In Brief

The Brazilian Cloud Forest Sensing Project is studying how cloud forests function in response to climatic variability. The project deployed more than 700 Internet enabled sensors connected to Microsoft Azure and is gathering integrated data on physical and biological processes within the study site. Through its partnership with Microsoft Research, the Brazilian Cloud Forest Sensing Project has created a repeatable Internet-of-Things (IoT) solution that revolutionizes how research can benefit from the use of a wireless sensor network, cloud technology, and automated data stream processing.

Rafael Oliveira
Professor of Ecology, University of Campinas

Carlos H. Brito Cruz
Scientific Director, São Paulo Research Foundation

Jie Liu
Principle Researcher and Research Manager, Microsoft Research

Rob Fatland
Senior Research Software Engineer, Microsoft Research

Websites:
www.azure4research.com

research.microsoft.com/cloud-forest

Understanding Cloud Forests Through the Power of Cloud Computing

Brazil is one of the most forested countries in the world. More than 60 percent of Brazil is covered by forest, including many cloud forests—moist forests characterized by persistent low cloud cover. Cloud forests help provide clean water because its trees intercept water from clouds. That water then drips onto the soil and feeds rivers, lakes, and irrigation systems, even during periods of low rainfall.

SEEKING NEW INFORMATION ON CLOUD FORESTS

The Brazilian Cloud Forest Sensing Project is an initiative of the São Paulo Research Foundation (FAPESP) Biodiversity Research Program, supported by the Microsoft Research-FAPESP Joint Research Center. Rafael Oliveira, a Professor of Ecology from the University of Campinas, conducts research for the project in the cloud forests of Campos do Jordão, Brazil.

The research initiative asks a broad question: how do cloud forests function? The goal of Oliveira's investigation is to understand how cloud forests work and then measure the impact of microclimatic variation on several ecosystem processes. How do the trees of the forest move around carbon, water, nitrogen, and other substances?

"It's very important for us to understand all kinds of forests," says Carlos Brito Cruz, Scientific Director at the São Paulo Research Foundation. "Learning the way a forest works allows us to more effectively conserve and utilize forest resources."

DEVELOPING THE RESEARCH FRAMEWORK

The research project focuses on a fragmented forest—which most forests in the world are—in contrast to a continuous forest such as the ones found in the Amazon. Most fragmented forests are in proximity to urban areas and are critical to the water supply of those communities.

Collaborators from the Brazilian Cloud Forest Sensing Project partnered with Microsoft Research to define research questions and develop software to analyze streams of data, which the Sensing Project team gathered every 15 minutes from a unified ensemble of more than 700 sensors on plants, in soil, and above tree canopies throughout the forest.

The Sensing Project team initially developed the sensors, equipment, power supplies, and data flow in the cloud forest. At the same time, they also worked with Microsoft Research to set up the technology needed to support the incoming data flows.

"This project is a unique opportunity to put together ecologists and computer scientists, and develop new tools to analyze data and visualize big datasets," says Oliveira.

To manage and process high volumes of complex data, the Sensing Project team uses Microsoft Azure to store, process, and visualize the data coming in from the sensors. The sensors themselves are connected to Azure as an instance of the Internet of Things:

"This project is a unique opportunity to put together ecologists and computer scientists, and develop new tools to analyze data and visualize big datasets."

Rafael Oliveira
Professor of Ecology
University of Campinas.

The sensors in the tree trunks will potentially help us understand the forest, such as carbon uptake on a daily basis. The project deployed more than 700 Internet enabled sensors connected to Microsoft Azure and is gathering integrated data on physical and biological processes within the study site.

devices embedded in the physical world sending data to the cloud (Internet) and changing their behavior based on the directives assigned to them.

The sensors are networked to and communicate directly with the Microsoft Azure cloud platform. "The data may not be very useful in its raw form, so we want to extract what will be useful in order to make decisions based on the information that it contains. All these things connected together provide the value that we call the Internet of Things," says Jie Liu, Principle Researcher and Research Manager at Microsoft Research.

AUTOMATING AND SPEEDING UP DATA COLLECTION

The Sensing Project has moved away from paper and pencil logging, data downloads by wire, and graduate students carrying USB drives filled with spreadsheet files from the forest to the lab.

"With the Internet of Things, we can stream data seamlessly from sensors through the network directly into the system and have the system manage that data and visualize it in real time," says Liu.

Because researchers have a constant stream of real-time data, they can quickly observe what's happening and if necessary, remotely change how the sensors collect data. This ability to make fast adjustments provides the researchers with high-fidelity data for specific time periods.

The researchers at the Sensing Project have created a repeatable technical solution, and researchers worldwide will be able to learn from it and apply these practices to their own sensor-based studies. The methodologies that are being developed will help Brazil's investigations and other global research projects. Using a network of 700 sensors to study a forest was a new concept, and the team had to determine all the pertinent details, such as how to manage the sensors, which sensors were needed, and what kinds of data to measure.

"When another project is initiated to study a particular forest, the researchers will be able to expand on what we have started and keep building knowledge about the environment," says Brito Cruz.

The Brazilian Cloud Forest Sensing Project is an example of the whole being greater than the sum of its parts because it created what the researchers call virtual sensors. With cloud forest sensors, the combination of interrelated data can measure something that can't be measured on its own. For example, no sensor exists that directly measures fog, but fog data can be gathered by combining data on temperature, sun, and humidity. Researchers use the sensors to flow data into the system, define the conditions under which fog would happen, and then can see precisely when it is foggy.

"We're able to actually see the phenomena happening on a scale of meters and over a timespan of seconds to minutes," says Rob Fatland, Senior Research Software Engineer at Microsoft Research. "That's something that's very difficult to do if you're just looking at a bunch of raw data files. We're providing this key bit of computer intelligence to convert data into an informational flow that humans understand."