

Using IoT to Study Life at Home

privacy, security, engagement, benefit

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Opportunities and Challenges

- IoT applications provide a new opportunity for social researchers to study daily life using digital sensors installed in people's homes.
- Implementing a good data collection strategy, persuading participants of the benefits of the research, and solving ethical and consent issues is challenging.

Background: HomeSense Project

- Making it easier and more productive for social researchers to use the digital sensors that are becoming available as a result of the rise of the 'internet of things' and ubiquitous computing.



- Developing guidelines for and examples of the use of digital sensors, including consideration of technical, methodological and ethical issues.

Background: Three strands

Demonstrate the use of sensors via household trials

Catalogue technical, methodological and ethical issues

Create guidelines for using sensors and analysing sensor data

Background: Sensors

Sensor box (egg)

- Temperature
- Humidity
- Light
- Movement
- Noise level
- Bluetooth



Energy monitor



- Electricity consumption

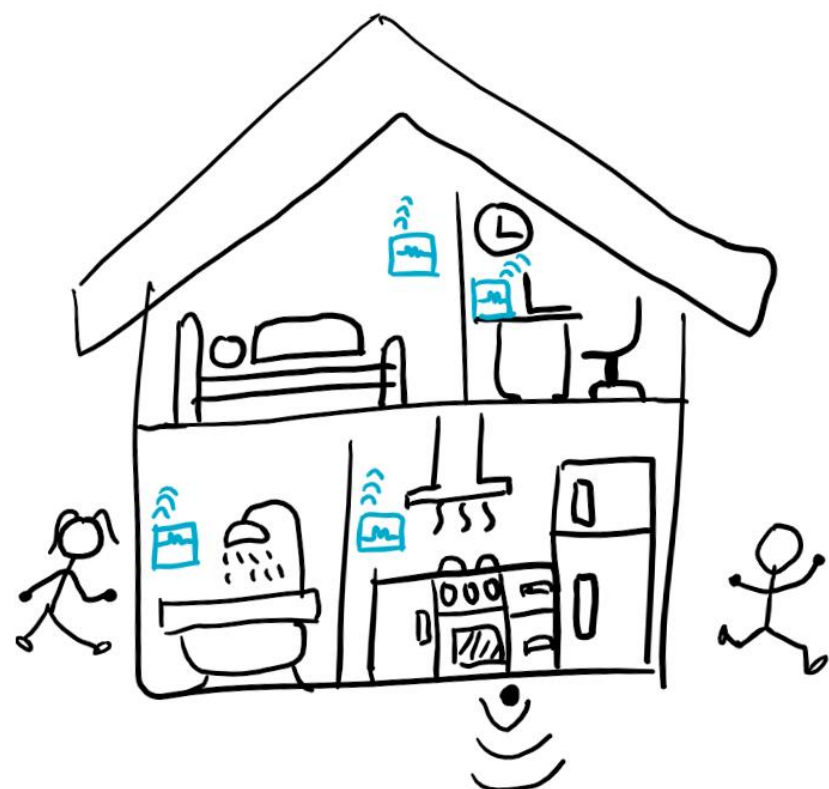
- Bluetooth
- Accelerometer



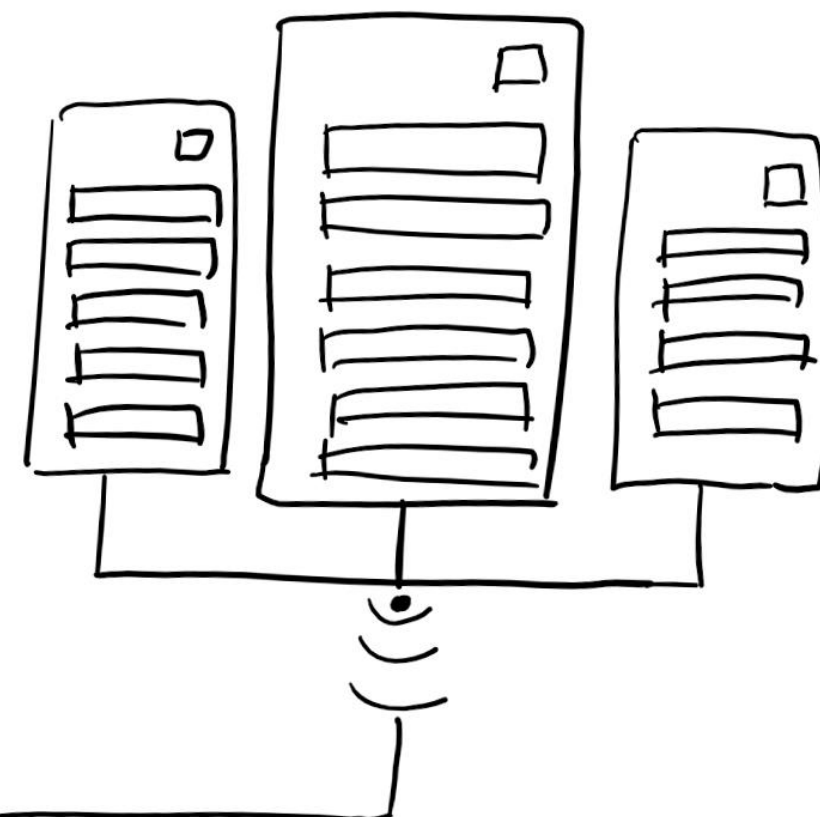
Activity monitor

Background: Data flow

Household

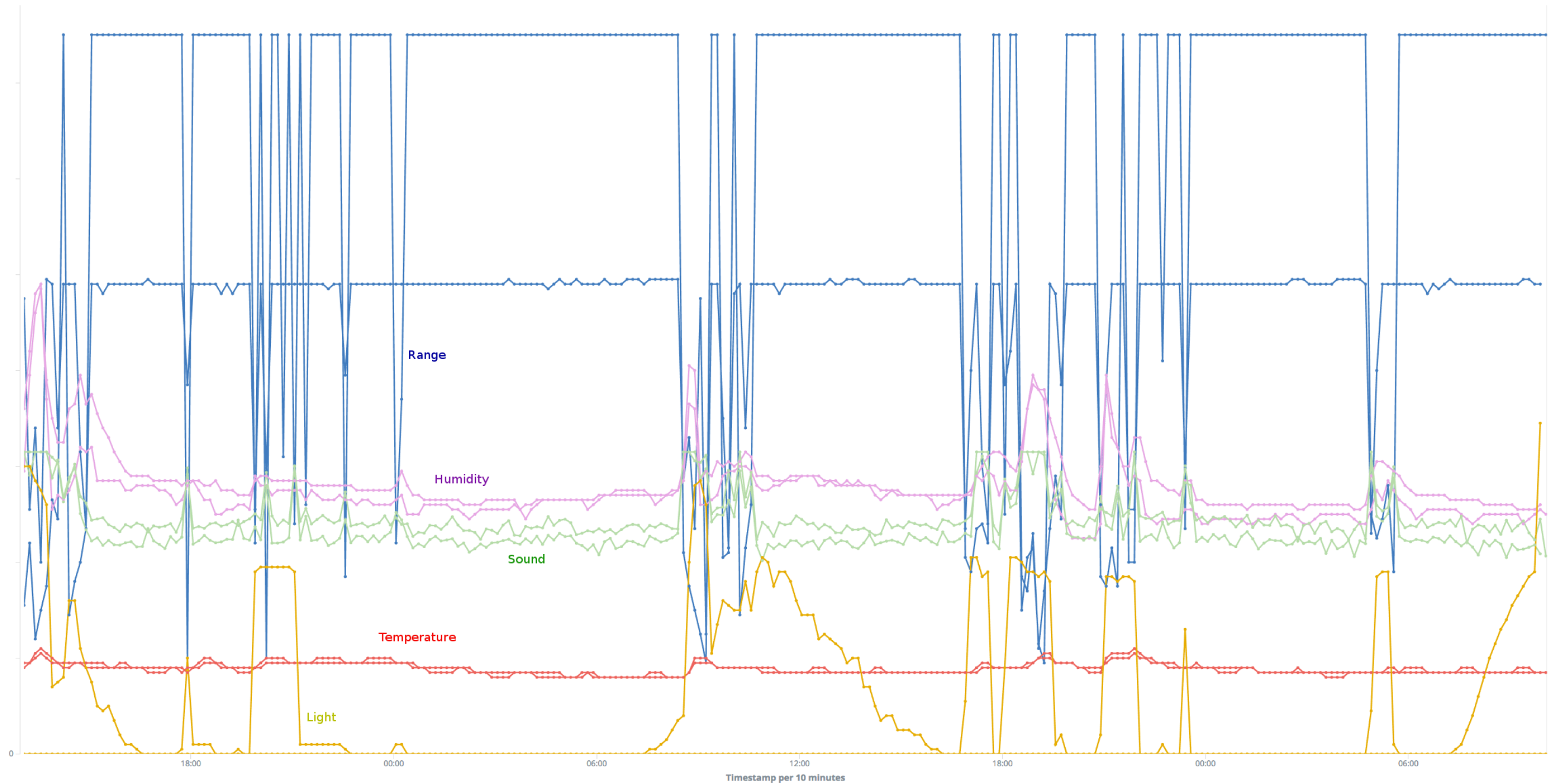


Data center



Encrypted data

Background: Sensor data



A kitchen

Background: Time use diary

Day 1 Afternoon

Time: 12pm – 6pm

Afternoon 12pm – 6pm	What were you doing? Please name one main activity	Were you doing something else at the same time? If so, please name one secondary activity	Using any devices? 1 = smartphone 2 = tablet 3 = computer practical 4 = computer game 5 = TV / entertainment 6 = washing machine 7 = kettle 8 = stove / oven 8 = other (please name)	Where were you? Somewhere away from the household? Please name location or mode of transport	1 = hall(way) 2 = nursery 3 = bedroom 4 = kitchen 5 = living+dining area 6 = dining room (if separate from kitchen) 7 = living room 8 = bathroom 9 = play room (if separate area) 10 = study / workshop 11 = living+dining+study area 12 = bedroom+study 13 = other (please name)	Were you alone or with someone?										How much did you enjoy this time? Scale 1-7 1 = not at all 7 = very much
						Alone	Spouse / partner	Mother	Father	Dependant(s) 0-18yrs	Other relative(s)	Lodger(s)	House mate(s)	Other(s) you know	Stranger(s)	
12pm-12:10						<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
12:10-12:20						<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
12:20-12:30						<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
12:30-12:40						<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
12:40-12:50						<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
12:50-1pm						<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
1pm-1:10						<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
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1:20-1:30						<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
1:30-1:40						<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
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Background: Samples

- Pilot sample of 20 households in South-East England, each participating for 10 weeks
 - ✦ Six households of one occupant;
 - ✦ Eight households of two or more adults;
 - ✦ Six households of parent(s) with dependent(s).

(These proportions correspond to household types recorded in the 2015 ONS (Office of National Statistics) survey of UK households and families.

What we have learned

Privacy



Security



Engagement



Benefit



Privacy: participants' concerns

- What kinds of data will be collected?



- What can be inferred from the data?



- How and with whom my data will be shared?



Privacy: researchers' concerns

- Acceptability
 - ✦ Sensitive data
 - ✦ Sensitive inference
- Problems with consent
 - ✦ Misunderstanding
 - ✦ Vulnerability
 - ✦ Trust issues
- Indiscriminate collection (ethical and legal)
 - ✦ Varieties (data)
 - ✦ Subjects (guests/visitors)
- Identity leakage
 - ✦ Aggregation level
 - ✦ Data triangulation

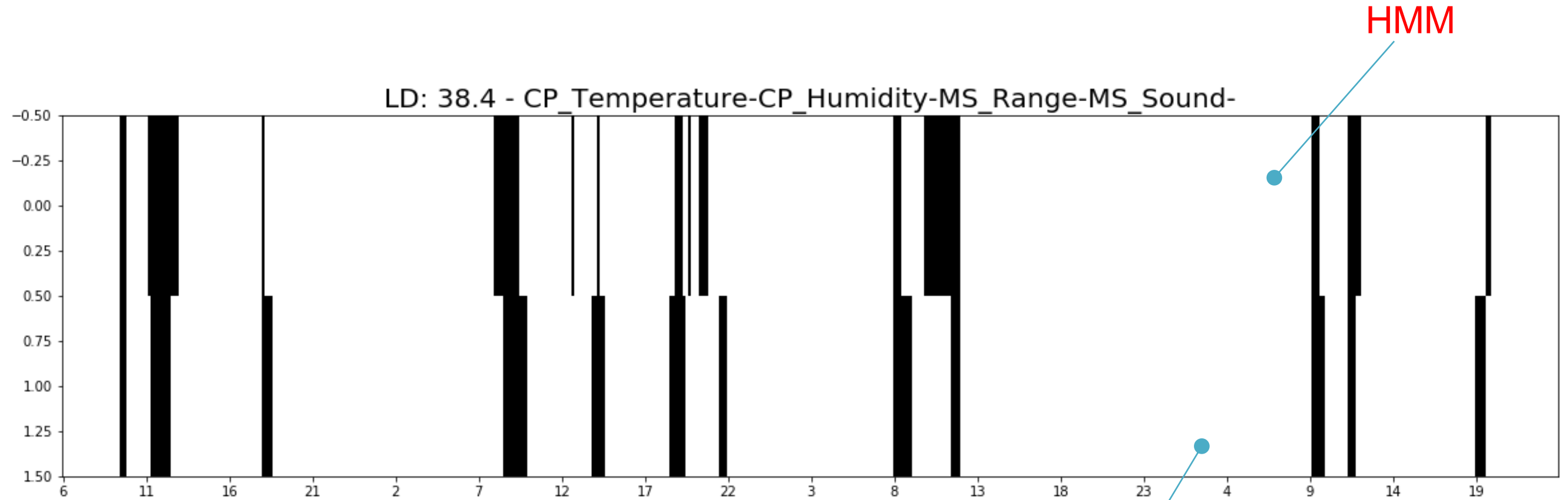
Privacy concerns: practices

- Demystify the operation of sensors by giving interactive demonstrations
- Demystify the study and participation by having face-to-face interviews and Q&A
- Written consent obtained from key respondent and from other household members aged 16 and over (and from parents on behalf of children)
- Information sheet given to key respondent to hand to visitors and guests
- Minimise the set of variables for data collection according to research goals
- Optimise data anonymization for participant identity protection as well as research operation
- Data sharing only at aggregate levels



Show case: activity inference

- Cooking activity
- Sensor data: Temperature, Humidity, Range, Sound



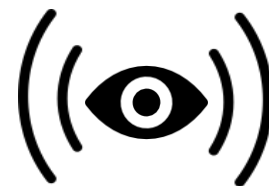
Time
Use
Diary

Security: participants' concerns

- Where and how my data are stored?



- How my data are transmitted?



- Will the sensors endanger my home network?



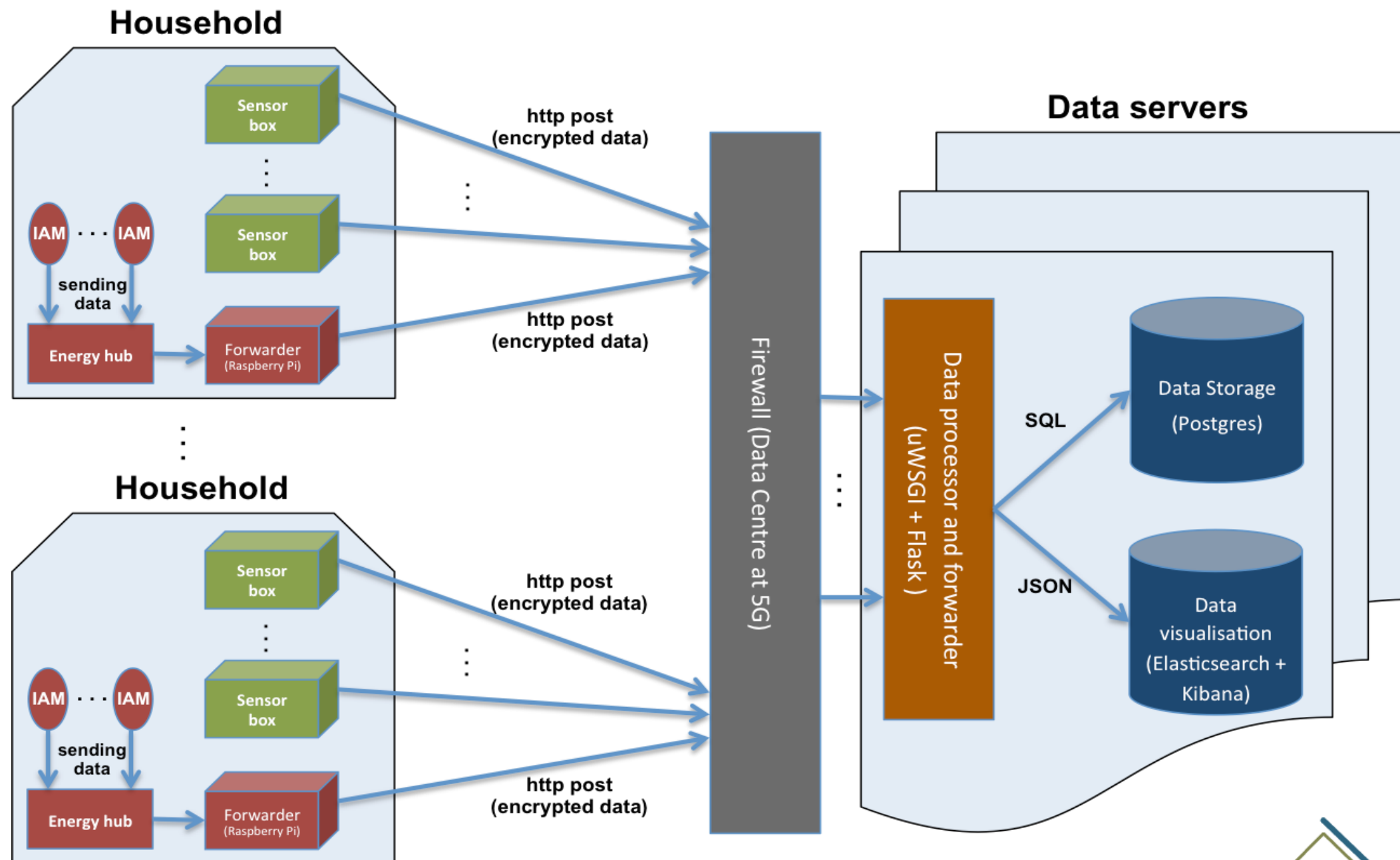
Security: researchers' concerns

- Unauthorised access
 - ✦ Sensors
 - ✦ Transmission channel
 - ✦ Data server
- Data loss
 - ✦ Server outage
 - ✦ Human errors

Security concerns: practices

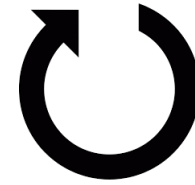
- End-to-end data encryption
 - ✦ AES, HTTPS
- System security enforcement
 - ✦ Firewall, sub-system isolation
- Account security enforcement
 - ✦ Key access, key rotation
- Data replication and backup

Show case: system diagram



Engagement: participants' concerns

- Do I need to take care of the sensors?



- Do I have control over the sensors?



- Will the sensors disturb my daily activities?



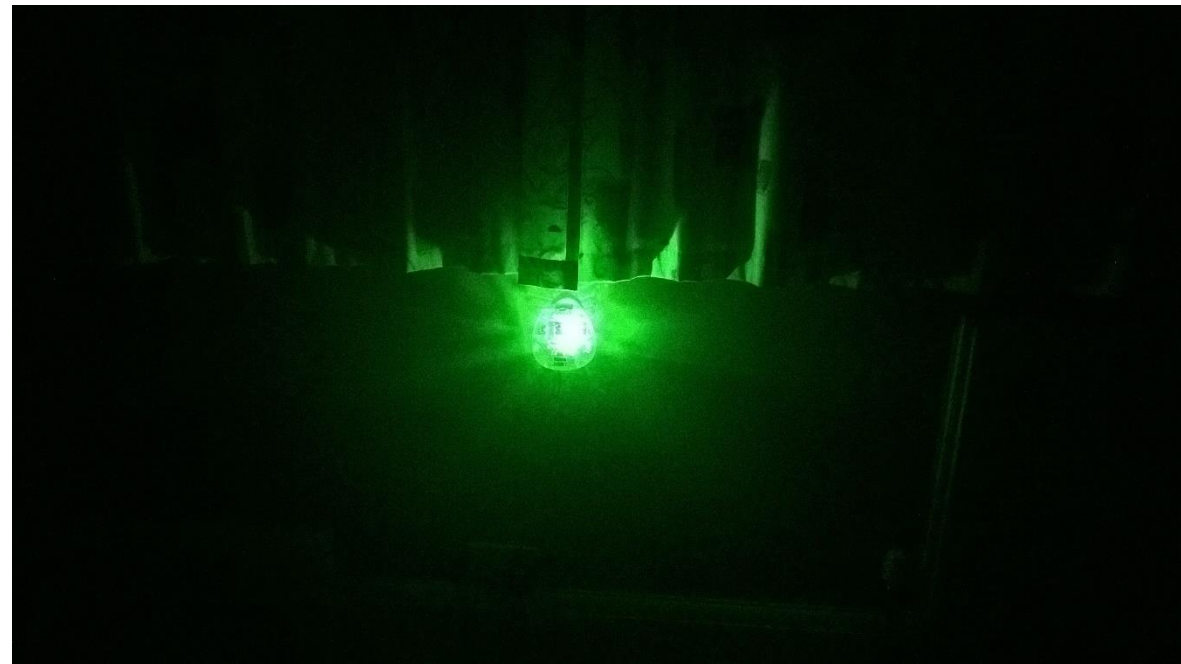
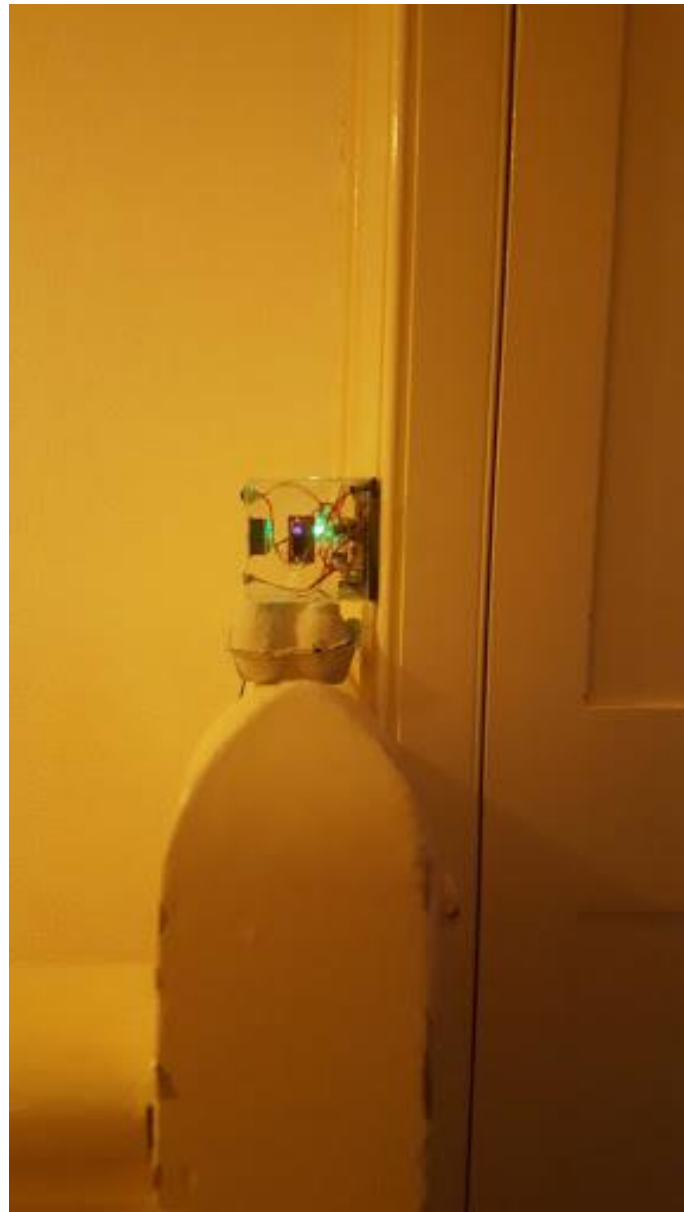
Engagement: researchers' concerns

- Overload participants
 - ✦ Acceptability
 - ✦ Behaviour diversion
- Disturbances
 - ✦ Quitting
 - ✦ Attitude diversion
- Data quality
 - ✦ Over intervene

Engagement concerns: practices

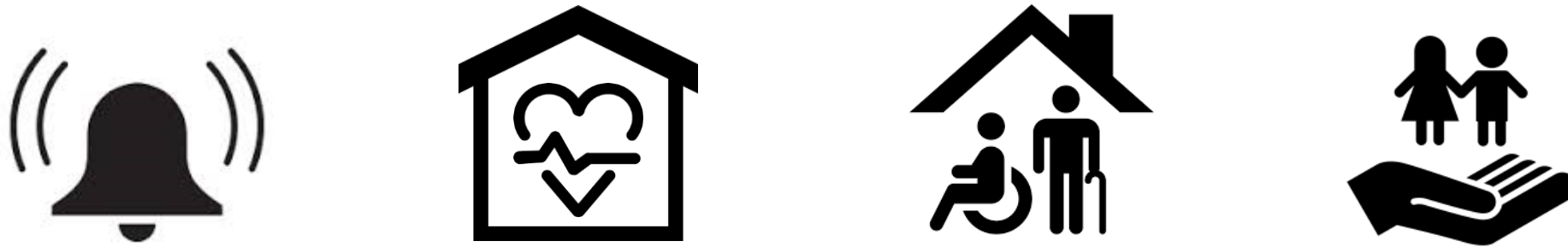
- Clarify the maintenance work that the participants need to do for the sensors
- Clarify the control that the participants can have over the sensors
- Walking interview around the home, to explain daily routines and what is done when and where, to identify convenient spots for putting sensors
- Customisable solutions depending on the participants' conditions and requirements

Show case: live with sensors



Benefit: participants' concerns

- What are the benefits from having sensors at home?



- What are the benefits from participating in the study?



Benefit: researchers' concerns

- Lack of motivation
 - ✦ Incentive for participation
- Deviate from research goals
 - ✦ Biased sample
- Conflicts with privacy
 - ✦ family members

Benefit concerns: practices

- Interactive demonstration to illustrate research goals as well as participation rewards
- Diverse rewards for recruitment
 - ✦ Payment, equipment, tutoring
- Balance the needs and rights of participating households

Show case: recruiting flyer



Researchers in the Sociology Department and the 5G Innovation Centre at the University of Surrey are trialling the use of sensors in households.

We are looking for participants:

1. **Resident in the south-east of England**
2. **Living in one of these 3 types of households:**
 - **Single occupant**
 - **Two or more adult occupants**
 - **Parent(s) w/dependent(s) 0-16 yrs**



This study has received a favourable ethical opinion from the University of Surrey Ethics Committee

We will demonstrate how the sensors detect trends and changes in temperature, humidity, noise and light levels, particulate density, electricity use and movement, followed by a trial of sensors installed in your residence for 3 months.

We will interview you at your residence regarding various aspects of everyday household life, and about your experience of participating in the study. We will also ask you to keep a diary of your time use for 4 days.

In return for your time and effort, you will be paid a total of £100 plus you get to keep the activity sensor. All other members of your household will be paid £25 for indirect participation, and a second member will be gifted an activity sensor, should they consent to wearing one.

Conclusions

- IoT devices (digital sensors) provide alternative ways of studying home life with less effort from both participants and researchers.
- HomeSense project will provide guidelines for using sensors in homes for researching energy-related practices, assisted living arrangements and aspects of family life.



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HomeSense

digital sensors in social research