Itron

Demand Response and IoT

Using Data to Maximize Customer Benefit

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WHITE PAPER

INTRODUCTION

Prior to the deployment of two-way devices for its demand response programs, Itron's utility clients conducted demand response (DR) control events using paging infrastructure to send one-way messages to control devices. These devices, connected to appliances such as air conditioners, water heaters and pool pumps, gave the utility the needed load curtailment, but provided little added value to the end customer or opportunity for utility interaction with these customers.

The deployment of two-way devices that use either a Wi-Fi or cellular network for a demand response program, coupled with smart data engineering and analytics, significantly upgrades the insights available to utilities, enabling more operationally valuable DR and additional value-add services to the end customer. Two-way devices — in our case devices such as Itron's smart thermostats and two-way load control switches, or third-party Bring Your Own Device (BYOD) smart thermostats — are Internet of Things (IoT) objects, generating large amounts of data every hour of every day. The data sets from Itron devices and connected BYOD devices are sent back to IntelliSOURCE® Enterprise™, then parsed, aggregated and modeled in IntelliSOURCE-Analytics™ to deliver these program-enhancing insights.

This white paper goes into detail about some of the benefits of two-way devices, in particular the improved forecasting and analytics that are made possible by the devices' data.

"The real value that the Internet of Things creates is at the intersection of gathering data and leveraging it."

—Daniel Burrus, *Wired*

BENEFITS OF USING TWO-WAY DEVICES

Improved Forecasts

In a recent white paper, we wrote about machine learning-produced curtailable load forecasts and how we have integrated those forecasts into IntelliSOURCE Enterprise. The forecasts we talked about in that white paper rely upon advanced metering infrastructure (AMI) data, preferably at hour-or-less intervals. This is a good solution for those utilities that already have AMI deployed at premises or have plans to deploy it soon.

But some utilities may not wish to or be able to invest in an extensive AMI architecture, so the AMI solution will not work for them. No problem! If instead utilities can invest in two-way devices as part of their demand response program, we can still provide accurate, curtailable load forecasts via machine learning. In fact, the curtailable load forecasts derived from two-way device data are usually more accurate than AMI-only forecasts.

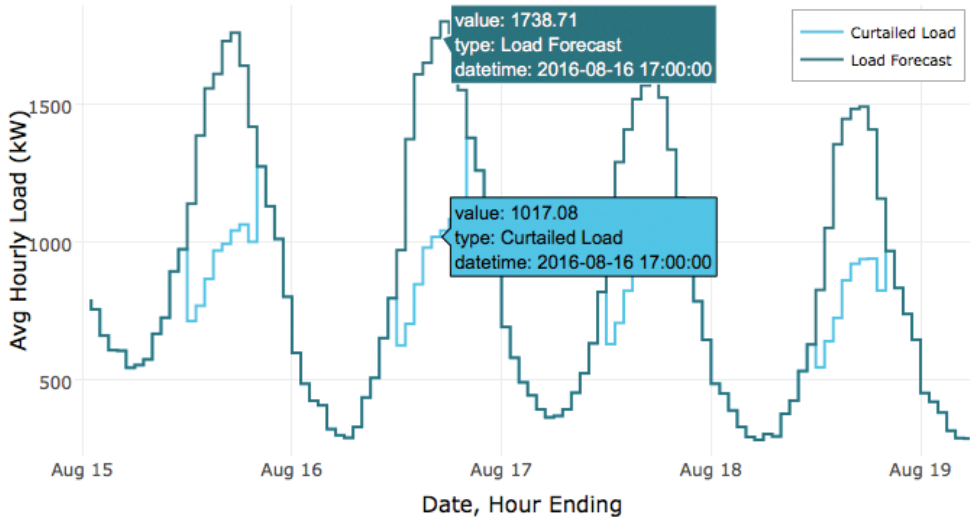
Even better, if a utility can invest in AMI and two-way devices, the curtailable load forecasts become even more accurate than either of the single-source solutions, after ensembling the two different models' predictions together.

This improved accuracy of curtailable load forecasts from two-way device data versus AMI-only forecasts is largely due to the fact that AMI reports all energy uses on a premises. So forecasting demand response, especially on small numbers of premises, can become a signal-versus-noise problem.

With two-way devices, there is far less noise since we are focused on forecasting energy use from just the equipment we are targeting for control.

Note that we have discovered that we don't need 100% saturation of two-way devices for the forecasts to work well. For instance, if we have a utility with a 50/50 split between one-way and two-way devices, we can use aggregated data from the two-way devices to provide a reasonable DR forecast for the one-way devices, as long as the two populations are similar in geography, appliance size, residential/commercial split, etc.

The chart below shows one example of a machine-learned demand response forecast that we generated from thermostat telemetry. The forecast is for approximately 850 air conditioners and shows the total appliance load forecast as well as the hypothetical curtailed load, should the utility choose to call a demand response event in that hour (note for this particular forecast we only show curtailable load forecasts for 13:00-20:00). Interval data from approximately 450 thermostats were used to generate an initial forecast, which was then scaled up to obtain a forecast for 850 air conditioners. Of note, we do not necessarily need data from 450 thermostats to produce these forecasts—we can usually produce load forecasts using data from as few as a dozen thermostats—but we have found that increasing the sample size tends to improve the forecast accuracy.

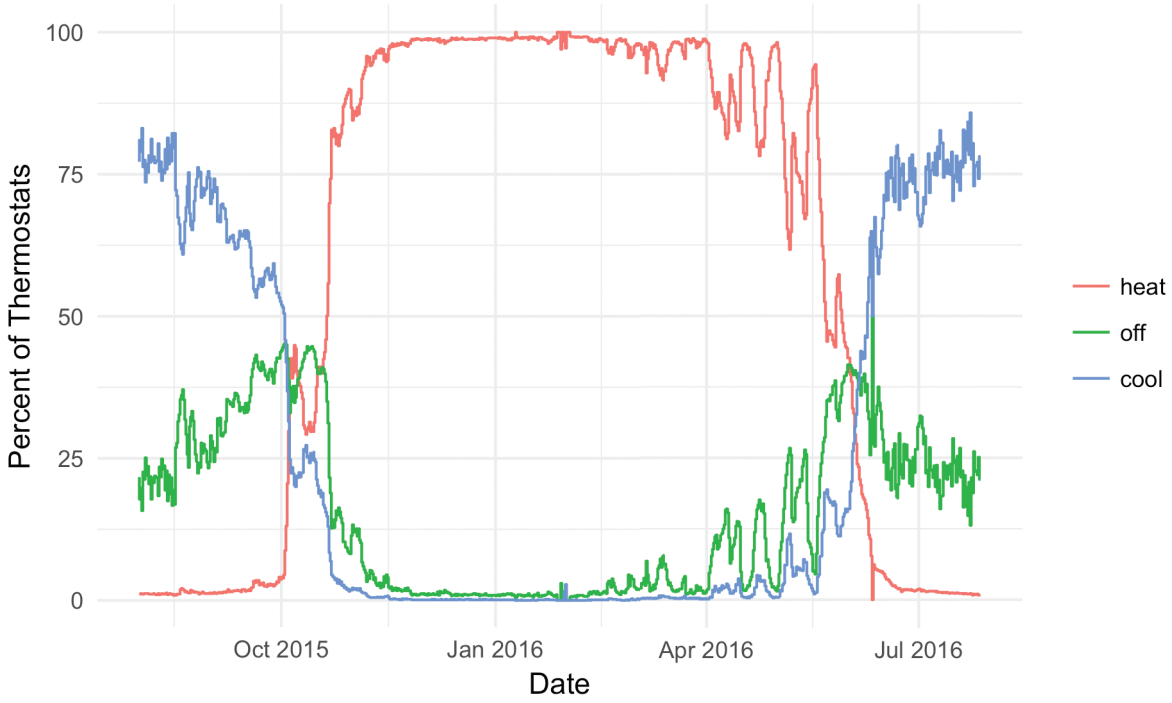


A/C Load Forecast, Curtailable Load 13:00-2:00

IMPROVED EVENT PLANNING INPUT

Another benefit from using the data from two-way devices comes with knowing which devices can actually be targeted during a control event and how many may respond. Our thermostats send back data about their **mode setting** – i.e., is the thermostat set to heat, cool or off? The figure below shows the percentages of thermostats colored by mode setting for approximately 1,000 devices in one service area. Sure, we might have a hot day in May, but does it make sense to call a control event for air conditioners? Have the customers even turned their air conditioners on yet? We certainly could not get this benefit from one-way devices.

Percent of Thermostats in Heat/Cool/Off Setting

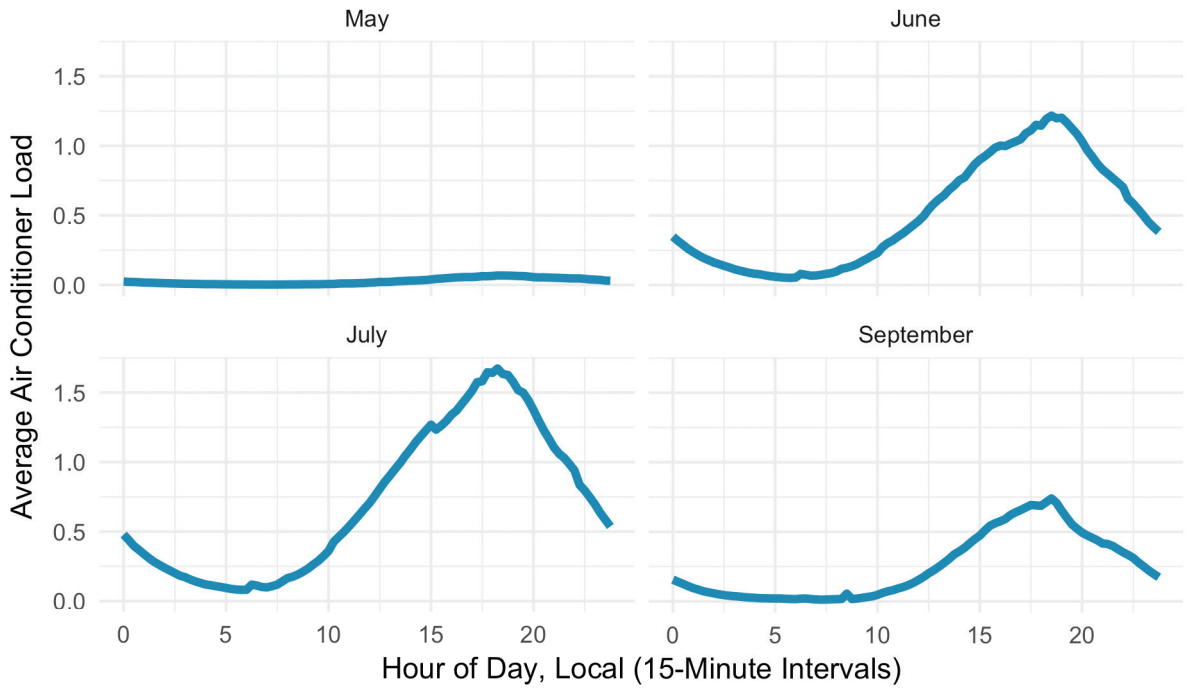


An air conditioner DR event in May, even on a hot day, will make little sense for this utility

OPTIMIZED DISPATCH OF SPECIFIC CONTROL GROUPS

As an extension to the previous section, data from two-way devices allows us to build typical usage profiles, aggregated over any set of premises that we might wish to control. The following two figures show examples of these profiles. The first figure shows one utility's average daily air conditioner load per premises, faceted by month. We can see that June and July will likely provide us much better DR load curtailment performance than May or September. Of course this is likely unsurprising, but the machine-learning algorithm will take these monthly effects into consideration when producing a curtailable load forecast, and the effect and accuracy, especially for the "shoulder" months, is greater than it would be for an AMI-only forecast.

Average Air Conditioner Load by Month

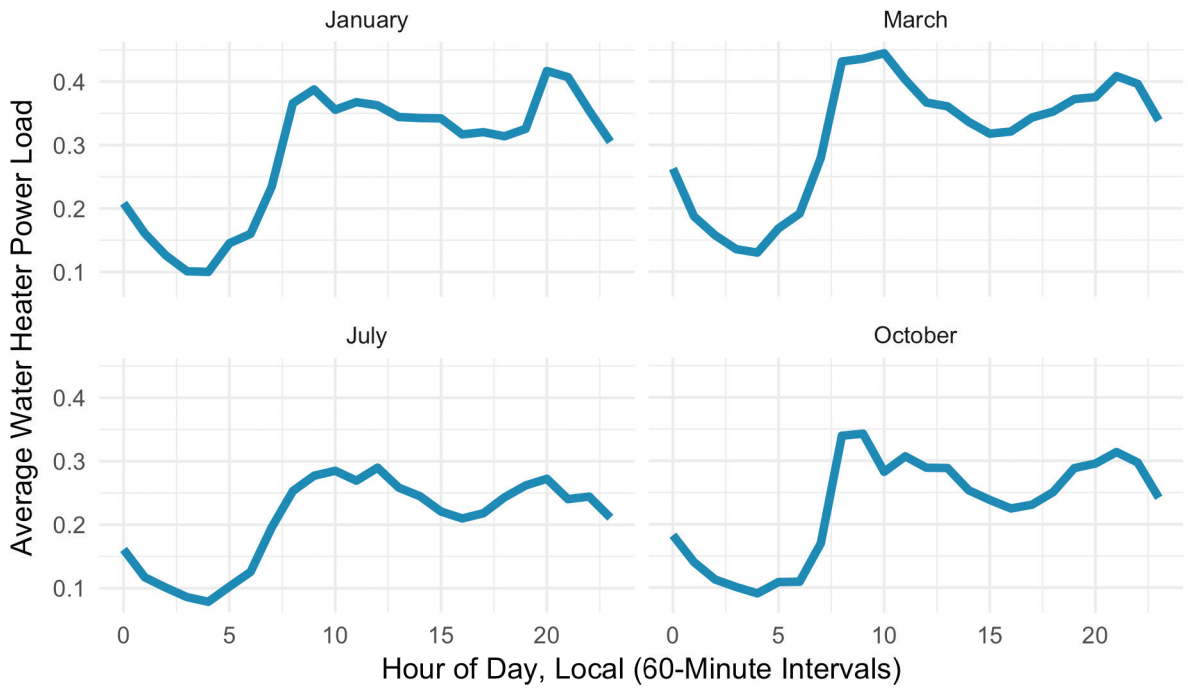


Example of average hourly air conditioner load by month per premises

The second figure shows the same utility's average daily electric water heater load per premises, faceted by month. Again, this is using data from two-way devices attached to the water heaters.

There appears to be some seasonal variation, but not nearly as drastic as with the air conditioner load. But, the machine-learning algorithm can take these monthly variations into account when providing a curtailable load forecast.

Average Water Heater Load by Month



Example of average hourly water heater power load by month per premises

Now why is this important? With the two-way devices, we have the ability to collect, process and act upon all the data, from all the devices, in near-real-time. This enhanced capability significantly improves our ability to do optimized dispatching, in particular by allowing us to:

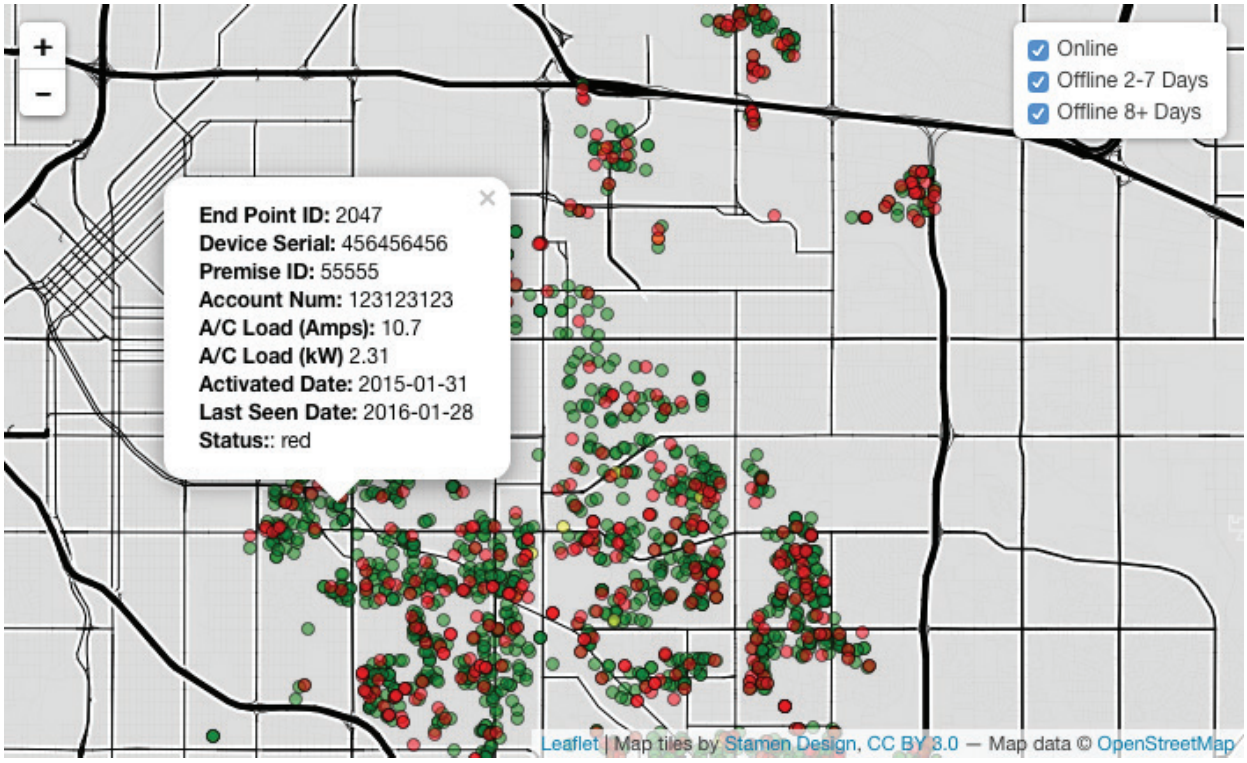
» Precisely forecast the aggregated runtime that specific appliance control groups will have at a given time, and

» Target for control those specific appliances that are most likely to give us the needed load at a specific time (and thereby helping to prevent customer notification fatigue).

IDENTIFICATION OF OFFLINE DEVICES

We can also use two-way data to identify which customers' devices are offline or missing, and thus unable to receive control commands. One problem with two-way devices that use Wi-Fi is the reliance on the customer having the device connected to the internet via their own network. If the customer changes their modem, modem password or ISP, they may forget to reconnect their thermostat or load control switch to the Internet. We have seen that, over time, this can lead to a growing number of offline devices when there is no utility intervention. Two-way devices using a cellular network do not present this problem.

With two-way device data, we can see when a customer is online or offline, merely by looking at the receipt of the device telemetry. With one utility client, after we implemented a communications program to notify customers to reconnect their offline thermostats, we were able to reconnect over half of the devices that had previously been offline, reaching an online rate of over 95%! This process of device recovery allowed us to significantly improve the overall efficacy of the DR events that followed, and allowed us to have positive interactions with the end-use customers that might have otherwise drifted away from the program.



Graphic Display Enables Easy Identification of Offline Devices

OTHER BENEFITS OF TWO-WAY DEVICES

The previous sections only detail a handful of the benefits we can deliver to utility customers who deploy two-way devices as a part of their demand-side management program. Some of the other ways in which we can leverage two-way data to provide benefits to the utility and end-use customers include:

» **Customized Dispatch:** In addition to the idea of "optimized dispatch," which we talked about in a previous section, is the concept of customized dispatch. For instance, using models created from data from two-way devices, we might modify the cycling strategies for premises based on time of day, thermodynamic properties of the premises or specific load requirements at the utility level. Or we might customize dispatch based on user-set "away" times, local commuting patterns or perhaps school schedules. These sorts of customized dispatch applications require runtime data provided by two-way devices, combined with data from various other sources, in order to help the users' homes and businesses use energy more efficiently.

» **Load Shifting:** Another exciting area of growth is the concept of changing a home's daily load profile by making its appliances work at lower-demand, lower-cost times of the day. For instance, what is the most effective schedule for pre-cooling a home, delaying a water heater's heating period or running a pool pump, in order to improve the overall system load shape? This is the type of dynamic optimization problem that requires the ability to combine two-way device data with the currently existing grid data. Opportunities in this space will continue to grow at

a fast rate as two-way devices become more ubiquitous, as new demand-side sources of energy come online and as the grid data itself matures to become more granular, local and responsive to system changes.

» **Energy Efficiency:** Using thermostat data, we can model the thermodynamic properties of specific premises. For those enrolled, we specify an efficiency period and optimize the daily thermostat operations to help utilities and their customers meet efficiency goals. As part of the program, using the premises-level models, we are able to deliver relevant, personal and actionable energy-savings insights to customers, and customize demand response dispatch strategies to maintain customer comfort and deliver maximum energy savings at each premises. This is an especially exciting topic that warrants further exploration in a future post.

CONCLUSION

In this white paper, we talked about several ways that a demand-side management program is improved by the analytics derived from two-way devices. Two-way devices, also known as IoT objects, provide large quantities of data that can be leveraged to, among other things:

» Improve curtailable load forecasts compared to AMI-only forecasts (or, for that matter, SCADA-only forecasts)

» Improve event planning by offering insights to the devices that may be available at a given time

» Optimize dispatch for control events through precise runtime forecasting for device control groups

» Identify offline devices for recovery, improving program efficacy

» Model home thermodynamics for energy efficiency programs

As we collect more and more data from Itron two-way devices and BYOD thermostats every single day, we are continually mining the data and exploring additional ways to bring value to our clients and their customers. The Internet of Things is poised for explosive growth in coming years and should impact almost every facet of our lives in beneficial ways. Itron is actively developing our solutions to take advantage of IoT in demand-side management and we are excited about continually refining our methods to bring maximum benefit to our customers.

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