Monitor: An Abnormality Detection Approach in Buildings Energy Consumption

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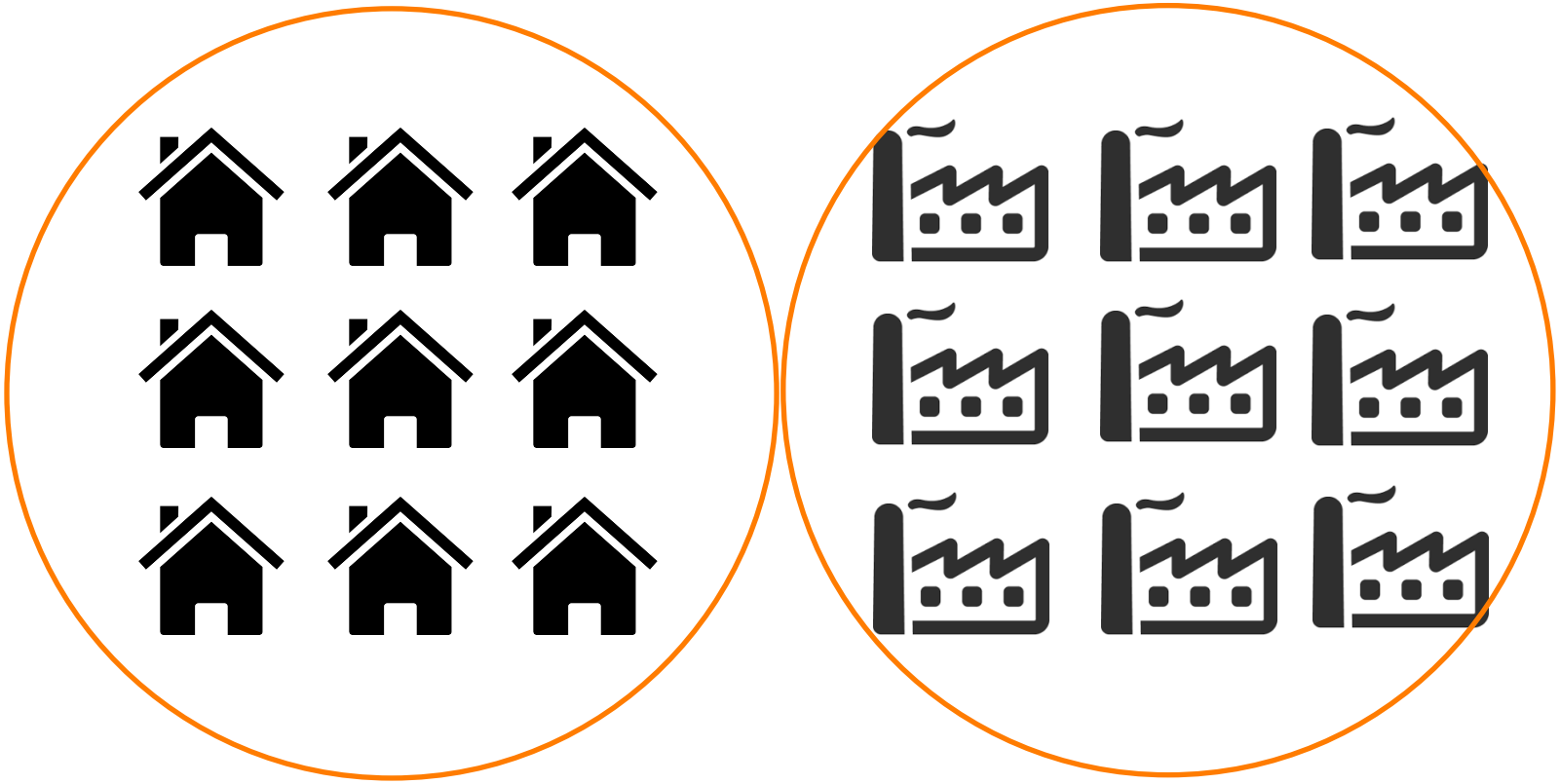
Buildings Consume 40% of Energy

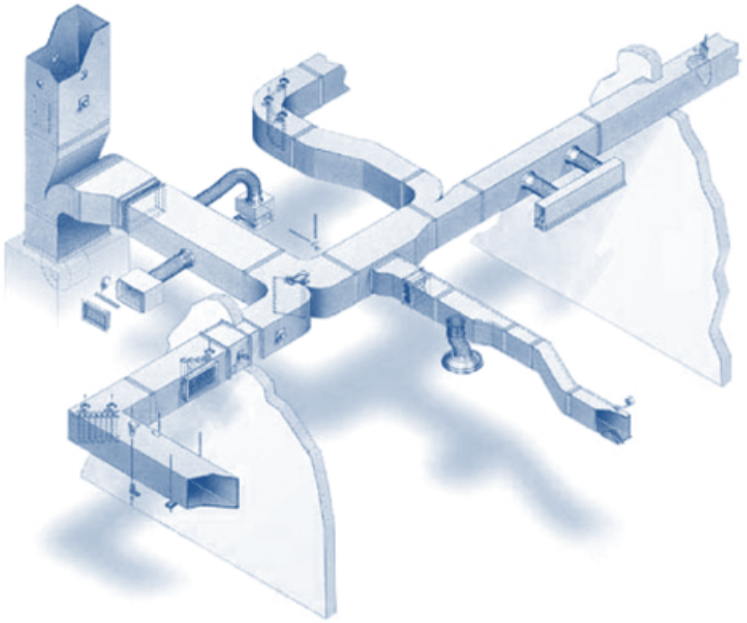


Residential Buildings

Commercial Buildings

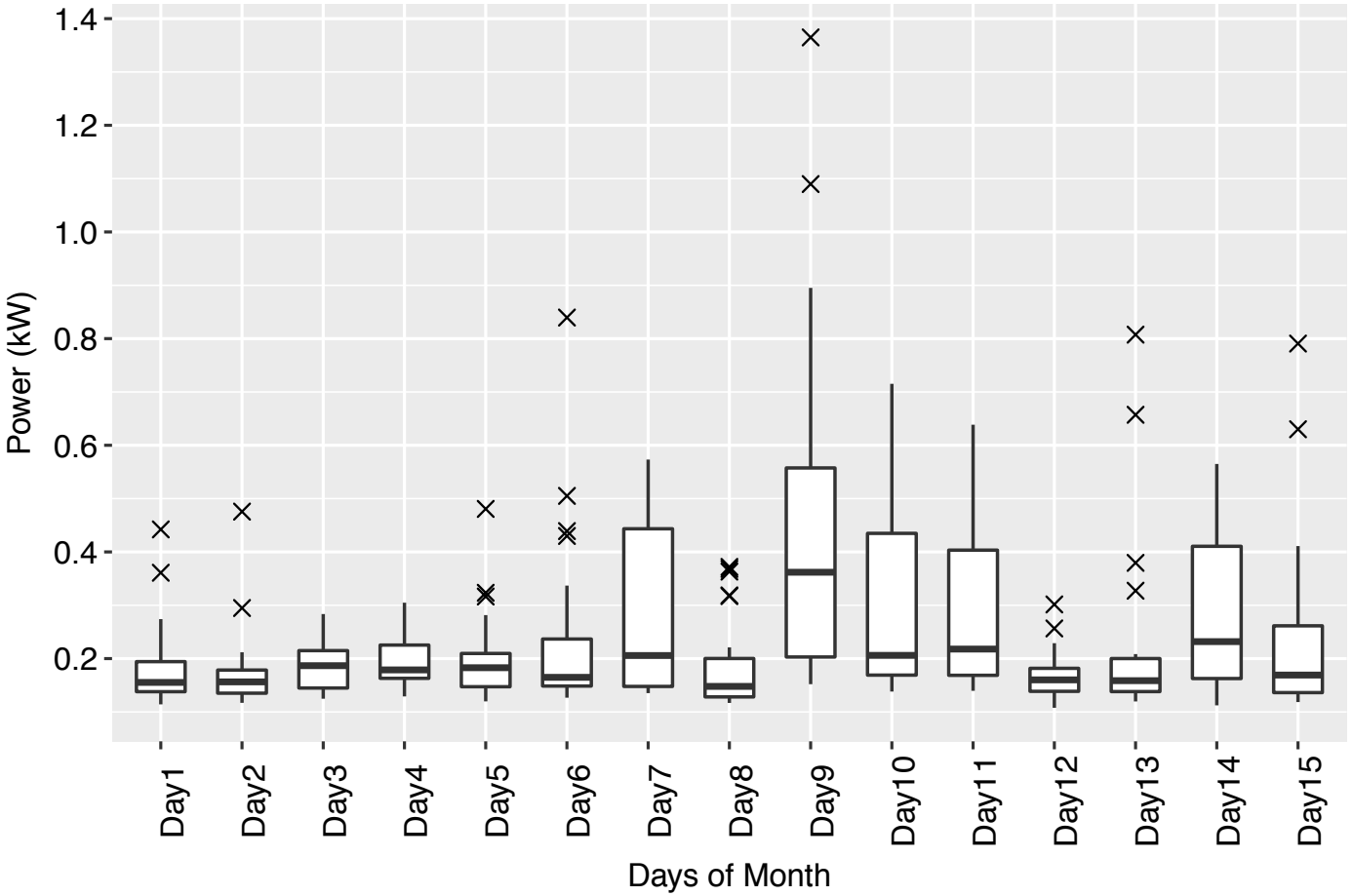
Buildings Waste Energy

- Faults waste up to 20%
- ON appliances in unoccupied space
- Device misconfigurations

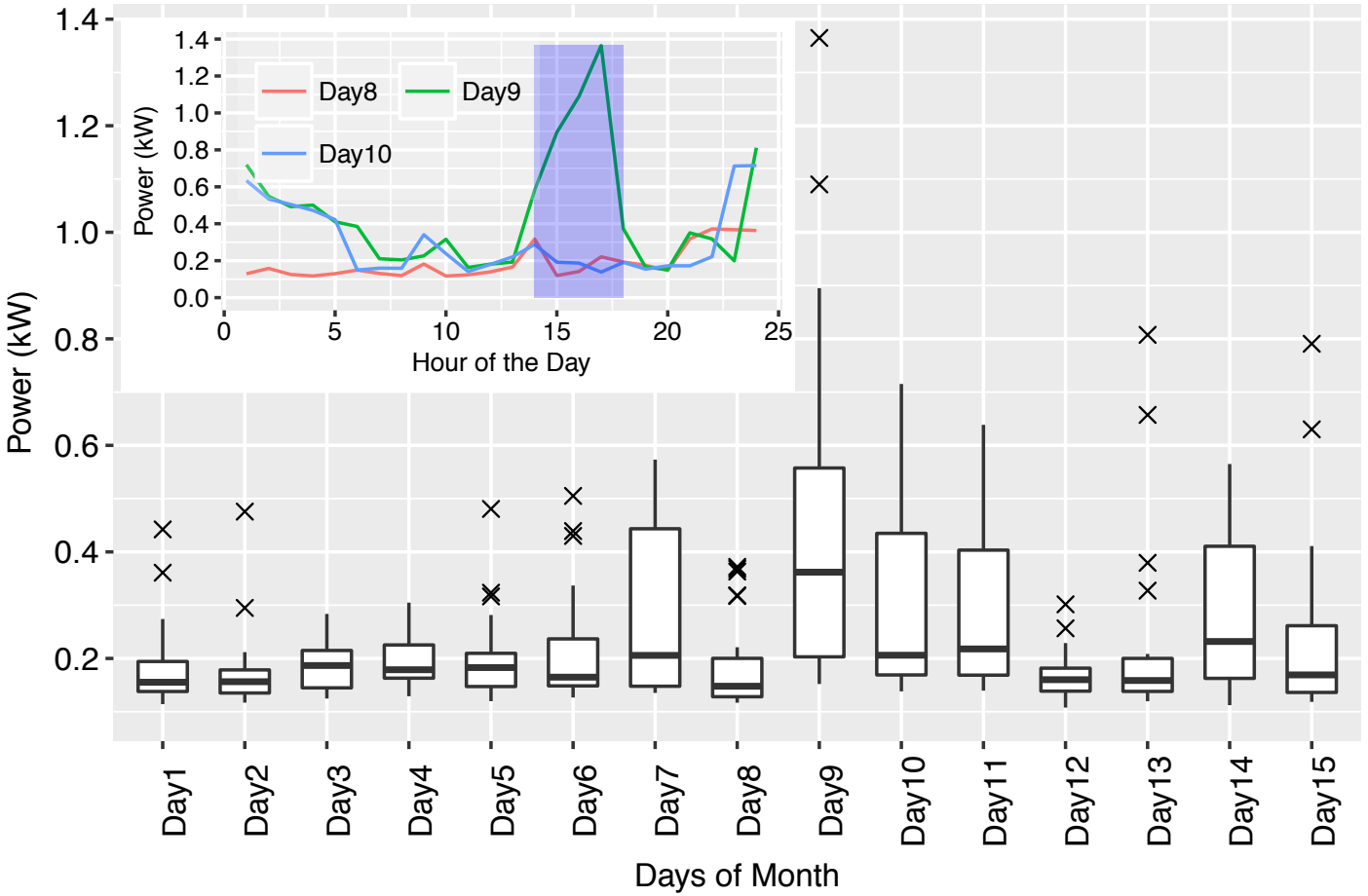


AC ducts

Energy Consumption of Day 9 is Abnormal



Energy Consumption of Day 9 is Abnormal



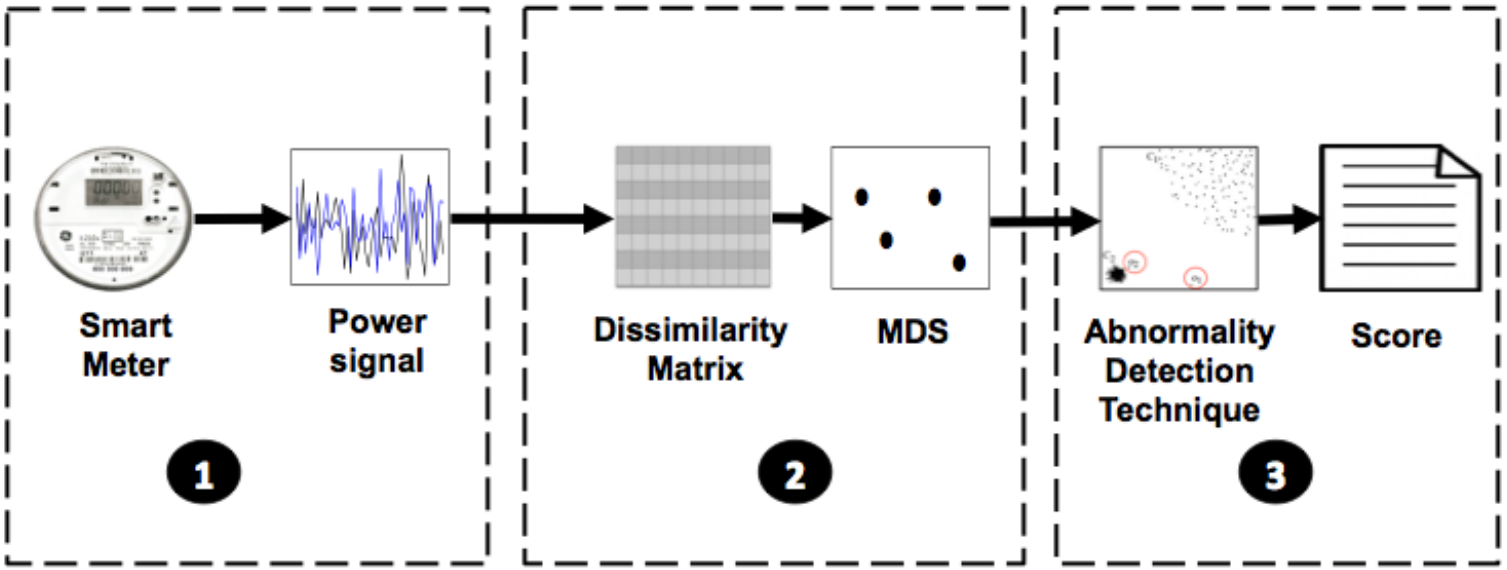
Problem Definition

Develop a reliable abnormality detection method using smart meter data only

Smart meter

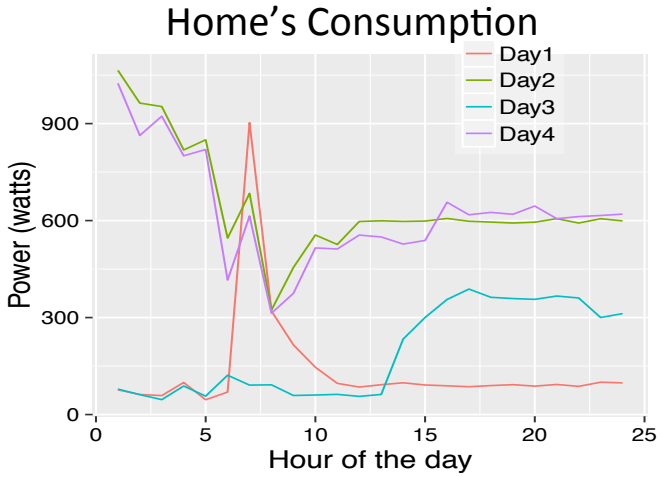
Time	Value
29/11/15 00:02	204.1066437
29/11/15 00:03	165.0479126
29/11/15 00:03	155.0028381
29/11/15 00:04	151.2414856
29/11/15 00:04	150.5730286
29/11/15 00:05	149.3900299
29/11/15 00:05	148.5323944
29/11/15 00:06	148.2239685
29/11/15 00:06	148.7650452
29/11/15 00:07	149.0418243
29/11/15 00:07	158.4056854
29/11/15 00:08	208.932785
29/11/15 00:08	209.9034576
29/11/15 00:09	149.928009
29/11/15 00:09	150.6716309
29/11/15 00:10	150.6894531
29/11/15 00:10	150.5117798
29/11/15 00:11	149.8588104
29/11/15 00:11	149.8042297
29/11/15 00:12	149.4410248
29/11/15 00:12	148.8970337
29/11/15 00:13	148.7256317
29/11/15 00:13	148.7540283
29/11/15 00:14	148.1561584
29/11/15 00:14	148.4674377
29/11/15 00:15	147.9857788
29/11/15 00:15	148.1070557
29/11/15 00:16	146.5702972

Proposed Method: Monitor



Data Input → MDS Step → Abnormality Step

Step 2: MDS



Dissimilarity Matrix

	Day1	Day2	Day3	Day4
Day1	0000	2789	1194	2699
Day2	2789	0000	2516	0254
Day3	1194	2516	0000	2371
Day4	2699	0254	2371	0000

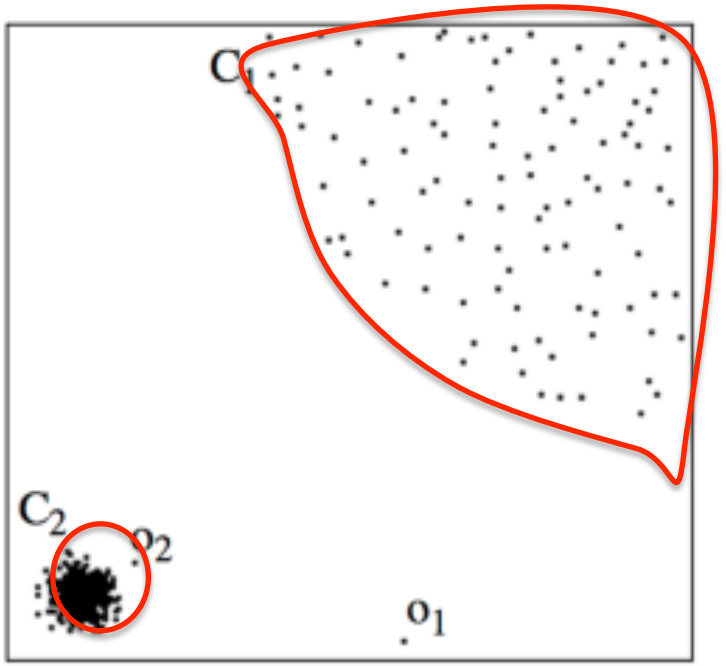
MDS

$$dist(day_x, day_y) = \sqrt{\sum_{i=1}^{n=24}(day_x^i - day_y^i)^2}$$

Data Input → **MDS Step** → **Abnormality Step**

Step 3: Abnormality Detection

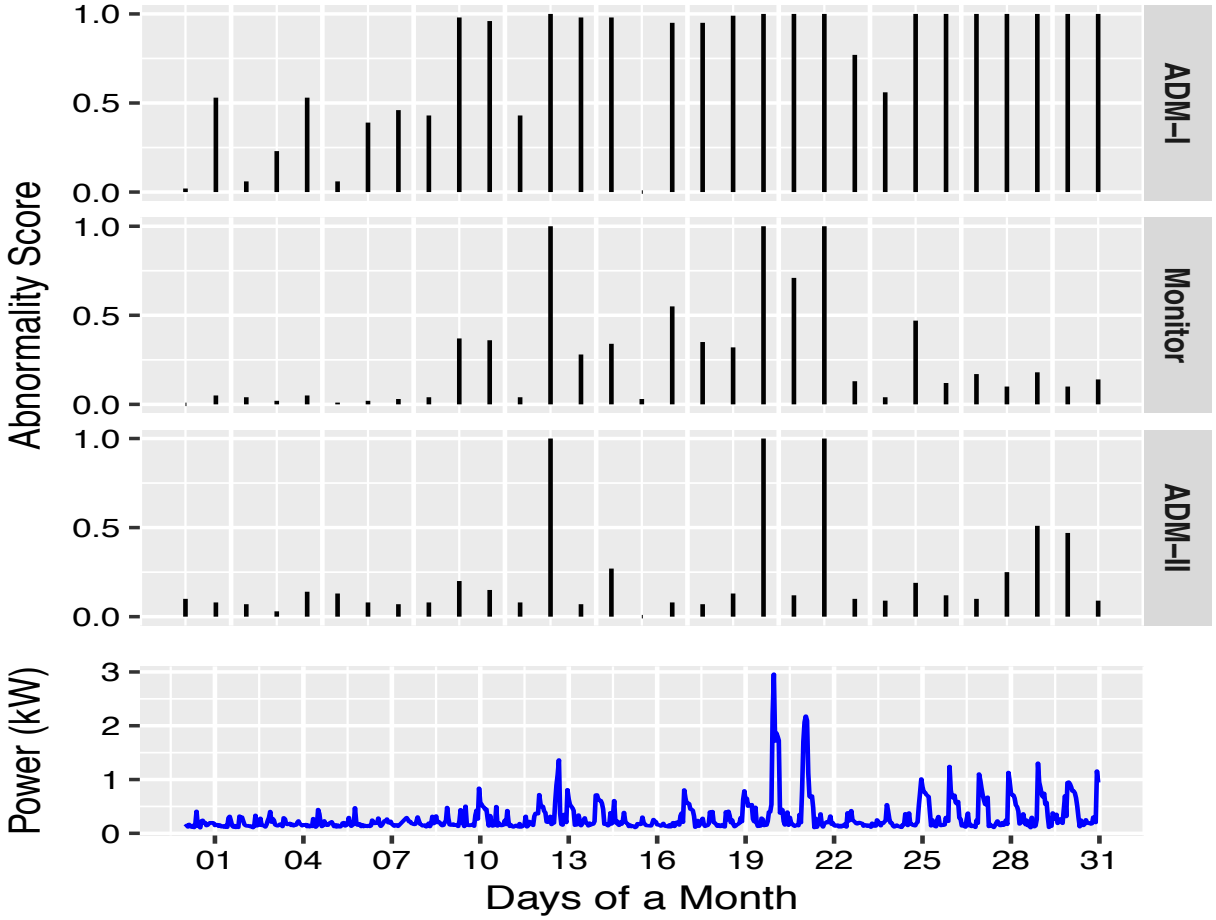
- Compute density for each day's consumption
- Compare densities
- Compute Normalized density corresponding to each group
- Present normalized density ad Abnormality score



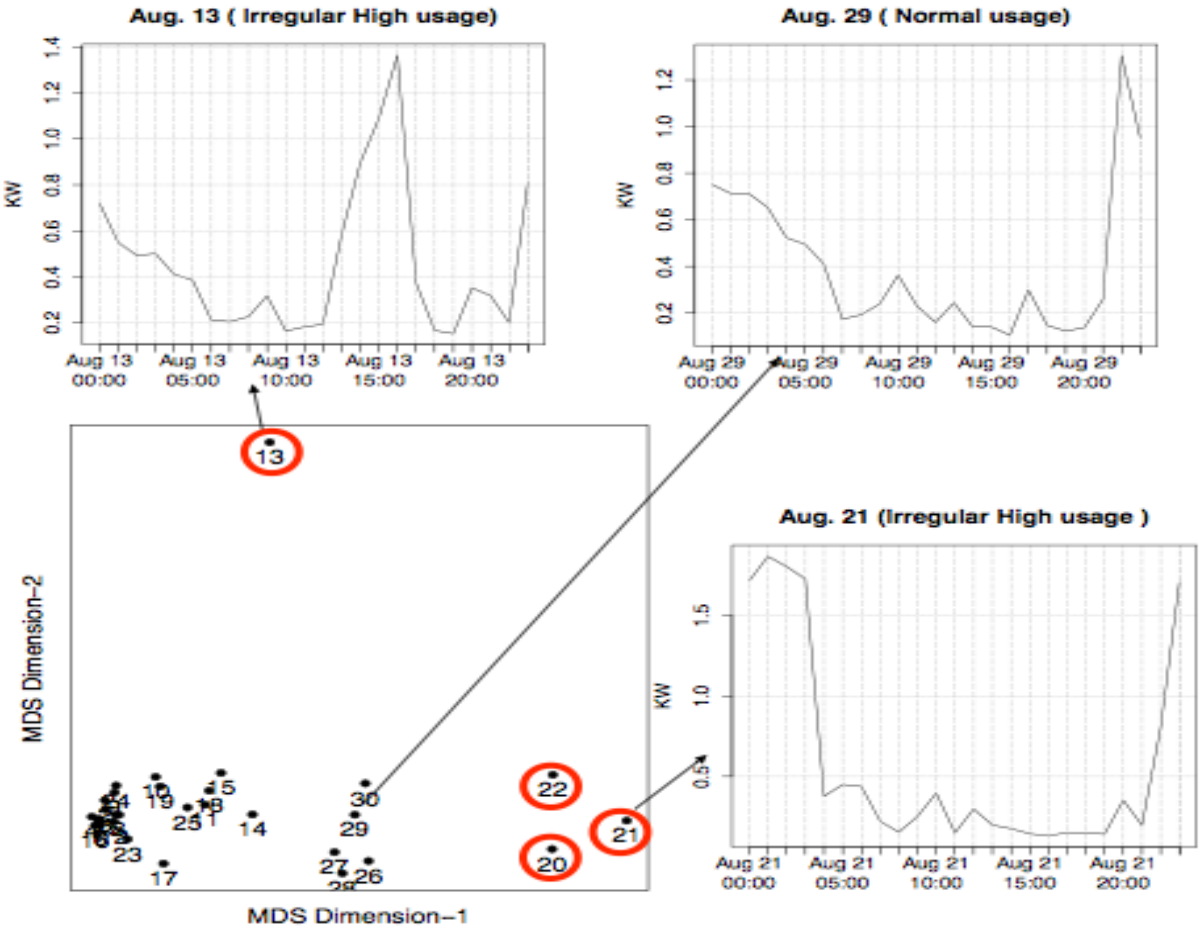
Experimental Setup

- Dataset: IIIT Campus
  - Two faculty apartments, a chiller and Lecture block
  - Duration: Sixteen weeks
  - Sampling: Hourly
- K value: 4 – 7 [Ensemble approach]
- Baselines
  - ADM-I and ADM-II

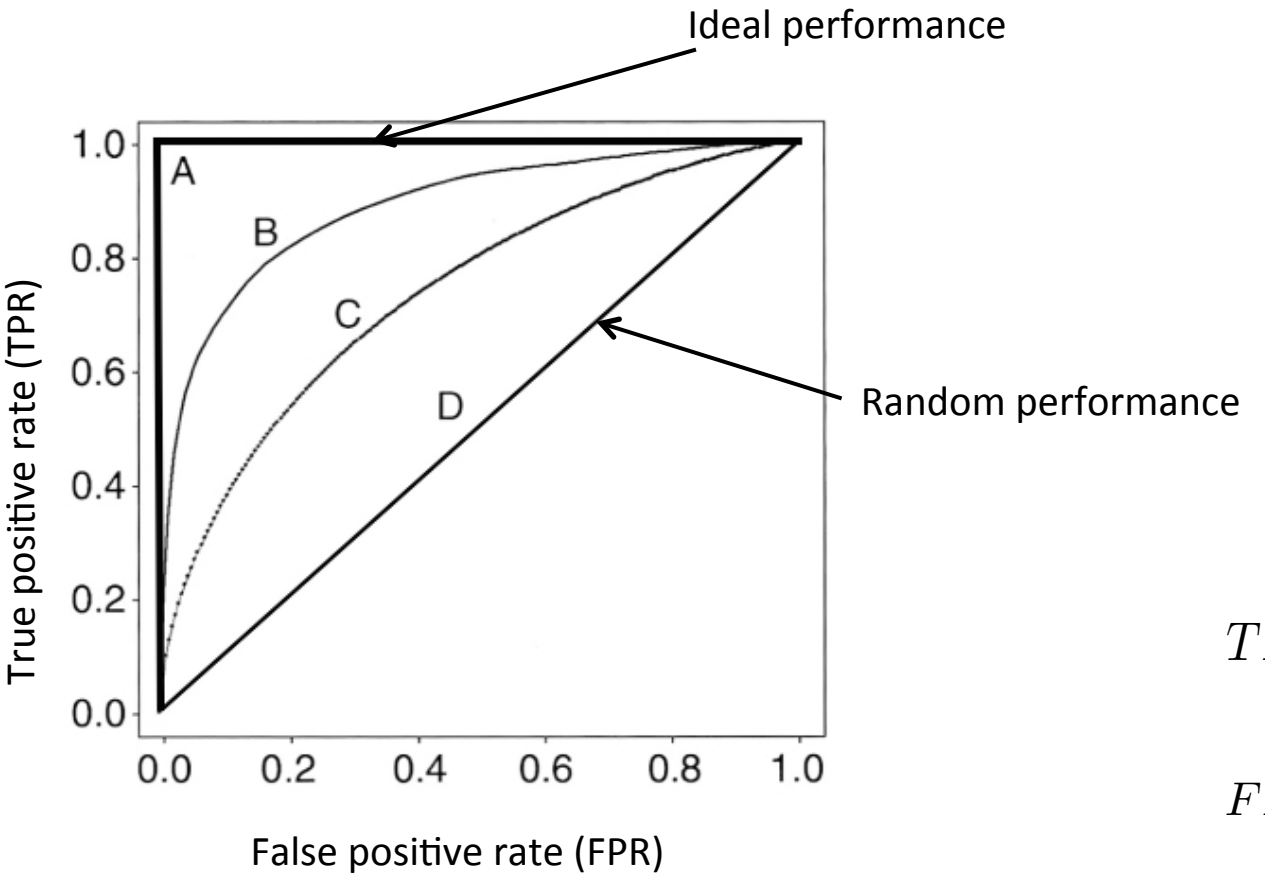
Compare Abnormality Scores of Monitor with Existing Methods



MDS Representation & Power Consumption Signatures of Apartment



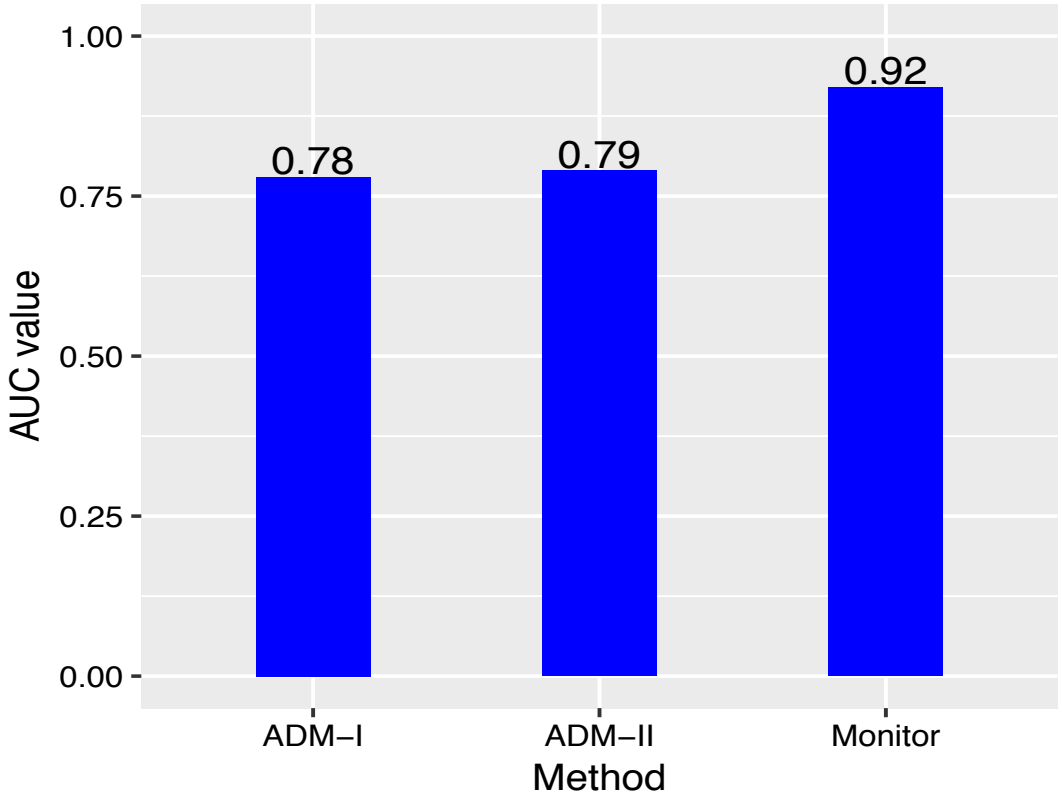
Accuracy Metric: Area Under Curve (AUC)



$$TPR = \frac{TP}{TP + FN}$$

$$FPR = \frac{FP}{FP + TN}$$

Monitor Increases AUC by 17%

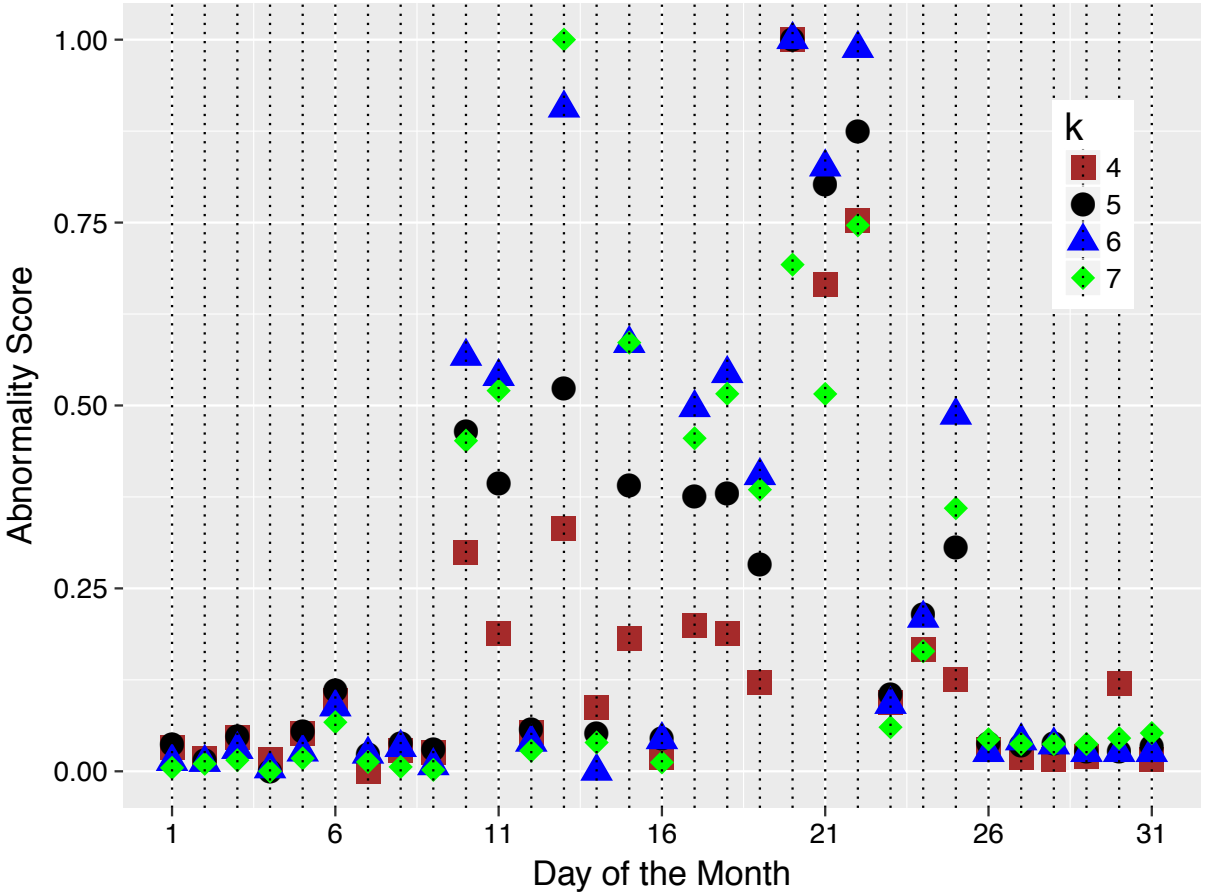


The higher the AUC, the better is the performance

Monitor Reduces False Positives by Larger Margin

Method	Apartment 1	Apartment 2	Lecture Block	Chiller
ADM-I	15	9	7	20
ADM-II	0	1	2	2
Monitor	**0**	**2**	**0**	**0**

Effect of k on Abnormality Score

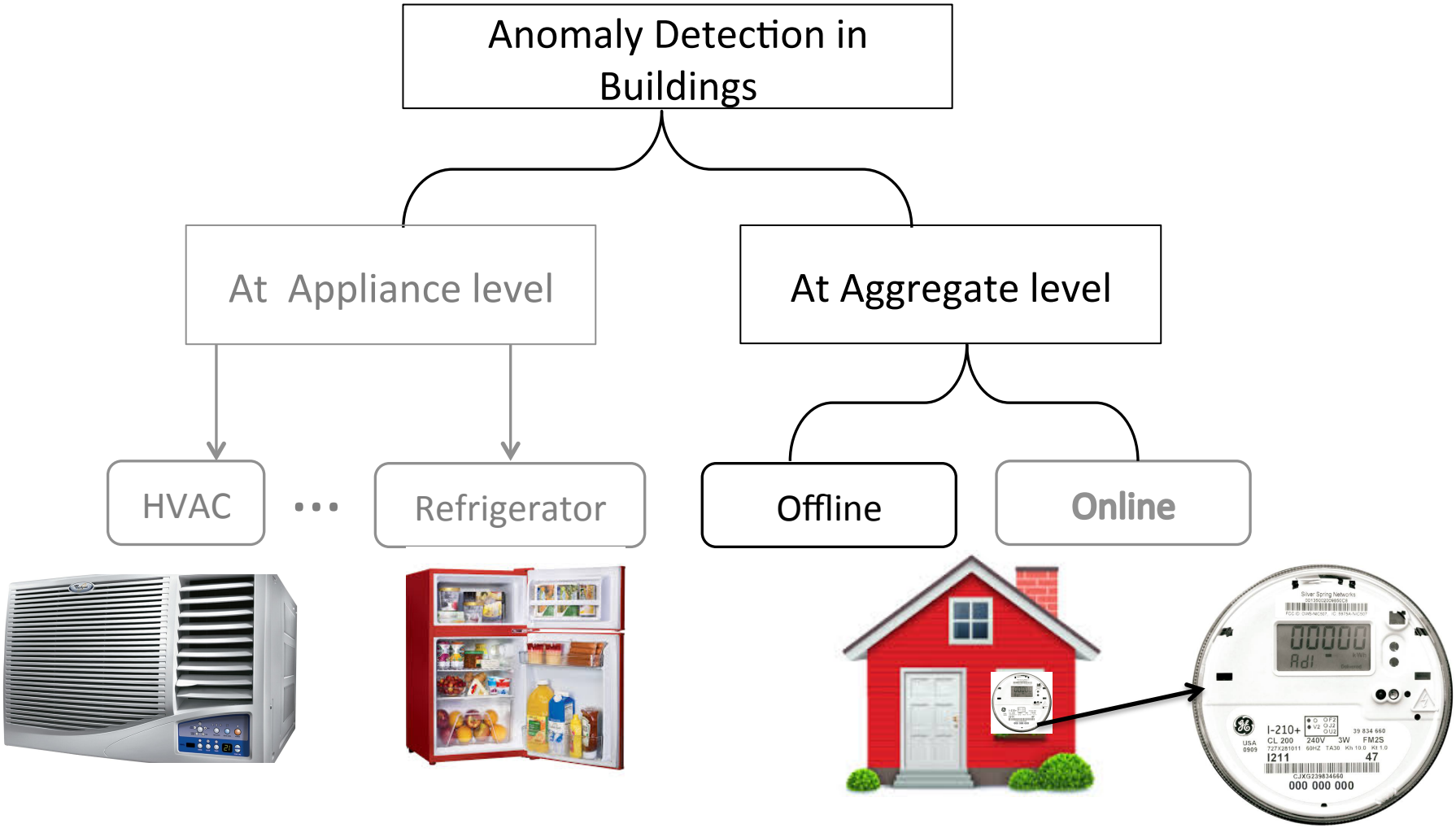


Conclusion

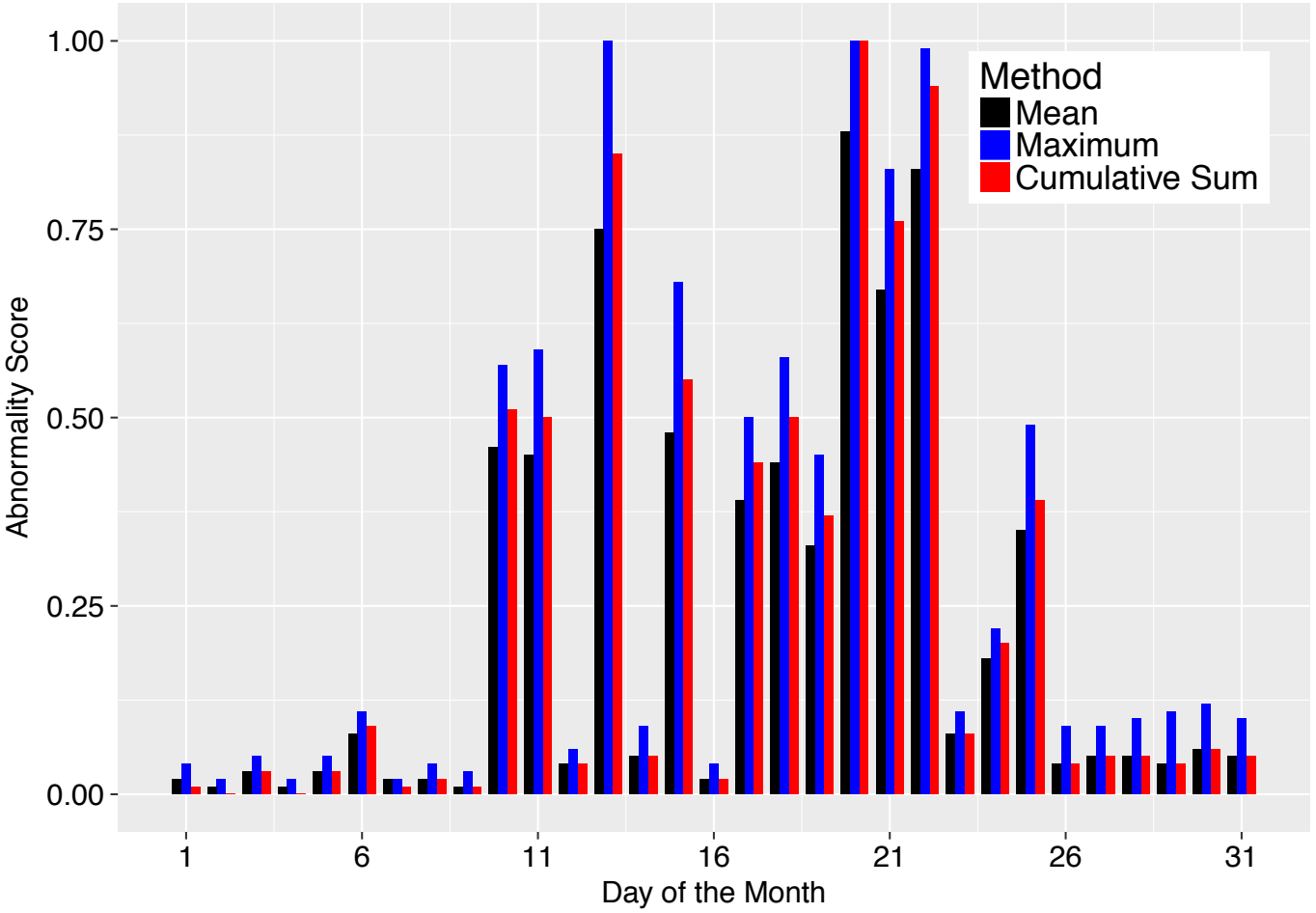
- Monitor improves AUC as compared to existing methods
  - Reduces false positives by large margin
- Is reliable as compared to existing methods

ANNEXURE

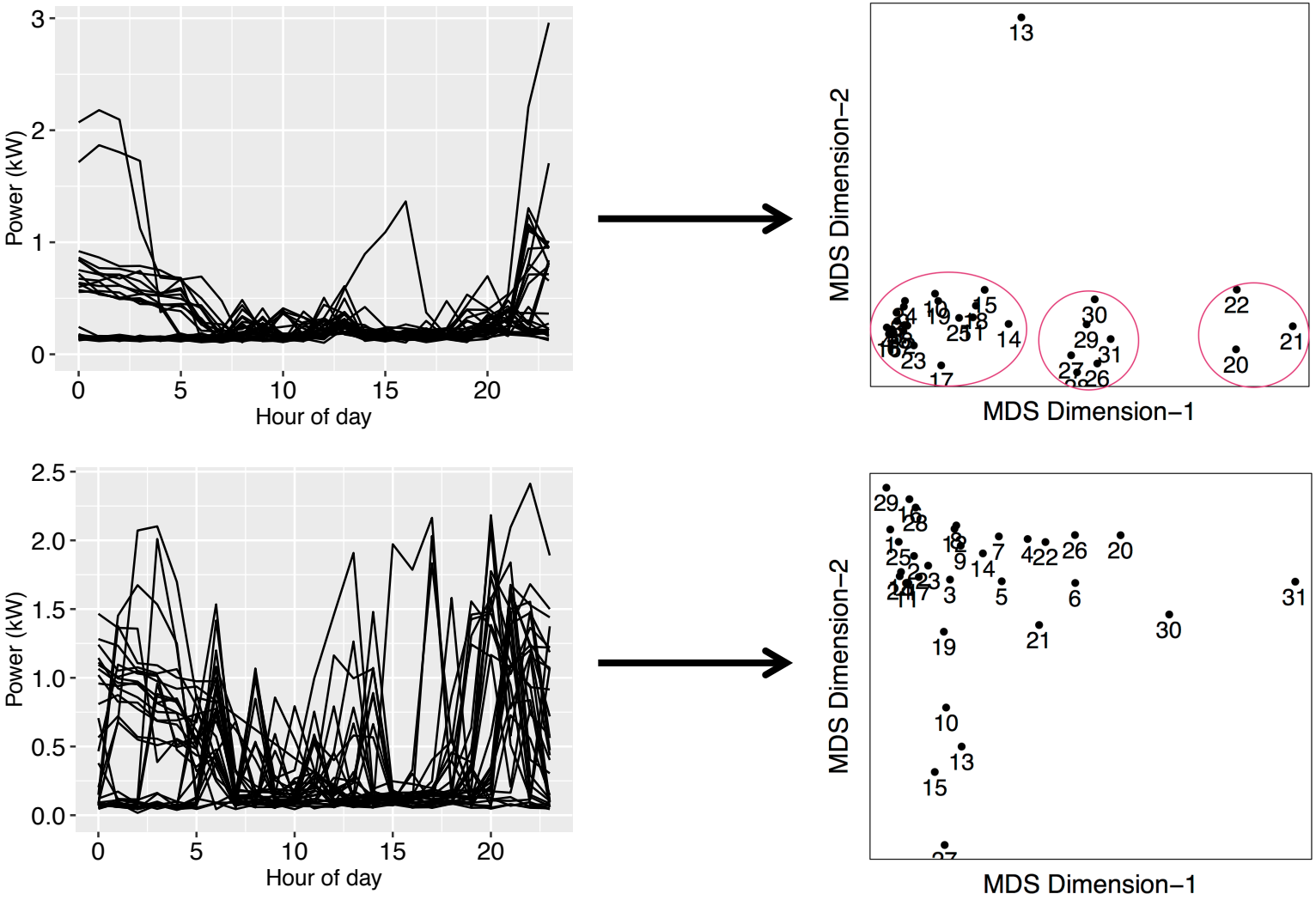
Anomaly Detection



Effect of Aggregation Methods



MDS: Example


Power (kW)
Hour of day
MDS Dimension–2
MDS Dimension–1
Power (kW)
Hour of day
MDS Dimension–2
MDS Dimension–1

False Negatives

Method	Apartment 1	Apartment 2	Lecture Block	Chiller
ADM-I	0	0	2	0
ADM-II	1	1	2	2
Monitor	**1**	**1**	**3**	**1**