The role of interoperability in the market for connectivity technologies

By Yoram Solomon

Abstract

When companies develop products they naturally seek ways to differentiate their products from those of competitors. However, differentiation should be considered very carefully, especially when it comes to connectivity technologies, wired or wireless. In this paper I will start with focusing on a specific type of connectivity, the one that connects products delivered by different manufacturers. I will discuss when differentiation is a viable strategy versus when standardization is sought. I will discuss the different between standardization and interoperability, two terms that are not synonymous. Finally, I will discuss opportunities for differentiation in an interoperable market for connectivity. During this discussion I will use examples from the Bluetooth, Ultra Wideband, Wi-Fi, 1394, USB and other connectivity technologies.

Foreword

It's hard to sell products or components in a commoditized market. Often manufacturers will seek ways to differentiate their products. Differentiation can take many different vectors. A company can differentiate their products based on price. People fly Southwest Airlines because they have the lowest fares. One might think that Southwest Airlines differentiates itself by their orange-and-purple coloring scheme of their aircraft but, let's face it, when was the last time you booked your trip based on the color of the plane? Another vector of differentiation can be performance. Sport cars differentiate on how long it takes to get from 0 to 60 (or to 100, or to 200…). There is value in such differentiation. Another vector of differentiation can be the feature set. Non-sports cars can differentiate on the features they include, whether those are safety features such as an airbag canopy for the rear seats or driver features such as a 6-CD changer, a navigation system or other features.

However, when it gets to connectivity technologies, is there room for differentiation or should we seek standardization? What is the difference between standardization and interoperability, and what are the viable areas for differentiation in a connectivity technology? In this paper I will attempt to answer those questions.

Types of Connectivity

The term "Connectivity" covers many areas. It covers the "on-board" connectivity technologies between different components within the same product, such as PCI and others. It covers single-manufacturer system connectivity, such as the one existing between a home cordless handset and the base-station. It also covers connectivity between different products manufactured by different manufacturers, such as Bluetooth connectivity between a cellular phone and a wireless headset. It also covers connectivity between a device and the infrastructure, such as the connectivity between the cellular

phone and the service provider base station. Connectivity can also be short range versus long rage, and can be wired or wireless. Those are all completely different types of connectivity, and will have different requirements for standardization and interoperability.

For the purpose of the following discussion I will focus on one type of connectivity – ***the connectivity between products (or silicon components in products) that are manufactured by different manufacturers and are expected to communicate with one another***. A cordless telephone, for example, will not fit this definition. When you buy a cordless telephone you expect to buy the whole system. You are not "mixing and matching" handsets from one manufacturer with a base station from another. There are too many user features that require the entire system to be built and sold by the same manufacturer. However, technologies such as Bluetooth, USB, Wi-Fi and many others are expected to be manufactured by different manufacturers (e.g. the handset may be manufactured by Nokia while the Bluetooth headset is manufactured by Motorola, and the Bluetooth silicon in both those devices may be manufactured by different silicon manufacturers such as Texas Instruments and Broadcom).

Connectivity – definitions

During the following I will use some of the following terms, so I thought it would be a good idea to define them:

Front-end interface – the interface used to connect one device to another. Examples will be Bluetooth, USB, Wi-Fi, etc.

Back-end interface – the interface used to connect the connectivity component to the rest of the system. For example – a 1394 component in a TV may have a PCI interface to connect it to the other components on the TV.

Differentiation vs. Standardization

I will focus on front-end interface when I make the following claim: ***there is no room for performance or feature-set differentiation in a connectivity technology***. Having a USB component capable of delivering 1Gbps when all other USB components deliver 480Mbps does not offer any value to the customer.

Standardization vs. Interoperability

But is it really standardization that we are seeking? Often will product manufacturers and users tell you that they seek "standardization" in connectivity products. However, when you dig deep, you will find that it is not standardization that they are seeking but rather interoperability. "And what is the difference?" you might ask.

First we need to ask ourselves what is the definition of a standard. There are standardization organizations that have the objective of creating standards. Such organizations are the IEEE (delivered 802.3 Ethernet, 802.11 Wireless LAN, 802.16 for Wireless MAN, and others), ITU (delivered V.90 for dial-up modems), ECMA, ETSI and others. Their deliverable is a "standard". Other organizations that create standards are Special Interest Groups (SIG), whose standards are sometimes called "specifications", but serve the same purpose. Such organizations are, for example, the USB Implementers Forum (that delivered USB 1.1, USB 2.0, and Wireless USB specifications), the Bluetooth Special Interest Group (delivered the Bluetooth family of specifications), the WiMedia Alliance (delivering the WiMedia UWB specifications), and others. In all those cases the deliverable is a document specifying the required behavior of the connectivity component of the product. For the purpose of discussion I will refer to both of them (standard and specification) as "standard".

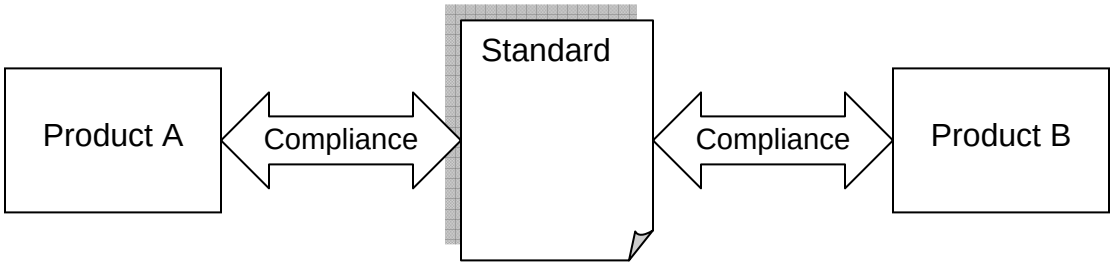
Standardization means compliance. The requirement is that a "standard product" complies with the standard and nothing else. So why do product manufacturers demand that connectivity component be standard (or, in other words, comply with the standard)? The reason is that those manufacturers believe that if product A complies with the standard and product B complies with the same standard – it means that product A and product B can communicate with one another. For example – if Nokia integrates a Texas Instruments Bluetooth connectivity component in a cellular phone and Plantronics integrates a Broadcom Bluetooth silicon connectivity components in a wireless headset, and if both components comply with the Bluetooth standard – they will communicate. Is that really the case?

As we've seen many times in history – this is not the case, for several reasons. First, the standards typically have many options in them. For example, the original IEEE802.11 Wireless Local Area Network standard specified three ***optional*** physical layer (PHY) alternatives in it. One was Direct Sequence Spread Spectrum (DSSS) radio technology, the second was Frequency Hopping Spread Spectrum (FHSS) radio technology, and the third was Infra-Red optical technology. Now assume that Texas Instruments implemented the DSSS option and Broadcom implemented the FHSS option. Both will be "standard compliant" (as both modes are optional), but they will not b able to communicate with one another.

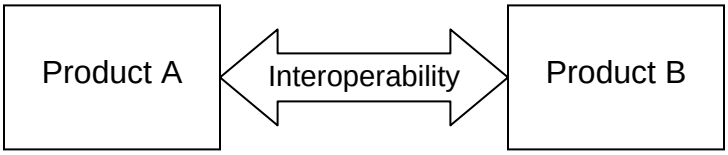
The second reason is that the standards are sometimes open to interpretation in more than one way.

The third reason is that sometimes the standard does not cover all. The standards might leave elements of a complete solution "open for interpretation" by technology, product and system manufacturers. Those elements, while not within the scope of the standard work, might be required in order for two products to interoperate. In this case, for example, even if the standard was very specific on how to implement the physical layer (PHY) and didn't leave room for options, two different product manufacturers might implement two different media access controllers (MAC) and thus not be able to interoperate although they are both compliant with the standard.

Standard Compliance



Product Interoperability



So, the basic assumption of the product manufacturer that demanding ***standard compliance*** from silicon connectivity component manufacturers assures that products will communicate with one another is not enough. What the product manufacturers really need is ***interoperability***. Interoperability (in the context of connectivity) is the ability of two different products to communicate with one another to a certain degree.

How is interoperability assured?

Interoperability is assured through several elements. The first is the existence of a detailed interoperability test specification that, if passed, assures that products will interoperate to the level expected by the user of the application. The second is the existence of test equipment or test suite that allows testing products for interoperability. The test equipment can be a specialty, dedicated test equipment which simulated one device while testing the behavior of another device (the device under test, or DUT), or a suite of "off-the-shelf" products with which the device to be tested for interoperability (the DUT) needs to interoperate.

What is tested?

Typically, a basic set of features and functionality is tested. Connectivity components are really only meant to connect different products, and so the basic functionality is the

ability to connect and allow content to flow over the connection in a way typically expected by the users. Functionality typically tested includes:

- Ability to connect in a timely manner
- Ability to achieve a minimum data rate in a consistent manner
- Ability to maintain a pre-defined quality of service
- Ability to recover from interference and errors
- Not causing interference to other products ("good neighbor")

In many cases not everything is tested. The standard, based on which the interoperability is tested, may include optional features. Those are typically not tested, as they are optional and not all products will include them, and thus interoperability cannot be assured. In some cases, optional features are tested and become mandatory in order to pass the interoperability tests. One example is the high rate of 54Mbps for the 802.11a and 802.11g standards. While optional in the IEEE 802.11 standard amendment (the highest mandatory rate in those standard amendments is 24Mbps), they became mandatory for tests in the Wi-Fi Alliance in order to significantly differentiate Wi-Fi products certified as 802.11a or 802.11g products from products certified as 802.11b products. In other cases there are interoperability tests that go beyond the content of the standard, when required for assuring the operation of the product as anticipated by the user.

Who is conducting the tests?

There are different approaches to the conduction of the interoperability tests. The following are the typical interoperability testing approaches, varying from the "looser" (the first) to the "tighter" (the last) approaches:

- Self certification – tests are conducted by the manufacturer who assures the interoperability based on an accepted set of tests
- Independent, non-accredited test facilities
- Independent accredited test facilities – those facilities conduct the tests based on guidance from the organization responsible for certification of such interoperability
- Tested by the certification organization – rare, as typically those organizations are not equipped to perform such testing.

Interoperability Certification

A key part of the interoperability assurance process is the interoperability certification. The user has no way to know if the products on the shelves will interoperate. Simply stating "complies with the 802.11b standard", for example, will not guarantee interoperability. The user might buy the product just to find out that the product is not interoperable (really not working) with other products who assured the same compliance. Typically the organization responsible for the interoperability assurance will develop a certification program that will include a logo that assures the product is interoperable. Manufacturers cannot apply this logo to their products unless they complied with an interoperability policy and passed the required interoperability tests. The user will seek

the certification logo on the product before purchase, and the existence of the logo will assure that the product will interoperate with any other product carrying the same logo in a basic, standard operating mode.

Conclusion

In the early days of some connectivity technologies, the consumer return rate was high. One of the major reasons was that those products simply did not work with one another. Simply stating that those products complied with the same standards was not enough, as those standards had non-compatible options implemented by different products, and sometimes didn't include all the functionality required for the operation anticipated by the users. For that purpose, a few organizations (such as WiMedia and Wi-Fi Alliance) were formed, and some other organizations (such as the USB Implementers Forum and Bluetooth) developed interoperability certification programs, assuring the two products carrying the same interoperability certification logo are, in fact, interoperable.