Innovative building operating system provides the brain for smarter cities

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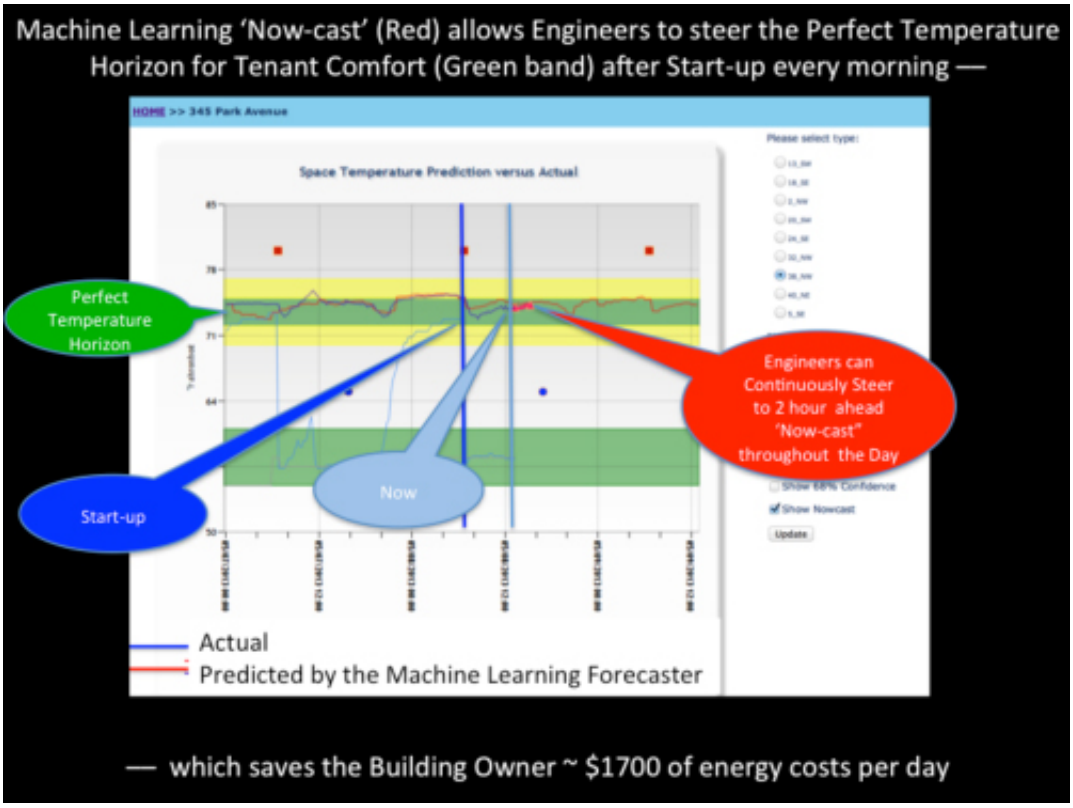

Figure A. TPO forecasts two hours ahead where a building will be if no corrective energy and comfort changes in HVAC are made.

Innovative technology developed by Columbia Engineering's Center for Computational Learning Systems (CCLS) is the driving force—in effect, the brain—behind Di-BOSS, a new digital building operating system that integrates all building operating systems into one, easy-to-use cockpit

control interface for desktops and portable devices, including laptops, tablets, and smart phones. This new machine learning technology, known as Total Property Optimizer (TPO), combines the need to provide comfort and safety for large building managers and tenants with situational awareness, energy savings, and re-commissioning (continuous optimal performance), and provides the smart analytics and communications needed for real-time operations.

"This system is so effective that in the last six months, it has already realized more than a half million dollars in energy savings in over two million square feet of Rudin Management properties in Manhattan, resulting in an astonishing return-on-investment. And this savings was gained in Rudin buildings that were already citywide leaders in energy efficiency," says Roger Anderson, senior research scientist at CCLS who led the advanced technology team.

TPO computes two kinds of forecasts every hour: a 24-hours-out forecast for energy and comfort throughout the building and a more dynamic "Now-Cast" that predicts two hours ahead where the building will be if no corrective energy and comfort changes in HVAC are made (see Figure A). The Now-Cast is unique to TPO, and designed to enable operators to "steer" the building to comfort, making improved real-time operational corrections that can then save in energy usage. The CCLS Team worked closely with Rudin Management, one of the largest privately held property management companies in New York City, to create this transformational system, and through Columbia Technology Ventures, licensed 19 patents covering the machine learning methods and techniques.

Powered by the CCLS team's TPO, Di-BOSS has been developed with the global technology company Selex ES, a Finmeccanica company. As Mattia Cavanna, Finmeccanica's Corporate Vice President for Strategy and New Initiatives, says, "Our DI-BOSS collaboration fits with our

sustainability-related smart cities innovations, and our interest in partnering with thought leaders such as Roger Anderson's team at Columbia Engineering."

One of the system's primary features is its ability to continuously track occupancy. "The technology to link the building management system with occupancy to control energy use is a cutting-edge capability," Anderson observes. "The ability to track occupancy on a large scale and link who is where and when to energy use is a key component to its success."

Figure B. Anderson's research aims to provide situational awareness in creating safer, smarter, and more comfortable cities.

"In addition," he continues, "the Di-BOSS system's continuous feedback loops give building managers reliable, up-to-date recommendations to make decisions that significantly improve energy efficiency and better serve the people in the building. Buildings currently do not have any operating system at all. Instead, they have hundreds of sub-system controllers that independently manage separate silos of responsibility, such as elevators, fire management, occupancy, and building and energy management systems. There is clearly large potential for energy efficiency improvement that is, as yet, untapped."

Anderson further notes that in large urban buildings, university campuses, military bases, hospitals, industrial and manufacturing facilities, the capacity to reduce energy consumption by 2020 in these sectors of the global economy will be more than 30% overall. But this improvement has to remain secondary to these operations' main functions: improved productivity while sustaining comfortable and safe operating environments. Such a system-of-systems approach requires that each building be treated as if it were an organism, with data sensors providing the innervation throughout all critical components, and a central brain providing the identification of problems, evaluation of possible solutions, and prioritization of actions—all in real time.

Since 2009, the CCLS team has been working with Rudin Management to develop data-intensive artificial intelligence tools for ingesting big data sets, defining the innervation of buildings, identifying clusters of correlation, and marrying them to future forecasting so that Di-BOSS can deliver predictions for optimal actions to operators and managers. Rudin piloted the Di-BOSS system in two of its largest New York City properties. Rudin employees provided critical user feedback that influenced the system's user interface design, report formats, and analytical capabilities. Di-BOSS is now being rolled out in all 14 remaining Rudin commercial properties.

"The Di-BOSS system's practical ease of use and ability to connect all of the building's systems are critical features that appealed greatly to our building managers and engineers. The Di-BOSS system had an immediate positive impact on our energy bill," says John Gilbert, executive vice president and chief operating officer at Rudin. "We were able to use its real-time forecasts to customize the next day's start-up and ramp-down schedules based on the weather and predicted occupancy. We also analyzed our tenants' specific energy consumption trends and worked together to generate cost savings for them as well. That's not only money saved but energy resources conserved."

The system also features the ability to analyze occupancy and energy consumption trends by tenant. Through secure online websites, tenants can check real-time occupancy and energy consumption data for their floors and can see their performance versus other tenants. Since tenants control roughly 60% of a building's energy consumption, Di-BOSS gives building managers the data to plan improvements that result in real savings for tenants and for the total building.

Anderson and his team at the Engineering School were happily surprised by the receptiveness of Rudin tenants across the board to this new system. "In fact," he says, "they're eager to use it in their facilities around the world to save energy on things like lighting (30 to 65% of total consumption), computers (20 to 45%), and other office and kitchen equipment (5 to 20%). To realize optimal energy efficiency, it's clearly essential that owners, operators, tenants, and local utilities collaborate if we are to achieve optimal operation of buildings, campuses, bases, and facilities into the next century."

The feedback loops programmed in Di-BOSS also enable the system to predict adverse conditions such as power grid failures and allow building managers to act in advance to clear elevators and put other security measures into place to minimize the impact on occupants. In addition,

because Di-BOSS tracks occupancy, building managers can provide headcounts by floor to emergency personnel if needed.

Anderson, who has spent almost 40 years as a research scientist at Columbia, has focused his work on building smart machine learning systems. He and his team spent seven years working with Con Edison at the Manhattan Electrical Control Center and co-wrote the Smart Grid Demonstration Project, the Department of Energy's largest Smart Grid grant under President Obama's 2009 stimulus package. The team has also worked closely with Boeing Energy Services to create computer-aided lean management systems, such as co-locating airplane inventory and tracking components so that each airline does not have to deal with maintenance independently.

"We are really interested in creating systems that can seamlessly and easily predict and adapt to whatever is about to happen, whether it's a powerful storm, an earthquake, blackout, or whatever," Anderson notes. "The whole idea of the intelligent building, smart grid, and smarter cities is to have enough computer intelligence so we can make cities safer and more comfortable places to live." (See Figure B.)

Provided by Columbia University

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