Electric Utility gets ahead of the weather with new forecasting models

Using advanced modeling from IBM and sensors from WeatherBug, a North American utility can predict where its people and equipment will be needed before damaging storms arrive

Smart is...

Predicting the impact of weather events that can disrupt a power network, estimating the likelihood of outages, and providing lead time to enable proactive allocation and deployment of people and equipment.

A North American utility company now can pinpoint – to a degree unimaginable before – the damaging effects of incoming storms that bring down trees, poles and lines. An IBM-developed weather and outage prediction service called Deep Thunder -- enhanced by IBM with the utility – can be used to call repair crews into action and spot them to the nearest utility substation from where the damage might occur. The program will predict the number of jobs that will be needed up to 72 hours before a storm. The benefits are immense – in responding to critical customer needs in a time of crisis and in saving the utility time and money. This ability was made possible by using detailed measurements of weather such as wind speed, temperature and humidity from dozens of collecting stations from IBM Business Partner WeatherBug, a division of AWS Convergence Technologies, Inc.

For most of the U.S. population, our reliance on weather forecasting means whether we should add a half hour cushion to our commute in the morning, take an umbrella, or maybe decide to work from home using the phone and the Internet. But for a utility company which operates in a highly populated area, the questions are a bit more immediate and consequential to the bottom line. This utility's service area has a population of about one million people spread out over 450 square miles with well over 300,000 housing units and many, many firms producing nearly $50 billion in wholesale and retail business. The utility has more than 300,000 customers – sending electrical power to them, coursing through a myriad of distribution lines. The utility doesn't want to keep its community waiting for very long while it restores electrical power after a storm.

From the time of Aristotle, people have been analyzing weather patterns, and as Mark Twain said, "Everyone talks about the weather, but no one does anything about it." The invention of the telegraph in the 19th century at least gave people the ability to alert downwind recipients of impending dangerous storms. In the early twentieth century, British scientist Lewis Fry Richardson, who pioneered the mathematics of weather forecasting, first considered the possibility of numerically simulating and thus predicting the weather. But that was just a dream because computers hadn't been invented, among other reasons. Now, of course, the National Weather Service provides many forecasts daily of regional and global weather patterns -- freely available to all interested parties.

Restoring power to the people

For an electric utility company, the ultimate goal is restoring power as quickly and efficiently as possible when the storm hits. And that means, literally, spotting the necessary crews and equipment as close as possible to the areas where the damage will occur. The logistical problems are very similar to what an Army faces under quickly changing battlefield conditions. It's all about placing critically needed resources where they will be needed – before they are needed. And this utility truly has an army of repair personnel, equipment and trucks it has to deploy to the field before incoming storms. In a typical storm, it can send out many repair people and trucks of various capabilities to clear and repair the

Business Benefits

- The electrical utility company now can predict and prepare for weather events that can disrupt the electrical distribution network
- The utility now can estimate the likelihood of outages down to the electrical substation level
- Gives the utility the lead time to enable proactive allocation and deployment of its resources – people and equipment -- to minimize the time it takes to restore power
- Enables the utility to be more proactive and efficient in its operations. This capability is novel and unique in the industry

damage. And they always can call on neighboring states and communities for more help when needed. But the eternal question remains: when and where to send them to do the most good?

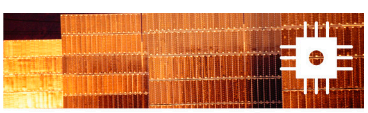
We all have read just how deadly and disruptive an incoming storm can be: leaving a number of people dead, countless vehicles and homes smashed, scores of roadways left impassable with hundreds of thousands of homes without power.

Collaboration begins

Several years ago, the R&D departments at the utility and IBM T. J. Watson Research Center in Yorktown Heights, N.Y., began a series of meetings and conversations. The utility determined that there were potential benefits that could be obtained from improved weather forecasting in its operations. This led to a collaboration that started late that year. The contractual arrangements were handled through IBM Global Business Services (GBS), which is the professional services arm of Global Services, including, systems integration, and application management services. It is the world’s largest IT consultancy. IBM’s weather forecasting effort is called “Deep Thunder” and had been in development since 2001. Deep Thunder is a service that provides local, high-resolution weather predictions, customized to business applications for weather-sensitive operations up to a few days ahead of time – a salable service and an on-going research effort. Prior to the collaboration, a prototype, operational system was built to provide 24-hour forecasts at 1 km (a little over six tenths of a mile) resolution for a nearby urban area, which were updated at least twice daily. It also produced forecasts at 4 km resolution, which covered the greater metropolitan area.

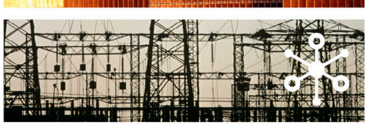
Within a year, the IBM and utility teams began work on a two-phase

Smarter Weather Readiness Electric utility uses modeling to deploy resources before incoming storms



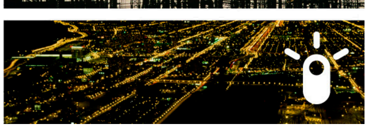
Instrumented

Uses data from many public and private sources to verify and improve storm forecasts. The forecast models are also used to provide virtual instrumentation – predicting what a real sensor would observe.



Interconnected

Integrates weather forecasts into the larger business decision making process by combining them with models and historical data to generate probable outcomes that the utility can then use to allocate and deploy assets to minimize downtime of the electrical grid.



Intelligent

Goes beyond the weather forecast by including models and historical data, allowing the utility to estimate the likelihood of outages down to the substation area level. The firm then can proactively base resources to minimize power outage durations.

Solution Components

Hardware

- WeatherBug Weather Station from AWS Convergence Technologies, Inc.
- IBM Deep Thunder Service, which runs on an IBM System p® at the IBM Data Center in Rochester, Minnesota
- Planetary Data Systems NOAAPORT Receiver System (for access to data from NOAA).

Services

- IBM Global Services - Global Business Services (GBS)
- GBS BAO: Business Analytics and Optimization,
- GBS ODIS: On Demand Innovation Services

"The bottom line for the utility company is getting its crews out to potential sources of damage before a storm hits. These weather prediction and outage models are beginning to meet that critical need."

–John Bosse,
Director Energy and Government Services,
WeatherBug

model for the utility's service area – weather forecasting on a detailed, -2-km scale across the utility's entire service territory. IBM contributed its mathematical and scientific expertise, and the utility supplied reams of information about its electrical grid – detailed information about its infrastructure of wires and poles. The utility also supplied five year's worth of historical data on storm damage: what poles and wires went down and when as well as issues that lead to failures. It was a large, complex data set. Then a sophisticated statistical analysis was used to understand characteristics related to outages – leading to the creation of a predictive damage model.

WeatherBug joins the research effort

During this time, IBM Business Partner WeatherBug was brought into the collaboration because detailed historical data for the past storm events and real-time weather data were critical. WeatherBug had been providing data to the utility separately. It was needed on this project because WeatherBug has over a dozen weather stations in the area and 400 in the region -- dense enough to supply enough weather input data to evaluate and improve the Deep Thunder model to zoom in to the scale that the utility needed. This collaboration produced a retrospective model, or "hindcasting" as opposed to forecasting. They enhanced the Deep Thunder weather model to accurately simulate past events using the utility's rich five-year set of historical data. This confirmed the validity of the model, a necessary first step.

At this point, the IBM researchers wanted to introduce better physics into the model. So they adopted one of the latest and most advanced approaches, called the WRF-ARW community model, which was developed by U.S. government agencies and universities here and around the world. (WRF stands for Weather Research and Forecasting model, and ARW stands for Advanced Research WRF). The research team then used the retrospective analysis to determine an appropriate configuration of WRF.

The team's initial goal for the utility's service area was a 24-hour forecast with 2-km resolution run three times daily, and a 72-hour forecast at four to six km resolution run daily. The team didn't really think they could create could create longer forecasts at the higher resolution with sufficient quality.

Looking below the 4km grid

The wall they hit was nature itself. To zoom in to a smaller scale, you leave the meso-scale (intermediate) simulation world and encounter micro-scale effects, such as what happens when winds interact in complex ways with tree limbs, turbulence around buildings, trees, utility poles and outcroppings. This would require two to three orders more computing power and sensor equipment. And even then, it wasn't obvious that meaningful results could be achieved.

As a result, the team broke the problem into two parts. They would do a weather prediction down to a -2-km scale, and then use a statistical model – not a physical model – for the damage, outage and restoration resource predictions. The resulting output that the damage model predicts, for example, would be something like "10 jobs will need to be dispatched to a specific substation on October 11 with a confidence level of 75 percent."

Beginning an operational evaluation

Beginning in 2009, the project moved to utility's emergency management area for operational evaluation -- integrating the model with its operations. The utility had been using the model for a little over a year. Early in the year, there was a severe snow and ice storm. The Deep Thunder forecast was available 18 hours ahead of the event and 15 hours before the NWS advisory. Most importantly, Deep Thunder predicted wind gust speeds, which cause the most damage in the service area and are not included in weather prediction model like WRF. They can be predicted statistically for the outage model.

The utility wanted the output of all these calculations and modeling to be easily used by dispatchers for assigning people and equipment across the county at the substation level. The model now is providing a weather forecast that extends 84 hours into the future – updated every 12 hours. And that feeds into an outage prediction model, calculating the likelihood that people and equipment need to be sent to substation areas for each of the next three days. These data are provided via customized visualizations (plots, maps and animations) on a Web site constructed specifically for the utility's use. "This is key to the success of the program," says Lloyd Treinish, senior technical staff member at the IBM Thomas J. Watson Research Center in Yorktown Heights, N.Y., and the chief scientist and "father" of Deep Thunder. "We have to present the data to the utility's dispatchers and associated staff in a form that is easily understandable and actionable. The program also provides site specific plots of temperature and wind. The forecasted variables also are provided in tabular data – for every 10 minutes of forecast time for the next 24 hours. And hourly over the next 3 days.

The models did well in predicting the effects of a brutal storm later in the year. A full report on the storm was up on the Web site two days ahead of time, and 37 hours before the National Weather Service issued its first advisory. On the damage prediction side, Deep Thunder predicted significant damage, but under predicted its effects. That's because there were no events in the utility's history of this kind of storm with these characteristics, particularly with wind gust up to 75 mph. The only record for a storm with similar weather patterns occurred several years earlier, but it carried no gusts near the strength of the storm. Now that data has been collected, the effects of the next storm can be predicted with more accuracy.

The Future

Deep Thunder also has being tested and developed for several other metropolitan areas, including Chicago, Baltimore/Washington, Atlanta and Fort Lauderdale/Miami as well as outside the U.S. Treinish says "The more measurement and historical data we are able to bring into the Deep Thunder model the better. But the key is predicting the impact of weather. That requires historical impact and infrastructure data from the clients that can benefit from such predictions. The organizations which will benefit from this approach for outage prediction the most in the short term are electric utilities. But Treinish also sees major applications for this approach being applied broadly – for renewable energy applications such as wind, solar and water power generation. He also sees a need to forecast the effects of storms on sewer overflows and water quality. But there are even broader applications in the areas of government operations, emergency management and transportation agencies.

The Inside Story: Getting There

Bringing WeatherBug into the Deep Thunder project was a natural progression. WeatherBug already was providing its service to IBM and the utility separately by 2006. And when the IBM/utility company team set their sights on developing a mesoscale weather and outage forecast for the utility's service area, they both immediately thought of WeatherBug, which has over a dozen weather stations in the area. Its weather coverage was dense enough to supply IBM with enough input data to initialize the Deep Thunder outage model.

WeatherBug was founded in 1992 and started in the education market by selling weather tracking stations to public and private schools. Later, the company began partnering with TV stations, and WeatherBug's local data began to be used in local TV weather reports. In 2000, the WeatherBug desktop application was launched, and later, the website. WeatherBug operates a network of over 8,000 weather stations, as well as the 1,470 Urbanet stations, thus making WeatherBug the single-largest weather network in the country. Most WeatherBug stations are located in schools in both metropolitan and rural areas. These are the stations that the WeatherBug application uses to display local data. WeatherBug also operates a network of over 1,000 weather cams and over 300 lightning detection sensors as a part of its new WeatherBug Total Lightning Network.

Let's build a smarter planet

In 2004, WeatherBug, the National Weather Service (NWS) and the Department of Homeland Security entered into a public-private agreement so that the WeatherBug stations could be used by Homeland Security to assess weather conditions in the event of a disaster. The agreement was renewed and expanded in January 2007 to allow NWS and NOAA (National Oceanic Atmospheric Association) access to the WeatherBug data.

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September 2010
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