EnerHarv 2024

PSMA International Workshop | 26-28 June, 2024 | Perugia, Italy

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EnerHarv 2024 Workshop:

CONNECT – Energy Research for Sustainable IoT solutions

Presented By –

Valeria Nico, Dr

School of Engineering, University of Limerick

valeria.nico@ul.ie

Thursday, June 27, 2024

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OVERVIEW

- **CONNECT Centre – Who we are**
- **Sustainable IoT working group**
  - Vibrational energy harvesting
  - Sustainable energy storage for IoT
  - Energy optimization
  - Energy Harvesting Testbed
- **Conclusions**

CONNECT Centre in NUMBERS

Ireland's **6G** Research Centre

€129M Funding
2015-2026

11 Universities and Research Centres

83 Principal and Funded investigators

36 Large companies

15 SMEs

5 Local Councils

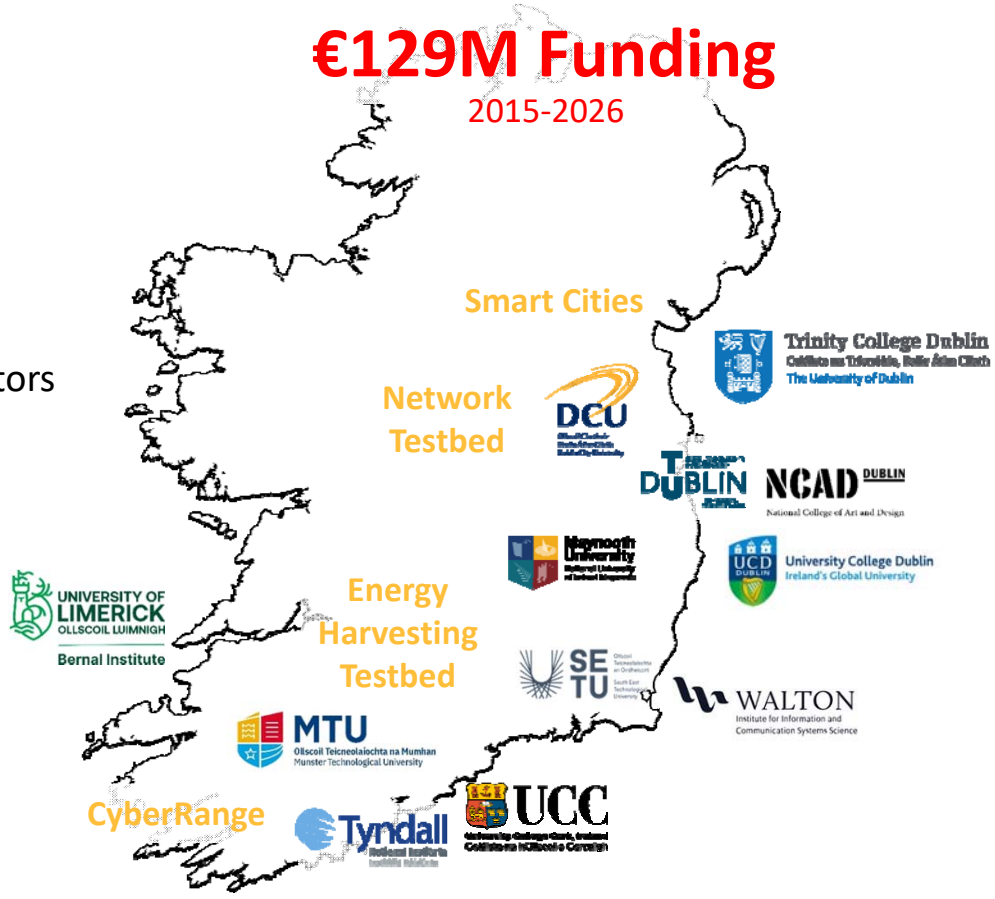
9 Research Themes

2293 Papers

4 Large Research Infrastructure

127 PhD students

9 Spin out companies



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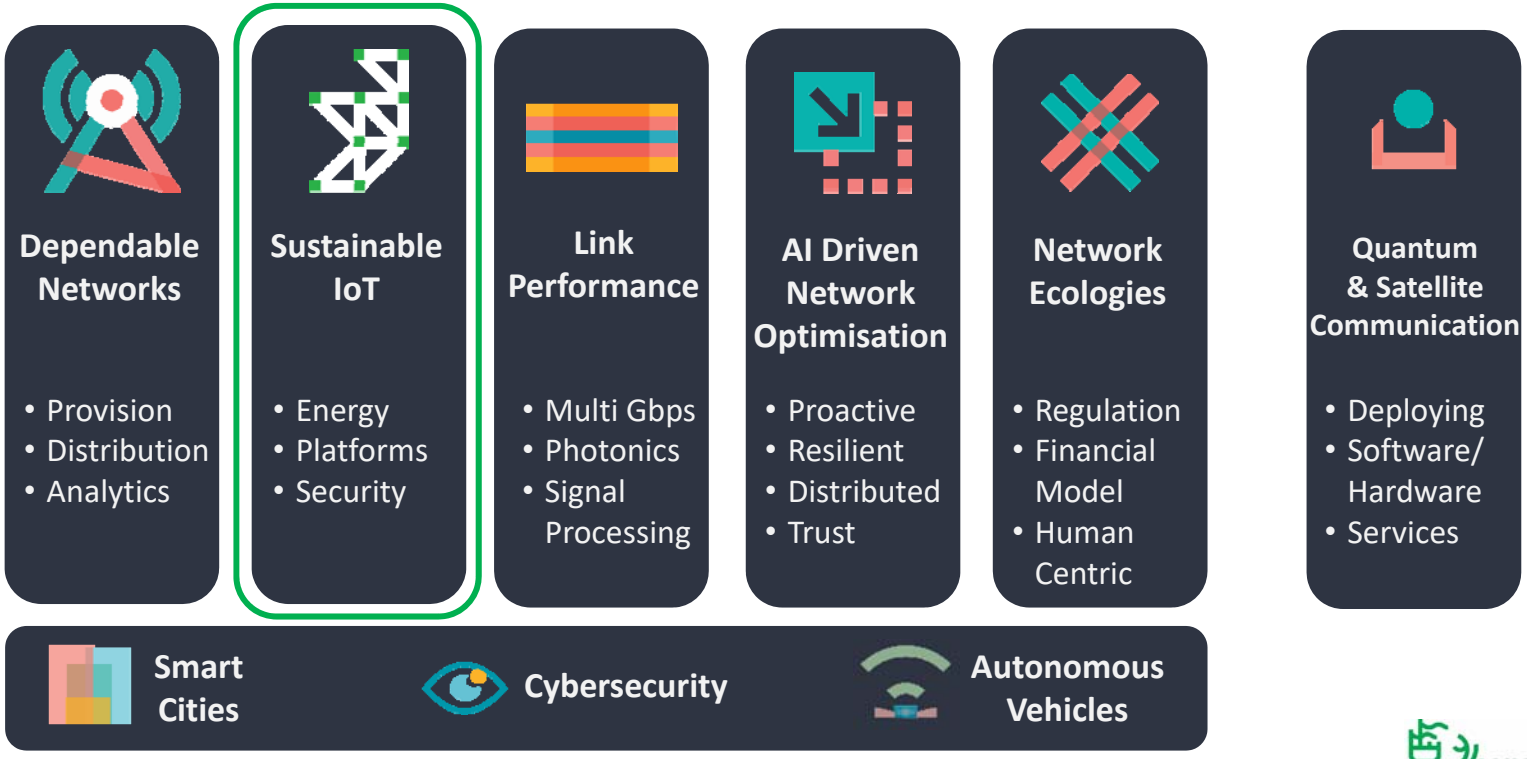
CONNECT Centre for Future Networks & Communications



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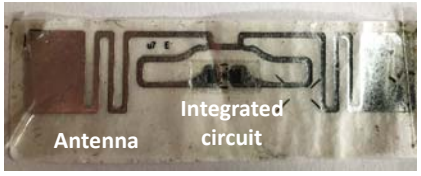
Sustainable IoT

Copilot Designer, AI generated

~ **30 billion** of IoT connected devices will be deployed by 2030

METI Convenience Store RFID Initiative (Japan): 100 billion RFID tags per year by 2025

1-9 million tonnes eq. CO_2 just to fabricate microchips



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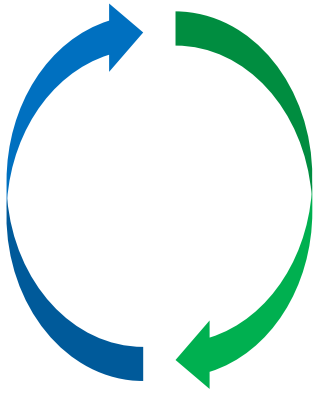
Sustainable IoT – Mission (Aidan Quinn, Connect Review 2023)

Develop resource-efficient fabrication, deployment and usage of **smart sustainable sensors** for “Edge of the Edge” Network

Co-optimisation



Maximise:

- Performance
- Security

Minimise

- Resources (including Energy)
- Cost
- Environmental Footprint Impacts
  Greenhouse Gases, Toxicity (Human, Eco)
  Ozone depletion, particulates *etc.*

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Platform Projects

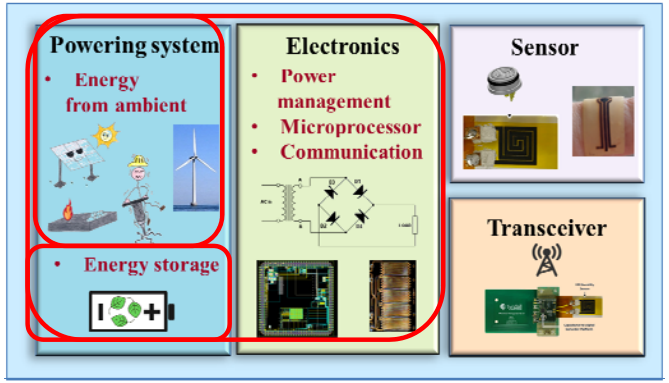
Energy

Planar Vibrational Energy Harvesting for eSIP (Valeria Nico)

Sustainable Micro Battery (James Rohan)

Energy Source In Package (eSIP) (Mike Hayes)

Energy Harvesting WSN Test Bed (Mike Hayes)



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Reconfigurable platforms

- Bayesian Theory for IoT Devices (Indrakshi Dey)
- UWB Transceivers for IoT (Somayeh Mohammady)
- Modelling Compostable Antennas (Adam Narbudowicz)
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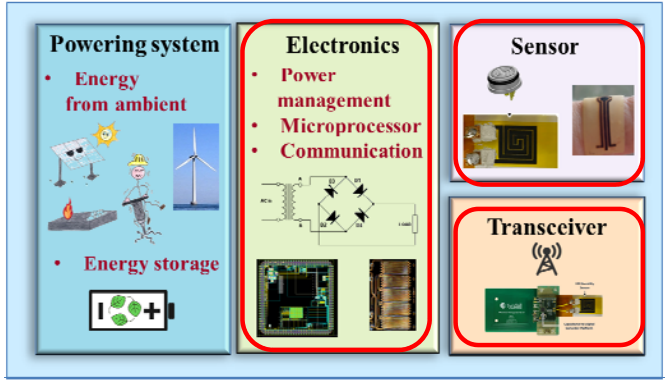


Security & Resilience

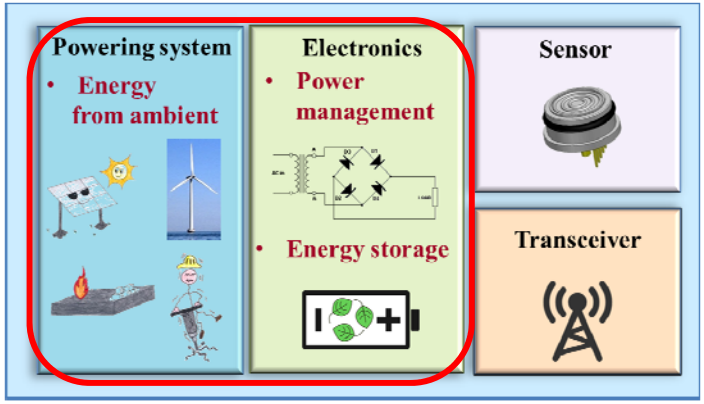
- WG9 Zero Trust for IoT (Donna O'Shea)
- WG9 Adaptive Privacy-preservation in IoT (Paolo Palmieri)
- WG9 AI enabled cybersecurity of UAVs in 6G (Bernard Butler)
- Resilient and Dependable Systems (Roedig, Sreenan, Pesch)

Sustainable IoT - Energy

OUR CHALLENGE

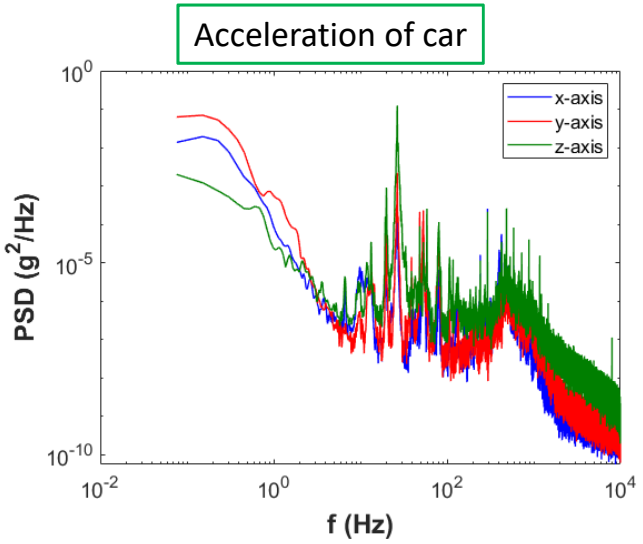
Provide a **sustainable energy** source to the billions of sensors forming the IoT:

- Recover **ambient energy** (vibration, thermal)
- Develop **sustainable batteries** for energy storage
- Minimise **energy consumption** of the sensor node
- **Optimise** how energy is used



Vibrational Energy Harvesting

Ibnu Taufan, Nouman Ghafoor, Jeff Punch, Valeria Nico, University of Limerick



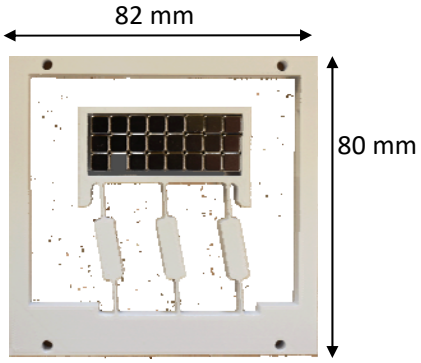
Challenge: to harvest energy from real-world **multi-axial** vibrations

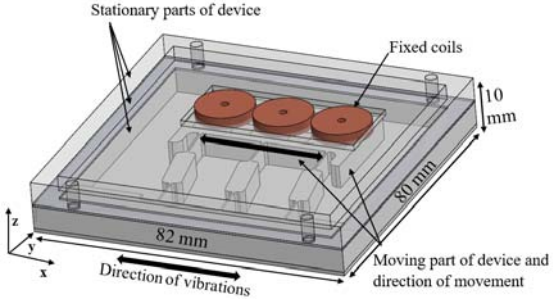
Hybrid Planar Electromagnetic and Out of plane Piezoelectric Energy Harvesting

Vibrational Energy Harvesting

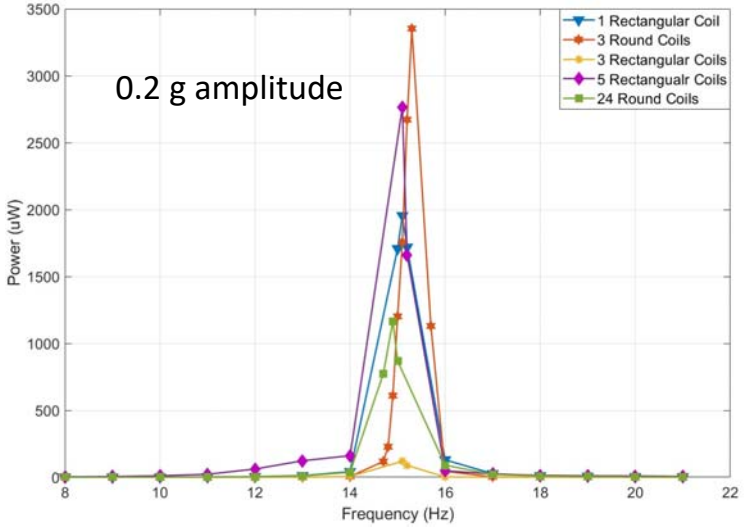
Nouman Ghafoor, Jeff Punch, Valeria Nico, University of Limerick

PLANAR Electromagnetic VEH





Assembly



Up to **3.35 mW** generated from an acceleration amplitude of **0.2g***

**For more information, check our poster*

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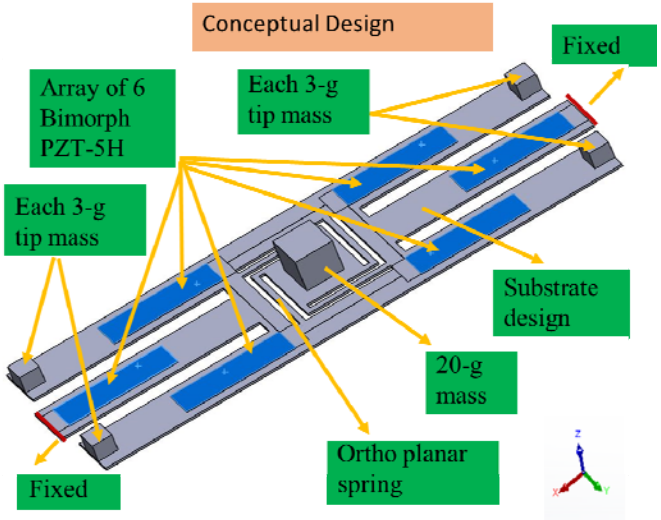
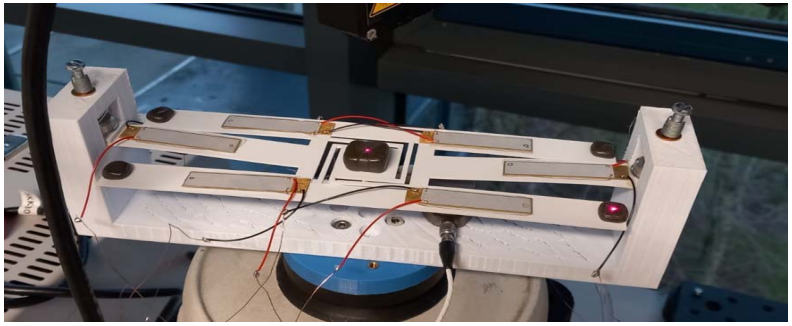
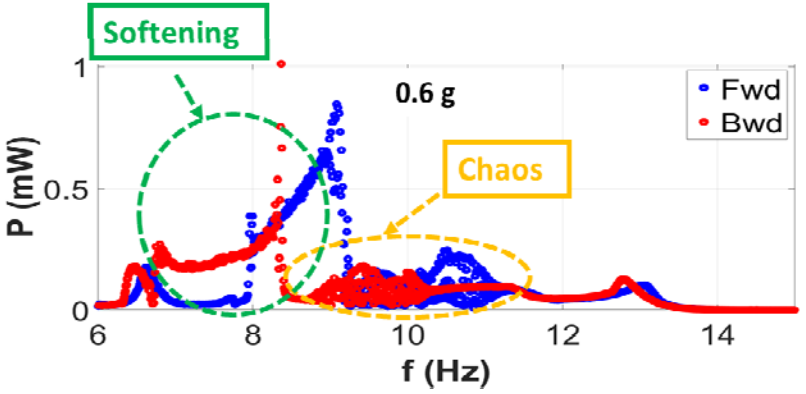
Vibrational Energy Harvesting

Ibnu Taufan, Jeff Punch, Valeria Nico, University of Limerick

Out-of-Plane piezoelectric VEH







**For more information, check our poster*

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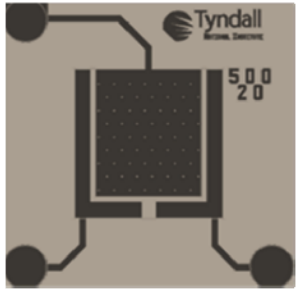
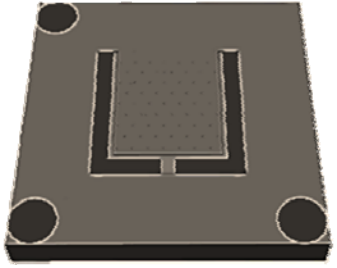
Sustainable Energy Storage for IoT

Neil Curtis, James Rohan, Tyndall National Institute

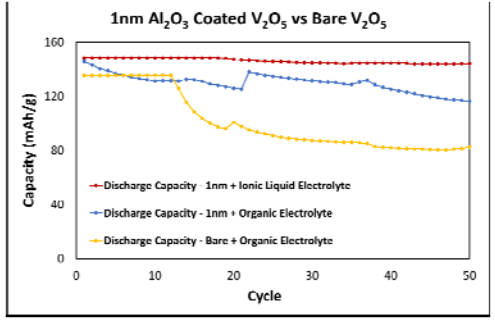
Tyndall National Institute
Institiúid Náisiúnta

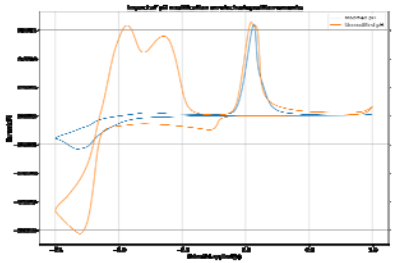
Microelectrode arrays for faster materials analysis

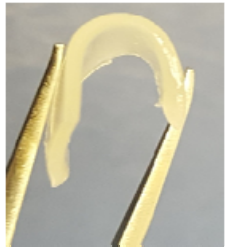




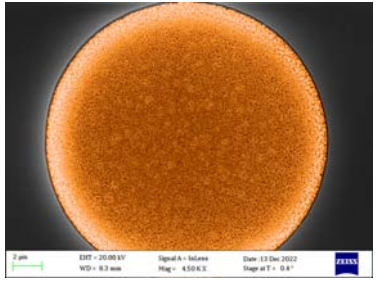
Sustainable materials for energy storage with reduced environmental impact

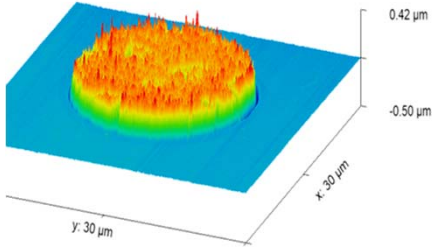






Nanoporous copper for enhanced nucleation and cycle life with Li metal anodes





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Evaluate Energy Efficiency in Low Power Pulse Signals

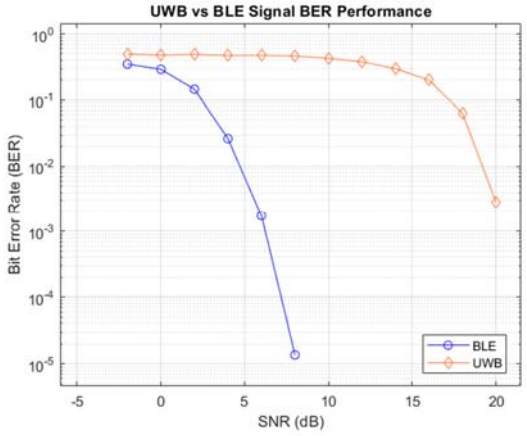
Yousef Sultan[1], Sachin Sharma[1], Liam Barry,[2] Somayeh Mohammady[1], [1] TuDublin, [2] DCU

Objective:
Highlight the importance of BER and SNR for energy efficient communications

Key Findings:
- Both show a positive trend towards lower BER with increasing SNR.
- UWB achieves optimal performance at higher SNR due to its broad bandwidth
- BLE shows lower BER at lower SNR, indicating better performance

Applications:
- Healthcare
- Manufacturing
- Environmental Monitoring

Future Work:
- UWB for crowd management
- UWB for emergency communications
- UWB for the assistance of the elderly



Energy Optimisation – Bayesian Theory for IoT Devices

Nirmal Wickraminsinghe, Indrakshi Dey, Walton Institute

Auction model for Optimal Resource Allocation

- An extended version of Bayesian Game theory for games with incomplete information.
- Auction Model: $A_G = < M, N, V, P, B, U >$

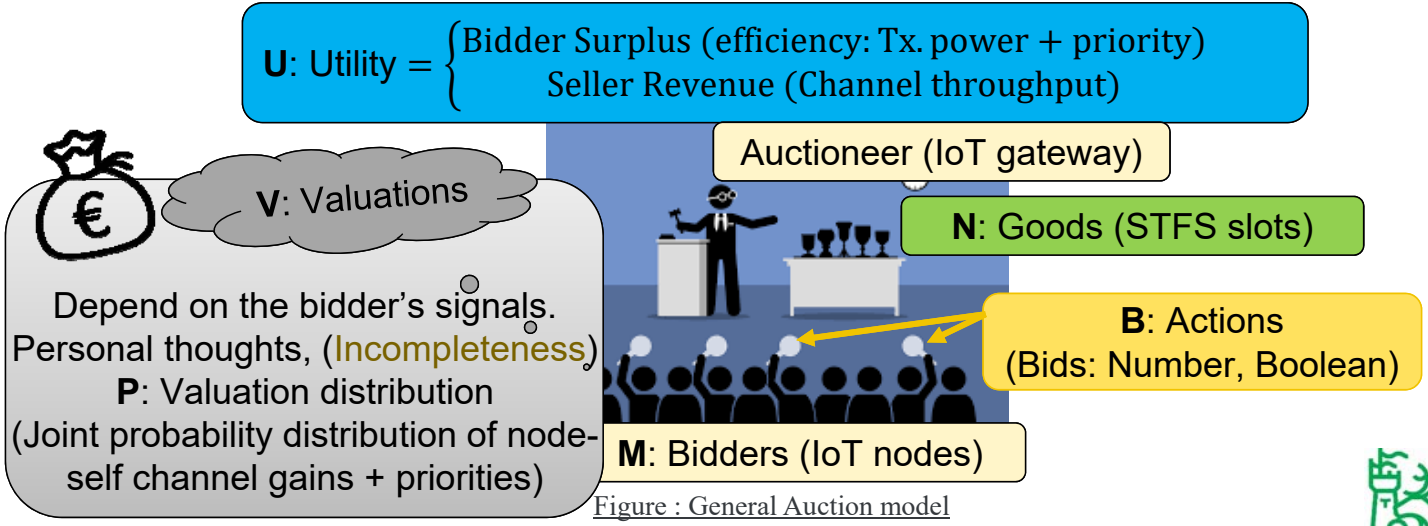
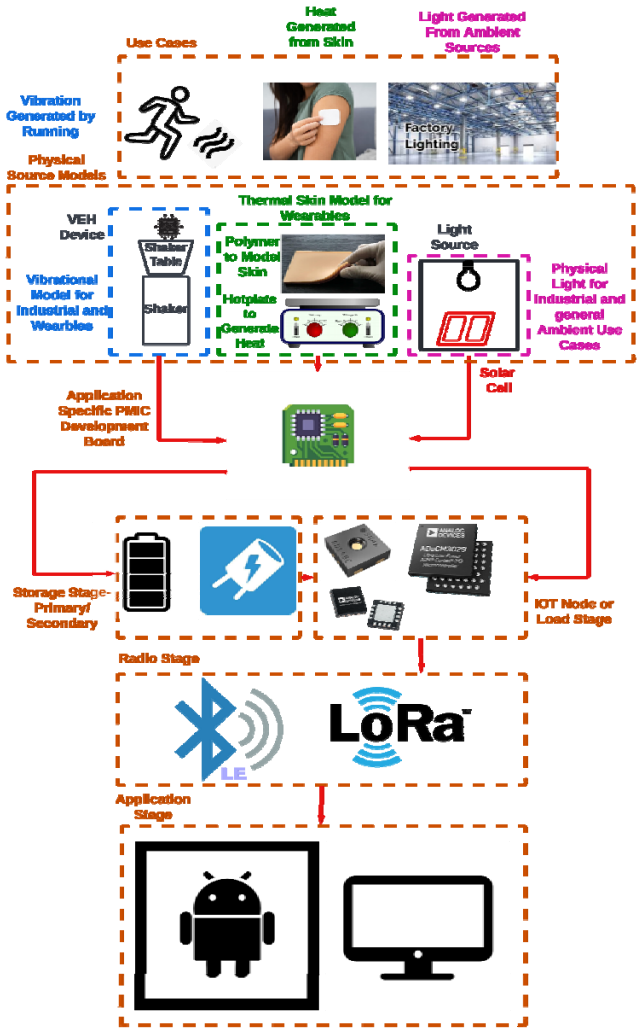


Figure : General Auction model

Energy Harvesting Testbed

Eoin Ahern, Mario Costanza, Prateek Asthana, John Flannery, Mike Hayes
Tyndall National Institute

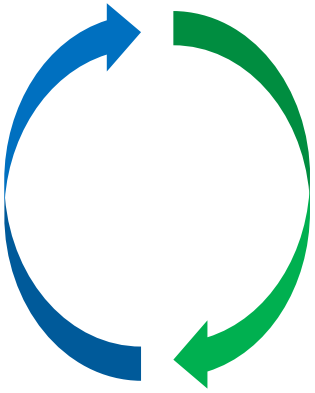
- Energy-Harvesting Powered Wireless Sensors to Cloud Application
- Incorporating Sensor technology, Wireless Communication, Power Storage and Management
- Aim to Provide Applications for Energy Harvesting Tech Developers, and Energy Harvesting Tech for Application Developers



Conclusions

We develop **smart sustainable sensors** for “Edge of the Edge” Network

Co-optimisation



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Q & A

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Thanks very much for your time and attention!

Questions/comments???

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IEEE ELECTRONICS PACKAGING SOCIETY

UBIGIoT

LoLiPoP-IoT Energy Harvesting An EPSRC Funded Network

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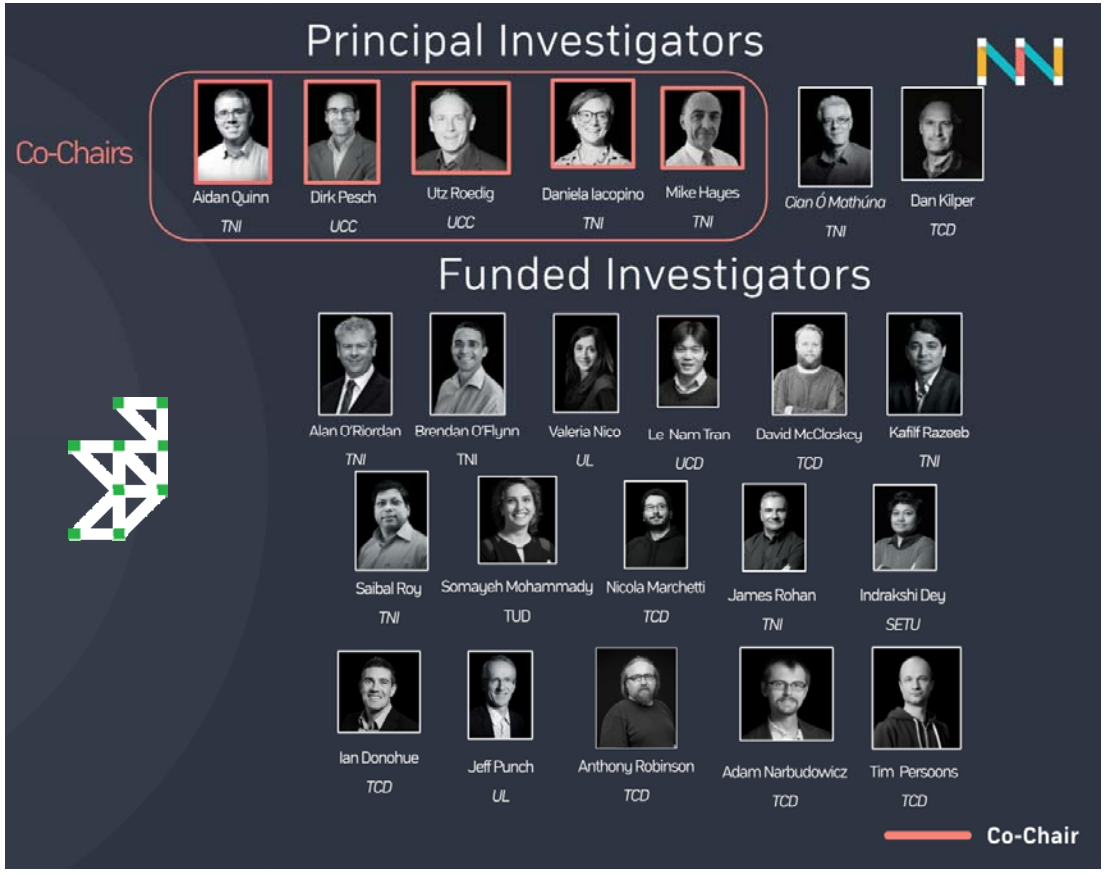
Sustainable IoT – who we are



7 Principal Investigators

5 Co-chairs

16 Funded Investigators

24 Projects

12 Platform projects

4 Industry projects

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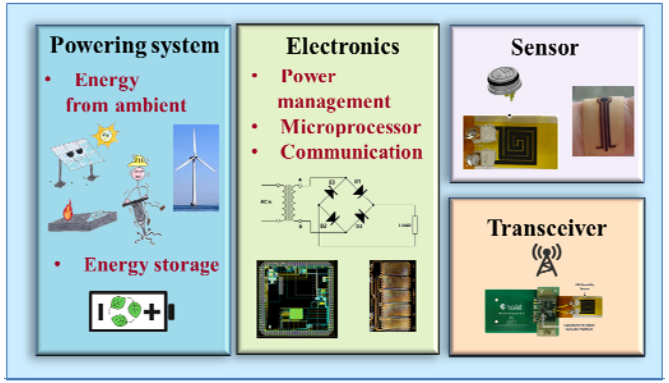

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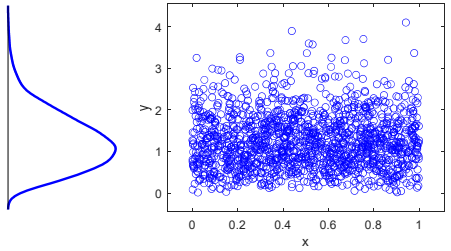
Energy Optimisation – Bayesian Theory for IoT Devices

Nirmal Wickraminsinghe, Indrakshi Dey, Walton Institute

- **IoT-** Game changing technology that enables the interconnection of heterogeneous devices.
- Challenges for resource allocation:
  - IoT nodes should be in low **SWaP**.
    - Small Size, Weight, and Power.
  - Spectrum.
  - QoS - Quality of Service.
  - M-ary **Hypothesis**, $H_i: i\epsilon\{0, \cdots, M-1\}$.
  - **Energy Efficiency*** (long-life battery).
- Goal: Implement new methods to handle and integrate computing resources within massive IoT networks via distributed decision-making approaches.

Rayleigh distribution: Small scale **channel fading**



Uniform distribution: **Priority** assignment

Figure: Joint distribution for node-self priorities with channel gain

[YOUR LOGO]