Sensor Networks for Ambient Intelligence and Smart Environments

Boon-Chong Seet

AUT UNIVERSITY

Senior Lecturer (ATB), PhD
Department of EEE

Who I Am

- Education:
  - PhD in Computer Engineering (mobile networks) from NTU, Singapore (ranked #39 by QS), 2005
  - Held Postdoc positions @:
    - NUS (Singapore): *adaptive location-aware computing*
    - UPM (Spain): *wireless sensor networks (WSN)*
- Research:
  - WSN and related areas over the last 7 years
  - 70+ refereed publications (> 25 in ISI-indexed journals)
  - Graduated 3 PhD students in WSNs (2014)

AUT UNIVERSITY

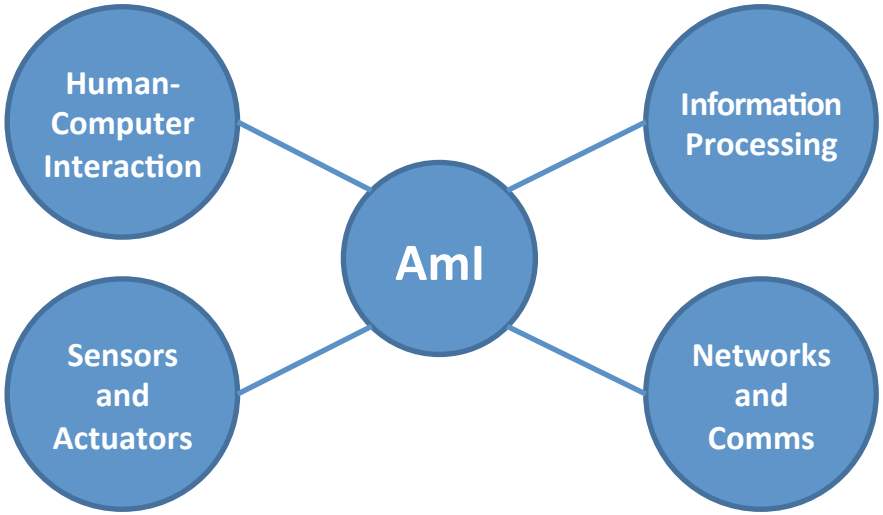
Introduction

- Sensor Network
  - A network of cooperative smart sensors equipped with *sensing*, *computing*, and *communication* capabilities
  - Sensor data is the basis of intelligence for higher-order cognitive systems, i.e. systems that perceive, reason, learn, and respond intelligently to their environment
  - Critical enabling technology of *Smart Environments*
    - *Smart buildings; Smart highways; Smart grids; Smart farms; Smart cities, etc.*

AUT UNIVERSITY

Introduction

- Ambient Intelligence (AmI)
  - Is a smart environment that is sensitive and responsive to the presence of *people*
  - Focus on *human-centric* applications that support people in their everyday activities



AUT UNIVERSITY

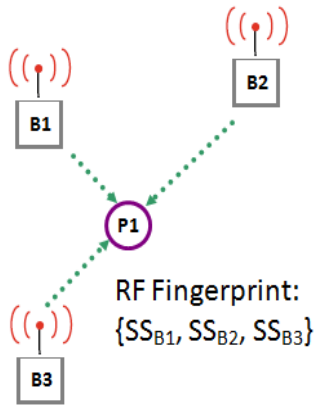
Completed Projects

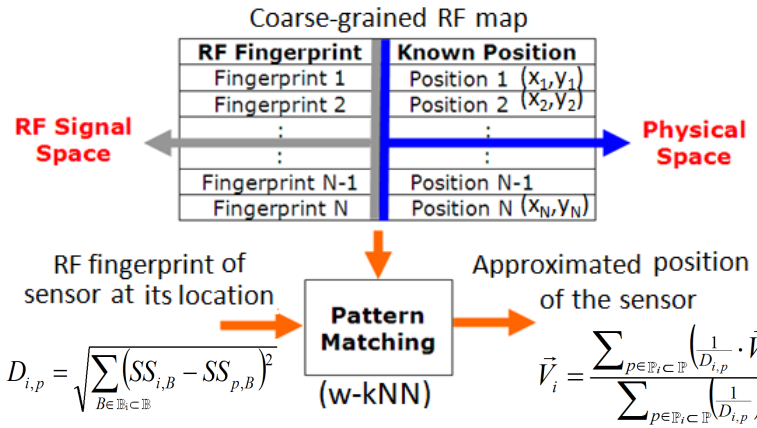
- Positioning
  - RF mapping and spring-relaxation based sensor localisation
- Networking
  - AmI-context aware cross-layer network optimisation
- Communications
  - Wavelet-based OFDM with virtual MIMO for multimedia WSNs
- Security
  - Image and video watermarking for multimedia WSNs
- Related projects
  - BIM for smart powered buildings
  - RFID tag for water flow monitoring
  - Smart sock (smart textiles)

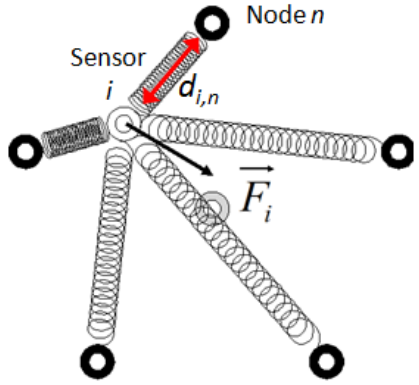
AUT UNIVERSITY

Exemplar (1)

- RF mapping and spring-relaxation based sensor localisation





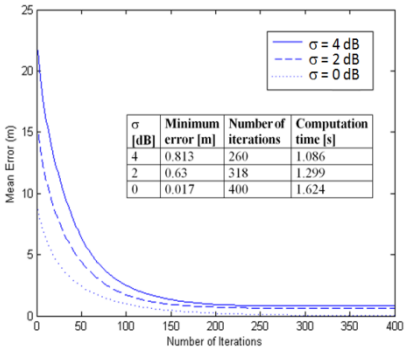


$$\vec{F}_{i,n} = \left(d_{i,n} - \left\|\vec{V}_i - \vec{V}_n\right\|\right) \times \mu\left(\vec{V}_i - \vec{V}_n\right)$$

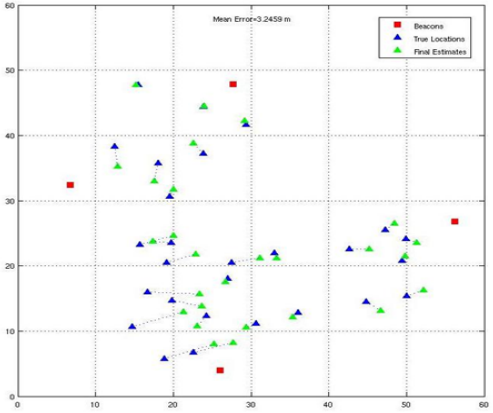
$$\vec{F}_i = \sum_{n \in \mathbb{B} \cup \mathbb{S}} \vec{F}_{i,n}$$

$$\vec{V}_i \leftarrow \vec{V}_i + \delta \cdot \vec{F}_i$$

Location refinement via spring-relaxation method



σ [dB]	Minimum error [m]	Number of iterations	Computation time [s]
4	0.813	260	1.086
2	0.63	318	1.299
0	0.017	400	1.624

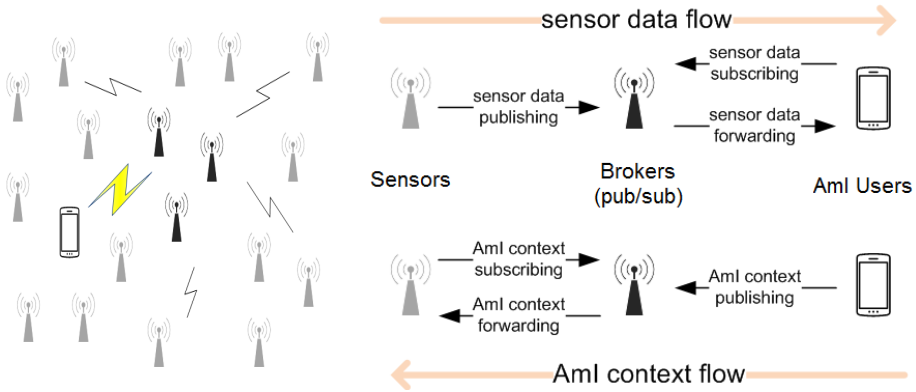


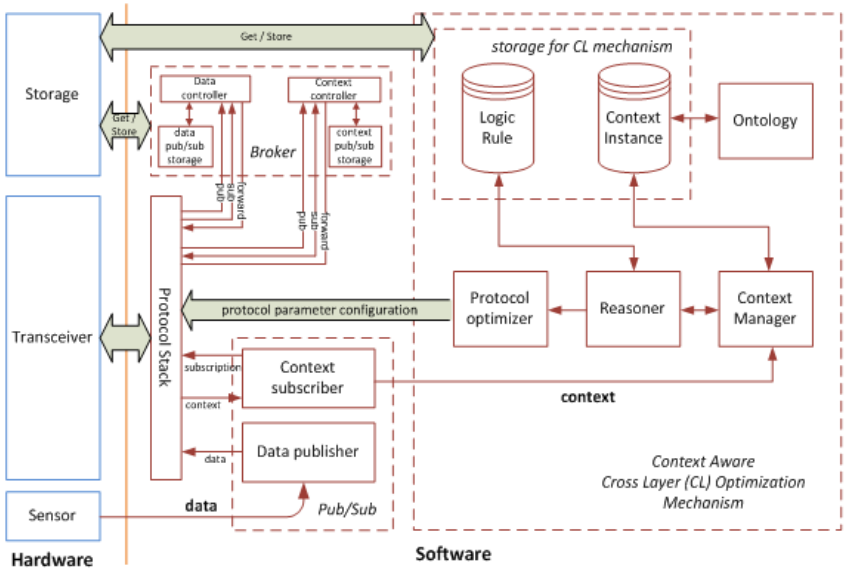
B.-C. Seet, Q. Zhang, C. Foh, A. Fong (2012). Hybrid RF Mapping and Kalman Filtered Spring Relaxation for Sensor Network Localization. *IEEE Sensors Journal*, 12(5): 1427-1435. (ISI impact-factor: 1.52)

AUT UNIVERSITY

Exemplar (2)

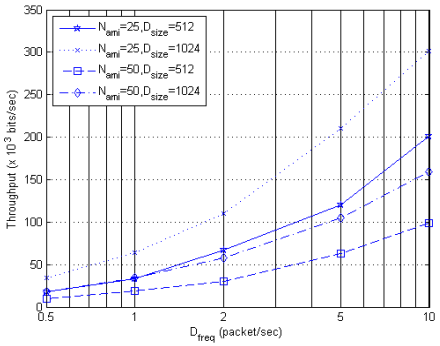
- AmI-context aware cross-layer network optimisation

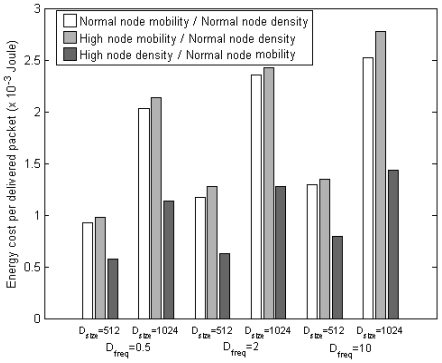




Set	NET Layer Protocol	MAC Layer Protocol
1	AODV	CSMA/CA
2	AODV	DR-MAC
3	AODV	DR-MAC (context-aware)
4	DAAM	CSMA/CA
5	DAAM	DR-MAC
6	DAAM	DR-MAC (context-aware)
7	DAAM (context-aware)	CSMA/CA
8	DAAM (context-aware)	DR-MAC
9	DAAM (context-aware)	DR-MAC (context-aware)

	Performance Ranking								
Performance Metric	1st	2nd	3rd	4th	5th	6th	7th	8th	9th
Throughput	Set 9	Set 8	Set 6	Set 7	Set 3	Set 5	Set 4	Set 2	Set 1
PDR	Set 9	Set 8	Set 6	Set 7	Set 5	Set 3	Set 4	Set 2	Set 1
End-to-end delay	Set 9	Set 6	Set 8	Set 7	Set 3	Set 5	Set 4	Set 2	Set 1
Control frames/packets	Set 3; Set 2; Set 1			Set 9; Set 6; Set 8; Set 7; Set 5; Set 4					
Energy efficiency	Set 3	Set 2	Set 9	Set8	Set 6	Set 5	Set 7	Set 1	Set 4

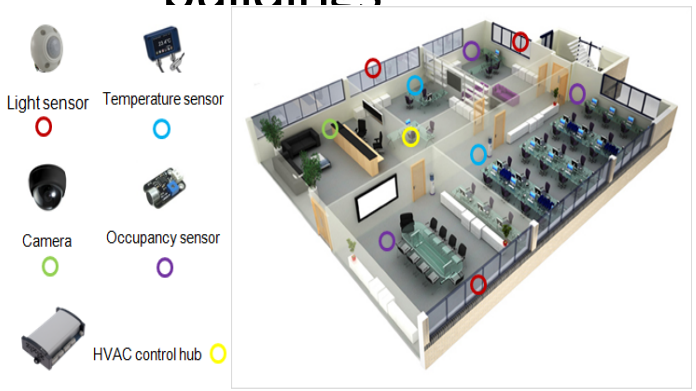


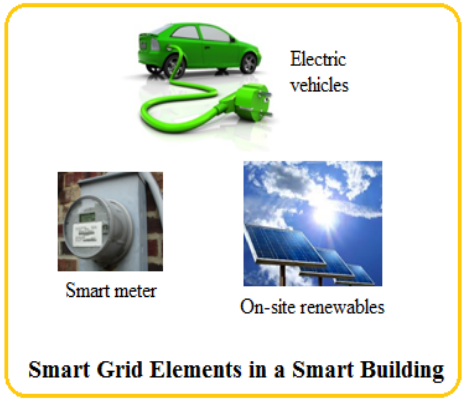


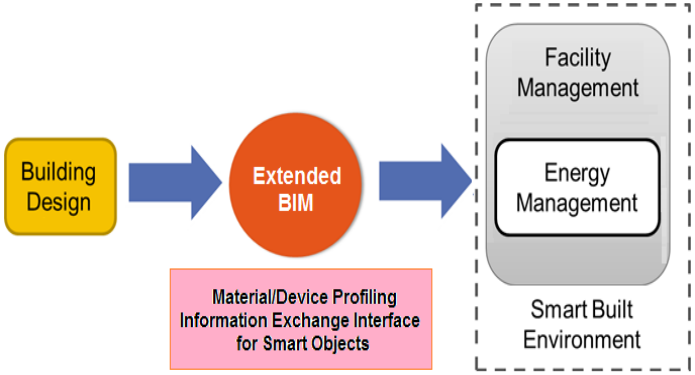
Y. Liu, B.-C. Seet, A. Al-Anbuky (2014). Ambient Intelligence Context-Based Cross-Layer Design in Wireless Sensor Networks. *Sensors*, 14(10): 19057-19085. (ISI impact-factor: 2.048)

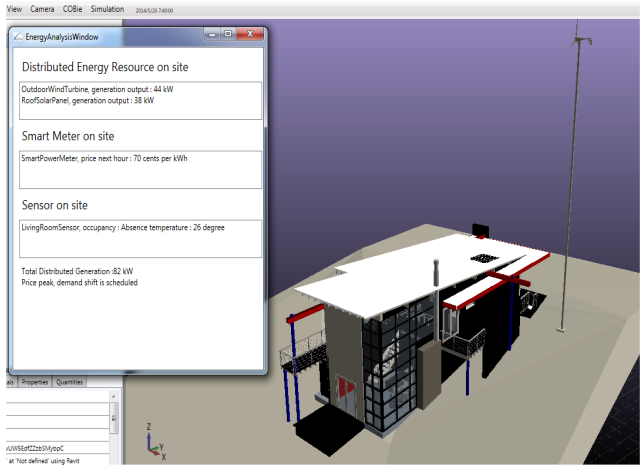
Exemplar (3)

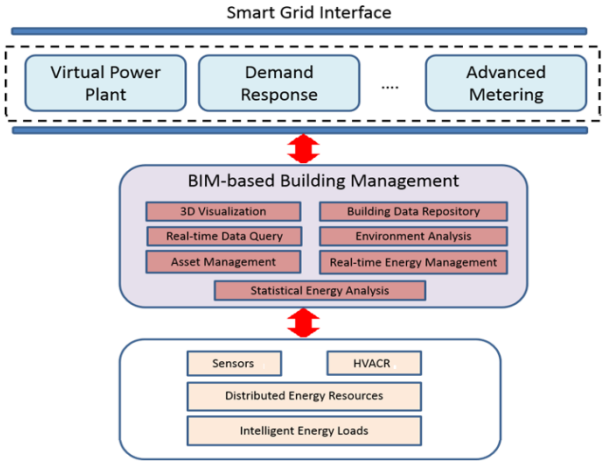
- Building information modelling (BIM) for smart powered buildings

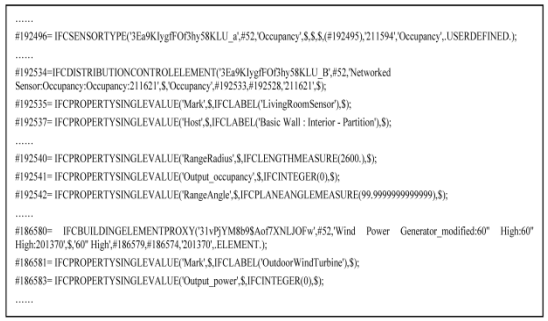










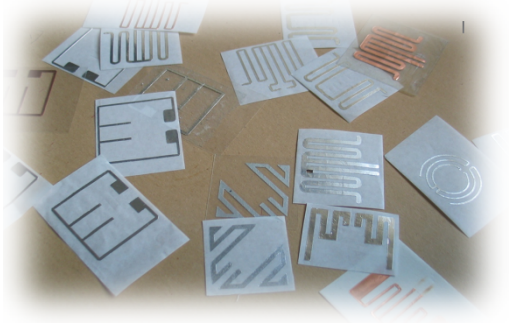


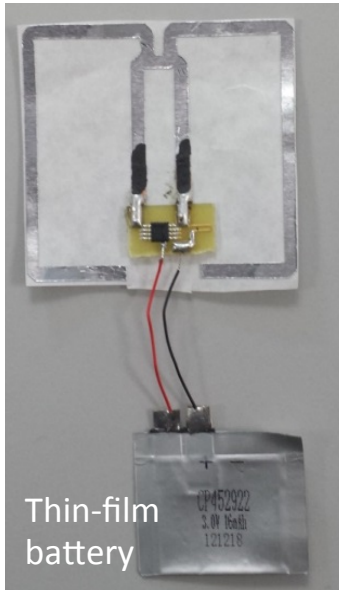
J. Zhang, B.-C Seet, T. T. Lie (2015). Building Information Modelling for Smart Built Environments. *Buildings*, 5(1): 100-115. (Invited paper)

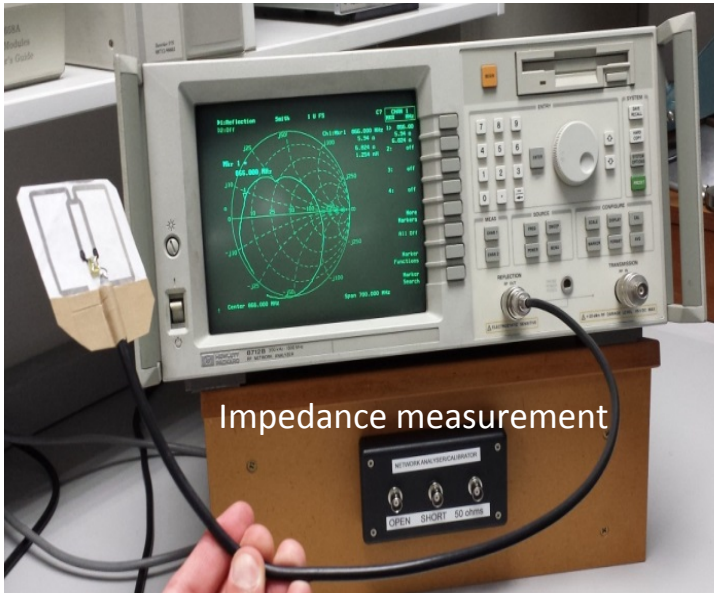
AUT UNIVERSITY

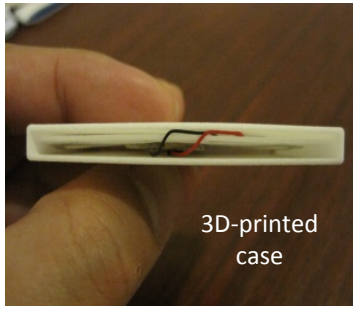
Exemplar (4)

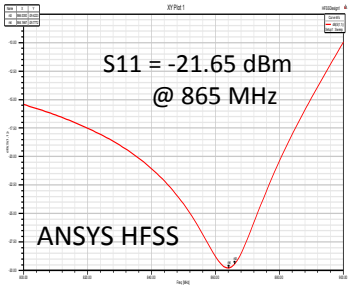
- RFID tag for water flow monitoring
  - Ultra-High Frequency (865 MHz)
  - Battery-assisted (semi-passive mode)
  - Meandered dipole on paper substrate

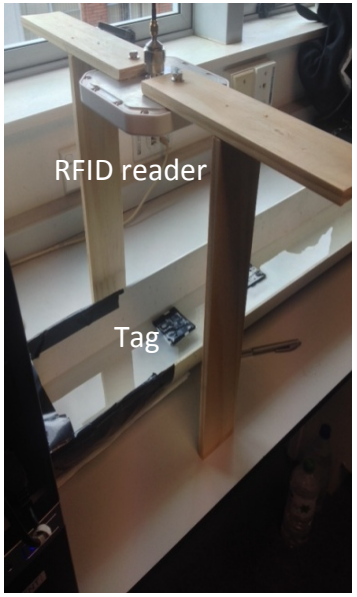






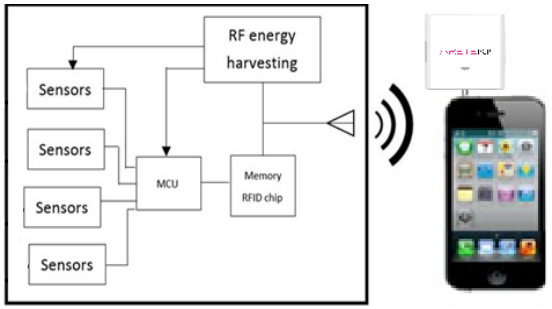


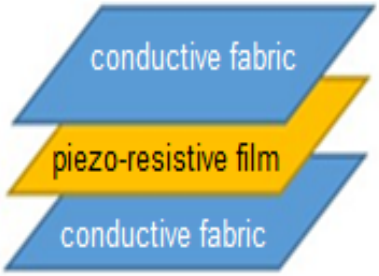


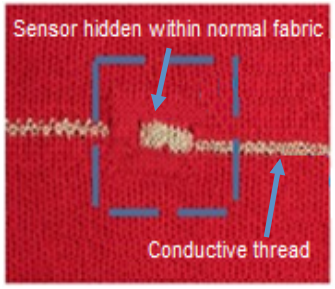


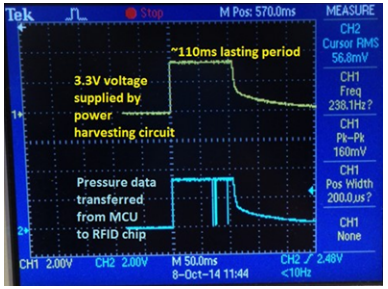
Exemplar (5)

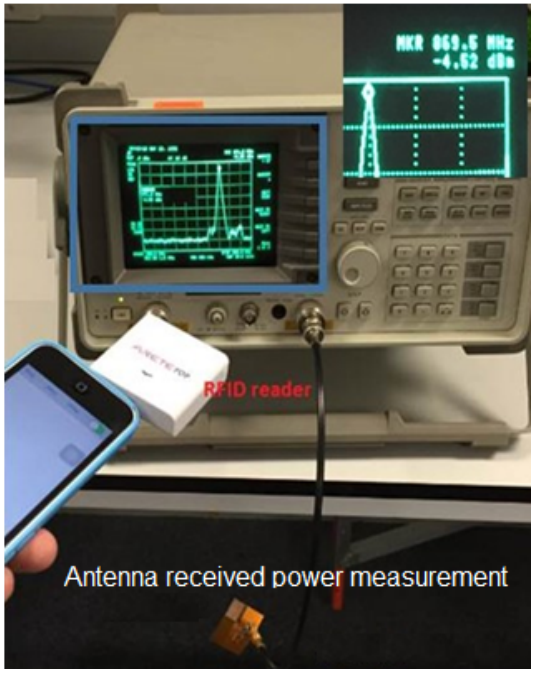
- Smart sock for diabetic foot ulcer monitoring
  - Fabric-based pressure sensors
  - RFID sensor tag
  - RF energy harvesting

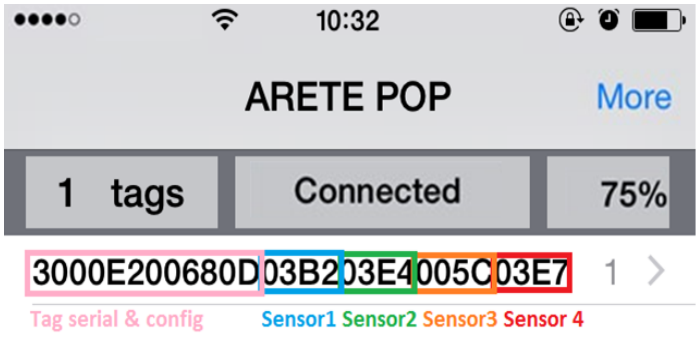


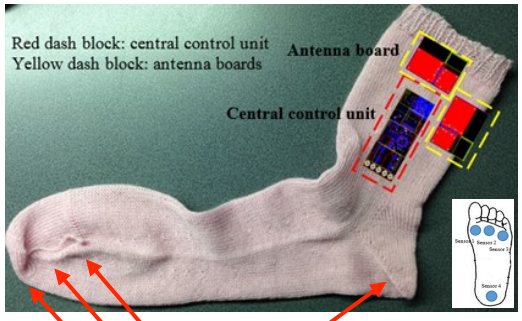












4 × fabric pressure sensors

Summary

- Over 7 years of research on sensor networks and related technologies
  - algorithm and protocol design
  - system modelling and simulation
  - prototyping and software development
  - measurement and testing
- Interested in (but not limited to) their applications to AmI and smart environments
- Open to collaboration and joint development of new solutions, proposals, and publications

Summary

- For enquiries, please contact:

Boon-Chong Seet (Dr)
Department of Electrical & Electronic Engineering
Auckland University of Technology
Room 405, Level 4, WS Block
34 St Paul Street, Auckland 1010
+64 9 921 9999 ext 5345
boon-chong.seet@aut.ac.nz
http://www.aut.ac.nz/profiles/boon-chong-seet

AUT UNIVERSITY