THE UNIVERSITY OF WESTERN AUSTRALIA

Achieving International Excellence

Mobile and Wireless Computing
CITS4419
Week 1: Introduction to Sensor Networks

Rachel Cardell-Oliver

2018

Wireless Networks

- No cables to connect the network
- Communication uses radio waves
- Many technologies from WiFi to bespoke radios and protocols

Mobile Networks

- We have many small and smart devices
- We'd like devices to co-operate
- They are carried by users so not fixed like a desktop computer
- Hence there is a need for networking mobile devices without infrastructure support
- Protocols need to adapt for the movement of the nodes

Ad Hoc Networks

- Mobile phone networks have infrastructure (mobile phone towers and satellites) and costs (registration with a provider)
- Ad hoc networks comprise mobile and wireless nodes that can set up and organise themselves into a network
- Decisions such as routing and scheduling are complicated to arrange in ad hoc networks

THE UNIVERSITY OF WESTERN AUSTRALIA

Achieving International Excellence

Our focus in CITS4419 will be on Wireless Sensor Networks

What are wireless sensor networks ?

What are they good for ?

Technology Drivers

- Sensors are becoming cheaper and more widely available
- Communication options for bluetooth, to radio, to using the mobile phone network, are also becoming cheaper and more widely available.
- Options for storing and sharing via the cloud are also growing
- These technology changes are enabling new applications for sensor networks

Sensors

Sapflow

20 cm

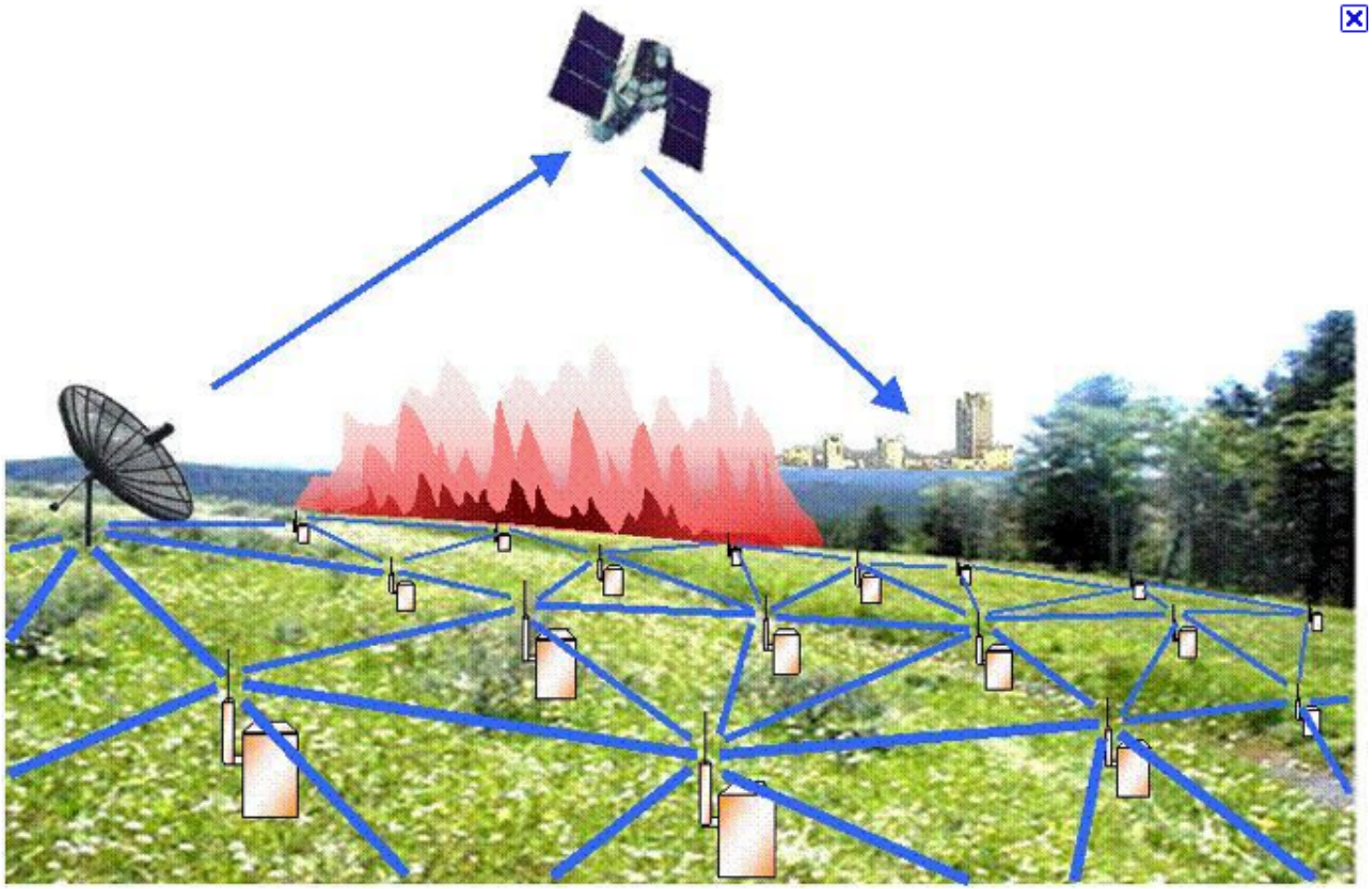
Decagon soil moisture sensors

Rain gauges
(logged and manual)

temperature sensor

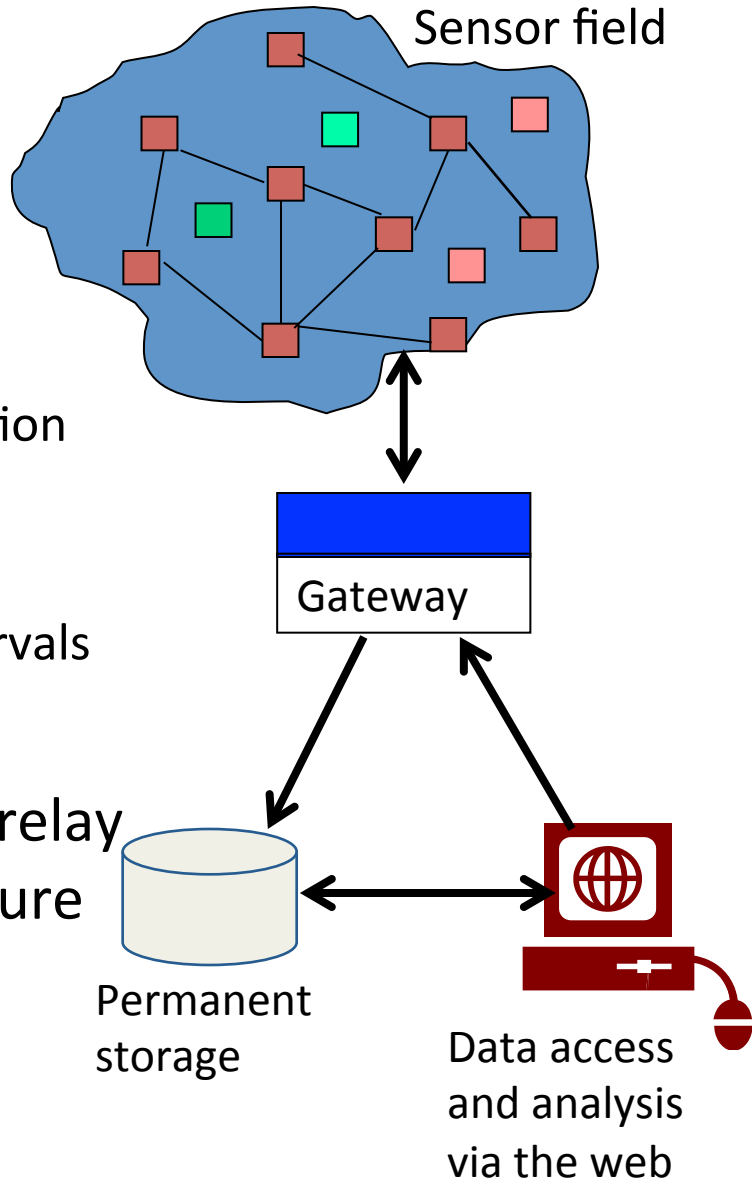
Micro-Controller Nodes

Wireless Networks Sensor Nodes and Gateway(s)

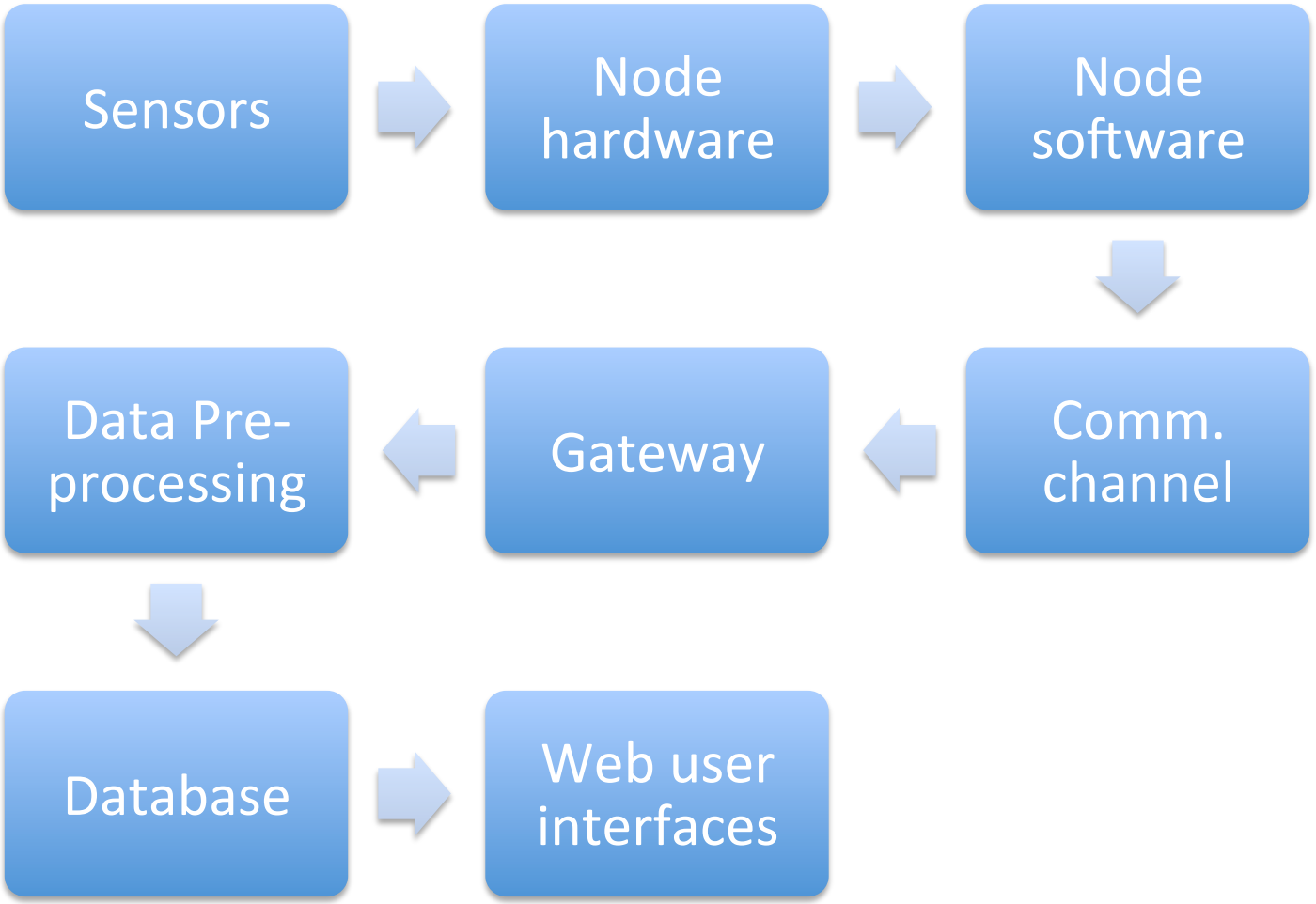


Sensor Networks

- Ad hoc Field Network
  - self-organising network
  - many sensing nodes
  - short range radio communication between nodes
  - 10 m to 10 km extent
  - 1 min to 1 month sensing intervals
- Gateway(s) gather data and relay it to permanent store for future analysis



Goal: end-to-end reliability



Requirements

- Energy saving
  - nodes are battery powered or even energy harvesters
- Self Organising
  - able to set up and adapt to a changing environment
- Fit for purpose
  - Sufficiently robust, reliable, cheap, fast, low maintenance, scalable **for the application**

THE UNIVERSITY OF WESTERN AUSTRALIA

Achieving International Excellence

Sensor Network Applications

Environmental

Sensor Network Technology Answers Users' Questions

Users with Questions

Sensor Network Technology

Natural (or man made) environments

Pinjar Soil Moisture Monitoring

WA Water Corporation 2004-5
Re-charge assessment over the Gnangara groundwater system at Pinjar WA, 12 Mica2 motes, rain, soil moisture sensors, 2 months

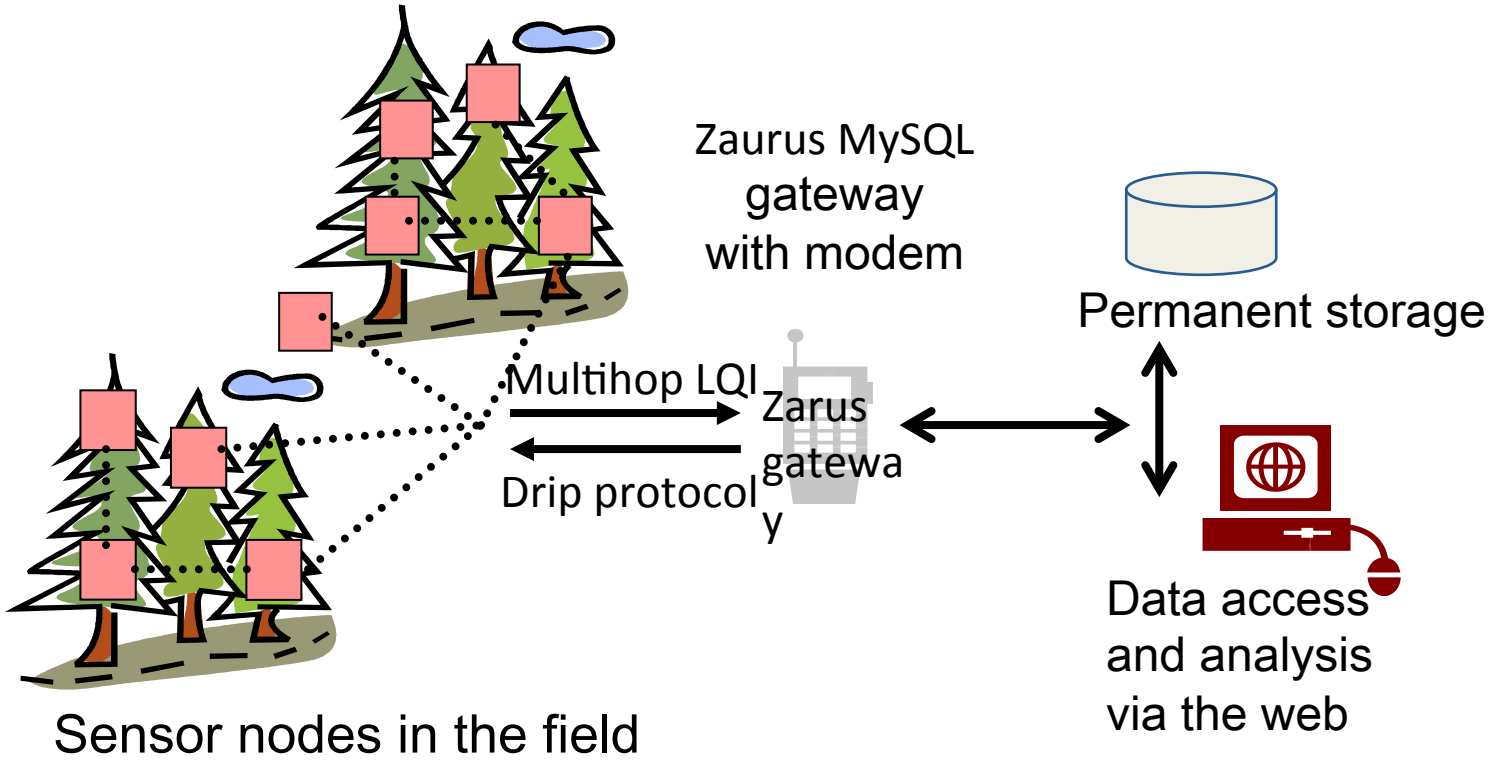
A Reactive Soil Moisture Sensor Network: Design and Field Evaluation, R Cardell-Oliver, K Smettem, M Kranz and K Mayer, in **Intl Journal of Distributed Sensor Networks** pp. 149 – 162, Vol 1, Num 2, April-June 2005

Microclimate Monitoring

California Redwood & WA Karri

Microclimate Monitoring

California Redwood & WA Karri



Harnessing wireless sensor technologies to advance forest ecology & agricultural research

S. S. O. Burgess, M. L. Kranz,, N. E. Turner, R. Cardell-Oliver, T.E. Dawson, **Journal of Agricultural and Forest Meteorology** Jan 2010

Vineyard irrigation project (2008-2010)

- Development of a soil moisture monitoring and irrigation control system for vineyards

Partners:
- University of Hohenheim
- IMKO GmbH

Vineyard

Shenton Park, Perth

Micro-Sensors for Animal Sensing

https://youtu.be/B2G4zmW8Gsk

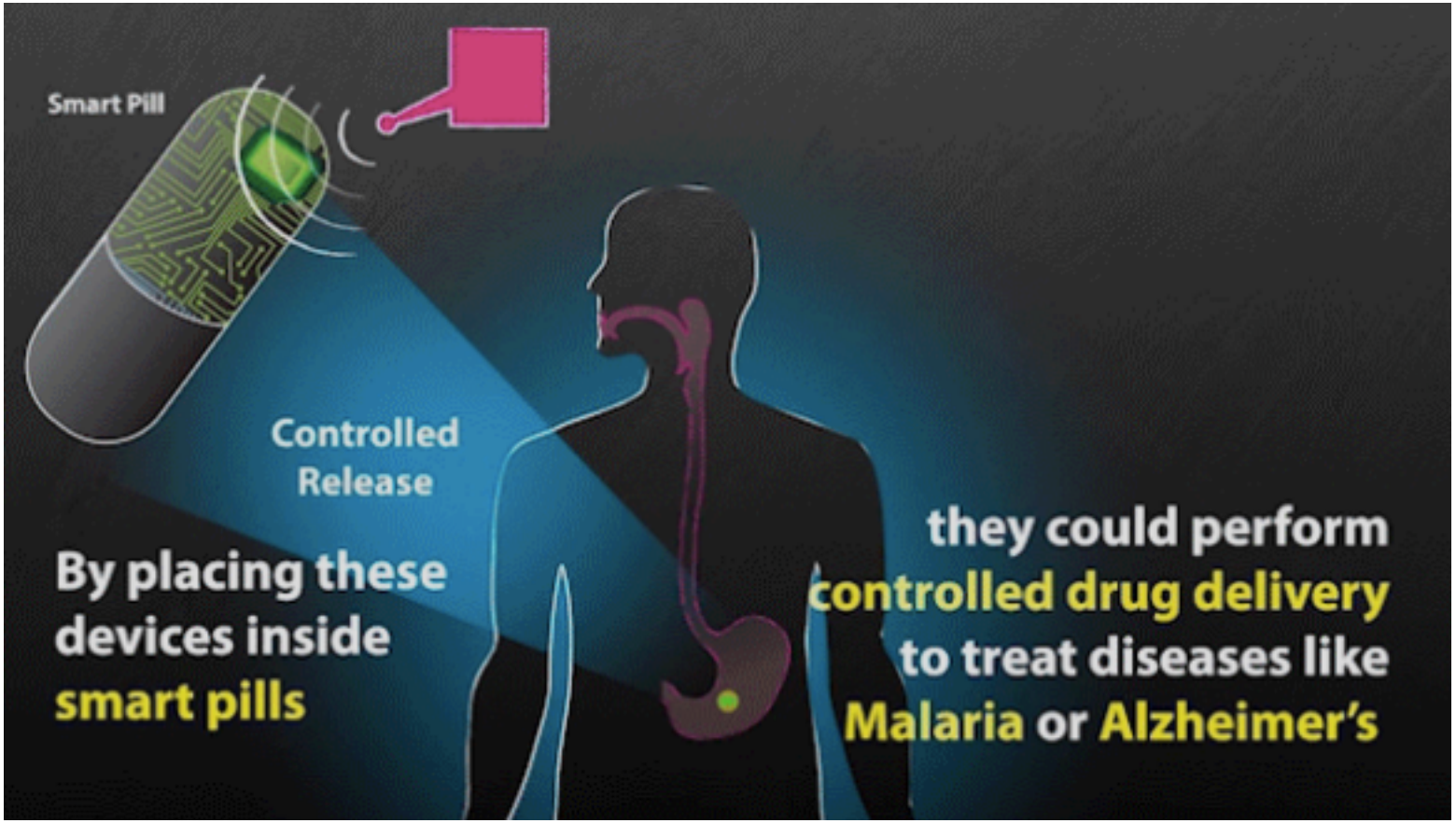
THE UNIVERSITY OF WESTERN AUSTRALIA

Achieving International Excellence

Sensor Network Applications

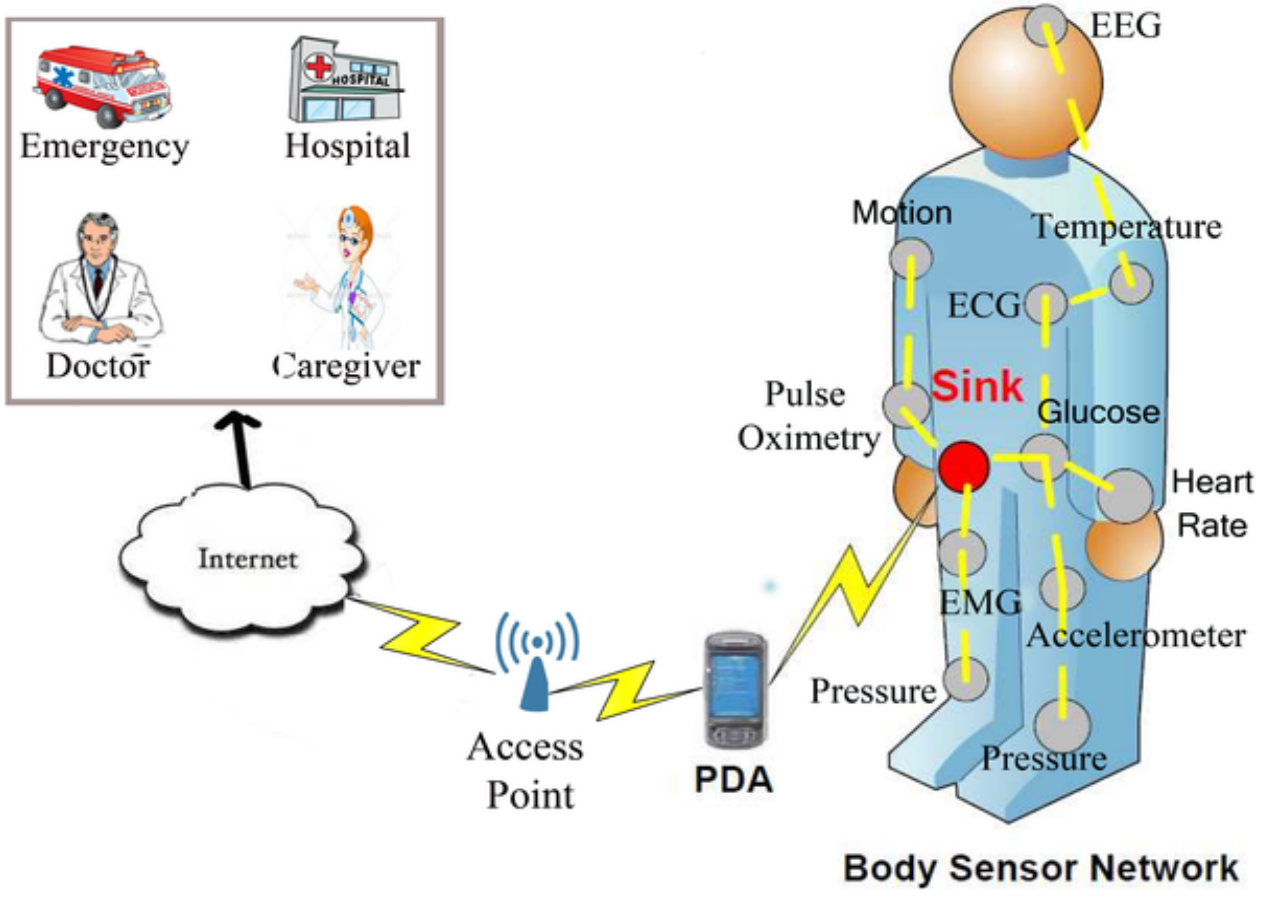
Health

In body networks



http://news.mit.edu/2018/wireless-system-power-devices-inside-body-0604

On Body Networks



Ayatollahitafti V, Ngadi MA, Mohamad Sharif Jb, Abdullahi M (2016) An Efficient Next Hop Selection Algorithm for Multi-Hop Body Area Networks. PLOS ONE 11(1): e0146464. https://doi.org/10.1371/journal.pone.0146464
http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0146464

THE UNIVERSITY OF WESTERN AUSTRALIA

Achieving International Excellence

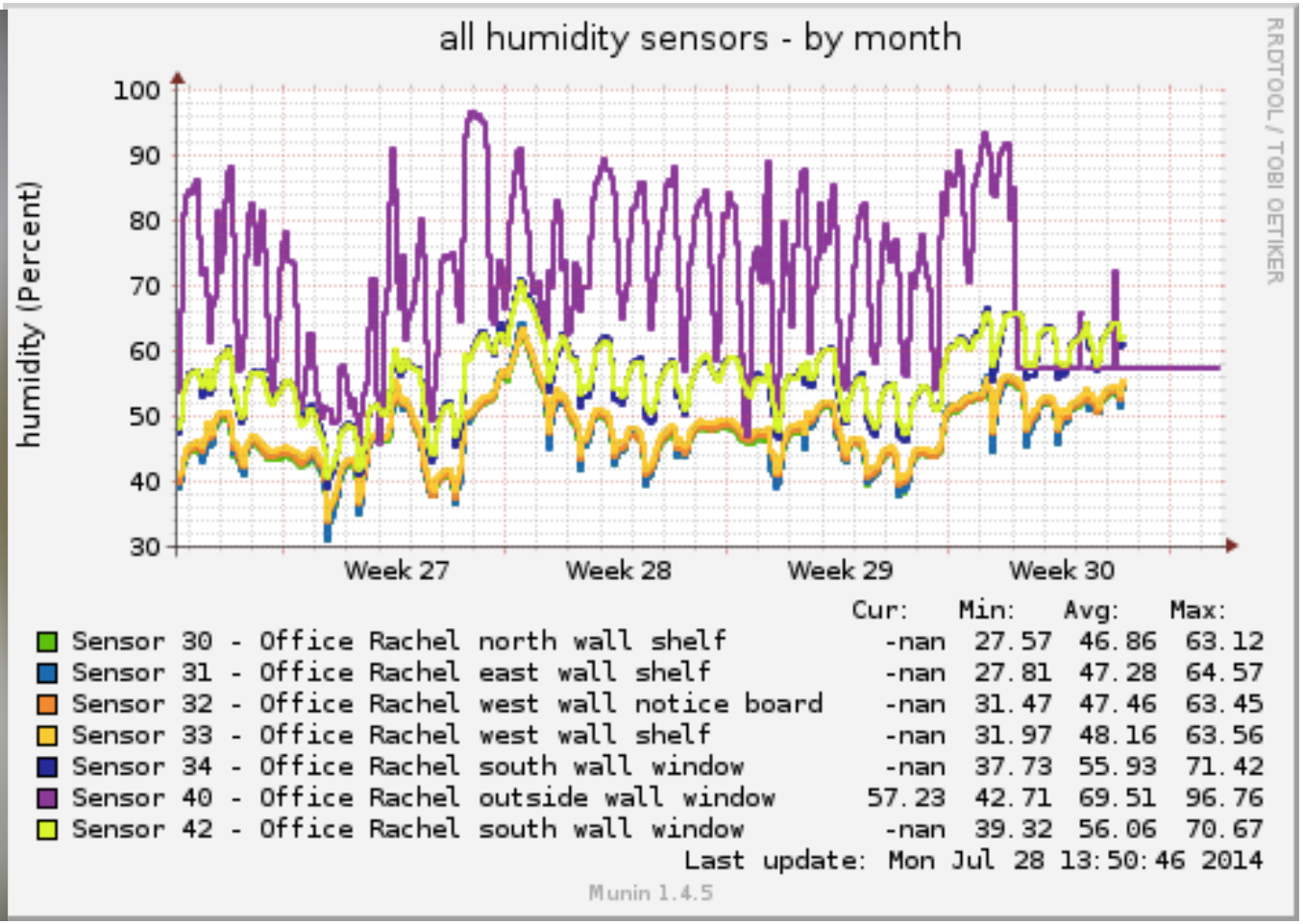
Sensor Network Applications

Buildings and Cities

Smart Cities: Singapore
https://www.youtube.com/watch?v=XNtdnPjRpzI

Office Monitoring Network

Homogeneous Sensors



Kalgoorlie Energy Efficient House

Heterogenous sensors / Data fusion

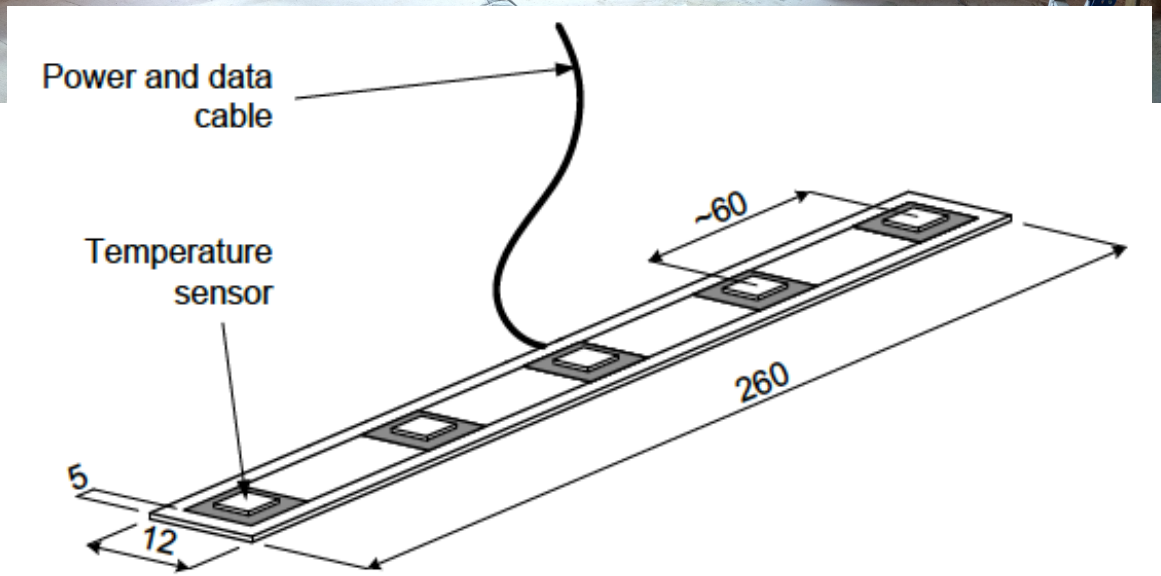
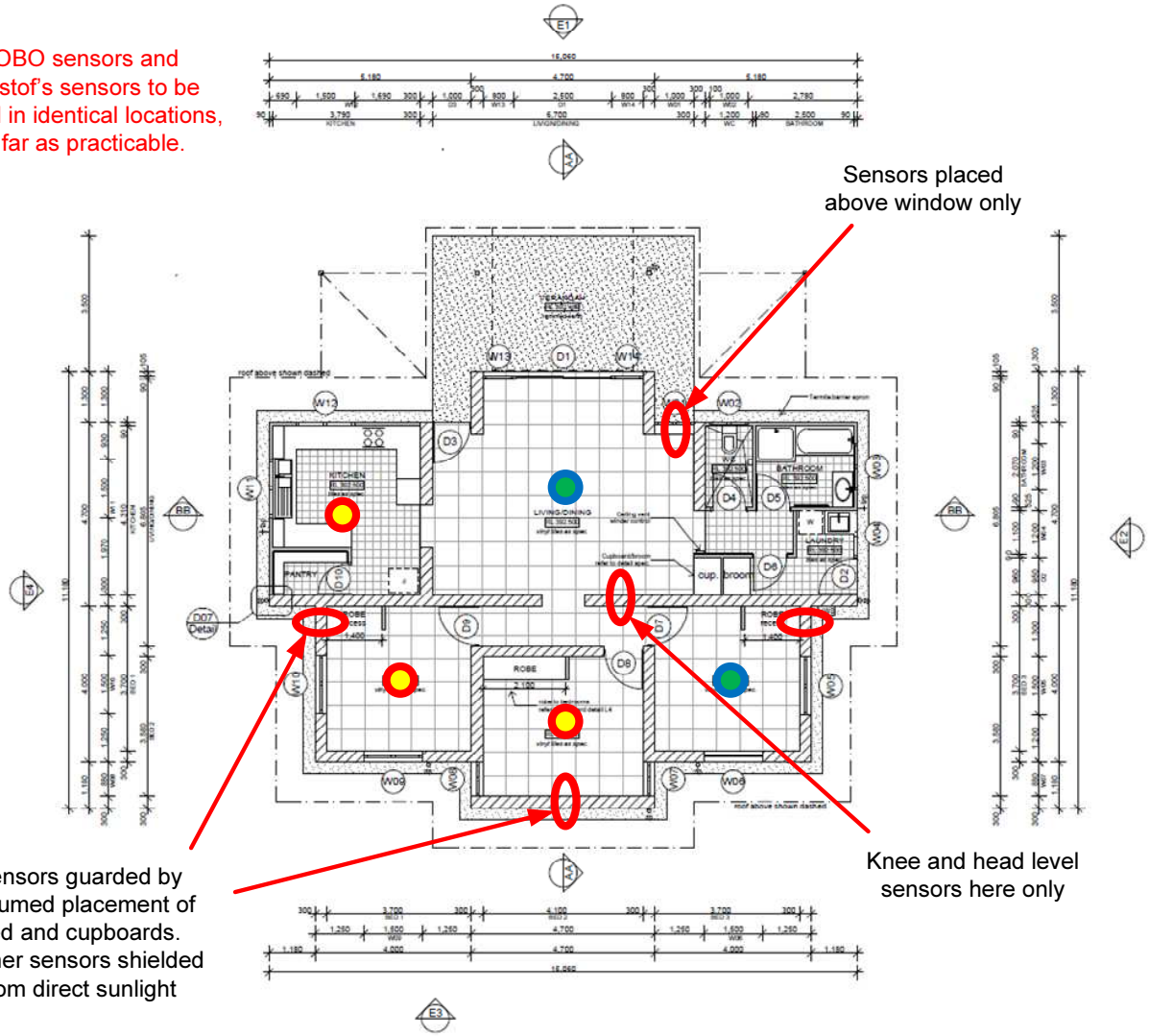


Figure 8: *In-house designed and built temperature sensor (dimensions in mm, not to scale)*

HOBO sensors and Christof's sensors to be placed in identical locations, as far as practicable.



Symbol key

- Embedded and surface sensors
- Temperature sensors
- Temperature and humidity sensors

Revision	No.	Description
03/04/2013	1	Issued for Tender

Troppo Architects (Fremantle) Pty Ltd
6 Shack St
FREMANTLE
West Australia 6160
ph : 08 9336 4533
fax : 08 9336 6669
ABN 35 002 688 250

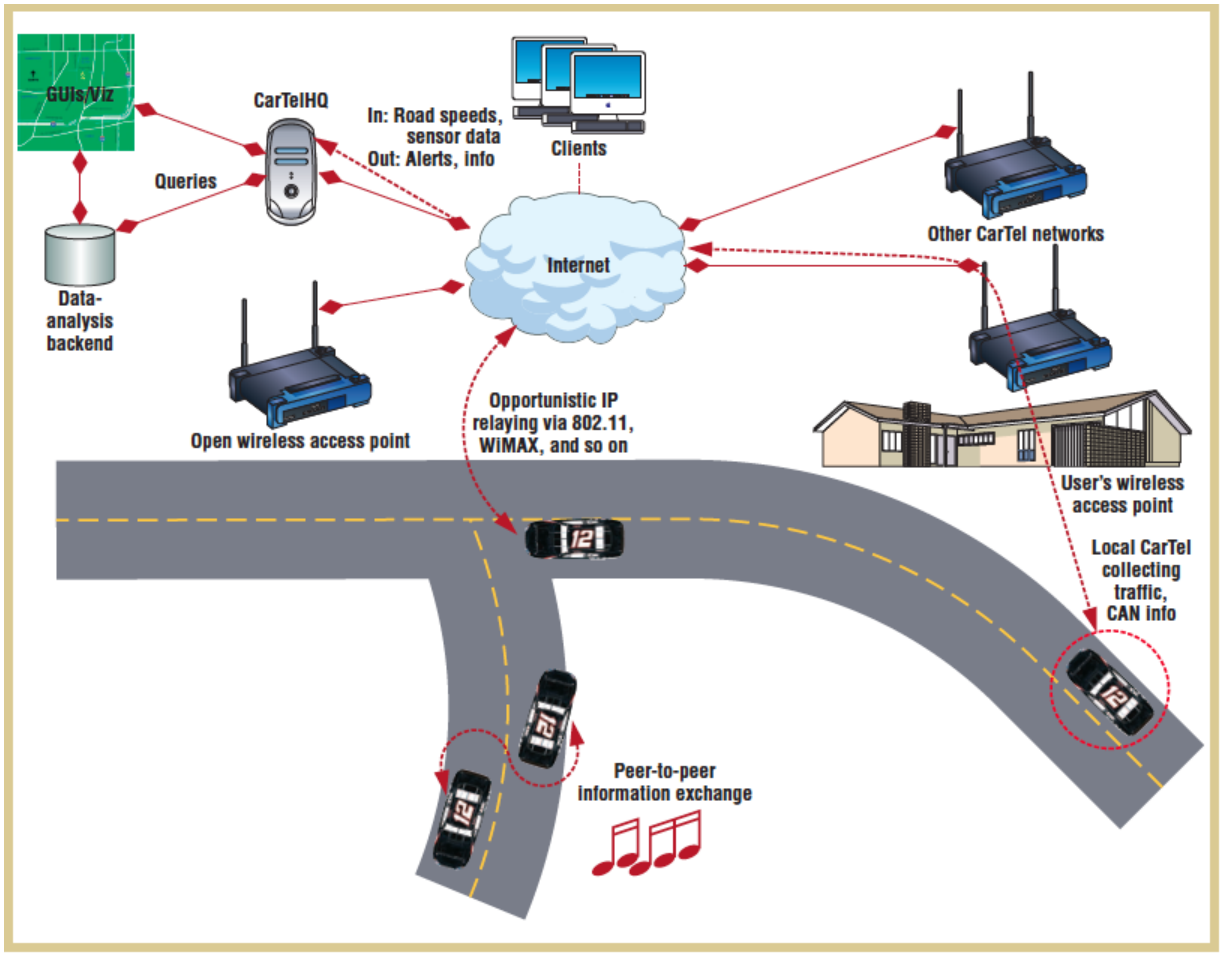
FOR TENDER

Project No:	2011.23
Project Name	DHW Rammed Earth Houses
Location	LOT 32, Cnr Cotter St, Eureka St., Kalgoorlie, WA
Drawing Title:	GROUND FLOOR PLAN
Drawing No.:	1.04
Scale:	as shown
Date:	3/04/2013

N

GROUND FLOOR PLAN
1:100

Vehicle Networks



CarTel. Reference Mobiscopes fro Human Spaces, Pervasive Computing 2007

From: The hitchhiker's guide to successful residential sensing deployments, SenSys 2011

(a) Three Generations of Light Switch Sensors

(b) Plug Load Monitor

(c) Three Generations of Doorway Sensors

(d) Motion Sensor

(e) Three Generations of Active Registers

(f) Power Meter

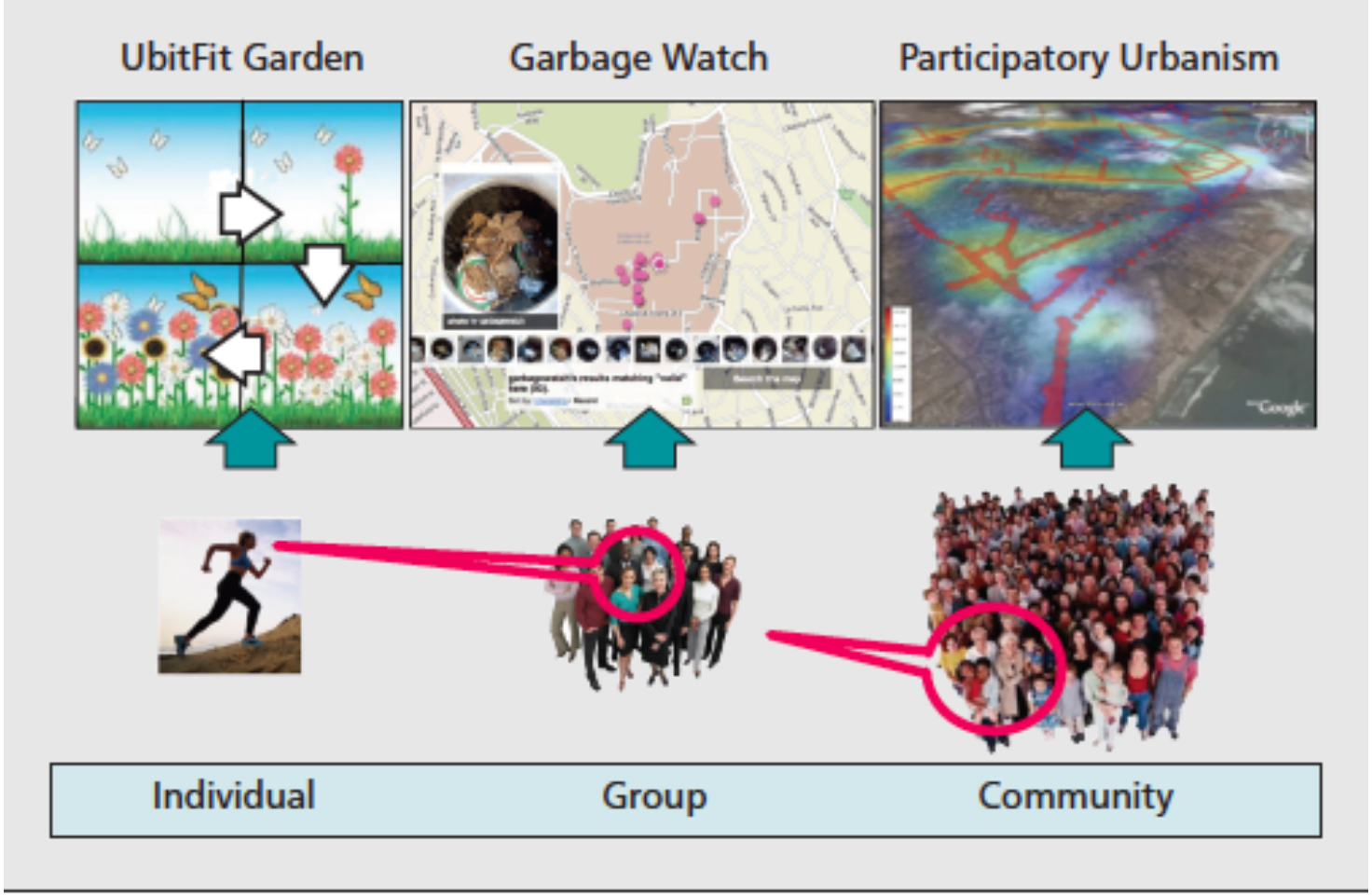
(g) Water Flow Meter

(h) Reed Switches on Water Fixtures

(i) Light Sensor on Window

(j) Temperature

Participatory Sensing



A Survey of Mobile Phone Sensing, IEEE Communications Magazine, Sep 2010

Crowd Sensing & Sourcing

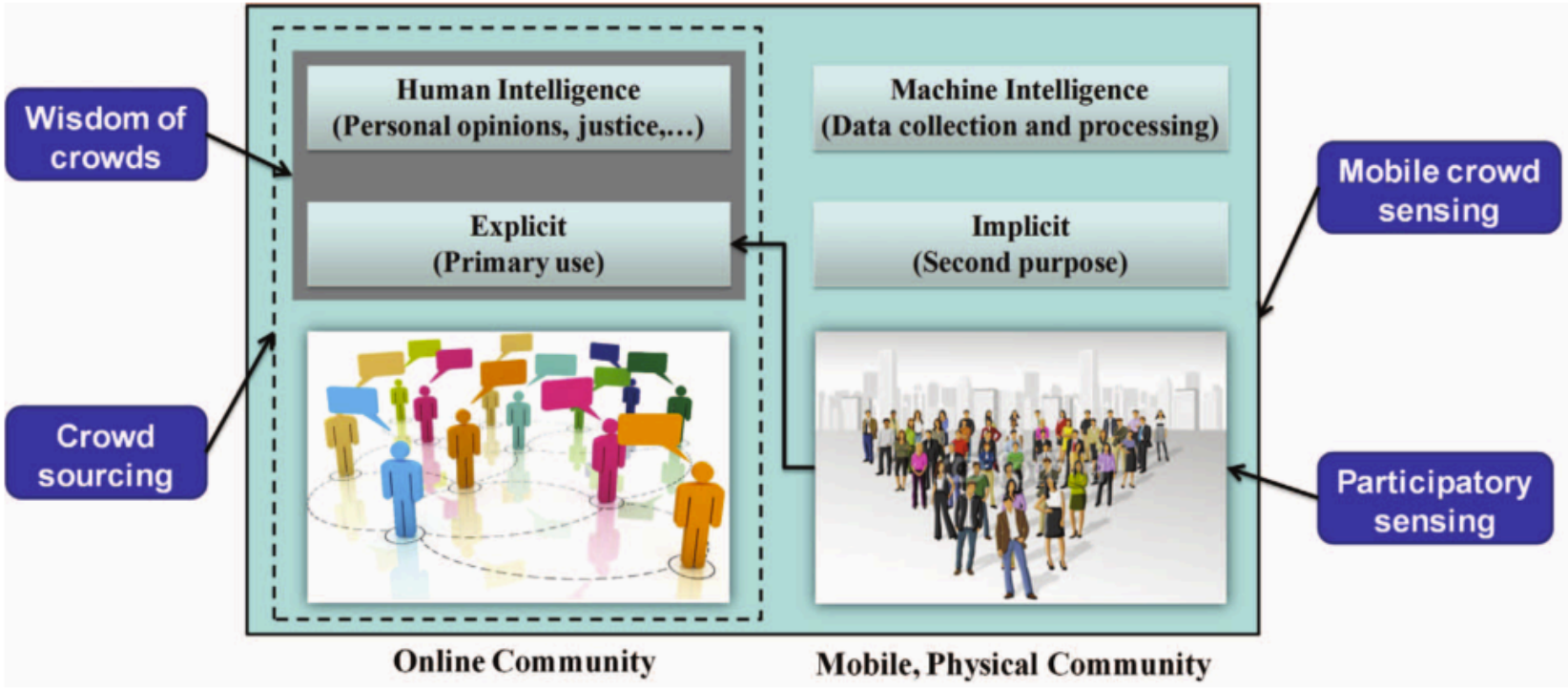


Figure 1. A comparison of MCS and related concepts.

Source: From Participatory Sensing to Mobile Crowd Sensing, Guo et al, Percom Workshops 2014

THE UNIVERSITY OF WESTERN AUSTRALIA

Achieving International Excellence

Sensor Network Applications

Industry

Industry Applications

- Machine Health
- Asset Tracking and Maintenance
- Utilities eg water distribution systems
- Safety eg air monitoring
- Structural monitoring eg buildings, roads, bridges

Industry Sensor Networks

Source: Global Industrial WSN market prophesied to grow at a faster pace by 2023 www.latestindustrynews.com/8672 from
Global Industrial WSN Market Research Report 2018

CITS4419
Unit Information 2018

CITS4419 Skill Set

During this unit you will learn to work with:

- Programming and Software
  - e.g. Python, Arduino C/C++
- Hardware
  - Raspberry Pi, Arduino
- Radios
  - LoRa radio, 816 transceivers
- Sensors
  - Mannheim temperature and humidity sensors
- Research Skills
  - Finding, Reading, Summarising, Citing
- And more …

CITS4419 Assessment

Group Programming Project	20%
Research Essay	20%
Exam	60%

Weekly Labs

- Wednesdays 3-5pm CSSE 2.03
- Reading, Programming, Short report
- Work in the lab on Wednesday and at home
- The labs are to reinforce lecture topics and to prepare you for the practical project

- Labs start in week 2 (no lab week 1)

Group Project

- Build a data collection sensor network application using
  - Raspberry pi, Arduino, LoRa shield, Web tools
- **Project is worth 20%**
- Work in groups of 3 or 4 (assigned by the unit coordinator based on students' experience and interests)
- Project due via cssubmit in week 8

Research Essay

- Individual assessment
- Based on review of a research paper
- Essay due via cssubmit in week 13

Exam

- November examination period

- Questions will be similar to those in the weekly lecture question sheets

Resources

- Web page: http://undergraduate.csse.uwa.edu.au/units/CITS4419/
- Help Forum: help4419 for discussion and questions
- This unit focuses on practical skills and group work
- This is **not** an online course.
- Attendance at the weekly lecture and lab sessions is necessary

Rights and Responsibilities

- Read the official **unit outline** for important rules and regulations (link on the web page)
- Read UWA's Charter of Student Rights and Responsibilities http://www.aps.uwa.edu.au/home/policies/charter

4.1 Every student has the right:

1) to expect the University to provide a high quality of education including a high quality of teaching, supervision, curriculum and unit content, a commitment to inclusivity, and good access to staff;

5) to assessment that is valid, educative, explicit, reliable and fair;

4.2 Every student has the responsibility:

1) to bring an open and enquiring mind and enthusiasm to their studies;
2) to participate actively in the teaching and learning and research environment, in particular by attending classes as required, complying with workload expectations, and submitting required work on time;