THE IMPORTANCE OF STANDARDS IN THE SMART RETAIL MARKET

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EXECUTIVE SUMMARY

Retailers are increasingly looking towards Internet of Things (IoT) technologies to help them deliver operational efficiencies, increase conversion, and to encourage customers to return to stores in the post-COVID-19 landscape. Use cases such as asset tracking, automated checkout experiences, Electronic Shelf Labels (ESLs), inventory management, and proximity services, among many others, will combine to enable this digital transformation. However, a confusing and fragmented technology landscape underpinning this variety of use cases has prevented smart retail from reaching its true potential. This whitepaper seeks to highlight how this fragmented technology landscape is hindering innovation. It will look at how the adoption of standards-based technologies and an open ecosystem of partners will help reduce potential obstacles for retailers looking to invest in IoT technologies and lead the market to greater scalability while ensuring deployment longevity.

INTRODUCTION

The retail landscape is undergoing a vast transformation. The deployment of a number of IoT technologies are helping to digitize the physical store, resulting in smarter retail experiences for consumers while vastly improving the efficiency and accuracy of retail operations. Smart retail technologies are helping to accelerate the transition to omnichannel experiences and services, automate retail operations, optimize inventory, and help to address some of the key challenges facing the retail industry while meeting the evolving demands and expectations from consumers. By adopting these technologies, retailers hope to increase profitability via cost savings, increasing conversion rates, improving customer retention, and generating new revenue streams. At the same time, COVID-19 has had a tremendous impact on the retail landscape. Restrictions, lockdowns, and store closures across the globe have led to an unprecedented shift to online retail and e-commerce. According to the Office for National Statistics, in the UK, in January 2021 the share of online retail as a proportion of total retail sales reached a record high of 36.3%, growing from 19.1% in February

2020, nearly double its pre-pandemic number. Retailers are also facing tremendous shortages of staff on the store floor, mainly for handling operational tasks such as updating prices, resupplying shelf inventories, and checkouts. Retailers are now being forced to adapt and improve their e-commerce experience as a result, with many in-store retailers now turning towards IoT technologies in order to increase operational efficiency to better compete with online competitors and encourage customers to return to stores. By improving operational efficiencies, associates can be redeployed to engage more effectively with customers throughout the sales process, enhancing the customer experience and conversion through better service, wider choice, and upsell via endless shelf implementations.

Consumer attitudes to the in-store experience have also changed as a result of the pandemic. Not only is there a desire for swifter, safer, contact-free shopping experiences, but there is also an expectation that the in-store experience and product prices should match or go beyond what can be provided online, as consumers often use their smart devices to identify the best deals available to them in-store or online and in real-time. Consumers, many of whom recently converted to online, are expecting more than ever from their in-store experience, and as a result, there is more urgency than ever before for retailers to invest in smart retail technologies that can help to enable more interactive, connected experiences and increased engagement. On the retailer side, COVID-19 has also exposed vulnerabilities in inventory management and the supply chain. Smart retail technologies such as asset tracking, electronic shelf labels, and shelf monitors can help to enable better planning and real-time stock updates for in-demand items by ensuring shelves are replenished, prices can be adjusted dynamically, inventory is optimized, and waste is reduced. According to Zebra's recently conducted Global Shopper Study, 77% of retail executives said that the pandemic had accelerated implementation plans for smart retail devices and solutions.

Accelerated by COVID-19, the smart retail revolution will be enabled by a number of key use cases, including (but not limited to) the following:

Table 1: Smart Retail Use Cases and Key Enabling Technologies

Smart Retail Use Case	Description	Key Enabling Technologies
AR/VR Experiences	Smart retailers can leverage innovative AR/VR technologies to enable unique in-store user experience for customers. For example, car dealerships can utilize the technology to show customers potential alternative vehicles that aren't present or how a specific customization could look. This can allow customers to better understand the value of upgrades and additional features. Retailers such as Audi have embraced VR across many of its dealerships.	Wi-Fi, Bluetooth, UWB, 5G, Camera, Ethernet
Asset and Personnel Tracking	Deploying RTLS technologies such as tags that use Bluetooth technology can help retailers track all their valuable in-store assets and personnel. This helps to ensure that any valuable assets are not lost or stolen, that backend warehouse processes can become more efficient and automated, and that the safety of personnel can be tracked. For example, in emergencies, staff can be located more efficiently and accurately, staff can be more effectively deployed depending on their location or be sent to customer requiring assistance. Frequently used equipment can be tracked, and usage optimized, ensuring maximum asset utilization in backend warehouse operations.	Bluetooth, UWB, Visual Light Communications (VLC), Ethernet
Automated Checkout	Automated checkout systems enable customers to walk into a store, pick up their items, and walk out of the store while paying automatically. This provides much swifter, seamless customer experiences and enables staff to be reallocate to other areas of the store. Current examples of automated checkouts include Amazon Go stores. These typically require a combination of technologies including cameras and machine-vision, RFID for automated checkout.	RFID, Camera, AI, Sensor Function, Ethernet
Digital Signage and Smart Displays	Digital signage, kiosks, and smart displays enable customers to access a wide variety of information and features, including advertisements, personalized offers, the ability to customize products, store navigation, and even allow customers to pay for items. This can help increase conversion and enable to translate the online experience for customers to one in store.	Wi-Fi, Bluetooth, Biometrics, Camera, Ethernet
Electronic Shelf Labels	Electronic shelf labels (ESLs) are digital e-paper display devices that are capable of solving ongoing retailer issues like out-of-stocks, check-out expenditure reduction, manual price coordination, overheads elimination, inventory and store layout management, omnichannel consistency, and efficient price management of shrinkage/perishable goods. These displays embed wireless connectivity to connect to a centralized network to be updated up to several times per day. This enables retailers to introduce new features such as dynamic pricing, shelf geolocation and enhanced picking efficiency and accuracy. Increasingly, ESLs are becoming more intelligent and supporting technologies such as color displays for animated information by beacons that use Bluetooth technology for proximity services, QR codes, and NFC for consumer interaction and engagement. Future trends also include sensor integration, LED-flashing, and computer vision. Large-scale retailers including Walmart, Carrefour, Coop, and Tesco, as well as smaller retail shops, are already implementing the technology in some of their stores.	Proprietary 2.4 GHz and sub-1 GHz, Wi-Fi, Bluetooth, Infra-red, mid-Infrared communications, 802.15.4*, NFC (for proximity), RFID, LoRaWAN, Ethernet
Heatmaps and Traffic Analysis	In-store Wi-Fi analytics can be utilized to better understand customer behavior, such as how they interact with products, areas of high dwell time, bottlenecks, footfall, queue lengths, and other metrics. This information can be utilized to optimize product layouts, exposing customers to more products, or ensuring popular products can more readily be found, increasing average spend. This same Wi-Fi infrastructure can also help to optimize staff deployment by understanding what times are busiest and where staff would best be deployed in store.	Wi-Fi, Bluetooth, UWB, Camera, AI, Machine Vision, Ethernet

**Commonly known as Zigbee and recently re-branded as Connectivity Standards Alliance (CSA)*

Smart Retail Use Case	Description	Key Enabling Technologies
Indoor Navigation	Retail indoor navigation platforms can help shoppers to gather items on their shopping list in the most efficient manner or select a product and be guided to it instantly. This can help customers save time and provide a much more satisfying in-store experience. It can also help to minimize customers being frustrated at not being able to find the correct item they came in for.	Wi-Fi, Bluetooth, UWB, VLC, Ethernet
In-Store Wi-Fi Access	In-store Wi-Fi can help to enhance customer satisfaction, attract customers to the store, have customers stay for longer and visit more often, and boost customer engagement and loyalty with the brand, among other benefits. A robust Wi-Fi network can also help customers when they tap a shelf label to bring up more information on their smart device, such as product reviews, demonstration videos, and other valuable information to help conversion. In addition, in-store Wi-Fi can help to deliver valuable customer data, enabling new customers to be added to their existing customer data platform to help increase conversion.	Wi-Fi, Ethernet
Inventory Management	A combination of IoT technologies is helping retailers to better understand and optimize their inventory. Smart shelf sensors embedded with cameras and combined with machine learning can help to detect the level of stock on a shelf or within a refrigerator and alert staff when they need to be replenished. Weight sensors can also be leveraged to determine stock levels. Machine vision can also help to detect when people have picked up a product. Combined, these insights can help much greater visibility into real time stock levels and avoid over or understocking items compared to manual inventory management.	RFID, machine-vision, Wi-Fi, Bluetooth, Weight Scales, Ethernet
Proximity Marketing	Stores can leverage technologies such as beacons that use Bluetooth technology to deliver personalized messages and offers based on when they have entered the store or a specific location within it. For example, when entering a certain part of the store, a notification with a special offer could appear on the shopper's phone, giving them a unique discount code or notifying them of relevant offers based on previous interests. This can help increase engagement and brand loyalty.	Bluetooth, NFC, UWB, Ethernet
Robotics	Retailers are increasingly leveraging robotics technologies powered by AI, machine learning, and high-speed connectivity on the shop floor, enabling use cases such as shelf-scanning for inventory management, price-checks, and misplaced items, customer engagement, cleaning, and other emerging use cases. This can also help optimize in-store resources and allow staff to be deployed to more important activities.	Wi-Fi, 5G, UWB, Bluetooth, NFC, AI, Machine Vision, Ethernet
Smart Lighting	The transition to energy efficiency LED lighting infrastructure has the potential to transform the way we think about lighting, shifting it beyond a standalone hardware deployment toward a backbone network incorporating multiple services and IoT data streams. Lighting-as-a-Service (LaaS) models can help enable lighting vendors to offer these value-added services that go beyond energy efficiency lighting, minimizing CAPEX, while greatly strengthening their value proposition. For end users, once this advanced infrastructure is installed, the embedded sensors or indoor positioning network can be used to drive further benefits, including the deployment of indoor asset tracking solutions, indoor location, and wayfinding services, increasing customer interaction and personalized advertising, enabling better customer experiences, improving space utilization, driving operational efficiencies, enhanced security and building safety, and further driving down energy consumption.	Proprietary 2.4 GHz and sub-1 GHz, Bluetooth, 802.15.4*, VLC
Wireless Sensor Networks	A number of different sensor types can be leveraged to enhance the in-store experience and optimize operations. Wireless temperature sensors can be equipped to refrigeration units to ensure produce is stored at the right temperature to minimize spoilage. Motion sensors can detect the most active parts of the store or be used to dim the lighting when nobody is around, saving energy. Air quality sensors can be leveraged to provide consumers with a positive experience. Weight sensors can monitor inventory while sensors that detect when soap, hand gel, or paper towels need to be replenished can also provide a better customer experience.	Proprietary 2.4 GHz and sub-1 GHz, Bluetooth, 802.15.4*, Wi-Fi, Camera

While this list is not exhaustive, it is clear that the retail industry is undergoing an enormous transformation across a number of varied use cases. Combined, these efforts will lead to increased operational efficiency, better consumer engagement and interaction, and greater understanding of consumer behavior, resulting in significant cost reductions alongside increased revenue generation. However, as retailers begin to deploy these technologies alongside each other, they will need to ensure that the enabling solutions are able to work together effectively. Only then will the true potential of these smart retail environments be realized. However, as Table 1 demonstrates, the market is made up of a number of different competing end-to end solutions, often use-case specific, proprietary, and vertically integrated, which is currently making it difficult for retailers to invest in and scale up these use cases. These proprietary approaches are raising the barriers for retailers to digitize their business as these players don't want to lock themselves to specific technology suppliers at this very early stage of the market development.

RETAIL TECHNOLOGY OVERVIEW: THE STATE OF THE MARKET TODAY

As has been discussed, the smart retail market is comprised of numerous use cases serviced by a multitude of technologies. These include wireless technologies such as Wi-Fi, Bluetooth, CSA, proprietary 2.4 GHz, sub-1 GHz, NFC, UWB, RFID, LPWA, and cellular, as well as other technologies such as VLC, machine vision, ultrasound, ethernet, Edge AI, and infra-red, among many others. Table 1 has already mapped some of the major smart retail use cases to each technology.

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This choice of available technologies has understandably led to considerable fragmentation within the smart retail landscape. As a result, some retailers have held back in adopting IoT technologies for fear of a technology becoming obsolete, the need to deploy multiple infrastructures, an inability for devices to effectively communicate with each other, vendor lock-in, security concerns, and a lack of education or complexity in deploying a certain technology. Further compounding this fragmentation is the fact that many existing smart retail and other IoT solutions are built upon proprietary protocols that are locked to a specific vendor's chipsets, devices, or infrastructure. For example, in the electronic shelf label (ESL) space, most of the leading vendors are currently deploying proprietary IR, 2.4 GHz or sub-1 GHz ESLs, and compatible gateways/dongles. This includes the likes of Displaydata, Hanshow, Opticon, Pricer, SES-Imagotag, and Solum, among others. While these are specifically designed to address the ESL use case in a specific store, these vertically integrated solutions make it difficult for retailers to create a single smart retail ecosystem. The multitude of siloed solutions often do not operate with each other, make it hard for retailers to aggregate information across multiple ESL solutions or from multiple use cases to form a single framework. This makes it very complex for them to be able to deliver on horizontal interoperability between different smart retail use cases, making it difficult to combine various smart retail devices together, adding complexity to deployment, operation, maintenance, and management. This means retailers can only extract a portion of the potential total value of retail IoT deployments. In order to address the most relevant use cases and generate valuable customer facing and backend process enhancements, as well as take advantage of future innovations, this would require extensive work on the part of the retailer in piecing these disparate siloed networks together. Not only is this difficult and time-consuming to achieve, but it also opens up potential security and quality of performance issues.

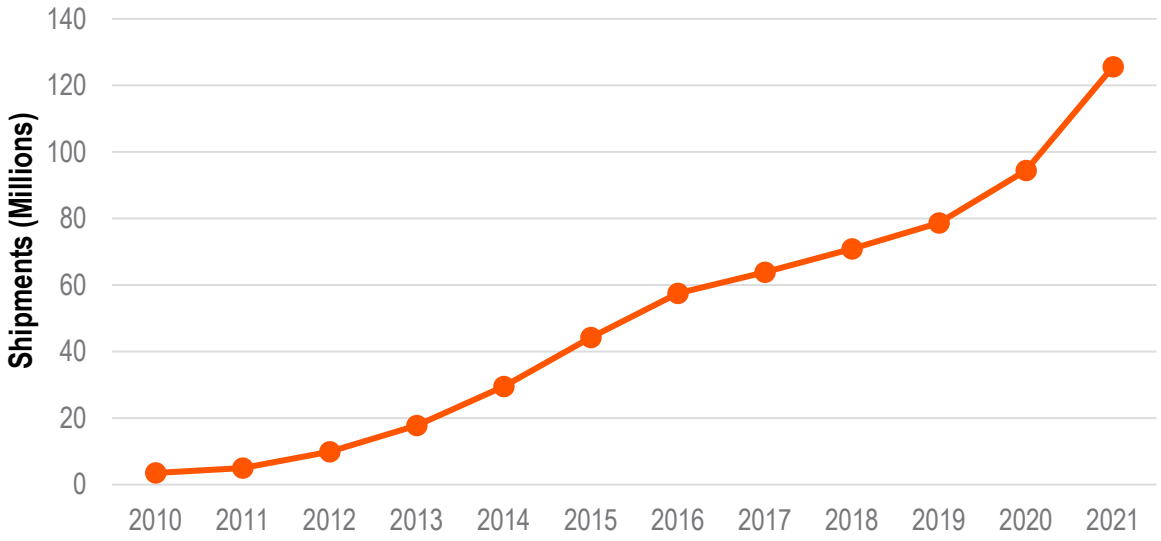
An alternative choice for retailers is to adopt an end-to-end solution across multiple use-cases from a single vendor. However, this option could lock the retailer into that choice and could potentially limit their ability to tap into innovation coming from the wider ecosystem.

As a result, this fragmented technology landscape combined with proprietary technologies means that retailers have been somewhat hesitant to adopt certain smart retail technologies with large scale for fear of vendor lock-in, technological obsolescence, and not being able to maximize their return on investment (ROI).

To illustrate this, let's have a deeper look at the ESL market. ABI Research expects the ESL installed base to reach 600 million by the end of 2021. This figure is derived from the cumulative shipments of major ESL vendors between 2010 and 2021 as shown in Figure 1.

Figure 1: Global ESL Shipments 2010-2021

(Source: ABI Research)



While the ESL installed base looks reasonably big, it represents less than a half percentage point of the potential addressable market, which means the entire ESL market is still largely a green field environment.

The issue of technology fragmentation has also been a challenge across many other IoT segments including the smart home, smart building, real-time locating systems (RTLS), and industrial IoT. There is a need to effectively integrate these diverse assets into a single platform that can extract the most value from the enormous amounts of data generated.

As more and more labels, tags, beacons, and sensors become connected in the retail market, this becomes increasingly complex, and requires the convergence of both IT and OT, alongside several other specialists. Retailers face the difficult challenge of rolling out different and varied technologies incrementally, while ensuring it is supported by a long-term retail IoT platform. Many disparate and independent systems will not be able to drive the same value as interconnected interoperable systems that can extract data in a meaningful way.

Furthermore, the IoT industry has been obsessed with technical performance metrics for some time, with constant comparisons around key areas such as accuracy, throughput, range, latency, and other metrics. While these are undoubtedly vital, what has often got lost within these discussions is that commercial performance indicators are of equal importance. How effectively a technology can be deployed and integrated, how it can help to form an ecosystem, how it can scale, how easily it can be managed and maintained, how it can interoperate with other technologies, how it is futureproof, and how it can maximize ROI are of equal concern to those wanting to deploy IoT technologies. Until these problems are solved, they will continue to hamper the IoT's potential. Ultimately, the retail market will support many different IoT connectivity technologies. However, as successful large-scale deployments increasingly rely on interoperability, information gathering, and sharing across many different use cases, retailers will need to avoid solutions that are incapable of working effectively with each other, and increasingly look towards open and modular platforms enabled by open standards.

CHALLENGES FACING THE MARKET AND HOW STANDARDS-BASED TECHNOLOGIES CAN ADDRESS THEM

The IoT and its various segments, such as smart retail, have been hampered by this technological fragmentation for some time. This spans across a number of markets including smart retail, smart home, smart buildings, smart cities, RTLS and location technologies, and the industrial IoT, among others. The consumer markets such as mobile devices and PCs which have embraced global standards-based frameworks and technologies such as Wi-Fi, Cellular, Bluetooth, and NFC, enabling various devices to connect and share information effectively. In contrast, the IoT has generally struggled to adopt universal standards which has resulted in limited scalability, security issues, interoperability challenges, fragmentation, confusion, and complexity. The proliferation of proprietary technologies that cannot effectively communicate or scale across multiple use cases via a single vendor's infrastructure is likely to prevent the formation of valuable smart retail ecosystems in the longer term. To date, this has limited the value of various ecosystems including smart retail.

Currently, there is no one-size-fits-all wireless connectivity technology that can adequately address the varied needs and requirements of the entire retail market. Technology choices for a particular application will depend greatly on its requirements and must be tailored specifically to the situational needs, which will depend on various metrics such as throughput, range, latency, coverage, scalability, robustness, reliability, power consumption, cost, mobility requirements, compute requirements, deployment density, flexibility, and security, among others. The vast majority of retail environments will require the use of multiple wireless connectivity technologies that can effectively communicate with each other in order to create truly intelligent use cases and leverage data from a number of different device types. This is where standards-based frameworks will have an increasingly vital role to play. This next section will elaborate on some of the challenges this is causing the retail market and the importance of standards-based technologies in helping to address them.

SCALABILITY

Proprietary technologies have their own advantages. They are often highly specialized solutions that can be heavily tailored to individual use cases to meet unique key performance indicators (KPIs) demanded by the retail market. For example, in the ESL world, proprietary solution providers can currently offer unique performance in terms of low latency, supporting up to 1000 simultaneous ESL updates per minute, with a capacity of up to 10,000 ESLs per access point, and a battery life lasting multiple years. However, these solutions are normally offered by a single vendor that is developing their own products and proprietary solutions. Realistically, this will limit the number of retailers they can support and potential markets they can address. Indeed, these vendors are often forced to customize their offering in line with the various requirements from different retailers, taking into account the topology of their store, the density of products supported, the integration with their IT, OT systems, and other IoT systems implemented, as well as compliance with their safety policies and other requirements. All these burdens of customization mean that these players cannot address demand adequately, which often limits their supply capacity while enhancing the cost related to implementing their solutions on the retail floor. In addition, these vendors will also have to take on the burden of developing their technology over time. In contrast, standards-based solutions will meet specific requirements regardless of vendor, chipset, or region. By enabling retailers to choose between multiple available solutions, this will greatly boost overall de-

mand and allow solution providers to increase production while taking advantage of the economies of scale of various wireless technologies. These can help to fuel more scalable adoption across the globe, reduce costs of solutions, and reduce the time it takes for solutions to get to market. Over time, as more standards-based solutions emerge, retailers will unlikely want to be locked-in to less futureproof and more expensive solutions that do not scale as effectively.

Leveraging standards-based technologies also help to enable greater economies of scale thanks to wider availability of solutions, multi-vendor sourcing, and increased competition. Technologies such as Bluetooth, Wi-Fi, NFC, and CSA have all benefited from being available from a large number of chipset and module suppliers, resulting in a highly competitive and low-cost device market across many use cases. The proliferation of these technologies within a wide number of low-cost IoT devices is testament to this. In contrast, single-supplier proprietary technologies will be unlikely to compete on cost when compared with these entire ecosystems, while standards-based technologies such as Bluetooth, Wi-Fi, NFC, are also well entrenched in mobile devices, enabling unique methods of customer and personnel interaction that other proprietary technologies cannot support.

HESITATION OVER TECHNOLOGY CHOICE

Given the vast range of technologies to choose from, many of which are proprietary, it is unsurprising that some retailers are concerned about making the wrong technology investment. Retailers do not want to invest in a technology or vendor that may become obsolete or that won't be able to compete in the longer term. By investing in standards, this enables retailers to choose from the very best vendors, have more visibility on technology roadmaps, avoid any potential lock-in, and allows them to take advantage of future innovation from other vendors on the market without ripping up the existing deployment. This will remove further barriers to adoption and help scale the market further.

This is essentially the same issue that has previously plagued the smart home. Consumers were unsure what technologies and product to adopt as they did not want to risk investing in a technology that would become obsolete. Today, much of the smart home is now converging around Wi-Fi, Bluetooth, and CSA based technologies and standards that can be effectively integrated into smart home platforms, gateways, and voice control devices. These platforms embed multiple standards-based technologies and have helped scale the market. At the same time, consumers who invested in proprietary smart home solutions were unable to adopt products using different standards that brought innovative features. As a result, they could not maximize the potential of their solution which hindered growth for some time. According to ABI Research, by 2030, standards-based solutions are expected to account for over 94% of all smart home device wireless IC shipments, growing from 86% in 2020.

Retailers now face this same challenge – how to invest in a technology that is able to address all of their needs and avoid being tied down to a single vendor that controls all product innovation and cuts them off from a wider standards-based market which may innovate more quickly, be lower in cost, and offer unique value propositions.

RISK OF VENDOR/TECHNOLOGY LOCK IN

By locking oneself into a single vendor's proprietary technology, this means that retailers will not be able to take advantage of other vendors on the market who are innovating by offering unique value propositions on cost, performance, scale, services, or other key metrics. In contrast, standards-based technologies continually evolve thanks to collaboration and competition from a wide range of industry leaders who are well versed in the ever-changing demands of a particular retail use case. This means that standards may add new features over time, continually enhance their offering, and go beyond what proprietary technologies can offer. These standards-based frameworks are also designed to address both existing and future use cases, while not being subjected to any potential risk of a solution provider disappearing or exiting the market. This allows retailers to select from a wide range of innovative products that best suit their needs and have confidence that investing in standards will be able to support them both now and in the future. By leveraging standards-based technologies, retail product designers are able to take advantage of solutions from multiple industry players that continue to innovate. For example, there are many Bluetooth chipset and module suppliers that continue to innovate in key areas around size and power consumption, while the technology continually adds support for new features and functionalities via the Bluetooth SIG and its members. Wi-Fi, likewise, continues to evolve through the IEEE to bring new enhancements via Wi-Fi 6 and 6E. Standards-based technologies also continuously evolve to support the latest security enhancements, reducing the potential for disruption to in-store networks and IoT deployments as they grow over time.

INTEROPERABILITY

As retailers increasingly deploy many of the aforementioned smart retail use cases, including asset and personnel tracking, automated checkout, ESLs, loss prevention solutions, and wireless sensor networks, among others, the interoperability of these diverse use cases will become increasingly important. Standards-based technologies will help to ensure interoperability between these different facets while also allowing considerable product differentiation. This means that retailers can pick and choose solutions that are more closely tailored to their specific needs and ensure that they maximize their ROI on any investment. Similarly, for product designers, by leveraging

standards-based technologies, they can focus more development time on differentiating their product from the competition rather than the enabling technology itself. Solution providers can build tailored software on top of the standards themselves to enable additional use cases or unique functionality. In addition, standards-based technologies can help to minimize potential interference for multi-use case deployments.

MULTI-USE INFRASTRUCTURE

In contrast to proprietary technologies which have traditionally required a separate overlay network to service a single use case, standards-based technologies can help retailers develop a much wider use case ecosystem via a single infrastructure. As the smart retail landscape grows in complexity and expands to support new use cases over time, it will be far too complex to deploy multiple disparate networks each with their own single infrastructure. For example, a retailer who wants to deploy multiple use cases such as asset tracking, automated checkouts, beacons, camera/machine vision, ESLs, and loss prevention for enhanced shopper experiences will need to invest in separate infrastructures. In contrast, open and standards-based solutions will enable them to establish an ecosystem capable of addressing all pain points and use cases. By deploying a futureproof backbone network using standards-based technologies, retailers can expand their services over time and compound the ROI on the initial investment. This means that additional use cases that may have struggled to justify their own separate infrastructure can now more readily embedded alongside other use cases which have clearer ROIs. Retailers can therefore get ROI from a single use case while incorporating others over time. Once this standard communication infrastructure is in place, it will help to enable smart retail ecosystems and new valuable services for backend and customer facing processes. For example, deploying a standards-based ESL infrastructure has clear ROI on price automation and reduced labor costs. However, this same infrastructure could also be used to deploy wireless sensors that track air quality, temperature, and motion to optimize in store efficiencies. It could also be used to control the lighting network to minimize energy usage or deploy proximity beacons to increase customer engagement. These solutions may have been unable to scale on their own merits. With many Wi-Fi access points (APs) now embedding standards based IoT technologies, this can help to streamline deployment further.

IMPLEMENTATION COMPLEXITY

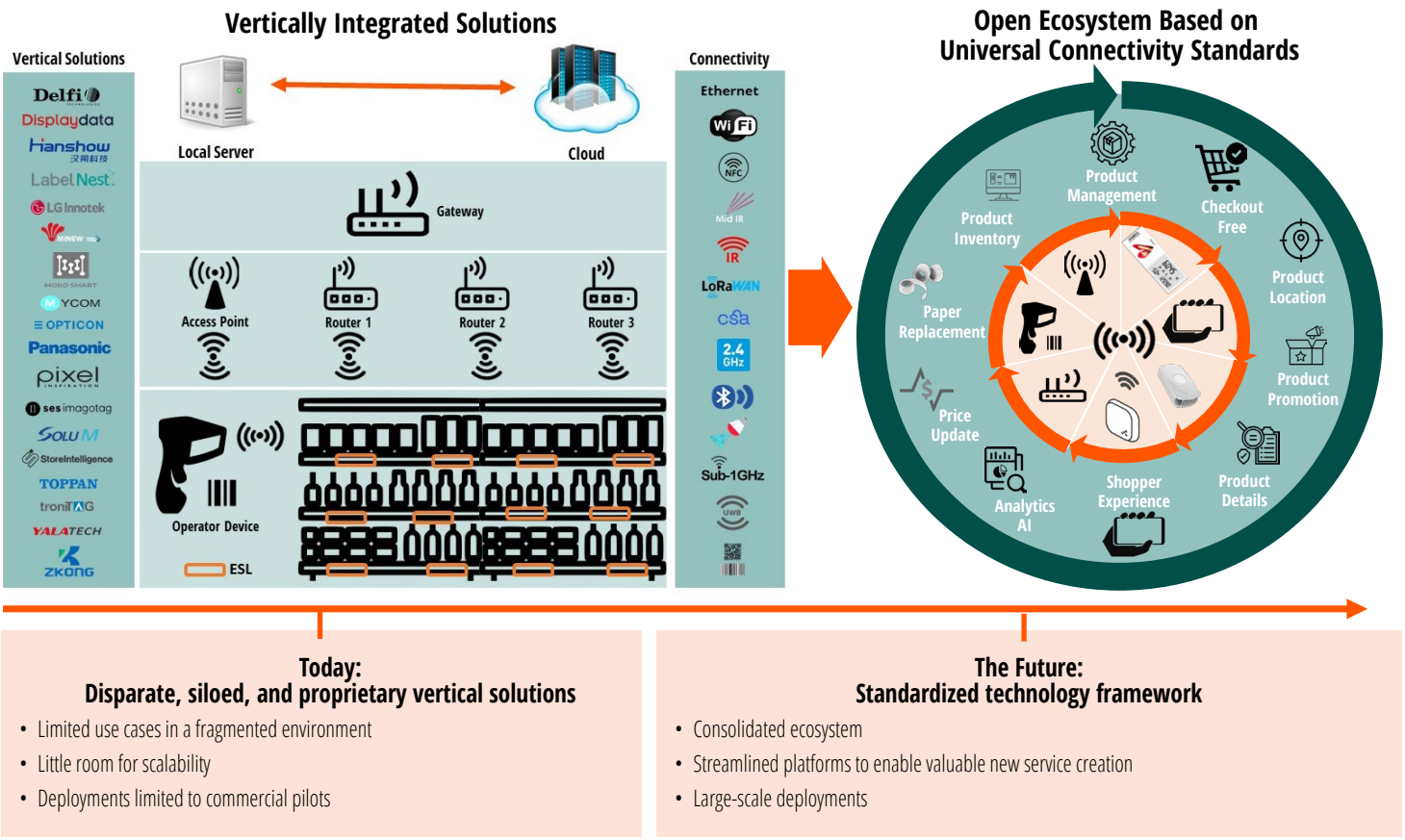
Retailers who adopt proprietary solutions are faced with more complex implementation challenges. These will often require the deployment of a discrete network infrastructure such as gateways and transceivers that enable their solution to work effectively. This is further exacerbated when needing to support multiple different use cases. Retailers will have the difficult challenges of implementing, integrating, managing, and maintaining multiple different technologies. Over time, as retailers support more use cases and want to extract as much data as possible, they may find that it is extremely difficult to deploy.

Many proprietary solution providers have partnered with Wi-Fi AP vendors to help deploy their equipment more easily across many different environments. For example, in February 2020, Juniper Networks announced that it partnered with a number of UWB and ESL vendors in order to help accelerate the rollout and eliminate the need for additional cabling and power. However, as each of these vendors offer proprietary products that do not interoperate with each other, retailers are still locked in to choosing a specific vendor's product portfolio. It will also be very difficult for networking vendors to partner with all the different proprietary implementations of each solution provider. Instead, by integrating standards-based technologies such as Bluetooth and CSA, this ensures the Wi-Fi AP will be able to communicate with a much wider range of solutions and enable retailers to pick their own partners while at the same time reducing the overall implementation complexity. By adopting standards-based smart retail solutions, retailers can more seamlessly integrate multiple retail use cases into the same infrastructure without the need to deploy lots of different proprietary networks.

The current market landscape is made up of lots of technologies solving lots of use cases. However, using a separate technology for each smart retail use case will become problematic as these begin to scale. Not only will it become very hard to integrate with IT/OT, but it will also be more difficult to manage and extract the full value of these deployments. Disparate systems that do not interconnect effectively will not be able to achieve the full potential of standards-based solutions that can effectively communicate and share information. These will be able to link different aspects of the business and unlock data that was previously irretrievable. This will enable retailers to find new efficiencies and links between difference use cases and create ways to improve the business that siloed implementations are not capable of. This will allow for the easier implementation of new smart retail use cases that have yet to be thought of which will help retailers maximize the ROI of their infrastructure rollout over time. In addition, end-to-end standards-based deployments can help to minimize gaps in security caused by these fragmented systems, as well as help to reduce any quality of system (QoS) pain-points via overlapping networks that can't communicate effectively. Figure 2 below shows this transition from vertically integrated solutions towards more open ecosystems based on universal connectivity standards. By using this framework, retailers can more readily plug in additional use cases as they develop over time.

Figure 2: The Transition to Standards-Based Frameworks Within Retail Applications

(Source: ABI Research)



COMMON APPROACHES TO STANDARDIZATION

There are a number of common approaches to the formation of end-to-end standards frameworks and ecosystems. Organizations such as the 3GPP, Bluetooth SIG, IEEE, Wi-Fi Alliance, FiRa Consortium, and NFC Forum, among many others, each have their own unique approaches to development of technical specifications and standards. What is common between them is that they rely upon contributions from various member organizations to develop enhancements to the existing specifications. Due to their complexity, they are often split up into many different sub-groups, enabling vendors to make contributions to specialist areas to ensure continued innovation. For example, within the Bluetooth SIG, numerous working groups have enabled the technology to adopt new features such as Bluetooth Mesh, Direction Finding, and LE audio. Within the IEEE 802.11 working group for Wi-Fi, various task groups build upon basic concepts via contributor submissions then come to common consensus on what features should be implemented and how this should be achieved. This helps to ensure products meet required functionality, can interoperate with solutions from other vendors, and meet stringent security and privacy requirements. For example, new features such as Wi-Fi 6, Wi-Fi Halow, and Wi-Fi 7 all stem from contributions task groups within the IEEE 802.11 working group. Similarly, within the 3GPP, various contributors come to common consensus around what features should be supported in upcoming Releases. Companies submit technological proposals which are discussed, adopted, or rejected based on consensus. These processes ensure that standards-based technologies continue to innovate, that essential new features are added in a timely fashion, and that new use cases are able to flourish and emerge. Vendors adopting these standards can differentiate further on top of these standards to provide their own unique features, driving further innovation while ensuring compatibility with the wider market. These standards allow for vibrant ecosystems to develop, for new products to come to the market, and for global scalability and interoperability.

It is clear that adopting standards-based connectivity have numerous advantages for retailers. Using standard-based solutions will enable retailers to take advantage of large economies of scale these technologies are creating cross multiple mobile and IoT markets. It will also enable them to align their technologies with the most innovative trends the mobile market is enjoying and create synergies with other use cases such as instore-location, proximity services, checkout free payment, etc. This paper will now examine the Electronic Shelf Label use case to further illustrate how standards-based solutions can bring benefits. With the deployment of ESLs matching the retailer stock-keeping unit (SKU) count, ESLs are likely to represent the largest number of connected devices within the in-store environment. Many retailers have already deployed tens of thousands of ESLs per store, while in larger retailers this could extend to beyond 100k radios in each store. Potential standards activities for ESLs using Bluetooth technology, for example, will no doubt help this market scale further.

CASE STUDY: STANDARDIZING ELECTRONIC SHELF LABELS VIA BLUETOOTH LOW ENERGY

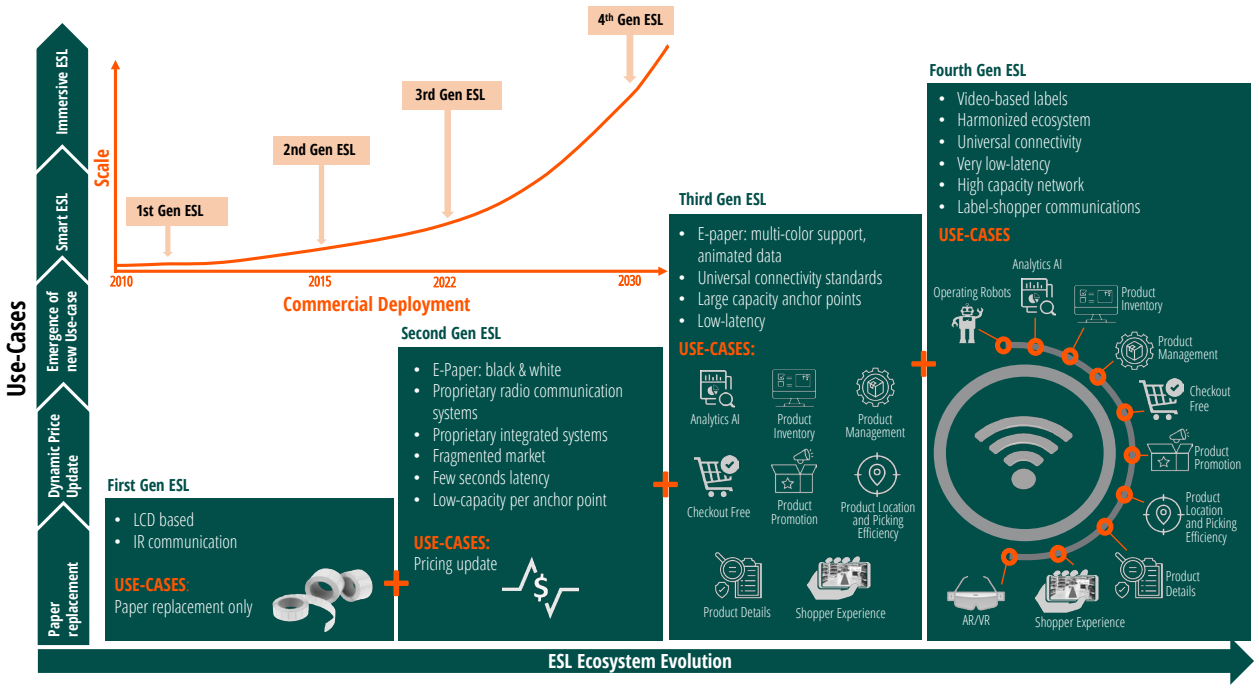
The retail market is increasingly adopting Electronic Shelf Labels, typically wireless-connected, battery-powered displays that contain information such as pricing, offers and promotions, inventory status, and product details. Embedded with low-power wireless connectivity technologies, these devices communicate with the store network to enable automatic updates of this valuable information. ESLs can enable tens of thousands of shelf labels to be updated within a very short periods of time, eliminating the lengthy time spent by retail staff in printing and replacing paper labels, allowing staff to focus on more important tasks, reducing waste, and improving price accuracy, while enabling new features such as dynamic pricing. In the post-COVID-19 world, removing manual updates of pricing information is increasingly desired to avoid unnecessary physical contact with shelves and the inventory to help protect staff and customers. At the same time, thanks to this related shift towards online retail post COVID-19, there is also a greater expectation from consumers that prices are aligned with what is online. By enabling multiple pricing updates per day, this enables the in-store and online pricing experiences to be closer than ever before. Retailers can also more readily adjust their pricing across their whole store network to support holidays or other promotional events without placing significant burden on their staff who can be reallocated to more useful tasks, such as enhancing the overall shopper experience.

Before discussing how the ESL market is evolving, it would first be beneficial to discuss the current market landscape. The following points highlight where ESL is today:

- The ESL market is currently dominated by vertically integrated proprietary solutions.
- The commercial availability of ESLs has been there for over a decade, but the market is struggling to reach large scale.
- The market is crowded with over 20 ESL suppliers in addition to over 40 software vendors, infrastructure suppliers, and distributors.
- There are dozens of wireless technologies being deployed to enable ESLs, most of which are proprietary technologies tied to a single vendor.
- The market has reached less than 1% of its total addressable market, and from this perspective it should be considered as a green field market sector.
- Retailers are still very much in the proof of concept and early pilots of commercial deployments, reluctant to deploy the technology at large scale or across their entire retail chains. Most retailers are partnering with multiple ESL vendors and diversifying their supply of ESLs to ensure they are not trapped into a single vendor. However, this makes it difficult to consolidate their supply and distribute this across their whole portfolio of stores. For example, Coop have partnered with Pricer, SES-Imagotag, Delfi, Hanshow, and Zkong, among other smaller players, while Carrefour has partnered with Pricer, Solum, and SES-Imagotag, among others.

Figure 3: Evolution of the ESL Market

(Source: ABI Research)

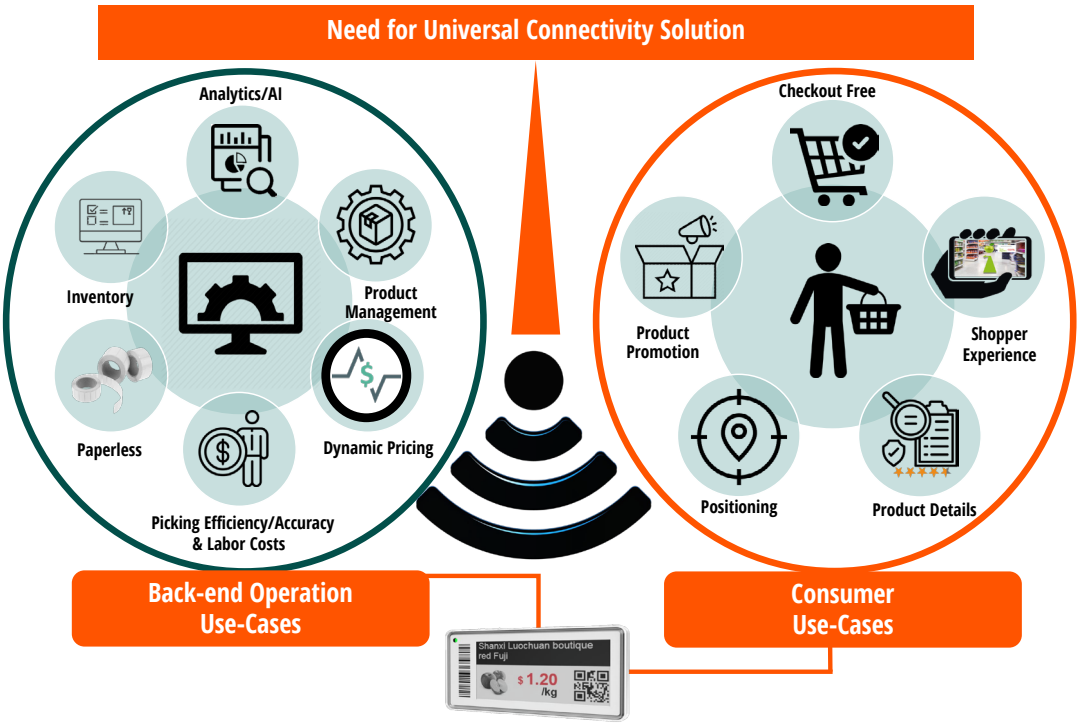


As Figure 3 above demonstrates, the first generation of ESLs were more basic LCD solutions with restricted functionality limited to pricing updates alone. However, the ESL market is continuously evolving to support new features and functionalities. The majority of solutions have shifted to e-paper displays, many of which now have support for multiple colors. Other solutions have begun to integrate LED lighting to help speed up and improve the accuracy of order picking, replenishment, and product finding. Meanwhile, by leveraging interactive technologies such as NFC tags and QR codes, personnel and customers alike can tap or scan the ESL with their smartphone or handheld scanner device to receive additional product information, such as full specifications, educational videos, product reviews, loyalty schemes, and personalized discounts, or potentially even pay for products at the shelf via their mobile payment platform of choice. Further innovative ESLs support more advanced IoT capabilities such as integration of beacons that use Bluetooth technology, sensor integration, and video displays. For example, certain ESLs from Displaydata's portfolio include embedded beacons that use Bluetooth technology, enabling the labels to push targeted, personalized, and contextually aware promotions to the customer's smartphone via the retailer's app. This enables retailers to deploy a beacon network that uses Bluetooth technology without the need to deploy an entirely separate beacon infrastructure, reducing cost and management complexity, as well as enabling a multi-functional densification of any existing beacon deployments. Other prominent retailers, such as Kroger with its EDGE ESLs, leverage Bluetooth technology to enable the labels to interact with the shopping list on a customer's device, lighting up the relevant product next on the list. Their solutions also incorporate Wi-Fi and CSA standards alongside Bluetooth technology for additional functionality.

It is clear then that ESLs are becoming increasingly advanced and moving away from standalone products that automate prices to multi-functional IoT solutions that will provide a number of benefits across both consumer-facing and backend operations. Figure 4 below highlights how this combination of benefits across both areas will provide compelling incentive for retailers to invest in ESL technology.

Figure 4: Smart ESL Use Cases for Back-End and Customer Facing Environments

(Source: ABI Research)



Many incumbent ESL vendors today have seen strong success thanks to the ability of ESLs to reduce labor costs. As a result, ESLs have unsurprisingly primarily been implemented in regions and countries such as France, Switzerland, and Scandinavia, which typically have higher labor costs than other areas. Much of this market has been dominated by a few ESL vendors with a combination of proprietary Infra-Red (IR), 2.4 GHz, and sub-1 GHz wireless connectivity technologies being leveraged as the ESL connectivity technology. However, as Figure 3 and Figure 4 demonstrate, the ESL market is evolving rapidly to provide benefits that go much further than pricing automation and reduction in labor costs, instead seeking to enable a variety of back-end and consumer facing smart retail applications. This includes increased consumer engagement, location and proximity services, personalization of shopper experiences, automated checkout, omnichannel coordination, dynamic pricing, optimized inventory management, improved understanding of customers, loss prevention, and enhanced safety and security.

As aforementioned, these will become increasingly essential in order to attract consumers back to the store in the post-COVID-19 world while maximizing operational efficiency and profitability for retailers.

This will require a strong connectivity infrastructure that is capable of gathering information from many different in-store use cases in order to maximize ROI and aggregate this effectively into various smart retail platforms. As a result, there is likely to be increasing traction for standards-based connectivity technologies within ESLs that can more effectively scale across different regions. While the market is growing today, it has barely scratched the surface of its potential addressable market. Proprietary solution providers are unlikely to be able to address the entire market, while scalable standards-based wireless connectivity technologies will be fundamental in enabling the market to reach its full potential. Smart retail infrastructures that can support multiple standards-based technologies will be increasingly attractive in order to futureproof smart retail deployments. This will enable ESLs to become just one part of a wider smart retail wireless network that is able to aggregate and analyze data from a number of different use cases and devices to generate more intelligent insights and services. One such standards-based technology that could enable this is Bluetooth Low Energy.

WHAT CAN BLUETOOTH LOW ENERGY BRING TO THE ESL MARKET?

Various stakeholders within the connectivity and retail industries are working together to develop a standards-based Bluetooth technology solution for ESLs. Instead of using a single-use proprietary technology or discrete overlay network for ESLs, an ESL Network that uses Bluetooth Low Energy technology would be able to connect to existing Bluetooth Low Energy enabled Wi-Fi access points or other in-store Bluetooth technology networking devices as part of the lighting, beacon, or sensor infrastructures. There are a number of potential advantages of using Bluetooth Low Energy technology for ESL and other smart retail use cases, including the following:

STREAMLINED DEPLOYMENT

The vast majority of enterprise Wi-Fi access points already include embedded standards based IoT technologies such as Bluetooth Low Energy, with many now also including CSA. This includes solutions from the likes of Cisco, Aruba, Juniper, Extreme Networks, Lancom, and Huawei, among many others. As a result, deploying ESLs with Bluetooth technology as the wireless networking technology will require minimal additional investment into a dedicated ESL infrastructure that uses Bluetooth Low Energy technology, reducing the cost and complexity of deployment. This is in contrast to proprietary technologies which have traditionally required a discrete network of transceivers in addition to the wireless AP in order to deploy the ESL network. According to Cisco, there will be nearly 628 million public Wi-Fi hotspots by 2023, with retail establishments expected to have the highest number of hotspots. With most retail environments likely to support a Wi-Fi and Bluetooth Low Energy technology infrastructure, this could allow ESL solutions that use Bluetooth technology to be more simply deployed than proprietary solutions. This also helps to reduce deployment and maintenance costs, improves the speed of rollout, and increases the scale of the potential market. However, some ESL vendors using proprietary technologies have successfully partnered with leading Wi-Fi AP vendors to embed their technology or support add-on dongles to help ease deployment challenges of a discrete proprietary network. This includes the likes of SES-Imagotag and Solum.

ABILITY TO ACCOMMODATE MULTIPLE USE CASES

By leveraging Bluetooth Low Energy technology, not only can the infrastructure be used to enable ESLs, but the same infrastructure can accommodate multiple additional Bluetooth Low Energy technology use cases including wireless sensor networks, beacons and proximity services, asset and personnel tracking, POS connectivity, and lighting and building controls, among many others. The same Bluetooth network used to connect the ESLs can also be deployed to support sensors that use Bluetooth Low Energy technology for monitoring the temperature of refrigeration units to ensure food remains fresh, track motion and traffic, engage with customers via beacons that use Bluetooth technology, detect ambient light and dim the lighting to save on energy bills, monitor air quality, monitor inventory, and create other valuable backend and customer facing efficiencies and services. This has the ability to drastically increase the value of a smart retail deployment's ROI while minimizing the cost and complexity of managing multiple use cases.

DENSIFICATION OF INFRASTRUCTURE AND ECOSYSTEM ENABLEMENT

Deploying ESLs that use Bluetooth Low Energy technology has the potential to enable a dense in-store network infrastructure. In the past, some retailers may have struggled to justify deploying a dedicated beacon or sensor network that uses Bluetooth technology due to unclear ROI. However, by deploying an ESL infrastructure that uses Bluetooth technology, retailers can get clear ROI on pricing automation and labor cost reductions while at

the same time using this highly dense deployment of ESLs to provide beacon capabilities. This will allow for the formation of a scalable ecosystem that uses Bluetooth technology that can move beyond single use cases and instead provide multiple tangible benefits. This will allow for ROI to stretch much further beyond pricing automation and lead to increased customer conversion and enhanced operational efficiencies. Single use cases that may not have scaled on their own merits can be combined to maximize ROI.

INNOVATION AND NEW ENTRANTS

While the ESL landscape has been dominated by proprietary solution providers, the availability of a standards-based ESL solution will help new solution providers to enter the market. This democratization and increased competition within the ESL market could lead to much faster innovation via new features, reductions in cost, increased awareness in the overall ESL market, and greater adoption within different regions. Various industry stakeholders will come together within the standards organizations to identify the primary requirements of the industry and help develop strong collaborative solutions. This will also lead to increased competition, additional value-added services to be created above the standard features and give retailers flexibility to choose which supplier's best fit their specific requirements. This allows for more tailored solutions rather than a one-size fits all approach that may be holding back adoption today. Underlying standards will also help shift the focus towards value-added features rather than core functionality, spurring additional innovation.

SCALABILITY

Though the market is dominated by proprietary technologies today, the market is seeing strong growth and existing solution providers offer very compelling product portfolios of ESLs. Many leading vendors have reported strong growth even during COVID-19. However, reaching the next level of scale — to hundreds of billions of shelf labels globally — is unlikely if retailers are tied to the product portfolios of a few proprietary vendors. Retailers across the globe will be at the mercy of a single supplier's proprietary technology and the fortunes of a single company. Any disruptions faced in the company's supply chain could negatively impact the market growth and retailers may be hesitant to tie their future plans to a single company which could decide to exit the market or no longer support a product. In contrast, by standardizing ESLs, retailers can benefit from the huge number of Bluetooth technology vendors, chipset suppliers, software developers, system integrators, and other industry players that continue to grow and evolve. By 2026, ABI Research forecasts that there will be nearly seven billion annual shipments of devices using Bluetooth technology, that are currently scaling up across a wide range of consumer and IoT applications.

COST

Retailers can also benefit from the enormous economies of scale that Bluetooth technology can rely on. Proprietary solution providers are unlikely to be able to compete with a deeply competitive ecosystem of Bluetooth tehnology solution providers once the technology is standardized. Bluetooth technology's availability from a number of chipset providers have rapidly driven the costs down, while competition from providers of ESLs that use Bluetooth technology will ultimately drive down the cost of the solutions. This may be essential in regions where labor costs are less of an issue and a primary driving factor is the ability to automate pricing alongside other benefits, such as increased consumer engagement and conversion. Retailers may be hesitant to lock themselves in to a single vendor's more premium product offering when more attractively priced alternatives will be available.

INTEROPERABILITY AND VENDOR LOCK IN

One of the major benefits of using a standards-based technology such as Bluetooth technology is it gives retailers the flexibility and choice to buy products and solutions from one vendor knowing that it will work with those from another. This allows them to tailor the solution to their specific needs and gives them the ability to choose their preferred supplier without losing out on potential innovations from other vendors. If a vendor falls behind on their promises or starts to lag behind the competition, the retailer is able to switch over to a different vendor without the need to deploy an entirely new infrastructure. Furthermore, as retailers increasingly deploy other smart retail technologies including wireless sensors, lighting controls, and beacon infrastructure, this will minimize friction in enabling an interconnected smart retail ecosystem that can provide additional benefits and ROI beyond a single use-case. The use of proprietary solutions for individual use cases will make it difficult to form a coherent, interoperable smart retail ecosystem. Retailers will have the flexibility to choose both the ESL provider and AP provider of their choice rather than being limited to vendors who are compatible with a specific proprietary solution.

FUTUREPROOF

Bluetooth technology standards have evolved over many years to support many new features, while the technology itself has been continuously improved. For example, Bluetooth 5.0 brought a 4x increase in range, doubled the throughput to 2 Mbps, and significantly increased the broadcast capacity. For retailers, there has been some hesitation in deploying solutions due to the promise of something better in the future. By leveraging standards-based solutions such as Bluetooth technology, vendors have more visibility on the technology roadmap, including performance and features that can be upgraded over time as various innovators contribute to the publicly available specifications. There is not a need to build totally new infrastructure, but the deployed infrastructure will be able to incorporate additional and improved features as they evolve. What is supported today may evolve to support some future smart retail use cases currently unheard of. This will also allow ESLs that use Bluetooth technology to be one component of a wider network of in-store smart retail applications. While proprietary solutions enable specific problems, such as pricing automation, to be solved today, futureproof standards-based infrastructures will lay the foundation for additional problems to be solved and for new services to be created over time, unlocking further value and ROI. As a result, once these standards-based solutions emerge, this may remove any lingering hesitation in adopting ESL technology.

FAMILIARITY

Standards based technologies such as Wi-Fi, Bluetooth, CSA, and NFC are all household names. There is likely to be less hesitance among retailers in adopting these technologies as they have been around for a long time, continue to innovate, offer strong interoperability, and have proven their security and scalability across many consumer and IoT applications. Standards such as those for Bluetooth technology and Wi-Fi also provide extensive testing, certification, and interoperability programs to increase confidence in buying end products. The presence of these technologies within mobile devices and other ecosystems opens up unique additional use cases for retailers that proprietary technologies are unable to support.

SUMMARY

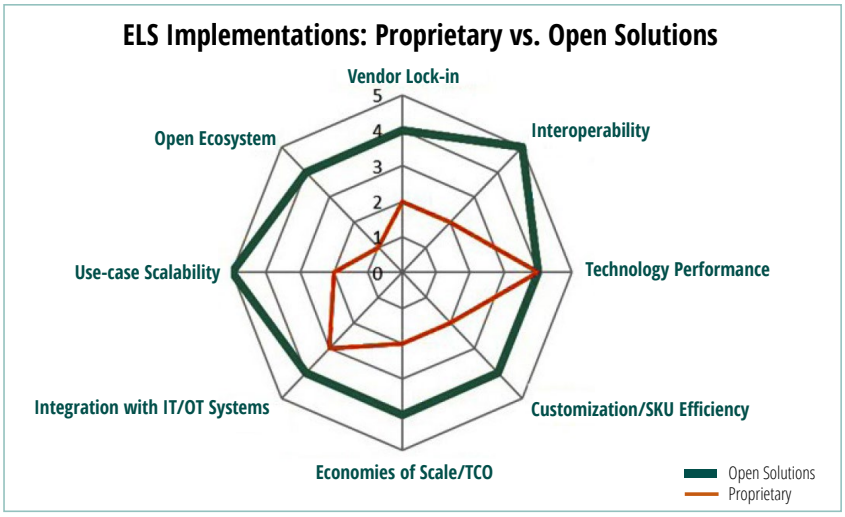
As Figure 5 shows, retailers increasingly desire open standards for a variety of smart retail use cases. Those hesitant to adopt proprietary solutions today are likely to be increasingly convinced by standards-based ESL technologies that can meet their KPIs beyond performance. Decisions will ultimately be made on how well a solution can reduce the total cost of operations (TCO), scale effectively, reduce vendor lock-in, be futureproof and tailored to meet specific needs. The solution should enable a more open smart retail ecosystem that can incorporate a number of use cases to generate further ROI and new ways of innovating. Standards-based solutions will help to remove any remaining friction for retailers looking to invest in smart ESL technology.

Figure 5: Key Requirements for Successful ESL Implementations

(Source: ABI Research)

Retail Solutions' KPIs Beyond Technology Performance

- **Open Ecosystem:** Developers, low barriers to innovation, roadmap visibility
- **TCO:** Economies of scale, implementation cost, maintenance cost, operation costs
- **Use-case Scalability:** End-to-end solutions, well integrated framework, futureproof solutions, simplifying the complexity of the technology, fast time to market for new use-cases
- **Vendor Lock-ins:** Ability to mix and match technologies to address key pain points, interoperability, easy integration with any IT/OT system
- **Low Barriers to Customization:** SKU efficiency, solutions tailored to pain-points they are addressing

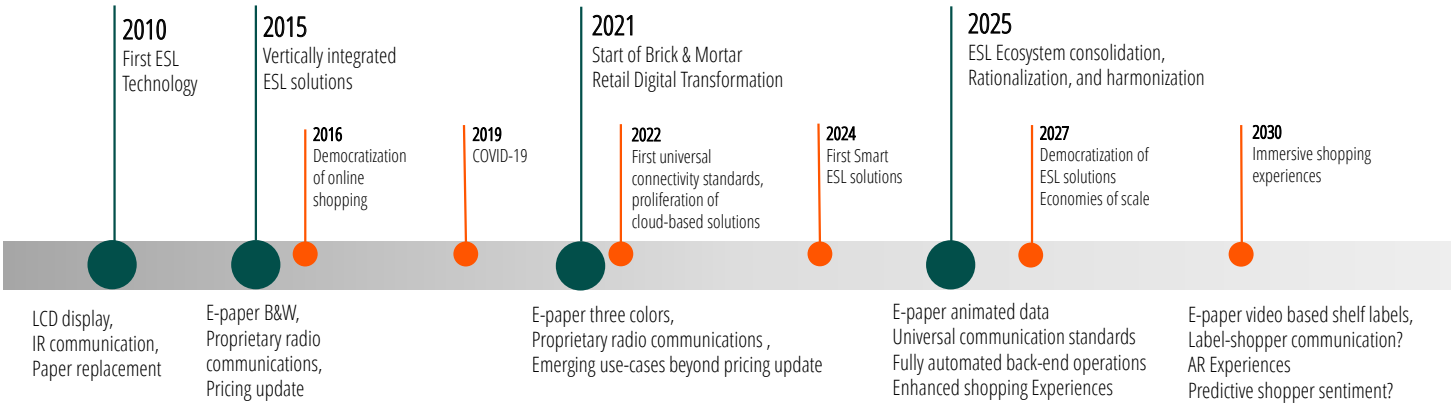


Work is therefore underway to standardize ESLs, with the first solutions likely to arrive in mid-2022. As Figure 6 shows, once these solutions arrive, ABI Research expects that this will lead to much more intelligent ESL solutions that can combine with wider smart retail use cases to create economies of scale, more immersive experiences,

and smarter ESL deployments that can combine back-end efficiencies with innovative customer facing experiences. Combined, these efforts will help to scale up the ESL market beyond what it has been able to achieve today.

Figure 6: ESL Market Timeline

(Source: ABI Research)



However, ESLs that use Bluetooth technology will still face a number of challenges. Firstly, many of the existing proprietary solution providers offer unique performance KPIs that are more tailored to the specific needs of retailers. ESLs that use Bluetooth technology will need to match their ability to quickly update thousands of labels with very low latency and without significantly impacting the battery life of the ESLs. In addition, interference mitigation techniques will need to be effective in ensuring that ESLs do not diminish other in-store connectivity deployments using the 2.4 GHz band whether on Wi-Fi, CSA, or Bluetooth standards. This standard is also not yet available and may take some time to build awareness in the market and for new or existing vendors targeting this space to emerge or transition to Bluetooth technology.

CONCLUSIONS AND STRATEGIC RECOMMENDATIONS

This whitepaper has highlighted how the retail landscape will evolve to support new use cases to help optimize operational efficiencies, develop new omnichannel experiences, and increase customer engagement and loyalty, all of which are increasingly vital in the post COVID-19 retail world. ESLs are one aspect of this innovation. These devices are increasingly becoming the smartphone of the retail space, incorporating multiple different connectivity technologies and features that will help to generate value and efficiencies in both backend and customer facing applications. While this market is growing today, it has been dominated by a number of different proprietary technologies and as a result it has a long way to go before ESLs are deployed in a much wider range of stores around the globe. As has been demonstrated, these solutions will enable the market to grow to a few hundred million units per year but will still find it difficult to enable the potentially of hundreds of billions of shelf labels around the world to be digitized. Moreover, these proprietary implementations may make it difficult for retailers to integrate ESL as part of a wider standards-based smart retail ecosystem. As a result, ABI Research believes that ESL vendors should increasingly work with standards bodies to help migrate their solutions towards open standards and frameworks to help scale the market. This will also allow them to take advantage of a much larger potential addressable market over time. Alternatively, as standards-based solutions develop, they may be at risk of becoming dwarfed by standards-based solutions from the likes of Bluetooth, which can enable more fully digitized operations. If retailers are aiming to deliver fully digitized stores that combine inputs from multiple areas including ESLs, wireless sensor networks, beacons, asset and personnel tracking, inventory management, automated checkouts, and other use cases, they will increasingly move away from vertically integrated solutions towards more open standards-based frameworks that enable scalability, interoperability, vendor choice, and continued innovation over time.

Published September 2021

157 Columbus Avenue 4th Floor

New York, NY 10023 USA

Tel: +1 516-624-2500

www.abiresearch.com

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