Client Alert

January 26, 2016

The Internet of Things: Evaluating the Interplay of Interoperability, Industry Standards and related IP Licensing Approaches

By Stephanie Sharron and Nikita Tuckett

The financial impact of the Internet of Things on the global economy will be significantly affected by interoperability. A 2015 McKinsey Global Institute report indicated that, "[on] average, interoperability is necessary to create 40 percent of the potential value that can be generated by the IoT in various settings […] Interoperability is required to unlock more than $4 trillion per year in potential economic impact for IoT use in 2025, out of a total impact of $11.1 trillion across the nine settings that McKinsey analyzed."[1]

However, at present, there is a lack of consensus between standards organizations and industry stakeholders as to even the most basic technical standards and protocols that apply to how devices communicate. Characterized as a "standards war" between technology groups, companies have competing incentives. While all vendors share an interest in aligned standards that promote IoT development and interoperability, individually some companies seek the perceived competitive and economic advantages of building proprietary systems based on proprietary standards and protocols (or so-called "walled-gardens").

The lack of a uniform standard that applies across devices and networks means that we lack any universally adopted set of semantics. As a result, without clear definition, opportunities for misunderstandings abound. We start then with the definition of two key concepts: the definition of the Internet of Things or "IoT," and the definition of interoperability as applied to the Internet of Things.

INTERNET OF THINGS

The term "Internet of Things" is arguably a misnomer in today's rapidly changing technical environment. The term has two components, both of which are somewhat misleading: "Internet" and "things."

The reference to the Internet is misleading because the Internet is not the only networking protocol over which devices communicate. While the Internet is a powerful enabler of the broad adoption of connected devices, the networks and communications protocols that support our connected world are far more diverse and continue to proliferate.

The term "things," while not limiting in and of itself, is vague at best. In this article, when we refer to "things," we intend to encompass all of the types of objects that have the ability to connect and communicate, whether those objects be sensors, computers or everyday things. The ability to connect with other objects and communicate data makes the object "smart."

[1] Manyika, James, et al., *The Internet of Things: Mapping the Value beyond the Hype*. McKinsey Global Institute, June 2015. p. 2. http://www.mckinsey.com/insights/business_technology/the_internet_of_things_the_value_of_digitizing_the_physical_world.

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INTEROPERABILITY

Interoperability is another term that is often articulated as being central to the growth and success of the products and services that leverage the IoT. While interoperability is widely believed to be essential, defining what is meant by interoperability is difficult, since interoperability can mean something different when applied to the different parts of the technology stack that comprises the IoT, than when applied to the data itself that is communicated and processed through that technology stack.

The European Research Cluster on the Internet of Things has proposed the following definition of interoperability:

> "the ability of two or more systems or components to exchange data and use information."[2]

The following definition of interoperability fleshes out some of the concepts that follow in this article.

> The ability of objects or devices, whether they be sensors, computers or other everyday things, to connect with each other and communicate data in a form and format that can be understood and processed by other persons or entities and is agnostic as to the hardware or software on which the data is to be further processed and stored.

These definitions are not bulletproof. Rather, they provide fodder for discussion and debate about the extent to which interoperability is desirable within the context of the IoT.

One area of potential confusion in regard to interoperability is distinguishing between the technology and systems required to *exchange* data from the technology and systems required for the *use* of that same data. Communications protocols and standards can be leveraged to ensure interoperability across heterogeneous hardware and software systems and platforms. This sort of technical interoperability, however, will not ensure that the data itself that is carried through networked layers of the technology stack are in a form and format that allows for transmission across systems. To support this sort of interoperability, agreed frameworks for syntax and the encoding of data (sometimes referred to as "syntactical interoperability") is needed. Finally, optimally systems will be designed over time that support the ability of users to obtain a common understanding of the information communicated across networked solutions that span diverse geographic and cultural boundaries. This sort of interoperability is referred to as "semantic interoperability." For organizations that use different technology across different cultures in different parts of the world, all three of the above types of interoperability may be desired.

BENEFITS OF INDUSTRY STANDARDS

Standards can offer a number of benefits. Standards can provide assurance to their members that if they implement the standards, their products and services will continue to operate within specified parameters with each other. Technical interoperability is often a goal of industry standards. The broader the set of specified hardware, software and communications protocols a standard supports, the broader the interoperability it may enable.

Choosing to develop in accordance with an industry technical standard can also provide a level of certainty with respect to intellectual property ("**IP**") infringement, albeit not blanket protection. This protection arises because

[2] IERC European Research Cluster on the Internet of Things, Internet of Things IoT Semantic Interoperability: Research Challenges, Best Practices, Recommendations and Next Steps (March, 2015).

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most standards bodies require that participants who contribute to the standard agree to license certain of their IP on pre-defined terms. The scope of the IP rights captured and the terms on which that IP is licensed, however, vary from standard to standard and are based on the participant's level of involvement and contribution. High-level descriptions of the type of license that applies to some of the most well-known IoT standards is included below, to the extent information about the terms is publicly available.

When there is a proliferation of competing standards that cover the same or similar subject matter, however, the standards have the potential to overlap or conflict. Without coordination as to what options or services products or components that comply with the standard will implement, lack of interoperability will result. This has led some industry observers to suggest that broader collaboration between standard-setting organizations, or even consolidation of various IoT standards, could be beneficial in the longer term.

A BUSINESS CASE FOR INTEROPERABILITY

Despite these early movements, whether and the extent to which the various standards bodies will coordinate or consolidate is an open point. Some question whether such consolidation is necessary or even feasible, because interoperability takes place at different layers within the communications protocol stack among IoT systems and devices. Others emphasize that true interoperability requires any IoT device to be able to speak the same language, and connect and share information with other devices and systems, irrespective of platform or operating system ("**OS**"), and that this requires one de facto protocol.

The time and investment required by industry stakeholders to participate in a range of standardization efforts is significant, but there is likely to be overlap and even conflicts between some of the standardization protocols. The lack of a collaborative effort to produce a uniform standard could produce conflicting protocols, delay product development and prompt fragmentation across IoT products and services.[3] Such a fragmented array of proprietary IoT technical standards will impede value for users and industry.

Central challenges raised by the proliferation of IoT interoperability standards include the following:

- Device manufacturers perceive a market advantage in establishing a proprietary ecosystem of compatible IoT products that limit interoperability to those devices within the manufacturer's product line. By maintaining the proprietary nature of these systems, developers exert more control over the user experience. These "walled gardens" are opposed by interoperability supporters as impediments to user choice because they arguably deter users from changing to alternative products. Some also argue that they create impediments to innovation and competition, limiting competitors' ability to develop new products compatible with the standardized infrastructure.

- One of IoT's primary attractions is the ability of connected devices to transmit and receive data to and from cloud services, which in turn may perform powerful analytic functions. The lack of a consistent, platform and OS-agnostic standard governing the collection, processing and sharing of such data may inhibit the ability of users to access the originating data, move to other service providers or perform their own analyses.

[3] Karen Rose, et al., *The Internet of Things: An Overview – Understanding the Issues and Challenges of a More Connected World*, October 2015, p. 33, http://www.internetsociety.org/iot.

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- The lack of an existing and proven standard that IoT device manufacturers may use to assess technical design risks in the development process increases development costs.
- In the absence of standardization, developers face the behemoth task of developing integrations with legacy systems, and end users will be faced with the challenge of configuring multiple individual devices across a range of standards. In addition, product developers may be dissuaded from developing new products due to uncertainty as to compliance with future standards.
- End users may be discouraged from purchasing products where there is integration inflexibility, configuration complexity or concern over vendor lock-in, or where they fear products may be obsolete due to changing standards. The complications posed by a lack of uniform connectivity standards for product development and industry growth are evident in the competing, incompatible standards for devices with a low-range and medium-to-low data rate (i.e., ZigBee, Bluetooth and LTE Category 0).
- Lack of reference and architectural models that take into account the various needs for interoperability and standardization may also have adverse consequences for the networks with which IoT devices connect, since poorly designed sensor networks may use disproportionate bandwidth, and be greedy consumers of available power.

In contrast, well-defined device interoperability standards may encourage innovation as disruptive technologies emerge, provide efficiencies for IoT device manufacturers and generate economic value as "things" become cheaper, smarter and easier to use. Barriers to entry may be lowered. Moreover, interoperability facilitates the ability of users to select the devices best suited to the user's needs in an environment where different devices can share and communicate data between each other. Nevertheless, such arguments remain counterbalanced by companies' perceived competitive and economic advantages of building proprietary systems for market domination in the IoT.

THE IOT STANDARDS SMORGASBOARD

IoT standards, including those that adopt protocols that specify communication details for IoT devices, are central to the interoperability discussion for the IoT. A number of standards bodies, consortiums and alliances are currently working on IoT standards issues. Below is a non-exhaustive list of some of the current major players in the development of standards, the covered products and services, and the licensing approaches that apply to the IP that is used by products and services that implement these standards.

Standards that offer limited protection from infringement of the IP rights of their contributors can lead to legal and business uncertainty. Legal uncertainty can arise because of the lawsuits for infringement that may be brought by contributors who have promoted the adoption of features or works into the standard that if used without a license, would infringe their patents or copyrights. There may be business uncertainty because companies lack predictability regarding what the ultimate cost of implementation of the standard may be should contributors charge for licenses to IP required to implement the standard.

Central to this debate is what the appropriate licensing terms should be for contributors to a particular standard. As seen in the telecommunications industry, standardized licensing terms can affect the way an industry evolves: licensing terms that are overly aggressive or demand too much of a participant will be eschewed in favor of more acceptable models. This alert examines the fragmented environment of IoT technical standards and analyzes the

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differences between the proposed licensing models, exemplifying how various standard bodies are attempting to reconcile the issue.

Open Interconnect Consortium	
Standard	IoTivity
History, Scope and Members	The Open Interconnect Consortium ("**OIC**") launched in July 2014, backed by such vendors as Intel, Samsung Electronics, Cisco, GE Software, Atmel, Dell, Honeywell, IBM, Mediatek, ZTE, Acer, Broadcom, Asus, National Instruments and many others. The OIC's stated focus is "defining a common communications framework based on industry standard technologies to wirelessly connect and intelligently manage the flow of information among personal computing and emerging IoT devices, regardless of form factor, OS, or service provider." In early 2015, the OIC released a specification called IoTivity, an open source framework implementing the OIC Standards for device-to-device connectivity. Operating on a constrained application protocol (CoAP), IoTivity has limited platform support, but is focused on security, simplicity and rapid development. The OIC's open source standards cover device discovery, communication, data exchange and other functions in multiple domains, including home automation, automotive, enterprise, health care and industrial scenarios, with an initial focus on smart home and office solutions.
License Approach	Under the OIC's Intellectual Property Rights Policy, the OIC's licensing policies contain a "**RAND-Z**" (or "**FRAND**") provision that requires participating companies to offer a zero-royalty, reasonable and non-discriminatory license to their code for member organizations. In addition, each member must agree that it will not seek to enforce its IP rights against another member if reasonable and non-discriminatory compensation ("**RAND**") for practice of IP rights can otherwise be obtained. Further, each member *and its affiliates* must grant the OIC a worldwide, irrevocable, non-exclusive, non-transferable, sublicensable, royalty-free copyright license to reproduce, create derivatives, distribute, display, perform and edit the member's contributions for the purposes of developing, publishing and distributing: the final specifications; products incorporating compliant portions based on the specifications; and submissions to an approved standards development organization. Subject to the member's retention of its copyright in the individual contribution, OIC owns all rights in the compilation of contributions forming the final specifications and related works. Code contributions under the reference implementation, IoTivity, are licensed under the Apache 2.0 license.

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AllSeen Alliance	
Standard	AllJoyn
History, Scope and Members	Launched in December 2013, AllJoyn is an open-source software system intended to enable compatible smart devices, irrespective of OS and network protocols, to find and coordinate with each other. The project was developed by Qualcomm Innovation Center and is now a collaborative open source project of the AllSeen Alliance. Members of the Alliance include Qualcomm, The Linux Foundation, Cisco Systems, Arcelik A.S., Canon, Electrolux, Haier, LG, Microsoft, Panasonic, Philips, Qeo, Sharp, Silicon Image, Sony, Asus, AT&T, Cisco, Honeywell, HTC, IBM, Lenovo, Symantec, TrendMicro, Vodafone and many others. The open source AllJoyn protocol enables device manufacturers to create custom apps for integrating devices onto a Wi-Fi network. Products that use AllJoyn include Panasonic's multi-room audio systems and LG's smart TVs; in November 2014, Microsoft announced it was building the AllJoyn framework into Windows 10. In early January 2016, the AllSeen Alliance announced its first update to the AllJoyn Gateway Agent Plan, originally released on April 19, 2015. This extension of the AllJoyn framework provides a standard and secure method to remotely access and manage IoT devices and applications via external/cloud networks and the Internet. This moves the IoT from a series of Internet-connected gadgets into a manageable system.
License Approach	Unlike the OIC, AllJoyn does not contain a RAND-Z licensing term—a key difference between the organizations. Members of the AllSeen Alliance and all non-members that contribute to the Alliance must pledge not to bring a claim of infringement of the contributor's pledged patent claims against any entity that uses, sells, offers for sale, leases, licenses, imports, distributes or otherwise exploits an official code release by the Alliance that meets the Alliance's certification requirements. Pledged patent claims are those that are directly infringed by the use, sale or other disposition of the code that is contributed by the contributor alone and not in combination with any other contribution. The agreement does not extend to contributions made by others, any modification of the contributor's contribution or combination of the contributor's contribution with anything else. This addition to the Alliance's patent policy was introduced in January 2015; previously, AllSeen's IP policies had covered only copyright. Code released by the Alliance for the AllJoyn framework is licensed to users under the ISC License, which grants permission to use, copy, modify and/or distribute the software for any purpose with or without fee, provided that a copyright notice appears in all copies. Contributors are required to enter into a Contributor Agreement pursuant to which contributors can elect either to assign to the Alliance the copyright rights and interests in the contribution subject to a license back to exploit the work, or to grant to the Alliance a non-exclusive, broad copyright license.

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Thread Group	
Standard	Thread
History, Scope and Members	Thread Group's "Thread", an IP-based wireless networking protocol, is an initiative launched by Google's Nest Labs, Samsung Electronics, ARM Holdings, Freescale Semiconductor, Silicon Labs, Big Ass Fans and Yale Locks & Hardware. Thread relies on a low-power radio protocol called IPv6 over Low Power Wireless Personal Area Networks ("6LowPAN"). Unlike Wi-Fi, which sends large quantities of data and consumes large amounts of power, Thread sends small amounts of data and consumes very little power. The protocol gives each device an IPv6 address and utilizes mesh networks that scale to hundreds of devices without a single point of failure (i.e., without the need for a hub device), and involve "banking-class" encryption. According to Thread Group, as the technology only defines networking, in theory, high-layer standards such as AllJoyn or IoTivity, which still utilize Wi-Fi or Bluetooth networks, could be used in Thread-enabled products.
License Approach	Like OIC, patents that are necessarily infringed by required portions of the final Thread specification are licensed on a perpetual, royalty-free basis ("**RAND-RF**"). Each participant must grant (a) the Group and each participant a worldwide, irrevocable, non-exclusive, non-transferable, royalty-free copyright license to reproduce, create derivative works, distribute, display and perform (with the right to sublicense) each final Thread specification for the purposes of developing, publishing and distributing the final specification and related materials, as well as for promotional materials. Subject to each member's retention of the copyright in its individual contribution, each member must convey to the Group a non-exclusive, undivided and equal ownership interest in any copyrights contributed to the final Thread specification, deemed "ownership of a collective work" under 17 USC 201(c). This copyright license survives any withdrawal from membership of the granting participant from the Thread Group.
ZigBee Alliance	
Standard	ZigBee
History, Scope and Members	Established in 2002, the ZigBee Alliance is a non-profit association of 452 members, including ARM, Belkin, AT&T, Bosch, Broadcom, Cisco Systems, Emerson, Huawei and many others. The ZigBee Alliance's standard, ZigBee, is a common wireless language that everyday devices utilize to connect to one another. In December 2015, the ZigBee Alliance announced that its members had ratified the ZigBee 3.0 specification, which includes a common application library that unifies the various application-specific versions of its wireless specification into a single standard. Millions of ZigBee-enabled products exist on the market today, including in smart homes, connected lighting, and the utility industry.

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License Approach	Under the ZigBee Alliance's Intellectual Property Rights Policy, each ZigBee standard is made available on a RAND basis: each contributing member must grant to each other member a non-exclusive license without a right to sublicense, to make, have made, use, import, sell, offer to sell, license, promote or otherwise dispose of the resulting product or technology. The license is granted only under claims of the contributor's patents that cover or directly relate to one or more of the specifications if: (1) the patent claim is necessarily infringed by the specification, (2) no commercially reasonable non-infringing implementation of the specification exists, and (3) such infringement is necessary to meet the implementation requirements of the specifications. The Alliance charges no royalty for any use of the standards, and RAND terms are available to members and non-members.
AVnu Alliance	
Standard	AVB/TSN
History, Scope and Members	Launched in August 2009 by founding members that included Broadcom, Cisco Systems and Intel, the AVnu Alliance is a consortium of automotive and consumer electronics companies collaborating to establish and certify the interoperability of open Audio Video Bridging ("AVB") standards. The Alliance focuses on "creating an interoperable ecosystem servicing the precise timing and low latency requirements of diverse applications using open standards through certification."
License Approach	Under the AVnu Alliance Intellectual Property Rights Policy, when a member or its affiliates make a contribution to a specification, the member and its affiliates must grant to other participants and their affiliates, on a RAND basis, a non-exclusive, non-transferable, non-sublicensable, irrevocable worldwide license (with or without compensation at the member and its affiliates' option) under certain of its patent claims that are necessarily infringed by compliance with the final specification and that are within a specified "scope" limited to functionality that enables products to interoperate, interconnect or communicate. The license grants the right to make, have made, use, import, offer to sell, lease, sell and otherwise distribute only those portions of products that implement and are compliant with the relevant portions of the final specification and are within the bounds of the above "scope." The Intellectual Property Rights Policy also contains a broad license grant by members with respect to the member's copyrights in any contributed materials. A range of AVnu-certified products are available across automotive, consumer and industrial electronics markets.

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Industrial Internet Consortium	
History, Scope and Members	Founded in March 2014 by General Electric, Cisco Systems, IBM, Intel and AT&T, the Industrial Internet Consortium ("**IIC**") focuses on industrial applications of the IoT and "setting the architectural framework for the industrial internet." The IIC has grown to more than 100 members, including Microsoft, Samsung and Huawei Technologies. The IIC reports that it will not develop a set of standards but will work with standards bodies to ensure technologies work together across business sectors and to identify, assemble and promote best practices. In particular, the IIC wants to encourage coordination among industries within which IoT and the older machine-to-machine ("**M2M**") technologies have been developed in relative isolation. That will involve defining requirements for standards, designing reference architectures and frameworks necessary for interoperability, and creating new industry cases and testbeds for real-world applications.
License Approach	The IIC's intellectual property policy incorporates a broad copyright license, but unlike many of the other standards initiatives, lacks any policy with respect to the grant of rights under contributor patents that may be infringed by their contributions. This may be in part due to the fact that the IIC is not establishing a standard itself, but rather working to encourage coordination across standards.
OneM2M	
Standard	OneM2M
History, Scope and Members	Established in July 2012 by a consortium of ICT standards development bodies, OneM2M is a standard that provides a common M2M service layer that can be embedded within various hardware and software to connect IoT devices. The partnership currently has 216 participating partners and members, including Alcatel-Lucent, Adobe, AT&T, BT, Cisco, Ericsson, Deutsche Telekom, IBM, Intel, Samsung, Sierra Wireless and Telefonica. OneM2M has two types of members: Partner Type 1 comprises membership organizations themselves, and Partner Type 2 comprises members who are also participants in a Partner Type 1 organization or have otherwise had their IPR policies vetted by OneM2M at the time they joined. Ultimately, each partner must have agreed to an IPR policy that is compliant with the OneM2M IPR principles.
License Approach	OneM2M's partnership agreement states that the copyright in technical specifications and reports are jointly owned by the Type 1 partners. Trademark usage is left to agreement among the Type 1 partners. With respect to patents, the organization's IPR principles state that members must comply with a FRAND IP rights licensing regime.

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Wi-Fi Alliance	
Standard	Wi-Fi HaLow
History, Scope and Members	In early January 2016, the Wi-Fi Alliance announced its new IoT specification, Wi-Fi HaLow, based on the pending IEEE 802.11ah specification, which is claimed to double the distance and cut the power consumption of traditional Wi-Fi. The Wi-Fi Alliance, which has about 700 vendors as members, expects to launch a certification process for Wi-Fi HaLow products in 2018; however, it is anticipated that products supporting the Wi-Fi HaLow specification will enter the market earlier.
License Approach	The IEEE requires IEEE members to license patents to users of the IEEE standards on FRAND terms. The IEEE IPR policy requires the licensing of patent claims the practice of which is necessary to implement either mandatory or optional portions of the standard when if, at the time of the standard's approval, there was no commercially and technically feasible non-infringing alternative means of implementation. The rights extend to any Compliant Implementation, which is defined as any product (including any component, sub-assembly or end product) or service that conforms to any mandatory or optional portion of a normative clause of an IEEE standard. In early 2015, in a hotly debated move, the IEEE amended its IP policy to clarify that members may charge a reasonable royalty that is based in part on the value that the functionality of the claimed invention or feature within the essential patent claim contributes to "*the smallest saleable Compliant Implementation*" that practices the essential patent claim.
IEEE	
Standard	IEEE P2413
History, Scope and Members	The Institute of Electrical and Electronics Engineers ("**IEEE**") project P2413 serves as a reference architecture incorporating more than 350 IEEE standards applicable to IoT, and more than 110 new IoT-related standards in various stages of development. P2413 is intended to define the "basic architectural building blocks and their ability to be integrated into multi-tiered systems." Among other things, project P2413 plans to turn the information from different IoT platforms into commonly understood data objects. The group held its first meeting in July 2014, with 23 vendors and organizations involved, and hopes to finish its work on the future standard by 2016. See the discussion of Wi-Fi HaLow for the IEEE's IP licensing approach.
License Approach	Not publicly available.

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ITU-T	
Standard	ITU-T SG20
History, Scope and Members	In June 2015, Study Group 20 of the International Telecommunication Union announced its work developing standardization requirements for IoT technologies, with an initial focus on IoT applications in smart cities and communities. The SG20 standard is focused on developing "international standards to enable the coordinated development of IoT technologies, including M2M communications and ubiquitous sensor networks."
License Approach	The ITU-T publishes a Common Patent Policy that describes a code of practice with respect to patents. Disclosure of known patents and patent applications (whether their own or third-party patent rights) by parties participating in the ITU is required. While in general the detailed arrangements with respect to patent licensing is left to the parties to negotiate, if a patent is disclosed with respect to a recommendation or deliverable of the ITU-T, and a patent holder is not willing to negotiate either a FRAND license (whether royalty-free or royalty-bearing), then "the Recommendation or Deliverable will not include provisions depending on the patent."
Google	
Standard	Brillo & Weave
History, Scope and Members	In May 2015, at Google's I/O 2015, Google announced Brillo and Weave. Brillo, an IoT OS that consists of an Android-based OS, core platform services and a developer kit, links IoT devices with each other, with other devices and with the cloud. Brillo uses Google's communications protocol, Weave, the standard that Google hopes to promote as the default standard for all IoT devices. Weave is a cross-platform protocol that enables device setup from a mobile phone, communication between devices and to the cloud, and user interaction from mobile devices and the web. Weave is operating system-agnostic, will work with Brillo but also with other operating systems, and will work on top of a variety of radio technologies (i.e., Thread, ZigBee, Bluetooth, and Wi-Fi). In August 2015, Google disclosed its product Google OnHub, the first Brillo-enabled device for the smart home. Intel announced that its Intel® Edison computer module is one of the first platforms to support Brillo.
License Approach	Not publicly available.

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Z-Wave Alliance	
Standard	Z-Wave
History, Scope and Members	Established in 2005, the Z-Wave Alliance's standard, Z-Wave, is a low-powered radio frequency communications technology that supports full mesh networks without the need for a coordinator node. The Z-Wave Alliance has over 375 members, and Z-Wave–powered products and applications cover a range of control and monitoring for residential and light commercial environments. The Z-Wave Alliance's stated goal is to "to bring advanced, yet practical wireless products and services to market that work together seamlessly, regardless of brand or vendor." According to the Z-Wave website, there are over 1,400 Z-Wave interoperable products available, and over 40 million Z-Wave products worldwide. The technology is licensed by Sigma Designs under a Z-Wave Technology License Agreement, the terms of which are not publicly available.
License Approach	Not publicly available.

OUR WAY OR THE HIGHWAY?

Disagreement over the appropriate IP licensing terms for each of the proposed standards has characterized the standards debate to date. In October 2014, Broadcom, a founding member of the OIC, reportedly quit the group due to a disagreement over the IP licensing terms that required companies contributing code to the project to waive their right to assert their donated IP against infringers. In contrast, at the time, the AllSeen Alliance did not have such a provision, but the Alliance's IP Policy was amended in January 2015 to include a comparable non-assert provision, seemingly rendering the dispute moot.

Will these standard-setting organizations learn from the historical experience in other sectors regarding standard-essential patents ("**SEPs**") and FRAND licensing terms? The problem is as follows: for IoT to operate in a seamless and interoperable way, standardized technology is essential. If the standardized elements of such technology are patented, this creates a barrier to entry to the IoT. Without a license, third-party users may be forced to either infringe upon such patents or pay exorbitant license fees. Other technology industries, such as the smartphone industry, have required owners of SEPs to offer non-exclusive licenses to prospective licensees on FRAND licensing terms to mitigate this issue. However, the process for agreeing to FRAND terms is seldom straightforward. Parties may not agree to what constitutes "fair and reasonable" in the context of IoT licenses, particularly given the prospect of enormous growth in the industry. Therefore, although many of the standards bodies above have adopted RAND or FRAND licensing models, the determination of what those RAND terms should be across the industry is far from settled.

Which standards will ultimately garner the widest adoption also remains unclear. Companies like Qualcomm and Intel have joined many of the standards organizations instead of backing a single one. Nonetheless, there have been recent movements by key players toward a more collaborative effort. In April 2015, the ZigBee Alliance and

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the Thread Group announced a collaboration to allow the ZigBee Cluster Library to run over Thread networks, representing one of the first steps toward interoperability in the fragmented IoT space. Qualcomm announced in July 2015 that it would join the Thread Group as a member of the board, opening the door for potential cooperation and collaboration between multiple bodies of which it is a member. In November 2015, the OIC announced that it had acquired the assets of the UPnP (Universal Plug and Play) Forum, which had been working on network connectivity since 1999. Earlier in 2015, the IIC and OIC announced a strategic liaison, including sharing use cases and architecture requirements, to "accelerate the delivery of an industrial grade communications framework for the IoT." Further, in December 2015, the ZigBee Alliance announced that it was working with EnOcean Alliance, a consortium for battery-less, wireless smart buildings and smart homes, to combine the benefits of EnOcean energy harvesting wireless solutions with ZigBee 3.0 for worldwide applications in self-powered IoT sensor solutions.

CONCLUSIONS

Technical and legal uncertainty, if left unchecked, can threaten to slow the maturation and growth of the technologies that the standards are intended to promote, as well as the businesses whose operations, products and services depend on the interoperability achieved through implementation of the standards. While it may seem that interests should align to create more certainty with respect to both technical and legal risks, this is not always the case. Barriers to entry can protect companies against competition and benefit those companies with the resources to understand and adapt to these risks. For many companies, however, the lack of harmonization can present substantial if not insurmountable obstacles.

For the IoT to achieve its potential for enhanced interoperability, adoption of standards and licensing practices that reduce technical and legal uncertainty are required so that information generated by smart devices may be shared across platforms to create new and innovative functionality. The myriad standards that define the wider framework of IoT interconnection are paradoxically competing to be the most open and most interoperable. As the IoT develops, networks of standardized technology (and the range of standards governing them) will continue to proliferate. Whether the IoT industry will move toward collaborating to achieve broader interoperability and adopting licensing terms that reduce IP risk likely will influence the extent to which the full potential for IoT will be achieved and how quickly emerging IoT technologies will mature and be adopted.

Contact:

Stephanie Lynn Sharron
(650) 813-4018
ssharron@mofo.com

Nikita A. Tuckett
(415) 268-7355
ntuckett@mofo.com

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