Smart Meter Disaggregation: Modelling Multi-State Appliances

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Poster competition 2012

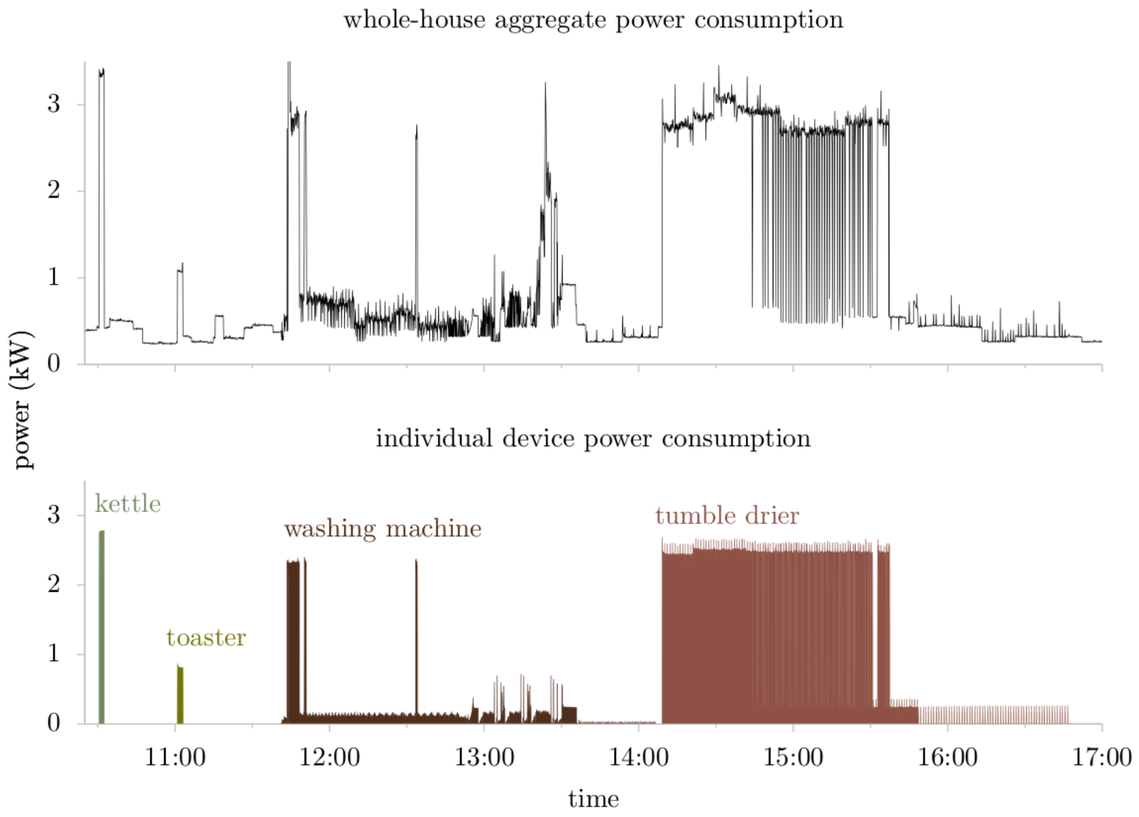
1) Motivation

- Every house in the UK will have a smart meter by 2019
- Disaggregated, appliance-by-appliance information enables consumers to manage their electricity consumption effectively
- Reducing energy consumption is a good idea for multiple reasons

2) Aim

- Build a disaggregation web service
- The only required input should be the smart meter signal
- Infer which appliances are active & energy used by each appliance

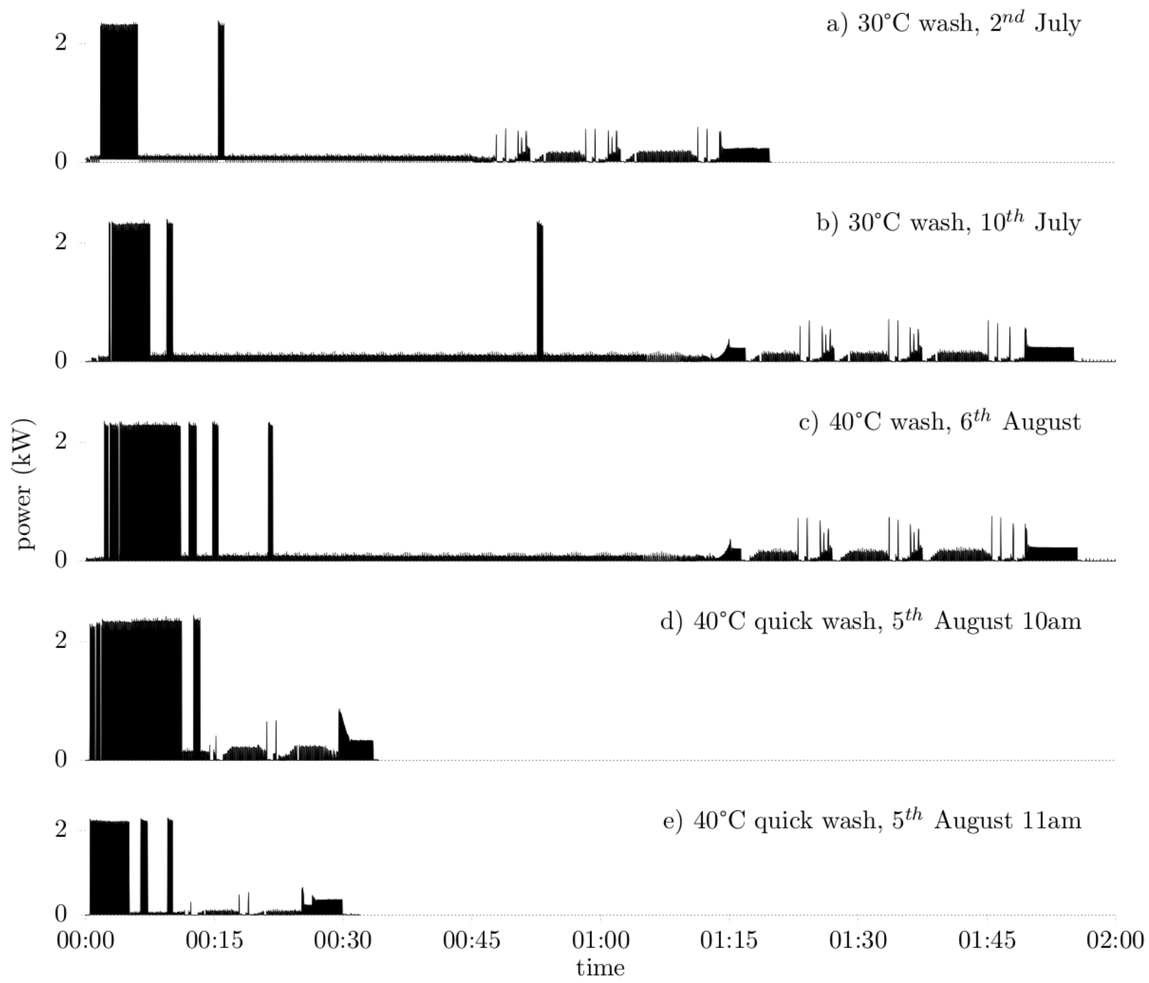
The following figure gives a feel for the task at hand:



3) The challenge

- An unresolved challenge in the literature is to model multi-state appliances like washing machines, tumble driers, dish washers etc.

- The following figure shows five runs of the same washing machine. Note that
- the washing machine has multiple states and
- the transition between states varies from run to run

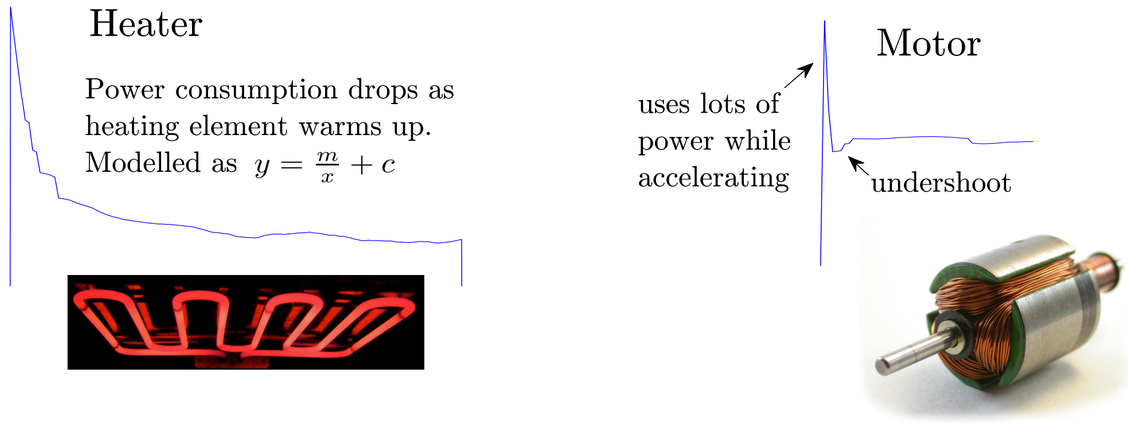


4) Our proposed solution

- Model the internal components of each appliance
- Hence build faithful, expressive models of appliances
- Our approach consists of 2 conceptual steps:

Step 1: Parameterised models of appliance components

- All appliances are constructed from a set of components such as motors, heaters, compressors and plasma screens, for example:



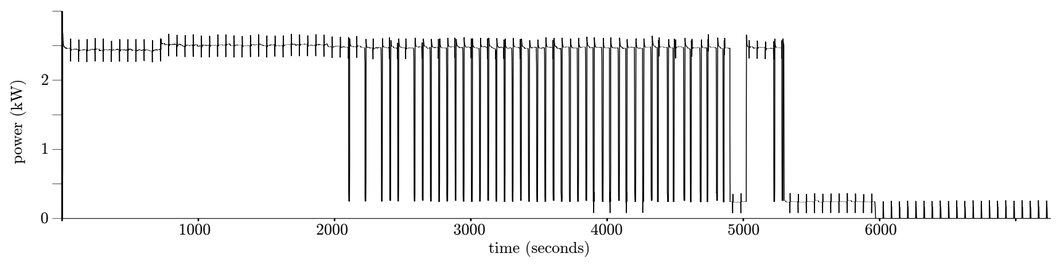
- Components will be modelled using simple mathematical formulae capturing the physical behaviour of the component
- For example, a tumble drier's components would be specified like this:

```
<appliance> <!--Using XML format inspired by Scalable Vector Graphics (SVG)-->
  <name>Tumble drier</name>
  <heater name="heater" inrushPower="2500W" decay="30s" stablePower="2100W"/>
  <motor name="fan"  inrushPower="260W" decay="1s" undershoot="20W" stablePower="240W"/>
  <motor name="drum" inrushPower="200W" decay="1s" undershoot="10W" stablePower="170W"/>
</appliance>
```

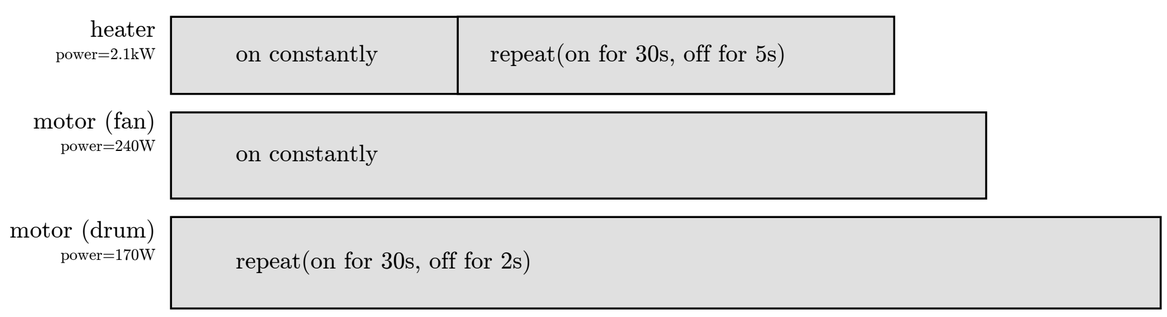
Step 2: Probabilistic graphical models of appliances

- The probability of observing a component state change will be represented by a graphical model
- The steps to produce a tumble drier model are outlined below:

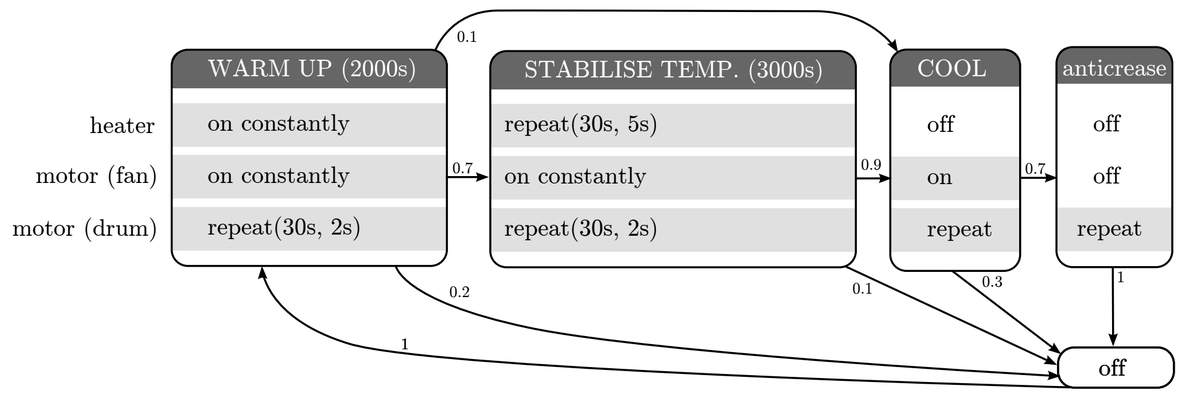
a) Record the power consumption signature of a tumble drier



b) Decompose the signature into a timeline where each row represents the state of a single component:



c) Use several signatures to build a probabilistic graphical model representing all possible state transitions



5) Next steps

- Implement the appliance modelling framework described above
- Experiment with training appliance models by hand from aggregate data
- Build an algorithm to automatically train appliance models from aggregate data
- Build an algorithm to automatically disaggregate smart meter data using the models