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The "Internet of Things" in AEC

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One of the technology catch-phrases that we are increasingly starting to hear more about is the "Internet of Things"—commonly understood as the notion that at some point in the near future, all devices will be Internet-enabled and able to communicate with each other (Figure 1). A popular example of this that is often cited is our home appliances talking to each other, such as the refrigerator detecting that there is no more milk and sending a reminder to our smartphone to pick it up, or perhaps even sending an automatic notification to an online grocery delivery service. The concept can also be extended to buildings, with leading technology companies like Intel and Cisco working to make homes smarter and more connected, as I pointed out in my review of the book "BIM for Facility Managers" in the Q3 2014 issue of AECbytes Magazine.

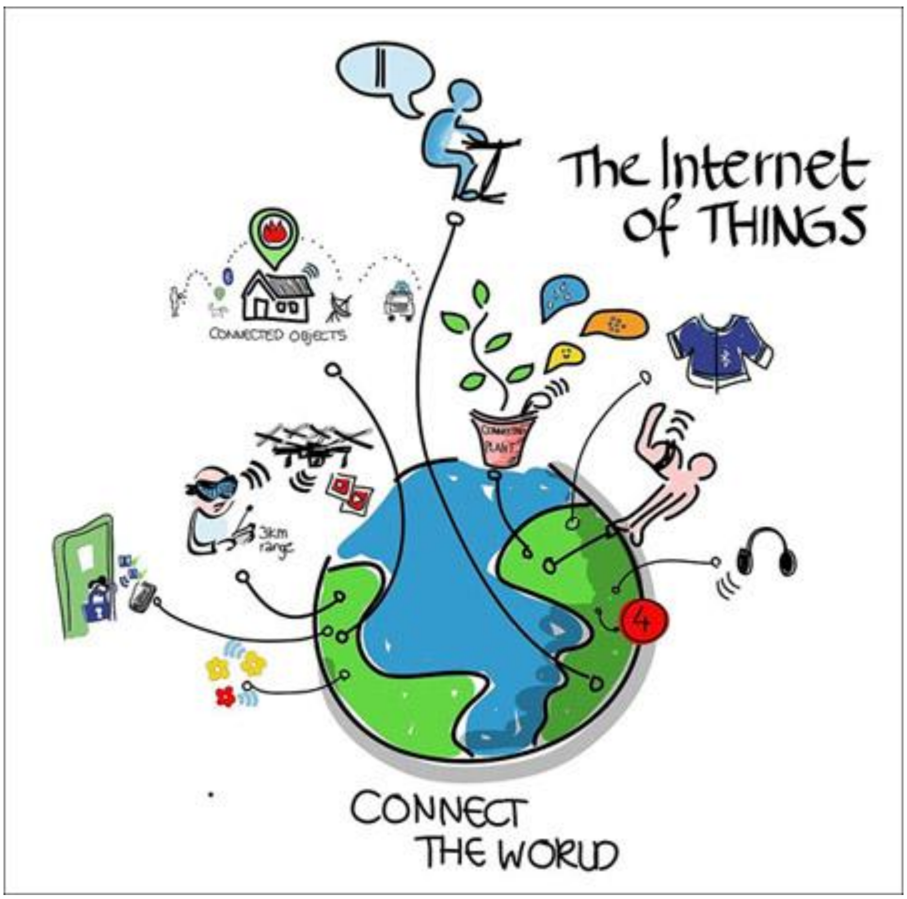

Figure 1. Illustration of the "Internet of Things" by Wilgengebroed on Flickr [CC-BY-2.0 (http://creativecommons.org/licenses/by/2.0)], via Wikimedia Commons.

It is not difficult to see how IoT (the acronym for the "Internet of Things") can be used to make buildings more responsive to their occupants once they are designed, built, and inhabited with smart building controls and sensors, such as the Nest Learning Thermostat acquired by Google earlier this year. A recent article in the Washington Post describes how the GSA (General Services Administration) in the US is experimenting with deploying IoT in the form of a network of sensors in its buildings to cut energy use and wasted resources by automatically manipulating shades, lights, air conditioners, power sources, etc. If the experiment is successful, IoT will be deployed in other federal buildings across the country as part of a "Smart Buildings" policy.

For those working in the core AEC industry and dealing with building design and construction, the interesting question is whether IoT can also be applied to their work in any way, whether it can help to make their tasks simpler, smarter, and more efficient. We already have BIM (building information modeling) as a smarter way of designing and constructing buildings. Can IoT bring us any additional benefits along the same lines, and if so, how? It is precisely such questions that this article sets out to explore.

"Internet of Things" in Building Design

There are two aspects to be considered when thinking about the application of IoT in building design: one is the design of the building itself, and the second is the tools that are used for the design. Let's look at the first question. If all buildings in the future will have a network of smart Internet-enabled devices connected with each other and capable of operating without human intervention—as IoT envisions—how will this impact their design? In other words, do we have to design "smart" buildings differently from existing "non-smart" buildings? It would seem so, but it might still be too early to provide a definitive answer, let alone anticipate what the changes might be until IoT gets more pervasive and commonplace.

The fundamentals of architectural design haven't really changed in decades, and as far as I know, no architectural texts are being re-written yet. But those who design buildings need to be aware that change might be coming. Companies like Dell are already talking about designing architecture for building automation, although at this stage, there are no concrete suggestions or recommendations. Architects themselves, by and large, are not yet talking about how the IoT could change what they do. In the course of my research on this topic, I found only one architect who had addressed the topic—this was a TEDx talk entitled "Designing for the Internet of Things" by Rodolphe el-Khoury, a practicing architect who also does teaching and research at the University of Toronto. He envisions homes of the future not having a computer but being computers themselves, with every element, fixture, or fabric monitoring and responding to conditions inside and outside the home. While this still gets more into the realm of FM and there are no specific examples of how the building design itself will be different, I found it interesting how the speaker envisaged IoT being applied to the entire fabric of our infrastructure, including buildings, roads, bridges, etc., interconnecting all parts like a "neural network" (Figure 2).

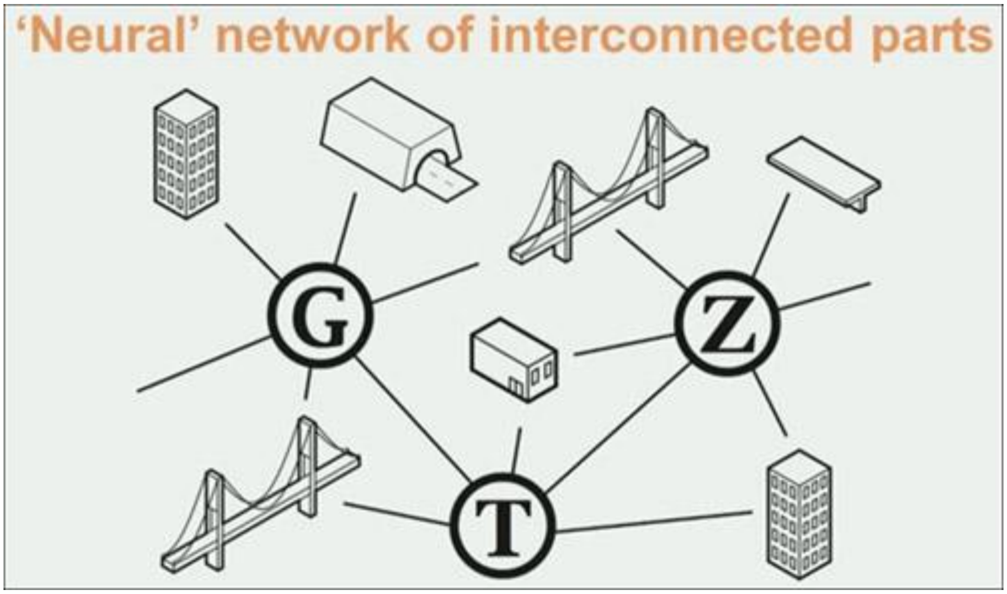

Figure 2. Slide from Rodolphe el-Khoury's TedX presentation envisioning the impact of IoT across all of infrastructure. (http://www.youtube.com/watch?v=tcUvg9jcfG8)

If buildings in the IoT era will be designed differently, it seems logical to conclude that the software applications used for designing them will also change. With regard to BIM authoring tools, there would certainly be additional "placeholders" to capture the additional "smart" properties of a building element. Presumably, the BIM application also has to take into account how these smart elements will interact with each other, simulating them digitally as they would behave in real life. So, for example, if a smart beam and a smart column "know" that they have to fit together in a certain way when they are being constructed, the design tool has to take that into account and make sure they come together in the same way in the BIM model.

Another possibility is for elements in a BIM application to have smarts that are not even present in those elements in real life. So, for example, space elements might "know" which other spaces they need to be next to, which spaces they definitely should not be next to, and perhaps even how close or far they need to be from other spaces. When the architect is then designing the building layout, all of these criteria built into the spaces will automatically come into play and help in the creation of an optimal layout. These particular smarts are not physically built into spaces, as they are only required during the design phase. Admittedly, the scenario described here seems to fall more into the realm of expert systems rather than IoT, but ultimately, we are looking at how to design smart buildings in a smarter way, so the exact terminology of the technology might not be that important.

In contrast to BIM authoring tools taking IoT into account while being used by architects and engineers to conceptualize the building design, the case for analysis tools—for lighting, energy, structures, cost, etc.—to do the same seems less ambiguous. If building elements will have smart devices and sensors built into them that will determine their performance, any kind of analysis tool will have to account for that in its calculations. So, for example, a lighting analysis tool will have to take into account the automatic adjustment of shades based on the position of the sun, the automatic turning off and on of indoor lights based on occupancy, and other similar factors while coming up with its estimates. The same is true of an energy analysis tool that will have to account for many of the building's built-in smarts and self-regulating capabilities in its calculations of heating and cooling loads, thermal comfort, etc.

"Internet of Things" in Construction

In contrast to building design, the application of IoT in construction seems to be a lot more straightforward. We already have RFID (Radio-frequency identification) as an established technology that is used in several industries, including construction, for asset management and inventory control. The technology consists of an RFID chip or tag that can be implanted in an object and can subsequently be wirelessly identified and tracked though a signal it transmits to an RFID reader. The reader, in turn, can be a part of a larger system that manages the signals from all the tagged objects, and compiles all the raw data into useful input for the application for which RFID is being used. (A comprehensive description of the RFID technology is available at http://en.wikipedia.org/wiki/Radio-frequency_identification).

For construction, specifically, the RFID technology can be used to monitor job sites, manage their logistics, keep track of materials that have arrived on the job site and monitor their use, determine which building components have already been used in the construction and which are in storage, keep track of personnel flow, manage work assignments, and so on. There are companies like ThinkMagic, a division of Trimble, that develop RFID products and solutions specifically for construction—I came across an interesting case study about how the well-known construction company, DPR, used their system to automate safety and access management during construction at the UCSF Medical Center at Mission Bay.

Imagine if the RFID tag embedded in an object could be augmented with any additional IoT information that is needed to make it Internet-enabled and smart. We could now have building elements carrying not just ID and location data, but which also "know" what their properties are, the potential signs of damage and deterioration, the communication protocols with other elements, and so on. For example, two elements might "know" how they fit together and provide an alert or error message if they are not properly connected. This could lead to easier and more accurate assembly, and perhaps, it would also simplify the ordering of materials where elements that are connected are ordered together. Taking another example, sensors embedded in concrete could be used to measure its quality during construction to ensure that its structural integrity has not been comprised during curing and installation (see Figure 3). Sensors embedded in foundation columns can provide an alert if they are not sufficiently reinforced to withstand the load they were designed to carry, or if they become damaged due to an earthquake or similar event.

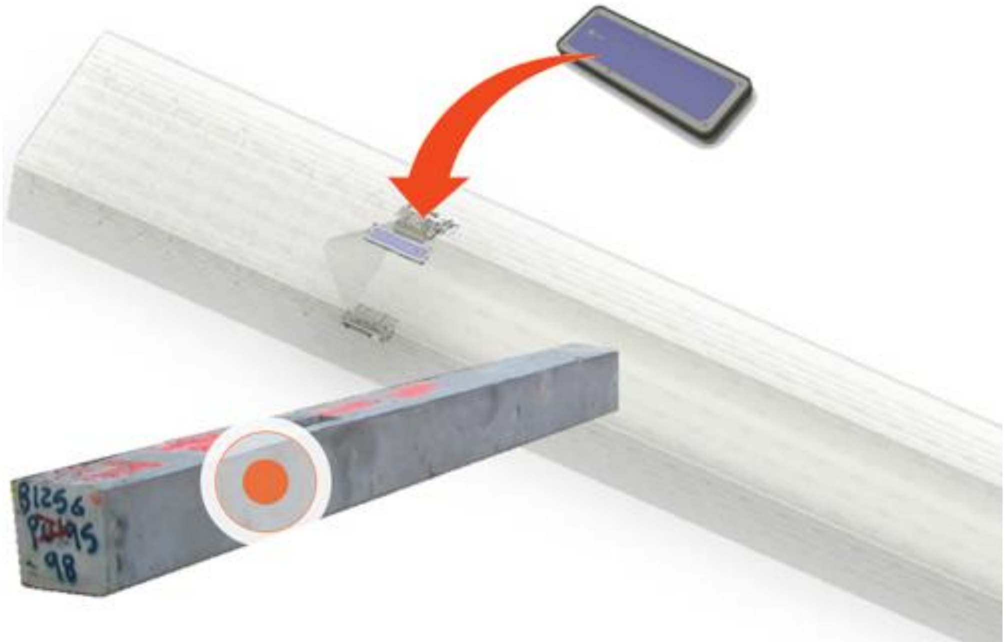

Figure 3. A company called Smart Structures has already developed a wireless sensor that can be cast directly into concrete structural elements to determine their quality and load capacity.

Numerous such examples can be cited of how building components can be made smarter with IoT to make construction faster, more efficient, and less wasteful. Unlike the possible impact of IoT in building design outlined in the previous section that was largely speculative, there is much more definitive and conclusive applicability of IoT in building construction.

Conclusions

It is understandable that the majority of the IoT discourse so far has been directed at the stage when buildings are completed and inhabited, given that it is applicable to society as a whole rather than just a segment of the population that works in the AEC industry. Any technology that is targeted towards the general public has the most far-reaching impact and naturally the greatest share of public discourse—look at Internet search, social media, electric cars, … the list goes on. With all our smart devices—smartphones, smartTVs, etc.—it seems that we are always looking for "smarter" ways of living, and smart homes powered by IoT seems like the next best thing we should have.

From an infrastructure perspective as well, the focus of IoT on the lifecycle management phase makes sense as the lifecycle cost of a building far exceeds the cost of designing and constructing it. So any process efficiencies and potential savings at this stage can have a huge impact on the overall cost of a structure. And it's not just the issue of money—there are so many environmental benefits as well if our buildings are more responsive to their inhabitants and can automatically adjust to internal and external changes. They can consume less energy, less resources, reduce pollution, and altogether become much more environmentally friendlier.

For those of us working in the AEC industry, this article has attempted to show that IoT will, sooner or later, also impact the way we design and construct buildings, and we should be prepared for that. While I am not sure if we really need “smart” refrigerators that can detect when our households are out of milk—shouldn’t we still be taking some responsibility for our lives?—it would be welcome to have smarter ways of designing and constructing buildings that can minimize any of the tedious and mundane work we need to do.

About the Author

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