Energy-Harvesting Wireless Sensor Node for IoT Networks

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A Modular IoT Node

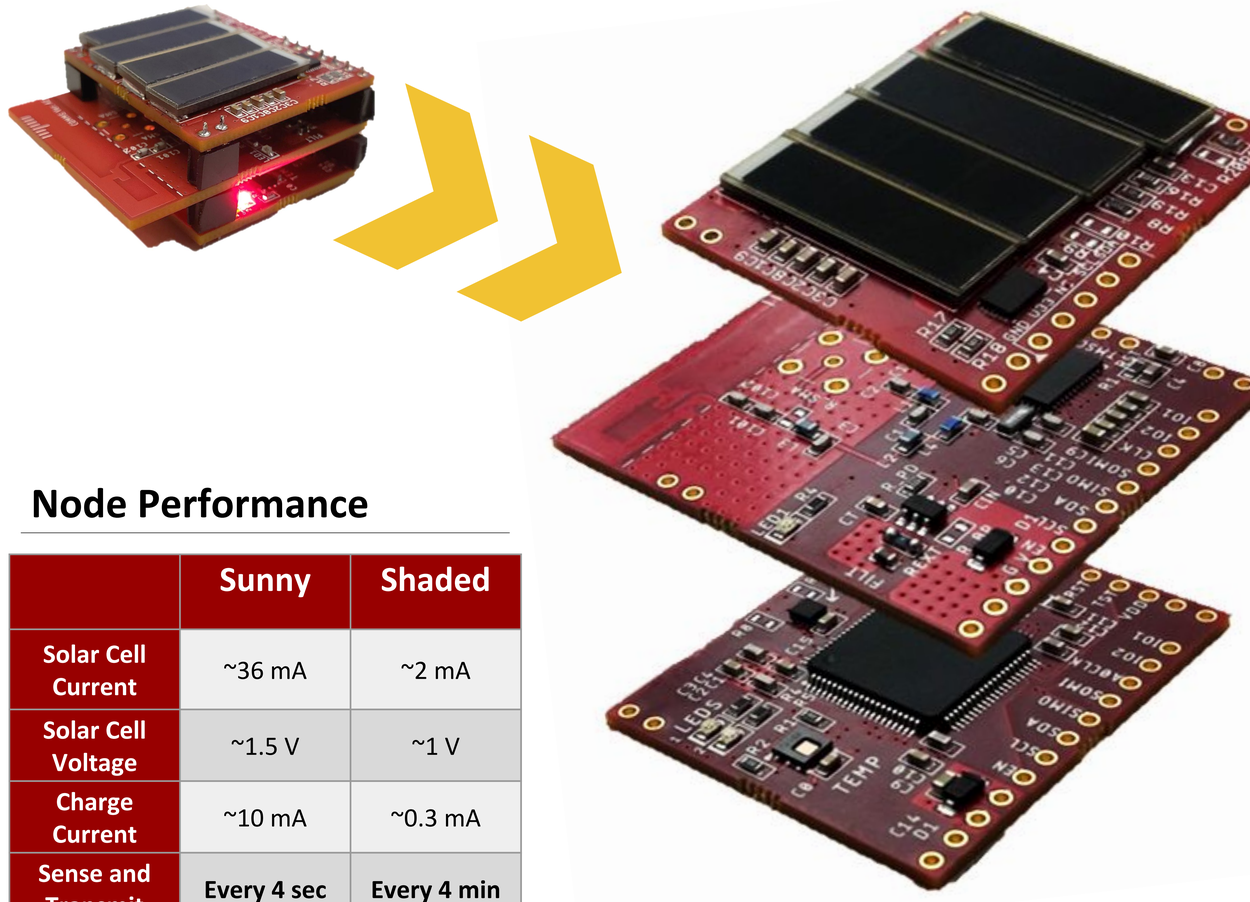
The Problem: Internet of Things (IoT) devices are becoming more prominent solutions to monitoring a wide array of environments. A powerful, flexible architecture is needed for these sensing devices.

Our Solution: We have created a **self-powered**, **modular**, and **compact** device that can easily be deployed in different environments, collect data from different sensor types, and **communicate** that data with other nodes in a **network**.

Design Criteria

	Our Design	
Modularity	Distinct energy harvesting, communications, and sensing modules	✓
Self-powered	Produces >12 mW in direct sunlight	✓
Networking Capabilities	Supports wireless transmitters with <30 mA peak current	✓
Sensing Capabilities	Supports sensors with <5 mA peak current	✓
Scalable (small)	40mm x 35mm x 20mm	✓

A Versatile Design for the Internet-of-Things Revolution



ENERGY HARVESTING BOARD

- Solar-powered 3.3 V output
- Small, high-capacity Li-Ion battery, for low-light intervals
- High-efficiency energy-harvesting battery charger
- Battery voltage tracker for dynamic power system management

WIRELESS COMMUNICATIONS BOARD

- Adjustable Wireless Transmission Schemes (Bluetooth, WiFi, ...)
- External power supply controlled by processor board
- Optional connection for higher range antenna
- Range: 119 meters

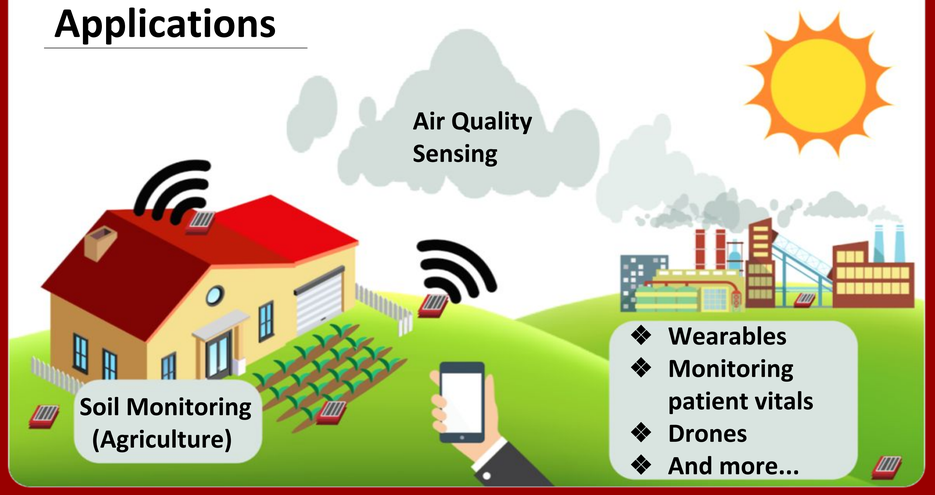
SENSOR BOARD

- Programmed to only acquire sensor data and transmit when there is sufficient power
- Retains programming and data during power loss
- Support for various sensor protocols (I2C, SPI, UART, …)

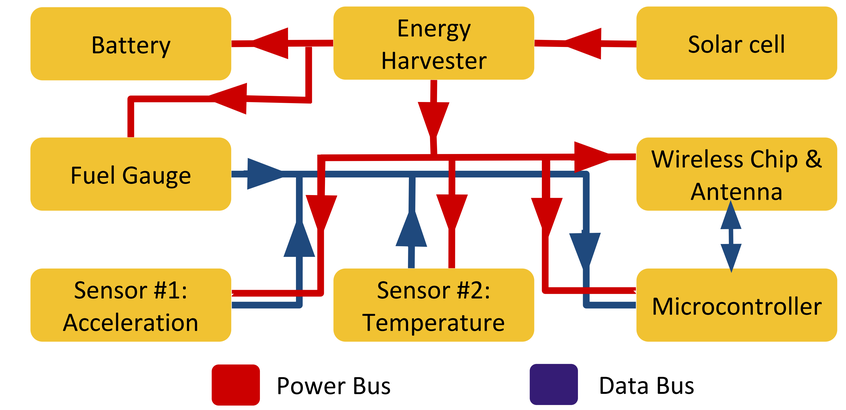
Node Performance

	Sunny	Shaded
Solar Cell Current	~36 mA	~2 mA
Solar Cell Voltage	~1.5 V	~1 V
Charge Current	~10 mA	~0.3 mA
Sense and Transmit	**Every 4 sec**	**Every 4 min**

Applications



System Diagram



Small Footprint, Huge Potential

Our design accomplished our primary goals of **versatility**, **modularity**, and **low-power**. Future work will involve developing node-to-node network protocols, robust power management techniques, and novel programming methods for a potentially pinless package. The CHARIoT node will be compressed into a System-in-Package, rapidly customizable for a variety of applications.

Acknowledgements

We would like to thank our faculty sponsors Gene Frantz, Erik Welsh, and Ray Simar, for their financial and technical assistance. Special thanks to Dr. Gary Woods for his invaluable guidance and mentorship.

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Modular IoT Node

We have created a **self-powered, modular,** and **compact** device that can easily be deployed in different environments, collect data from different sensor types, and **communicate** that data with other nodes in a **network**, all with **minimal redesign**.

Design Criteria

Criteria	Our Design	
Modularity	Distinct energy harvesting, communications, and sensing modules	✓
Self-powered	Produces >12 mW in direct sunlight	✓
Networking Capabilities	Supports wireless transmitters with <30 mA peak current	✓
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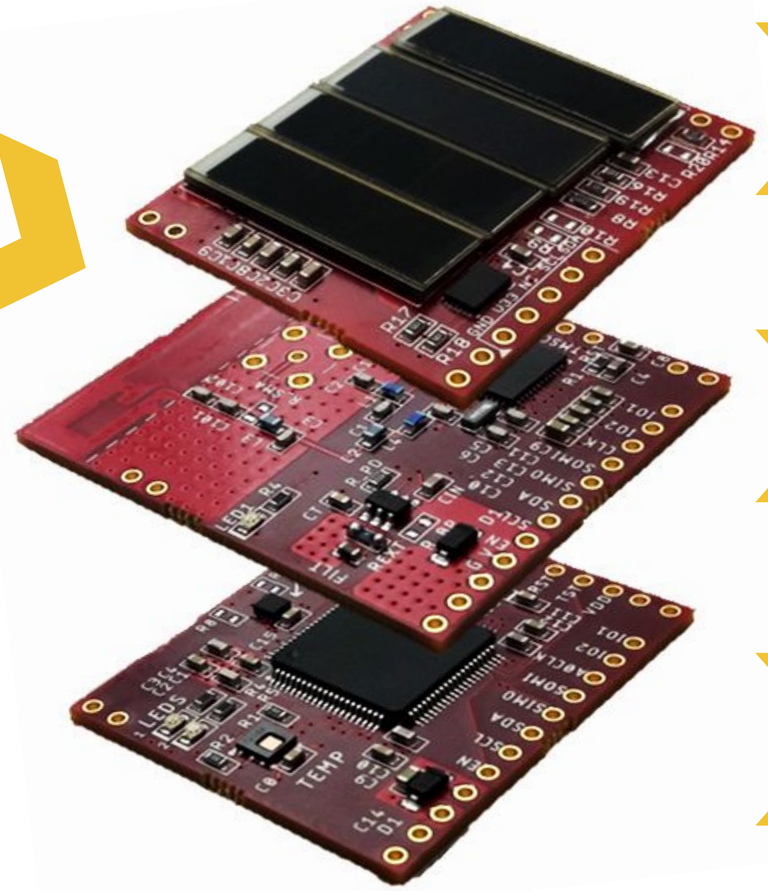
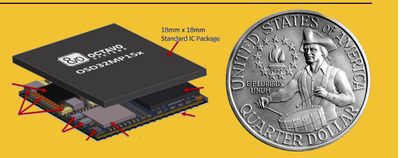
CHARIoT Node



Applications

- Industrial (VOCs)
- Health Care (Patient Vitals)
- Agriculture (Soil Quality)
- And more...

Scaling Down



The ultimate vision of this node encapsulates the entire design in a single System-in-Package (SiP) smaller than a quarter.

ENERGY HARVESTING BOARD

- 3.3 V and optional 5 V power rails
- Maximum power point tracking (MPPT) for efficient charging
- Battery charge tracking for dynamic sleep adjustment

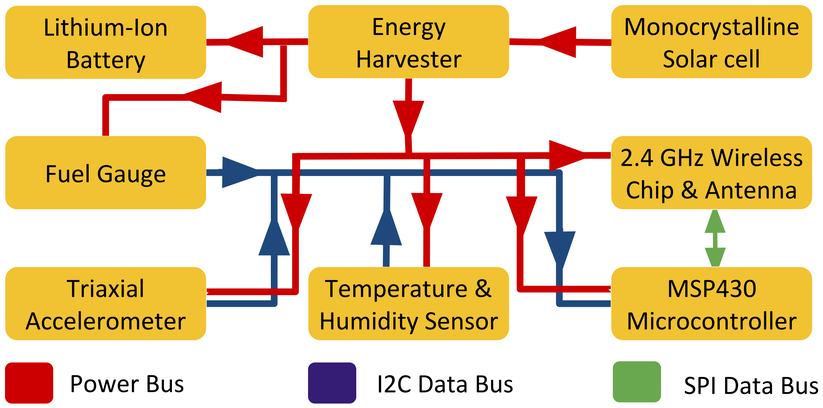
WIRELESS COMMUNICATIONS BOARD

- Adjustable 2.4GHz Transmission Schemes (Bluetooth, ZigBee, ...)
- External power control by processor board
- Optional SMA connection for higher gain antenna

SENSOR BOARD

- Multiple low-power modes
- Persistent program and data memory in case of power loss
- Support for I2C, SPI, and UART sensor protocols

System Diagram



Demonstrated Performance

Conditions	Charge Current	Time to Fully Charge Battery*	Sense and Transmit
Sunny	30 mA	5 hours	Every 3 sec
Cloudy/Shaded	5 mA	22 hours	Every 20 sec
Indoor (Direct Light)	5 mA	22 hours	Every 20 sec

*Dependent on weather and time of day

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