the inferencing engine
  - TensorFlow and others are good choices
- DNN Inferencing
  - Either full data needs to be uploaded to the cloud
  - Or, needs to run on the local processor
  - Many frameworks available, but not for embedded
  - Model files are often large, need to extract minimal data

Processors: MCU/CPU based

- 32b core (MCU) + FPU
  - ARM M-class
  - Ambiq Apollo 2: Ultra low power ARM M4F
- DSPs or Custom variants:
  - Certain operations are hardened into gates for acceleration
  - Bosch Sensortec DSP "Fuser Core": BHI160
  - Greenwaves Tech: GAP8, RISC-V with HW NN
  - Custom instructions: Tensilica, ARC

Processors: Neuromorphic

- Building the nodes (neurons) directly in silicon
  - Analog approach vs digital approach
  - Parallel operation
- General Vision + Intel
- Qualcomm Zeroth NPU (Neural Processing Unit)
- IBM TrueNorth processor (1,000,000+ neurons)
- Toshiba TDNN (Time Domain Neural Network)



Conclusion

- New algorithmic schemas are pushing computation back to the cloud
- Drive for distributed computing is too great
  - mobile cores are too cheap and too capable
- ANNs are well suited for edge processing
- New dedicated hardware is coming to accelerate

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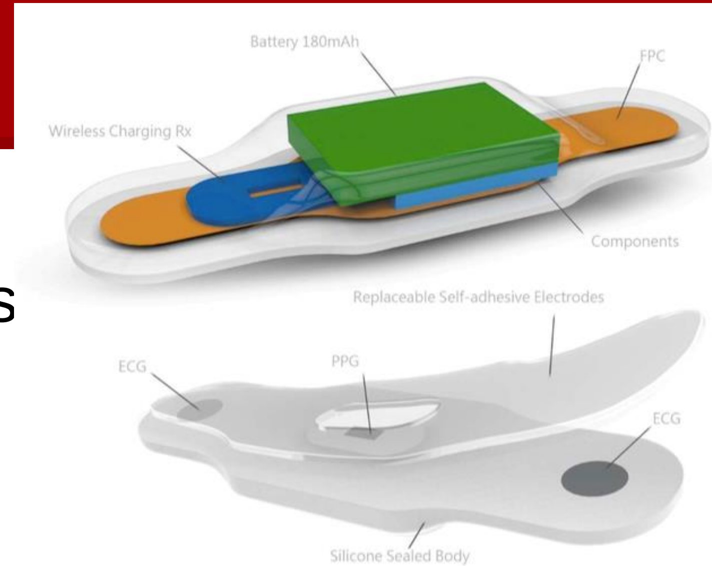
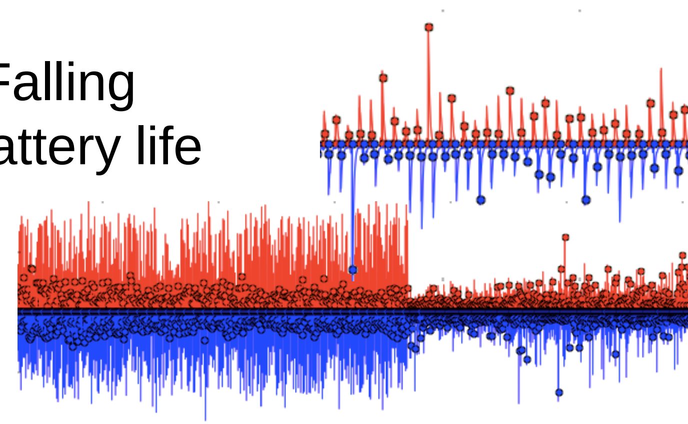


- Building Machine-Learning algorithms for embedded sensors
  - Focus on activity recognition
- Ai^2 Active Living Monitor©
  - Products to track wellness in Aging
  - Software & Hardware Platform
    - Detect Vitals, Activities of Daily Living, Falling
    - On-body sensor computation for long-battery life
  - Hardware Platform reference design
    - Sensors, MCU, BLE and PMIC



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