WHITEPAPER

Ambient IoT: Open (Standards) for Business



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Ambient Internet of Things (IoT) — a true Internet of everything, everywhere — will revolutionize supply chains and much more, enabling it to scale efficiently. Wiliot's approach to ambient IoT employs current open APIs, standards-based communications, and other technology norms to ensure companies aren't locked in by proprietary technology and can grow their ambient IoT networks rapidly and cost-effectively.

However, going forward there is scope for new, more ambient IoT-dedicated standardization. In this paper we outline the current standards that are key to ambient IoT today, as well as the areas that will be important to standardize for ambient IoT to achieve its full, world-changing potential in the future.

01

Executive Summary

Ambient IoT describes a ubiquitous, intelligent, wireless network capable of connecting everything to the Internet, from products and materials to packaging and places. The "things" we are talking about here include valuable things as well as everyday things such as food, medicine, and clothing.

This Internet of Everyday Things will be made possible by a new combination of very low-cost tags affixed to anything and comparatively lower cost tag readers that either already exist today – in our communications devices, appliances, and smart devices (and are therefore "free") – or new readers that, rather than costing hundreds or thousands of dollars, cost tens of dollars, even tens of cents. That's because ambient IoT is about a network of receivers that extends through every product that has a radio inside.

One of the ways we reduce the cost of tags and readers is by dispensing with batteries or wired connections and enabling them to power themselves by harvesting the energy they need from radio waves.

By imbuing trillions of things with low-cost compute capacity and wireless communications, all the things that surround us become "smart" and share their status with manufacturers, distributors, retailers, consumers, and others. A new generation of ambient IoT tags will function similarly to the Apple AirTag® or Bluetooth®-based Tile® tracker, but rather than costing $25 each they will cost less than 10 cents — and in the future, a lot less.

Ambient IoT removes the cost barriers associated with putting things online, as well as the cost of the receivers of signals from all those things. With the right standards, every existing device with a radio can be securely listening and talking to things. Look around you now. How many of the electronics that surround us have wireless components? Wi-Fi access points, computers, phones, cellular radio infrastructure, televisions, cars, fridges, washing machines, smart speakers, doorbells, and security cameras can all provide energy and talk to the "things" we want to put online.

Ambient IoT expands the limited concept of an Internet of Things beyond just expensive things (smart homes, cars, and appliances) to include every single thing with value (clothes, packaged goods, pharmaceuticals, documents, luggage, shipping containers, cases, crates, and more). Rather than just the fridge or shipping container going online, all the things inside the fridge and shipping container will be connected and intelligent.

Why do this? The positive impact of ambient IoT on global supply chains will be immense. By creating real-time visibility into the location and condition of products, materials, and packages on a unit basis, ambient IoT can dramatically improve supply chain efficiency, reduce waste, eliminate fraud/counterfeit, enable traceability, improve food and drug safety, and contribute to much greater sustainability. Its power to solve the world's most complex challenges derives from its ubiquity. As more businesses build out vast, interoperable ambient IoT networks of their own, its potential grows exponentially.

Companies seeking to reap the benefits of ambient IoT are wise to study the technology required. Supply chains are necessarily interconnected systems, and no business wants to build a closed, proprietary solution. As the first company to create truly ambient IoT solutions, Wiliot has taken an open approach, while contributing to new standards that will enable further interchangeability going forward and understanding well that to be truly ambient requires a vast ecosystem of solution providers that are organized and innovating around those standards.

Observers may question why Wiliot would seek to commoditize the revolutionary tags and readers that it has pioneered. Why open up reference designs and contribute to standards? It's about accelerating scale and unlocking the value in the data that passes through the cloud platform required to marshal the insights at a scale that has never been seen before.

Because Wiliot's ambient IoT platform takes advantage of standards-based technology and is aligned with future standards, companies can develop their supply chain networks using a choice of hardware and third-party software building blocks. With Wiliot's commercialization of ambient IoT, they can adopt, implement, scale, and utilize vast networks of everything they wish to track, both quickly and cost-effectively. In this paper we outline the existing standards used and provide pointers to further opportunities and initiatives for creating an even more comprehensive standards framework.

02

The Dawning of Ambient IoT

Everywhere you look, supply chains need reinvention. In 2023, the Food Industry Association found that nearly half of retailers said supply chain issues were hurting their business. COVID-19 showed us how dysfunctional supply chains can become with visibility lacking, surpluses hidden, and demand signals failing to be heard.

Tracking everything that moves through the world's complex supply chains is more critical than ever to achieving greater efficiency, productivity, traceability, and sustainability. The way to do it? Give everything in the supply chain — products, parts, materials, packaging — the intelligence to communicate their status throughout their journey, continuously. Ambient IoT makes that happen.

Ambient IoT represents a critical evolution of ambient computing and the Internet of Things, both of which have been around for decades. What the two have in common is billions of intelligent computing devices attached to the internet and communicating data about buildings, homes, appliances, even vehicles.

What's been missing until now is the innovation needed to bridge the two and make everything smart. Not just smart speakers or refrigerators, but smart clothes, packaging, crates, vaccine vials. That's because until now there was no way to combine the power, processing, and communication needed to make everything smart without an outlet or a battery.

Now there is. Wiliot's ambient IoT is on its way to enabling trillions of connected things, not just billions. The key for Wiliot — and the other suppliers of ambient IoT technology that will doubtless follow, leading to an unprecedented jump in the size of the 2connected world — is to build on existing open standards for the express purpose of maximizing ambient IoT's reach and influence. And beyond existing standards, there is an opportunity for new standards that bring together all the companies, from giants to startups, and infrastructure managed by telecommunications operators and Wi-Fi vendors.

03

Building Blocks of the Wiliot Ambient IoT

Supply chain tracking technologies are not new. Nor are standards-based tracking platforms. Perhaps the most recognizable are based on radio-frequency identification (RFID).

An RFID tracking system consists mainly of a radio transponder, receiver, and transmitter. Its design and implementation adhere to a broad set of international standards overseen by the International Organization for Standardization (ISO) and others. But even though the early proponents of RFID were the first to coin the phrase “Internet of Things,” the technology has been hobbled and never achieved the full vision conceived in its first attempt to scale a lofty summit. RFID is not ambient IoT technology. To track RFID-tagged things requires human intervention (a hand-held scanner) or expensive infrastructure (smart tunnel readers).

Wiliot’s ambient IoT tracks everything differently. In the Wiliot platform model, compute power and connectivity are literally all around us — no tapping or scanning and no expensive infrastructure. The ambient IoT equivalent of RFID transponders are tiny, self-powered, and cost pennies each. And today they can communicate with any device that speaks industry-standard Bluetooth.

The building blocks of an ambient IoT platform include:

Smart tags

Stamp-sized, printable compute devices. Wiliot calls these IoT Pixels. They can be affixed to anything, or integrated directly into products, containers, clothes, packaging, and more. Despite including advanced programming and communications, these tiny compute devices cost a few pennies to produce. Once attached to products and materials, IoT Pixels can connect trillions of things to the ambient IoT. Wiliot openly shares the specifications for IoT Pixels so that existing ecosystems of smart tag and RFID manufacturers can “print” them in the mass quantities required for a truly ambient IoT.

Wireless Communication

Wiliot IoT Pixels use wireless antennas and sensing technology that can detect and provide information like temperature, location, fill level, and humidity. They communicate via standard Bluetooth wireless devices, but new versions will work over forthcoming IEEE 802.11 and 3GPP 5G and 6G wireless networks as those standards begin to include ambient IoT in their specifications. Both standards bodies (802.11 and 3GPP) have started drafting ambient IoT sections.

Ambient Power

Wiliot IoT Pixels are self-powered. They harvest energy from radio waves, emitted either by existing network devices, including Bluetooth devices, LoRa WAN devices, legacy RFID radios and smartphones, or by low-cost, off-the-shelf wireless bridge transmitters, all using existing standard chipsets. To date, no other mass production IoT or ambient computing platform sources its energy this way. This ubiquitous, low-cost source of energy is what makes Wiliot's implementation of ambient IoT unique and has allowed it to scale faster than previous auto-ID technologies that required new standards.

Going forward, the frequency bands and patterns used to broadcast this energy are ripe for further standardization, still using and respecting existing communications standards, but in a way that will maintain coexistence, as well as interoperability and choice between what will be a growing number of vendors of ambient IoT tags and edge devices.

Cloud-based processing and analytics

The data collected by Wiliot IoT Pixels is transmitted to the cloud, where companies can process and analyze it. The connection between the wireless network and the cloud is made using standard web services over standards-based wired, Bluetooth, LP WAN, satellite, and cellular networks. The firmware required to initiate connection between network devices and cloud is developed by Wiliot as open-source software so any hardware manufacturer can build and offer Wiliot ambient IoT-enabled devices.

04 The Case for Standards in Ambient IoT

Permeating all the Wiliot ambient IoT building blocks are technology standards. The platform is, by design, an open platform created to avoid vendor lock-in. A standards-based ambient IoT is critical for several reasons:

Standards ensure the broadest possible adoption of ambient IoT.

Reinventing supply chains won't happen unless the many interconnected supply chain participants can utilize interoperable ambient IoT platforms and infrastructure. A standards-based approach allows stakeholders to confidently adopt ambient IoT without the risk of being locked into proprietary technology.

Standards ensure choice, flexibility, and diverse functionality among ambient IoT solutions.

The ambient IoT ecosystem needs many solution providers — network device manufacturers, producers of IoT Pixels, app developers — to develop products at scale that interoperate and drive down the cost of deploying ambient IoT, while improving performance and reliability. Having multiple sources of standards-based ambient IoT technology allows companies to build out their supply chains more quickly and cost-effectively.

Standards encourage innovation and competition.

The drafting of standards is a carefully balanced effort to foster innovation and economic growth while protecting heavy R&D investments and ensuring interoperability and openness. Ambient IoT will take various forms, enabled and specified by the leading wireless standards, including Bluetooth and 802.11 Wi-Fi for unlicensed bands, and 3GPP-5G/6G cellular for licensed bands. However, this is just the dawning of the ambient IoT, as each will include ambient IoT feature sets in its offering. The ecosystem can expect an explosion in the variety of new technologies, enhanced capabilities, new vendors, ambient connectivity, supporting systems, and use cases, with a clear roadmap for future products and technology.

Standards foster new ideas and concepts.

Being open and public, newly published standards foster a wave of academic work and entrepreneurship, usually resulting in ideas and use cases that were not envisioned by designers of the standard.

In short, standards are essential if we are to scale from billions to trillions of connected things that unlock the full power of ambient IoT, not to mention other exciting technologies, such as artificial intelligence (AI) and cloud, as they're applied to the physical world.

05

How Wiliot's Implementation of Ambient IoT Uses Standards

Wiliot's ambient IoT platform adheres to current standards throughout its technology stack, from communications, to serialization and identification, to data formatting and transmission, to the platform's revolutionary method of self-powered IoT Pixels. That said, future devices will take advantage of newer standards for better performance, connectivity, and product variety.

Communications Standards

At the heart of Wiliot's standards-based approach to ambient IoT is the Bluetooth low-energy wireless technology standard for exchanging data between IoT Pixels and ambient IoT network devices. Wiliot is an active member of the Bluetooth Special Interest Group (SIG). Wiliot is also actively engaged in other wireless standards bodies, which we will discuss in the next section.

Specifically, Wiliot IoT Pixels communicate using the Bluetooth Low Energy (LE) protocol, developed by the Bluetooth SIG, over 2.4GHz frequencies. Bluetooth LE was developed more than two decades ago for for applications requiring short-range connectivity while consuming much less power than traditional Bluetooth and at a lower cost.

Energy Harvesting

Wiliot's IoT Pixels power themselves by harvesting signals from standard sources like Bluetooth and Wi-Fi signals and turning them into energy. They are also designed to harvest energy from other standard sources, including from RFID readers and LoRa devices.

IoT Pixels include two dedicated antennas for harvesting energy over 2.4GHz and sub-gigahertz bands. Wiliot's design can harvest existing radio energy despite its "bursty" nature by incrementally storing available RF energy before executing compute functions. As ambient IoT grow ubiquitous, Wiliot is making available open-source software for designing off-the-shelf, edge devices that can ensure predictable RF energy flow across the 2.4GHz and sub-gigahertz bands. This middleware is available on GitHub to any ecosystem participant that designs infrastructure devices to energize and read IoT Pixels and to securely route the data over Wide Area Networks (WANs) and Low Power WANs to the cloud.

Security and Identity

Wiliot's ambient IoT platform currently employs standards-based AES 128-bit encryption and authentication for protecting data as it moves between IoT Pixels and wireless network gateways and bridges. As standards bodies include ambient IoT in their standards, Wiliot expects security specifications to evolve. Membership and engagement in these standards bodies ensures the Wiliot platform will always adhere to the most advanced security protocols.

In addition, Wiliot's ambient IoT platform utilizes international standards for identifying each unique thing on the network. Each of the IoT Pixels that is affixed to or integrated with a tracked product, material, crate, etc. needs a unique identity. Supply chain systems then map those identities to their own product ID scheme for tracking. Wiliot utilizes GS1 standard serialization to assign a unique ID, a Serial Global Trade Item Number (SGTIN), to all IoT Pixels. GS1 is the international nonprofit organization that oversees global standards for bar codes, location codes and other unique identifiers used in most warehouses and retail stores.

Cloud APIs and Apps

As ambient IoT evolves, IoT Pixels will provide supply chain participants with much more information about the things they wish to track. This will include events that relate to changes in location, a standard way to describe these locations, and sensor data about the condition of products and materials. Wiliot expects the newly ratified GS1 EPCIS 2.0 standard to play a significant role in the exchange of such data.

EPCIS 2.0 includes a Web API for describing events in a supply chain, including, for example, the temperature and humidity at which goods were shipped. The Wiliot platform can collect that data and transmit it via applications to supply chain companies using EPCIS 2.0 standard data.

Today's Wiliot ambient IoT platform uses standard Web services to securely transmit data from IoT Pixels to the cloud. This means that a supply chain company employing the Wiliot platform will always be able to access, share, process, store, and migrate its data by standard means.

06 Future Proofing for Ambient IoT

While the current Wiliot ambient IoT platform utilizes Bluetooth technology, dedicated ambient IoT standards are in various stages of being developed by other wireless standards bodies as well.

5G/6G

Wiliot is a member of 3GPP, a consortium of the world's major telecommunications standards development organizations, which oversees what is commonly known as 5G Advanced/6G cellular standards. The scoping of the work for Release 19 is still ongoing, but it is clear that Ambient IoT is one of the main items to be included.

Wiliot has actively contributed to Release 19, and 3GPP working groups are currently defining the specifications that will target, among other things, the use cases that Wiliot's ambient IoT tracking platform is implementing – but using new protocols over the licensed bands of 5G Advanced, and eventually 6G wireless networks.

While networks that are operated by telecommunications companies traditionally cost more to operate than the free-to-use, unlicensed spectrum in the ISM (Industrial, Scientific and Medical) bands used by Bluetooth and Wi-Fi, telcos offer assurance of service availability and quality, improved manageability and billing, and improved performance. They also have a relationship with consumers and households, so that when ambient IoT ends up in the home, there is a known, trusted entity that can provide support and privacy management.

802.11

The Institute of Electrical and Electronics Engineers (IEEE) is at the early stages of deciding how to connect with ambient IoT tags via an evolution of its Wi-Fi protocol. Currently, the IEEE has formed a topic interest group (TIG) to report on the feasibility of ambient power (AMP) communication across 802.11 networks by IoT devices. They recently voted to move forward and create a study group for preparing a project on 802.11 to support ambient IoT.

Among the topics TIG is exploring is energy harvesting, which could be accomplished using radio frequency energy from the WLAN, a model Wiliot has proven over Bluetooth, or other sources, including solar or thermal energy. Wiliot continues to participate in the 802.11 standards groups and sees use cases for ambient IoT that would benefit from WLAN deployments. Having the vendors associated with selling and supporting Wi-Fi devices (giants of the technology industry) offering ambient IoT infrastructure as part of the existing communications systems that they service in almost every enterprise will help to fuel the spread of the ambient paradigm.

In any case — Bluetooth, 3GPP 5G/6G or IEEE 802.11 with AMP IoT — Wiliot's experience building its ambient IoT platform around standards positions it to rapidly deliver solutions for the broadest possible set of applications.

07 Conclusion: Ambient IoT in the Real World

Pockets of ambient IoT exist today. Grocers have adopted ambient IoT in their supply chains, ensuring customers get the freshest food while the grocery retailer can potentially cut in half the time it takes products to go from producer to distributor to store. IoT Pixels have been integrated into vaccine vials to trace location, temperature, authenticity, and fill levels. They've been affixed to totes of meat and dairy — in some cases to products themselves — to monitor safe handling and supply chain logistics.

As we progress toward trillions of things communicating via ambient IoT, a broader deployment of pervasive networks will be needed to read tags and route data where it can make the most difference. All of it must be built on standards. Bluetooth has shown itself to be a flexible and reliable platform for ambient IoT in its earliest instances, but there is potential for additional complementary standards to accelerate the growth of a ubiquitously connected future.

It's going to take a vast, open ecosystem of stakeholders to maximize the reach and potential of ambient IoT. Inclusion in Bluetooth, 5G/6G cellular network standards, already in development by 3GPP, as well as future IEEE Wi-Fi standards, will make ambient IoT truly pervasive. We believe in standards for many reasons. It's about more customers, more vendors, more choice and ultimately, it's about realizing the full potential of ambient IoT to change the world for the better.

ABOUT WILIOT

Wiliot is an ambient IoT data carrier platform as a service company. Our Visibility Platform connects the digital and physical worlds using IoT Pixels, battery free smart tags that push data to the cloud in real-time without human intervention. Our platform exists within a fast-growing ambient IoT ecosystem. We have partners in that ecosystem that provide tags and edge devices.

Ambient IoT is an evolution of legacy IoT and RFID technologies with lower costs, end-to-end privacy and security, and the addition of new intelligence and sensing capabilities. It's on a path to scaling to trillions thanks to telecommunications standards - Bluetooth, 5G Advanced, and 802.11 AMP.

Our mission is to make every single thing an agent of change, enabling ambient IoT by adding intelligence and automation to food, apparel, packaging, pharmaceuticals, and other products.

Connecting new categories of things through AI and the internet is transforming manufacturing, distribution, and product use to deliver on our vision: a minimum waste, full trust, perfectly timed world where people, profits, and the planet are aligned.

Visit www.wiliot.com to learn more