XIM GEN4 Q&A

ANSWERS TO FREQUENTLY ASKED QUESTIONS

(And some not-so-frequently asked)

Contents

XIM Gen4

Q: Are there any limitations in product options or implementation?

A: The current XIM portfolio is almost as extensive as our XTM portfolio, and XIM Gen4 will have the same, broad product portfolio. Out of the gate, it will be compatible with the same, wide range of heat sinks, power supply units and reflectors and lenses.

Q: Is XIM Gen4 a drop-in replacement for a standard XIM?

A: Yes. If a luminaire is designed to support our existing XIM, the XIM Gen4 will drop right in without any changes thermally or electrically, but radio performance will need to be tested.

Q: Other than the XIM Gen4 module itself, what else is required to build a system?

A: Nothing, really, if your needs are simple. A small site – say, a retail store, or home, or restaurant – can install XIM Gen4 lighting, provision light levels from software on an existing Windows laptop or Surface tablet (and in the future, an iOS or Android tablet), and control it from a smartphone, or turn it on and off with a simple light switch. No additional equipment is required.

However, if you want to scale your system to hundreds or thousands of lights, or want to be able to control or monitor it remotely, you can purchase the Xicato IP Gateway (XIG-0101). XIG makes it possible to manage large sites, multi-story buildings, distributed campuses, or even geographically distributed buildings around the globe.

Q: Can you control linear sources with the Xicato App?

A: Not in 2016. Xicato is developing a Xicato Intelligent Driver (XID) that can drive many 3rd party products, and is exploring the possibility of offering Xicato linear solutions.

In the meantime, we are participating in the Bluetooth SIG standard working group and talking with potential partners to find the best ways to support interoperability between devices and systems.

Q: What is the range of Bluetooth, and what is the impact of the fixture on the range?

A: The range of a radio is defined by its maximum transmission power and receive sensitivity (in decibel-meters or dBm), and signal to noise ratio. Xicato has standardized on a new generation Bluetooth radio with an amplifier that significantly improves radio frequency (RF) performance. For our modules, these numbers are:

- Transmit power: -10 to +9.5 dBm

- Receive sensitivity: -95 dBm

- Signal to noise: 5:1

This means the maximum range of our amplified Bluetooth modules is 400 meters, line-of-sight with no obstructions.

However, real-world performance is certainly less than 400 meters. Our modules are often wrapped in metal housings, installed in ceilings, in buildings with walls, cubicles, people, and equipment. A reliable and practical range is more like 30-60 meters in a typical environment. We can "see" most but not all of the modules in our building on our iPhones from outside our building, beyond the 100 meters distance usually stated by Bluetooth.

If necessary, range can be extended using repeaters, using a gateway such as XIG to a "backbone" of Ethernet or Wifi, or using the future capabilities of Bluetooth Mesh. In the meantime, we do not see range as an issue in most lighting applications.

Q: How do I extend the range of the system?

There is a new standard called Bluetooth Mesh that promises to extend the range of compatible systems by retransmitting signals through multiple "hops" from one device to the next. While there are a few pre-standard implementations of Bluetooth Mesh, this oft-delayed standard will not be complete until at least the 2nd or 3rd quarter of 2017, and fully standardized and multi-vendor compatible implementations will almost certainly not appear before 3Q 2017.

Even with a fully standardized and mature Bluetooth Mesh protocol, there will be times when the "next node" is out of reach of any Bluetooth radio. In these cases, we can do what networking companies do – we use high-speed IP backbones to connect Bluetooth zones. In some cases, such a backbone will deliver performance superior to mesh solutions, due to its higher data rate[1] and reduced number of hops[2]. In fact, a backbone will be preferable in many situations even where Bluetooth Mesh might otherwise work, for performance reasons.

To this end, and until the Mesh standard is mature, **Range Extension** can be done using Xicato IP Gateways (XIG-0101). Connect the gateways over a high-speed IP backbone (Ethernet or Wifi), and the gateways will pass messages between BLE zones, and between BLE zones and a centralized Control Panel, and even beyond through the internet to distant cities. There is no limit to range, using this technique.

This is not to say that Xicato is a "disbeliever" in Bluetooth Mesh. On the contrary, we are active participants in the Bluetooth SIG group that is developing the standard, and are working hard to ensure that it has the features and performance required by our demanding commercial customers.

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[1] Inexpensive gigabit Ethernet operates at one billion bits per second, vs. Bluetooth maximum of 1 megabit (million bits) per second… a difference of 1000x.

[2] Each hop imposes a delay time that is a function of how much traffic is on the network, the speed of the links, and the performance of the switching/routing function. Ethernet can be extended indefinitely with negligible latency.

Q: Can Bluetooth go through wall and windows?

A: Yes… but. Bluetooth works in the same 2.4GHz radio spectrum as Wifi and ZigBee; so it can penetrate any structure that Wifi can, including windows and walls. And as with WiFi, there is some attenuation of the signal when passing through objects containing metal or water, including walls, trees, and people, depending on the thickness (and juiciness) of the object. ☺

Q: Can an end user set a maximum intensity level for a light fixture to prevent glare or over-illumination?

A: Yes. The Xicato Control Panel is a Windows-based provisioning and administration app that allows an end user the ability to set a maximum intensity level on the XIM Gen4 module, which can only be changed by the provisioning software but not an end user control app.

Q: Will Xicato make a software tool available for lighting systems manufacturers to set maximum light output?

A: Yes. The Xicato Configuration Tool (XCT-0101), released in November 2016, lets lighting OEMs program a lower, maximum output level for an XIM module to as low as 50% of the rated level. For example, the maximum intensity of a 1300LM XIM can be set to 1000 lumens or a 2000LM product can be sold as a 1600LM product, saving on SKUs at the price of a slightly higher-cost module. It also allows the OEM to tune the output so as not to exceed the maximum thermal capacity of the luminaire heat sink.

Q: Is the permission to set OEM configuration (maximum flux, OEM info, etc.) different from the commissioning permissions?

A: Yes. The Xicato Configuration Tool requires direct, wired access to the XIM, and is a different software application from the provisioning application. The Control Panel software cannot override the maximum output set by the XCT.

Q: Will the modules be upgradable with more features or bug fixes?

A: Yes. Xicato XIM Gen4 modules support Over The Air (OTA) updates of baseboard and Bluetooth firmware and application software. This will include the eventual update to Bluetooth Mesh.

Q: How long does it take per node for OTA updates?

A: This depends on the extent of the update. A major update such as moving from Xbeacon to Bluetooth Mesh will probably take 3-5 minutes per node. A more incremental update of XIM firmware may take as little as 10 seconds. Generally, expect updates to take 30-60 seconds per node.

OTA updates require either a person with a provisioning app or a gateway within radio range of each node to be updated. Updates occur sequentially – one node at a time. A

good strategy for an extensive update might be to conduct the updates at night, one group at a time.

A future capability of the Xicato IP Gateway will be to conduct OTA updates on a distributed basis, from the XIG rather than from a central or mobile Control Panel. This will dramatically speed and simplify the update process.

Scalability

Q: How many nodes (devices) can be supported?

A: The system supports over 4 billion (2^{32}) secure networks, each of which can support $2^{15} - 1 = 32,767$ individual nodes, for a theoretical total of over 140 trillion nodes.

These are obviously huge numbers; therefore, the practical limit on the number of nodes will be the reach and bandwidth of the Bluetooth radio. There is no upside limitation imposed by software or application implementation.

By contrast, DALI has a max of 64 nodes per controller. Zigbee is limited by bandwidth and the complexity and latency of the mesh to no more than 250 nodes.

Q: How many devices can be supported?

A: Each secure network can be configured with up to $2^{15} - 1 = 32,767$ devices. This means that the theoretical maximum number of nodes per site is over 140 *trillion*.

Q: How many groups can be supported?

A: Each secure network can be configured with up to 16,383 groups.

Q: How many scenes can be supported?

A: Each secure network can be configured with up to 65,535 scenes.

Safety & Security

Q: What will be the safety rating (related to wireless signals)

A: The XIM Gen4 conforms to the Bluetooth SIG requirements for Bluetooth Smart, as well as meeting UL, FCC Class B and equivalent CE requirements.

Q: Will the system be secure? How do you prevent someone from hacking into the lights and start messing with them?

A: Administrators can optionally enable AES-128 encryption at the network layer, which causes the XIM and other network members, such as sensors and gateways, to encrypt the network data.

Users gain access to a network of secured modules by entering a secure network name (ID) and password (PW) into the application. Through a complex algorithm, the application converts ID+PW into a 128-bit encryption key (3.4 x 10**38 different keys!) with which it encodes all future communication with that device. The application will remember the name and encryption key, so there is no need to reenter it unless the Administrator changes the password.

In addition, there are application layer protocols in place to prevent common hacks and attacks from unauthorized people.

Q: Is there a security "back door" to allow access to modules in case the administrator forgets the passwords?

A: Back doors are security holes that could enable criminals or mischievous hackers to gain unauthorized access to entire IoT networks.

There is no way to wirelessly access a member of a secure network without the proper network ID and PW; therefore, Administrators MUST REMEMBER THE PASSWORDS, or it will require physical (wired) access to the modules to reset the lights.

With physical access to the module, it is possible to restore the XIM Gen4 module to "non-provisioned" state by physically touching pins 3 and 4 together for 5 seconds while the unit is powered. These pins are not used for normal operation – they are the two pins that are neither the power wires nor the wired communications wires.

There is currently no way to recover a sensor. So DON'T FORGET YOUR PASSWORDS.

Q: Is there a way to save secure network, group, and scene information to a file?

A: Yes. The Control Panel saves this information in separate files in its program folder. You can save these files to another location by clicking the Export button for each function (Secure Networks, Groups, Scenes). These buttons are next to the respective configuration areas on the Settings tab in the Control Panel.

You can Import these files to new copies of the Control Panel, or use them to restore your settings if you lose them.

Q: How is security managed?

A: Security is managed in a similar way to a Wifi network, except that, unless you are told of the existence of a particular secure zone and given the ID and PW, you will not be able to see any of the data or control any of the lights in that zone. The ID and PW combination creates an encryption key that encrypts data passed between the application and the units, between the units, and between the units and gateways.

Distribution of access privileges depends on the abilities of the Administrative software. In Xicato's first release, secure network IDs and PWs are created using the Control Panel or provisioning app. IDs and PWs are then provided to each user, who enters the ID and PW on the appropriate screen in the XIMtroller app.

In the future, it will be possible to establish access control groups and distribute the IDs and PWs automatically to registered end users.

Q: How are access permissions distributed to different users?

Fundamental access to a secure network of lights is provided through the secure network ID and password. If a user doesn't have the network ID and password they will not be able to see or access the devices on that secure network. Initially at least, users will have to be told the ID and PW of secure networks to which they want access and enter it into their XIMtroller applications.

In addition, there will be up to 8 configurable levels of security within each network that grant different permissions to access, provision and control network nodes. These might include, for example, Administrator, Supervisor, User, Facilities, and Public, but up to 8 levels can be named and configured to provide more fine-grained access control.

The Administrators of the network will assign a security level to different features of the light and a security level to each user given access to the secure light network. A user will be able to access features at their security level and below.

As of right now the control panel always operates with Administrator access, but this will be modified in future releases.

Q: What happens if the administrator forgets their password? Is there a reset option or a backdoor somehow?

A: There is currently no way for Xicato to remotely or wirelessly help a user who forgets or misplaces the password to the Control Panel application. Doing so would create a security hole that might be exploited by a hacker.

If the password to a secure lighting group is lost by all users and administrators, access can be restored by gaining direct, wired access to the XIM module.

Q: How many lighting groups can be configured in an installation/system?

A: Users can configure up to 32,767 groups in each of up to over 4 billion secured or unsecured networks.

Q: Can an individual light belong to more than one secured network?

A: No.

Q: Can lighting groups span multiple secure networks?

A: Not natively. It is possible to develop an application that can group lights in different secure networks into one virtual group, and issue separate commands to the lights in each secure network within that group, using the encryption keys appropriate for each secure network.

Accessories

Q: Will Xicato software support 3rd parties BLE switches and sensors, such as Casambi, Silvair, or Avi-On?

A: Casambi, Silvair and Avi-On have proprietary mesh implementations based on Bluetooth 4.x. They are not standards-based, regardless of what they say, because there is no mesh standard. Neither Casambi nor Avi-On has published their interface API, so compatibility is not possible. They appear to be trying to lock-in their customers so that they can only buy from them. Silvair is marginally more open, but again, you have to buy their chips or products to be compatible with them, at least until the Bluetooth Mesh standard is finalized in 2Q or 3Q 2017.

Because the application layer specification is not open, Casambi solutions can only be controlled by Casambi software, and Avi-On solutions by Avi-On software.

Xicato, by contrast, has provided its API to multiple third parties so that they can develop compatible software and hardware. Our protocol is based on Bluetooth Low Energy, which is part of standard Bluetooth v4.1 and later, and will be Bluetooth Mesh compatible as soon as the standard is finalized. Existing users will be able to update current software and firmware to Mesh using an Over The Air field update.

Q: Will XIM Gen4 app & control software support "open system" accessories?

A: Yes. When the Bluetooth Mesh standard is complete and mature, Xicato will adopt the standard, so that we will be able to control hardware that is built to the standard, and so that standards-compatible 3rd party devices and software can interoperate with Xicato devices and software.

Unfortunately, there are currently no "open system" accessories. Each vendor has its own proprietary implementation that must be controlled using their own software.

Switches

Q: Can I turn lights on and off using a standard light switch?

A: Yes. XIM Gen4 will work like a typical fixture with a power switch. The fixture will remember its name and configuration, and will be fully operational immediately when the power is restored. It can also be configured to return at power-up, at a configurable ramp speed, to either a fixed, preset dim level, or at its last setting.

However, while the power is off, the entire module will be shut down – beacons, broadcasts, and the ability to probe the lights will be disabled.

Q: Do any dimming switches work with XIM Gen4?

A: Yes. EnOcean 2.4 GHz energy-harvesting switches transmit Bluetooth Smart for on/off/dimming. One or more of your XIM Gen4 modules can be programmed to interpret the switch commands in any way you like.

In the future, we expect a large ecosystem of vendors supplying switches compatible with Bluetooth Smart and the Bluetooth Mesh protocol. Xicato is working to ensure that third parties implement compatible switches.

Q: Is XIM compatible with switches that use the EnOcean protocol?

EnOcean is a protocol of its own, and not compatible with Bluetooth. But EnOcean, the company, sells switches that use the energy-harvesting attributes of EnOcean and do in fact transmit BLE messages. Our XIM can be programmed to hear these BLE advertisements and interpret them as simple on/off or dim commands, or as scene commands.

Q: Will Xicato develop a BLE switch?

Xicato may eventually create a basic hardware platform (a PCBA, for example) that can form the guts of such a solution, but we definitely want to stay out of the switch business — it is a fashion business!

Sensors

Q: Does XIM Gen4 work with sensors?

A: Yes. If desired, or if required for building code compliance, you can add sensors at any time to detect motion/occupancy/vacancy or lux/ambient light/daylight and program the lights to respond appropriately.

Initially, these will need to be Bluetooth-enabled sensors compatible with the Xicato Xbeacon protocol. Xicato is already selling beta versions of lux and motion sensors for this purpose. These sensors also include temperature, humidity, and an accelerometer to detect vibration and large motion of the sensor itself (and what it is attached to).

In the future, we expect a large ecosystem of vendors supplying a wide variety of sensors compatible with Bluetooth Smart and the Bluetooth Mesh protocol.

Q: What kind of sensor form factors will Xicato sell? When will there be a detailed datasheet?

Xicato is working on two Xicato Wireless Sensor (XWS) form factors:

1. A "spider sensor" (XWS-0201) that has a central body (XWS-0200) powered by a standard 3V coin battery, with temperature, humidity, and accelerometer sensors, to which up to 3 "legs" can be attached; two for lux (XWS-0002), and one for PIR motion (XWS-0001).

2. A fixed "integrated" multi-sensor (XWS-0101) in a small rectangular form factor that includes PIR motion, light level (lux), temperature, humidity, and accelerometer, and has two ports that allow two additional PIR motion sensors to be attached up 100 feet away. This sensor requires DC power at 6V to 52V, such as provided by a 9V battery, or by a DC track running at 12V, 24V, or 48V.

These designs will be available in beta in 1Q 2017, and production released in 2Q. Xicato is selling these sensors as PCBA "guts" that can be packaged by third parties, or used "bare" if appearance is not an issue.

Gateways

Q: Does XIM Gen4 require a gateway?

A: No, not for small sites with simple requirements. However, to integrate a larger site, or to enable remote access to controls and operational data, you can add gateways that translate messages between the Bluetooth network and your local LAN, and can be accessed from anywhere in the world.

Q: Will Xicato offer a gateway product?

A: Yes. The Xicato IP Gateway (XIG-0101) will be released in February 2017 to enable range extension and remote access to XIM Gen4 BLE zones.

We also expect others to create standardized gateways as the Bluetooth market expands.

Q: What will the initial release of the XIG allow me to do?

A: The first release of the XIG will allow users that are sharing the LAN with the XIG, or who have gotten access to the LAN through a VPN, to see and control devices within range of the XIG. This includes commanding on/off/dim levels for individual lights or lighting groups, and collecting basic operating data, such as intensity level, LED temperature, power consumption, input voltage, and operating hours.

The XIG will also distribute network timing to keep devices synchronized for the purpose of scheduled control.

Q: How much will it cost for a gateway?

A: A reasonable budgetary assumption is $250 for a gateway with Bluetooth, Wifi and Ethernet. Final pricing will be set at the time of the February 2017 release.

Xicato Intelligent Driver (XID)

Q: Can I control non-Xicato luminaires using Xicato's sensors and software?

A: Xicato is working on a driver that will allow BLE control and management of third party luminaires. Contact your Xicato representative for more information.

DALI and 1-10V Bridges

Q: Will Xicato develop devices that convert between BLE and DALI or 1-10V?

Xicato recognizes the value of these kinds of devices, both to add BLE to an existing DALI network, and to transition a DALI network to BLE.

There are a few companies that are developing "bridges" between their proprietary Bluetooth Mesh implementations and DALI. We are having internal discussions about whether to do this ourselves, and expect we probably will deliver such a product in the 3Q 2017 timeframe.

Once the Bluetooth Mesh standard is finalized and interoperability is demonstrated, we expect these devices to be available from many vendors.

Beacons

Q: What is a BLE beacon?

A: A BLE beacon is a short message that is advertised on a periodic basis from a Bluetooth device. It is like a lighthouse, constantly advertising its presence, without knowing how many ships are looking at it. It does not create a connection with a mobile device, but applications on the device – or web pages to which it points the user – can interpret the beacon to provide information or services to the user. BLE beacons are designed to provide services that are "location aware", meaning that the information is relevant to the physical location of the user. This may work like GPS, providing a location on a map, or it may present information about something that the user is close to, such as a museum exhibit, merchandise on a retail shelf, a check-out counter, or a historical monument. Beacons can be used indoor or outdoor, but they have special value indoors, where GPS satellite signals do not penetrate, or in dense urban environments where GPS has problems with tall buildings.

Q: Does XIM Gen4 support Apple iBeacons?

A: Yes. XIM Gen4 supports Apple iBeacons today. These beacons are easy to configure using the Control Panel application. iBeacons are useful when receiving devices have an Apple-registered application specifically designed to receive those beacons. Apple iBeacons do not require Internet connectivity if the application contains all the required content.

Q: Does XIM Gen4 support Google Eddystone (Physical Web) beacons?

A: Yes. XIM Gen4 supports Eddystone beacons today. These beacons are easy to configure using the Control Panel application. Eddystone beacons are useful when the receiving device has a Physical Web application or a Google Chrome browser, and access to the Internet.

Q: What is the difference between an iBeacon and an Eddystone beacon?

A: Apple iBeacons have a different message structure from Eddystone, and they interact differently with the mobile operating system.

Apple iBeacon messages are constructed of a UUID, a major and a minor identifier. The UUID is specific to a beacon vendor, the major identifier is specific to (say) a region, like a store location; and a minor is specific to a sub-region, like a department within a store, or another very specific location. The identifier is recognized by an app, which is programmed either to present a screen of information such as a map, merchandise description, or museum exhibit information, or to perform some other location-specific task.

Eddystone beacons are simply short URLs (Universal Resource Locator addresses… web addresses). They are designed to work with browsers, which must have an Internet connection to retrieve content or make meaning of the beacon.

iBeacons are designed to work with specific mobile applications. These applications may have all of the content embedded in the application, and can be internet-independent, although many such applications do leverage the Internet for deeper content and real-time services.

Q: How do Apple iOS and Google Android devices differ in the way they use beacons?

A: Apple's iOS operating system is constantly scanning for BLE beacons; you do not have to have an application open – in either foreground or background – for the operating system to recognize that you are in range of a beacon and for it to either present a notification or open an application for you.

Android requires that you have an application open at least in the background for the beacon to be recognized.

Q: What are some companies that develop beacon-enabled applications?

There are many companies developing beacon-enabled applications native to iOS and Android for museum, retail, and other markets. Some of which we are aware include:

- TapMe Media in the Netherlands (iBeacon): www.tapme.nl
- GuideKick in California (iBeacon): www.guidekick.com
- Hellonet in Italy (iBeacon): www.hellonet.it
- B-Kin / PhyNet in the US (URI beacons): www.phy.net

Software

Q: Do I need software to use XIM Gen4?

A: No, not if you don't need the Bluetooth control, management or beacon capabilities. XIM Gen4 will work as a 48V DC LED module without software or Bluetooth connectivity. Power-on and power-off will work as usual. And because XIM Gen4 will initially come with either DALI or 1-10V in addition to Bluetooth, these control systems can be used as usual, leveraging the XIM driver, until Bluetooth control can be implemented.

Q: So I can start with XIM Gen4 with DALI or 1-10V control, and add Bluetooth controls later?

A: Yes. You can buy XIM Gen4 with DALI (for example) and use it in your existing DALI system. When you want to start using Bluetooth, you simply walk in with a provisioning app and begin!

Q: Who is developing software for XIM Gen4?

A: Xicato has developed reference applications to get things started, and is talking with multiple 3rd party software developers about working with XIM.

Q: What software is available right now?

A: Xicato has developed a Windows-based Control Panel application for provisioning and administration, and an iOS app named "XIMtroller" for basic control. These give you everything you need to get started right now.

Q: Is Xicato providing provisioning and commissioning tools?

A: Basic commissioning will be available initially through the Xicato Windows Control Panel app. The goal and focus is to provide a robust and reliable software tool. The UI is clear and concise, and the functionality is very deep, but the app is not super slick and "glossy" with fancy user interfaces.

As we see it, wirelessly controllable sources can fundamentally change the commissioning process, because the process can occur completely within the lit space, with the person wirelessly interacting with and configuring the lights. This is the paradigm we established with XIM Gen4 in 2016 that we will expand and enhance going forward.

Q: What is the functionality of the Windows Control Panel application?

A: The Control Panel application currently runs on a Windows Surface™ tablet or laptop with a USB dongle, and provides full provisioning, control, monitoring, and data logging capabilities. It can see and name lights, create secure access zones, create lighting groups and scenes, and program associations between lights, sensors, and

switches. It can control the intensity of lights and lighting groups, and command scenes. It can probe the lights for all available operating data and keep data logs of operational data broadcasts. It can configure simple or complex behaviors based on occupancy and lux sensors, time and day of week, switches, and mobile control. And it can be used to enable and configure iBeacon and Eddystone beacons for location-based services.

Q: What is the functionality of the iOS XIMtroller app?

A: The XIMtroller app runs on an iPhone or iPad and has the ability to see individual light fixtures, their Bluetooth signal strength, and current lighting intensity. It can control the intensity of individual lights, groups of lights, or all lights using a slide switch, and can probe individual XIM modules for configuration information and basic operating data, such as temperature and intensity.

Q: Will there be an iOS and/or Android-based provisioning app?

A: Yes. We are currently developing an iOS app called "XIMmissioner" that will run on Apple iPads. For now, provisioning is done using the Windows Control Panel, which can run on a portable laptop or Surface tablet with a Bluetooth dongle.

Q: What is the schedule of Google (Android) based GUI?

A: First implementation is on iOS because iOS has had a more mature BLE implementation than Android, and because iOS is a more uniform platform with fewer variations in screens size, interface, etc. between different vendors. Xicato hopes to implement Android-based control and provisioning in 2017.

In addition, Xicato will have a web-based interface that will provide a more universal interface through the XIG. This will be accessible to iOS, Android, Windows, MacOS, and any other system with a standard web browser.

Q: What happens if a module dies? How easy is it to reconfigure a group or scene and add to an existing network?

A: The new module can simply be installed and provisioned in the same way as the original unit. If the provisioner remembers the original setup, this process should take just a few minutes.

Groups

Q: Can lights be configured into groups?

A: Yes. Each node can be a member of up to 16 groups, in addition to being addressed individually and as part of a broadcast to "all", so there are up to 18 ways to address a given light for the purposes of control.

Q: Can a single dimming or scene command apply to an entire group?

A: Yes. Users can select a group and use a slider, trim button, or intensity command to control all the lights at once. Scene commands can be "group provisioned", but the command itself applies to individual lights, not groups. A scene can be assigned to all the lights in a group, to individual lights within a group, or to individual lights in multiple groups, or to all the lights in multiple groups, depending on programming. The Control Panel application simplifies scene programming of multiple lights at once.

Q: Can a light be a member of multiple groups? How many?

A: Yes, each light can be a member of up to 16 groups, in addition to being individually addressed and being part of a broadcast command to "all". So there are a total of 18 ways to address each light.

Q: Can groups be nested? Can they overlap?

A: Yes, groups can overlap, or can be nested within each other.

Q: How many groups can be created within each secure network?

A: Each secure network can contain up to $2^{15} - 1 = 32,767$ groups.

Q: Can a single group be part of (span) multiple secure networks?

A: No.

Scenes

Q: What is a Scene?

A: At its simplest, a scene is a predetermined set of simultaneous intensity settings for one or more lights.

In the Xicato system, the XIM modules are intelligent – they ARE the control system. Each light individually understands the scene command to mean something specific to itself. This means that a single, simple command (literally a scene number advertisement) can instantly and simultaneously apply to multiple lights, and that each light can interpret that command differently.

The light's response has three basic attributes:

    (1) Delay – how long the XIM waits before it implements a change
    (2) Ramp or transition time – how long does the XIM take to achieve the final intensity level
    (3) Intensity – the final or destination dim intensity level

In other words, to each individual XIM, a Scene is simply an intensity level, achieved after a ramp time, which begins after a delay. Because it is a single, broadcast

command, the lights hear it at the same time, and respond instantly and simultaneously, according to their programming.

Contrast this with a centralized controller-based system. In such a system, the controller has to issue separate commands to each light. It is impossible to do this all at once – it is done sequentially, which means lights do not respond simultaneously.

Q: Why create a scene?

A: The advantage of a scene command is that it is a single command – a single button press, for example – that can apply to multiple lights, each of which can respond in its own individual way. It enables instantaneous, simultaneous response, while minimizing the network traffic and delays associated with issuing separate commands to each light.

Q: Can a single scene apply to lights in multiple groups?

A: Yes. Scenes and groups are logically separate. Scenes can apply to all lights in a group, individual lights within a group, individual lights in multiple groups, or all lights in multiple groups.

Q: How many scenes can be configured in each secure network?

A: Up to $2^{16} - 1 = 65,535$ scenes can be created in *each* secure network.

Q: How many scenes can apply to each light?

A: Each light can be programmed for up to 16 scenes. Each module keeps in its own memory the command identifiers of the scenes that pertain to it, and how it will behave to each scene command. No external controller is required.

Q: Can a single scene apply to lights in multiple secure networks?

A: No. Different encryption would have to be applied to the scene command sent to lights in different secure networks. While in theory this could be done at the application layer, it would require two separate commands to be issued by the application.

Modes

Q: What is a State?

A: A State is a condition under which a light responds to inputs (e.g. from sensors, switches, time clocks, etc.) in a particular way, which may be different depending on what State the light is in. A State is associated with a set of logical, If-Then instructions that may cause it to listen to some inputs and ignore others, or respond one way to a sensor in one State and a different way to the same sensor while in another State.

Q: How many State can be configured into a light?

A: A light can be configured with up to 4 defined States.

Q: What causes a light to go into a particular States?

A: Modes can be triggered by virtually any input – sensor input, a switch button being pressed, a mobile app, or a remote command through a gateway. It is entirely up to how the individual light is programmed through Provisioning.

Q: How do States work?

A: For example, a light in a museum that is illuminating a painting may be configured to understand four states,

(1) Unoccupied (no one in the room)
(2) Occupied (someone in the room but not near this painting)
(3) Near (someone at one of the nearby paintings, or approaching the painting)
(4) At (someone standing in front of the painting)

Each State will cause the light to react differently to ambient light and motion sensors in the room.

A light in a conference room may be configured with:

(1) Vacant state, triggered by an occupancy time-out, where lights are dim or off, and occupancy sensors are ignored.
(2) Meeting state, triggered by a switch or mobile command (but not occupancy sensors) and maintained through occupancy sensors, where lights are at relatively high intensity
(3) Presentation state, where lights are dim and they ignore occupancy sensors

Scheduling

Q: Does the Windows Control Panel support scheduling?

A: Yes. Control Panel can program a schedule into each XIM, in the same way it programs sensor response. In effect, time becomes a sensor, with the schedule triggering different States in the light, potentially in combination with sensors, switches and mobile commands.

XIM hardware and firmware can keep a not-very-accurate clock in the XIM. To keep it in sync, a timing signal can be periodically transmitted either by a gateway such as XIG that is connected to a network time source, or by Control Panel software, or by mobile devices with accurate time.

What we will NOT do is to exactly reproduce the complicated, dynamic scene capabilities of DMX. Sorry. If you want DMX, you should buy DMX. But we can do things like implement time-of-day changes in lighting settings, e.g. for restaurants, hotels, museums, and other commercial establishments with defined operating hours.

Operating Data & Analytics

Q: How much operational data (in thousands of hours) can the XIM store before it starts overwriting?

A: The amount of operational data that the XIM stores doesn't really change, once it begins operating. There is a fixed array of memory that the module periodically updates with the latest information. For example, there is a 4-byte memory location for how many hours the module has operated in total, at each intensity level, and at each temperature level. The value in this location starts at 0. Every so often as the module is operated at that level, the module updates that number. It does not change the size of the memory allocated to that data; it just puts a bigger number into that slot.

For example, the biggest number of operating hours that can be stored in each memory location is 4 bytes = 2^{32} = 4,294,967,296. This is over 489,957 years. We think this is enough!

Q: Can operational data be imported into a database for analysis?

A: Control Panel data logs can be dumped to files that can be parsed and imported into a database for further analysis. Xicato expects that any long-term operational data logging will be handled through a gateway device that passes Bluetooth message data from the lights to an IP network, and then to an Administration app on a local server and/or the Cloud.

Cloud Services and Remote Access

Q: Can I control and monitor lighting remotely (i.e. out of Bluetooth range)?

A: The Xicato IP Gateway (XIG-0101) can be seamlessly added to an existing XIM Gen4 installation with very little effort. XIG allows control and monitoring of an entire installation, and will eventually have a large feature set including provisioning, OTA update distribution, and more.

Q: Will there be a cloud service?

A: Xicato expects to build cloud capability in the future.

Q: Will Xicato charge for software?

A: Not initially, although we will need to figure out a way to pay for ongoing support, maintenance and upgrades. We are still evaluating our software pricing strategy.

Q: Will Xicato charge for the cloud?

A: Not for the cloud, as such, but for additional services that we make available that are cloud based. These services will be optional. However, we will require cloud

connectivity from XIM Gen4 to support a warranty that extends beyond our standard 7 year / 50,000 hour warranty.

Building Codes and Demand Response

Q: Is XIM Gen4 compliant with California Title 24 building codes?

A: Yes, although code compliance is not a function of the LED module itself, but of the design of the control system implementation. XIM Gen4 can be configured to respond to occupancy, vacancy, and ambient light sensors in a way that is fully compliant with any building code.

Q: How about Automated Demand Response?

A: Yes. With XIM Gen4, this should be easy. Simply program a Scene into the XIMs that will dim the XIMs by the required amount in response to an Auto-DR request.

ADR requires that lights be dimmed by a designated percentage in response to requests from the utility to reduce electrical loads and prevent brownouts during periods where electrical demand is expected to outstrip supply. Companies must have a building management system (BMS) or other mechanism to receive the ADR request. They can then either manually issue the ADR scene request to the XIM network, or directly tie the BMS to the XIM system using a protocol gateway from a company such as Sierra Monitor.

XBeacon, Bluetooth Mesh, and Interoperability

Q: Why Bluetooth?

A: Bluetooth is a widely available technology already installed on billions of devices, worldwide. You probably have it in your pocket! It is a free, open standard that addresses the entire software "stack", from the network to the application layer, so has the best chance of ensuring interoperability between different devices from many vendors. It has technical advantages vs. every other protocol currently available (which we can discuss *ad nauseum*). And it already has several, easily implemented IoT capabilities – such as beacons – that add immediate value to lighting control in commercial spaces.

Q: Does Xicato use "Standard Bluetooth"?

A: Yes. Xicato uses the Bluetooth Low Energy protocol (also known as Bluetooth Smart or BLE) that is part of Bluetooth v4.1 and is already installed in billions of devices worldwide. And we use the standard Bluetooth 4.1 stack and advertising message formats that can be created and read by these devices. But we have structured the content of the standard BLE beacons to create a new protocol we call Xbeacon.

In other words, we have made Bluetooth work in a lighting control environment by using the existing protocol in some unconventional but very effective ways that deliver powerful benefits to users without requiring dedicated hardware and software stacks.

Q: Why did Xicato create a new light control protocol?

A: The quick answer is because there was no open protocol defined or available that we could use that would meet our requirements for scalability and responsiveness. After analyzing the Bluetooth Low Energy (BLE) protocol, we realized that we could achieve our goals by creating a custom Bluetooth broadcast advertising packet (that we have dubbed "Xbeacon") to send messages between devices. We intend to use our Xbeacon protocol, gradually evolving it to keep up with known attributes of the evolving Bluetooth Mesh standard, until the new Bluetooth Mesh protocol is ready and robust. In the meantime, we are sharing Xbeacon openly with 3rd parties so that they can work with our products.

Q: How does XIM Gen4 work with other Xicato light sources, such as XTM or XIM without Bluetooth?

A: XIM can work with other Xicato products (or other vendor products, for that matter) through another protocol they have in common, such as 0-10V analog control or DALI. Because XIM Gen4 can be controlled by both Bluetooth and either 0-10V or DALI, depending on model, the common protocol can be used to control the overall environment, while Bluetooth can be used, in addition, to control just the XIM Gen4 luminaires.

This also allows a gradual transition to Bluetooth control.

Q: How does XIM Gen4 work with other light sources in the space (non Xicato)?

A: Initially, what we offer will work wirelessly only with sensors, switches, and light sources using the Xicato Xbeacon protocol. A wired control system (DALI or 1-10V) can be set up to overlay our wireless (Bluetooth) controls, for interoperability with legacy systems.

Xicato is exploring other solutions to offer interoperability with our Xbeacon protocol to accelerate integration with other sources. However, we do not have anything formal in place at this time.

In the future, we expect a large ecosystem of vendors supplying light sources and drivers that are compatible with the Bluetooth Mesh protocol.

Q: What is "mesh networking"?

A: Mesh networks are networks where each node is connected to two or more other nodes. This provides multiple ways for data to get from one end of the network to the other, and provides path diversity to prevent the loss of one node or link from preventing a message from being successfully delivered.

There are two basic types of mesh networking, (1) routed mesh, which can be either source routed or destination routed, and (2) flood mesh.

Standard, routed mesh networking grew up in wired networking and is the basis for the Internet, but it is a double-edged sword. It is good for extending the range of devices through multiple "hops", and for increasing the reliability of the network when a node goes down, when a wire or fiber is cut, or in a wireless network when a barrier temporarily blocks a wireless signal. But in a wireless environment, the need to traverse multiple "hops" can result in inconsistent delays in lighting response. It is particularly problematic in low-speed networks, such as those based on IEEE 802.15.4, and is therefore one weakness of Zigbee and Thread networks, for example.

Q: What is flood mesh?

A: There is an excellent article at http://industrial.embedded-computing.com/article-id/?4098=# that explains the relative advantages of routed vs. flood mesh networking. To simplify: flood mesh networks are better when there are many node in a relatively small area, where predictable latency (low, consistent delay) is a critical requirement, where bandwidth is relatively limited, and where reliability and simplicity are important to keep power consumption, computing and memory cost to a minimum… as in lighting and IoT applications!

One effect of flood mesh networking is to substantially increase overall network traffic. Each flood mesh repeater node retransmits every message it hears, effectively doubling the number of messages in its zone. If there are two such nodes, the result is potentially a four-fold – or more! – increase in network traffic. As long as there are relatively few nodes, or nodes are not transmitting too often, this can have only a minor impact on performance, but as networks increase in density, and if each node is transmitting frequently, it can lead to network congestion, long and inconsistent response time, or unresponsiveness.

In addition, repeater nodes are inherently more complex and expensive than nodes that are not capable of repeating, since they have to have additional processing power and memory to manage the repeater function and message queues.

Q: Does XIM Gen4 use a mesh network?

A: Not exactly. Xbeacon uses "advertisements" (i.e. broadcasts) to communicate between XIMs, sensors, switches, gateways, and mobile devices. One XIM can listen to the broadcast of another and treat it like a sensor input to change its behavior. This is virtually identical to "flood mesh" networking, but without the extra hops.

Sensors advertise their data ("I detect motion", or "I detect a lux level of 100"), and switches advertise their button presses. Each XIM has the intelligence to listen to or reject advertised data (commands, sensor data, etc.) and interpret it according to individual programming that is stored inside the XIM module. This is why we say that

the *XIM is the control system*. The XIMs also advertise information about themselves that can be read by appropriate, permitted devices, allowing proactive management.

Q: Why doesn't Xicato use the emerging Bluetooth Mesh protocol?

A: The Bluetooth Mesh protocol has not yet been standardized, and is not ready for Prime Time. All current implementations are "pre-standard" and proprietary. We will adopt Bluetooth Mesh when it is stable, reliable, responsive, interoperable, and delivers the many other benefits we believe are important to end users.

Fortunately, we do not need a mesh protocol to accomplish reliable, responsive control. Instead, we have created a broadcast protocol on top of good old Bluetooth v4.1 that we have dubbed "Xbeacon" and which has many attributes in common with Bluetooth Mesh, in that it floods the network with commands and sensor data, relying on the intelligence of receiving devices to decide whether to listen and what to do.

Xicato is participating in the Bluetooth Mesh working group that is developing the Bluetooth Mesh open standard. We will support Bluetooth Mesh after the formal release of the standard and after confirming that we can maintain the same overall level of functionality as devices running our Xbeacon based protocol.

Q: Will Xicato eventually adopt the emerging Bluetooth Mesh open standard protocol?

A: Yes. Xicato is a member of the Bluetooth SIG (special interest group) and is actively contributing to the progress of the standard. New protocols normally take a year or so to work out the bugs, compatibility and interoperability issues before they become robust and reliable. Xicato will embrace the Bluetooth Mesh open standard when it is truly ready, meaning that it enables the services and performance that Xicato believes are important to end users. We expect to occur some time in 2017.

Q: Will I be able to update my XIM Gen4 modules to Bluetooth Mesh without disrupting my installation?

A: Yes and no. Updating the XIM Gen4 to Bluetooth Mesh will be a firmware update. Even our first release of hardware can be updated over-the-air (OTA), without the need to gain direct physical access to the lights. However, because this process is likely to take some time (we expect about 3-5 minutes per light), we will recommend this process be conducted in "off hours" – at night, for example, or perhaps one room at a time.

Q: Does Bluetooth have problems with network congestion?

Bluetooth uses the open 2.4 GHz ISM (industrial, scientific and medical) spectrum, which spans 2.4 – 2.5 gigahertz, (1 GHz of total spectrum). Depending on the physical layer encoding method, this can provide up to several gigabits per second of bandwidth. There is a LOT of digital bandwidth in this spectral band.

The 2.4 GHz wireless spectrum is shared with Wifi and Zigbee – and microwave ovens, by the way. Both Bluetooth and Bluetooth Low Energy (BLE) use the lower half of this spectrum (2.4-2.49 GHz). BLE divides this space into 40 2-megahertz channels. Each channel is 1 Mbps. BLE uses Adaptive Frequency Hopping with Direct-Sequence Spread Spectrum modulation. AFH allows the device to quickly find channels that are not congested, and DSSS makes it easier for the receiver to distinguish the signal in the presence of interference. Both AFH and DSSS make the signal much less prone to interference from other signals sharing the same spectrum, at the expense of spectral efficiency.

The limited range of BLE has been criticized by a few competitors as a limitation, but in fact it also limits network congestion by preventing transmissions from distance nodes from interfering with local traffic. This is referred to as "spectral re-use", and is an advantage of shorter-range protocols.

In other words, while it is possible to congest the BLE spectrum, the raw bandwidth of 2.4 GHz, and the way that BLE shares it, makes the protocol very robust and responsive.

Bluetooth vs. Other Protocols

Q: How is Xbeacon the same or different from what others are doing with Bluetooth? Are you compatible with Casambi, Gooee, CSR, Silvair, etc.?

A: Like Xicato, these companies have worked out ways to use Bluetooth to provide lighting control. Some of them are using techniques that will be part of – or similar to parts of – the future Mesh standard, such as a form of flood mesh networking. However, despite what any vendor says about their compatibility with the Bluetooth Mesh standard currently under development, it is not possible to be compatible with a standard that does not yet exist. The standard is not yet complete, much less mature. Consequently, none of the current Bluetooth control systems are interoperable.

What these companies are doing is to develop pre-standard products that will need to be updated once the standard is ready. Just like Xicato.

Furthermore, these are software companies. One has to question whether their business models give them any incentive to provide more than very basic compatibility between their products.

Q: Why not Zigbee?

A: Zigbee uses the 802.15.4 MAC layer, which limits its bandwidth to less than 250 kbps, vs. 1 Mbps for BLE (moving to 2 Mbps in Bluetooth 5).

The Zigbee architecture is also fundamentally limited. It does not allow direct interaction between lights, switches and sensors - all interaction must always be through a hub. This creates delays in responsiveness, adds mandatory costs, and creates a single point of failure for the system.

Zigbee communication is not installed on mobile devices so, again, you need to work through a hub and gateway or try to attach a dongle to your mobile device.

All this means that Zigbee can exhibit high latency, so that response time is slow and lighting may not respond simultaneously to commands.

Q: Why not Thread?

A: Thread is a new standard targeted at home networking and supported by a lot of big vendors. But it has a number of shortcomings in commercial applications, in large part because it is based on the IEEE 802.15.4 standard (like Zigbee) that inherently limits its bandwidth, and therefore makes it susceptible to response-time delays and node limitations that are not a problem with Bluetooth. It also requires a hub.

Q: Why not Wifi?

A: Wifi is great at providing high bandwidth for large data file transfers and streaming media services such as audio and video. But those are not applications required for lighting control and IoT, and the high bandwidth of Wifi comes at a cost. Wifi consumes many times more power than Bluetooth, and Wifi hardware is much more expensive than Bluetooth. Furthermore, its "star" architecture limits its range, forces all communication to flow through a single access point, and creates a single (and likely!) point of failure in the network. And these are just a few of many disadvantages.

Wifi is an excellent complement to Bluetooth – which is why both are on your smartphone. But it is no substitute.

Q: Why not Lutron's ClearConnect protocol?

A: Lutron is an expert in lighting control, there is no doubt, and the ClearConnect protocol was their way of addressing the many deficiencies of wired control (including their own) at a time (10 years ago) when there was no standard, wireless alternative.

But that is no longer the case. Compared with Bluetooth, ClearConnect is a closed, proprietary protocol operating in a very narrow radio spectrum with limited bandwidth and node capacity. It has no support from any other vendor, is not on any mobile device, and does not enable any new IoT services.

However, Xicato is working on ways to allow interoperability with Lutron systems, so that customers can add XIM with Bluetooth to Lutron ClearConnect and Lutron Ecosystem installations and use the Lutron front-end software control.

XIM control with other protocols

Q: Will DMX be available for XIM?

A: For DMX to be implemented, it requires the address to be set on the module. With a wired solution, this has to be done in the factory or physically on the module (with for

example dip-switches). Neither is a practical solution. Bluetooth is a lot more practical. One must question whether DMX will still be desired when lights can be controlled wirelessly.

That being said, it is possible, if difficult, to create a DMX-to-Bluetooth gateway.

Q: Will XIM be available with Lutron Ecosystem?

A: We are still scouting this option; evaluating specifications, and demand because in many spaces we co-exist with Lutron. We created demonstration samples in April and May of 2016 of a potential XIM 70mm product that incorporates Lutron Ecosystem. But control technology is evolving quickly. We will continue to work with Lutron to determine the best way of enabling interoperability across our product lines, and are evaluating several very different options. Stay tuned!

In the meantime, our XTM product is frequently paired with Lutron drivers, which already provides Xicato lighting quality with Lutron control.

Q: Would an XIM with Lutron Ecosystem support Bluetooth?

A: At this point in time, these are mutually exclusive interface options.

Q: Will XIM work with RFID?

A: Not at this time. RFID is a completely different protocol that has not been implemented in XIM.

Q: What effect will 5000 XIMs in a shopping center have on the performance of RFID tags?

RFID can work in many different spectra, the highest (and most power intensive) of which is the same 2.4 GHz band that both BLE and Wifi occupy. Xicato has not evaluated the impact of BLE on RFID, but this is the kind of consideration that normally goes into the development of standards built for the same environment, such as Wifi, BLE, and RFID.

Q: Will Xicato's control system talk to BACnet?

A: Xicato recognizes that BACnet is a popular protocol for building management systems (BMS), and that large users may want to incorporate lighting control and other IoT functions into a centralized BMS.

The flexible, distributed Xicato architecture makes BACnet interworking possible in a number of ways, including through protocol translators that reside in a centralized computing device, or through protocol gateways (such as our XIG IP Gateway) that may be distributed throughout a facility, or through a cloud based platform.

One company that makes multi-protocol gateways is Sierra Monitor. We anticipate building protocol conversion into our XIG, and in fact have implemented MediaLON for one customer.

XIM Gen4 Availability and Pricing

Q: When will XIM Gen4 be available?

A: XIM Gen4 was launched into full production on October 25, 2016. It is generally available today.

Q: How do I get samples?

A: Contact your Xicato representative or an authorized Xicato distributor. These are listed on our website.

Q: Can I participate in beta trials of new XIM Gen4 related product releases?

A: Xicato will be able to support a limited number of paid beta trials prior to each product release. Please contact our Business Development team today if you are interested.

Q: Will XIM Gen4 be available in all the LES, CCT, CRI, and lumen options now available with the standard XIM?

A: Yes.

Q: Can I add Bluetooth to XIM modules that I already have?

A: No. Xicato will not support field upgrades of XIM to XIM with Bluetooth.

Q: Will XIM continue to be available without Bluetooth (i.e. with DALI and 1-10V)?

A: Yes.

Q: Will Xicato offer a Bluetooth-only module in the future?

A: Probably. We expect Bluetooth to become the new paradigm for lighting control, so it is likely that we will offer a Bluetooth-only module once demand justifies the development expense. However, we expect that physical access to the module will continue to be required for programming.

Q: What will XIM Gen4 cost?

A: Bluetooth control will initially be an adder to the cost of the base XIM module. We expect it will save far more than that in design cost, control wiring, dedicated controllers, and commissioning costs. Contact your Xicato representative for more information.