ICT TODAY
THE OFFICIAL TRADE JOURNAL OF BICSI

January/February/March 2024
Volume 45, Number 1

EMBRACING THE AI REVOLUTION:

HARNESSING THE POWER OF ChatGPT

PLUS:

+ The Case for Multicast in Smart Buildings
+ Your Building Has a Story to Tell: Let AI Narrate It

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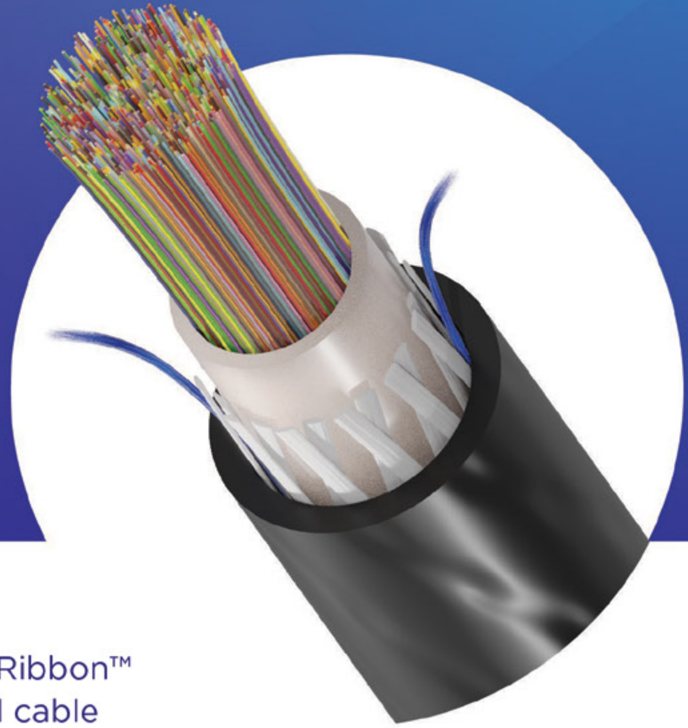

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From BICSI's Board President David M. Richards, RCDD, NTS, OSP, TECH, CT

EMBRACING TECHNOLOGICAL INNOVATION

As we delve into the fascinating realm of technology and innovation in this edition of *ICT Today,* it is with great enthusiasm that I invite you to explore the transformative power of artificial intelligence (AI), particularly in the context of BICSI's mission and the broader landscape of smart building design, standards, and future infrastructure.

The articles featured in this issue paint an intricate picture of the strides we've made and the potential that lies ahead. "Embracing the AI Revolution: Harnessing the Power of ChatGPT" signifies a pivotal moment where human-AI collaboration transcends boundaries, empowering us to navigate complex challenges with newfound efficiency and insight related to ICT design.

Moreover, the two articles covering smart buildings, "The Case for Multicast in Smart Buildings" and "Your Building Has a Story to Tell: Let AI Narrate It," help to illuminate the profound ways in which technology interweaves with our physical spaces, offering not just efficiency but also a narrative that echoes the essence of the buildings we use.

I am especially proud that Gautier Humbert, the most recent BICSI Board of Directors EMEA Regional Director, provides us with some incredible technical depth in his article, "Structured Cabling—Category 7A and Category 7A 22AWG: What are the Advantages?" He underlines the importance of understanding the differences between international and North American standards, highlighting how nuances in cabling can significantly impact our digital capabilities.

Lastly, "Artificial Intelligence Technologies Incorporated in Smart Buildings, Smart Cities, and Data Center Design" amplifies the interconnectedness of AI, smart infrastructure, and the broader urban landscape, underscoring the pivotal role technology plays in shaping the buildings, cities, and data centers of tomorrow.

In light of the incredible talent showcased in this issue of *ICT Today*, I am sincerely honored to take on the role of Board President for BICSI's Board of Directors in the upcoming two years. BICSI is at an exhilarating juncture as we stand on the brink of the fourth industrial revolution, as outlined by Klaus Schwab, the founder and executive chairman of the World Economic Forum. The convergence of AI and infrastructure presents a tremendous potential to improve ICT accessibility, sustainability, and efficiency around the world.

BICSI stands at the crossroads of this convergence, and our commitment remains firm—to harness innovations not just for their novelty but for their capacity to advance the ICT profession and drive positive change.

I invite you all to explore these articles with a critical eye, to envision the possibilities they present, and, most importantly, to consider how we can leverage these technological advancements to serve our communities better.

Thank you for your support, and may this edition of our journal spark conversations that propel us toward a future where technology and humanity come together for the greater good.

Best regards,

COVER ARTICLE

By Carlos Pagan

EMBRACING THE AI REVOLUTION:

HARNESSING THE POWER OF ChatGPT

FORWARD

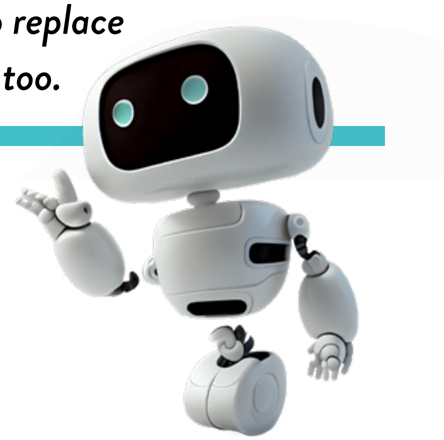
The rise of artificial intelligence (AI) is making a powerful comeback—captivating the imagination of many. However, AI and other technologies often spark skepticism regarding their human-like and futuristic capabilities. While these technologies may seem extraordinary to the everyday person, they have become quite common within the ICT industry. Through the years, we have been exposed to various machine learning applications that may appear otherworldly to the average person. Technologies like facial recognition cameras and radio coverage mapping algorithms have been widely embraced and utilized in our industry for years. With the mainstream emergence of AI tools such as ChatGPT, Dall-E 2, and Rose AI, many ICT leaders have started asking questions like "Should I use AI?", "How can I use AI?", and "Is AI going to replace me?"

AI has quietly worked behind the scenes for several years, enhancing various aspects of our everyday lives. In the security industry, AI-powered machine learning algorithms have been used on visual monitoring networks to track individuals, trigger alarm events, and even speed up the post-event review process. Tesla's Full Self-Driving (FSD) feature relies on AI algorithms that continuously improve themselves, allowing vehicles to operate with user input. Even SpaceX's achievement of autonomously landing an orbital rocket booster owes its success to the company's own AI model. Recently, AI has come to the forefront of our day-to-day lives, with school-age children actively using AI to assist with homework and other assignments in the classroom.

With the digitization of our lives accelerating rapidly, the demand for ICT design professionals is reaching new heights. In this dynamic landscape, BrightTree Studios is driven by curiosity to explore the optimal ways of leveraging the power of widely available AI models within its existing workflows.

Throughout this case study, the intersection of AI and ICT design, diving into the potential benefits of integrating AI models into its workflows, from streamlining repetitive tasks to improving the precision of its designs, will be explored. What can an ICT designer gain by embracing AI as a tool in their everyday design process? As ICT designers navigate the realm of AI-powered ICT design, they must decide if AI elevates performance, making a significant impact in their field, or if it is coming to replace them in their jobs, too.

As ICT designers navigate the realm of AI-powered ICT design, they must decide if AI elevates performance, making a significant impact in their field, or if it is coming to replace them in their jobs, too.



CASE STUDY—LEVERAGING AI FOR ICT DESIGN

Revit has established itself as the go-to design tool in the AEC community. It has become increasingly evident to ICT design professionals that working in Revit is no longer optional—it is essential for staying relevant and winning valuable projects in the industry. While there is a significant push to use this design platform, there are few tools built into the program specifically for ICT design. Because of this, design firms and individual designers often find themselves in a position where they must develop their own tools.

For this case study, we will explore using ChatGPT to create a plug-in to determine the best placement for wireless access points while considering the signal attenuation through different types of materials within a structure.

Part 1—Concept and Research

Starting out, a simple concept was developed (Figure 1). A dodecagon would form the basic boundary of coverage representing the maximum attenuation value acceptable for the given network configuration. Each spoke of this polygon was adjusted based on the depth of materials the spoke passed through, resulting in an irregular shape when placed within an active model. The length of the spokes would be calculated independently of one another and would account for the wall, door, and window materials where these spokes would intersect.

To calculate the necessary distance to subtract from the spokes when they intersected different materials, discussions with ChatGPT began. The overarching goal was to identify the most effective approach to account for signal loss across various materials. The first conversation centered around linking the R-value, which represented a material's insulation against heat transfer, with the signal loss encountered when transmitting through different wall types. The R-value is already incorporated into many wall assemblies. The question provided to ChatGPT was as follows: "How does the R-value of a material correlate to how well a radio wave can penetrate that material?" After some cursor blips on the screen, the team was given its answer.

Despite prior assumptions, ChatGPT confirmed that there was no correlation between a material's R-value and how that material blocked out radio signals. Because of this, a chart of values that the tool could reference to estimate the signal loss accurately had to be developed.

The conversation then shifted to a deeper look into the topic of permittivity and its impact on wireless signal propagation through different materials. Through a series of questions, ChatGPT was encouraged to familiarize itself with this crucial aspect. With the algorithm now well-versed in the subject matter, it was time to put its capabilities to the test. The updated request was to generate a series of charts that would serve as a valuable frame of reference for calculating the optimal lengths of the spokes. The verbiage used was as follows: "Generate a chart showing signal strength of various radio wave frequencies as they pass through common wall assemblies found in modern construction." This resulted in a chart detailing the various attenuation

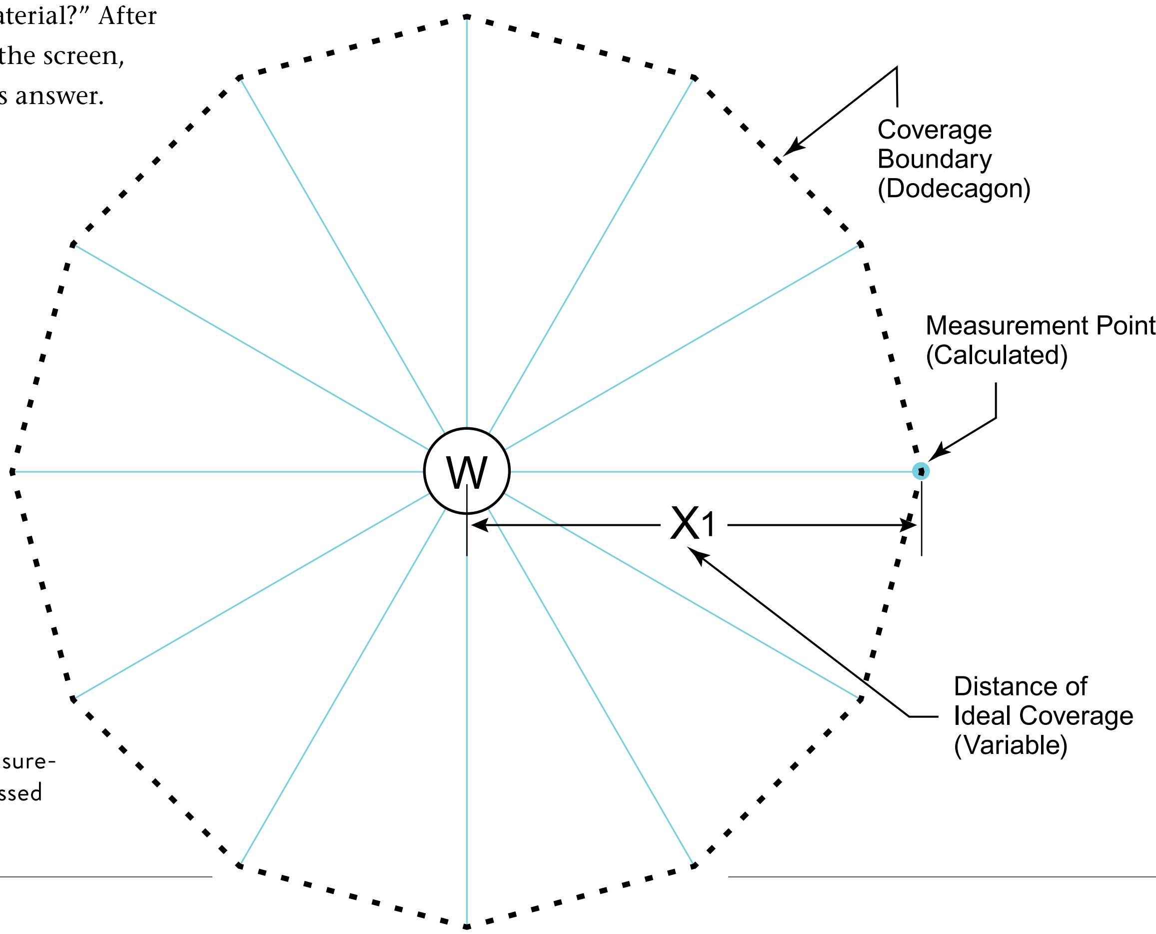


FIGURE 1: Depiction of a dodecagon and measurement points being discussed throughout the study.

levels for signals on the 900mhz, 2.4Ghz, and 5.8Ghz radio frequencies (Figure 2), accompanied by an explanation that it is a general chart, and achieving more detailed figures would vary based upon characteristics of the specific elements being transmitted through. Surprised by the program's user-friendliness, it was decided to continue to push the AI and explore its capabilities within Revit's visual programming tool Dynamo.

Wall Assembly	Frequency: 900 MHz	Frequency: 24 GHz	Frequency: 5.8 GHz
Standard Drywall	Low Attenuation	Moderate Attenuation	High Attenuation
Concrete	Moderate Attenuation	High Attenuation	High Attenuation
Brick	Moderate Attenuation	Moderate Attenuation	Moderate Attenuation
Glass	Low Attenuation	Low Attenuation	Moderate Attenuation
Wooden Studs	Low Attenuation	Low Attenuation	Moderate Attenuation
Metal Studs	High Attenuation	High Attenuation	High Attenuation
Insulated Panels	Moderate Attenuation	Moderate Attenuation	High Attenuation
Concrete with Rebar	High Attenuation	High Attenuation	High Attenuation

Note:

• Low Attenuation indicates minimal signal loss.

• Moderate Attenuation indicates moderate signal loss.

• High Attenuation indicates significant signal loss.

Please bear in mind that these values are generalizations and represent expected trends rather than precise measurements. The actual signal strength and attenuation can vary based on the specific characteristics and conditions of the construction materials and the radio wave frequencies involved.

FIGURE 2: Visualization of the AI-generated chart detailing the various attenuation levels for signals on the 900mhz, 2.4Ghz, and 5.8Ghz radio frequencies.

Part 2—Learning Together with AI

The next phase of the AI journey revealed a valuable lesson in navigating the program. As the AI was challenged with increasingly complex tasks, the significance of precise wording and concise instructions became clear (Figure 3). Through the ongoing conversations, it became clear that individuals with advanced coding experience and high proficiency in Dynamo would be able to complete the next step more efficiently.

CA write me a dynamo that creates a polygon with 6 sides

CA write me a dynamo script that creates a polygon with 6 sides where each point on the polygon has an adjustable length to the center of the polygon

CA write me a dynamo script that creates a polygon with 6 sides where each point on the polygon has an adjustable length to the center of the polygon independent of the other points

CA write me a dynamo script that creates a polygon with 6 sides where each point on the polygon has an adjustable length to the center of the polygon independent of the other points. Then tell me how to have revit use this dynamo script as if i've never used dynamo before.

FIGURE 3: Transcript of a discussion with an AI program through ChatGPT showcasing the steps taken to reach the desired response.

Previous research pointed toward starting with a simple request and building upon its instructions with each iteration of code. To begin, the AI was asked for a script to create a polygon. Then, building upon that script, the AI was asked for a polygon with adjustable spoke lengths built into it until the program could dependably generate an irregular polygon where the AI could specify the distance between the polygon's center and each of the spokes. From here, the AI was asked to generate the code for calculating each of the spoke distances to eventually create the wireless access coverage polygon (Figure 4).

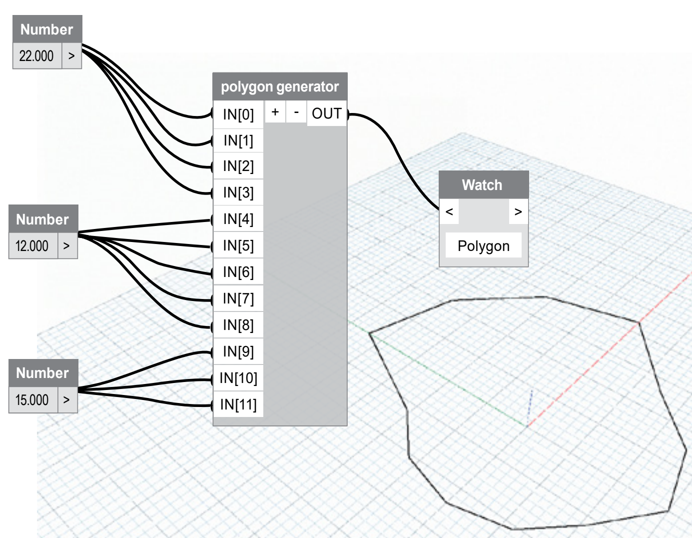


FIGURE 4: Depiction of a polygon generator within Dynamo with customizable spoke distances.

As the interactions continued to evolve, ChatGPT became well-acquainted with the information being provided. When code was requested, the AI provided the raw code block for a Python script and generated a concise explanation of how to incorporate the code into Dynamo. What is even more impressive is that the AI added comments within the code, providing insights into the purpose of specific lines of code. This enhanced level of customization resulted from the AI incorporating previous feedback and learning to cater to the team's specific needs. Throughout this exercise, it became increasingly evident that communication was evolving, and the more the model was engaged with, the more it adapted and tailored its responses to the ongoing collaboration.

Part 3—Pulling It All Together

Assuming the role of someone new to the aforementioned programs, more research was needed to successfully complete the case study and validate the process. In lieu of turning to Google, YouTube, and other online resources, ChatGPT was utilized to provide this information.

Using ChatGPT was quicker with assistance, debugging code, and discovering different methods to access and execute scripts within Revit. Throughout this process, the model responded as if the two were having a conversation—adapting and adjusting along the way. While this malleability was generally beneficial, there were moments when the AI had to be firmly directed back on track to achieve the desired results. To do this, instructions were fine-tuned and provided specific details of the desired result.

If a piece of code developed from ChatGPT generated an error code within Dynamo, the AI could reevaluate the code it had previously created, acknowledge its mistakes, and propose revised solutions. This interactive process proved invaluable in the process of debugging the code block and accelerating the implementation phase. The dynamic back-and-forth between Dynamo, its error codes, and ChatGPT enhanced the user's ability to identify and resolve issues efficiently (Figure 5). The process was comparable to having an active, in-person collaborator who learned from their mistakes and adapted their responses based on real-time feedback and discussion.

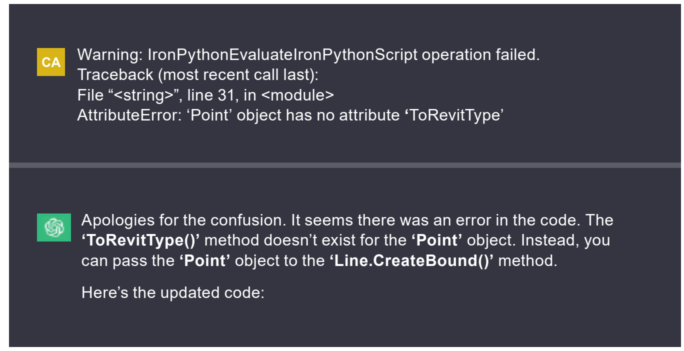


FIGURE 5: Depiction of the ChatGPT AI program providing solutions to program errors as a result of previously provided coding.

Nearing the finish line, it became more apparent that the abilities of the ChatGPT model and its capability to write code that could interact with Revit directly only went so far. However, taking a step back, breaking down each segment of the code into pieces, and beginning to build a more complex Dynamo graph, things started to gain traction. Once again, very specific prompts were given to ChatGPT, but for this iteration, the goals of each code module were very narrow in scope and compartmentalized the process. This approach finally began to yield results within the model view of the Revit model, and this is where it was decided to halt this exercise.

Part 4—Next Steps and Lessons Learned

Throughout the writing process, the code continued to be fine-tuned to refine this tool for full deployment. As a deeper understanding of ChatGPT's limitations was gained, exploring other AI models specifically designed for code authoring was a logical next step. These models may offer greater efficiency in code writing and debugging tasks, which were essential for this exercise. One significant realization throughout this process is that ChatGPT is not a universal solution for problem-solving. However, it serves as a valuable tool for delving into new subjects and sharpening long-unused skills. It is like having an additional resource in your toolkit, ready to assist in the exploration and skill development journey.

SUMMARY

The rise of AI has sparked intense debates in several industries regarding the potential ethical implications and fear of job displacement. Writers for television and film, authors, and technical writers have expressed their concerns about roles being threatened by ongoing technological advancements. The field of generative design is not free of scrutiny either, as programs are being trained to mimic the artistic styles of animators and CGI artists on YouTube who showcase their techniques for animating live-action clips in video form. However, it is the team's opinion that in the ICT design industry, these ethical concerns seem to be absent. The demand for ICT design experts continues to soar, surpassing the number of professionals entering the field. This high demand, coupled with the ever-increasing complexity of the systems we design, ensures a robust market for ICT design professionals.

Text-based chatbots like ChatGPT can significantly enhance users' ability to quickly find relevant information and offer custom tool creation for problem-solving. Nonetheless, using AI effectively requires time and training for both users and the AI models themselves.

In a recent incident, a law firm used ChatGPT and cited non-existent cases in a briefing. This instance highlights the importance of properly training AI models, as an improperly trained model could make major mistakes. It became evident during this exercise that not only do the words used in communicating with the AI model matter, but the implied tone also plays a role. While generative design programs can manipulate images, the ICT design process encompasses much more than symbols on architectural plans.

Looking ahead, artificial intelligence models will have the chance to evolve into essential tools, similar to Excel and Revit, and failing to embrace their use would put both firms and individuals at a significant disadvantage.

At the end of this exercise, the team concluded that as of today, AI poses no threats to taking the position of human ICT designers. It is also important to note that AI models, like text-based chatbots like ChatGPT, need proper training on both the AI and the user's behalf to best utilize the program. As we look to the future, AI models are setting their sights on becoming indispensable tools, empowering ICT designers to thrive in an increasingly complex and demanding landscape. Still think you can spot AI-generated design and writing? The title of this article was generated using ChatGPT.

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Carlos Pagan is an IT and telecom designer at BrightTree Studios with more than 15 years of experience in the ICT design industry. Since beginning his career, Carlos has gone on to earn his RCDD and, in addition to his experience with BrightTree Studios, Carlos's designs have supported millions of square feet of high-end space in transportation and education markets. His experience has equipped him with industry-leading know-how, including network electronics and structured cabling. He can be reached at cpagan@brighttreestudios.com.

The Case for MULTICAST in Smart Buildings

By Akram Khalis

As the number of internet of things (IoT) sensors and devices grows, it is imperative that technology developers think strategically about how these devices communicate. To achieve optimal reliability, efficiency, and scalability of smart-building investments, engineers must consider not only the infrastructure challenges of today but also those of tomorrow—when 17 billion endpoints easily could become 17 trillion.

Multicast routing is among the most effective solutions (Figure 1). The protocol has the potential to accelerate the impact of smart buildings across a range of outcomes, including:

- Preserving bandwidth
- Enhancing user experiences
- Improving security
- Achieving sustainability

Advocating for multicast does not necessitate the diminishment of other communication protocols. Unicast and broadcast, for example, are each effective in defined use cases. Multicast, however, is the optimal protocol for iterative smart buildings, specifically those with owners who intend to continuously improve their properties alongside fast-advancing IoT solutions.

FIGURE 1: Multicast network topology grouping allows for floor-by-floor or even room-by-room configuration in smart buildings. This enhances the user experience, improves security, preserves bandwidth, and achieves sustainability.

Because one source sends data to multiple interested recipient devices simultaneously, multicast excels at efficiency. The reduction of network load and congestion, not to mention the enhanced security that comes from selective transmission, makes the protocol a highly reliable and scalable alternative for larger, enterprise-level networks.

NETWORK COMPLEXITY IS SECOND NATURE FOR MANY

The ICT space is, of course, familiar with multicast. It is commonly found powering low-voltage systems, such as voice over internet protocol (VoIP), internet protocol (IP) cameras, and closed-circuit communication platforms. Today, however, the smart building ecosystem brings many more devices to the table for the deployment of multicast. This includes lighting, every building's highest-density component. The opportunity for ICT to now "own" lighting could be perceived as overly burdensome; it could also be seen as potentially empowering, given the opportunity to further demonstrate the power of connectivity.

Because of the familiarity with the protocol, many of the perceived challenges around the network complexity of multicast may have been solved thanks to fully functioning—or, minimally, fully replicable—networking infrastructures already in place.

That said, there are some design and installation considerations ICT pros will want to think through and plan for. These include bandwidth requirements, network topology, device grouping, system agility, and cybersecurity.

BANDWIDTH REQUIREMENTS

Multicast technology can be a strategic asset in addressing bandwidth requirements in smart buildings. By enabling the simultaneous delivery of information to multiple endpoints, multicast conserves bandwidth. This is particularly true for internet of things (IoT) environments with devices that frequently require the same data—such as updates, streaming video, or real-time analytics. By sending a single stream of data that all devices subscribe to, multicast reduces the network load. The approach ensures that bandwidth is used more efficiently and is available for critical tasks, leading to improved overall network performance.

The ability to throttle equipment is important. The goal is to enable high speeds only when necessary and dial those speeds back when they are not needed. Lighting platforms are not configured for optical fiber cables. But access points and cameras are because they need to send large volumes of data at high speeds.

We can now transmit at a high speed, but it does not mean we want to send data back upstream again. We want it to be on edge, which means that the infrastructure needs to support it. With multicast, you are basically doing everything on-premise.

NETWORK TOPOLOGY

Multicast groups can be configured however the smart building's networking team desires. Maybe it is floor-by-floor, or maybe it is room-by-room. The idea is to eliminate the need for IoT devices to decipher whether a particular message is intended for them. Such unnecessary filtering creates latency.

Regardless of the layout, multicast needs Layer 3 network topology at a minimum to function properly.

When it comes to topology design, ICT professionals should consider two best practices: avoiding overcomplication and carving out time for validation. For example, one multicast group per zone is a best practice for preventing unnecessary complexity. Validation is similarly important. Once a multicast grouping is deployed, it is important for the team to take the time to evaluate the results. Are they what you expected, or do you need to make changes?

With the democratization of artificial intelligence (AI), testing and validating are becoming much simpler and more automated. Generative AI is also making it much less complicated for stakeholders with varying degrees of technical skill to use these tools. A user could, for instance, tell a GenAI multicast design program to create the ideal grouping for a building with 400 lights, 300 shades, 20 HVAC systems, and 40 conference rooms. The user could then direct the program to validate the configuration after deployment.

DEVICE GROUPING

Within a multicast framework, devices subscribe to a single group. They are connected, which means the network itself, rather than an outside routing mechanism, is doing the job.

Device grouping allows a set of devices to be addressed all at once. In the context of smart buildings, this means that instructions or data can be sent to multiple IoT devices simultaneously rather than individually. This approach not only enhances the efficiency of the network by reducing the number of messages that need to be sent, but it also conserves bandwidth, as a single data packet can serve multiple devices. It is particularly useful for applications like software updates, audio/video streaming, or synchronizing settings across a system of devices, ensuring that all devices receive the same data simultaneously.

When it comes to determining device grouping, it is best to start with a good control narrative developed by process engineers in close collaboration with contractors and designers. What is the sequence of operation that will create the best user experience? ICT pros can then use that control narrative to define nodes, optimize them, and then logically separate them based on functionality. If devices do not need to talk to each other, they do not need to be in the same group.

That said, devices that do not need to communicate today may need to tomorrow. This is again where multicast is beneficial. The protocol is ideal for iterative smart buildings with owners who intend to continuously improve their properties alongside fast-advancing IoT solutions.

SYSTEM AGILITY

In multicast networking, system agility refers to the network's ability to easily adapt to changes, such as adding new devices or enabling communication between previously disconnected devices. This flexibility is crucial in dynamic environments like smart buildings, where the network landscape is continually evolving with the addition of new IoT devices and systems.

Multicast allows these changes to be made with minimal effort—often just a simple configuration change that tells the device which multicast group it belongs to.

The network then automatically incorporates this device into the group communication streams, ensuring seamless integration and communication without the need for complex reconfiguration or manual intervention.

When a new device is added or when two legacy devices that did not talk now need to, it is a simple logical movement that tells the device it now belongs to a new group. You are simply changing a network configuration, and the network automatically adjusts going forward.

CYBERSECURITY

Multicast goes a step further than virtual local area network (VLAN), which was created to virtually separate or segment multiple silos. It allows devices to cross-communicate, but in a smaller group. It also reduces complexity. VLAN logical segmentation can get difficult. What is more, VLAN only scales horizontally.

Tagging devices for a particular multicast group communication restricts other devices and their components from talking to those outside the group. This is a nightmare for cyber intruders who typically enter a system through the path of least resistance and then jump from one endpoint to another, seeing how far into the network they can get … and how much data or control they can steal along the way.

In a multicast environment, several cybersecurity considerations should be solved during the design and installation phase. These include:

- **Secure Multicast Protocols:** Implement protocols that support secure multicast transmission, like internet protocol security (IPsec) for encryption.

- **Authentication of Multicast Sources:** Ensure the source of multicast streams is authenticated to prevent spoofing.

- **Group Key Management:** Develop a robust key management system for encrypting multicast traffic, ensuring only authorized devices can join the multicast group.

- **Multicast Traffic Control:** Control multicast traffic at the network level to prevent unauthorized access and ensure that only legitimate multicast data is transmitted.

- **Network Resilience Planning:** Plan for network resilience to ensure the stability of multicast streams against distributed denial of service (DDoS) attacks.

- **Security Policy Compliance:** Ensure that the multicast design complies with relevant security policies and standards, such as those provided by the National Institute of Standards and Technology (NIST).

- **Device Hardening:** Harden IoT devices against attacks by disabling unnecessary services and securing configuration settings.

- **Logging and Monitoring:** Implement comprehensive logging and monitoring strategies for multicast traffic to quickly detect and respond to potential security incidents.

SMART BUILDING PROJECTS BEGIN IN THE MINDS OF TECHNOLOGISTS

The most effective multicast integrations will come as a result of building projects with a master systems integrator (MSI) contributing from the outset. This practice aligns with a foundational shift in the holistic design of smart buildings. Whereas yesterday's blueprints often began in the minds and AutoCAD modules of architects, many of today's innovative building projects are beginning with technologists.

The most successful builds start with networking IT professionals who map out the nodes, switches, and protocols necessary for optimal performance of all things "smart." This initial step empowers architects and other designers to bring a big vision to life without compromising the efficacy of a client's investment in intelligent spaces.

In the fall of 2022, Chuck Wilson, the CEO of National Systems Contractors (NSCA), wrote about the emerging market need for MSIs: "… there will likely come a time when building owners will have so many systems that they want to work with one company that can take sole responsibility for them all."[1]

Mr. Wilson was correct. That time is now. Multicast is but a single example of the innovations these experts will inject into the field, vastly accelerating the reliability, efficiency, and scalability stakeholders expect when they set up a smart building.

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Akram "AK" Khalis is CEO of MHT Technologies, a smart building technology firm based in New York, and co-founder of MHT's flagship product, Inspextor. AK led the development of Inspextor's advanced smart building automation platform, which is built on a Power-over-Ethernet (PoE) structured cabling backbone. He is also a member of the PoE Consortium. AK can be reached at ak@mht-technologies.com.

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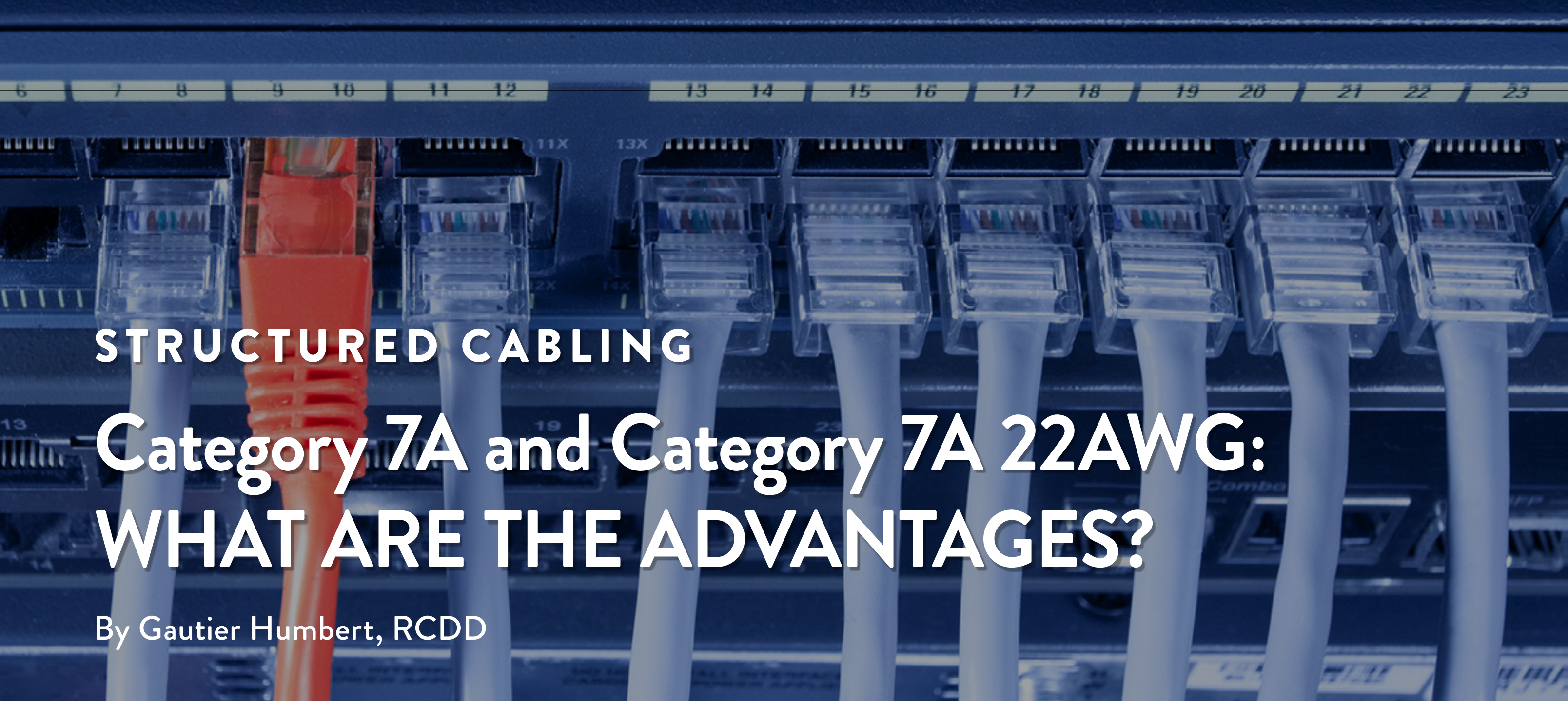

STRUCTURED CABLING

Category 7A and Category 7A 22AWG: WHAT ARE THE ADVANTAGES?

By Gautier Humbert, RCDD

PREAMBLE

Let us start by understanding some differences in the standards. Although standards treating the same subject in various areas of the world try to harmonize, there can be some differences. Categories 7 and 7_A are part of those differences.

The ISO/IEC 11801 series is the international standard relevant to structured cabling. The ANSI/TIA 568 series is a North American equivalent, and the committees responsible for the two coordinate together. But Categories 7 and 7_A represent a point of disagreement. They exist in the international documents but not in the North American documents.

So, to the question, "Do they exist in the standards?" the answer depends on what standard is being referred to.

HISTORY

To understand Category 7_A, it is important to start with a bit of history of the categories. This description, unless specified, refers to the ISO/IEC 11801 series.

The complete chronology is shown in the diagram below (Figure 1).

The starting point is Category 5, ratified in 1991, which evolved into Category 5e[1] in 1999 to support Gigabit Ethernet.[2] This was the first time that all four pairs were used in the cables, and each was used for

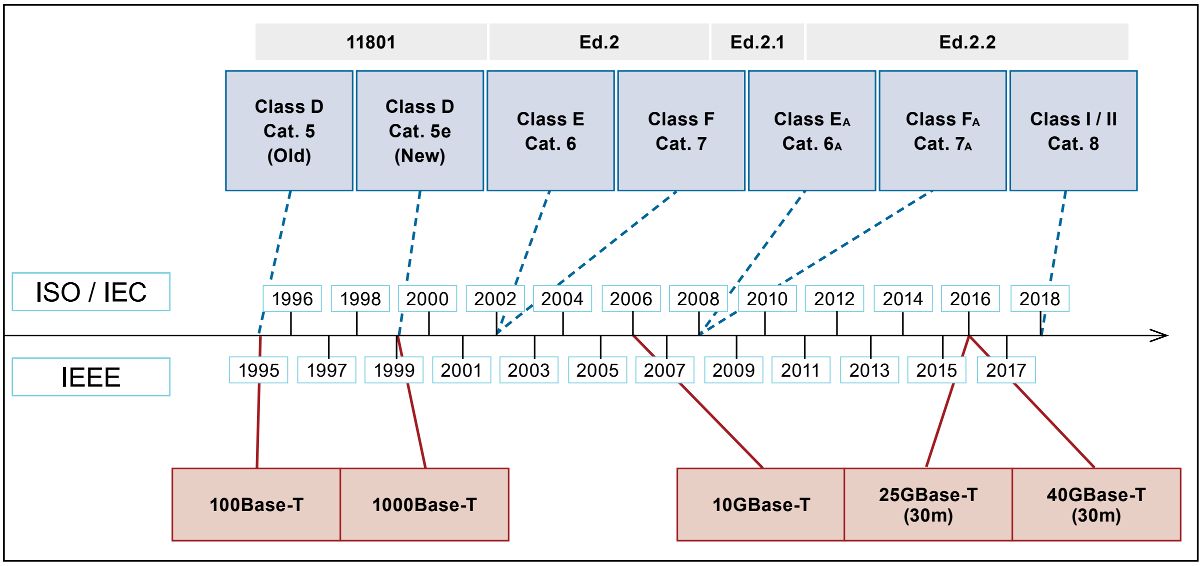

FIGURE 1: Chronology of categories and classes.

sending and receiving transmissions simultaneously. Because of this technological leap, the network interface cards (NICs) were quite expensive compared to fast Ethernet 100Mbps.

In 2002, Category 6 was invented to allow the use of theoretically lower-cost gigabit[3] NICs. By doubling the frequency bandwidth available, it allowed doubling the data rate per pair, hence sending on two pairs and receiving on two pairs. The use of specific duplex technology on a single pair was, therefore, not needed.

At the same time, Category 7[4] was ratified and planned for a future 10Gbps data rate. It was assumed that defining the system up to 600MHz would be sufficient for this yet nonexistent application. But at the time, the technology did not exist for producing the following components at that frequency:

- Unshielded Cables: Hence, the mandatory S/FTP construction.
- RJ45[5] Connectors: Alternative non-interoperable connectors were proposed.

Ratified in 2006, 10 gigabit Ethernet[6] was ensured to work on (future) Class E_A, F, and (future) FA.

Classes correspond to the system (permanent link or channel), while the categories apply to components. A class must always be composed of the corresponding category components or better. The figure below shows all existing, starting with Category 5e (Figure 2).

System: Class	D	E	EA	F	FA	I	II
Components: Category	5 (5e)	6	6_A	7	7_A	8.1	8.2

FIGURE 2: Categories versus classes.

In 2008, thanks to improved technology, Category 6_A was ratified with both shielded and unshielded options using the universal "RJ45" connector. This meant that all active equipment manufacturers adopted the "RJ45" connector for their 10 gigabit NICs.

FOOTNOTES:

1. To be precise, the Category 5 components were renamed Category 5e in North American TIA documents, while in international ISO/IEC documents, the connectors kept the Category 5 terminology with new performance, only the cables changing terminology.

2. Gigabit Ethernet on Category 5e is IEEE 802.3ab 1000Base-T. It operates at a frequency generally defined as 77MHz.

3. Gigabit designed specifically for Category 6 was 1000Base-TX. It operated theoretically around 150MHz but never appeared on the market as higher volume allowed lower cost on the 1000Base-T NICs for Category 5e. In fact, it was never part of the IEEE 802.3 document and only existed on paper in the TIA-854 standard.

4. Category 7 was ratified in ISO/IEC standards but not in the North American standards ANSI/TIA. The same applies to Category 7_A.

5. RJ45 is the common but incorrect name. The term used in North American standards is 8P8C (8 position 8 contacts), while the name used in international documents is modular connector. For ease of comprehension, the term "RJ45" is used in this document.

6. 10 gigabit Ethernet was ratified as IEEE 802.3 and 10Gbase-T.

The result is that the market lost interest in Category 7 because of the need for specific connectors. Hence, Category 7_A[7] was ratified, using the same specific connectors at the highest possible frequency available at the time: 1000MHz.

Then appeared Category 8[8] in 2018, for 25Gbps and 40Gbps.[9]

DATA RATE

The first question concerning Class F_A/Category 7_A is the data rate: does it allow more than Class E_A/Category 6_A?

As mentioned before, Class F and Class F_A provide the same 10 gigabit performance as Class E_A, at least in theory. But the class must use all components of the same category or better, and as of today, no switch or end device has NICs using connectors other than the "RJ45." This means that in reality, Class F and Class F_A provide no data rate at all since, in order to connect, a Class F_A permanent link must use patch cords with RJ45 connectors at the ends, hence creating a Class E_A channel at best.

As for higher data rates, there has been an ISO/IEC TR 11801-9905 document explaining if 25Gbase-T could function on existing cabling other than Category 8 (Classes I and II).

This document clarifies on-site tests, such as re-certification up to 1250MHz and the dreaded time-consuming "Alien-NEXT" test, but also the lab test for coupling attenuation.

While theoretically possible, these are very impractical, especially knowing that, at best, the maximum reach would be 30 m (≈98.4 ft), far from the 90 m (≈295.3 ft) limit used in traditional LAN cabling.

This document also includes a clause stating: *"Component requirements are not provided in this document and should not be inferred from the channel limits provided."* This means that a manufacturer cannot use this document to promise that a cable or a connector other than Category 8.1 or 8.2 can guarantee 25Gbase-T.

In conclusion of this part, Class FA/Category 7_A does not provide any improved data rate compared to Class EA/Category 6_A (Figure 3).

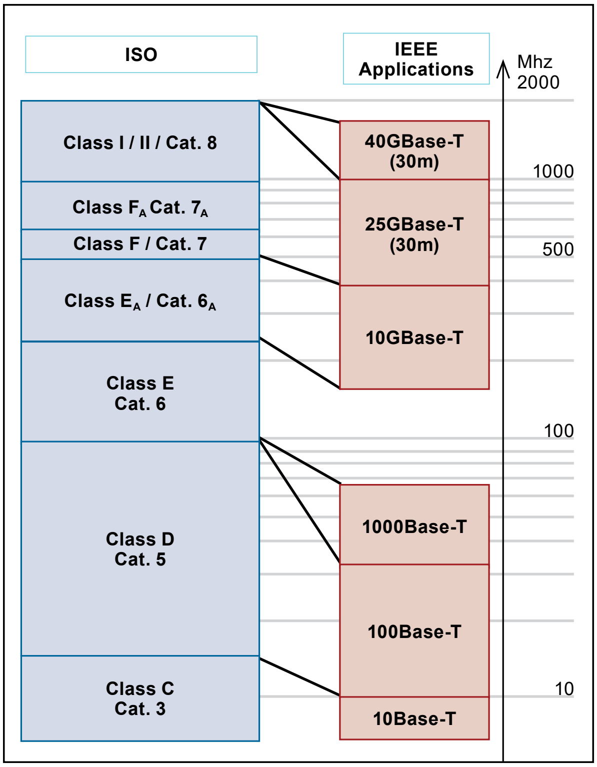

FIGURE 3: Applications according to category.

FOOTNOTES:

7. Category 7_A was created as an upgrade of Category 7, intended to support a future 25Gbps or 40Gbps data rate, if possible. History, as explained later in the document, has shown that these data rates require a minimum Category 8.

8. Category 8 is the term in TIA documents. In ISO/IEC, there are two versions: Class I, composed of Category 8.1 components with RJ45 connectors, and Class II, composed of Category 8.2 components with alternative connectors similar to those used in Categories 7 and 7_A. These Classes I and II are not incrementing the previous C to FA because they are limited to 30 m (≈98.43 ft) for data centers, rather than the traditional 100 m (≈328 ft) for LAN.

9. These are IEEE 802.3bq 25Gbase-T and 40Gbase-T.

SEGREGATION

Segregation is the term used for the minimum separation required between electrical cables and data cables. It depends on the type of cable tray used and the total current in the power cables (Figure 4).

The values for segregation are found in the installation standard ISO/IEC 14763-2, but these show the distance when either data or power cables are in a metal cable tray. The formula to recalculate with two cable trays using their respective shielding efficiencies is found in EN TS 60659.

Figure 5 shows the segregation difference for Category 6_A and Category 7_A when there are 13 to 15 electrical circuits of a maximum 20Amp each.[10]

While it is true that Category 7_A does have a significant improvement over Category 6_A when only looking at numbers, it is important to recognize that these values are in millimeters and, therefore, roughly the thickness of the cable trays.

The reality is that power and data cable trays are generally separated by approximately 20 cm (≈7.87 in), in which case the improvement provided by Category 7_A is irrelevant (Figure 6).

Cable Type	2 Trays, Type Wiremesh	2 Trays, Type Perforated
Category 6_A Shielded	28 mm (≈1.1 in)	13 mm (≈.51 in)
Category 7_A	6 mm (≈.24 in)	3 mm (≈.12 in)

FIGURE 5: Segregation for categories 6_A and 7_A when both power and data are in metal cable trays, and power is composed of 13 to 15 circuits of a maximum of 20 Amp each.

PoE HEATING

Power over Ethernet (PoE) heating refers to the heat created when sending a current in a cable with a certain resistance according to the formula: $P = RI^2$.[11]

Compared to Category 6_A, Category 7_A cables offer no advantage if they have the same conductor size, usually 23AWG.[12] However, some 22AWG Category 7_A cables exist on the market. Higher conductor size means less resistance and, therefore, less heating. This has an influence on the number of cables in a bundle and the maximum distance allowed for the channels.

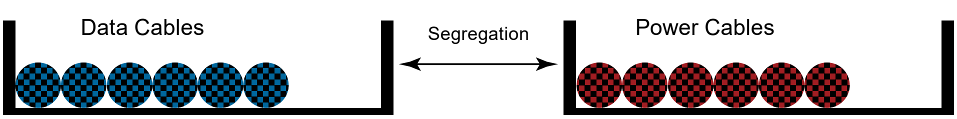

FIGURE 4: Segregation of power and data.

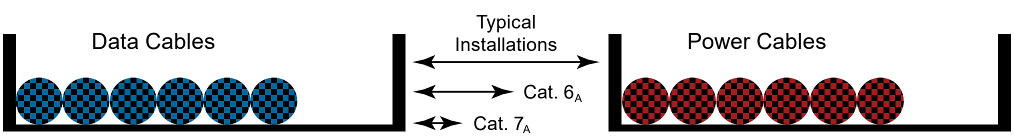

FIGURE 6: Segregation comparison of typical installation and categories.

FOOTNOTES:

10. The distances are calculated assuming that Category 6_A cables are only segregation classification "c," while they could be "d," and that Category 7_A is segregation classification "d," reflecting the majority of products in the market but not required in ISO/IEC 11801 series. (Theoretically, Category 6_A cables superior to Category 7_A could exist.) The segregation using a different number of electrical cables can be obtained using the power cabling factor in Table 13 of ISO/IEC 14763-2: 2019.

11. P = heat, R = resistance, I = current.

12. AWG is widely used in marketing documents rather than the official millimeter measurements in the standards. 22 AWG is roughly 0.64 mm (≈.03 in) conductor section, while 23 AWG is roughly 0.57 mm (≈.02 in).

Number of Bundles of 24 Cables	1	2	3	4	5	6
Total number of cables	24	48	72	96	120	144
T° Increase (°C) for Cat.7_A 23AWG	3.24	4.94	6.07	6.94	7.65	8.27
T° Increase (°C) for Cat7_A. 22AWG	2.74	4.18	5.14	5.87	6.47	7.00
Difference (°C)	0.50	0.76	0.93	1.07	1.18	1.27

FIGURE 7: Difference of heat increase between 23 AWG and 22 AWG cables according to ISO/IEC 14763-2.

This is directly linked to the Category RP3[13] defined in the ISO/IEC 14763-2, which requires compliance with the two following points:

- The channel temperature cannot exceed 60°C (≈140°F).
- The maximum allowed channel and permanent link lengths must be recalculated according to the estimated temperature.[14]

Assuming there are bundles of 24 cables, all laid next to each other without separation in a perforated cable tray, the following figure provides the temperature increases[15] for RP3 compliance (Figure 7).

The temperature can then be used to obtain the maximum lengths. The difference in maximum distance between the 23 AWG and the 22AWG is approximately 20 cm (≈ 7.87 in).[16] Considering that the field length measurement is only precise to 4 m (≈ 13.12 ft),[17] this improvement is, therefore, negligible.

PoE EFFECTIVENESS

PoE effectiveness refers to the ability of a cable to deliver power with minimal loss. Once again, the larger the conductor, the lower the resistance and the more efficient the cable. For the same reasons as the previous case, Category 7_A cables offer no advantage compared to Category 6_A with similar conductor size, but 22AWG Category 7_A will have improved efficiency over 23AWG.

FOOTNOTES:

13. RP3 (Remote Powering 3) is a category of installed cabling that ensures that any device connected to the cabling can be remotely powered to maximum 500mA per conductor without risk of disconnection of itself or other devices due to overheating of the cables. RP3 is a requirement for compliance with the ISO/IEC 11801 series. Noncompliance means that administration is required before the connection of any PoE device to the network.

14. The commonly used 90 m (≈295.23 ft) and 100 m (≈328.08 ft) for respective permanent link and channel are defined at 20°C (68°F). Higher temperature implies higher resistance and, therefore, shorter links.

15. These are calculated with Tables 19 and 20 in the ISO/IEC 14763-2:2019 standard using typical 65Ω/m resistance for 23 AWG cables and 55Ω/m resistance 22 AWG cables, and for 500mA per conductor.

16. Table 18 of ISO/IEC 14763-2: 2019 only has increments of 5°C (41°F). Calculations were made using Table 3 of ISO/IEC 11801-1:2017 with cable temperature 40°C (104°F), minus 1.5°C (34.7°F) for the 22AWG.

17. See Table 18 of IEC 61935-1:2019, where length accuracy is ± (1 m [3.28 ft] + 4 percent). For a 90 m (≈295.28) permanent link, this is ± 4.6 m (≈15.09 ft).

Below is a table of the PoE types and the PoE classes (Figure 8).

The maximum current per conductor varies according to the PoE types. It is important to consider, once again, that the formula $P = RI^2$ corresponds to the power transformed into heat in the conductor and is, therefore, lost in the point of view of efficiency.

The figure below shows the efficiency improvement of using 22AWG instead of 23AWG for various typical types of PoE using a permanent link of 90 m (≈29.52 ft) (Figure 9).[18]

However, the 90 m (≈29.52 ft) permanent link is the maximum allowed, while in general, projects have around 45 m (≈147.64 ft) average lengths.[19] The figure below shows the same results in this case (Figure 10).

PoE Power Over Ethernet Simplify Technical Sheet	802.3bt							
	Type 3						Type 4	
	802.3at							
	802.3af Type 1			Type 2				
Classe of (Power Sourcing Equipment - PSE)	Class 1	Class 2	Class 3	Class 4	Class 5	Class 6	Class 7	Class 8
Max Power at PSE	4 W	7 W	15.4 W	30 W	45 W	60 W	75 W	90 W
Minimum Power at PoE Device	3.84 W	6.49 W	13 W	25.5 W	40 W	51 W	62 W	71.3 W
Number of Pairs Used	over 2 pairs		over 2 or 4 pairs		over 4 pairs			

FIGURE 8: PoE types and classes.

PoE Type	Type 1	Type 2	Type 3	Type 4
Power (W)	15	30	60	90
Current (A)/Conductor	0.15	0.3	0.3	0.45
PoE Pairs	2	2	4	4
Efficiency improvement of 22 over 23AWG	0.6%	1.3%	1.3%	1.9%

FIGURE 9: PoE efficiency improvement of 22AWG over 23AWG for channels using 90 m (≈29.52 ft) permanent links.

PoE Type	Type 1	Type 2	Type 3	Type 4
Power (W)	15	30	60	90
Current (A)/Conductor	0.15	0.3	0.3	0.45
PoE Pairs	2	2	4	4
Efficiency Improvement of 22 over 23AWG	0.3%	0.6%	0.6%	1.0%

FIGURE 10: PoE efficiency improvement of 22AWG over 23AWG for channels using 45 m (147.64 ft) permanent links.

FOOTNOTES:

18. The actual values used include the resistance of connectors and 10 m (≈32.8 ft) of patch cord to reflect the 100 m (≈328.1 ft) channel loss. Only the typical most representative currents are used. Other variations exist. DC Loop resistance used reflects real products and not standards limits (128Ω/km for AWG22 and 152 Ω/km for AWG23). Efficiency is the ratio of the power available to the end device (PD) compared to the total power sent by the emitter (PSE). Improvement of efficiency is the difference between that of 23AWG and of 22AWG.

19. The 45 m (≈147.64 ft) average is obtained from project test results submitted in warranty requests.

Considering typical office space usage, such as described in the figure below, and understanding that devices are often idle or not consuming the maximum power, the estimated improved efficiency of 22AWG compared to 23AWG is lower than 0.5 percent (Figure 11).[20]

Outlet Usage	Percent of Outlets	PoE Type	Percent Usage of Maximum Power
Computer/Printer	30%	None	N/A
IP Phone	30%	1	10%
CCTV/WiFi	5%	3	50%
CCTV/WiFi	5%	4	50%
Not in Service	30%	None	N/A

FIGURE 11: Estimation of typical usage of PoE in an office space.

Unless the project concerns cabling for full PoE Type 4 90W for all outlets, such as PoE lighting, the 22AWG does not provide any significant improvement over 23AWG cabling.

CONCLUSION

Class F_A/Category 7_A systems do not offer any improved data rate over Class E_A/Category 6_A.

The Category 7_A cables may have an improved segregation class compared to Category 6_A, but in typical projects, this does not translate into benefits.

The lower resistance of specific 22AWG Category 7_A provides a small improvement in heating while under PoE, but this does not translate into any measurable distance improvement for RP3 compliance. While it also does provide an energy efficiency benefit, it is extremely limited, generally lower than 1 percent.

On the other hand, Category 7_A cables, because of their S/FTP construction, use more material and are heavier than Category 6_A F/UTP or U/FTP cables, while the 22AWG versions can require 35 percent more copper than the 23AWG versions.[21]

Therefore, in most projects, the use of Category 7_A 23AWG or Category 7_A 22 AWG generally provides few benefits while having a significantly greater negative impact on the environment.

It is, therefore, important to reserve those cables for very specific uses.

AFTERWORD

What about 22AWG Category 5e?

The same conclusions apply to this cable as to the 22AWG Category 7_A cable: it should be reserved for specific uses, which is exactly the intent of this product. It is designed for low data, high power applications such as PoE lighting, not for generic cabling for commercial buildings where Category 6 is the minimal requirement. So, the conclusions of this white paper do not contradict the market need for a 22AWG Category 5e for the applications it is intended for.

AUTHOR BIOGRAPHY:

Gautier Humbert, RCDD, has been in the industry for more than 20 years, with experience throughout the world. He is currently the standards coordinator for digital infrastructures and participates in multiple international and European committees. In particular, he is on the ISO/IEC JTC 1 SC25 WG3 group responsible for the 11801 series and is the current chair of the CENELEC TC215 WG2 group responsible for the European installation standards. He received the BICSI European Member of the Year Award in 2012 and the BICSI Global Member of the Year Award in 2020. He has also been the BICSI EMEA region director from 2021 to 2023.

FOOTNOTES:

20. Project efficiency improvement is the sum of the values of the previous table multiplied by the coefficients in this table.

21. Based on product datasheets. Figures used were 26 kg/100 m (≈328.01 ft) for 23AWG and 35 kg/100 m (≈328.01 ft) for 22AWG.

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YOUR **BUILDING** HAS A STORY TO TELL:

Let AI Narrate It

By Lauren Long

OUR LIVES ARE LIVED INDOORS

According to the United States Environmental Protection Agency, today's Americans spend approximately 90 percent of their lives indoors. Whether at home, at work, or during play, this statistic clearly explains why buildings are important to us. Beyond obvious reasons for comfort, convenience, and protection, buildings are not always an intelligent place to be. Fortunately, the technology to make buildings into better, smarter facilities exists; we just need to put it into action.

SMART BUILDINGS AND ICT

Buildings become smart because of data coming from a network of technologies. The amount of data created each day is accelerating as more technology is connected and begins tracking its intended source. From individual sensors like Fitbits and Apple watches to community-centric sensors, buildings are a wealth of knowledge. Here are a few ICT sources that support the foundation of AI-powered buildings and, eventually, cities:

- **BMS**—Building Management Systems are a central monitoring system for buildings. They integrate information from various building systems like HVAC and more, based on the individual building.

- **Occupancy**—How many people are inside and where they are within a building is valuable information. By understanding this, buildings can activate occupied environments without wasting energy and money on spaces that are empty. Occupancy can be measured through a variety of ways such as traditional turnstiles or by people-counting sensors installed over entranceways or via Wi-Fi. The more detailed occupancy information is, the more a building can improve how it operates because of it.

- **Lighting—**Automatic lighting can be connected to a network to share knowledge if a space is occupied or vacant. Beyond reducing expenses by lighting empty rooms, lights can also become more intelligent by changing intensity based on the time of day and the direction the windows face. For example, south-facing rooms with large windows likely do not need artificial lighting during the day and may, in fact, require shades to reduce light glare and associated heat.

- **Weather—**By knowing the predicted temperatures and other weather characteristics for the day, buildings can operate in a prepared manner. Say the temperatures are higher than normal, buildings can expect to use more energy to cool the space and change when they start to condition the building, or they may utilize more shade via blinds than usual for that time period.

- **Transit—**As buildings become more aware of what is going on within them, knowledge of what is going on outside matters, too. By connecting buildings with outside transit and traffic information, buildings could schedule an elevator for occupants to use to make sure they reach their train on time.

- This is just the beginning. Every day, new ICT elements are added to the pool buildings can use to make themselves smarter, leading to smart cities.

SMART BUILDINGS ARE NOT STANDARDIZED

The term "smart building" has existed for years, yet a concise definition has yet to exist. Buildings are snowflakes; each one is unquestionably unique from others due to operational technology, geographic location, materials used during construction, individual wear and tear, and more. Because of this, it is not surprising that a standard to measure the smartness of buildings does not quite exist. Some certifications and standards take different angles of the measurement:

- **LEED—**LEED (Leadership in Energy and Environmental Design) is the world's most widely used green building rating system. LEED certification provides a framework for healthy, highly efficient, and cost-saving green buildings, offering environmental, social, and governance benefits. LEED certification is a globally recognized symbol of sustainability achievement, and it is backed by an entire industry of committed organizations and individuals paving the way for market transformation.[1]

- **WiredScore—**WiredScore provides a standardized framework to assess capacity for technology and user experiences. WiredScore helps landlords and developers assess and improve their buildings' digital infrastructure and assists tenants in understanding the connectivity and technology resiliency when searching or comparing prospective leases.[2]

- **WELL Building Standard—**Managed and administered by the International WELL Building Institute (IWBI), the WELL Building Standard® is a performance-based system for measuring, certifying, and monitoring features of the built environment that impact human health and well-being through air, water, nourishment, light, fitness, comfort, and mind.[3]

- **BREEAM—**BREEAM (Building Research Establish ment Environmental Assessment Method) is a science-based suite of validation and certification systems for sustainable built environments.[4] While each of these approaches the smart building destination with a different route, there is one item they all have in common: data. Now, we just have to master it.

DATA CAN BE BURDENSOME

To reach a smarter building, owners and operators must know what is happening first. This benchmarking process sounds easy. Simply take note of what is current, right? That assumes that data-collecting mechanisms are already in place. It has been argued that the richest trove of data about buildings is within the operators' minds or potentially hand-written notebooks that are hopefully not too far buried in the basement. This may sound archaic after reading about the futuristic certifications available to buildings because, if this is the case, how would buildings ever achieve anything noteworthy? This collection is the first step in getting to a smarter building.

The more information a building has about what is going on within its walls and beyond, the more intelligent it can become. However, the other side of that coin is that the smarter and more connected buildings become, the more complex the systems behind them must be. Each door opened, light switched on, and temperature adjusted creates a data point. Where is this data collected? Who is looking at these data points? What is done with the data?

It can quickly become burdensome to the already busy building operators. The idea of adding something else they need to monitor and master is not always met with open arms. In fact, there is often pushback and dissent directed at the technology teams trying to upgrade the technology running in their buildings.

THERE ARE MANY CHAPTERS IN BUILDINGS' STORIES

Taking a moment to step back from the stress and even distrust that new technology can be greeted with from traditionally manual teams, the power of data can create a refreshed story. This is a story that offers a glimpse into the heartbeat of the building, painting a detailed picture of its operational rhythms and the beauty of how technology can create and seize opportunities within it.

The opportunities created by data are numerous. Through detailed, accurate, and plentiful data, buildings can become:

- **Energy Efficient.** The push for buildings to become more energy efficient is the result of many drivers. Environmental, social, and governance (ESG) initiatives come from:
  - **Corporate Net-Zero Goals:** Enterprise commitment to net-zero carbon emissions goals has been pervasive across the corporate ecosystem.
  - **Consumers & Investors:** Consumers demand climate action from corporations, and investors reward sustainability and ESG commitments.
  - **Carbon and ESG Regulation:** Regulatory mandates from the SEC around ESG reporting, as well as federal, state, and local carbon emission fines, have already entered commercial markets demanding decarbonization.
  - **Energy Price Volatility:** Global volatility in energy markets and the rising cost of electric power, water, and natural gas, combined with the high cost of procuring renewable energy, have caused energy risk.
- **Healthy.** Especially after the COVID-19 pandemic, the potential risks of indoor spaces have climbed to the top of occupants' minds. As offices try to entice workers back, people want proof that they are entering a safe environment that will not make them sick but will also positively contribute to their health, happiness, productivity, and relationships with coworkers.

- **Automated.** As budgets tighten and demands increase, the ability to do more with the same or less is the perfect situation for technology to step in and make data more than just points of information but actionable pieces of insight. At a basic level, automation is simply "if this, then that" (known widely as IFTTT conditional programming), yet many buildings have not reached this level of operation yet.

As technology enters the scene in more complex ways, buildings must evolve. If buildings are not responsible members of society, working to make the world a better place, then people will not go to them. As of today, 40 percent of global carbon emissions come from commercial real estate buildings, and cities account for over 70 percent of global CO_2 emissions.[5] If people opt out of going into buildings the way they are today, the foundation of our civilization will change. There has never been a more urgent time for technology to step in, and maybe seeing what happens three chapters ahead will be enough to convince buildings and the IT teams putting everything together to invest and commit today.

YOUR BUILDING IS TALKING. ARE YOU LISTENING?

The capabilities of technology within real estate are vast, but the introduction of artificial intelligence within the building space takes it to a necessary and needed level. The types and quantity of data discussed may sound like a headache and a complicated maze of access and permissions to IT teams, but the opportunities unlocked with AI-powered buildings are unmatched.

Once data sources are connected, whether sensors or operational systems or from a third party, the right technology acts as a translator. To evolve a building into a smart building, we must be able to hear and listen to what buildings are saying.

But why stop there? AI can empower a building's story to one where data accelerates the narrative. Let us walk through a few chapters of what buildings powered by AI can be.

Real-Time Occupancy-Based Energy Optimization

Traditional commercial office building energy demand turns on around 5 a.m. and blasts all day until 5 p.m. This timeline was created so that buildings would maintain a desirable level of comfort from the moment occupants arrived until they left. This demand curve created a rhombus of energy demand, which is predictable, as every day, it is the same but wasteful.

Think about how offices are today. New York City offices are at 50.5 percent of pre-pandemic occupancy.[6] Tuesday has emerged as the most popular day, followed by Wednesday and Thursday, according to the security company, Kastle.[7] Offices are seeing the highest occupancy around 11 a.m. and again at 2 p.m., with dips between for lunch and dropping off again starting at 3 p.m., according to the occupancy sensor company, VergeSense.[8]

This means that offices are being conditioned as if they are full even though they are most likely not even close to half of that. Think of the wasted energy! The unnecessary costs!

Offices that utilize AI and real-time occupancy can condition only spaces that are occupied as correlated with BMS command and control. By combining historical data about when offices are occupied, buildings can plan to run only when necessary without any waste, using the least amount of energy to maximize indoor comfort. By implementing floor-by-floor occupancy, operational systems can ignore the unoccupied spaces by tenants using a hybrid schedule.

What about surprise events? AI can react immediately when an unforeseen dip in occupancy happens and stop conditioning the now-empty space. An example would be a day with an eclipse, as happened in New York on March 9, 2016. Occupancy in the building rose from 8:45 a.m. until 11:30 a.m., then dropped for lunch from 12:00 p.m. to 1:15 pm, then rose back up to full occupancy levels. However, occupancy dropped again at 1:40 p.m. as people left the building to watch the eclipse at 1:59 p.m. The building was able to reduce energy demand as large spaces were unoccupied.

Carbon Fine Mitigation

New York's Local Law 97, Boston's BERDO, Washington DC's BEPS … the list of regions demanding decarbonization progress from buildings continues to grow every year. If new limits are not met, these buildings can face fines as soon as 2024, with limits becoming more stringent in some places by 2030 and beyond.

By collecting benchmark data on carbon emissions from buildings, AI can notice trends and predict what carbon emission levels will be by the time fines are active. Operators can see where they are predicted to be and how far that is from where they want to be (ideally, zero dollars in fines) and can make plans to reach that place before it hits their pocket. Using the prescriptive analysis capabilities of AI, buildings can plan for what technology they need to add to their stack in order to hit their goals. If they add in occupancy-based HVAC and lighting, plus automated window shade capabilities, as well as renewable energy resources, will that be enough to hit their goal? Maybe it is not enough of an answer to justify investment in technology, but data-backed predictions may be enough to get the building one step closer to being smarter.

Automated Demand Management

Thirty to seventy percent of the average commercial real estate manager's utility bill is made up of demand charges. These demand charges are a monthly fee paid as part of the cost of maintaining the electric utility's infrastructure required to deliver electricity to buildings and are based on how high the energy use measured in kilowatts (kW) peaked during the month. The higher the peak usage in kW, the higher the demand charge.

Smart buildings with AI can calculate the optimized demand limit for specific billing periods and automate the ability to stay beneath that kW level. This results in buildings being able to stay below the preset electrical peak in exchange for a significant reduction in demand charges.

Visualization of the impact of the choice is another part of the solution. Clear data and graphs that show the measures taken before the demand event, like pre-cooling, the duration of the event, the kW reduction during the event, how many events occurred during the billing period, and much more, are justifications for the installation and ongoing implementation of the smart solution. With data-backed reasoning, operators can trust the AI to make the best decisions about when and how much to reduce demand, allowing them to focus on other priorities.

Automated Demand Response

A dangerous side of energy demand is when the demand becomes too strong on the grid, which leads to blackouts. When large areas of the city or region are suddenly without power, the population becomes unable to function as normal as our lives are not set up to operate without electricity. In cases of people who are connected to machinery for their health, the demand surge can become life-threatening.

With AI, buildings can become connected to the utility power grids. By opting in to become part of the solution and receive monetary compensation for it, buildings and utilities can create their own network. Summer afternoons, when air conditioning is maxed out, put a lot of stress on the grid and can lead to blackouts. Grid-interactive efficient buildings, or GEBs as coined by the Department of Energy,[9] are smart, efficient, connected, and flexible buildings. In these facilities, energy loads can be shed, shifted, and modulated to optimize energy efficiency, reduce emissions, increase occupant comfort, and secure grid reliability. GEBs turn the built environment into flexible grid resources that are more valuable for building owners and grid operators alike.

What does this look like? The utility knows it will likely hit too much grid stress at 1:42 p.m. and will ask buildings opted into their program to reduce their load at that time. Buildings reduce their demand, potentially raising the indoor temperature a couple of degrees, and are compensated for their participation. Occupants are largely unaware of the change, the utility provider avoids hitting dangerous demand levels, and the city remains powered. As weather becomes more extreme and the demand on the grid increases due to the electrification movement, smart buildings capable of being an interactive member of the city are necessary.

Smart Cities

You cannot have smart cities without smart buildings. Buzz around the smart city idea has faltered in recent years as the complexity and infrastructure needed to create these places is not something that will happen within the next five years.

However, if we know where we want to go, we have a better idea of where to start. Data quantity is only increasing, and we will be left behind, unable to optimize what currently exists to build what we want to have next, if we do not utilize the potential of AI in real estate operations. In a world increasingly driven by data, understanding and optimizing your building's operations is no longer a luxury—it is a necessity.

The foundation of any city is the buildings that make it a place. Buildings are like miniature cities with a surplus of information and data, too much for people to keep track of alone. As buildings learn to tell their stories and control their narrative for the better, cities can learn by their example. This is all greatly made possible through AI, taking what data we have, recognizing what data we need, and creating opportunities to better our worlds one building at a time.

The 90 percent of our lives we spend indoors has room to improve, and technology can enable us to make it happen. We are largely still getting comfortable with and learning how to best use AI across many aspects of our lives, but when you think about what it can do today in regard to what it can do in the future, there is no doubt smart buildings are just around the corner.

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ARTIFICIAL INTELLIGENCE TECHNOLOGIES INCORPORATED IN

Smart Buildings, Smart Cities, and Data Center Design

By Ruqayyah Kechiche, RCDD

INTRODUCTION

Innovation by design is a primary necessity in future planning that will enable sustained solutions as the bedrock for the coming of the 4th Industrial Revolution, "cyber physical systems." The traditional approach to electrical power is wasteful; given our current global climate crisis, smart cities and smart buildings offer an opportunity for significant sustainability through the deployment of technologies, such as artificial intelligence (AI) and the internet of things (IoT). AI, sensors, and IoT are being deployed to better understand a building's energy efficiency and how society interacts within the structure, leading to better decisions that reduce op-ex costs and promote energy efficiency. Global governments are developing plans to construct smart cities with rapid advancements; AI currently takes center stage, being woven into the smart city architecture for multi-usage purposes. Existing Scandinavian data center developments inhabit multi-purpose functions that renew existing energy used to heat homes and are shown to be an example of a creative, eco-friendly solution for circulating existing energy consumption from one source that can facilitate many. The themes of this article include existing and new technological advancements that are being fused together and the ways in which they are being deployed in relation to smart buildings and smart cities. The effects of these advancements result in an increased demand for data centers and creative innovation techniques that, in effect, are proving to promote energy efficiency in current areas that are being neglected and unnecessarily overpowered. AI is not yet a full-blown solution, but it can provide numerous benefits when used correctly.

SMART BUILDINGS

Post-pandemic hybrid work trends have led to inconsistent use of buildings previously used at full capacity. Deploying software to analyze microgrid loads is crucial for optimizing building energy consumption. The use of AI can ensure sustainability by providing insights into energy performance. Smart buildings are now equipped with sensors that collect data on energy usage, which is then sent to building management systems (BMS). These systems use algorithms to operate buildings, ensuring efficiency without compromising functionality.[1] Given current fluctuations in vacancy brought about by hybrid work flexibilities, a building's AI can now regulate the lighting and HVAC according to real-time actual occupancy. A smart building's AI can then go one step further via weather predictions to plan, heat, or cool a building before the peak demand for power. This type of real-time optimization would not be possible without the use of sensors working hand in hand with AI.[2] Smart buildings integrate people and systems by providing solutions using safe and secure settings, network connectivity, functional spaces via a B-IoT, and AI-enabled environments to accomplish improved business productivity.[3] The use of autonomy control is a benefit toward reduced operating costs and reductions in energy waste. A high-performance structured cabling system is essential in operating a smart building, supporting multiple applications to cope with increased bandwidth while decreasing network downtime. Crafting versatile physical layer connectivity rests upon a well-designed network, a robust cabling topology, tailored media selection, wireless mobility, and consideration for multi-application support. This collectively paves the way for an open system platform where hardware and software are synced together, resulting in efficiency and productivity across the network (Figure 1).

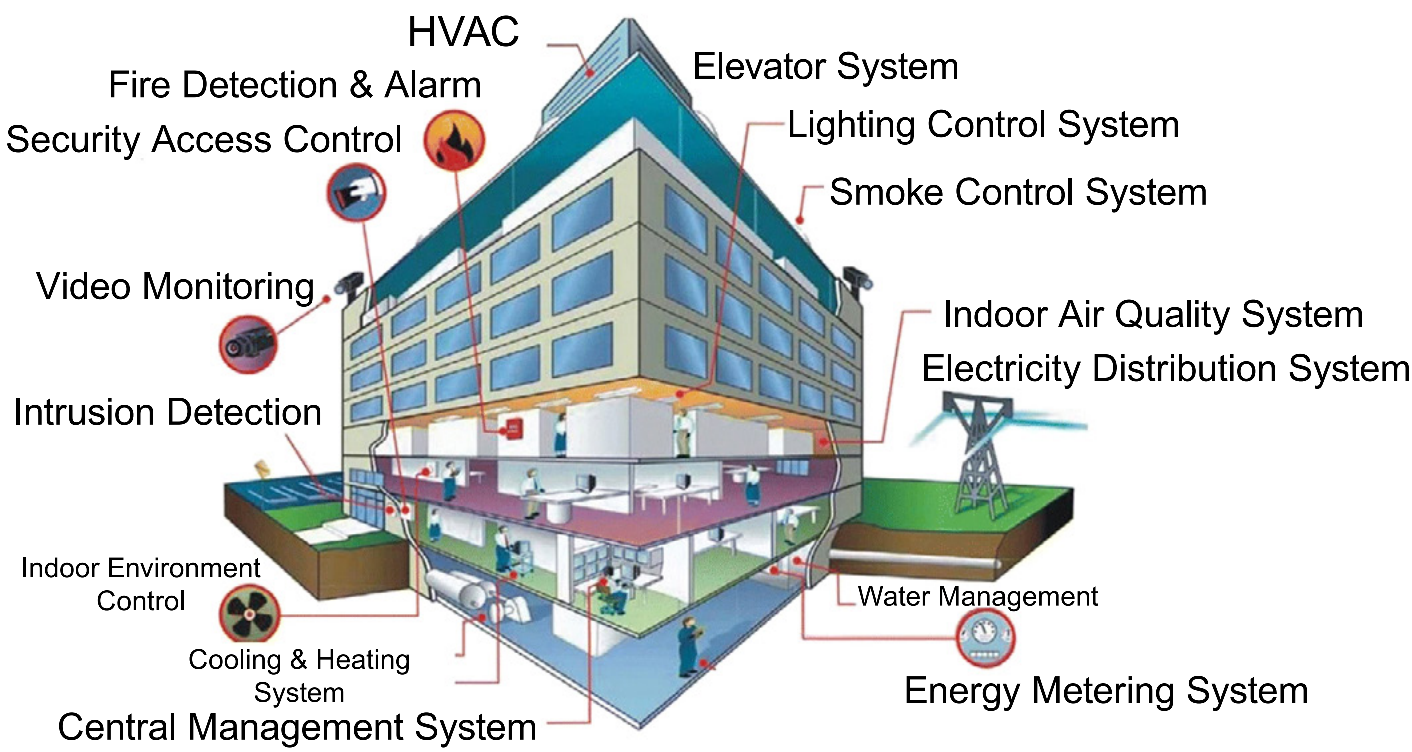

FIGURE 1: A smart building is intelligent as it connects all the building systems coherently, integrating in ways that provide value to both owners and inhibitors of buildings in terms of functionality, efficiency, comfort, and sustainability. Image Credit: https://energyinformatics.springeropen.com/articles/10.1007/s42162-018-0011-9/figures/1

> ***The most significant advantages of integrating AI and smart building automation systems are the potential for energy savings.***

At the BICSI South Pacific Pursuing Net-Zero Conference & Exhibition 2023, leading industry experts presented the PoE approach in smart buildings, reducing energy wastage using DC infrastructure implementation. The number of technology applications running on structured cabling (voice/data, CCTV, A/V & AC, lighting, HVAC, amenities, elevators, smoke detection, fire control, metering, facility assets, and parking) makes everything in the building PoE-controlled.[4,5] By adopting DC power infrastructure complemented by AI, smart buildings will become revolutionary in energy efficiency throughout the buildings' present and future usage. The digitalization of facility management incorporates smart platforms such as AI, BIM, BMS, IoT, and analytics; AI can be used in smart buildings for energy management. By using renewable energy as the fuel of power, it can transform into an electrification of assets by unlocking smarter, data-driven decisions.[6] This could potentially reduce op-ex costs by housing the ability to anticipate, and not just record and respond, in areas such as HVAC that, in turn, will minimize energy wastage and increase energy efficiency. The most significant advantages of integrating AI and smart building automation systems are the potential for energy savings. Another advantage of integrating AI and smart building automation systems is the potential for improving the health of occupants by breathing cleaner air (possibly reducing the risk of airborne viruses), as AI can monitor air quality (HVAC) within a building, adjusting ventilation systems as needed. Among other advantages, AI can also help to identify potential security threats, such as unauthorized access or suspicious activity.[7] AI technology is understandably new; however, its adaptability and versatility to existing devices already designed within smart buildings will make it a tool that will be inevitably used.

SMART CITIES

Cities are continuously innovating with the help of AI due to the AI technology used within smart cities. AI is becoming a toolkit that is being used to determine more sustainable decisions that will facilitate the needs of urban populations, given AI's potential to improve planning and advanced functions. Currently, smart cities are comprised of various components that include IoT devices, data analytics, communication networks, metropolitan infrastructure, and public services.[8] The benefits of AI are considered to be at the intersection of driving forward existing IoT technologies. The combination of IoT and AI will result in the evolution of smarter urban transportation networks, improved water supply and waste disposal facilities, and more efficient lighting and heating systems that are designed to promote energy efficiency.[9] Smart cities cause lesser effects on climate change, promote smarter decisions, and improve the quality of life for residents.[10] The upcoming reality within these smarter urban metropolises is by adopting AI technologies as the new engine for smart city development, the ability to derive the collected data to optimize the environment around us. To actualize the desired urban upgrades, segmented stages need to be implemented upon delivery when constructing the fabric for the next generation of smart cities. Within the top layer stage sits the first dimension, which is the creation of multi-domain environments by combining IoT and AI; it is now possible to channel the power of information created in multiple-domain environments while choreographing large digital infrastructures to seamlessly sync its collected data that, in turn, fuse everything together, generating a mass-governed data lake. The "AI ladder," developed by IBM, is a proven methodology to turn the collected data into insights. It provides four key areas of consideration: data collection, data organization, data analysis, and Infuse AI: Operationalize AI.[11] Upon the instance of smart cities, this will be incorporated on an expediential scale for real-time data deployment efficiency. The mid-level stage is the creation of a bio-diverse ecosystem that would require large telecommunications companies and service providers of mid- to smaller-size companies that collectively embrace technologies by innovating new business models surrounding the platforms that larger companies can possibly provide. Lastly, yet most importantly, is the ground-level stage, which is the Layer 1, a physical layer consisting of mass telecommunications infrastructures that are the fundamental basis of connectivity within smart city architecture (Figure 2). Regarding smart city connectivity, the technology that will have the biggest impact is information communications technology.

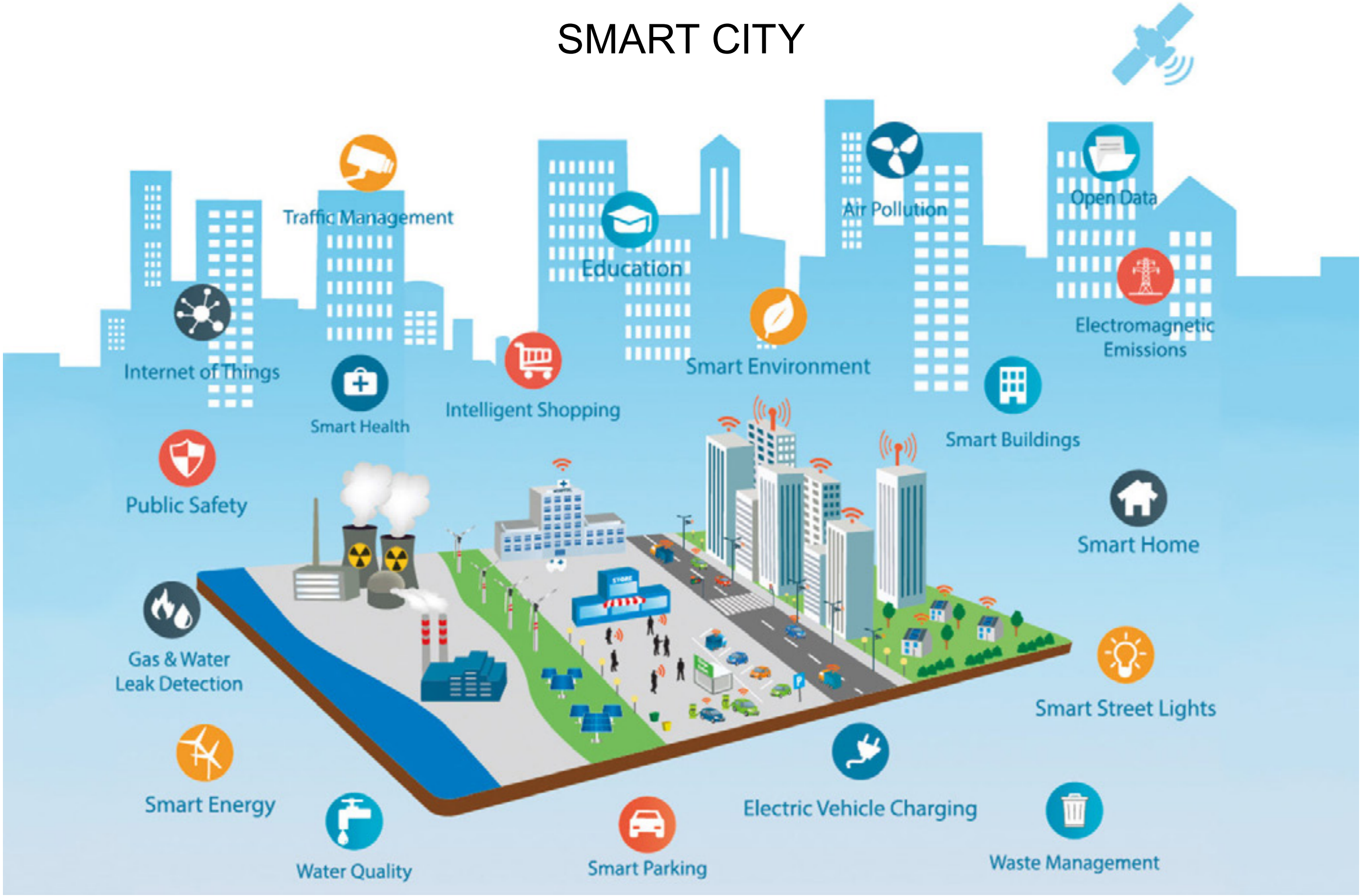

FIGURE 2: Smart city infrastructure provides a wide variety of intelligent applications that collectively enhance urban environments. Image Credit: www.datasciencentral.com/smart-cities-of-the-future-powered-by-iot

FIGURE 3: Data center designs are constantly evolving, while rapidly growing to meet ongoing demand in selected geographical locations for long-term sustainability. Image Credit: www.eidasolutions.com/key-challenges-in-data-center-construction

Structured cabling is fundamental in creating infrastructures that support intelligent systems. It is essentially the foundation of smart cities. As buildings, cities, and businesses transition toward smart operations, structured cabling ties all systems together. The expansion and development within the smart city sector presents massive growth within the telecommunications industry.[12] Smart cities as a whole incorporate multiple sectors, all of which require individual connectivity while interconnecting as a collective. An example sector includes the health care sector; health care integration offers the potential for tailored cabling solutions as the health care industry's reliance increases upon technology. In the IoT sector, the growth of IoT devices requires an infrastructure-structured cabling that is IoT-ready. The need for structured cabling solutions is increasing in the education sector as e-learning, virtual classrooms, and digital campuses are becoming the norm. Future structured cabling systems will likely integrate more closely with AI, providing predictive analytics and intelligent performance optimizations.

DATA CENTER DESIGN

AI is evolving rapidly; the efficiency of innovation is highly prevalent in data centers to maintain sustainability and capacity for ongoing rapid growth. Meta's global director of data center strategic engineering, Alan Duong, said at a press event detailing the company's next-generation data center design, "Next-gen data centers can become complex as the growth of AI tech needs to ensure data centers can adapt to what is still evolving."[13] Constructing next-gen data centers can become complex due to the fact that AI is currently still in its infancy, and designing for today must also incorporate planning for the future by future-proofing. Future-proofing requires air and water cooling but at a damaging cost toward increased energy usage.[14] The reality is that there are not enough data centers to support the evolution that is currently at our doorstep. This current obstacle provides an opportunity. It is important to not only be conscious of facilitating technological advancements and their effects but also of the environmental impacts of constructing these data centers (Figure 3). Upon design, the focus needs to include areas such as "passive house technologies" that incorporate the location of the data centers to ensure inclusion for multi-purpose functions. For example, in Stockholm, Sweden, the "Stockholm Data Parks" project comprises multiple major Stockholm data centers that not only house data but also heat Stockholm's homes by using the heat from the cooling process and feeding it via pipes to heat-generation facilities. A main incentive for data center companies to join the project is that they get to sell their waste heat and, in turn, open up an additional income stream while minimizing the use of traditional gas central heating.[15] The transposition advantages pivot data centers from their primary storage function by the virtues of regenerative heat to enable multiple functions.

CONCLUSION

In conclusion, the importance of embracing the rise of integrated AI technologies can lead to more adaptable and resilient environments. Structured cabling is a physical platform source upon which sensors, BMS, IoT, and the current showcase of AI sit firmly. The rise in demand draws for connectivity infrastructure from which innovations stem (Figure 4). It is not too far-fetched to invest in the idea that we can evolve from a reactive society by using measures via technologies such as AI to better understand inevitable climate changes so we can work toward predicting and thus reducing energy waste. To balance the freight that is presented, creative solutions are a necessity, not a luxury, as the decisions made today are the concrete

FIGURE 4: Smart infrastructure design is the core foundational function that supports intelligent systems, increasing in prevalence. Image Credit: www.smartcitiesworld.net/news/news/report-reveals-critical-gaps-in-governance-of-smart-city-tech-6613

that cements tomorrow. We can create more efficient, sustainable, and adaptable urban environments by using smart buildings and smart cities. The multipurpose design approach can be incorporated across new constructions of smart buildings, smart cities, and data centers. It opens up an alternative sustainable route that forms a new beginning toward preserving natural resources while ensuring adaptability for the ongoing technological advancements rapidly molding global society. Collectively, the objective is to increase efficiencies and productivity at the forefront of long-term sustainability.

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Ruqayyah Kechiche, RCDD, has many years of experience and has been responsible for successfully generating and delivering contracts within the UK's public and private sectors. She has coordinated projects related to the design and installation of optical fiber networks, copper transmission, voice cabling, and CCTV security systems. Ruqayyah's experience includes estimating, (i.e., the design of network infrastructures for tender submittals). Project management includes liaising with industry suppliers, deployment and resourcing of sub-contractor engineers, and attending site meetings with clients to achieve end-to-end smooth delivery of project installations.

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