

The Case for Apportionment

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BuildSys, 3 November 2009

Computing for the Future of the Planet

- Computing is a crucial weapon in our armoury for ensuring the future of the planet
- Computing will play a key part in optimising use of physical resources and ultimately their substitution by the digital world
- Computing will be a tool for enabling developing societies to improve their standard of living without undue impact on the environment



Andy Hopper, Andrew Rice. Computing for the Future of the Planet.
Phil. Trans. R. Soc. A, 366(1881):3685—3697, October 2008.

A Personal Energy Meter might inspire savings

- Information about individual energy consumption (direct and indirect)
- Present itemised breakdown
 - travel, heating, water usage, transportation of food etc.
- Use world model
 - Upload own energy use to help digital optimisation
 - Download energy profile of devices and goods
- Lots of computing problems!
 - measurement, indexing, caching, event delivery, prediction, use of social networking, security, privacy, correctness etc.

Simon Hay. A global personal energy meter. In Adjunct Proceedings of the 7th International Conference on Pervasive Computing (Pervasive 2009).

The inefficiency of splitting the bill

“Bistromathics itself is simply a revolutionary new way of understanding the behaviour of numbers...

The most mysterious piece of non-absoluteness of all lies in the relationship between the number of items on the bill, the cost of each item, the number of people at the table, and what they are each prepared to pay for...

Douglas Adams. *Life, The Universe and Everything*.

U. Gneezy, E. Haruvy and H. Yafe. The inefficiency of splitting the bill. *The Economic Journal*, 114(495):265-280, 2004.

Apportionment should be complete and accountable

- the process of dividing up the total consumption of a building, organisation or other entity and allocating it to individuals

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 - **completeness:** the sum of the energy apportioned to all individuals = the total energy to be apportioned

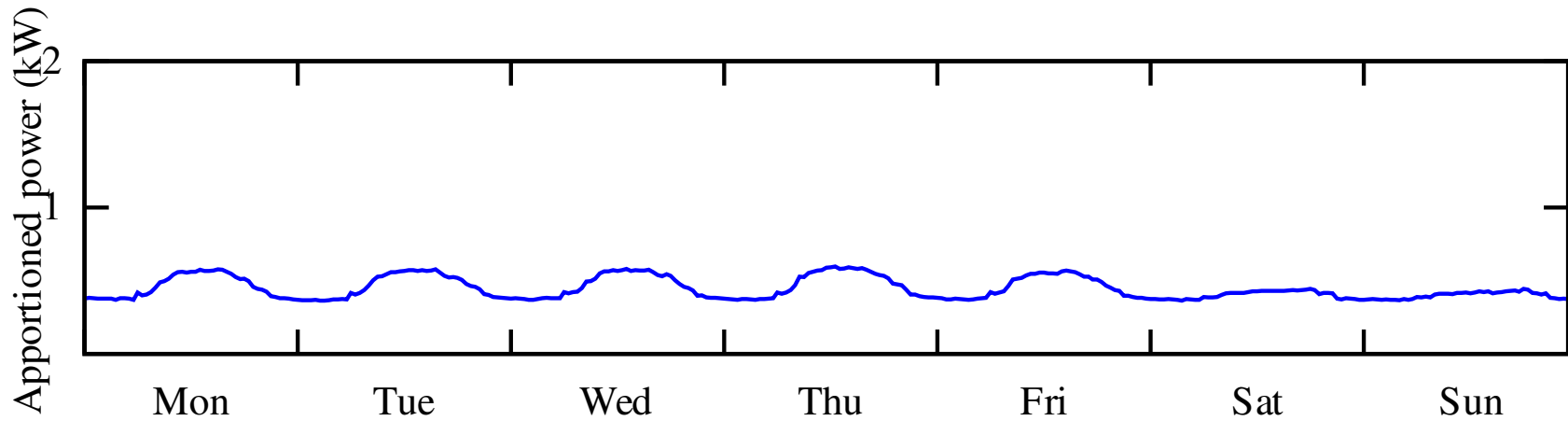
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- different policies will suit different buildings and organisations
- desirable properties:
 - **completeness**: the sum of the energy apportioned to all individuals = the total energy to be apportioned
 - **accountability**: actions by an individual should have a maximal effect on their own allocation and a minimal effect on others

Our three example individuals

Description	Pattern	Hours
Member of staff	0900-1700 Mon-Fri	40
PhD student	1100-1900 Mon-Fri	40
Visiting professor	1100-1700 Tue, Thu	12

'Equal' policy is unfair



Total energy (kWh) for a week

	Member of staff	PhD student	Visiting professor
Equal	150	150	150

Occupancy can be estimated from access logs

1. count the number of distinct pseudonyms in a 24 hour period, and assume this is the maximum occupancy for that day

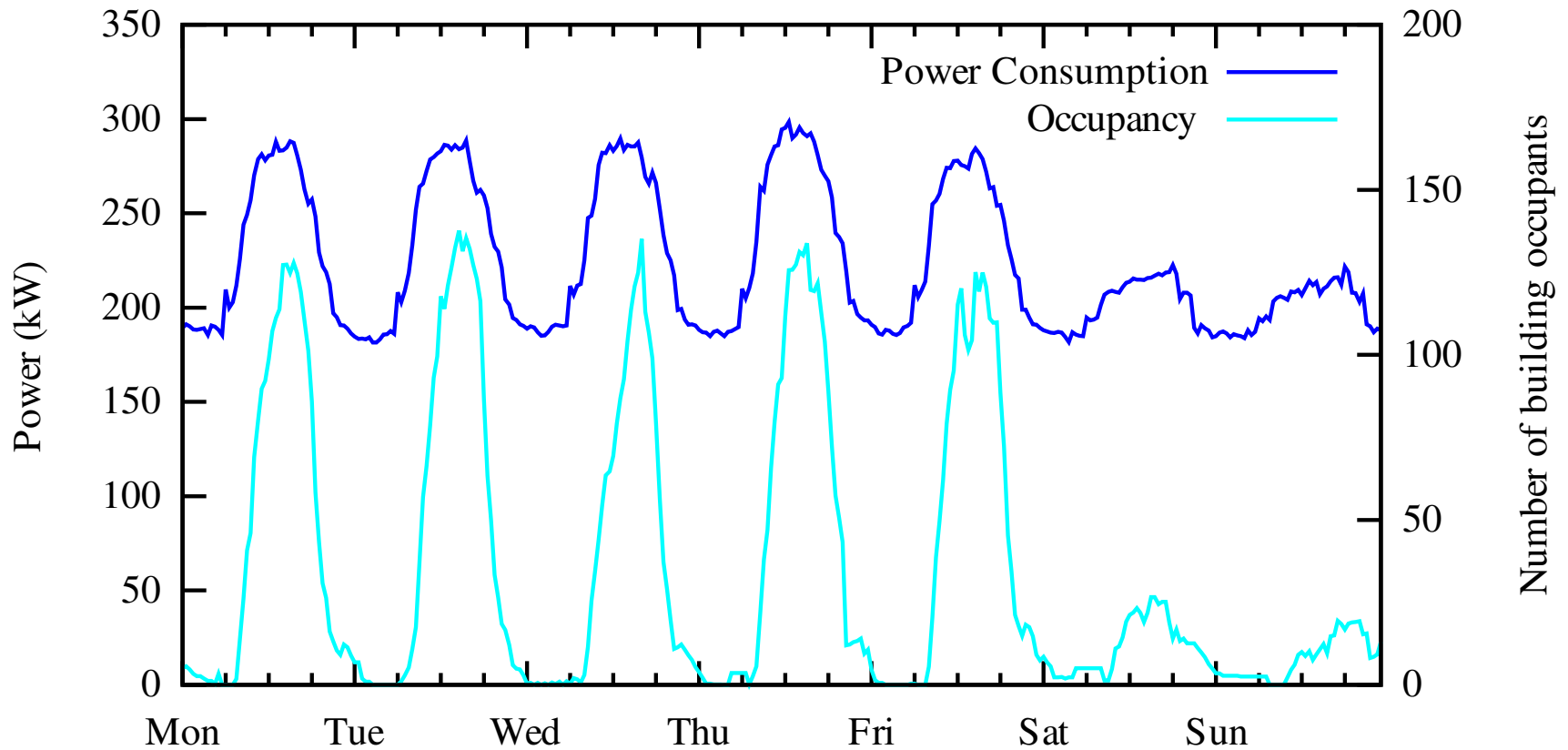
Occupancy can be estimated from access logs

1. count the number of distinct pseudonyms in a 24 hour period, and assume this is the maximum occupancy for that day
2. calculate the ratio between people entering on 'entry' events and people leaving on 'exit' events so that the occupancy drops to zero at 5 AM

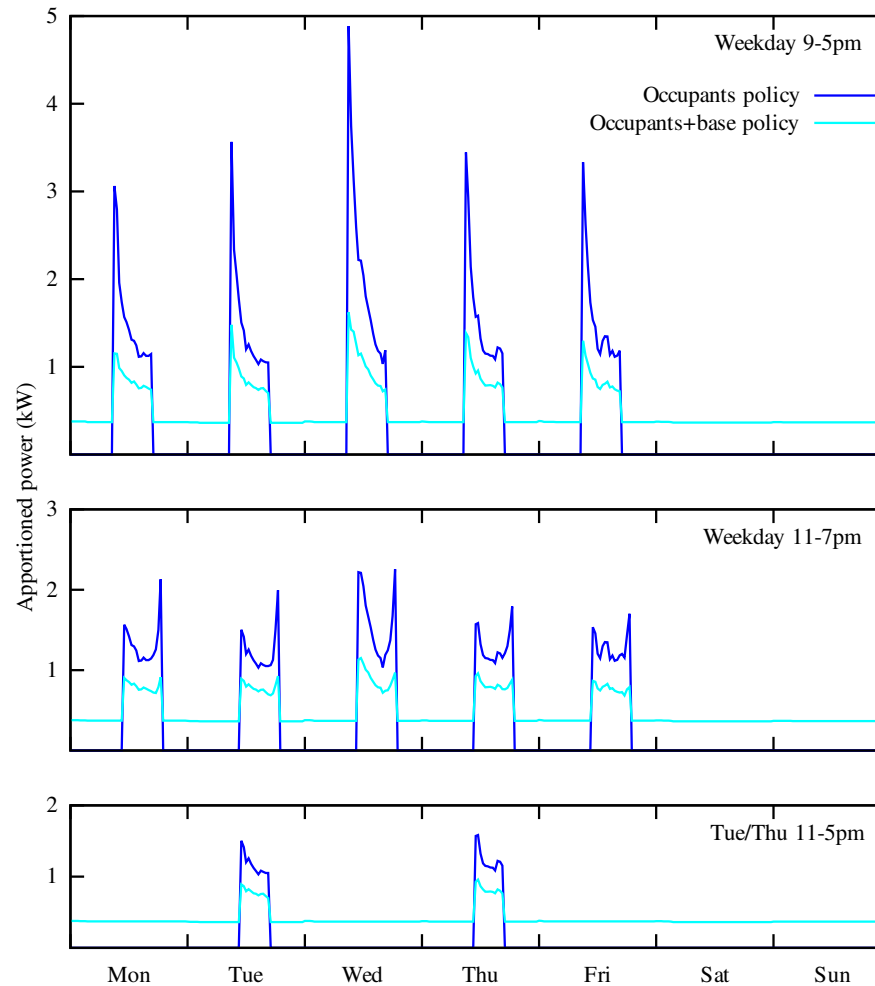
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1. count the number of distinct pseudonyms in a 24 hour period, and assume this is the maximum occupancy for that day
2. calculate the ratio between people entering on 'entry' events and people leaving on 'exit' events so that the occupancy drops to zero at 5 AM
3. scale each day's estimates so that the peak occupancy is equal to the total number of 'entry' events calculated in step 1

Power consumption varies with occupancy



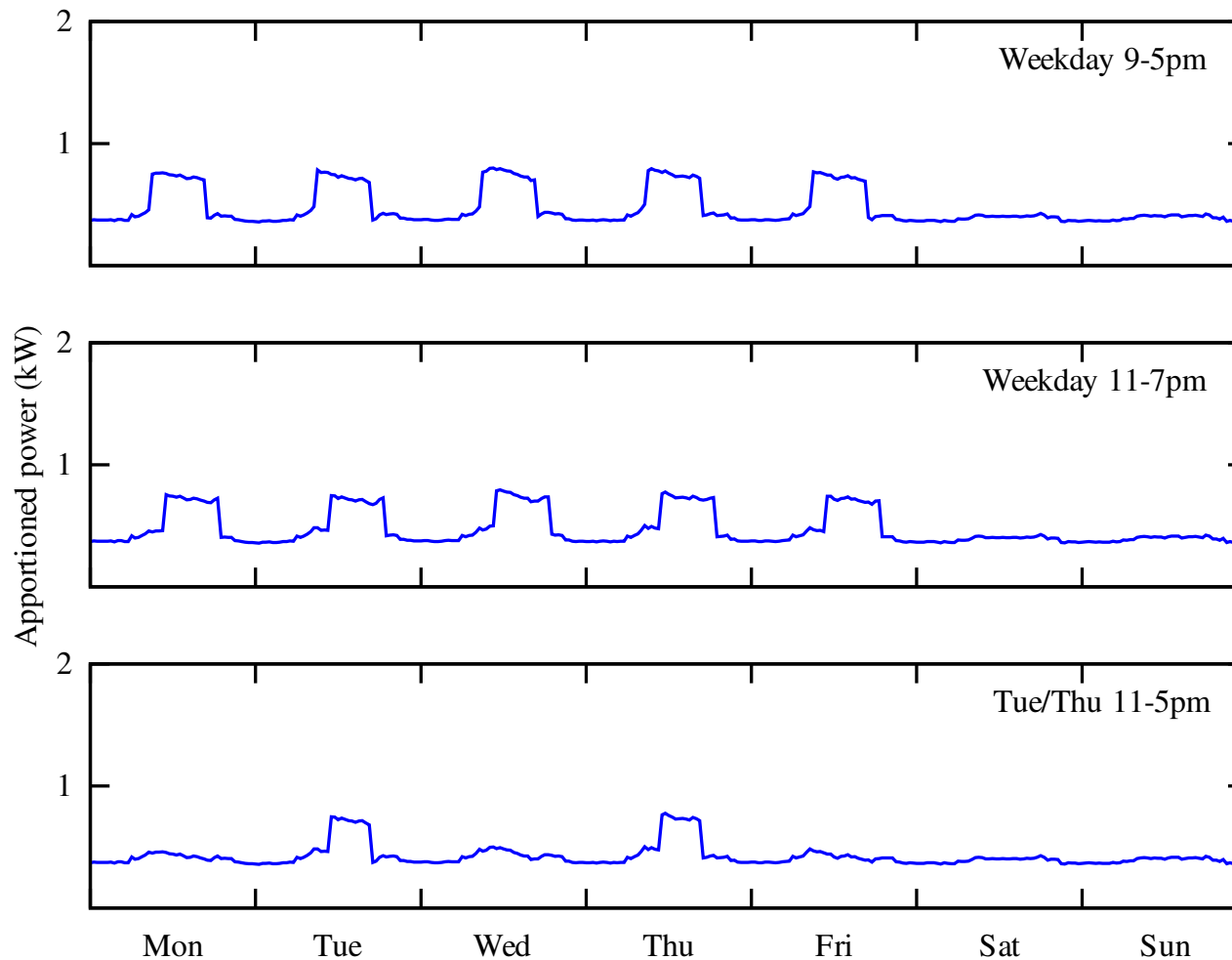
'Occupants' policies penalise some working patterns



Total energy (kWh) for a week

	Member of staff	PhD student	Visiting professor
Equal	150	150	150
Occupants	132	107	28.9
Occupants+base	168	160	135

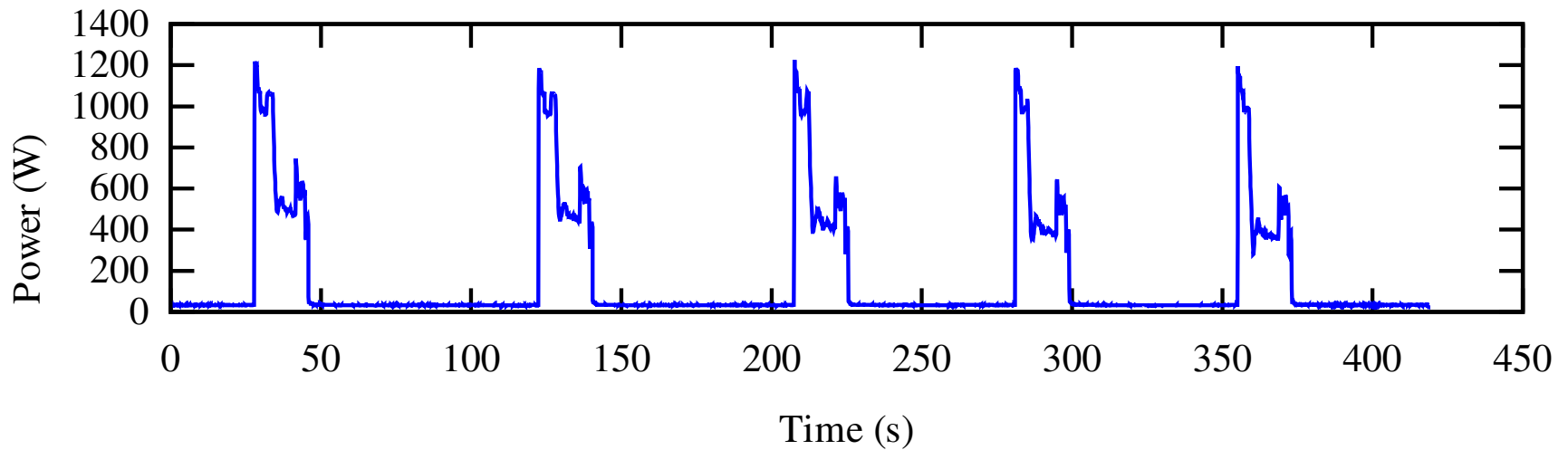
'Personal load' policy provides better incentives



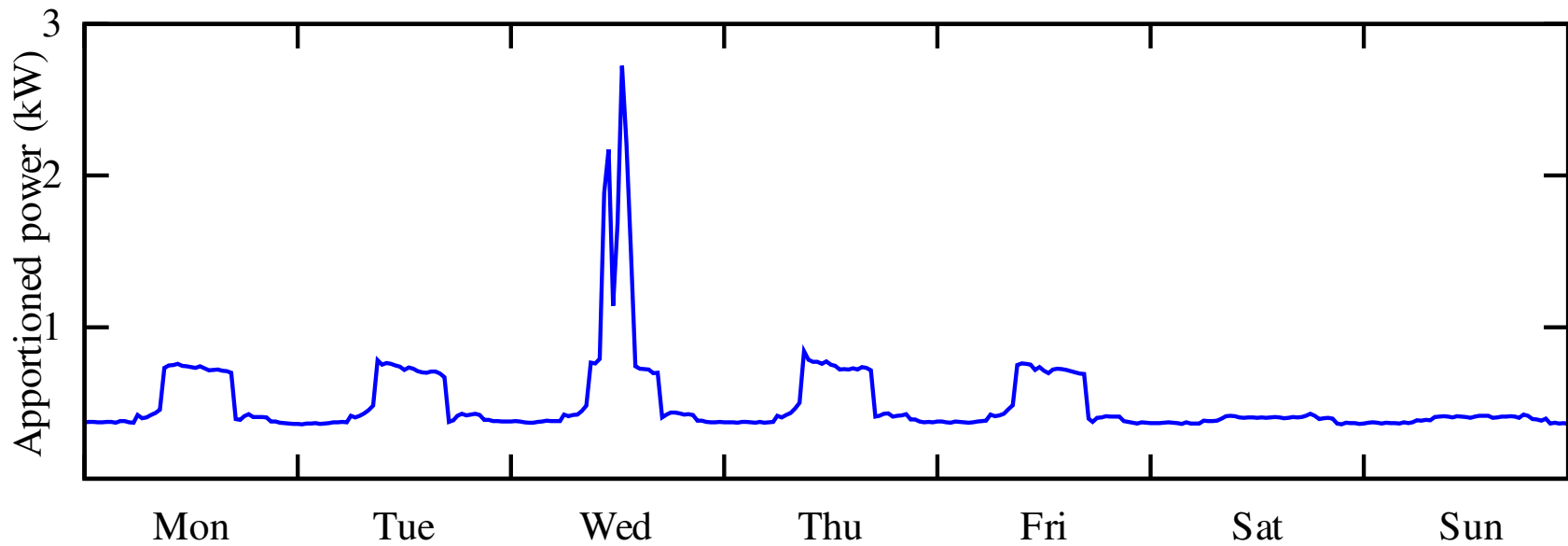
Total energy (kWh) for a week

	Member of staff	PhD student	Visiting professor
Equal	150	150	150
Occupants	132	107	28.9
Occupants+base	168	160	135
Personal load	160	160	143

Printing: an example of a shared resource



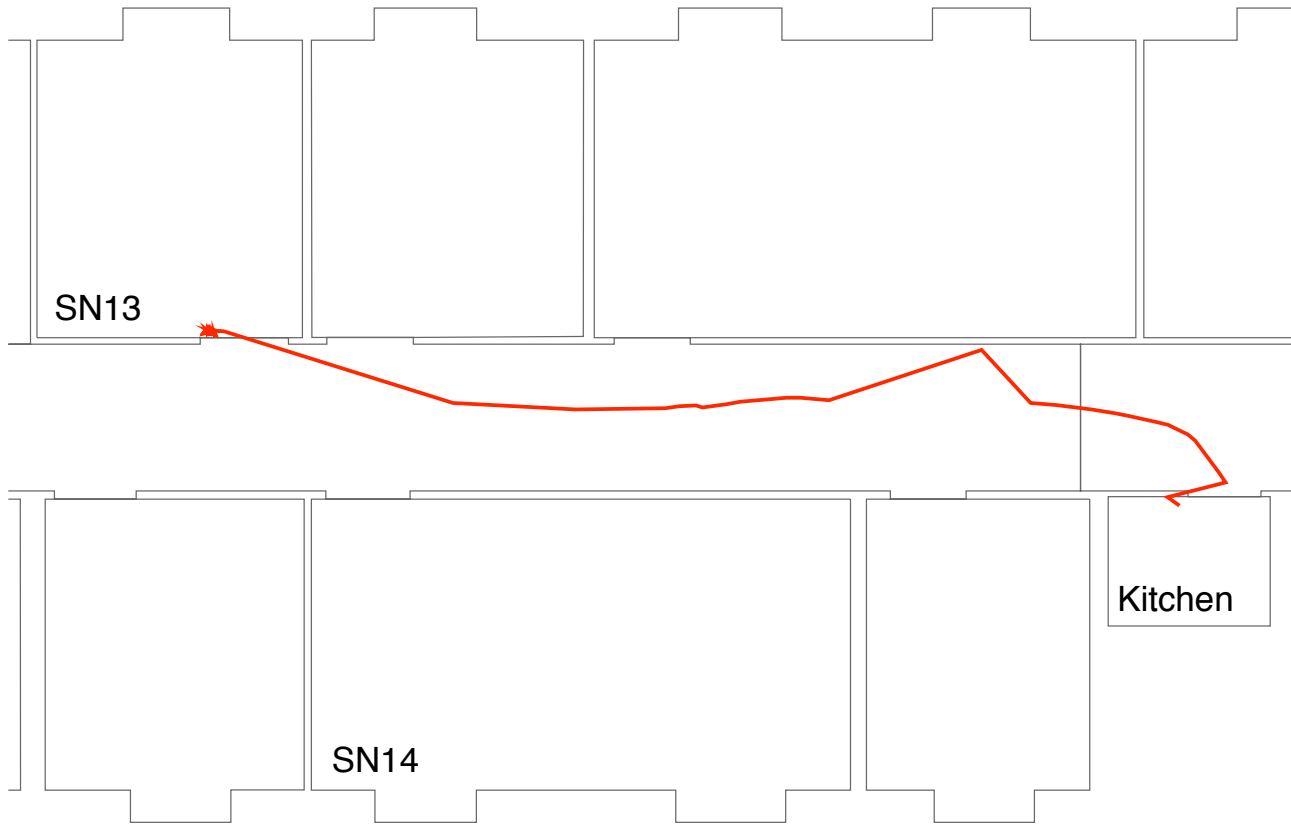
Personal load with printing costs



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Occupants+base	168	160	135
Personal load	160	160	143
Personal load+print	168	160	143

Coffee machine: location as usage proxy



Thank you!

Any questions?

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More information:

<http://www.cl.cam.ac.uk/~sjeh3/apportionment/>

<http://www.cl.cam.ac.uk/research/dtg/planet>