Energy-Driven Occupant Behaviour Sensing

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Outline

1 Motivation
- Occupant Behaviour Sensing
- Energy-Driven Systems

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   - Occupant Behaviour Sensing
   - Energy-Driven Systems
2. Challenges and Solutions
   - Intermittent Computing
   - Transient Networking
   - Node and Network Architecture

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   - Energy-Driven Systems
2. Challenges and Solutions
   - Intermittent Computing
   - Transient Networking
   - Node and Network Architecture
3. Case Studies
   - Example: Activity Recognition on WISP

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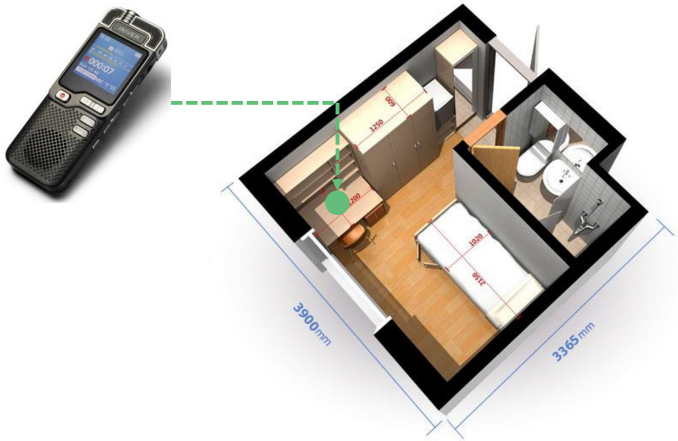
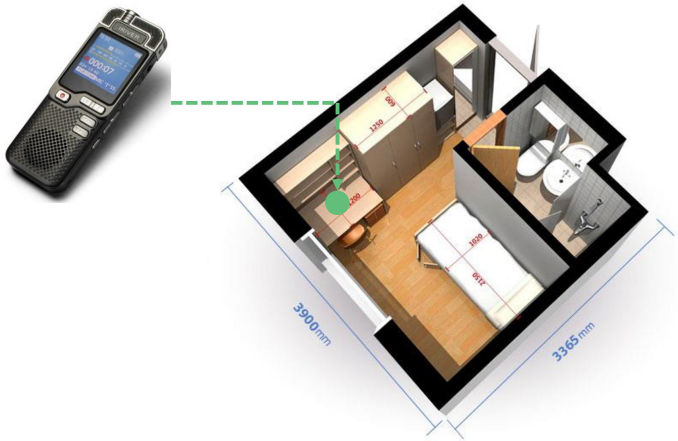
- Embedded sensors for quality data.

Examples



- (Kim et. al. 2020)
- Uses a voice recorder.
- Privacy concerns?

Examples



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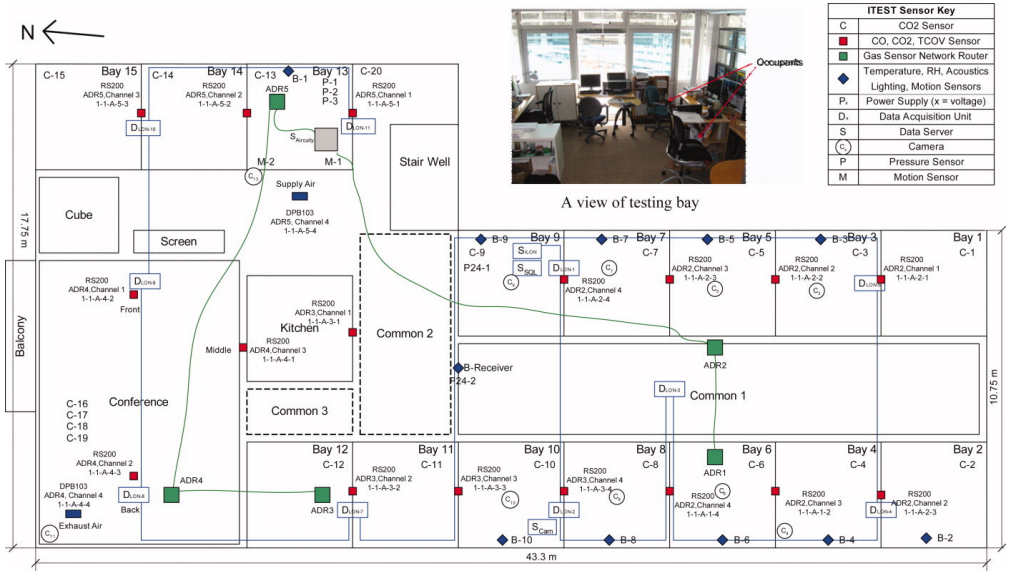

A view of testing bay

ITEST Sensor Key	
C	CO2 Sensor
	CO, CO2, TCOV Sensor
	Gas Sensor Network Router
	Temperature, RH, Acoustics Lighting, Motion Sensors
P,	Power Supply (x = voltage)
D,	Data Acquisition Unit
S	Data Server
C,	Camera
P	Pressure Sensor
M	Motion Sensor

- (Dong et. al. 2011)
- Heterogeneous network of sensors.
- Cost of Maintenance?

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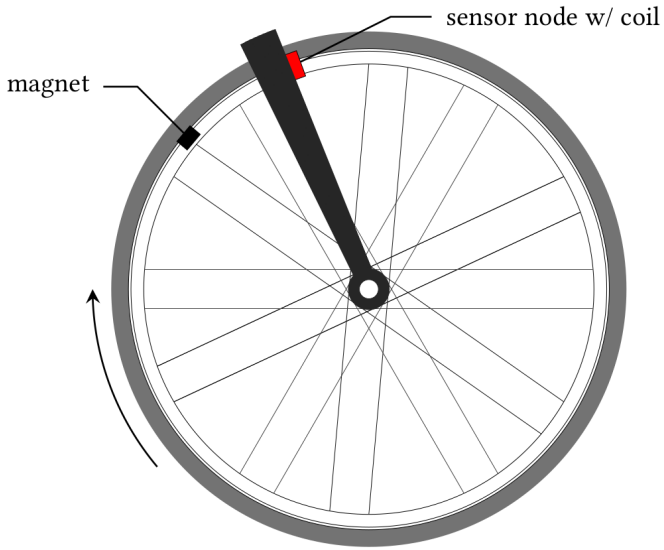
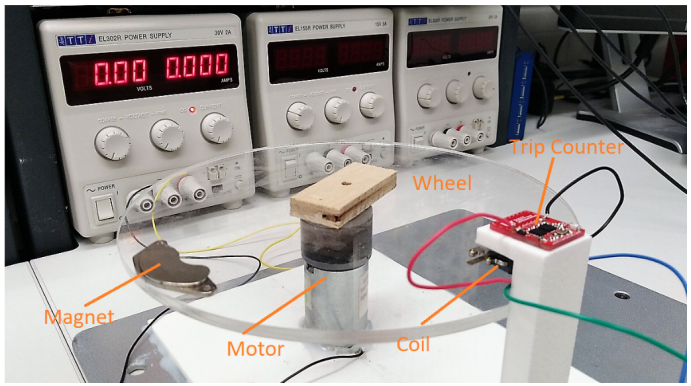
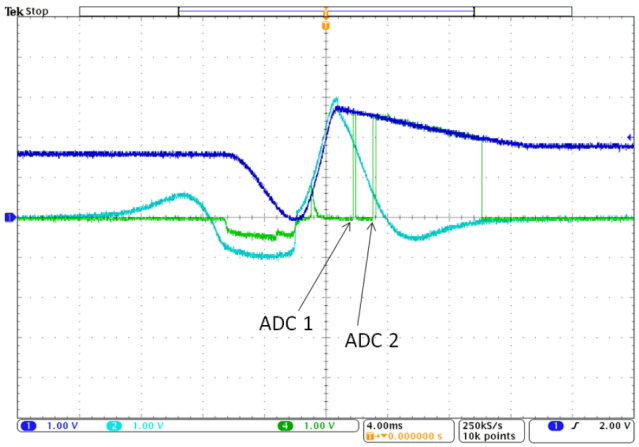
- Extra dimension for design trade offs.
- Instead of adding a harvester to prolong battery life, design around the harvester such that application requirements can be met. Maybe that battery is not required?

Example

A battery-less cycle computer. (Wong et. al. 2018)

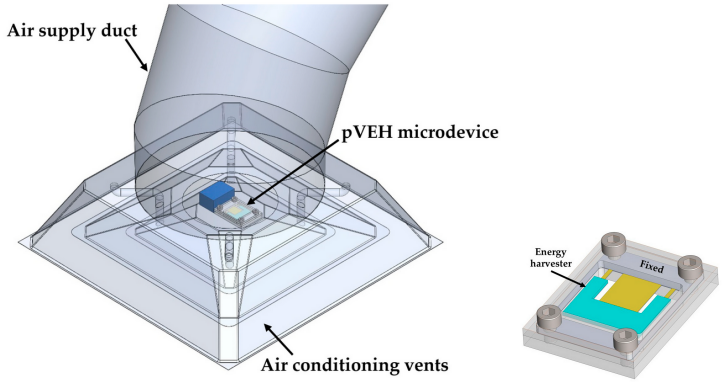






- 2.4 GHz wireless link.
- No batteries required.
- Shape of pulse used to determine angular velocity.

Indoor Energy Sources



(Ernesto et. al. 2019)

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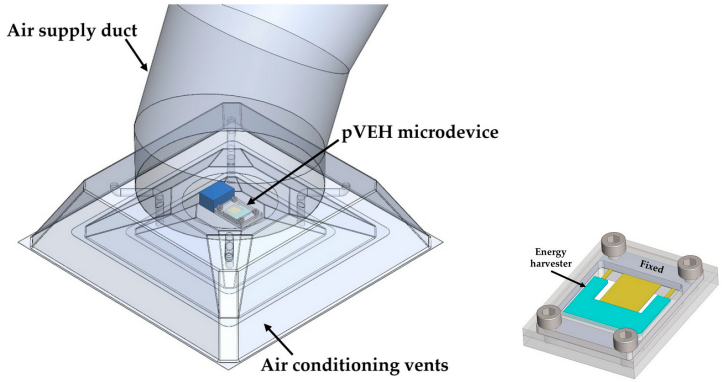

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(Pavegen.com)

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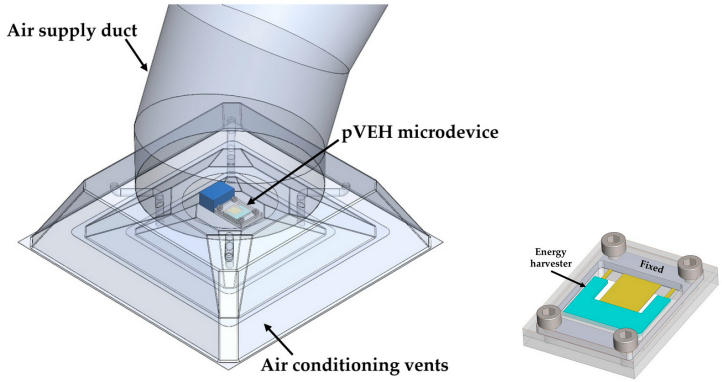

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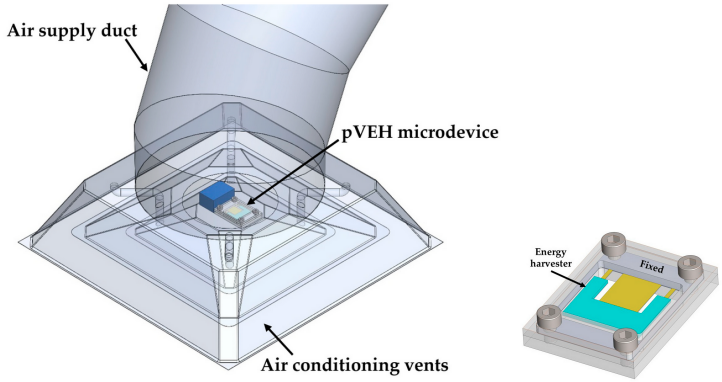

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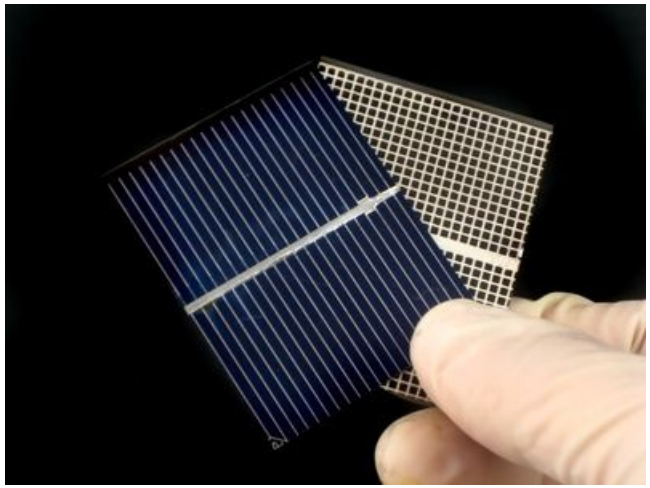

(solar)

Intermittent Computing

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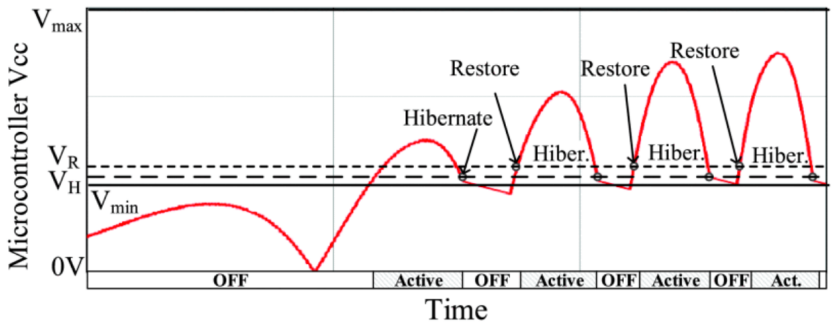
Solution - *quite mature, focus is on efficiency*

Sustain computation through intermittent power cycles using checkpoints or other schemes with the goal of maximizing forward progress in the compute task.



(Balsamo et. al. 2015)

Transient Networking

Problem

1. Nodes go offline intermittently. Clocks go out of sync.
2. Energy availability vary among nodes in the network.

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Solutions/Proposals

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3. Energy-aware networking/routing protocol.

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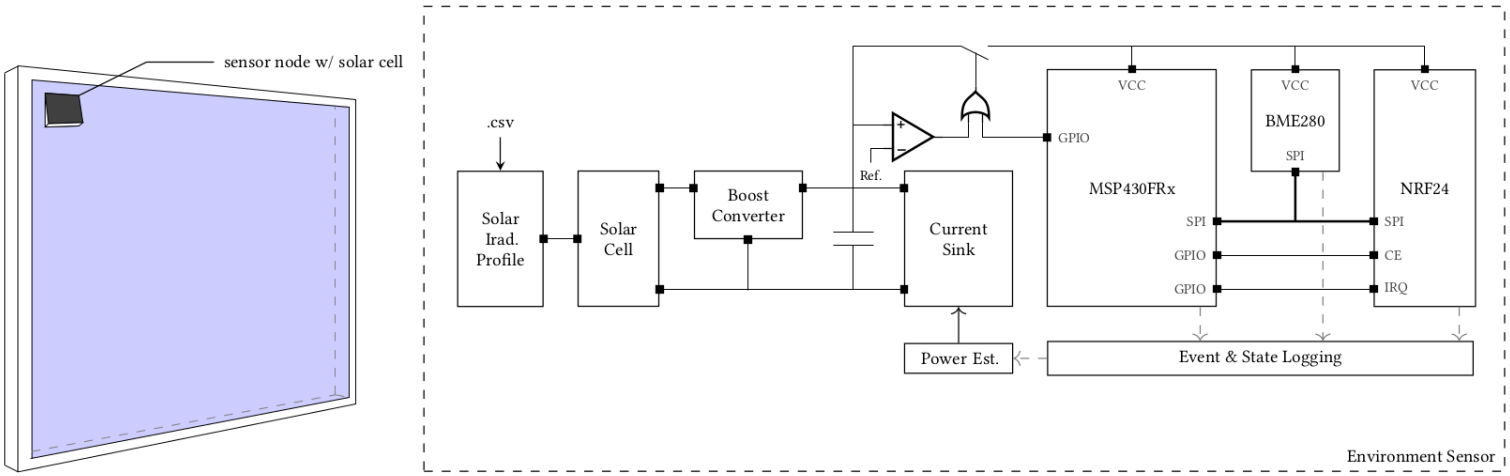
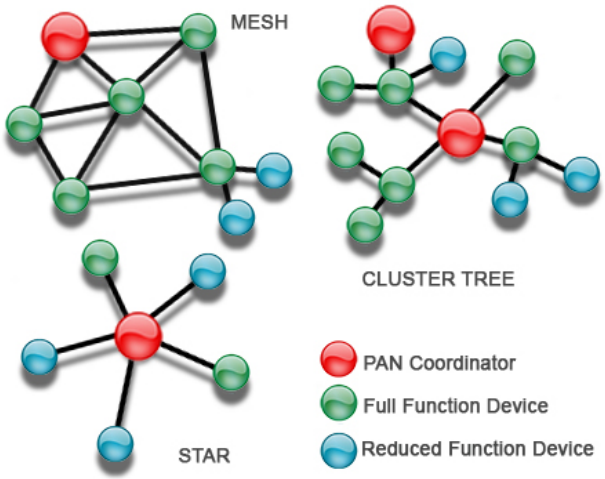
Complications/Motivation: IoT

Internet Protocol on Energy-Driven nodes? Security?

Node and Network Architecture

UNIVERSITY OF Southampton





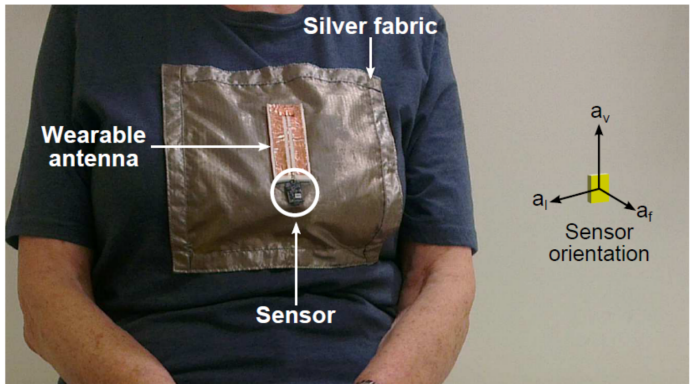
(icpdas-usa.com)

	IETF IoT Protocol Stack	TCP/IP Protocol Stack
Application Layer	IETF COAP	HTTP, FTP, DNS, SSH, SMTP, NTP, ...
Transport Layer	UDP	TCP, UDP
Network Layer	IPv6, IETF RPL	IPv4, IPv6
Adaption Layer	IETF 6LoWPAN	N/A
MAC Layer	IEEE 802.15.4 MAC	Network Access
Physical Layer	IEEE 802.15.4 PHY	

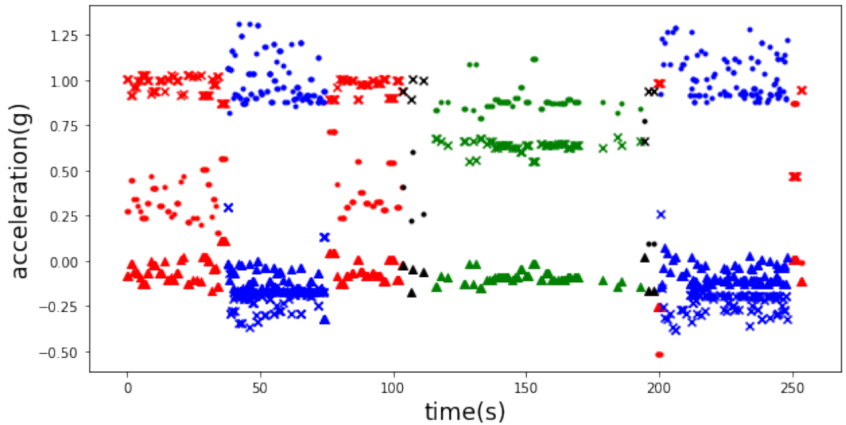
(Lin et. al. 2016)

Example Application

Activity recognition from WISP accelerometer measurements.



- Sensor data and image from (Wickramasinghe et. al. 2017)
- WISP is a battery-less RF powered tag.
- Type of activity can be discerned easily from the sparse accelerometer data.



	Train	Test
Sit on Bed Precision	0.99	0.97
Sit on Bed Recall	1.0	1.0
Sit on Chair Precision	0.98	0.96
Sit on Chair Recall	0.95	0.92
Lying Precision	1.0	1.0
Lying Recall	1.0	1.0
Ambulating Precision	0.98	1.0
Ambulating Recall	0.95	0.9

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