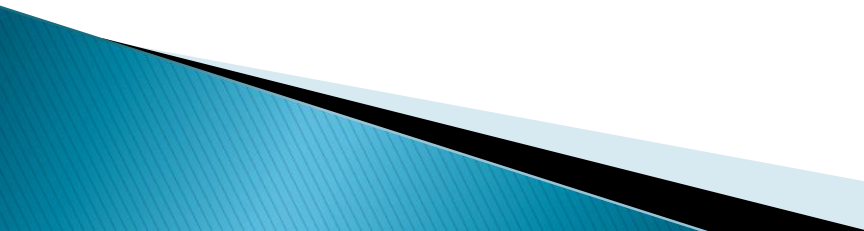


Understanding Household Consumption

Approaches to automatic load
disaggregation

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Reducing consumption

- ▶ Limitation on building/device efficiency gains:
 - Insulation.
 - Efficient boilers, appliances.
 - Retro-fit limitations, old housing stock.
 - ▶ Rest must come from changes in behaviour.
 - ▶ Human behaviour is hard to affect/regulate.
- 

Understanding consumption

Understanding how households consume energy can help to reduce consumption.

How?

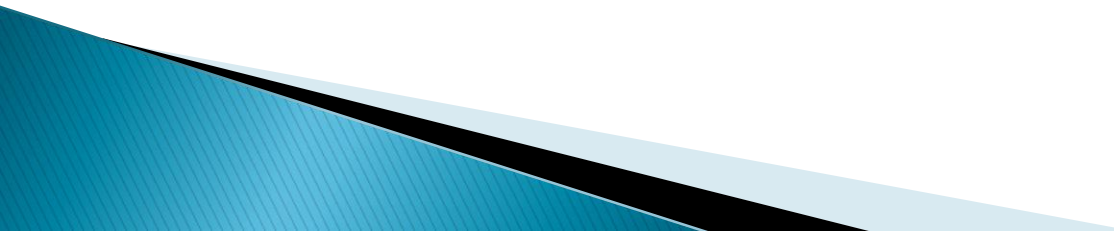
- ▶ Quantify impacts of behaviour change.
 - ▶ Identify most significant changes.
- 

Understanding consumption

- ▶ Questionnaire responses from households.
- ▶ Benchmarking by:
 - Location, building type, occupants, etc.
- ▶ Continuous monitoring of consumption:
 - Smart meters, Automated meter reading.
 - Sub-metering.

Profiling consumption through load monitoring

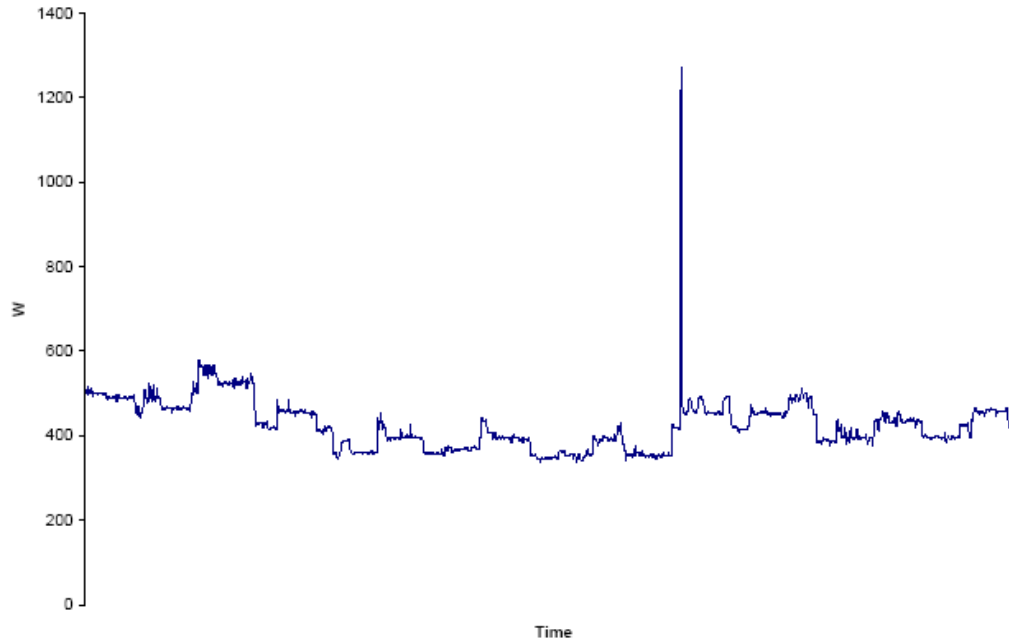
Intrusively:

- ▶ Directly measure the load characteristics of each device in a household.
 - ▶ Use sub-meters or portable equipment.
 - ▶ On-site interaction.
 - ▶ Impractical, expensive.
- 

Nonintrusive load monitoring

- ▶ Non-intrusive (NALM):
 - Passively observe the total load.
 - Needs to disaggregate the overall load into individual devices.
- ▶ Hybrid approach using:
 - Sensors.
 - Serious games.

AMR or Smart meters



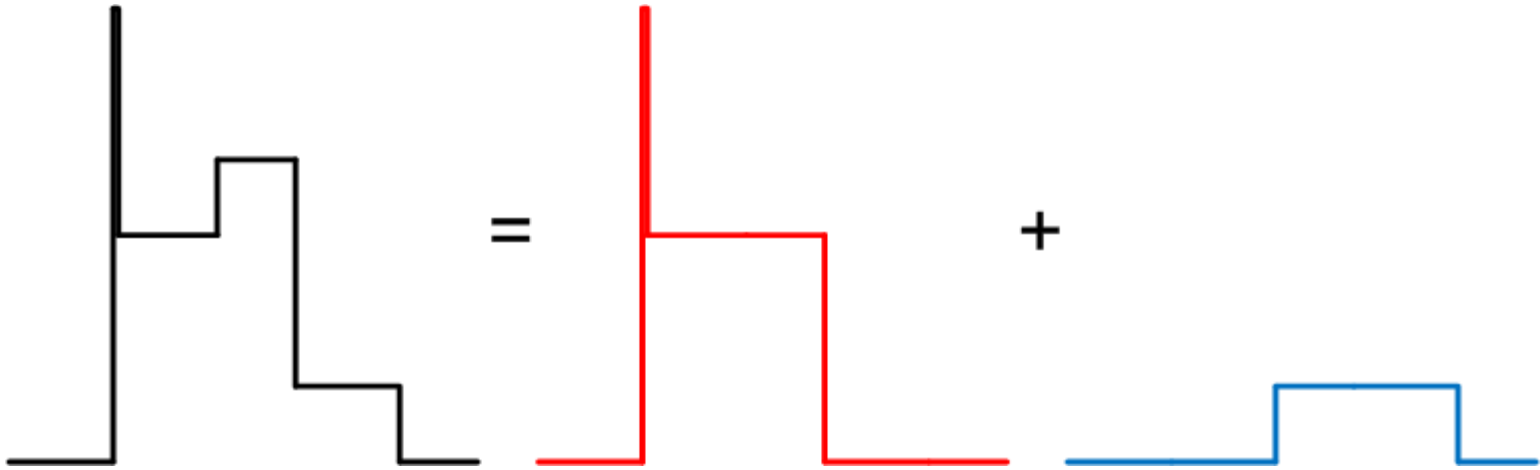
- ▶ Smart meters:
 - Continuously monitor/capture load.
 - Recorded every few seconds.
 - Maybe more than just kWh.

Disaggregation

The disaggregation task:

- ▶ Isolate individual device profiles.
- ▶ Attempt to identify devices.

Isolating devices

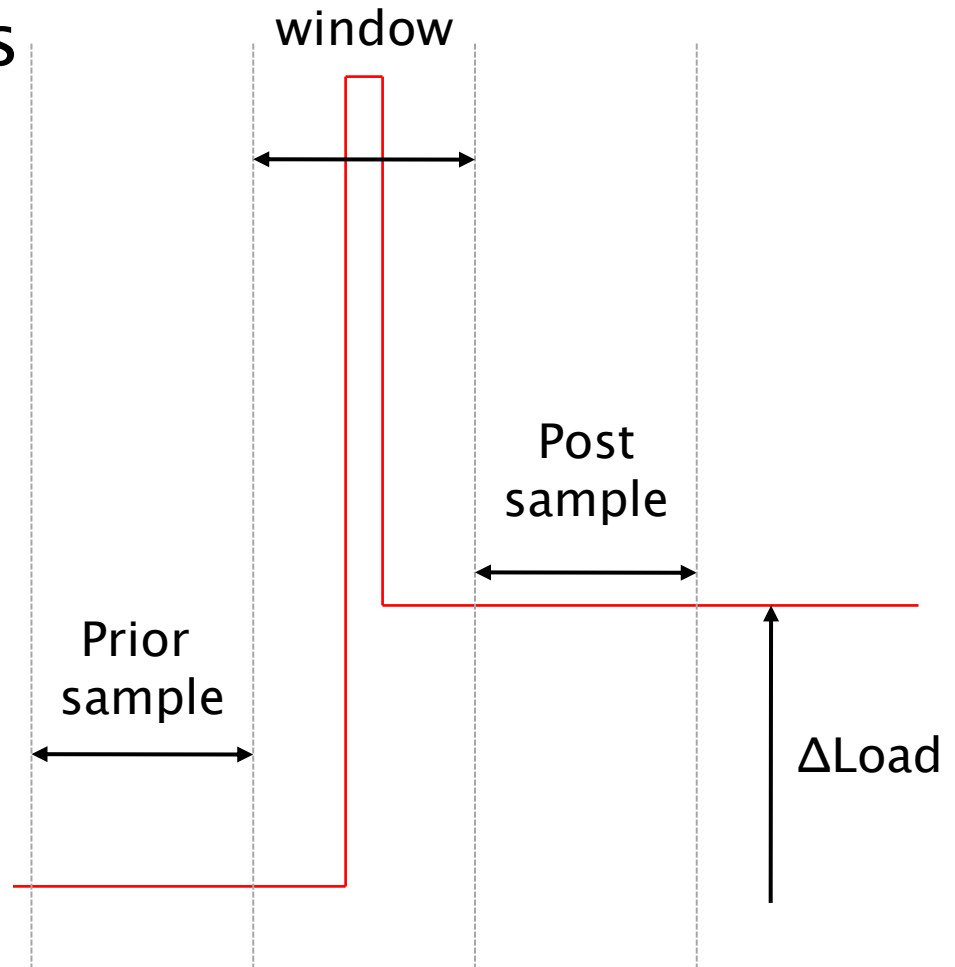


Problem:

- ▶ Analogous to edge detection.
- ▶ Extremely noisy.
- ▶ Devices may overlap.

Isolating Devices

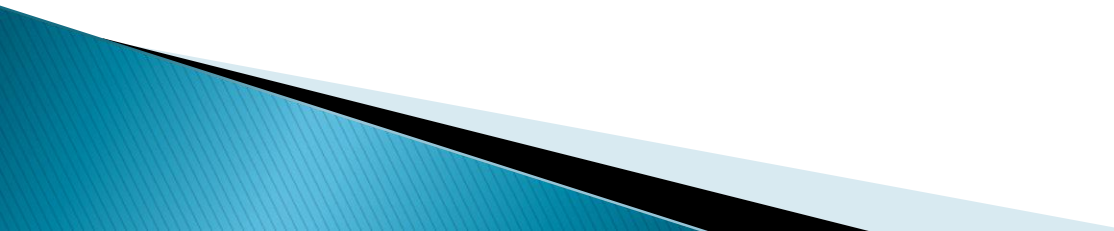
- ▶ Statistical hypothesis testing using:
 - t-test.
 - a prior and post sample.
 - a spike window.



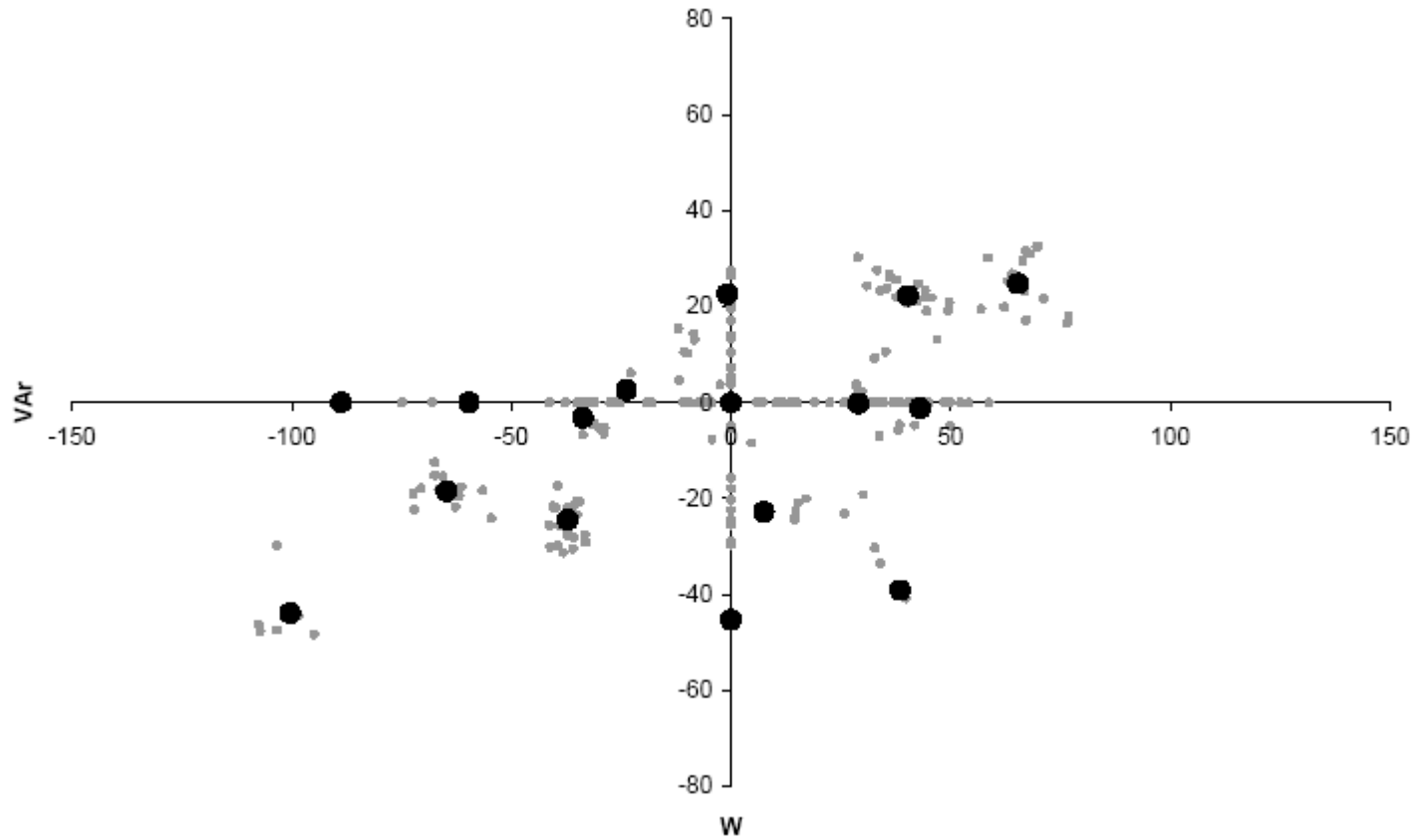
Isolating Devices

- ▶ Advantages:
 - Robust to device type/load profile.
 - Low computational cost.
- ▶ Disadvantages:
 - Struggles where devices on/off overlap.
 - Treats on and off profiles distinctly.
 - Cannot associate multiple behaviour with one device.

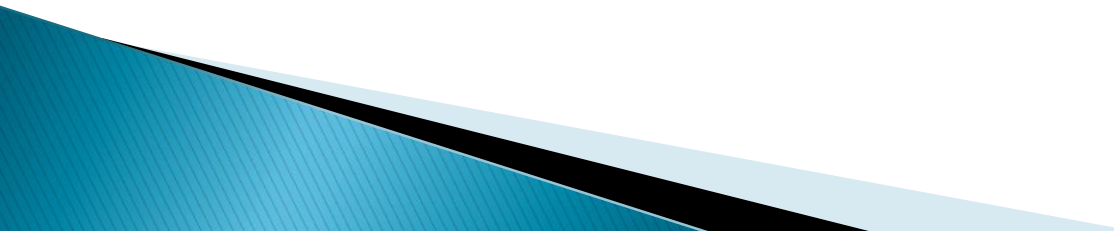
Identifying Devices

- ▶ Should:
 - Match device on and off profiles.
 - Distinguish between devices.
 - ▶ Clustering techniques:
 - Account for symmetry in on/off profiles.
 - Robustly identify device clusters.
- 

Identifying Devices

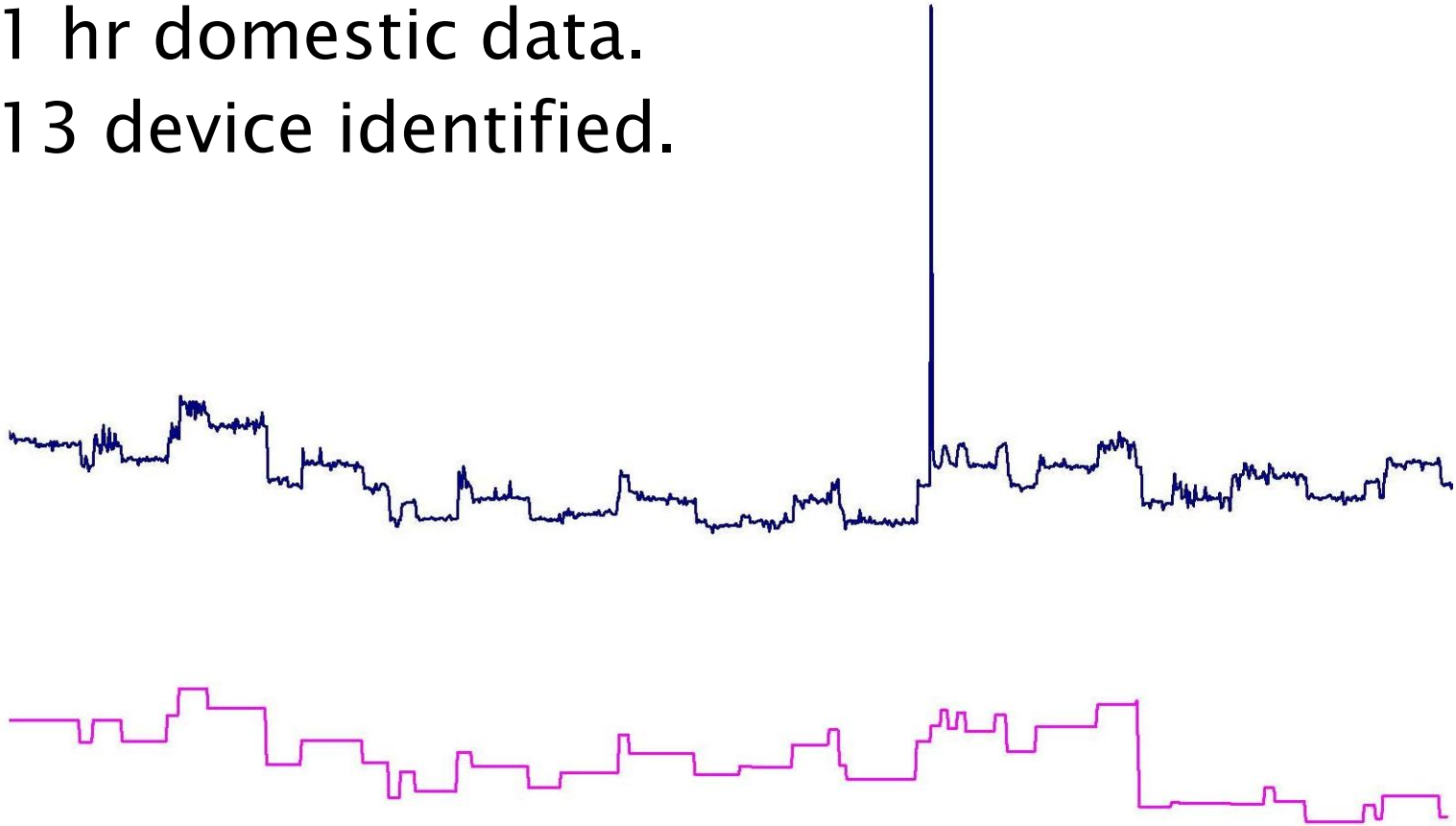


Device cluster detection

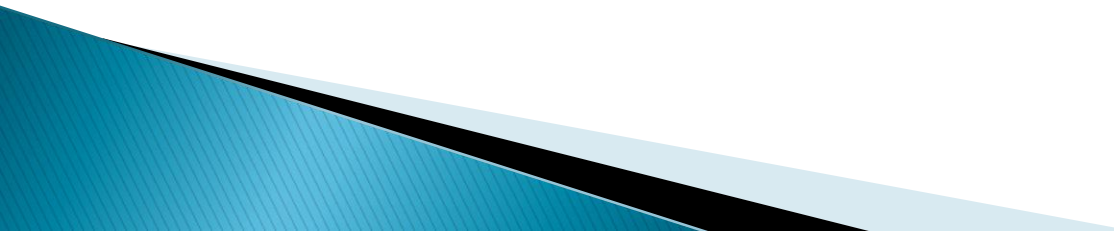
- ▶ Clustering method should be:
 - Robust.
 - Scale invariant.
 - Computationally efficient.
 - ▶ Evolutionary cluster optimiser:
 - Evolve set of device profiles.
 - Evolve the cluster range.
 - Handle on/off profiles.
- 

Some results

- ▶ 1 hr domestic data.
- ▶ 13 device identified.



Future

- ▶ More complex device profile:
 - Washing machines cycle settings etc.
 - Markov models.
 - ▶ Hybrid approaches:
 - Integrate device models with serious games.
 - Direct user feedback.
 - ▶ How to influence user behaviour?
- 

Thanks

Questions?