IEQubes

EDWIN WEALEND 2017

Cundall London

IEQubes

The problem

As consulting engineers, we spend the clear majority of our time designing systems, spaces, and buildings with little in the way of feedback as to the success or failure of our designs. Unless something goes catastrophically wrong, often the attitude that 'no news is good news' is adopted. There are frameworks in place to combat this approach, such as "soft-landings." However, these are labour intensive and often there is little enthusiasm or budget once the building is handed over.

In building physics, outcomes are equally less certain, as they are often measured over months or years, e.g. in the case of climate based daylight modelling and school thermal comfort criteria. As such, the initial intent of the project was to create a solution that allowed long-term validation of daylight and thermal simulations, with the intention of comparing measured data from our own offices, to that of simulations.

As the project progressed, other problems with the indoor environment have become more prominent, and the scope of the solution has shifted from verification of simulations, to verification of real-life air quality standards, particularly for WELL Certification. With recent spells of bad air in London and other major cities, this focus on indoor air quality has taken on more urgency. Monitoring solutions do exist, but are usually one of the following:

- Integrated into a BMS and therefore not portable or scalable. (e.g. Siemens)
- Extremely accurate and hence expensive. (e.g. Testo)
- Inexpensive standalone/handheld monitors.
- Mains powered, proprietary, or Power over Ethernet devices – limited portability.

The design of the IEQubes was meant to be accurate enough for our purposes, relatively inexpensive, and able to be dropped into any building without interface with a BMS or IT system.

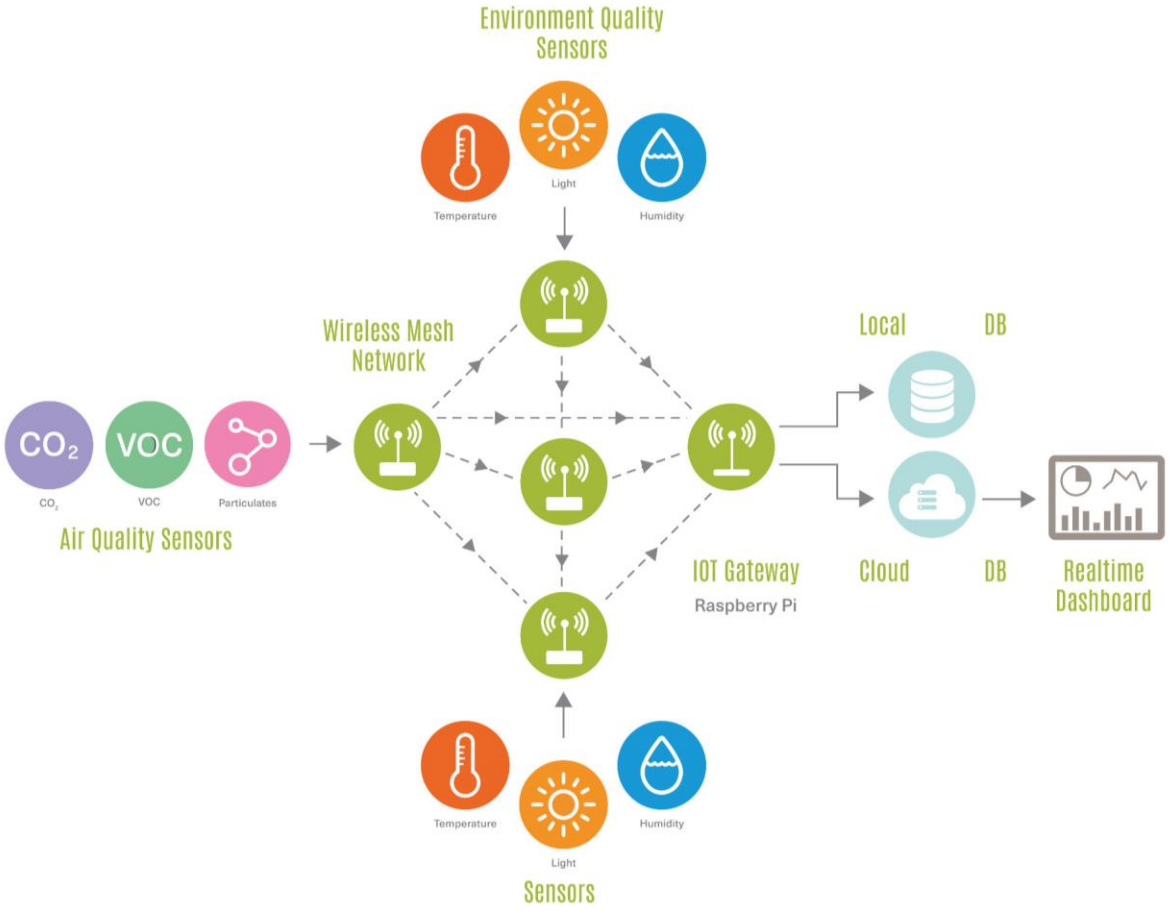
The solution

To solve the problems identified above, I developed a fully functioning building monitoring system from scratch. The system has the following features:

- Real-time multi-variable measurementiii (Illuminance, temperature, humidity, VOCs, CO2, PM2.5, PM10) – We can measure the most important indicators of indoor environmental quality as they happen.
- Automated – Once initial set-up is complete the system is plug-and-play. Anyone can use it, view, download and analyse the data. It will work as long as there is an internet connection.
- Low-cost – The entire project, producing enough sets of sensors for all Cundall's largest offices, cost less than the purchase of two less useful commercially available manual monitors.
- Calibrated – Using software based calibration means that even though the sensors are relatively low accuracy, they can show trends as well as far more expensive systems.

London Office dashboard
IEQube project wiki

- Low-energy – The running current of the entire system is less than 2amps.
- Reliable – The Original prototype IEQube has been running continuously for almost a year. The mesh network technology means that if a sensor goes offline, the network will self-heal and other sensors will continue to operate.
- Wireless and building independent – The system communicates using either Ethernet, WiFi, or the cellular 3G network. This means we can install them in almost any building, without compromising network security, or talking to FM or IT teams.
- Scalable – The system communicates over a self-healing mesh network, meaning that all sensors can send their readings to the internet via each other. This means that the system can be scaled to suit any size of building, just by plugging in more sensors.
- Environmentally friendly – The cases are locally sourced, from local FSC certified, near zero-formaldehyde plywood. All adhesives and finishes used in their construction are zero-VOC. The PCBs are lead free.



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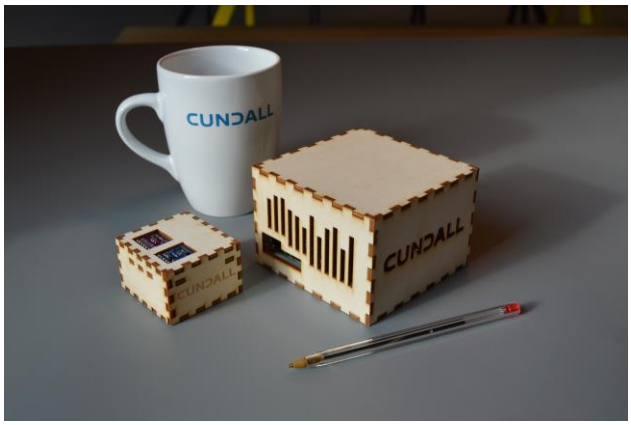
Technical Excellence



I believe the IEQubes project demonstrates technical excellence in a variety of ways. Whilst it operates using several complex functions and technologies, and well over 1000 lines of code, the user only needs to plug the sensor in to use it – the dashboard is clear and simple and the data is easily downloaded and analysed. I have learnt many of the skills as I've needed them, a summary of which is:

- Two new programming languages – C and Python, with well over 1000 lines of code written.
- The physical and system architecture of Arduino and Raspberry Pi – common IoT devices..
- Linear circuit design, including designing three custom printed-circuit-boards which I had manufactured (mostly successfully!) by a PCB manufacturer.
- Design and manufacture of the cases, firstly through 3D printing for the early prototypes, then through laser cutting.
- Soldering and assembly. – All the IEQubes were hand-soldered with zero failures in over 60 individual devices.
- Internet of Things (IoT) architecture – I have a thorough understanding of how the internet of things functions, including low-energy, low bandwidth devices, security, big-data etc. All of which whilst relatively new to the Building Services industry, are likely to be a big part of its future.
- Real-time data analysis – The system takes real time reading and converts them into usable engineering metrics, such as PPD, PMV and UDI – also in real-time, allowing us to make comparisons of real buildings to virtual ones.

From a commercial perspective, the IEQubes have proven to be far more successful than I predicted during their initial inception. We have just been instructed on our first indoor environmental monitoring exercise for a client, using a bespoke IEQube setup to assess CO_2 and air quality levels in their offices. By being allowed to investigate low-cost sensors and IoT devices, and develop them into a functioning device, we have planted the seed of an entirely new revenue stream for Cundall.

It has also enabled us to get out into the marketplace and talk to companies involved in IoT, big data, monitoring and dashboards, and take a real leadership position within the traditionally slow-adopting building services industry.

The IEQubes project has demonstrated our ability to develop novel solutions to problems, like monitoring of the indoor environment, that our clients are becoming more aware of, in a significantly cheaper and more effective way than our competitors.

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