AN APPROACH TO DEVELOPING AND INTEGRATING INTELLIGENT-BUILDING SYSTEMS - ON A LIVE PROJECT

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ABSTRACT

Birmingham City University have investing £180 millions in developing its university estates with integrated technologies. The main part of that investment is the building of two new intelligent-campuses or intelligent-buildings. BCU's new intelligent-buildings will integrate business and building systems on one network. The systems will communicate through an Enterprise Service Bus (ESB) and be orchestrated with relevant business rules. A layer of business-intelligence will then sit above the integrated orchestrated systems able to extract the data and information required.

In this paper, the approach and process of developing an intelligent-building from a protocols and standards based approach through the intermediary of an Enterprise Service Bus will be discussed. Also, the intelligent building systems integrated and the cost and process improvements realised. Including how the ESB systems are a scalable, interoperable and orchestrated eco-system with integrated business-rules across business and building systems.

Additionally, the intelligent building roadmap of planned developments will be discussed. This discussion will include:The development of BCU's Building Information Model (BIM) with mobile location technology. Integrating CCTV analytics to interrogate and harvest unstructured-data. Applying business-intelligence to structured and unstructured harvested data to gather more "emotional" data.

Keywords: intelligent-buildings, systems-integration, interoperability, service-orientated-architectures

1. INTRODUCTION

It is widely accepted that the smart or intelligent building industry is in its infancy in many ways. The lack of any international standards to define what is an "intelligent-building" does not help those who seek a defined path to correct intelligent-building development (Derek & Clements-Croome, 1997). The lack of international standards does not detract from the need for and interest in developing ever more intelligent buildings. According to research by IBM "buildings consume 42% of all electricity" and "by 2025, buildings will be the largest emitters of greenhouse gases on our planet". Aside from the drivers to optimise energy consumption in buildings; there are opportunities to augment buildings with technology to make them "smarter".

As more interpretations of smart-buildings appear across the globe they add to the body of evidence that will help those currently missing International Intelligent building standards get set and adopted across the world's construction sectors.

Birmingham City University found itself in the position of having no "intelligent-building" reference point when it started planning in 2009 to build its first intelligent building. After consulting widely within the construction and technology industry for an intelligent building roadmap to develop to, it became apparent that one did not exist. Every building and the needs of its users is different and the technology underpinning the structure and user needs must attempt to mirror those factors in its own unique way. This point helps to explain

why there is no “one size fits all” roadmap to developing an intelligent building. The definition “intelligent-building” is as subjective and nuanced as is the range of buildings it applies to.

Considering the level and means of achieving a building’s intelligence is open to such wide interpretation; Birmingham City University approached the development of their intelligent building project in a way that matched their aspirations. The fundamental criteria for BCU was to integrate open, scalable, interoperable and orchestrated systems that enhanced the capabilities of the building and its users whilst keeping implementation and on-going operational costs as low as possible.

Despite the individuality of each intelligent building the over-arching drivers for delivering intelligent buildings seems to be universal. The need to reduce costs, energy usage and related pollution and the need to constantly evolve user-services in the pursuit of excellence.

The Boston Consulting Group speculated in 2010 that if China could reduce energy consumption in its public buildings by 70 percent, as well as from its residential buildings by 55 percent, it could save roughly 1,950 terawatt hours (TWh) of electricity while cutting carbon dioxide emissions two billion tons annually by 2015. (Interfax, 2011)

Figure 1: Concept picture of the intelligent-building

Figure 2: Concept picture of the intelligent-building

2. OUR APPROACH

The approach to integrating building systems into an intelligent and orchestrated systems estate mirrors BCU's ICT business-systems roadmap. The vision for the new campuses remained, once set, to have all systems, business and building, to have the potential to integrate with one another. The rationale for this approach remains to share information between systems more readily and to apply business-rules for orchestration. Visibility of the systems estate is also advantageous for interrogating the systems to mine for business intelligence.

Not wanting to settle for a building that was not as "intelligent" as it might be by procuring an out-of- the-box or proprietary vendor solution; Birmingham City University undertook an extensive investigation stage to scope-out its requirements. This scoping and investigation period comprised of wide ranging consultations with all stakeholders and interviews with potential suppliers and accompanying vendor-audits, as necessary. The findings where that BCU's stakeholders' needs could best be met and investment costs managed by procuring those systems that could be integrated into the existing estate of university systems and developed against BCU's evolving business needs.

In the process to assess potential systems suppliers an audit was conducted to establish the IEEE and ISO protocols and standards that each system connected to other systems with; namely if and how potential systems could connect into the BCU estate of systems. In order to make this "connectivity- audit" simpler BCU took the approach of assessing whether each vendors system could connect into Microsoft BizTalk, the ESB Enterprise Service Bus utilised by BCU. MS BizTalk "adaptors" accept a wide range of IEEE protocols including most of the common protocols used by building management and environmental systems; such as BACnet, OPC and ODBC.

Adopting a protocols and standards big-picture approach to the task of assessing whether potential building systems could integrate with BCU's existing systems estate was advantageous for several reasons. The primary advantages were around retaining control of any new systems and the ability to integrate and manipulate them against BCU's business-process requirements; avoiding the need to purchase further consultancy from outside integrating firms every time configuration changes are necessary. By integrating all systems under one overarching Service Orientated Architecture (SOA) provides better visibility across the systems estate (Stack, Manzoor, Menzel, & Cahill, 2009); and the structure lends itself to being able to establish one source of data-truth. One, or a more refined, source of true-data across the entire estate can then be data-mined with effective business-intelligence software for management information.

As discussed, the benefits of developing and then evolving a SOA in-line with business-process needs is an holistic and practical approach to matching a business's needs with symbiotic technology. The approach parallels business scaling needs and can be reactive to quick changes that are unexpected or for long-term strategic planning concurrent with a pro-active approach.

Work-flows of business-rules can also be applied more readily across systems that are integrated. Traditionally business and building systems within UK universities may have been established on a siloes model, possibly due to funding, politics, technology limitations and in-line with the business-processes in operation at the time. As technological advancements and changing business cultures marry and work in parallel it is likely that the silo system will become rarer; and the advantages of sharing information across systems estates will become more widely accepted and acknowledged.

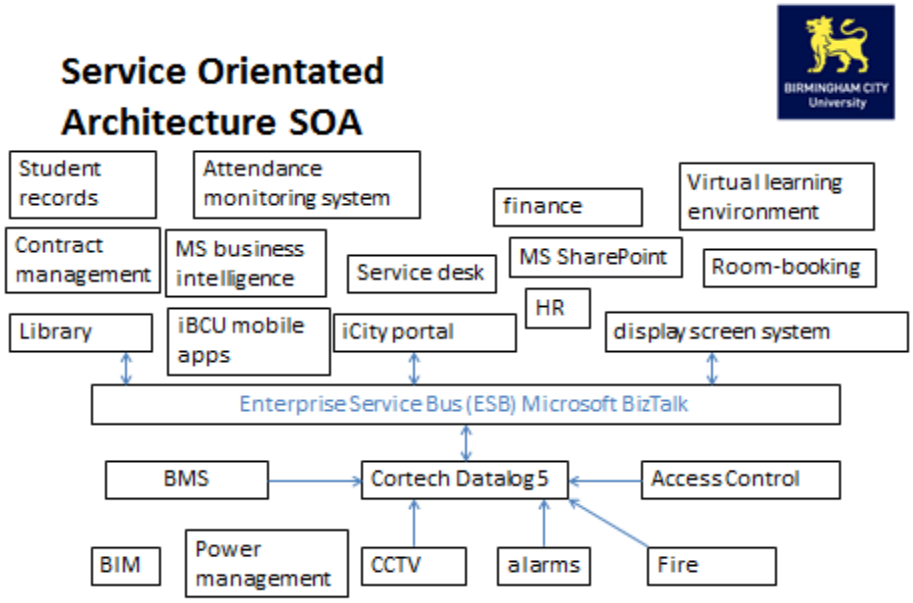

Figure: 3 SOA Structure

Table 1: Systems and devices deployed in BCU's intelligent-building

System Function	Company	Product	Controls
Building management	Delta	Orca-web	HVAC
Security integration	Cortech	Datalog 5	CCTV and alarms
Access-control	Grosvenor	Janus Enterprise	door-access
Power-management	Verdiem	Surveyor	power-policies
Mobile phone boosting	Blue Mountain	Cell-Antenna	Mobile phone coverage
Wireless access Points	Cisco	Aironet	wireless-coverage
Digital Display screens	TriplePlay	TripleSign/TV	display screens and IPTV
Lecture capture	Sonic-Foundry	Mediasite	lecture recording
Room-control	Crestron	room-view	room-control

3. COST AND PROCESS IMPROVEMENTS REALISED AND BEING REALISED AT BCU BY INTEGRATING-SYSTEMS ACROSS THE BUSINESS AND BUILDING SYSTEMS ESTATE

3.1 One network infrastructure

In the initial stages of the BCU new campuses planning and scoping activities the topic of having two separate networks and their related infrastructures was thoroughly assessed. BCU opted for one network, with the exception of the fire-safety/life system. One network offered the university advantages immediately relating to the saved costs on cabling and wiring for two separate networks that relate to a building of approximately 183,00 m^2 in size. The related separate professional fees for consultation, planning, designing, commissioning and witness testing should also be factored into these considerable cost savings.

Further up the OSI technology stack more infrastructure savings are achieved by deploying network-switches that cater for both business and building systems traffic. A greater level of network redundancy and resilience is also built into the network topology by patching building and business systems devices across arrays of switches. One example would be were CCTV cameras are not isolated to one switch, but patched across many in-case that switch fails; the result being that only one CCTV camera fails mitigating the effects of losing a whole bank of CCTV cameras.

Another effect that maybe missed or under-estimated is the effect of bringing university departments and specialist disciplines together to host their respective services from one network platform. Although mostly intangible the process of bringing teams together helps to build understanding and trust in seeking to establish co-operative working relationships that aid the overall business. As each team gains a better understanding of other teams' requirements and vision a process of naturally helping one another achieve and integrate unfolds to better serve the needs of the overall business. This collaborative and integrative working approach when working optimally runs in parallel with the technology decisions that strongly underpin delivering a successful project.

4. INTEGRATING BUILDING AND ENVIRONMENTAL SYSTEMS INTO THE BCU SOA SERVICE ORIENTATED ARCHITECTURE

The main advantages of integrating building management, environmental and security systems into BCU's SOA and then applying business-intelligence can be broadly classified as for: safety and security, monitoring usage for space planning, and for service-enhancements.

4.1 Safety and security

Birmingham City University has approximately 24000 students and 2500 staff; their safety is of paramount importance. An example of how user safety systems are enhancing the new campus is by how BCU's fire-safety system connects to the digital display screen system. When a fire-alarm is activated a message is displayed on every display screen through the building with a message "Fire: evacuate the building immediately". This seems like a small accomplishment, but maybe instrumental to savings lives in the event of a fire. In-line with this development BCU has also developed a facility to automatically announce such emergency information on the university web-portal.

BCU have integrated the new campus's access-control system with the security integration system. The result is that when an alarm is triggered in an area the nearest CCTV pans onto that area and the record rate is speeded-up. The footage is then stored securely in a highly resilient data centre environment to protect any evidence that may be required later.

BCU's security infrastructure also allows for the addition of CCTV analytics. BCU are investigating ways in which CCTV analytics and other identity services can be used to alert users to services. A simple example might be to alert a user that they have a library book or piece of marked course work ready for them to collect. CCTV analytics can also be used to produce heat-maps of usage or to help manage traffic-flows around the building.
Emergency and security procedures can also be stored on Microsoft's SharePoint Server which will integrate through Microsoft BizTalk adaptors with BCU's security and building management systems. When an alarm is

triggered the correct set of procedures can be served-up to the security officer or nominated person attending the incident. This use of systems integration simply and elegantly helps insure efficiency and compliance when dealing with incidents. The system described here is also on BCU's technology roadmap to serve-up procedures onto mobile devices.

4.2 Monitoring usage

Birmingham City University's two new campuses are located in the Eastside district of Birmingham England near the centre of the city. Consequently real-estate prices are high and BCU endeavours to maximise value by optimising space utilisation. Again, utilising building and business systems to help achieve desired results in this area is being practiced at BCU. Energy costs to maintain a large university campus are high and any reductions possible through systems optimisation are welcome. BCU also seeks to reduce its carbon output where possible as a responsible and forward thinking organisation and in-line with UK government directives.

The UK has committed to reducing carbon emissions by 80% by 2050. (Committee on Climate Change) (UK Green Building Council)

BCU's access-control system monitors traffic in and out of the new campus, which produces useful statistics in its own right. However BCU is in the process of upgrading its current room-booking and time-tabling system that will either incorporate or integrate with a new or existing student attendance monitoring system. The integration between these two systems allows for a more granular and precise approach to gaining actual usage statistics. To explain further, a user can book a space that might cater for 40 people, but only 6 people attend, by using a student attendance system in conjunction with a room-booking system BCU can discover the level of actual usage.

Investigating the actual usage data can enable BCU to identify usage-patterns and work towards optimising available space against such data. Space usage data is also helpful in discovering how different people using different type of space inside the building.

Energy from fossil fuels consumed in the construction and operation of buildings accounts for approximately half of the UK's emissions of carbon dioxide. (Constructing Excellence, 2008)

Several other systems can help to provide usage data, PIR's in rooms, CO2 sensors, audio-visual control devices, power-management and user-logons to network services. All of the building's data can be collected and consolidated for analysis and decision-making once base-lines and ranges have been established.

The fastest and least expensive way to lower energy usage is to optimize the building's insulation and windows for energy efficiency and put in sensors, which can turn off lights and monitor air quality. ... Knowing when and where energy is consumed reduces peak usage and offers more flexibility in meeting utility company demand-response program. Cisco Energy Management Solution. (CISCO, 2007)

Power-management can show dramatic cost savings of 25% energy usage once energy needs have been surveyed and base-lined and appropriate policies applied. BCU are able to deploy power-management software agents across its integrated estate of systems; both business end-user devices such as PCs and VOIP phones and building management systems devices. Once energy usage patterns are established it is possible to leverage the information to optimise energy supply contracts and to take advantage of demand-shedding.

In 2004, for example, the public sector accounted for 34% of new non-domestic building construction and 37% of non-domestic refurbishment (totalling 1.45% of UK GDP). (Constructing Excellence, 2008)

4.3 Service enhancements

BCU is continually seeking to build upon past and present successes to improve the user-experience. Using technology in clever ways can help to achieve an enhanced user experience. As an example, a mobile app has been developed by BCU which allows user to scan-in a QR quick-reference code at multiple locations in the new campus. The QR code is linked to floor-plans and building information from BCU's BIM or Building Information Model, a virtual model of the building. In this way the user can view information such "where am I" or "what's near me". As BCU's first new campus is built for the Birmingham Institute of Art and Design, QR codes and their linked information will also be used in gallery space and at exhibitions. Users will in this way be able to read narrative around each piece of art as they choose.

BCU also plans to integrate the university BIM with its room-booking system to enhance the amount of information the user has the option to see, such as, what equipment the room contains: projectors, plasma-screens and end-user devices. BCU's BIM will also be further integrated with new service-desk upgrades and potentially a reactive maintenance system. The rationale being that integrated systems that share data can be formed into workflows that reflect business-process needs. From when a call or query is placed or raised to when it is successfully completed the chain of events should be executed effectively and measurably.

Employing a smarter buildings strategy can help your organization reduce energy use by up to 50%, and increase facilities utilization by up to 85%. (IBM, 2013)

Integrated-systems and their respective web-interfaces, many that will be viewable from BCU's web-portal allow user's more autonomy over their university environment. Enabling users to interact with the systems that augment the new campus with a virtual-skin of technology builds upon BCU's strong user-engagement.

In a world where employees are spending less time in the office and more time in alternative workplaces, a smarter buildings strategy can also enhance employee productivity up to 18%. And as a result, costs decline. (IBM, 2013)

5. BUSINESS-INTELLIGENCE AND "EMOTIONAL-DATA"

The physical and the virtual worlds are converging as part of the continued growth of ubiquitous- computing. Our world is growing a technological virtual-skin of sensors and smart objects that are augmenting physical objects such as buildings. The resultant data and information produced by this "Internet of Things" is ever increasing. According to Eric Schmidt CEO of Google, we humans create as much data in 2 days as we did in all of history up until 2003. There is a growing trend across sectors to try to make use of this "big data" by mining out the pertinent aspects.

Businesses, academics and journalists are using sentiment analysis to tap into this social media buzz. By applying analytics and natural language processing technologies, they gain a better understanding of consumer preferences, market trends and brand awareness. (IBM, 2013)

Birmingham City University wants to find "meaning" in the data it produces to continue to build upon our excellent services; whilst remaining completely compliant with the UK Data Protection Act 1998. BCU has a department that concentrates on teaching and learning methods and the technologies employed to deliver that learning in the most effective ways.

BCU's users are all unique and they have learning-styles of their own that they favour. BCU's students are encouraged to be co-creators of their student experience. As it becomes possible to mine data in more sophisticated ways it is likely that more "emotional and user-relevant" data will be available for analysis. This approach is in-line with the movement for more tailored-services that meet the individuals' particular needs at that particular time.

Educational institutions face high expectations of continuous performance improvements and efficient operations. (IBM, 2013)

BCU do not profile their users, but subject to a user's agreement it would be possible to offer services to that user from profiled information that would be in the format that the user preferred. Each individual has a preferred method of using and storing information that is particular to their learning-style; this is sometimes referred to as their "representational state". Communicating in the style that a user-prefers is more effective for all concerned.

"Learning is a specific context. People have different learning styles; knowing your Profile in that Context (or that of the people you are teaching) is useful for accelerating the speed at which new material can be integrated. (Charvet, 1997)

In a similar way BCU's users can set their preferences on their university web-portal iCity. Each student's iCity portal has the "widgets" or "apps" that are relevant and chosen by them and presented in a style that they like. BCU students may also have a virtual-portfolio of their academic work that is unique to them and their continuing educational journey. As BCU's systems continue to become interwoven and the business-intelligence applied is able to extract more pertinent information tailored to the user it is probable that BCU can empower its user's even further.

CONCLUSION

BCU is on an unfolding journey of discovery to continue developing and evolving its increasingly intelligent-buildings. The results so far are improving security, operational-expenditure and user-experiences through environmental enhancements with integrated, interoperable technology-systems that are orchestrated. BCU is successfully modelling it's technology strategy to match its business-requirements for the present and foreseeable future. If BCU's business-requirements change suddenly the technology that underpins BCU's operational and strategic needs can scale to fulfil changing parameters. This same technology-model is inherent in BCU's new intelligent-buildings; where the physical intelligent-building is integrated and interwoven with technology that anchors it to BCU's technology-infrastructure.

BCU's SOA Service Orientated Architecture of technology-systems will change symbiotically with the needs of the university moving-forward. For now BCU has laid the foundation-stones of a technology platform that is serving its users' needs with matching technology. The goal now is to make the best use of the estate of technology-systems that have and can be integrated to keep improving university business-processes and workflows and extracting pertinent "emotionally-intelligent" business-intelligence. Ultimately, BCU is using technology imaginatively and creatively across its campuses to make things better for it's users.

The convergence of IT and Building Technologies provides data-focused services to reduce building energy and emissions up to 40%. (Hannus, Kazi, & Zarili, 2010)

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