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Work stream 1: Adaptive sensing and behavioural phenotyping

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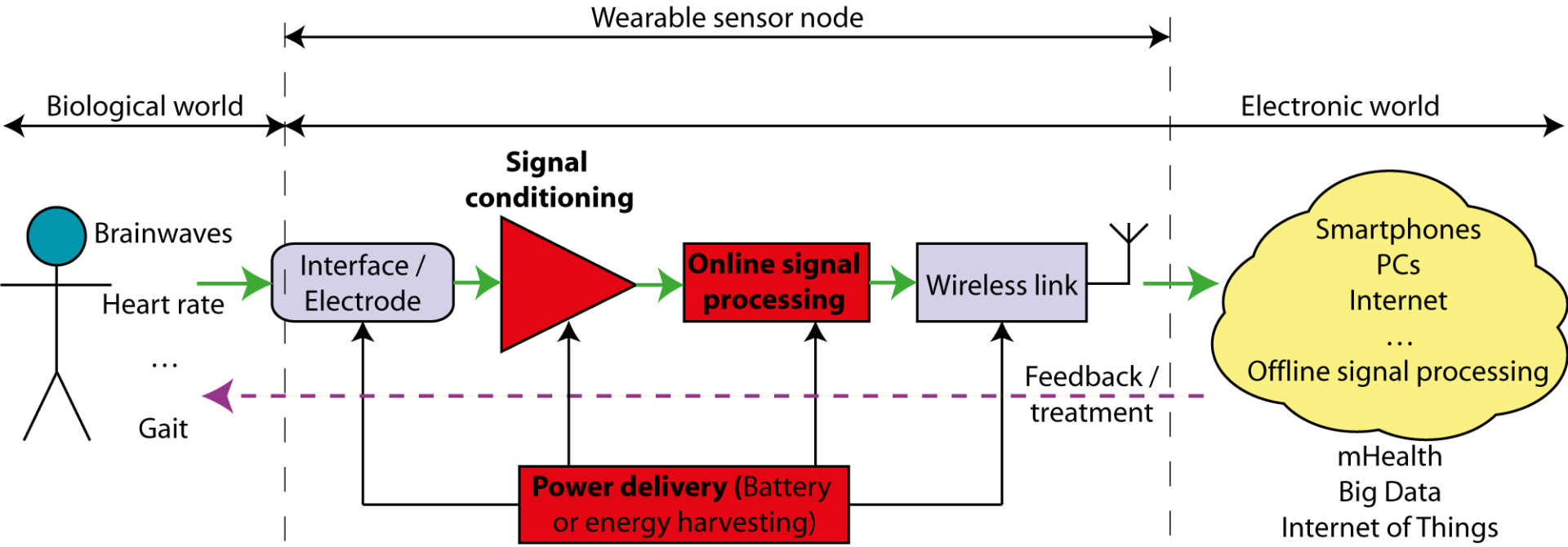
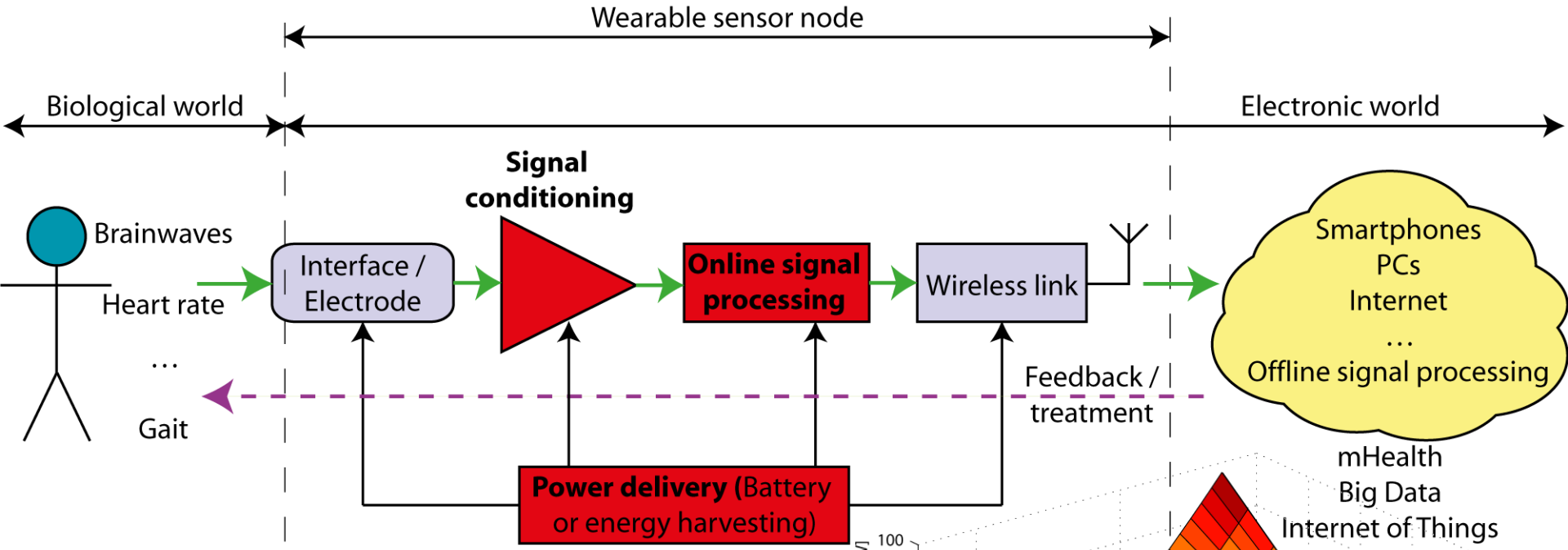
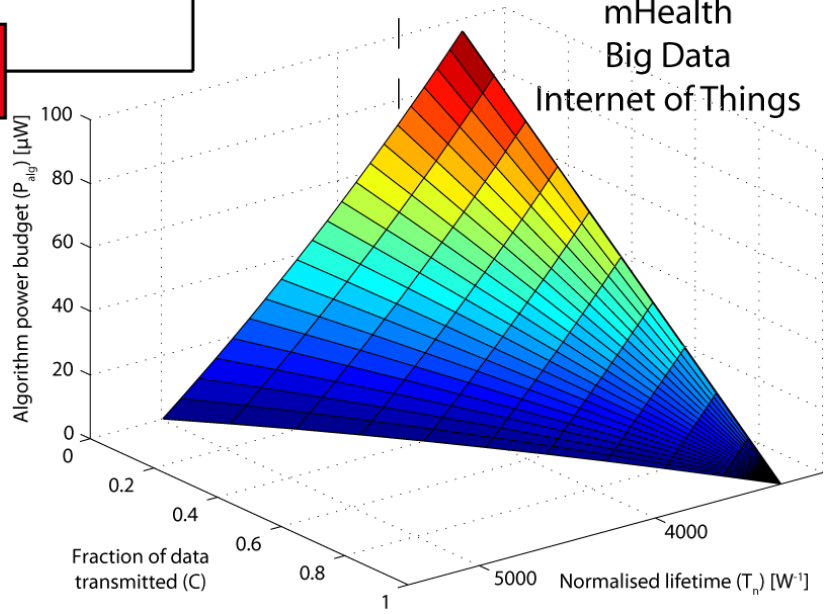
Smart sensors



Online signal processing



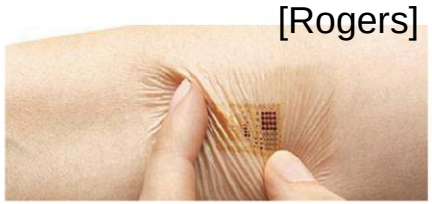
✓ Reduce system power.



[Chen et al., Wearable sensors, 2014]

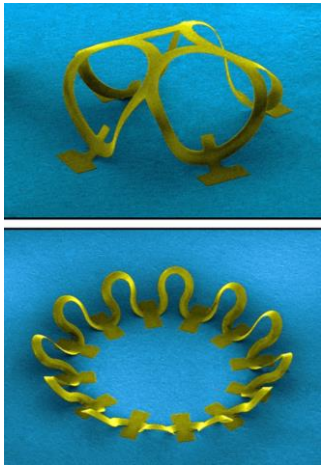
Project 1: Flexible sensors

1980s: Desktops | 1990s: Laptops | 2000s: Smartphones | 2010s: Wearables | 2020 onwards: Conformals



[Rogers]

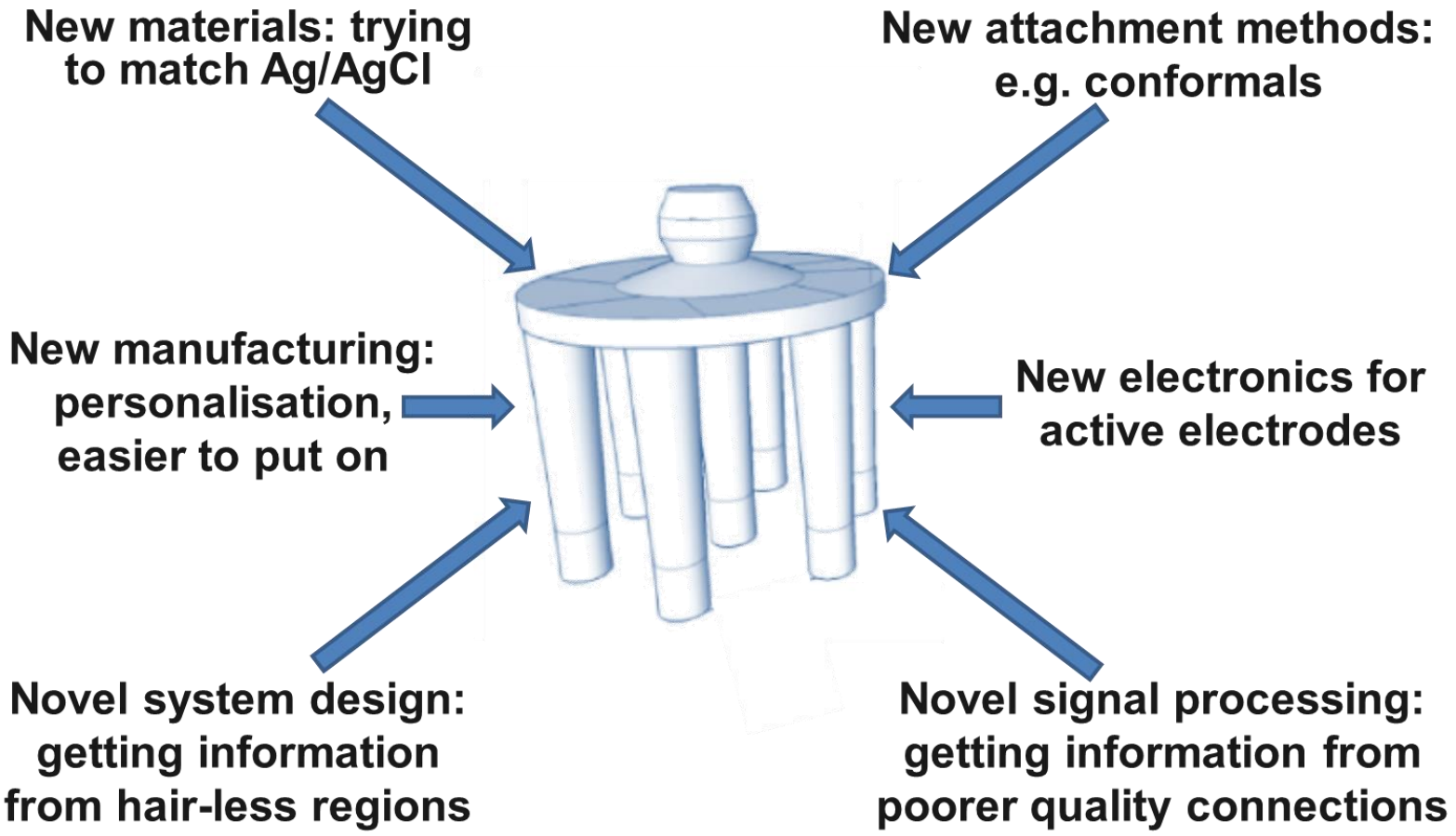
Bio-degradable conformal electronics
EPSRC funded, £1.6M, 2017 - 2020



- ✓ Printed Graphene tracks and bio-degradable substrates for ease of disposal at end of life
- ✓ Roll-to-roll scale up manufacturing
- ✓ 3D pop-up antennas
- ✓ 30 µW power budget for 3m range RFID wireless powering
- ✓ Sensing: ECG, EMG, EEG, IMU, Temp, Strain, Pressure

Project 2: Contacting through hair

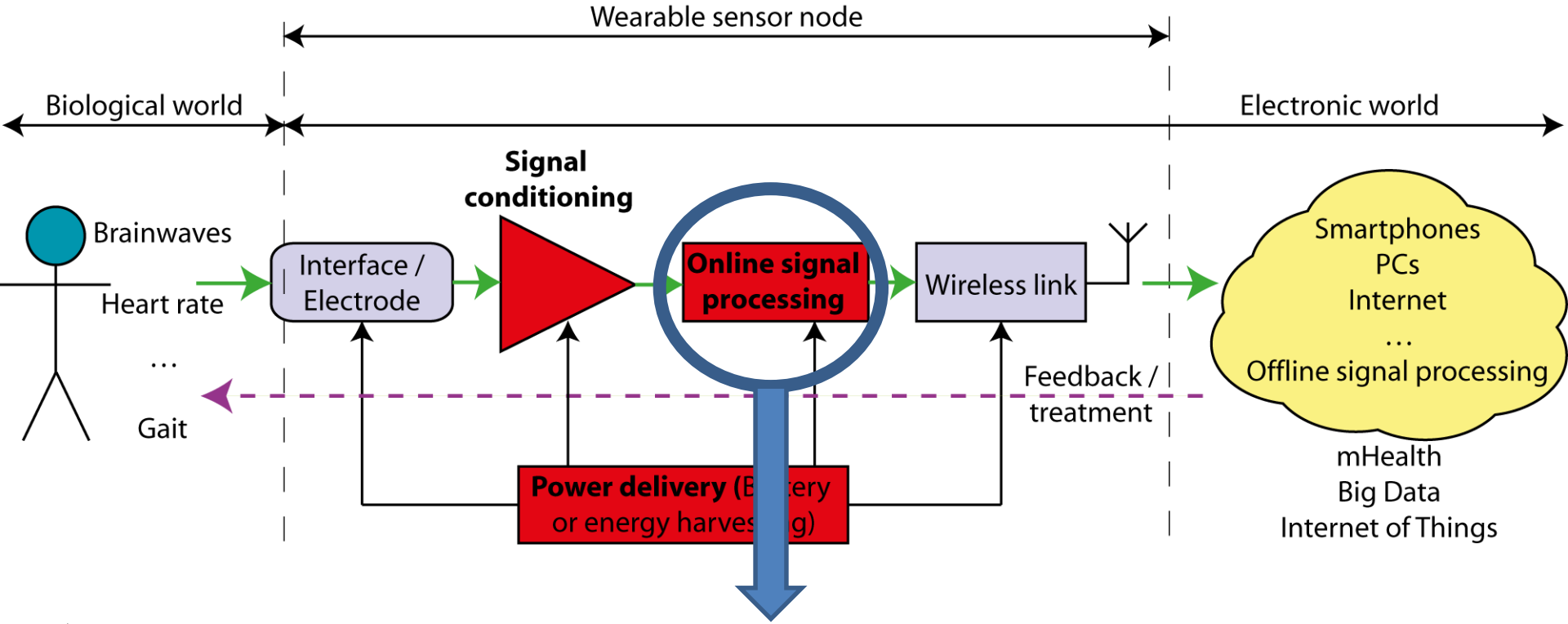
Personalised electrodes for better penetration through hair
MRC funded, £140k, 2018 - 2019



Project 3: Data based treatments

Closed loop wearables
MRC funded, £150k, 2017 - 2018

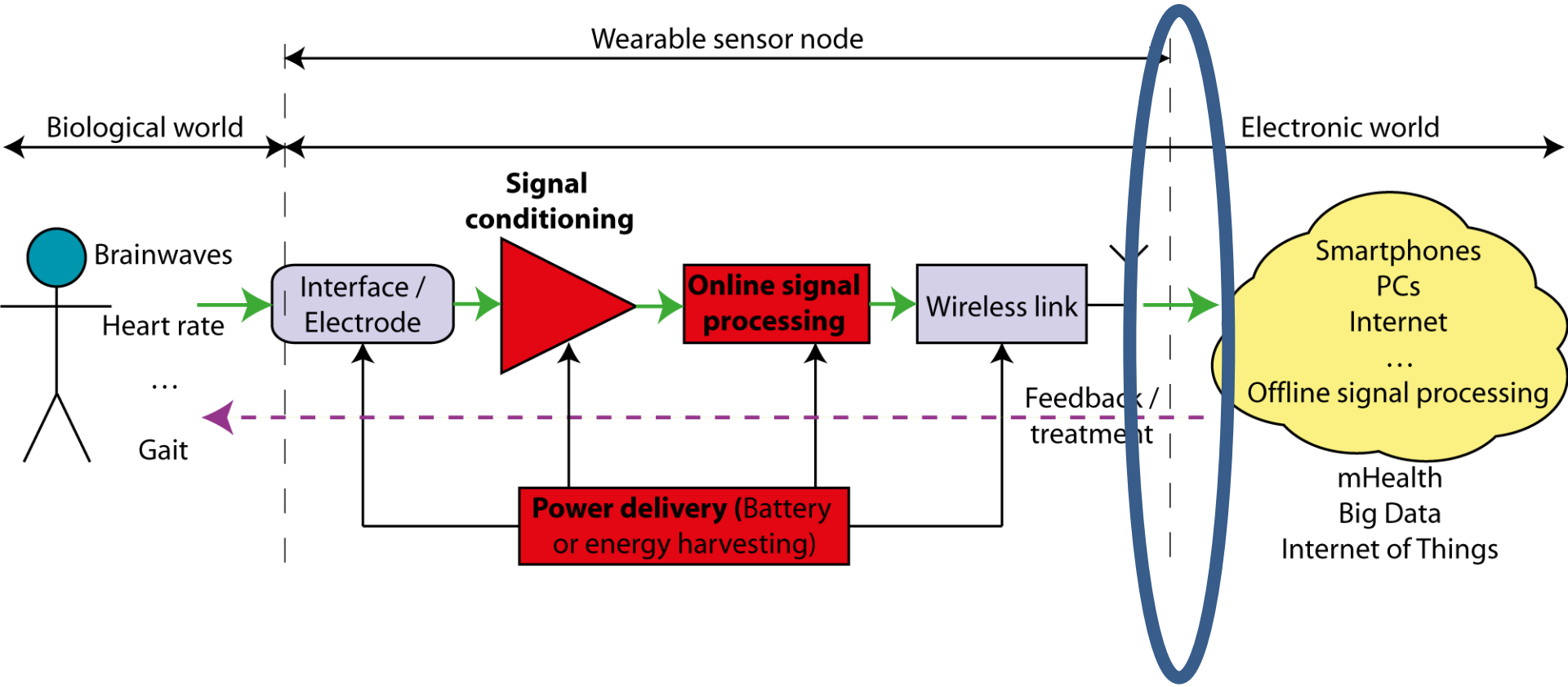
Current wearables just collect data. We want to create devices that analyse the data in real-time and release a very time targeted treatment



- ✓ Signal processing is now power AND time constrained: for <10 ms accuracy don't have time to send to an off-sensor-node computer

Project 4: EHR integration

The wearable clinic
EPSRC funded, £2M, 2017 - 2020



1.1 Adaptive sampling

Key aim

Increase monitoring lifetime without degrading information utility from wearable

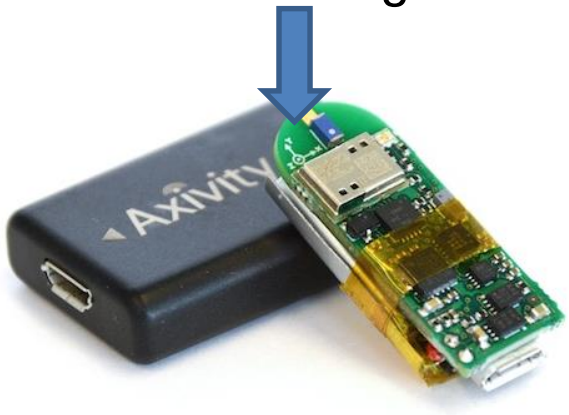
1.1 Adaptive sampling

Only turn on sensing when EHR indicates it is needed

Example:

- ✓ Sensor in sleep mode by default
- ✗ Appointment missed
- ✓ Pull data from wearable
- ✓ Supplement EHR with new information, despite no appointment
- ✓ Compare activities to usual profile
- ✓ Significant power savings due to discontinuous monitoring
- ✓ Allows very long term sensing

Focus on accelerometery/activity monitoring



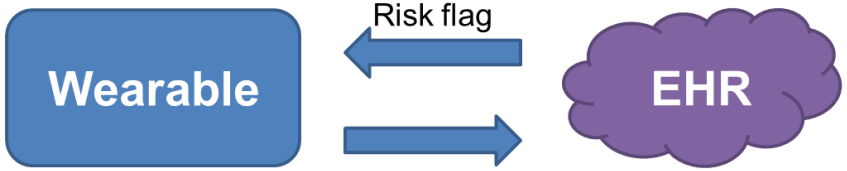
Variation on data driven adaptive sampling

- In addition to data from sensor itself, use time spare EHR as meta-data
- Mainly back-end processing rather than on-node
- A number of different variations are possible

Variations

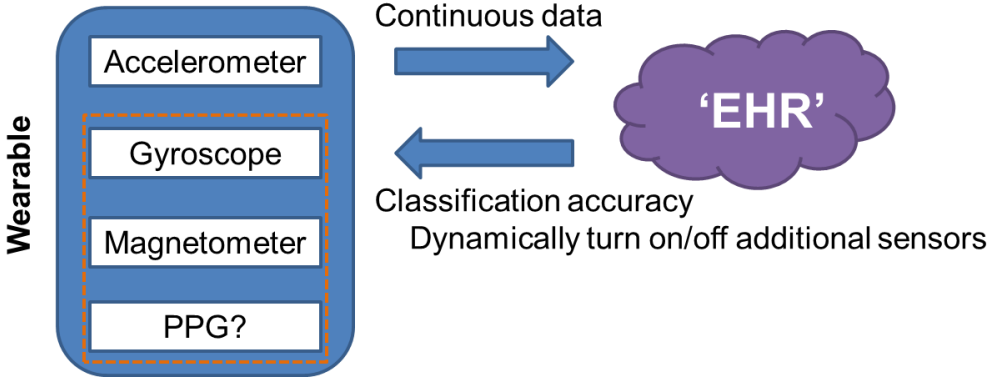
Five variations identified so far. Three examples:

One



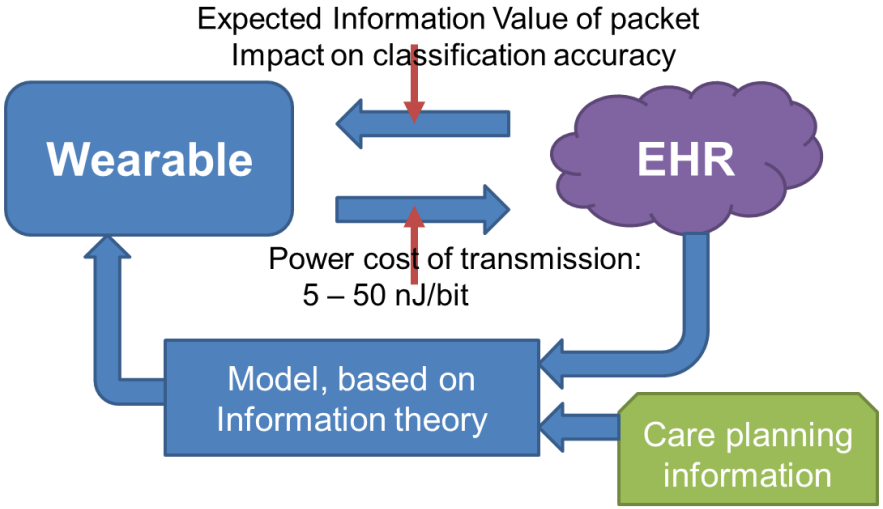
Switch between:
- High resolution data vs low resolution data
- Accelerometer only or full IMU

Two



Dynamically turn on/off additional sensors

Three



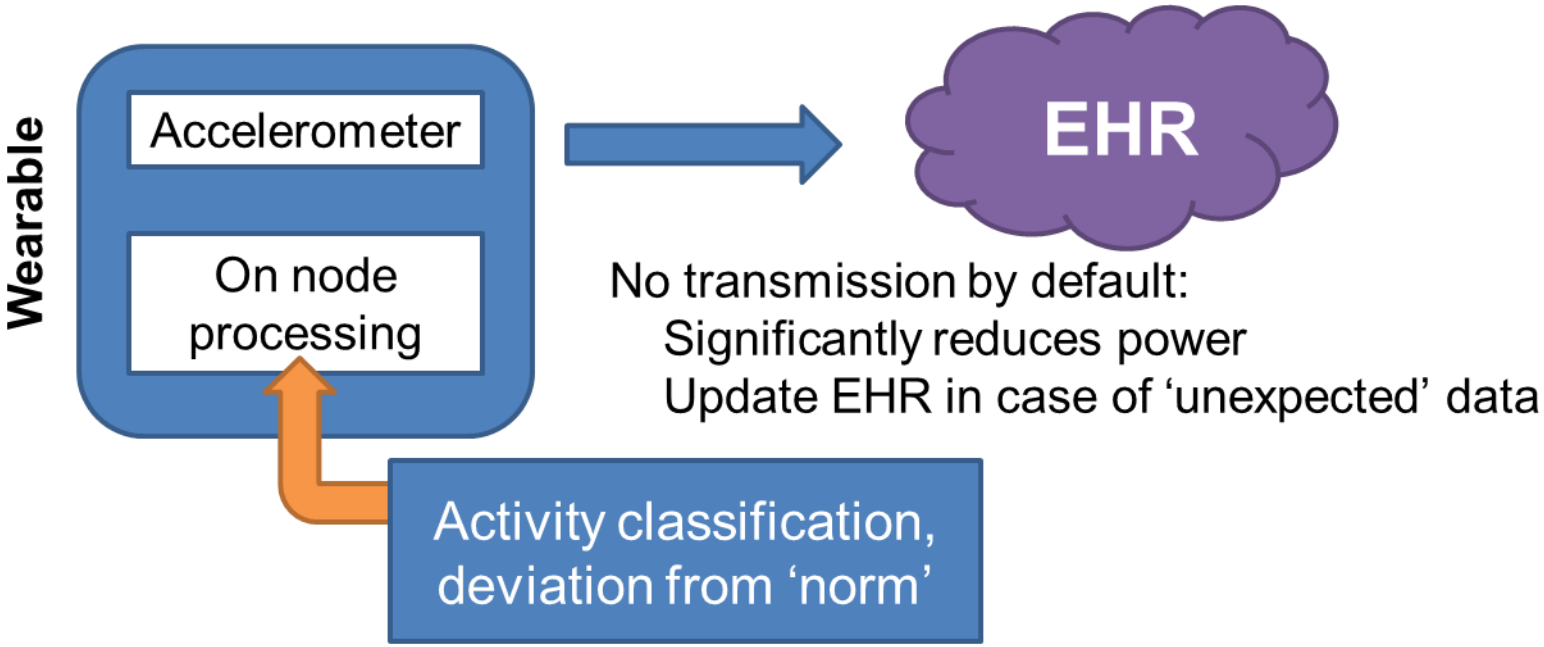
1.2 Behavioural phenotyping

Key aim

Unsupervised machine learning algorithms for discovering new, ‘computable behaviour phenotypes’

1.2 Behavioural phenotyping

On node processing to inform EHR



Example: bring forwards appointments based on wearable data

- Unsupervised machine learning (e.g. kNN)
- Validate using accelerometer data from Biobank
- Some pilot data collection

Tasks

Setup

1. Systematic literature review of wearable sensors in chronic kidney disease and serious mental illness
2. Set up wearable and link with ‘EHR’
3. Biobank data access

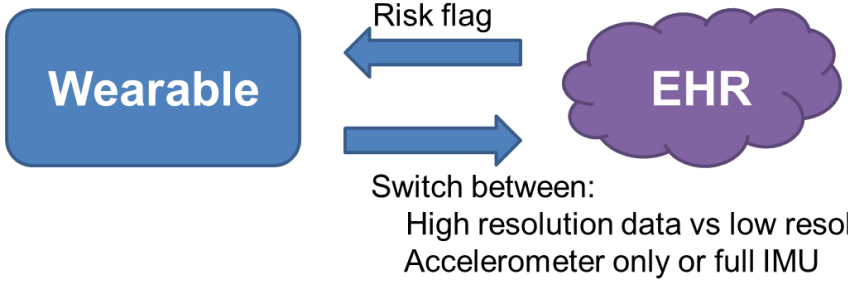
1.1

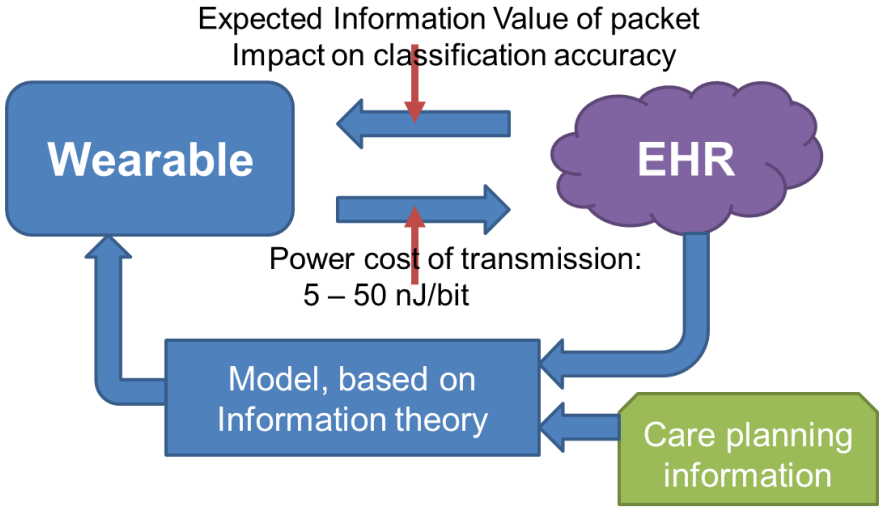
4. ‘Low hanging fruit’ adaptive sampling
5. Information theory based adaptive sampling model creation.

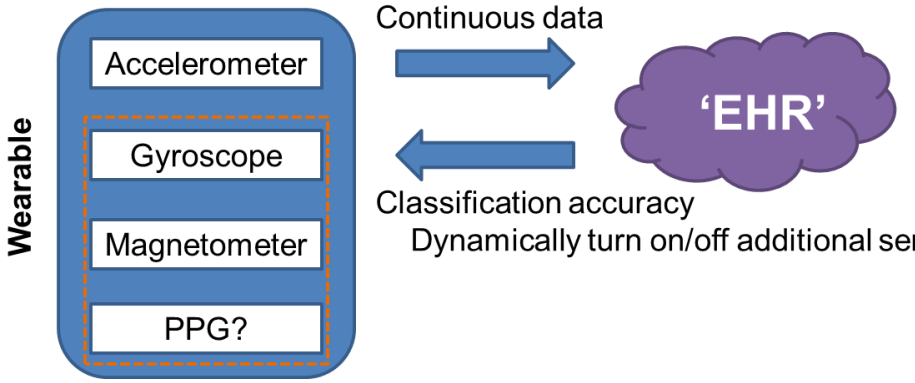
1.2

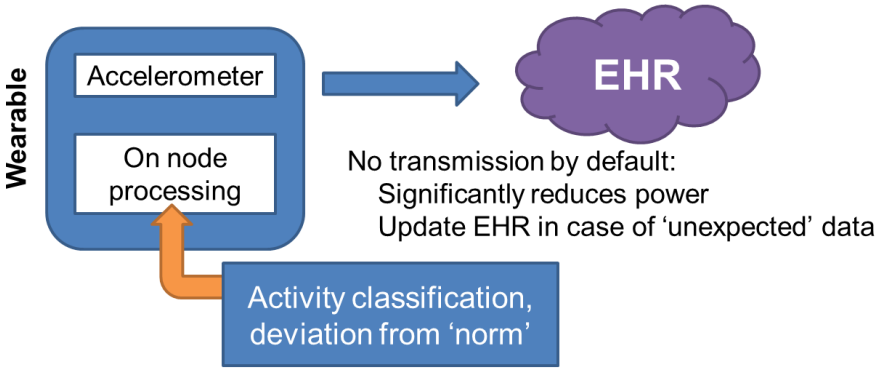
6. Creation of behaviour clustering algorithms
7. Porting of algorithms to run on the sensor device

Interactions









Overlaps with work stream 4 throughout

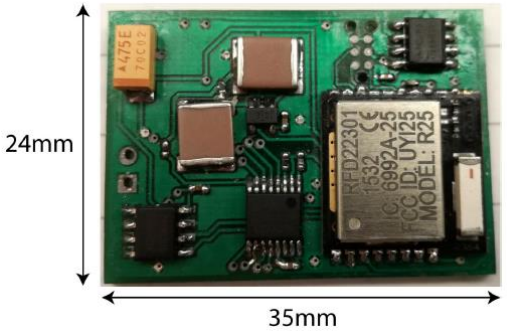
Challenges

- ✓ Grant written assuming WAX9
- ✓ Programmable, wireless, 9-axis IMU
- ✗ Not sold any more!

Alternatives

- ✓ Build ourselves
- ✗ Schematics difficult to access

- ✓ Adds heart rate
- ✗ Complex firmware
- ✗ Not CE marked



- ✓ Fully customisable
- ✗ Not optimized
- ✗ Not CE marked

Challenges

Need coordinated Biobank application

- ✓ First validation of behavioural phenotyping using Biobank data
- ✓ We want accelerometery data and EHRs
- ✘ Complex application with cost associated and 4 month lead time

Do other work packages want/need linked data?

We are currently talking to other investigators in Manchester who have applied to the Biobank previously

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Summary

Wearable hardware and software

Task 1.1 is adaptive sampling

Task 1.2 is on-node grouping of behaviours

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