SENERGY: Micro-scale Energy Harvesting from an Idle Sensor

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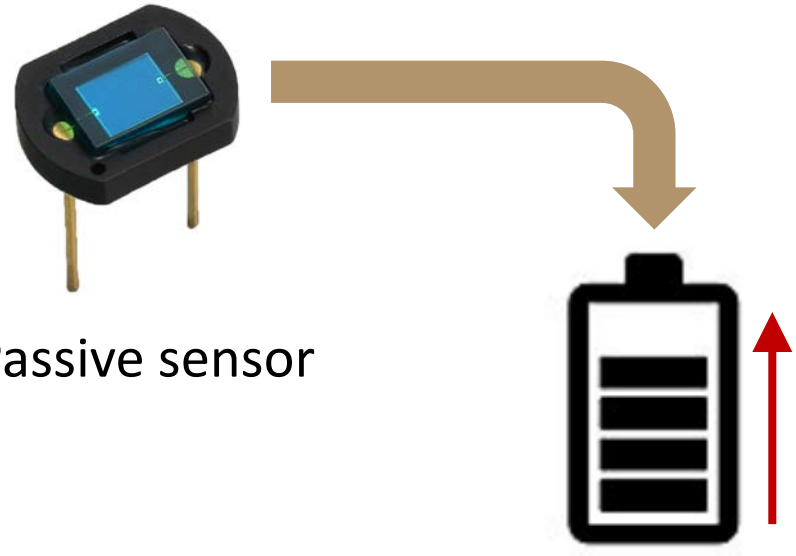
Abridged

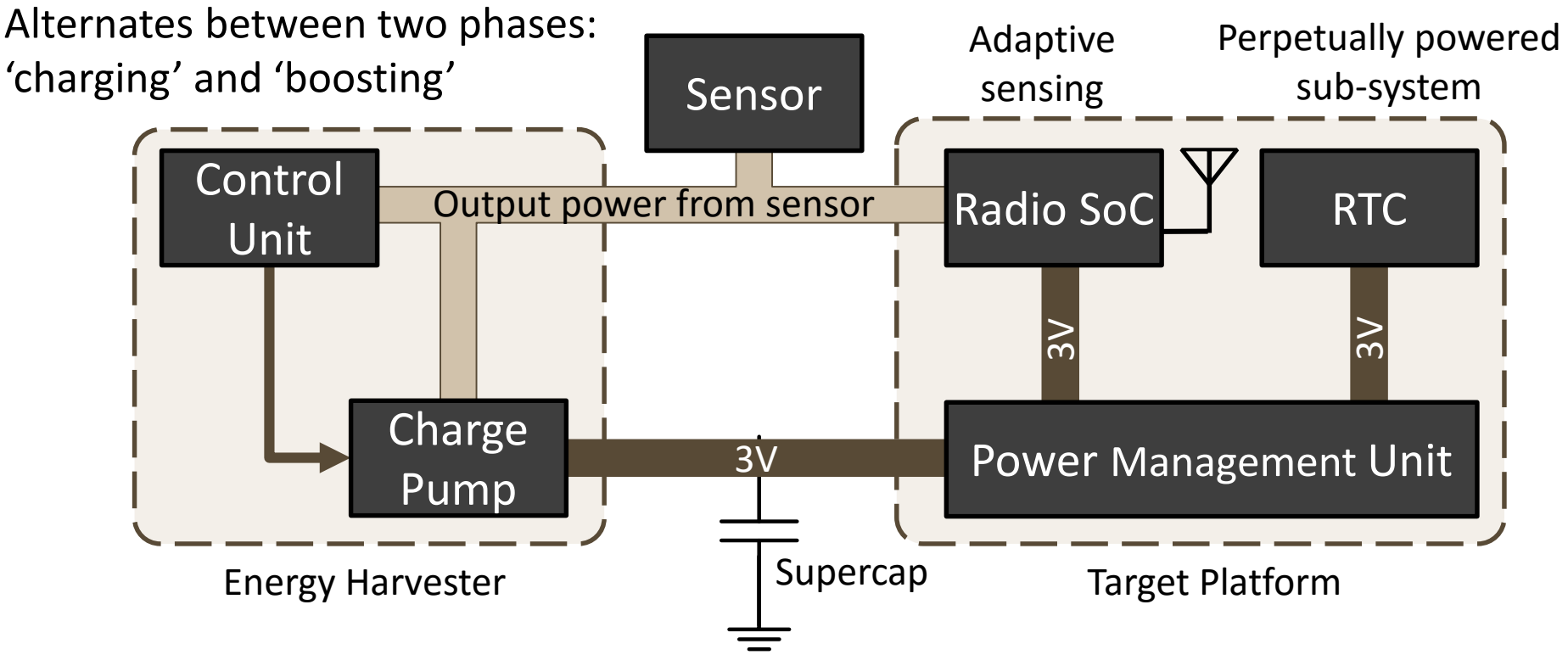
Key Idea

- Wireless sensor devices are highly duty-cycled to save energy
- Often, passive sensors are preferred to further save energy
- During idle, the output power from sensors is being wasted
- If harvested, we could supply the device during active time



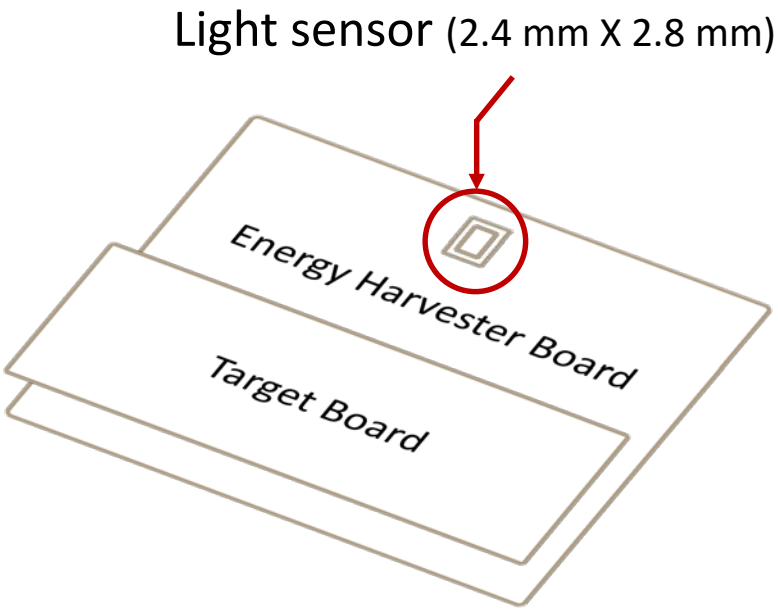
Hardware Architecture

- Energy harvester & Target board
  - Share a sensor as either a power source or a sensing element



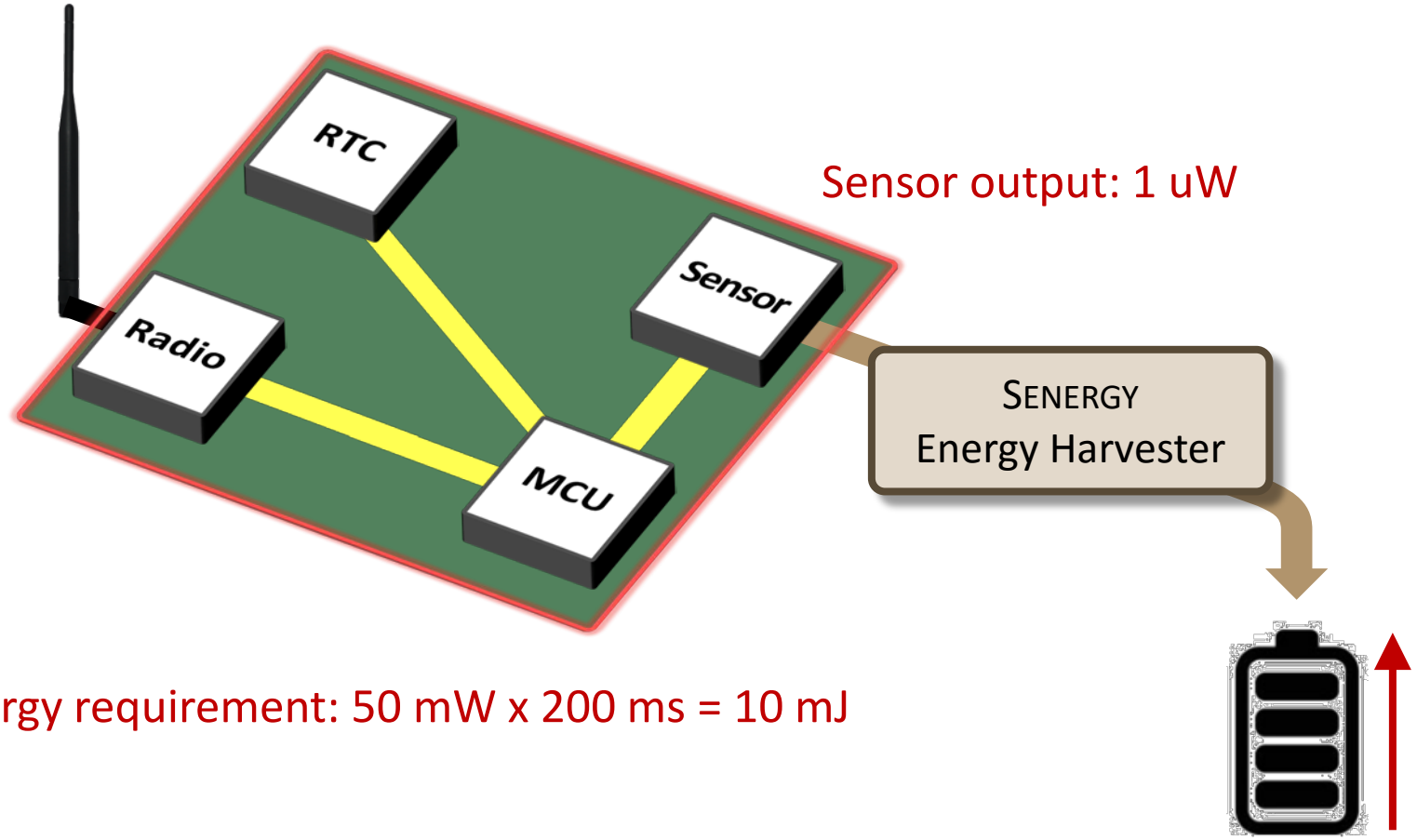
Implementation

- Energy neutral wireless sensor node using photodiode sensor
- Energy harvester
  - Built using the exponential charge pump that we propose and design
  - Minimum operating conditions: 250 mV, 6 uA (~ 450 lx)



Use Case 1 - Adaptive sensing

- Intermittently power the entire system

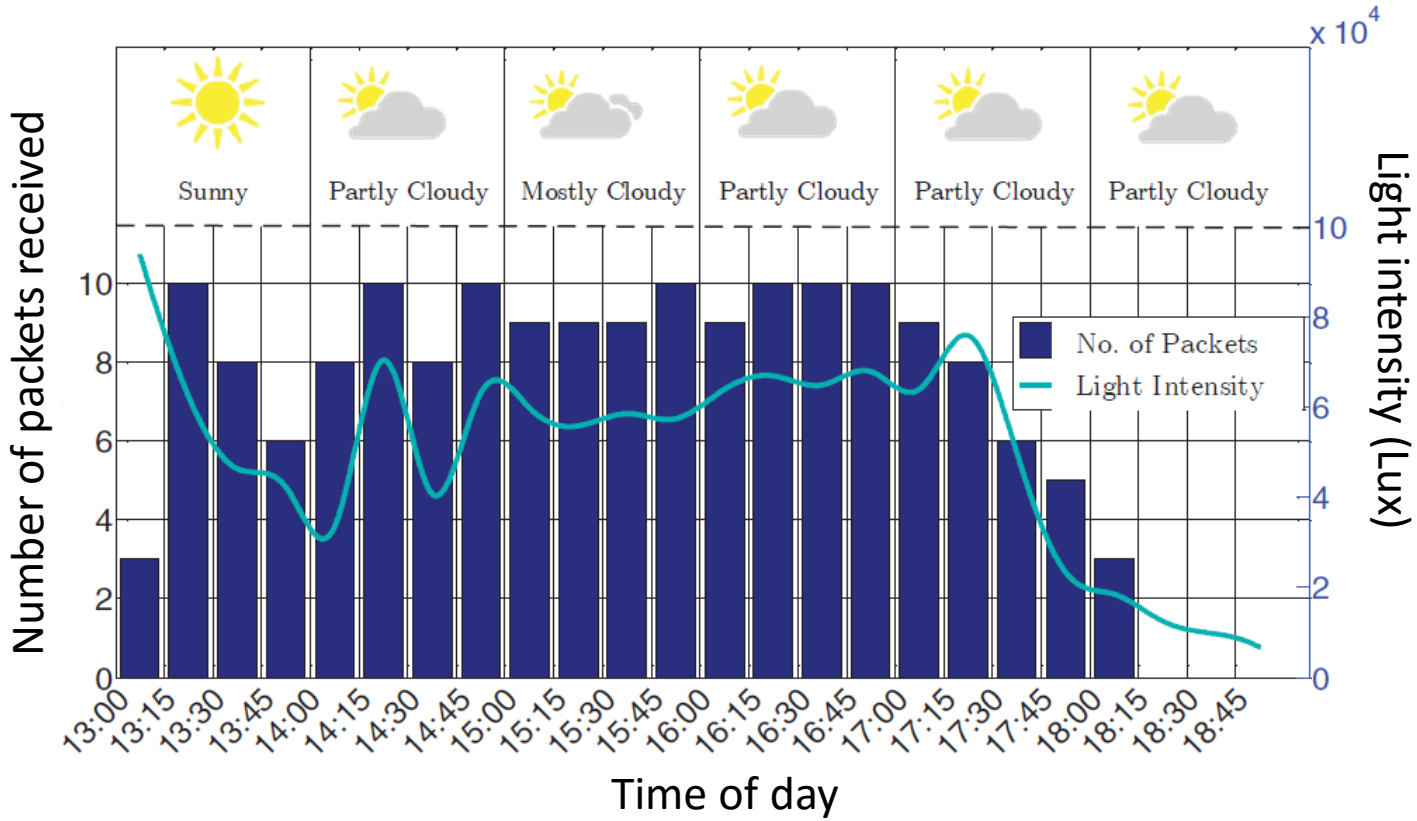


Sensor output: 1 uW

Energy requirement: 50 mW x 200 ms = 10 mJ

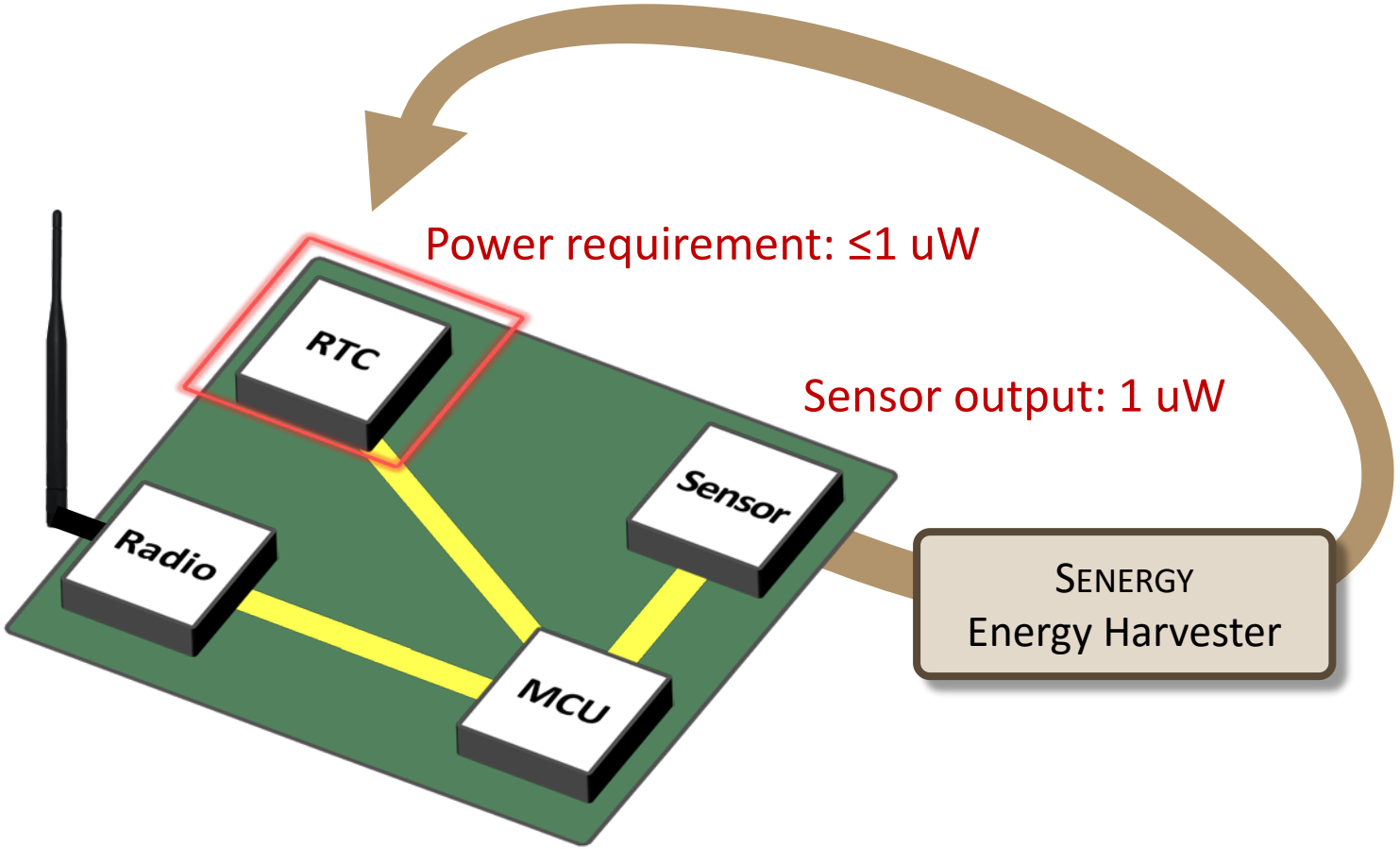
Use Case 1 - Adaptive sensing

- Transmitted sensor data whenever sufficient energy is collected
- Achieved one packet transmission per every 100 seconds



(*Apr 24, 2014 in West Lafayette, IN*)

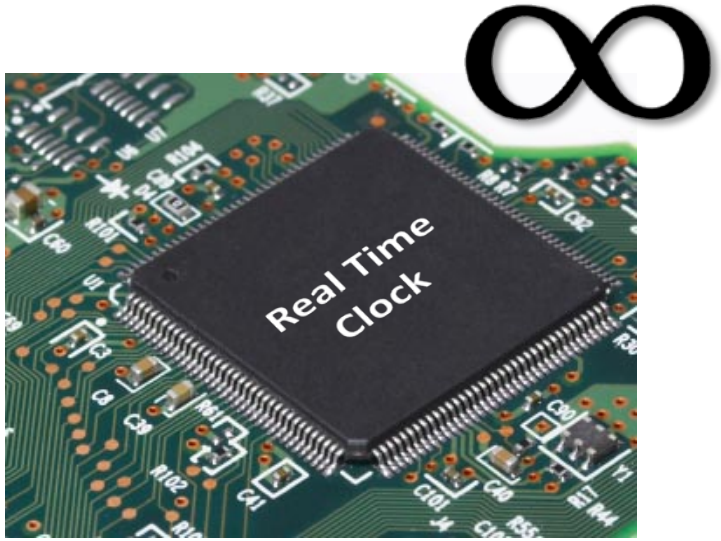
Use Case 2 – Perpetually Powered Sub-system



- Perpetually operating mission-critical low-power sub-system

Use Case 2 – Perpetually Powered Sub-system

- Perpetually power RTC IC so as not to lose time-sync
  - NXP PCF2123 (100 nA @ 1.1 V)
- In the previous experiment, we have harvested total of 3.76uAh
- Possible to operate the RTC IC for 37.6 hours
  - More than enough until next sun rise



Conclusion

- SENERGY is the first system that utilizes a sensor as both a sensing element and a power source

- We designed and implemented an exponential charge pump-based energy harvester that is able to interface a low-capacity power source (*e.g.*, passive sensor), which has voltage and current as low as 250 mV and 6 uA