Using a Sensor Network to Create a 3D Model of Indoor Environmental Conditions Over Time to Research and Address Sick Building Syndrome

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According to U.S. Environmental Protection Agency (EPA), Sick Building Syndrome (SBS) is used to describe a situation wherein occupants of a building experience acute health and comfort effects due to their time spent in the building. Symptoms of SBS usually include fatigue and headache, and often include dryness of hands, cough, and burning eyes. Factors causing SBS are still being researched but have been shown to include air flow, foul odors, airborne particulate matter, microbial concentrations, gas levels, temperature, and stress. A key feature of SBS is that affected people's condition improves over time when they are removed from that space.

The variations in symptoms and contributing factors have made SBS difficult to define. Research has been further hampered by limitations to how scientists have been able to collect data. Most comes from surveys of people living or working within the target areas, relying on individual self-reporting. Environmental samples have been limited to periodic testing, for example, taking samples in a hospital for one hour once a week.

In the US, the common way to address SBS in office or home environments is a walkthrough by a building inspector who interviews inhabitants and looks for possible contributing environmental factors. The inspector makes recommendations primarily based on information obtained from people, environmental data is only collected in rare circumstances.

In both research and commercial cases, environmental data either isn't being collected or it's being collected on a limited basis. This contributes to significant uncertainty when trying to understand or improve conditions in a building.

An improvement in data gathering methods that would allow for more sensors to provide better coverage for extended periods of time would have a significant effect on researchers' ability to understand the cause and effect relationships underlying SBS. An improvement that is also relatively cheap and easy to set up would enable commercial applications to efficiently solve real-world problems.

Our proposal is to blanket a space in small, efficient, self-contained sensor nodes which would take continuous measurements for weeks or months. Researchers and professionals would be able to build a 3D model for a set of factors and track changes over time. Such a dense sensor network would enable a researcher to monitor where changes are coming from and thereby identify pollutant pathways and sources. One could see how they change over time, or identify areas of relative concentration.

Some technical challenges to this proposal would be to secure an adequate power supply, preferably harvesting it from the environment; to package the sensors in a format that is compact and easy to install; and to utilize sensors that are adequate to the task but cheap enough to be deployed in large quantities.

We are already working on an energy harvesting solution and have the sensors themselves in hand. We will be using ZigBee low-power sensor nodes based on the CC2530 system-on-a-chip. These will relay with a ESP32 gateway in order to upload data to the cloud where it can then be modeled and analyzed. Both of these boards are relatively cheap, retailing for under $15.