Dynamic Demand Response Optimization in Smart Grids

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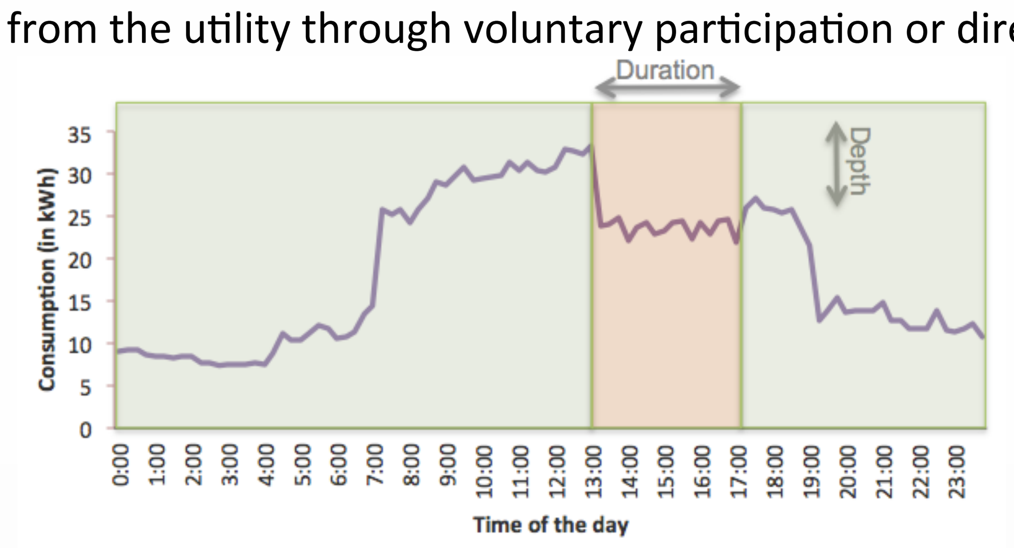
Dynamic Demand Response (D^2R)

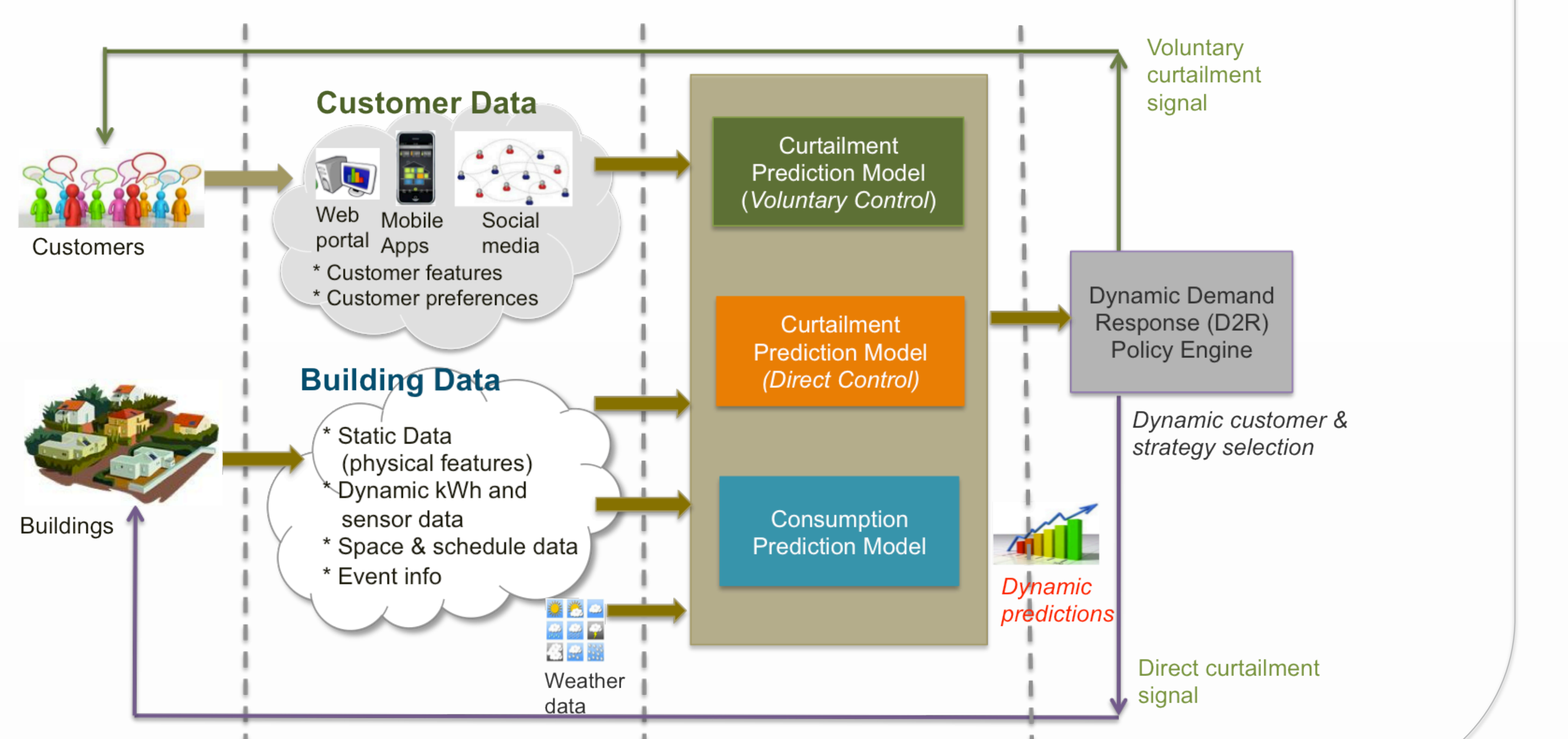
Demand Response (DR):
Adjustment of electricity consumption during peak load periods in response to a signal from the utility through voluntary participation or direct control.



Challenges

- **Information Integration**: many, diverse sources
- **Data Modeling:** machine learning algorithms
- **Dynamism**:
  - Deviations in achieved voluntary curtailment
  - Fluctuating number of participants
- **Scalability**:
  - Huge number of customers (~1.4 million customers at city-scale)
  - Large-scale streaming sensory data (~5.6 million data points every hour)

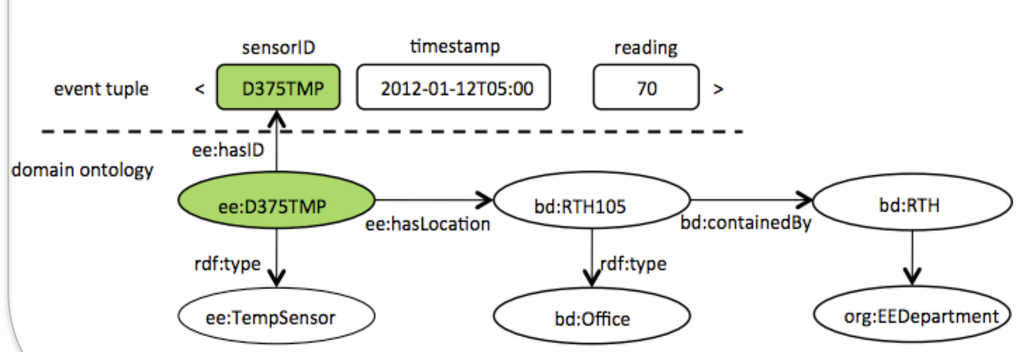
Dynamic Demand response (D^2R):
Decision making about when, by how much, and how to reduce electricity consumption



Information Integration

Challenge: Ingest, parse and semantically annotate sensor data
Approach:

1. Information Integration from diverse sources
2. Semantic Information Model for Complex Event processing (CEP)

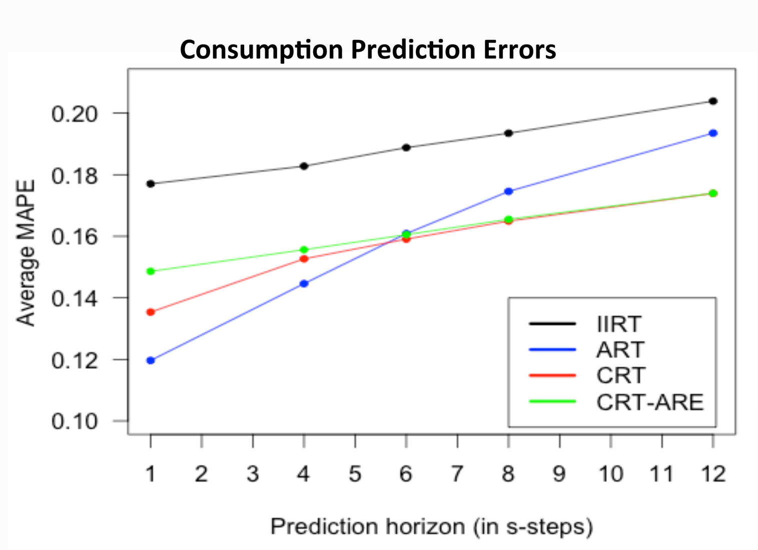


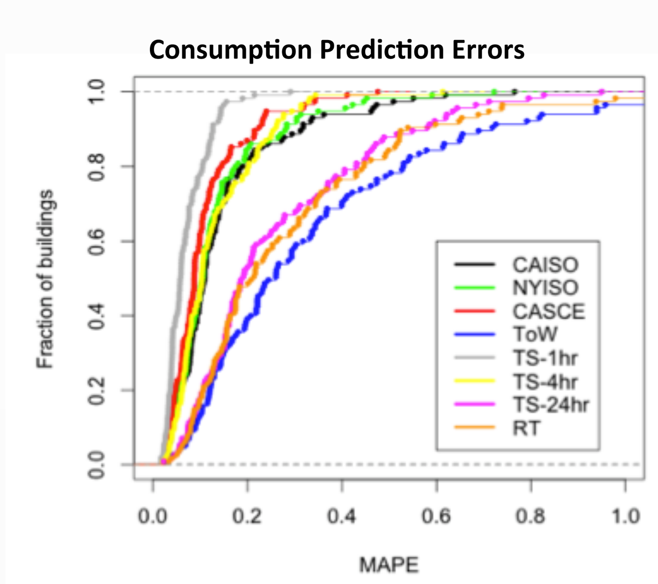

```
SELECT ?t
WHERE {
  ?t  evt:hasSource  ?src .
  ?src  ee:hasLocation ?loc .
  ?loc  rdf:type bd:MeetingRoom .
  ?src  rdf:type bd:TempSensor  ee:TempSensor .
  ?t  evt:hasValue  ?reading .
  bd:GreenBuildingTemp  bd:hasValue  ?val .
  FILTER(?reading < ?val) }
```

Predictive Modeling

Challenge: Predict consumption and curtailment for individual consumers
Approach:
Consumption Modeling

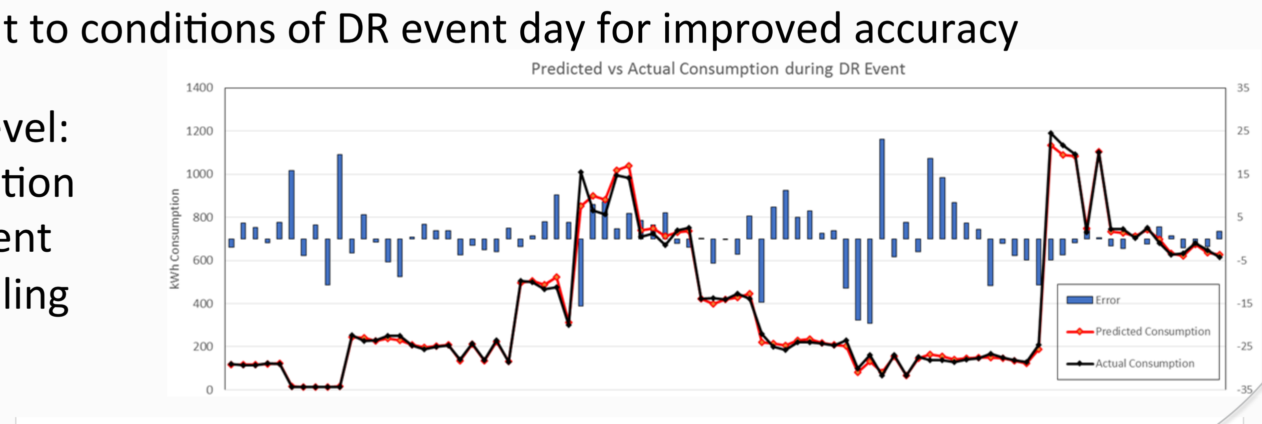
1. Indirect Indicators based Model (IIRT)
2. Time Series based Models (ARIMA and ART)
3. Causality based Regression Tree Model (CRT)





Curtailment Modeling

1. Building–level
   - Curtailment prediction based on similar events (same curtailment strategy)
   - Adjustment to conditions of DR event day for improved accuracy
2. Equipment–level: Bottom-Up prediction based on equipment curtailment modeling



Dynamic Decision Making

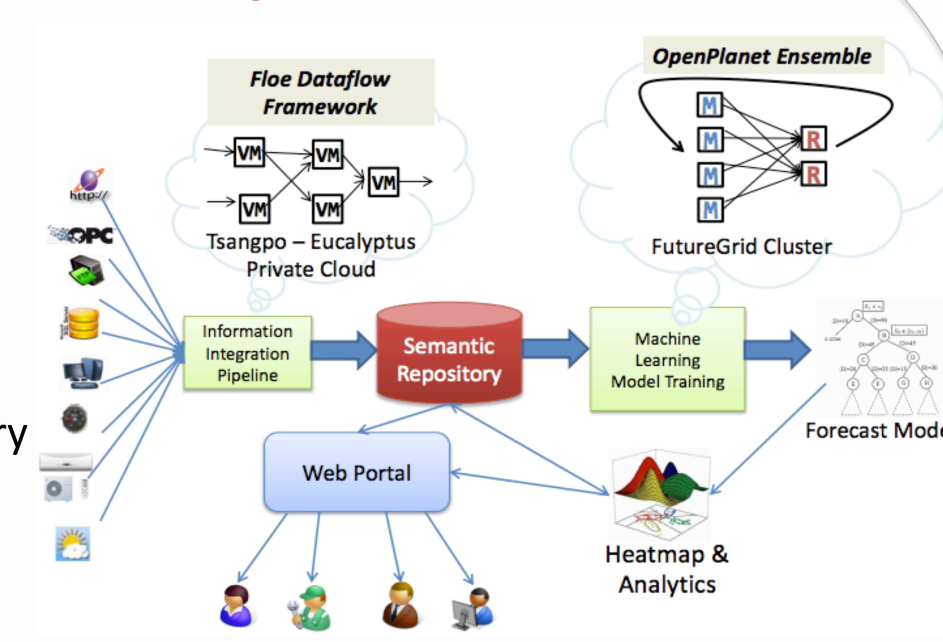
Challenge: Automated DR decision support
Approach:
DDS (Demand Response Decision Support System):

- DR Decision Support System : http://smartgrid.usc.edu/dds-javadoc/
- DR Scheduling Engine: http://smartgrid.usc.edu/sgpe/

Scalability

Information Integration

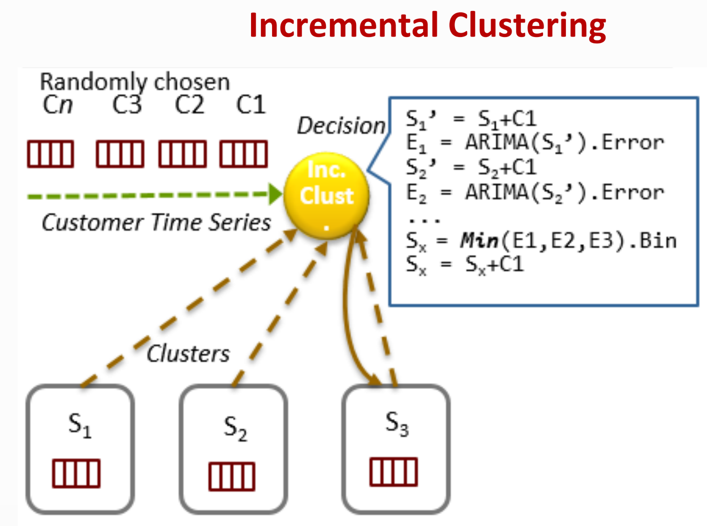
1. *Floe*: Continuous data flow framework using Eucalyptus Private Cloud
2. *Streaming CEP*: interactive query processing over real-time data



Data-driven Demand Prediction Modeling

1. *OpenPlanet* –MapReduce based algorithm for regression tree training
2. *Scalable prediction using Incremental clustering*:
   - Customers grouped into virtual customers
   - Incremental addition based on reduction in cluster prediction error

Incremental Clustering

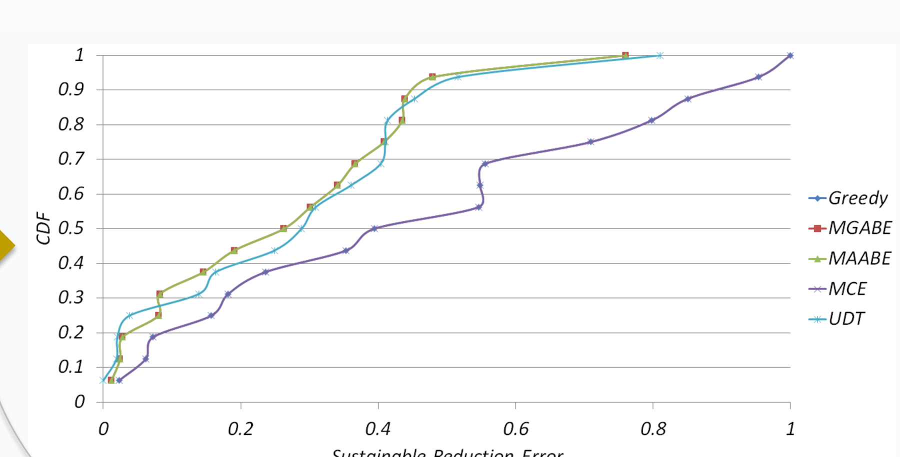


3. *Leveraging Big Data for Scalable Prediction*
   Build prediction models for representative customers using real time data and extrapolate for *similar* customers

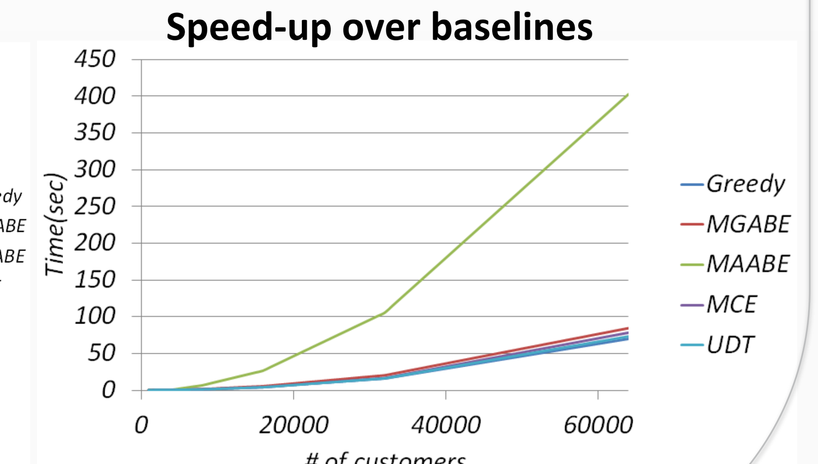
Customer Groups

Efficient Customer Selection for DR:

- Scalable Greedy Algorithm to select <customer-strategy> combinations
- Sustainable consistent reduction between consecutive customer re-selections
- Minimum number of participants selected to achieve a target curtailment



Speed-up over baselines



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