IoT IN FIRE MANAGEMENT

by Ir. Vekneswaran T. Arasappan

With the advent of digital technology, the automation and data exchange initiatives that began in the manufacturing industry have turned into a full-blown revolution that cuts across sectors from agriculture, mining and construction to transportation, communication, utilities, finance, insurance, healthcare and real estate. The rate of the transformation is unprecedented, and it is now known as the 4th Industrial Revolution (4IR).

Driven by technology, Industry 4.0 increasingly employs automation, while accelerating mechanisation, with more robotics taking over routine and labour-intensive tasks. Digitalisation is rife, depending heavily on computers and software for almost everything, culminating in the widespread use of apps and digital devices across all workstreams. The advent of cyber-physical systems enabled by the Internet of Things (IoT) and cloud computing, is making phenomenal changes to the landscape, never before seen in the history of the world.

For the building services sector, Industry 4.0 is the next step in its gradual evolution. The key lies in how the various mechanical and electrical systems associated with a building can function in their inter-relations to provide a much higher level of service.

PURPOSE OF BUILDINGS

About a million years ago, man started moving into caves, primarily to seek shelter from harsh weather and wild animals as well as to have space for communal purposes. The discovery of fire kept man warm, provided protection from wild animals and enabled cooking activities.

Today, Wikipedia describes buildings as serving societal needs, "primarily as shelter from weather, security, living space, privacy, to store belongings, and to comfortably live and work". In today's context, electricity takes the place of fire as an enabler.

Whether it's caves or buildings, man's needs have remained pretty much the same. This is encapsulated in Abraham Maslow's hierarchy of needs (see diagram 1).

Today's buildings fulfil man's physiological needs by providing shelter with comfortable indoor weather and an environment controlled by the air-conditioning and lighting systems.

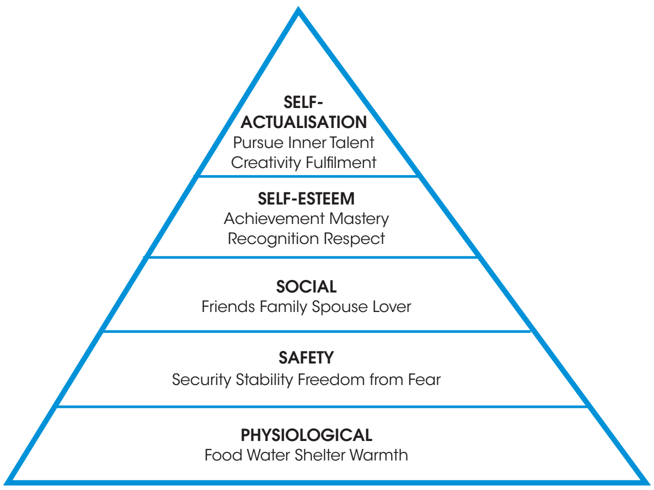


Diagram 1: Source: Maslow, A. Motivation and Personality (2nd ed.) Harper & Row, 1970

Safety and security are provided by the fire detection and prevention systems with CCTV and card access for auto doors/gates.

The telephony, network and the lift systems enables communication and connectivity within the social community for collaborative activities.

The technology in buildings today has evolved tremendously in the last few decades. Continuous learning and continuous improvements with each construction project, have resulted in buildings that are engineering feats today. However, the purpose remains the same: To serve man's needs.

These needs have also become significantly complex over the years. Given the current trend of "personalisation" and a focus on customer experience, an air-conditioning service may evolve into providing comfort-as-a-service and, instead of a fire-fighting system, it may be safety-as-a-service while cleaning services could become hygiene-as-a-service. Thus, a building-as-a-service, will take building services to another level altogether.

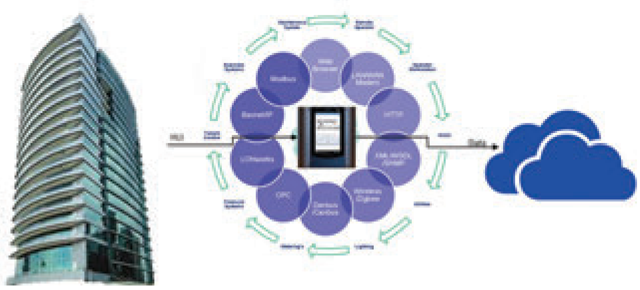
Imagine a building with ambient intelligence that enables it to recognise an approaching tenant, whether by way of long-range RFID, bluetooth low energy or even facial recognition through video analytics. The building is then able to "greet the tenant" by playing preferred music or displaying the tenant's name on an electronic signage. The auto-gate automatically opens while the lift is signalled down to the lobby. When the tenant enters the lift, the floor button alights by itself and the lift automatically goes to the correct floor. Stepping into the floor lobby, the auto door is activated to open while the room air-conditioning and lighting switches turn on to the preferred setting. And perhaps a message is sent to deliver the beverage of choice to the tenant.

The coming together of all the systems in the building to serve the tenant's needs gives the impression of a building that is alive, one that is conscious of the needs of its occupants. This idea isn't too far-fetched, given that vehicles are going autonomous. 4IR has undoubtedly accelerated the evolution towards smart buildings and enabled building-as-a-service to become a reality.

TECHNOLOGY IN BUILDINGS TODAY

The 4IR has brought on a radical paradigm shift to the world of engineering, starting the age of digitalisation in almost every industry. The advances have culminated in an ecosystem of IoT, which is described by Wikipedia as a system of interrelated computing devices, mechanical and digital machines, objects, animals or people provided with Unique Identifiers (UIDs) and the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction.

Already, most buildings have some form of Building Management System (BMS) or Building Automation System (BAS), which enables the monitoring and control of the building remotely. Most of the time, this is limited to the power supply, air-conditioning and lighting systems. IoT takes this one step further by connecting these systems as well as other disparate systems (fire-fighting systems, lift, CCTV, and card access systems in the building) to the internet, literally putting the entire building online.



Source: UEM Edgenta

When a digital power meter goes online, it can send up to 30-40 pieces of information per second, depending on the model and make. The same goes for an air-conditioning chiller, which can send up to 150 parameters per second. Data extracted from these and various other systems is streamed over the internet and into the cloud (see diagram). This data then needs to be interpreted and in the cloud, the data is structured and aggregated for the purpose of data analytics.

Data in the cloud is analysed using the various algorithms available, to produce business and operational insights. Some of the more complex algorithms include anomaly detection and machine learning. Anomaly detection studies data on unusual events that's not consistent with the streaming data. The fault detection is then investigated to identify the root cause for immediate rectification. Machine learning on the other hand, analyses historical data to predict possible future outcomes so that potential failures can be detected and avoided altogether. Real-time streaming and analytics of data enables the reduction of time-based preventive maintenance works and encourages more condition-based and predictive maintenance works.

Source: UEM Edgenta

One important aspect of analytics is the visualisation of the data and insights on a dashboard (see picture above). The dashboard is accessible on a computer, tablet or mobile device and it can be accessed anytime and anywhere in the world via an internet connection. Its capabilities are not limited to monitoring but also includes control as well, depending on the authorisation level. All these and more can be done in the cloud.

Cloud computing, the enabling engine for IoT, allows for interaction of data between different systems such as using the card access system data to control the air-conditioning and lighting systems based on the detected presence of occupants. A rule-based engine can be built on the cloud and programmed to monitor all the sensors in the buildings with a call to action when the readings exceed the threshold. Building operation rules can be written to enable simple functions such as switching on the air-conditioning or switching off the lights automatically. Programming the rule-based engine to instruct a building to generate its own

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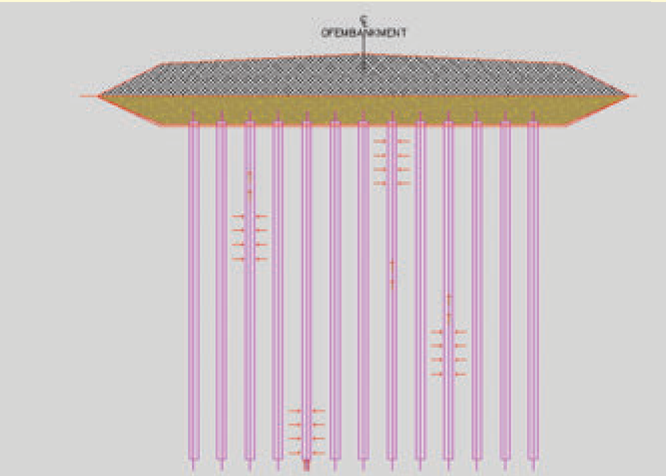

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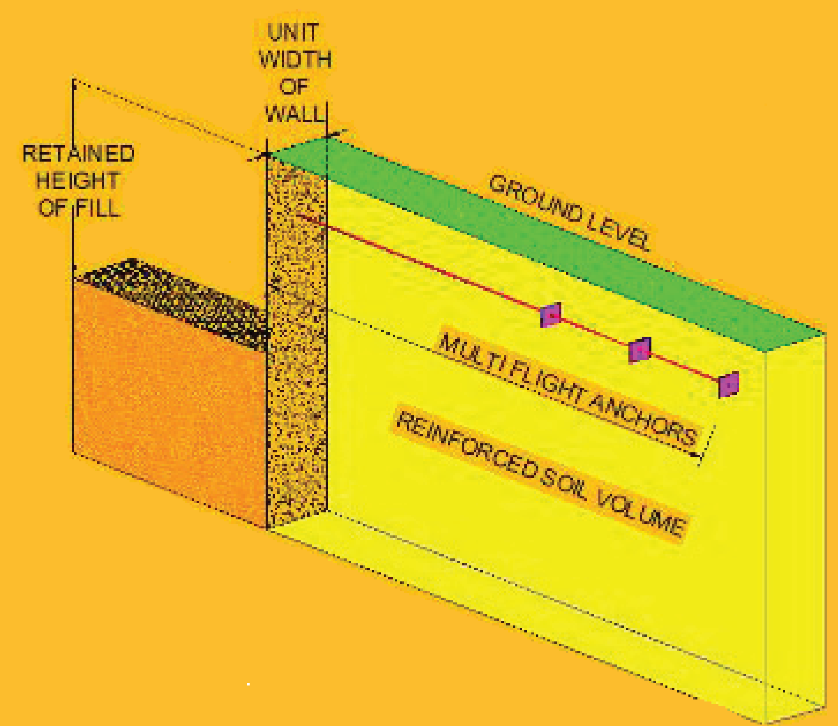

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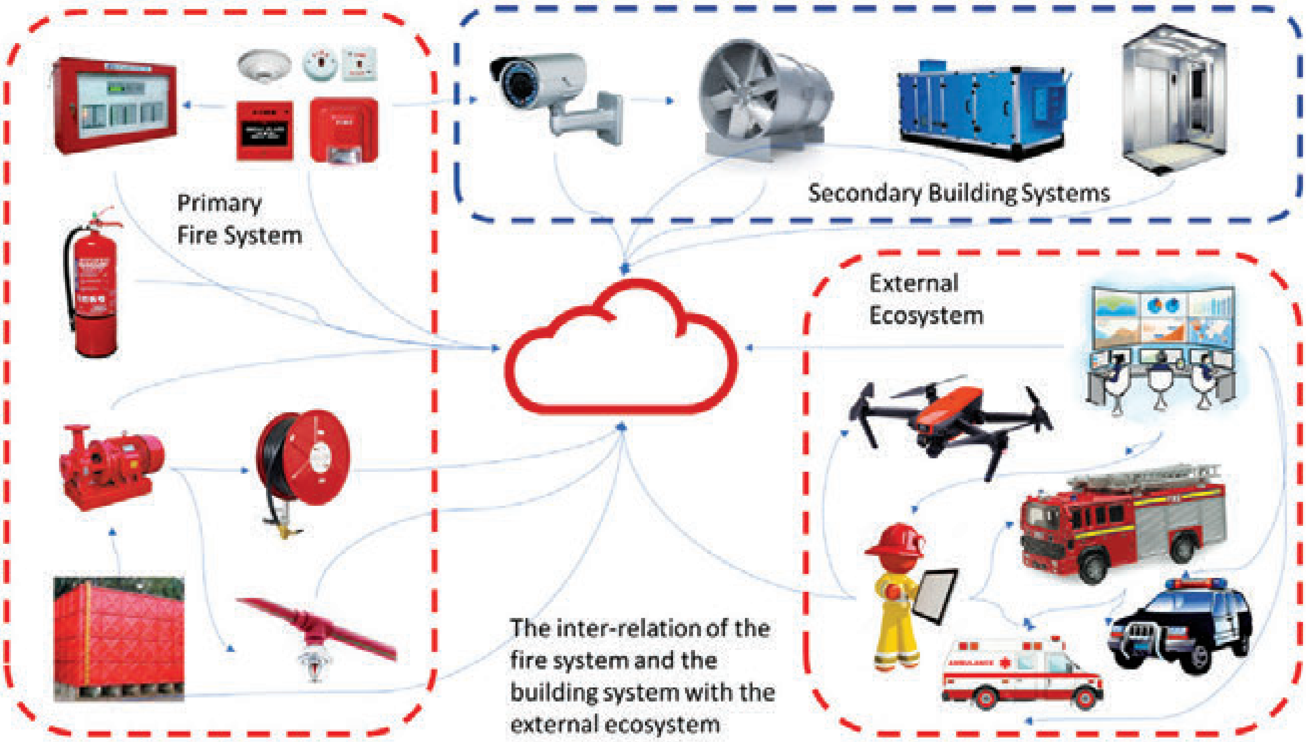

Source: UEM Edgenta

work orders and to assign it to the respective technicians can bring it one-step closer to building artificial intelligence.

The main risk is cybersecurity, so network security must be addressed with a virtual private network with the necessary firewalls, anti-virus and anti-spyware. Information security must be protected by cryptography and user authentication while application security must be enhanced by session management and input parameter validation. Disaster recovery will require risk assessment along with the back-up storage. Cybersecurity concerns must have a concrete plan and implementation.

The application of IoT in buildings in Malaysia is still in its infancy. It is mostly a manufacturer-driven market and new products are getting more and more sophisticated in terms of technology. New buildings will be inherently designed to use more digital applications while the retrofit of older buildings is subject to the owner's appetite for smart buildings. Nevertheless, the rapid advancements in technology will definitely be a driving force for smarter buildings in Malaysia within the next decade or two.

IMPLICATIONS OF IoT IN FIRE MANAGEMENT

Safety has always been a priority requirement in building design and construction. Technology is increasingly being used to enhance the safety of occupants and these include newer fire detection and prevention systems.

A conventional fire detection system refers to smoke and heat detectors connected to the fire alarm panel and fire alarm notification system while fire prevention systems include the standard fire extinguishers, hose reel systems and sprinklers. The influence of technology on these systems can be categorised into the advancement of each system on its own, the inter-relation of these systems with other building systems and the interaction of these systems with the external ecosystem (see diagram above).

Firstly, on its own, each system can be enhanced by applying IoT technology on the various components. The most basic, primary fire-fighting equipment is the fire extinguisher. Most buildings and facilities have fire extinguishers located at various spots according to Bomba guidelines and building requirements. These need to be checked periodically to ensure they are in good, working condition.

With IoT, new fire extinguishers can be fitted with a digital pressure gauge, which will send a signal should the pressure in the canister drop, so that immediate rectification or replacement is done. An electronic tether can hold the fire extinguisher in place and trip a circuit when it is removed from its position or tampered with. A proximity sensor can even be installed to ensure that nothing blocks the fire extinguisher and that it is accessible when needed. When the fire extinguisher is used, it will immediately trigger sensors to send an alarm via a network that connects all, to alert authorised personnel in real-time to take immediate action or make an emergency call.

Similarly, hose reels can also be fitted with sensors to detect tamper or use. Water flow sensors and digital pressure gauges on the sprinkler pipeline will provide relevant information on the integrity and readiness of the system. The same applies to the water tanks; Sensors can be installed to ensure the required water capacity is available and to trigger an alarm if it's not. Pumps can be connected online and programmed to run at intervals and to self-check various parameters to determine if everything is operating at optimum level. If an anomaly is detected, the system can trigger an alarm to the relevant personnel who can then remotely operate the pump or check it in person.

All these systems will be connected to the same network as the smoke and heat detectors and fire alarm panels. These will enable the management, operations and maintenance of such critical systems in real-time and ensure a high degree of uptime. Since all these systems are connected and always online, any failure can be immediately detected in real-time and rectifications carried out swiftly.

Secondly, independent fire-fighting systems can be programmed to work with other systems in the building. For example, a trigger on any of the smoke or heat detectors will activate the CCTV to focus on that direction and allow video analytics to determine if there is smoke or a fire. If so, the system can automatically activate sprinklers or the fire suppression system remotely. At the same time, the smoke spill system can be activated, the air-conditioning/ventilation system shut down, the power supply to certain areas switched off and lifts called to the ground floor. An alarm can be sent to the relevant authorities/personnel and an alert to the building occupants via siren, signages or even a pre-recorded message on the PA system.

IoT connects all these devices via the wired or wireless network and sends data to the cloud whereby algorithms such as machine learning, anomaly detection, predictive analytics and video analytics are deployed to analyse the event and call for action. The action is governed by a rule-based engine built on the cloud, which then sends a command to the actuator to react accordingly, based on the analysed information. The ability of the system to perform all these functions is known as artificial intelligence.

Thirdly, the interaction of the building with the external ecosystem can be a game changer for Bomba as it will be able to monitor all connected facilities and respond in real-time in an emergency. A connected building will be able to provide critical mapping information to enable firefighters to easily navigate to the building as well as identify the location of the triggered alarm. Access to such information will enable them to pre-plan their rescue entry plan en route to the scene.

At the scene, information from the lift system will be useful in helping firemen manoeuvre their way into the building or to use the lifts to rescue occupants. Connected systems such as the card access system will provide vital information such as the number of people in the building and the last known location of those trapped inside. Firefighters can also access the CCTV system to "see" the danger zone and remotely control the smart building fire suppression system to activate directed extinguishing at specific areas.

In future, firefighters will communicate and use sensors to track the movement of rescue personnel in a burning building and fire engines will be wi-fi hotspots for operating digital devices used in rescue operations. All information can be shared with various rescue agencies, including police personnel, first responders, ambulance services and hospitals.

In time, robots and drones fitted with cameras can be remotely controlled to aid in fire extinguishing or to deliver face masks, blankets or oxygen canisters to trapped victims. However, advances in technology come with a caution; cybersecurity issues must be addressed while fire standards, guidelines and regulations must keep up with technology changes accordingly.

CONCLUSION

With the 4IR, there has been tremendous advancement in IoT, sensors and digital applications. As fire safety cannot be compromised, technology is constantly being applied to improve the ability to detect and prevent fires as well as manage emergencies. In Malaysia, it is important that stakeholders come together to set the base standard for technology requirements in fire detection and prevention systems. This will then be an impetus for the widespread adoption of more technologically advanced fire-fighting systems within the local building industry. ■

Author's Biodata

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