Powering Computers Without Batteries or Wires

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Session I

Introduction To Powering Computers

Our Goal: to Understand

- Power usage in computers
- Power supply for computers

- The computers in the future?

Question: What is Energy? Power?

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Measuring Electrical Energy

SI system:

Energy: Joule (J)

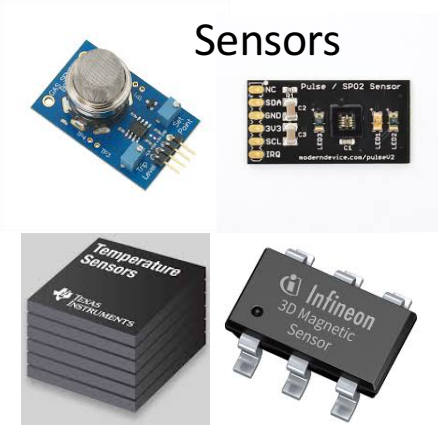
Power: Watt (W) = J/second

1 kWh=1000W x 3600s

= 3.6x10^6 J

Typical Power Numbers

Microwatt



Milliwatt

10-100W

10^10W

20 W

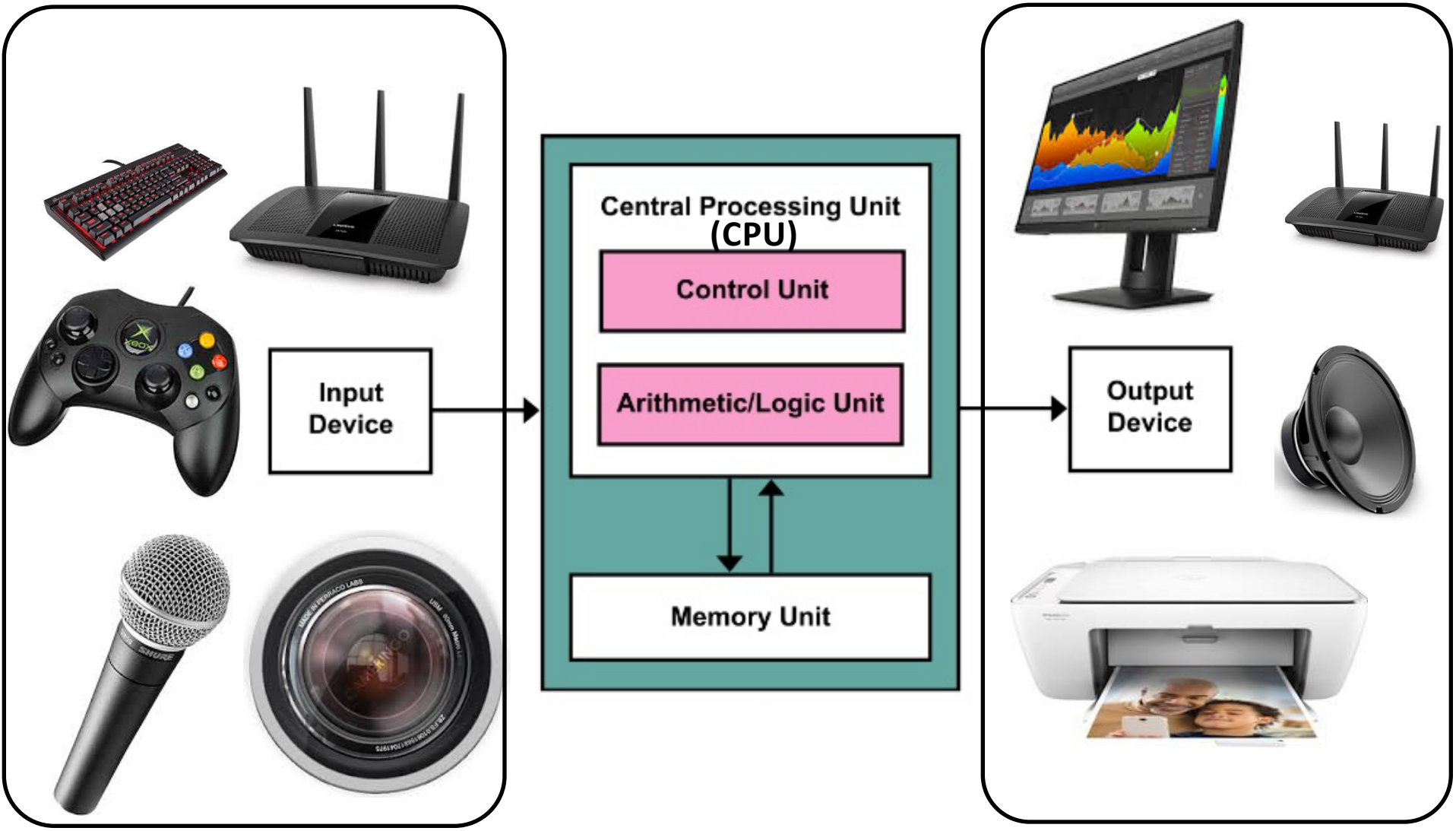
100 kW

10^26W

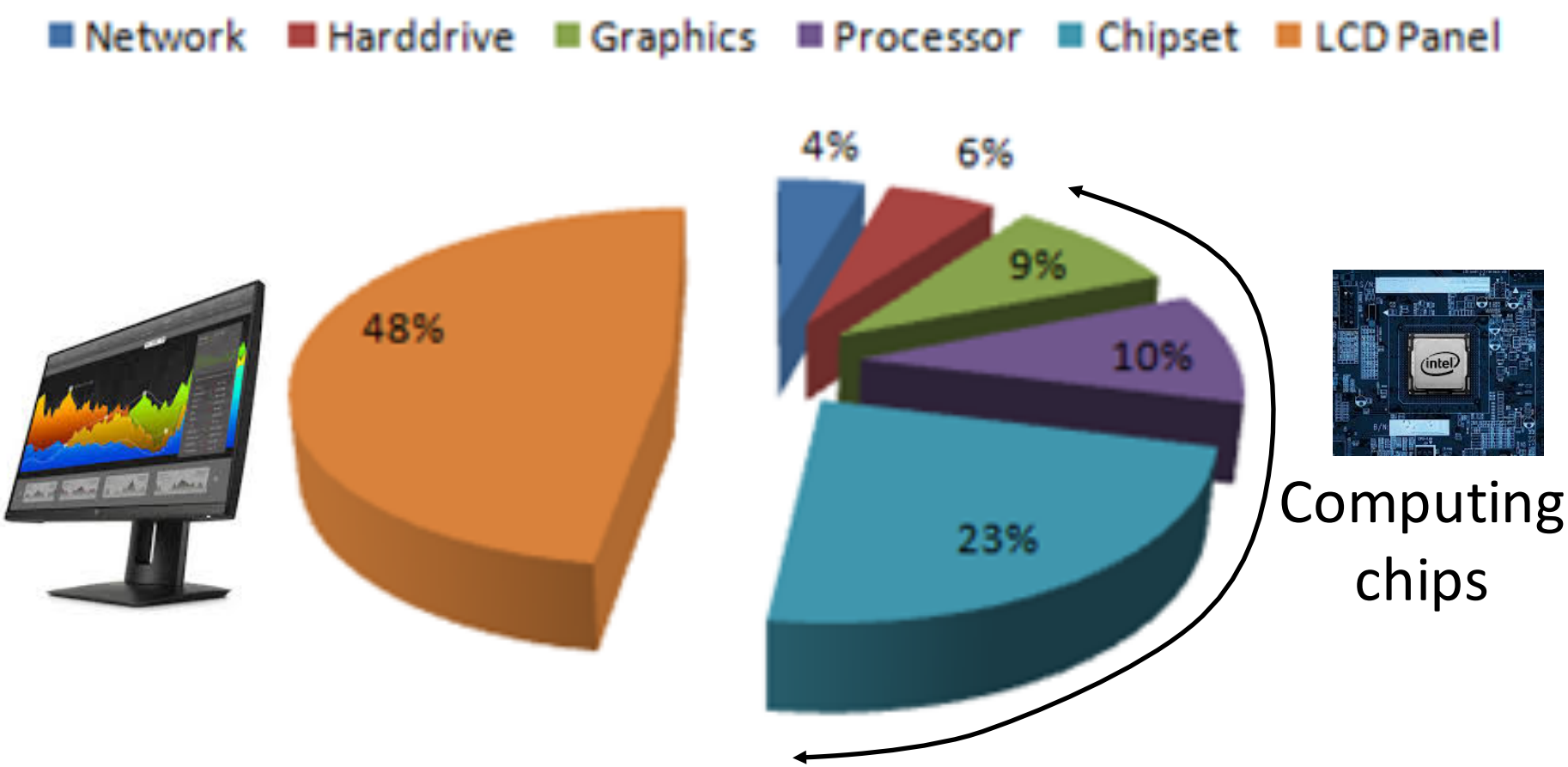
Zero-Power-Consumption Computers?

- Can computers run without energy?

Computer Architecture → Systems



Energy Consumption By Parts

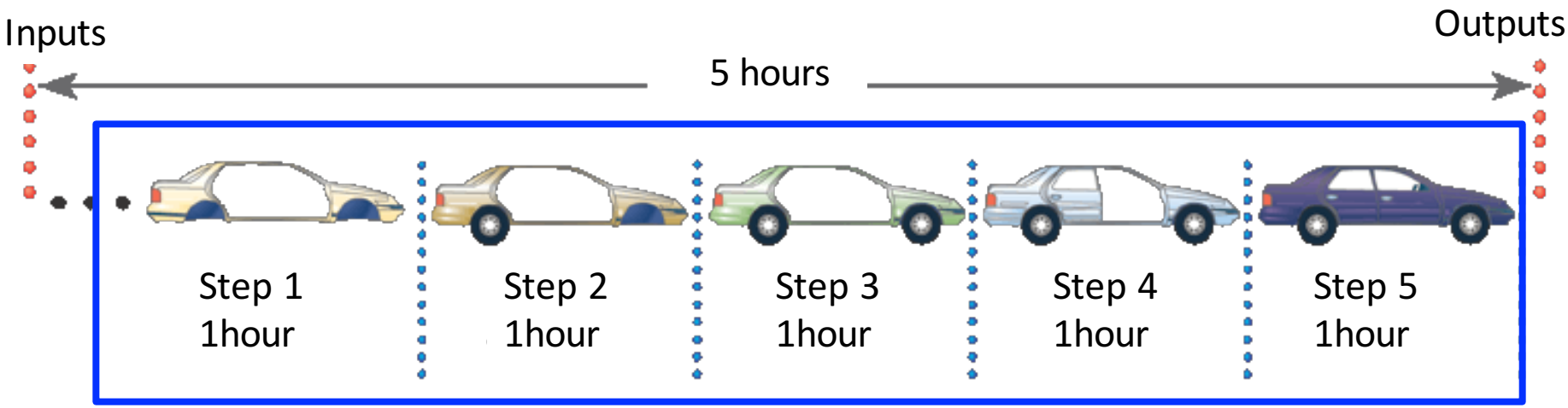


http://blog.unlockforus.org

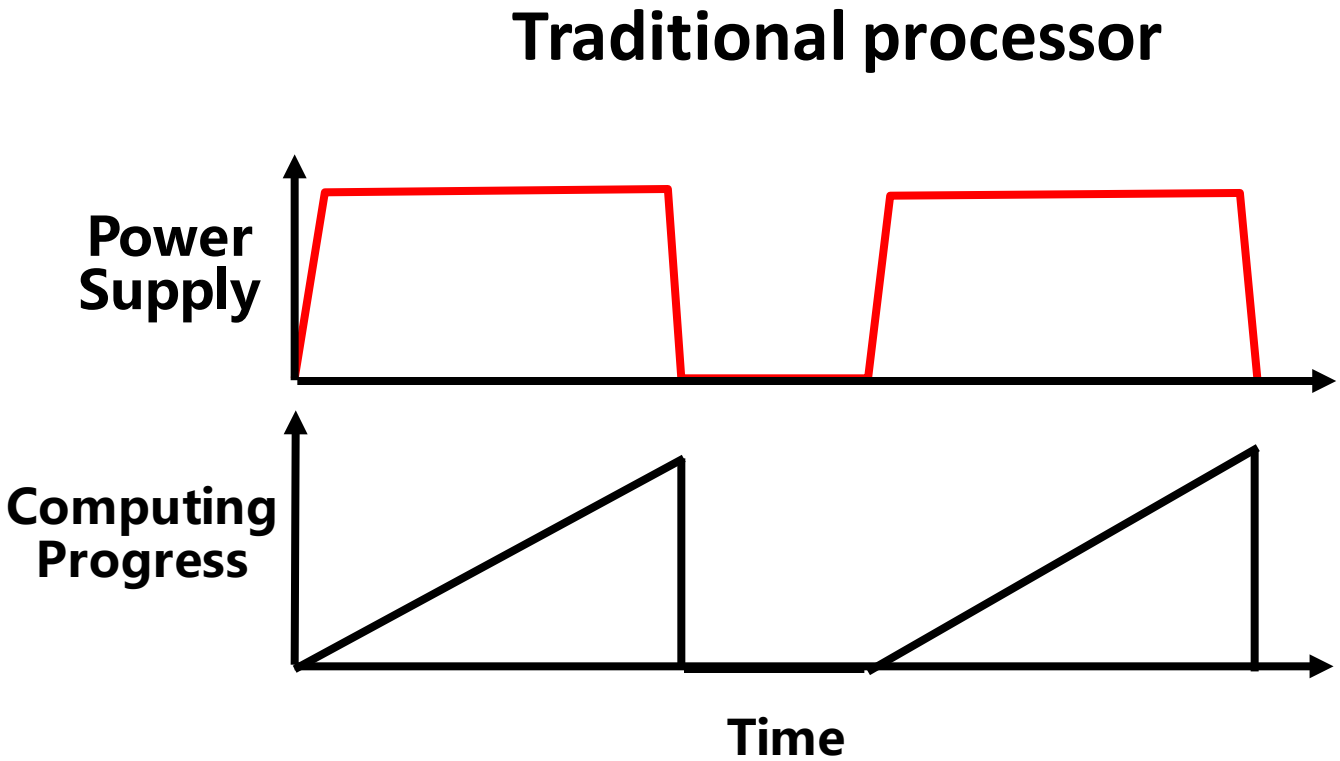
Memory States Inside Computers

- Computers need to remember temporary states

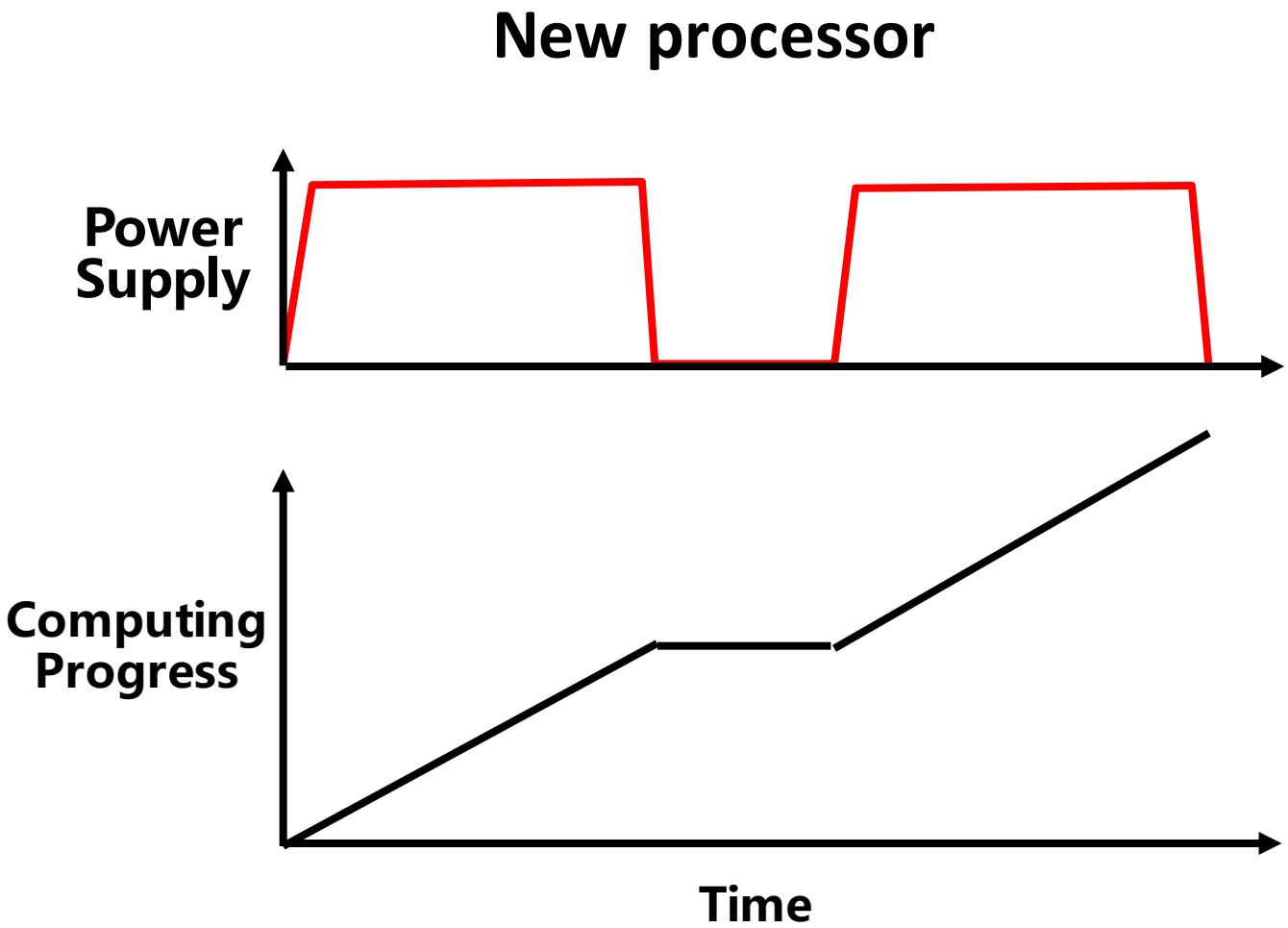
e.g. 1+5+10+20→ **6** + 30 → 36



What if Power is Unintentionally Cut Off?



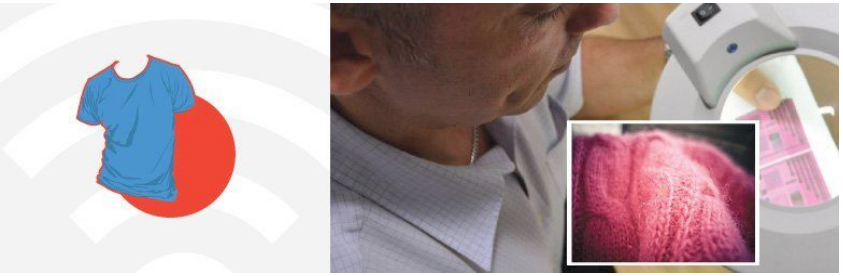
Nonvolatile Computing: Tolerating Power Outages



Energy-Harvesting Nonvolatile Computing Systems

Walking the streets (Piezo: 1 square, up to 2.1 watts)

Parking your car (Solar)



Wearing your clothes (Thermal: ~uW)

From the sky (RF: 1nW to 100uW)

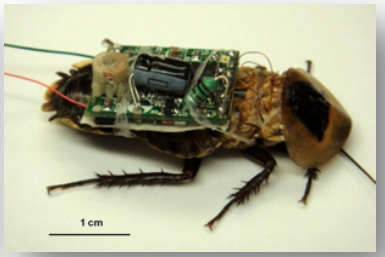
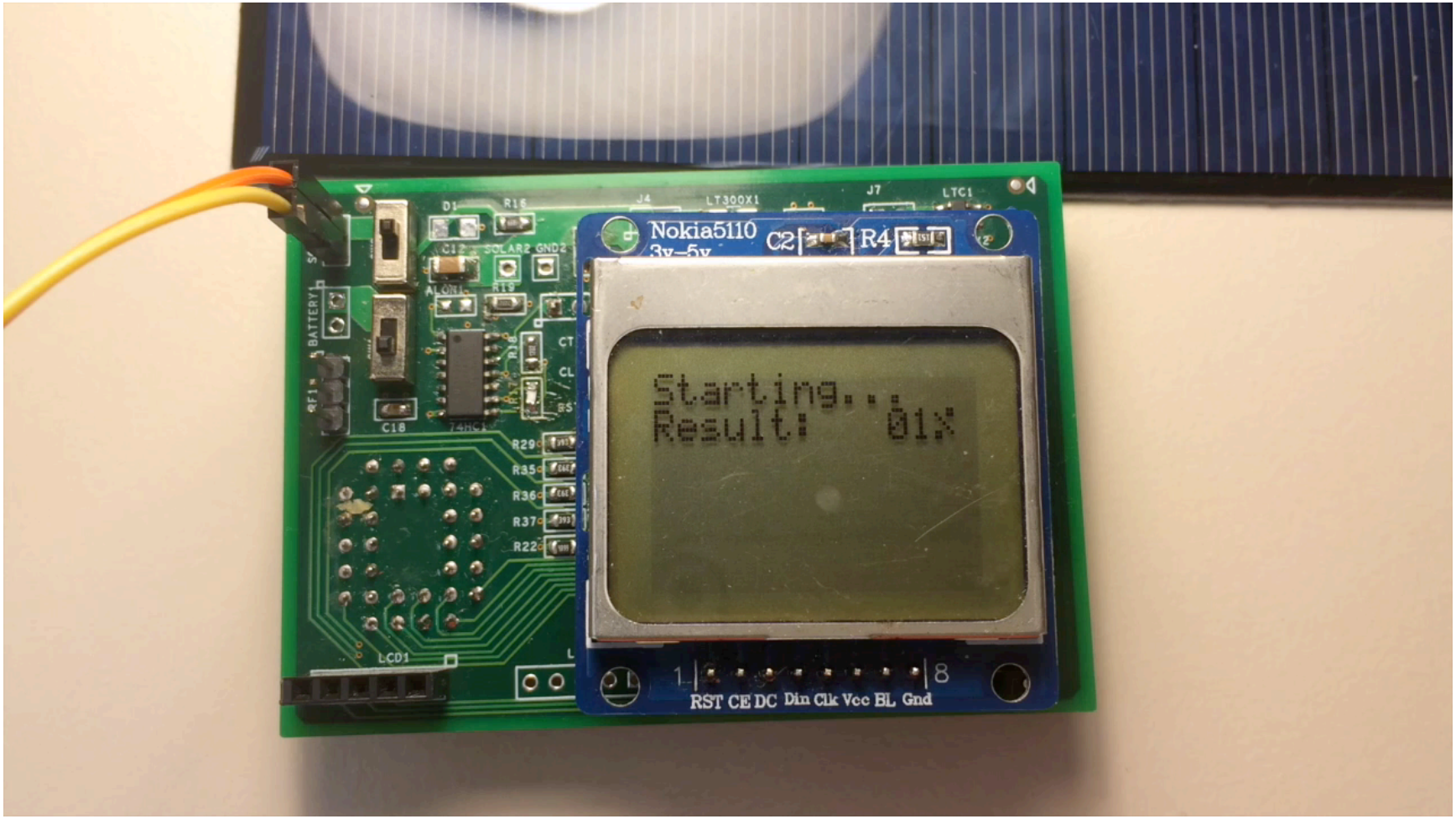


Image Source: http://www.postscapes.com/energy-harvesting-smart-cities/, University of Washington, DARPA, NAU, Google

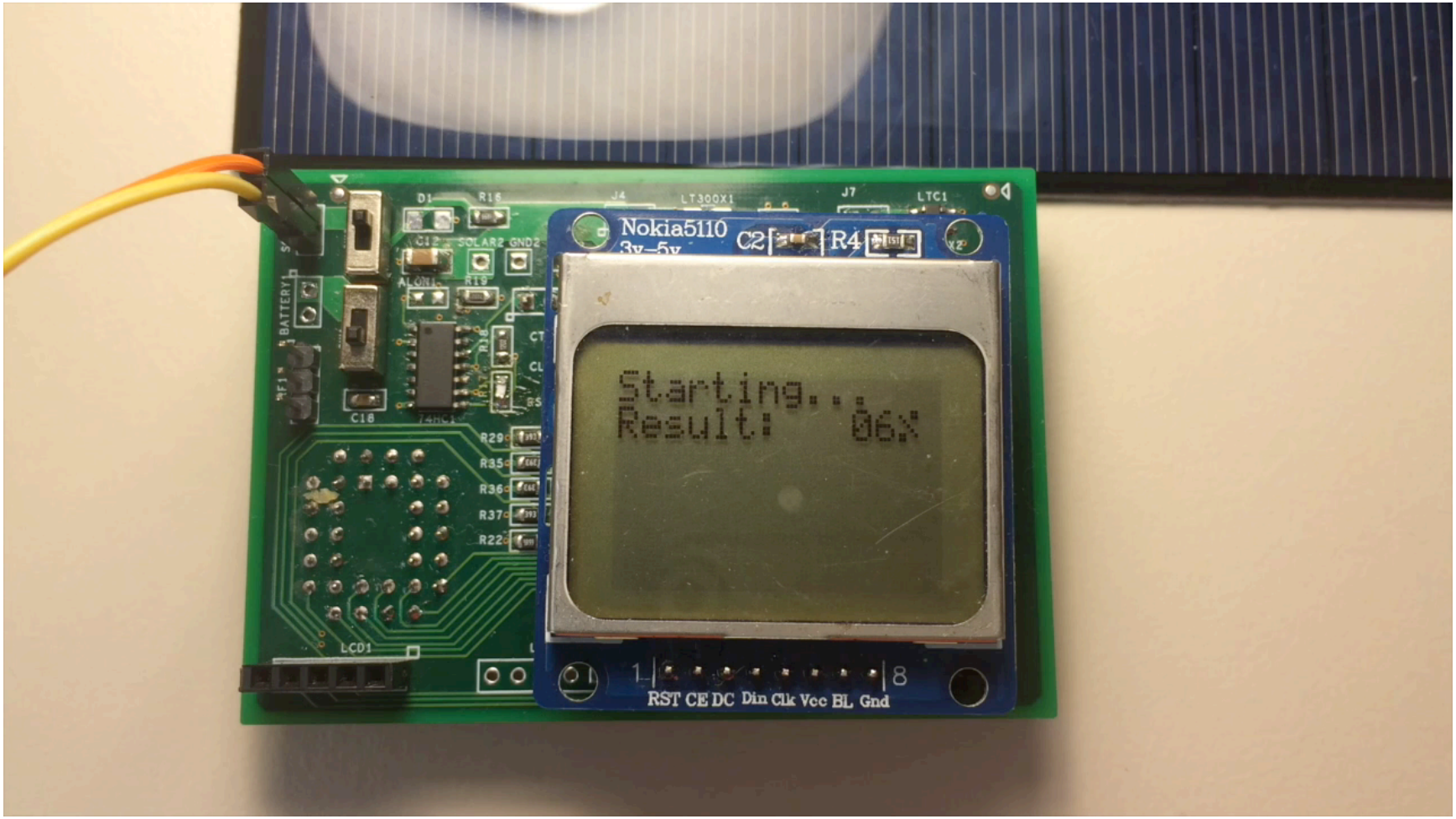
Demo 1: Brain/Heart Signal Diagnosing

Traditional Processor



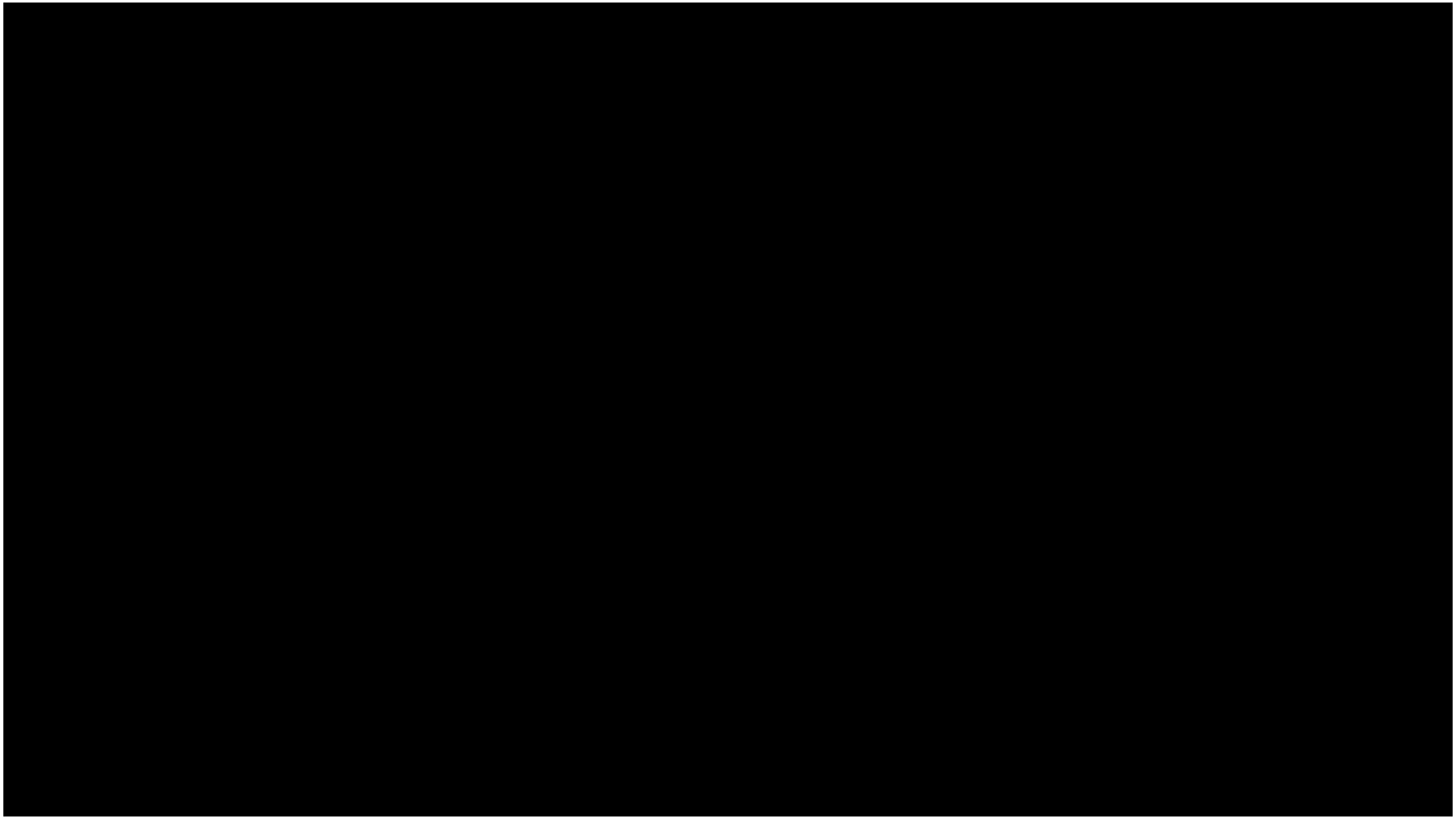
Demo 1: Brain/Heart Signal Diagnosing

New Processor



Demo 2: Learning Processor

Demo 3: In-Sensor Harvesting



Session II

Hands-On

Approximately 1 hour

Hands-on Activities

- Energy Harvesters
  - Solar cells
  - Radio
  - Movements

Think about:
(i) Energy harvester features;
(ii) possible NVP applications

- Nonvolatile Processing Platforms
  - Brain signal analysis: pattern matching
  - Self-learning Processor
  - Breathing monitoring: Sensor-harvester integration
- Summary of what you learn

Session III

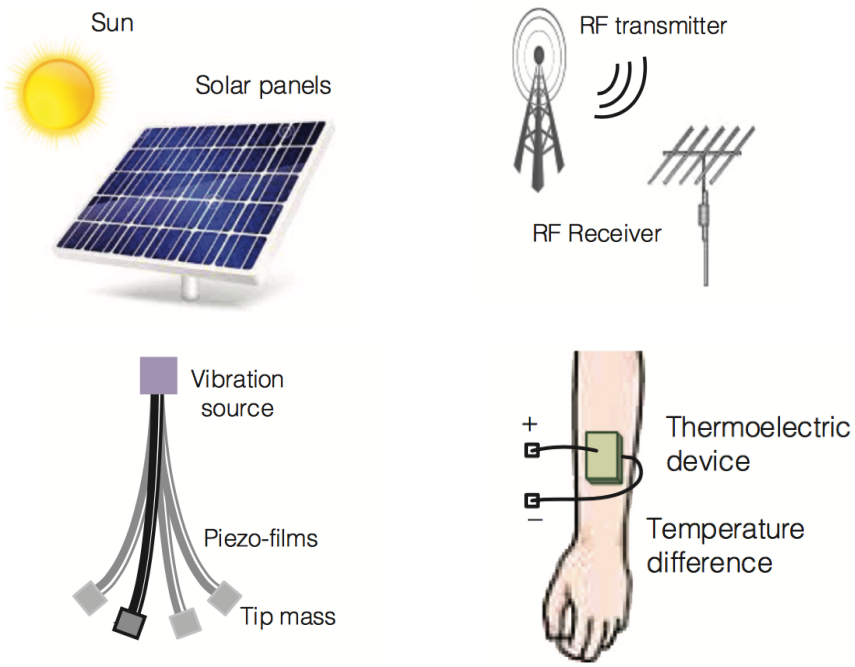
Discussions

Pros & Cons of Using Batteries/Harvesters

- Reliability (availability and intermittency)
- Scenarios with ambient energy sources
  - Outdoors Parking Lot in State College
  - Newborn intensive care room
  - Training shoes
  - Near the train tracks
  - Deep in the ocean
  - Outer space of the earth

Pros & Cons of Using Batteries/Harvesters

- Reliability (availability and intermittency)
- Energy density
- Weight
- Cost
- Size
- Pollution
- Safety
- Maintenance
- Charging endurance and Life time
- …



Internet of Things (IoT)

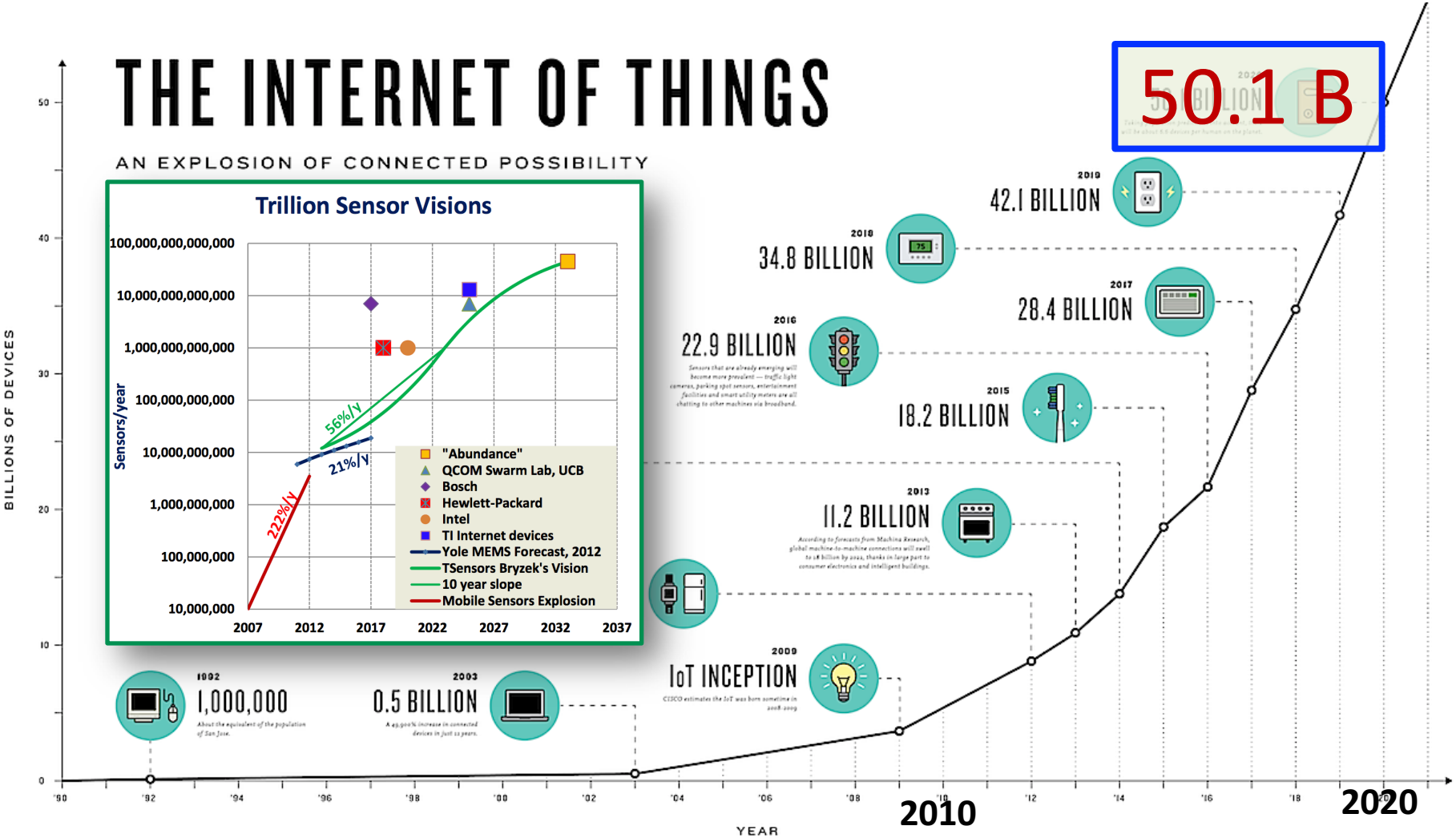
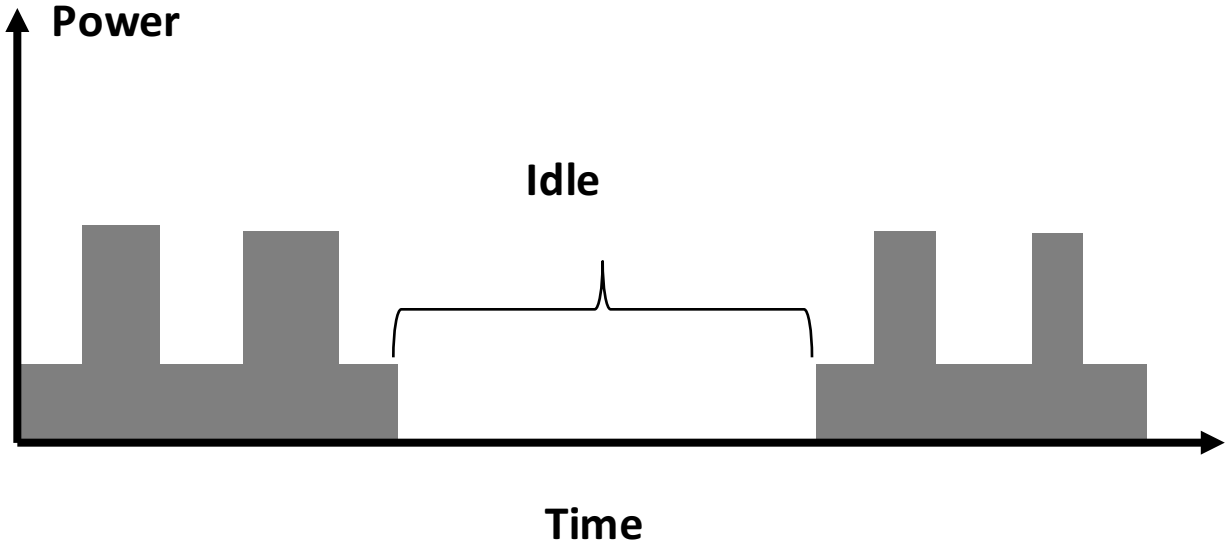


Image Source: https://opentechdiary.wordpress.com/category/iot-basics/, Fairchild: Roadmap for the Trillion Sensor Universe

Can We Use NVP with Batteries, or a Stable Power Supply?

- Power-gating



Summary of Potential NVP Applications

- Prompt wakeup;
- Normally-off computing;
- Ultra-small size and weight (e.g. implanted);
- Energy harvesting with intermittent low energy income

THANKS