THE FUTURE OF BUILDING INTEGRATION COULD BE OLD WIRING

How to adopt high-speed IP networks with low cost and minimal disruption, using the twisted-pair wiring already installed in your building

Technical Resource Guide
T1L Long-Distance Ethernet for Building Networks

Honeywell

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OVERVIEW

Get an IP network without overhauling your building's wiring

Companies and organizations around the world rely on networking technology to transmit ever-greater volumes of data, causing demand for cloud storage, processing speed, and low-latency apps to surge.

Yet a potentially rich transmission source may already be installed in your building, ready to support strategic building operations such as optimizing occupant comfort while managing energy consumption, and making progress toward sustainability goals.

YOUR BUILDING CAN TRANSMIT MORE DATA

Given the demand for more data and faster networks in systems of all kinds, including a building's operational technologies, many building owners and users want to upgrade their building's network performance and security to the standards-based approach of an Internet-protocol (IP) network.

The good news is that better networking can potentially be obtained over a single twisted pair of wires using your building's old cabling and existing infrastructure.

WHAT'S THE SECRET?

T1L Long-Distance Ethernet: A promising networking technology that enables rapid, dependable data transfer over long distances.

In fact, T1L can reliably transmit data between devices that are up to a kilometer apart, offering a cost-effective option that goes further than many other IP-cabling technologies. Fiber-optic cable, by comparison, can provide longer distances, but comes with prohibitive costs.

And because T1L is simply a different physical network layer of Ethernet connectivity, it's a practical alternative to other physical network layers such as BACnet™ MS/TP or LonWorks®.

The advantage of T1L Ethernet: The potential to reuse a building's existing wiring.

This enables a faster path for upgrading building technologies, with more options for system optimization than a complete rip-and-replace to install a Cat 5 Ethernet network.

By combining your building's existing network cables with Ethernet speeds, T1L can deliver the biggest benefits of both: IP speeds and security, with the cost-effective reuse of traditional infrastructure that's already installed.

ABOUT THIS GUIDE

This technical resource guide is designed to help you navigate the basics of T1L Ethernet and understand the technical concepts that make it possible.

We'll review the key terms, tools, and practices of T1L, as well as some examples of applications and benefits – with the goal of enabling your building's network to attain new lengths, strengths, and speeds.

HIGHLIGHTS

- T1L Ethernet is a two-wire networking standard that enables you to adopt an IP network without the usual barriers of cabling infrastructure and complex network installations.
- This ease of implementation gives T1L the potential to transform building automation and industrial-process automation by reducing the costs and barriers to IP adoption.
- In a building management system (BMS), T1L offers significant benefits over traditional networking technology, including higher bandwidth, long-distance connectivity, and better network resilience.
- Honeywell has introduced T1L Ethernet capabilities into its own building technologies. In this guide, we will review examples of how it can benefit buildings.

WHAT IS T1L ETHERNET?

A non-proprietary networking standard to enable IP communication between devices over long distances

What makes T1L Ethernet so useful is that no special cabling or wiring is required. The standard doesn't define a cable specification – it only defines characteristics for the cables used.

This flexibility to choose the cable is one of the main benefits for buildings that upgrade to T1L: You have the option to reuse cable already installed in your building if it can comply to the standard.

A STANDARD IS BORN

On 7 November 2019, the Institute of Electrical and Electronics Engineers (IEEE) approved T1L as a new open standard, IEEE802.3CG, also known as 10BASE-T1L. The standard allows for cables up to 1 kilometer long and can transfer data at a speed of 10 Mbps (10 million bits per second).[1]

T1L is a "single-pair Ethernet" (SPE) standard, meaning that it only needs a single pair of twisted wires, rather than the two or four pairs common to many other Ethernet standards.

According to the IEEE, T1L has been developed with building automation, process automation, and the industrial Internet of Things (IoT) at its foundation – in order to account for the installed environments of such applications, as well as networking requirements like longer cabling distances.

T1L is designed to let networks support a wide variety of software and systems, and offers flexibility for industrial IoT across numerous industries.

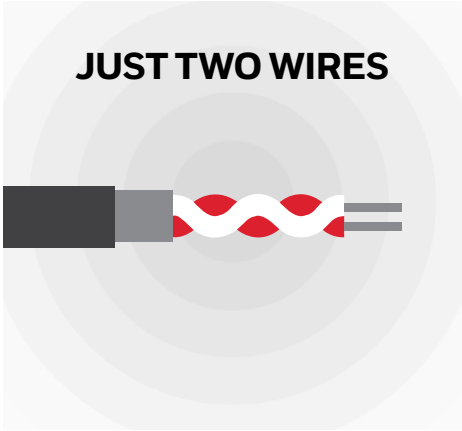
WHAT CUSTOMERS WANT

Recent market reports clarify what building customers increasingly want in order to fully benefit from industrial IoT: They want a networking solution based on an open standard that is IT compliant and compatible, while also being low risk to adopt and cost-effective to install.

Consumer feedback also shows that building owners and facility managers want access to the higher bandwidth and enhanced cybersecurity of IT networks as well as IT management capabilities, which are often more convenient than how operational technologies (OT) are traditionally managed.

These findings highlight the need for a high-capacity IP network that isn't complicated by high overhead costs and installation challenges (such as already-installed cabling, cabling practices, the installation environment, cost per point).

In many cases, T1L can fit the bill. And as a non-proprietary standard, a range of technology companies have been investing in T1L technology over the past ten years – such as Texas Instruments, Analog Devices, Broadcom, Cisco, and Honeywell – to develop components and products that support the adoption and use of T1L Ethernet.



"T1L ... can be used for industrial IoT, building automation and other applications where longer cabling distances are required."

Source: IEEE Standards Association Control Consultants, Inc.

1. IEEE Standards Association. "IEEE Standard for Ethernet – Amendment 5: Physical Layer Specifications and Management Parameters for 10 Mb/s Operation and Associated Power Delivery over a Single Balanced Pair of Conductors," IEEE Std 802.3cg-2019, 05 February 2020. Accessed on 06 June 2023: https://standards.ieee.org/standard/802_3cg-2019.html

T1L BENEFITS FOR BUILDING MANAGEMENT

Buildings are where T1L shows its greatest promise, providing significant value to building owners and users

> **Because T1L Ethernet simplifies the adoption, installation, and maintenance of IP networks, in part by reusing a building's existing wiring, it can lower the cost to transition to IP technologies, and potentially the lifecycle costs of IoT capabilities.**

WHY T1L IS IDEAL FOR BUILDINGS

T1L Ethernet enables buildings to implement standard IT protocols and applications on the networks used by operational technologies (OT), without having to rip out and replace older wiring.

T1L also enables direct IP addressability of sensors and nodes, helping to cost-effectively drive secure, high-bandwidth connectivity across entire buildings.

MARKET TRENDS

In both the equipment and unitary space, IHS Markit reports and market research from independent firms have indicated two important trends:[2]

- IP controller adoption is increasing within buildings.
- End users say smart buildings are a goal, but their building is fragmented by unconnected systems.

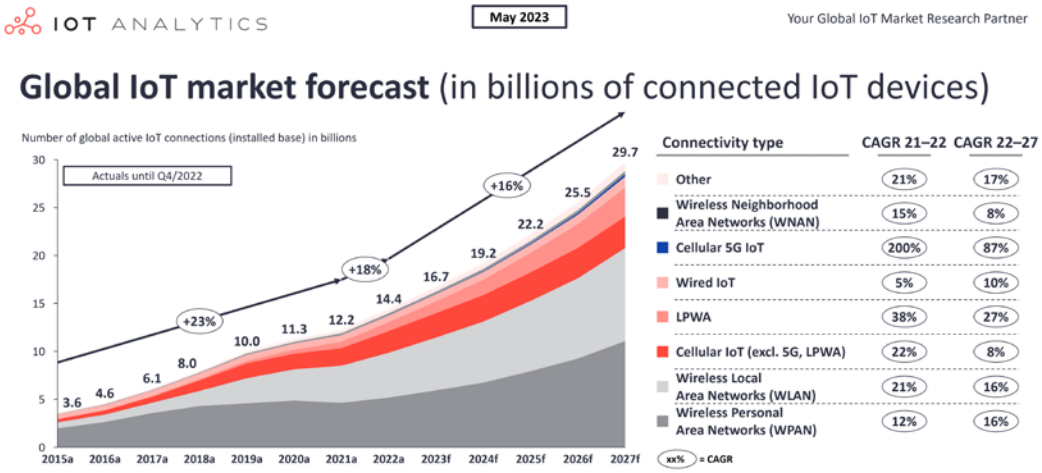
The reports indicate that over the last five years, these trends have been strongest in Western Europe, where an IP-capable solution enables a decentralized system.

Growth of the global IoT market will likely accelerate over the next two years. In a 2023 global market forecast, research firm IoT Analytics estimates nearly 30 billion connected IoT devices by 2027, as costs drop and supply constraints ease.[3]

STATE OF THE MARKET

- Buildings are often fragmented with disparate systems throughout the facility.
- Adoption of IP-capable controllers is growing as costs decline.
- Upfront costs and availability of equipment are the biggest barriers to adoption.

Source: IHS Markit



Note: IoT connections do not include any computers, laptops, fixed phones, cellphones, or consumer tablets. Counted are active nodes/devices or gateways that concentrate the end-sensors, not every sensor/actuator. Simple one-directional communications technology not considered (e.g., RFC, NF). Wired includes ethernet and fieldbuses (e.g., connected industrial PLCs or I/O modules); Cellular includes 2G, 3G, 4G, 5G; LPWA includes unlicensed low-power networks; WPAN includes Bluetooth, Zigbee, Z-Wave or similar; WLAN includes Wi-Fi and related protocols; WAN includes non-short range mesh, such as Wi-SUN; Other includes satellite and unclassified proprietary networks with any range.

Source: IoT Analytics IoT-Analytics.com/Number-Connected-IoT-Devices/

BARRIERS TO IP ADOPTION

IHS Markit reports suggest that there are several barriers to the adoption of IP-capable networks.

Foremost is the initial cost of an integrated building management system (BMS) and its connected equipment.

Typically, the average cost per IP device can be 10–20% higher than traditional building devices, with some systems often having 20% higher costs.

Especially in retrofit projects, many building owners lack the funding to improve their infrastructure. Thus systems are often only fixed or replaced when they fail.

Beyond cost, a 2020 smart-building survey published by the research firm Omidia identifies three key difficulties for integrating smart-building operations:[4]

1. Legacy equipment, availability of infrastructure for applying IoT
2. Lack of employee skills and knowledge
3. Software interoperability and data-exchange issues

HOW T1L HELPS OVERCOME THESE HURDLES

Up to now, a building's subsystems have typically operated in silos – the BMS, fire safety, security, access control, elevators. Each system functions independently, and often, they don't share data or communicate effectively. These subsystems can also have various networking technologies for the building owner to maintain.

The more siloed systems a building has, the more challenging and costly it becomes to manage them via an elaborate system architecture, and to scale them with other building services.

Thus when new expectations and regulations turn more complex goals into imperatives – such as building health or carbon management – it can become difficult to coordinate all building systems in the service of these needs.

But moving to a common IT network can integrate and simplify the building's system architecture, making it much more practical and cost-effective to coordinate subsystems.

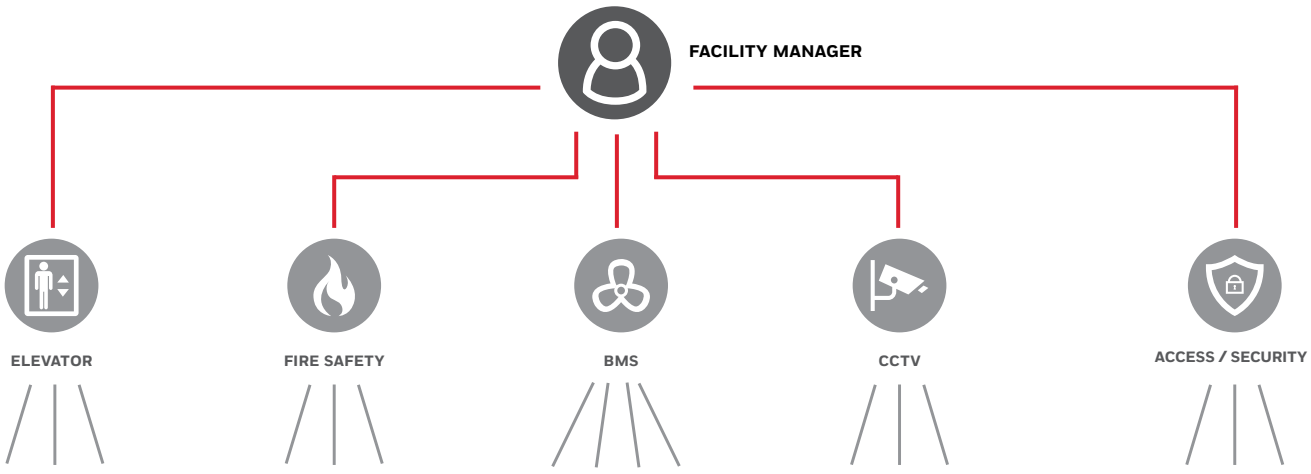
Likewise, unifying building systems also tends to make training and daily use easier and more efficient, helping to overcome knowledge gaps among facility staff.

Fortunately, the world is trending towards an interconnected built environment, and T1L offers a way to ease cost, bandwidth, and distance needs, without the hurdles of new cabling infrastructure or complicated network installations.

OBSTACLES TO IMPLEMENTING IP

- Higher initial costs of BMS platforms and connected equipment
- Low availability of networking infrastructure
- Lack of employee skills and knowledge
- Issues with interoperability, data exchange

2. IHS Global Automation Equipment & Service Reports 2017, 2019, 2020.
3. Sinha, Satyajit. "State of IoT 2023: Number of connected IoT devices growing 16% to 16.7 billion globally," IoT Analytics, 24 May 2023. Accessed 06 June 2023: https://iot-analytics.com/number-connected-iot-devices/
4. 2020 Smart Building End Users Survey, Omdia.



Traditional building network with siloed systems and various networking technologies

HOW T1L SIMPLIFIES FIELD NETWORKS

T1L can strike the optimal balance for a building's field network

Field networking consists of the final 500 meters in a building from the backbone network to the edge.

Cat 5 TCP/IP Ethernet has long been the undisputed king of backbone networks, but with field networking, buildings face a mix of competing options for networks, protocols, and wiring – each with varying degrees of communication efficiency, cybersecurity, and cost.

IN THE FIELD: NETWORKS, CABLING, AND PROTOCOLS

Among established building technologies, many are based on "open network protocols" – rules that enable connected devices to intercommunicate despite differences in design, manufacturer, and internal processes.

The leading protocols and cabling for a building's field network include:

LON®, which is short for "local operating network." Also known as LonWorks®, this is a protocol used for networking devices in building automation systems. LonWorks is proprietary, so you may have to buy chipsets from a specific manufacturer or pay a license fee.

The biggest benefit of LonWorks has been that it enables devices from different manufacturers to intercommunicate, providing an open solution for device integration.

BACnet™ is a communications protocol established by the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE). It defines how wired devices intercommunicate, but it doesn't specify the physical network layer nor how systems are engineered.

Like LonWorks, BACnet supports intercommunications between devices from different manufacturers.

MS/TP stands for "master-slave token passing." This is a protocol used in BACnet for exchanging information between building devices. It is a form of RS485 networking, whereas Cat 5/6 is a form of Ethernet networking.

BACnet MS/TP is a protocol that offers low cost but also low bandwidth. Conversely, Cat 5 and Cat 6 Ethernet offer higher bandwidth, but at high cost.

Cat 5/6 Ethernet, or Category 5 and Category 6 Ethernet each use a network cable made of four twisted pairs of copper wire terminated by an RJ45 connector. Cat 5/6 Ethernet is the cabling most often used in home and business IT networks, transmitting data at high speeds ranging from 10 Mbps to 10 Gbps.

T1L Ethernet is a newer open standard that uses a single twisted pair of wires, which can potentially be the same wiring and connectors used in traditional BMS networks (such as MS/TP or LonWorks). T1L Ethernet works with cables up to 1000 meters long, and can transmit data at high speeds up to 10 Mbps.

FACTORS ON A FACILITY MANAGER'S MIND

- "I want faster access to more of my building data."
- "New network wiring in a retrofit can be a significant part of the total cost."
- "Maintaining multiple networks in a building is expensive."
- "We need a secure, standardized solution that reduces stress – something that can use standard IT protocols and visualize devices."

TRADITIONAL BMS NETWORKS

LonWorks, BACnet MS/TP, and other proprietary BMS networks have worked well for buildings, and for good reason: They can span the necessary distances, are comparatively easy to install, and have simple connectors that make installation, configuration, and maintenance more efficient.

But network technologies are not all created equally. The table below highlights some of the strengths and tradeoffs for each.

	TRADITIONAL BMS NETWORKS		IP NETWORKS	
CHARACTERISTIC	**LONWORKS® FTT-10**	**BACNET™ MS/TP**	**CAT 5/6 ETHERNET**	**T1L ETHERNET**
CABLING CONNECTORS				
TOTAL WIRE LENGTH	500m	1200m	100m*	300m*
TYPICAL SPEED	78 Kb/s	32 Kb/s	10 Mb/s, 100 Mb/s, 1 Gb/s	10 Mb/s
SUPPORTS BACNET SECURE CONNECT	No	No	Yes	Yes
SUPPORTS IT STANDARD PROTOCOLS	No	No	Yes	Yes
SUPPORTS ENCRYPTION	No	No	Yes	Yes
PROPRIETARY	Yes	No	No	No
COST	$	$	$$	$

* Distance between node and switch or between devices in daisy-chain

T1L enables high-capacity, cost-effective wired networking.

Although traditional BMS networks have worked successfully in most traditional use cases, they lack the bandwidth and cybersecurity to effectively support new and emerging industrial-communication applications.

IP NETWORKS

Depending on the project, building, and budget, Cat 5 Ethernet can work in the field, and Cat 5/6 resolves many shortcomings of traditional networks. But Cat 5/6 networks also have their own drawbacks.

For example, to maintain resilience in a Cat 5/6 network, the recommended distance between devices is a mere 50 meters. What's more, unless the installation is planned so that it can use measured or premade cables, costs can mount quickly due to variables such as cabling installation, connection points, and distance.

By comparison, the 10BASE-T1L standard can use the same simple connectors as traditional networks, and it defines a maximum distance of 1000 meters – though to improve network resilience, the recommended distance between T1L devices is 300 meters.

So why do these shorter distances increase network resilience?

The strategy is to have enough proximity between devices that if two were to unexpectedly switch off, the rest of the network can still remain stable and functional,enabling the other devices on the network to continue communicating.

Thus with a recommended distance six times longer than Cat 5/6 Ethernet, T1L Ethernet can provide similar IP capabilities and security using cabling that is less expensive, and easier to install and maintain – especially when it reuses cable that's already installed in the building.

WHY T1L IS A WIN-WIN FOR BUILDINGS

The physical benefits of a traditional BMS network, now at 100 times the bandwidth with Ethernet connectivity

T1L Ethernet provides a cost-effective way to enhance capabilities while reducing the complexity of system architecture. It's simply a new physical layer, comparable to 10BASE-T (Cat 5), but capable of reusing existing twisted-pair cables.

With TCP/IP, T1L supports the latest IT applications and security standards, including certificate management for encryption – providing secure transmission all the way to the building's edge.

WHY HONEYWELL SUPPORTS T1L DEVELOPMENT

Honeywell is introducing T1L Ethernet in its building technologies with an aim to support IP-capable networking that is versatile, cost-effective, and resilient.

Depending on the system or application, the technology can be adopted in diverse ways. Some of our systems use T1L in I/O modules, providing remote IP I/O. Other systems use the technology as the new fieldbus network for unitary controllers.

I/O MODULES

We use T1L Ethernet for the bus between the controller and I/O modules. I/O modules connect to the plant controller either directly via "touch flake" terminals on the sides that connect via contact, or remotely using wiring adapters.

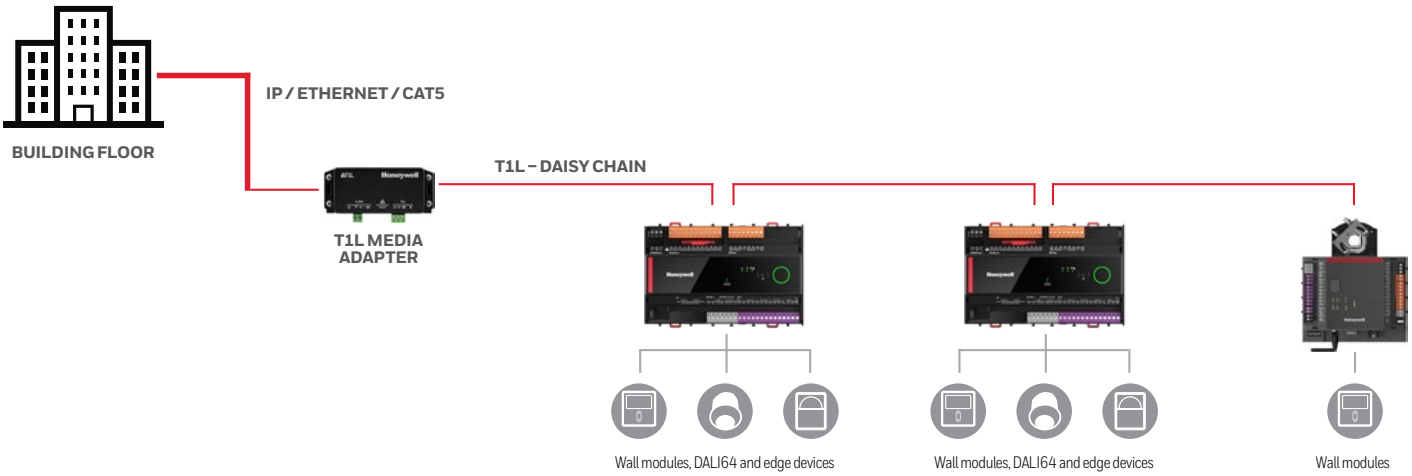
The T1L network supports recommended distances of up to 300 meters between devices and uses daisy-chain network protection to improve the resilience of the system. Should a device switch off, downstream devices can still communicate – all with a round-trip time (RTT) of less than 100 milliseconds.

Additionally, with IP-based certificate encryption, communication between the controller and I/O is safeguarded right down to each input and output.

Looking ahead, T1L Ethernet will also enable useful developments such as smart I/Os with MQTT brokers (an IoT-device protocol) and virtualized controllers.

10BASE-T1L BRINGS ETHERNET TO THE EDGE ON TWISTED-PAIR WIRES

- Non-proprietary
- Standards-based, with support for standard IT protocols
- 10 Mbps transmission speed
- Distances of up to 1 kilometer between devices (environment may affect actual distance)
- Functions as an Ethernet physical layer – T1L just uses different cables and connectors
- Single twisted-pair fieldbus cable (no Cat 5/6 cables needed)
- Solution for I/O and comms module bus
- Full duplex, point-to-point



Unitary control diagram

UNITARY CONTROL

For unitary bus controllers, T1L offers numerous benefits:

- Uses a simple two-core network cable
- Supports IP and open protocols
- Enables a bus daisy-chain network
- Can also be installed as a ring network for enhanced resilience
- Supports longer IP distances between devices (>300 m)
- Greater bandwidth with speeds at a rate of 10 Mbps

EMBRACING T1L TECHNOLOGY

As an open technology, T1L Ethernet can augment legacy networks by adding IT protocols and speeds to the current infrastructure. As such, it represents a significant upgrade opportunity for existing sites.

Note, however, that even with its considerable benefits, T1L Ethernet is not automatically the "best" technology for every situation. The right type of network will still vary by the building and the needs of the people using it.

For instance, in buildings with the budget and intended scope, installing a 100 Mbps Cat 6 Ethernet system may still be the most effective solution.

Other projects may call for a low-budget refurbishment or service extension to an existing network, in which case a BACnet MS/TP network and devices could be more appropriate.

Nevertheless, T1L Ethernet gives building owners, operators, and facility managers a valuable opportunity for increasing the capabilities of their building, and for upgrading systems where a full network rewire is not suitable.

FUTURE NETWORKING WILL REDUCE COMPLEXITY

In many buildings around the world, facility managers still must contend with a great deal of complexity: the cost of building technologies and networks; cabling and distance; limited bandwidth; siloed systems.

From wall modules and actuators to field controllers and meters, it can become complicated to simultaneously operate different networking technologies on a traditional BMS network.

Combining a traditional TCP/IP Cat 5 Ethernet backbone and a T1L Ethernet fieldbus simplifies the system architecture of the future – by running standard TCP/IP network protocols throughout the entire building, and using a field technology that's suited to the installed space. T1L Ethernet removes complexity by unifying multiple physical networks and subnets into one common networking technology.

T1L BEYOND THE BMS

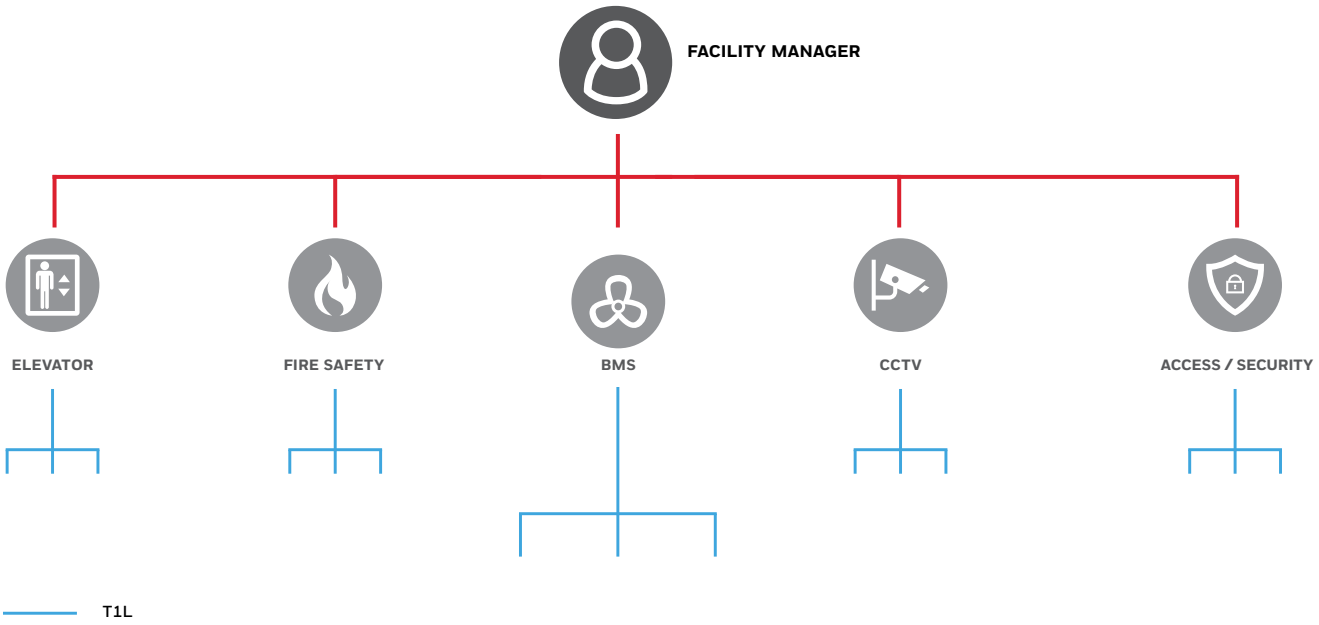
As the adoption and use of T1L Ethernet spreads, buildings will increasingly gain the benefits of streamlined systems, and infrastructure that runs on IT networking standards.

And these benefits aren't limited to building controls or BMS systems. T1L is also suitable for other building systems and devices such as IP cameras, WANs for fire-safety systems, access control, security, elevator systems.

It's also an opportunity to extend the usefulness and value of millions of devices that have been installed over the past 20 years, giving them modern IP connectivity and capabilities.

Cisco and Honeywell have been collaborating on ways to further enable smart buildings, including developments in Cisco's DNA spaces and network switches that support T1L Ethernet. And Honeywell is exploring further uses in many other building technologies, such as sensors, actuators, meters, gas burners, and fire-safety systems, as well as possible wireless uses.

The full capabilities and promise of T1L Ethernet are emerging now, and will accelerate in the years to come as its value becomes recognized and put to use.



Example of T1L system architecture

CONCLUSION

T1L Ethernet is a promising open network technology for helping buildings operate more efficiently and effectively

> **T1L Ethernet is a non-proprietary IEEE standard that provides a straightforward network for I/O, comms modules, and field controllers.**
>
> **It also offers a cost-effective mix of convenience, compatibility, and cybersecurity – due to its high bandwidth, its support for IT protocols and encryption, long distances between devices, and the opportunity to reuse existing twisted-pair wiring.**

NEXT STEPS

The market has been moving towards IP-based solutions for some time, but up to now, end-users have found costs and existing infrastructure to be pain points. Meanwhile, traditional systems frequently remain isolated and incompatible.

In many cases, T1L Ethernet offers an easy way to overcome these obstacles, which may help accelerate the global IP-transition, and extend its reach into facilities that might not have previously been seen as candidates.

Naturally, T1L won't be the answer to every application, so Honeywell and others will also continue to develop and offer technologies based on standards such as Cat 5 Ethernet and BACnet MS/TP.

T1L simply expands the opportunities that buildings have to increase their integration and functionality – which is vital for addressing the complex challenges our buildings face, such as providing indoor environments that are healthier and more sustainable for a rapidly urbanizing, integrated world.

HONEYWELL KNOWS BUILDINGS

Helping buildings achieve safer, smarter, and more efficient operations has been the bedrock of our business for generations – which is why today, Honeywell technologies are in more than 10 million buildings worldwide.

How? Because we've established expertise in each part of the job – from developing the software and equipment, to integrating open systems, and engineering the performance that buildings of every type depend on to get results.

We're always ready to help

Contact us today to learn how your building can achieve better outcomes

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