<table>
<thead>
<tr>
<th>Topic</th>
<th>Date</th>
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<tbody>
<tr>
<td>Evolution of Bluetooth 5, 5.1, &amp; 5.2</td>
<td>10a.m., Tuesday, May 26</td>
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<tr>
<td>Bluetooth Mesh Solutions &amp; Tools</td>
<td>10a.m., Thursday, May 28</td>
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<tr>
<td>15.4 Mesh Networking Technologies</td>
<td>10a.m., Tuesday, June 2</td>
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<td>Bluetooth AoX Solutions</td>
<td>10a.m., Thursday, June 4</td>
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<td>Connected Home Over IP (CHIP) for Beginners</td>
<td>10a.m., Tuesday, June 9</td>
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<tr>
<td>Device &amp; Network Security for the IoT</td>
<td>9a.m., Thursday, June 11</td>
</tr>
</tbody>
</table>
David works as Sr. FAE in North China team of Silicon Labs, focusing on Bluetooth, Mesh and Timing products as well as technical supports to Customers.
Bluetooth Mesh Solutions & Tools

MAY 2020
Why Mesh Networking?

- **Extends the range** of connections from gateways or mobile devices with multi-hop communication.
- **Increases system scale** by supporting a large amount of devices in a single network.
- **Improves system reliability** with multipath messaging; network is not dependent on single nodes or routes.
- **Delivers optimal responsiveness** with device-to-device communication.

*) Silicon Labs has tested up to 240 devices.
Why Bluetooth Mesh?

- **Scale**: Bluetooth mesh scales from small ten node networks to commercial grade networks with hundreds of nodes.

- **Phone connectivity**: Phones can be used for easy network setup and configuration and mesh network can be used to deliver location services.

- **Gateway is optional** in Bluetooth mesh networks, but can be used when it makes sense.

- **Industrial grade security**: Bluetooth mesh implements state-of-the-art two-layer security with protection against all known security attacks.

- **Full stack interoperability**: A Bluetooth SIG defined and driven standard from RF to application layer.
Unicast, multicast and broadcast: Bluetooth mesh supports unicast, broadcast and multicast to address everything from a single node, to a group or a whole network.

Multipath: Bluetooth mesh uses a managed flood message relay that can inherently provide multipath delivery.

Managed flooding:
- Time To Live (TTL): TTL is used in all Bluetooth mesh messages to control the number of hops over which a message will be relayed.
- Message cache: A message cache is implemented by all nodes and it is used to prevent recently seen messages from being transmitted again.
- Relaying is optional: All nodes do not need to implement relay feature.
Bluetooth Mesh Publish - Subscribe

- The act of sending a message is known as **Publishing**

- Nodes are configured to select messages sent to specific addresses for processing, and this is known as **Subscribing**

- Typically, messages are addressed to group or virtual addresses

- The configuring application (i.e. mobile app or gateway) can assign meaningful names to the group/virtual addresses, making them easy and intuitive to use

- Only the device that is installed or replaced needs to be configured
Bluetooth Mesh: Models

- Standard functionality defined by the Bluetooth SIG
- Client / Server
  - Server – has data
  - Client – reads or writes data
- Lighting Models
  - Light Lightness Client/Server
  - Light OnOff Client/Server
  - Light LC Server
Sensor Client / Sensor Server

- Over 100 standardized properties (Current, Voltage, Light Level, Temperature, Device Run Time, Occupancy, etc.)


- Each sensor server can send one or more properties on a defined interval or as the data changes
Vendor Model

- Used to implement custom functionality that’s not defined by the SIG models
- Can stand alone and also be used on top of standard models to extend functionality
- Defined by custom opcodes that are used in the messaging

For example:
- opcode 0x1 = Command Set
- opcode 0x2 = Status Get
Example: Bluetooth Mesh for Lighting

- **Lighting controls**
  - Multiple controls are supported from simple On/Off to composite devices with On/Off, dimming and scene capabilities
  - Controls can be mains or battery powered

- **Sensors**
  - Typical use cases for sensors are occupancy and ambient light level sensing
  - Again sensors can be mains or battery powered

- **Led bulbs, drivers and luminaires**
  - Light sources are controlled by control or sensors
  - For commercial lighting the Bluetooth mesh provides a Light Controller (LC) that controls lighting automatically based on inputs from controls and sensors
  - These devices are typically mains powered and could for example also support Bluetooth beaconing

- **Smart phone apps or gateways**
  - Smart phone apps can be implemented for easy and fast network setup and configuration and management of devices
  - Gateway is optional as intelligence is distributed to devices but it can be used where it makes sense
Example: Bluetooth Mesh for HVAC

- HVAC compressor and air handler implemented with vendor models.
- Can use off the shelf sensors for occupancy, temperature/humidity.
- Can perform local control via mobile device when connected.
- Optional gateway enables cloud connectivity (remote control, diagnostics, etc.)
Industry leading Bluetooth 5.1 and 5.2 SoCs and pre-certified modules

In-house developed stacks with latest Bluetooth 5.2 and the industry’s most complete mesh model implementation

ADK, reference applications, and source code for iOS and Android

Free-of-charge software development and protocol analysis tools to boost productivity
# Bluetooth Mesh - Mesh 1.0 Profile Features

<table>
<thead>
<tr>
<th>Feature</th>
<th>Value(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Supported features</strong></td>
<td>Relay, Proxy, Friend, Low Power, Simultaneous BLE + BLE Mesh (GATT, custom beacons, etc.)</td>
</tr>
<tr>
<td><strong>Provisioning bearers</strong></td>
<td>PB-ADV, PB-GATT</td>
</tr>
<tr>
<td><strong>GATT services</strong></td>
<td>Proxy, Provisioning</td>
</tr>
<tr>
<td><strong>Security</strong></td>
<td>OoB authentication, Replay protection, Key refresh (blacklist), ECDH, AES-128 encryption, authentication and obfuscation</td>
</tr>
</tbody>
</table>

**EFR32BG21/13/12**
Support all Bluetooth mesh features (Relay, Proxy, Friend etc.)
768-1024kB flash recommended for OTA

**EFR32BG22**
512kB parts support Bluetooth mesh LPN
No support for Relay, Proxy or Friend
Bluetooth Mesh Application Development Kit (ADKs)

- ADKs enable Bluetooth mesh application development for phones
  - Both iOS and Android platform are supported
  - ADKs provide a Bluetooth mesh stack for both platforms
  - ADK contains example code how to provision, configure and control mesh devices
  - LE connectivity uses the underlying Bluetooth API provided by the OS

- Features
  - Node provisioning over LE connection and PB-GATT
  - Mesh node settings configuration
  - Mesh model configuration
  - Node control
  - Mesh database import/export

- Download for evaluation from iTunes or Google
## Supported Bluetooth Mesh Models

<table>
<thead>
<tr>
<th>Model Group</th>
<th>Model</th>
<th>Stack/APIs</th>
<th>Example app(s)</th>
<th>iOS APIs</th>
<th>iOS reference app</th>
<th>Android APIs</th>
<th>Android reference app</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vendor</td>
<td>Any vendor model</td>
<td>✓</td>
<td></td>
<td>✓</td>
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<tr>
<td>Generic</td>
<td>OnOff</td>
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<td>Light &amp; Switch</td>
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<td>✓</td>
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<td>Light &amp; Switch</td>
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<td>Default Transition Time</td>
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<td>Light &amp; Switch</td>
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<td>✓</td>
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<td>Light &amp; Switch</td>
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<td>Power Level</td>
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<td>Sensors</td>
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<td>Time and Scenes</td>
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<td>Q2'20</td>
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<td></td>
<td>Scheduler</td>
<td>Q2'20</td>
<td>Q2'20</td>
<td>Q2'20</td>
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</tr>
</tbody>
</table>

SDK = Bluetooth Mesh SDK
ADK = Bluetooth Mesh ADK for Android and iOS
Gateway Building Blocks: Network Co-Processor (NCP)

- **Network Co-Processor (NCP) architecture**
  - Bluetooth stack runs on the Blue Gecko SoC
  - Provides Bluetooth API over UART I/F
  - Application runs on a separate MCU

- **Host API**
  - Host API is 100% identical to SoC API
  - Provided in source code and implements BGAPI serial protocol parser and API
  - Various host example applications provided in the SDK

- **NCP features**
  - AES-128 encrypted UART communications
  - 4-wire UART with RTS/CTS
  - 1x GPIO for EM2 low-power management (optional)
  - 1x GPIO to wake up host on Bluetooth events (optional)
  - 1-3x 802.11 co-existence interface via GPIO pins
  - NCP can be extended with custom APIs

- **Firmware update**
  - Secure firmware update over UART
Best Development Tools for Bluetooth Mesh

- **Network analyzer**: Captures and decodes all Bluetooth traffic from every node in the network from a single PC

- **Energy Profiler**: Run time analysis of nodes energy consumption to optimize battery life

- **WSTK**: Development kits that can be Ethernet connected to build and test large mesh networks
Network Analyzer captures and decodes Bluetooth LE and mesh packets
- Understand the network traffic easily
- Debug connectivity or protocol issues

Packets are received from a dedicated interface on EFR32
- Accurately captures what a device transmits or receives
- A Bluetooth sniffer only captures what it hears

Capture directly from WSTK’s USB or Ethernet
- Live capture from multiple Ethernet networked WSTKs from a single PC
- Allows much more coverage than a sniffer
Advanced Energy Monitor (AEM)

- Capable of measuring currents in the range of 0.1uA to 50mA
  - 0.1mA resolution at current > 250uA
  - 1uA resolution at current < 250uA
  - Can detect changes as small as 100nA when < 250uA

- Sample rate 10 ksp

- Correlation capabilities
  - Packet trace
  - Code instructions
  - Interrupts
  - Radio Activity (RX/TX)
Wireless Starter Kit (WSTK)

- **Interfaces:** Ethernet/TCP and USB
- **Functionality (Available over USB or TCP):**
  - Packet Trace
  - Firmware flashing and debugging
  - Serial console interface
  - Advanced Energy Monitor
- Works with installed Silabs radio modules as well as external targets connected to WSTK via debug cable
- WSTKs can be used to build large test networks
  - Silicon Labs has WSTK networks sized at 200+ nodes
BG21: Optimized for Secure Mains Powered Devices

Radio
Up to +20 dBm TX
Extremely good RX sensitivity
Bluetooth 5.1
802.15.4

Current Consumption
8.8 mA RX (1 Mbit/s GFSK)
10.5 mA TX @ 0 dBm
33.8 mA TX @ 10 dBm
4.8uA EM2

World Class Protocol Stacks
Bluetooth 5.1 and Bluetooth mesh
Zigbee 3.0
OpenThread
Apple HomeKit

Compact Size
4x4 QFN32 (20 GPIO)

ARM Cortex-M33 with TrustZone
80 MHz w/ FPU and DSP
Up to 92kB RAM and 1024kB flash
50.9 µA/MHz

Peripherals Fit for Purpose
3x USART, 2x I2C
1x 12-bit ADC, 2x ACMP
7x timers
Up to 20x GPIO

Security
True Random Number Generator
Hardware Accelerated Crypto Engine
Secure Boot with root of trust
Secure debug with lock/unlock
DPA Countermeasures

With Secure Vault™
Anti tamper
Secure attestation
Secure key management and storage
Advanced crypto

BG21 can be paired with EFP to reduce active TX/RX current consumption
BG22: Optimized for Battery Powered Bluetooth LE and Mesh

Secure Bluetooth 5.2 SoCs for High-Volume Products

Radio
- Bluetooth 5.2
- +6 dBm TX
- -99 dBm RX
- AoA & AoD

Ultra-Low Power
- 3.6mA Radio TX
- 2.6mA Radio RX
- 1.4uA EM2 with 32kB RAM
- 0.54uA in EM4
- RTC in EM4

World Class Software
- Bluetooth 5.2
- Bluetooth mesh LPN
- Direction Finding

Compact Size
- 5x5 QFN40 (26 GPIO)
- 4x4 QFN32 (18 GPIO)
- 4x4 TQFN32 (18 GPIO)

ARM Cortex-M33 with TrustZone
- 76.8 MHz
- FPU and DSP
- 352/512kB of flash
- 32kB RAM

Peripherals Fit for Purpose
- 2x USART, 2x I2C, 2x PDM and GPIO
- 12-bit ADC (16 channels)
- Built-in temperature sensor with +/- 1.5 °C
- 32kHz, 500ppm PLFRCO

Security
- True Random Number Generator
- Hardware Accelerated Crypto Engine
- Secure Boot with root of trust
- Secure debug with lock/unlock

BG22 (512kB flash variant) only support Bluetooth mesh Low Power Node feature and software support is available in Q2’20 SDK

BG13 or BG21+EFP can also be used for low power applications
# Silicon Labs’ Bluetooth SoC Families

<table>
<thead>
<tr>
<th></th>
<th>Series 1 - xG13</th>
<th>Series 2 - xG21</th>
<th>Series 2 - xG22</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Target applications</strong></td>
<td>General purpose Bluetooth LE and mesh</td>
<td>Mains powered Bluetooth LE and mesh</td>
<td>Lowest power Bluetooth LE, Direction Finding and Bluetooth mesh LPNs</td>
</tr>
<tr>
<td><strong>Bluetooth features</strong></td>
<td>5.1 and mesh 1.0 (1M, 2M, LE Coded PHYs and AE)</td>
<td>5.1 and mesh 1.0 (1M, 2M, LE Coded PHYs and AE)</td>
<td>5.2 and Bluetooth mesh LPN (1M, 2M, LE Coded PHYs, AE and AoA/D)</td>
</tr>
<tr>
<td></td>
<td>2/4(G)FSK, OQPSK/(G)MSK, DSSS, DBPSK TX, OOK/ASK</td>
<td>N/A</td>
<td>2/4(G)FSK, (G)MSK, OQPSK, DSSS</td>
</tr>
<tr>
<td><strong>TX / RX (1M, GFSK)</strong></td>
<td>+19 dBm / -95.8 dBm</td>
<td>+20 dBm / -97.5 dBm</td>
<td>+6 dBm / -99 dBm</td>
</tr>
<tr>
<td><strong>TX Current (0 dBm)</strong></td>
<td>10.5 mA</td>
<td>10.5 mA</td>
<td>4.1 mA</td>
</tr>
<tr>
<td><strong>RX Current (1M, GFSK)</strong></td>
<td>9.5 mA</td>
<td>8.8mA</td>
<td>3.6 mA</td>
</tr>
<tr>
<td><strong>CPU / Clock Speed</strong></td>
<td>Cortex M4 (38.4 MHz)</td>
<td>Cortex M33 (80MHz)</td>
<td>Cortex M33 (up to 76.8MHz)</td>
</tr>
<tr>
<td></td>
<td>Up to 1204</td>
<td>Up to 512</td>
<td>Cortex M0+ for radio</td>
</tr>
<tr>
<td><strong>Flash (kB)</strong></td>
<td>512</td>
<td>Up to 1024</td>
<td>Up to 512</td>
</tr>
<tr>
<td><strong>RAM (kB)</strong></td>
<td>64</td>
<td>Up to 96</td>
<td>32</td>
</tr>
<tr>
<td><strong>Sleep Current (EM2)</strong></td>
<td>1.3μA (16kB RAM)</td>
<td>4.5 uA (96 RAM)</td>
<td>1.24 uA (8kB RAM) - 1.44 uA (32kB RAM)</td>
</tr>
<tr>
<td><strong>Active Current (EM0)</strong></td>
<td>70μA/MHz</td>
<td>51μA/MHz</td>
<td>25μA/MHz</td>
</tr>
<tr>
<td><strong>Security</strong></td>
<td>2x AES-128/256, SHA-1/2 ECC, ECDSA and TRNG</td>
<td>AES-128/256, SHA-1/2 ECC, ECDSA and TRNG</td>
<td>AES-128/256, SHA-1/2 ECC, ECDSA and TRNG</td>
</tr>
<tr>
<td></td>
<td>Secure boot with RTSL</td>
<td>Secure boot with RTSL</td>
<td>Secure debug with debug lock/unlock</td>
</tr>
<tr>
<td></td>
<td>Secure debug with debug lock/unlock</td>
<td>DPA countermeasures</td>
<td>DPA countermeasures</td>
</tr>
<tr>
<td><strong>Operating Voltage</strong></td>
<td>1.8V – 3.6V</td>
<td>1.8V – 3.8V</td>
<td>1.71V – 3.8V</td>
</tr>
<tr>
<td><strong>Packages (mm)</strong></td>
<td>7x7 QFN48, 5x5 QFN32</td>
<td>4x4 QFN32 (20x GPIO)</td>
<td>5x5 QFN40 (26x GPIO)</td>
</tr>
<tr>
<td></td>
<td>4x4 QFN32, TQFN32 (18x GPIO)</td>
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<td>4x4 QFN32, TQFN32 (18x GPIO)</td>
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</tbody>
</table>
# Silicon Labs’ Bluetooth Module Families

<table>
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<tr>
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<th>BGM13P</th>
<th>BGM13S</th>
<th>BGM210P</th>
<th>BGM210L</th>
<th>BGM220P (Q3’20)</th>
<th>BGM220S (Q3’20)</th>
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<tbody>
<tr>
<td><strong>Protocols</strong></td>
<td>5.1 and mesh (1M, 2M, Coded PHY and AE)</td>
<td>5.1 and mesh (1M, 2M, Coded PHY and AE)</td>
<td>5.1 and mesh 1.0 (1M, 2M, Coded PHY and AE)</td>
<td>5.1 and mesh 1.0 (1M, 2M, Coded PHY and AE)</td>
<td>5.2 and mesh 1.0 LPN (1M, 2M, Coded PHY, AE and AoA/D)</td>
<td>5.2 and mesh 1.0 LPN (1M, 2M, Coded PHY, AE and AoA/D)</td>
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<tr>
<td><strong>EFR32 SoC</strong></td>
<td>BG13</td>
<td>BG13</td>
<td>BG21</td>
<td>BG21</td>
<td>BG22</td>
<td>BG22</td>
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<tr>
<td><strong>Antenna</strong></td>
<td>Built-in or U.FL</td>
<td>Built-in or RF pin</td>
<td>Built-in or RF pin</td>
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<td>Built-in</td>
<td>Built-in or RF pin</td>
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<td><strong>Max TX power</strong></td>
<td>+8 / +19 dBm</td>
<td>+8 / +18 dBm</td>
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<td><strong>Sensitivity (1M)</strong></td>
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<td>24,25</td>
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<td>1.8V – 3.6V</td>
<td>1.8 – 3.8V</td>
<td>1.8 – 3.8V</td>
<td>1.71V – 3.8V</td>
<td>1.71V – 3.8V</td>
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<td>-40 to +85°C</td>
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<td>-40 to +105°C</td>
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<td><strong>Dimensions W x L x H (mm)</strong></td>
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<td>6.5 x 6.5 x 1.4</td>
<td>13.0 x 15.0 x 2.2</td>
<td>13.0 x 15.0 x 2.2</td>
<td>13.0 x 15.0 x 2.2</td>
<td>6 x 6 x 1.3</td>
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<tr>
<td><strong>Certifications</strong></td>
<td>BT, CE, FCC, ISED, Japan, S-Korea and Taiwan</td>
<td>BT, CE, FCC, ISED, Japan &amp; S-Korea</td>
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Getting Started

1. Order Gecko kit(s)

2. Install Simplicity Studio

3. Download the Bluetooth Mesh mobile app for iOS or Android

4. Explore our online resources

https://www.silabs.com/support/getting-started/bluetooth/bluetooth-mesh
Learn how to develop and deploy more powerful, efficient, and secure IoT products with your own BG22 Thunderboard – free for all registrants!

North America: May 19th–21st, 2020
10:00AM –11:30 AM CST
(Other sessions available for Asia Pacific and Europe)

Digital Protocol Capture and Analysis

WSTKs have a Packet Trace Interface available
Can be used to capture all packets the radio sends and receives
Packet Trace is also accessible over IP

WSTKs can also be used to build large test networks
Silicon Labs has WSTK networks up to 240 nodes

Promo Code: WWSH
50% off Early Bird
Thank You  | Questions

Any query, please contact us or email to Kenny.Kong@silabs.com

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<th>Date</th>
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<tr>
<td>Evolution of Bluetooth 5, 5.1, &amp; 5.2</td>
<td>10a.m., Tuesday, May 26</td>
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<tr>
<td>Bluetooth Mesh Solutions &amp; Tools</td>
<td>10a.m., Thursday, May 28</td>
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<tr>
<td>15.4 Mesh Networking Technologies</td>
<td>10a.m., Tuesday, June 2</td>
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<td>Bluetooth AoX Solutions</td>
<td>10a.m., Thursday, June 4</td>
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<td>Connected Home Over IP (CHIP) for Beginners</td>
<td>10a.m., Tuesday, June 9</td>
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<tr>
<td>Device &amp; Network Security for the IoT</td>
<td>9a.m., Thursday, June 11</td>
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