Computation Overview, History, and Trajectory

Jennifer Hasler

Inside an iPhone7

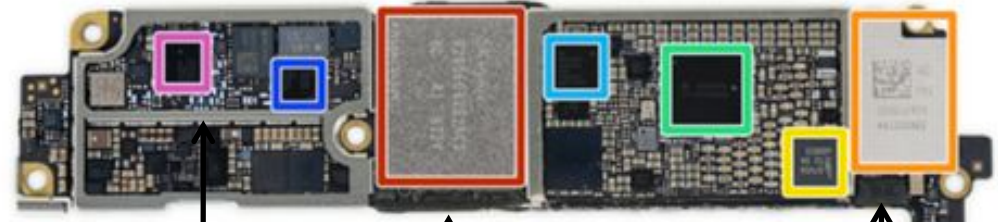Take a look inside your device

<u>Top side of Electronics Computation</u>

CPU + RAM: Apple A10 Fusion APL1W24 SoC + Samsung 2 GB RAM

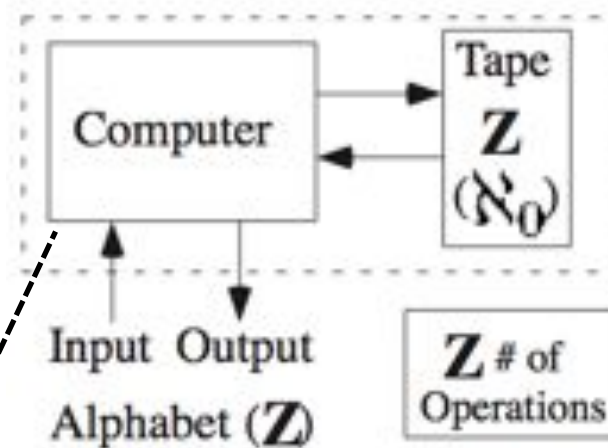<u>Bottom side of Electronics Computation</u>

Memory: SK Hynix 32GB Flash

Murata WiFI/ Bluetooth Module

Qualcomm RF Transceiver

MOSFET Scaling

Microprocessor Transistor Counts 1971-2011 & Moore's Law

"smallest size transistor…a gate oxide thickness of Snm, a substrate doping concentration of 4 X 10^{17} cm^{-3} and a channel length…0.15um." - Hoeneisen & Mead 1972

$\longrightarrow$ 180nm Transistor in 1997

(Intel Coppermine Processors @ 180 nm CMOS 1999)

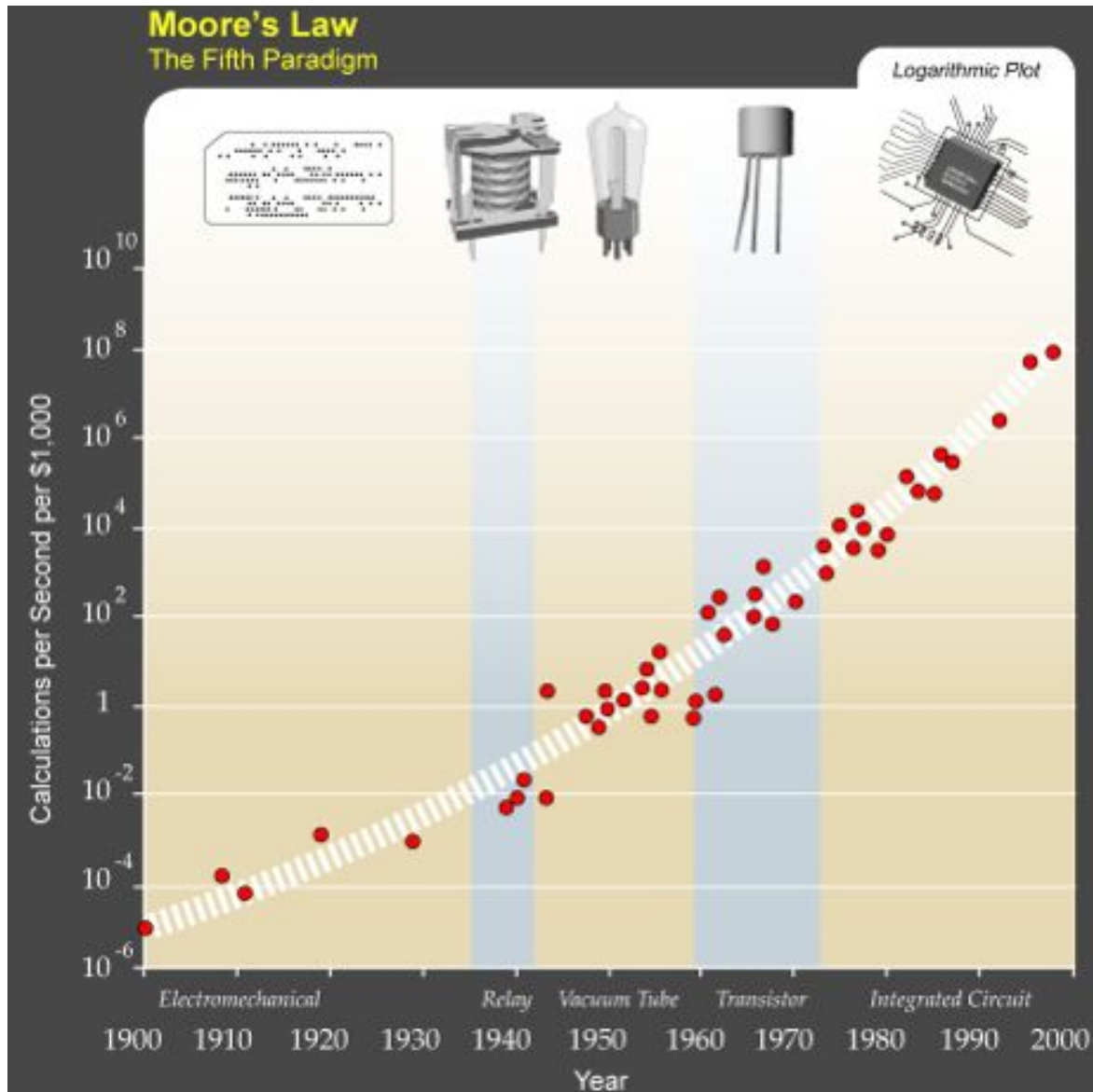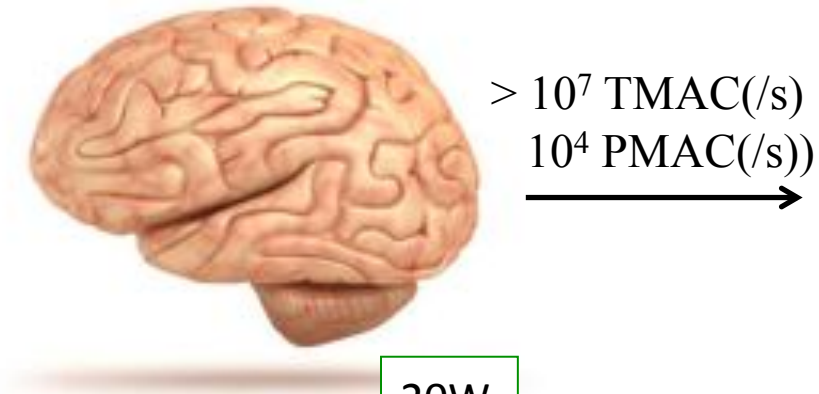# Digital Computing Approach

Kurzwell: Increasing Exponential Improvement

Brain Computation
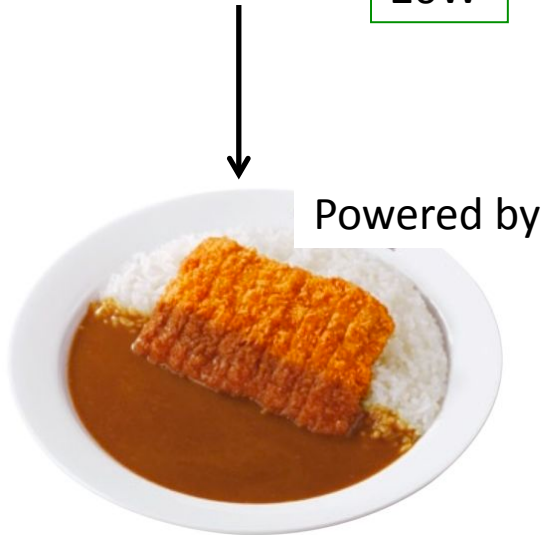
Digital Computation: >10000x IBM Sequoia

$> 10^7$ TMAC(/s)
10^4 PMAC(/s))

20W

>10MW

Powered by

Powered by
many

Revolutionary Ultra-Efficient Computation

Power Efficiency Scaling

10MMAC(/s)/W ——— 1st DSPs (1978 - 1981)

100MMAC(/s)/W ———

X1000 Improvement

1MMAC(/s)/mW ———

10MMAC(/s)/mW ——— Energy Efficiency Wall (32bit inputs)

X1000 Improvement

100MMAC(/s)/mW ———

1MMAC(/s)/uW ——— AnalogSP

10MMAC(/s)/uW ——— Typical Analog VMM

100MMAC(/s)/uW ——— FPAA compiled Dendritic Classifier (350nm IC)

X100000 Improvement

1MMAC(/s)/nW ———

10MMAC(/s)/nW ——— Dendritic Classifier (350nm IC)

100MMAC(/s)/nW ——— Shrink by scaling L, V_{dd}

1MMAC(/s)/pW ——— (<) Biological Neuron