Relative Humidity, Light & Temperature, and the Implications for Building Monitoring

Caburn Solutions are an innovative, and specialised Internet-of-Things (IoT) company with a background in health and environmental monitoring. Our focus being the development of ground-breaking managed home gateways and sensors which place occupant privacy, wellbeing, and security to the fore. Our innovative approach to home monitoring removes barriers between smart-home technologies, telehealth and indoor environmental-monitoring. Where a range of different commercially available and highly specialised sensors are connected to a single gateway. Our secure cloud-based systems ingest data for visual presentation and analysis, while notifying stakeholders to act via simple messaging or instructions.

We apply these technologies to advancing the understanding of building environments, their preservation and maintenance, together with the associated material, physical and health benefits that can be contributed via their careful management.

Relative Humidity, Temperature & Light

Relative Humidity (RH) is a significant factor in preserving important materials and artefacts in public, private and commercial buildings. Building preservation organisations, museums and art galleries have long understood optimum ranges exist for conserving sensitive, organic, or oxidising materials[1]. Construction masonry, metals, wood, leather, documents, and paper are all at risk (Brown & Rose, 1996; Watkinson, et al., 2019). Combinations of temperatures (high or low), light and humidity also risk internal damp, which endangers building integrity. High humidity with a variety of temperature conditions creates condensation or dew, and thus mould growth (Wolkoff, 2018). Conditions detrimental to building status and resulting in further emissions via damp, condensation, rot, and mould growth (ibid).

Optimum RH for buildings, however, varies upon the region, time of day/night, occupancy and building context. Some materials and organics benefit from certain types of conditions, while others suffer damage or are spoiled (Erhardt & Mecklenburg, 1994). For instance, certain plants grown indoors or in greenhouses require particular temperatures, light and RH to grow most productively, whilst others are spoiled or risk microbiological contamination (Santosh, et al., 2017). For important artworks, crafts, manufactured or cultural objects, and the most sensitive hygroscopic cases, the environment is strictly recommended to be controlled between “50 ± 5% RH and 20 or 21 ± 2°C” (Atkinson, 2014, p. 205). Commercial or personal artefacts, possessions, and collections, decorations and furnishings are carefully designed and represent significant time, effort, and expense for individuals and organisations. Building must

[1] For example, a high RH can increase the corrosion of some materials such as wrought iron (Watkinson, et al., 2019).

also therefore serve to store and protect valued personal, business, trade, or retail goods.

Seasonal effects and latitude are important factors when considering RH (Brown & Rose, 1996). For example, in Northerly climates, a RH of less than 40% can damage buildings (ibid). Indoor heating to 18 degrees typically reduces the RH to less than 20% (ibid). Raising RH, however, can raise the dew point of internal air above the external air temperature. Forming condensation on those elements cooled by contact with the external environment (ibid). In these sorts of regional contexts, it is therefore recommended in unoccupied properties, that temperatures should be maintained at a lower level, while RH should be maintained at the middle range to prevent condensation (ibid). Additionally, for those properties left unoccupied in winter, temperatures should as a minimum be kept above 5° Celsius to avoid frost damage to walls or frozen water-pipes (ibid). This similarly applies to produce that needs to remain unspoiled and kept within certain optimal ranges. Excessive exposure to natural and artificial sources of light and Ultraviolet (UV) radiation, also diminishes many biological and manufactured materials; 'bleaching' colourants, furnishings, clothing, treasured artefacts and even plastics. Lux is the ubiquitous method of measuring light in most building or conservation environments, but spectral charactaristics tend not to be considered (Garside, et al., 2017). Rather, decisions are usually based upon human selections which seek to limit exposure [i.e. UV] (ibid).

Humidity, temperature, and light are therefore not only important factors for building's maintenance and preservation, but also for the produce, objects, and artefacts they permanently or temporarily house. A key concern for public and private building administrators, landlords, retailers, tenants, and (absent) homeowners. This, however, is not only a complicated area for the circumstantial management of assets. There are often conflicting needs between optimum heating and lighting conditions for buildings and those needed for human comfort (Neuhaus & Schellen, 2006). Humidity, temperature, and light are the source of environmental interactions with individuals, impacting upon their comfort, mood, health, and well-being. For example, low humidity is associated with discomfort for individuals (Wolkoff, 2018). Winter influenza transmissions are also significantly linked to low temperatures, or dry conditions caused by indoor heating (Lowen, et al., 2007). Low temperatures appear to increase transmission as does a RH below 20%, whereas a RH of over 80% means transmission can be potentially nullified (ibid). High humidity, however, can also increase the survival and transmission of certain types of other viruses (Wolkoff, 2018).

Monitoring systems of buildings and structures are conventionally absent, or at best snapshot interventions via manual, on-site sample collection. Given the likely implications on buildings, health, and comfort, new studies employing in-depth real-time monitoring and measurement via remote live sensors are needed. Caburn Solutions have developed and integrated cost-effective solutions for remotely monitoring and measuring levels of RH, temperature, and light in indoor environments. This accumulation of data allows a broader analysis of the potential impact towards buildings, occupants, objects, and residents. The detrimental effects of which are wellknown, but their sustained presence remains a high concern. Implementing building monitoring can also help us to understand the contextual or lifestyle conditions which might be exacerbating problems, i.e. a lack of ventilation.

Technical Implementation

Caburn Solutions technical implementation is highly innovative as it uses prevalent smart-home technologies to interface with a local OEM gateway. The Caburn Solutions' gateway software is programmed onto a Java programming platform, providing gateway/sensor integration/management, and communications administration. The gateway uses low-overhead Mqtt IoT protocols to communicate over a multinetwork GSM modem and SIM card. This secure and encrypted transmission of data is then ingested from a Mqtt broker and stored using Microsoft Azure cloud systems. The data being presented via Caburn Solutions' own systems for dashboarding, charting and detailed historical analysis. They not only monitor data, but also the wide-area and local connectivity status of gateways and sensors, providing a visual/historical log of any downtime. The systems also provide alerts to warn of preventative/planned maintenance needs. For example, battery low warnings in sensors. The gateway utilises a low-voltage power-supply (5V), which includes an onboard battery to enable communication for up to 2-hours if power is lost. The systems also provide notifications to residents via web-portal-access, email and SMS; Providing recommendations for corrective actions for improving air-quality and reducing the level of pollutants. One instance being, measuring door and window opening/closing for managing air-ventilation.

Our solution for building monitoring is innovative and competes well as it is scalable and infrastructure independent; utilizing 3G/4G GSM licensed networks (having the benefit of also being able to use fixed broadband if required). The system uses well-established open smart-home encrypted wireless device protocols such as ZigBee (The Zigbee Alliance) and Bluetooth. One benefit of Zigbee being the formation of a mesh-network between sensors to extend ranges between devices in the home. The flexibility of our IoT gateway technology means connecting new sensors via software downloads in the future is simple. Our other sensors (or new ones as they become available) can be easily added.

The Intellectual Property of Caburn Solutions' system resides in; i) the Java based gateway software; ii) the Mqtt broker and subscriber interface; iii) the gateway and sensor management platform; iv) the connectivity management platform; and v) the data management platform. There is significant software development invested in the gateway, sensor data ingestion, storage, management platforms, and the data presentation/notification systems. Involving; a) the aggregation of multiple sources of sensor and gateway data into a logical, organised and manageable structure; b) the storage of information; c) the selective presentation of data and management information into easy to understand web interfaces; d) the availability of live and historical histogram charts for any device and any measured parameter; e) the flexible configuration of sensors, gateways, and intervention parameters for creating alerts; f) the ability to allocate contacts for incident management for automatically communicating problems by email or SMS to appropriate stakeholders; g) the ability to audit connectivity for both the links between sensors and gateways, as well as between the gateways and the cloud/server systems (and if necessary create alarms); h) the ability to create warnings for operational maintenance events (such as sensors or gateways being off-line, or sending low battery warnings).

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