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World Peace Industrial Group

从4.2到5.0——BLE现状及未来浅谈

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2016.9.27

PMT华北技术支援组

Agenda

- Bluetooth--BLE的前身

- BLE现状

- BT5.0——BLE美好愿景
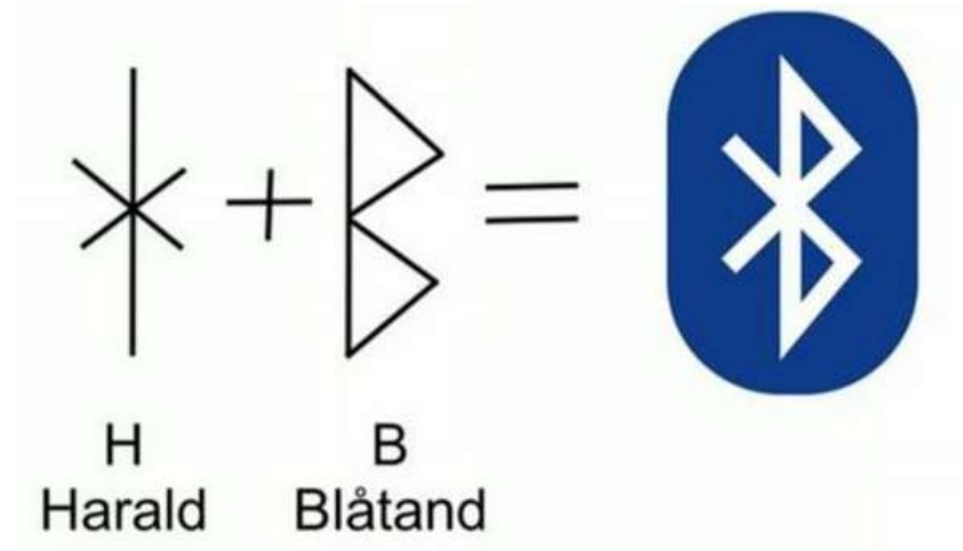
- **Bluetooth--BLE的前身**

- BLE现状

- BT5.0——BLE美好愿景

Bluetooth的由来1—历史典故

- 说起哈拉尔国王，很少有人会知道他是谁。但是一提起大名鼎鼎的蓝牙技术，可谓人人皆知，而蓝牙技术这个名字的来源，就是因为哈拉尔国王

- 哈拉尔蓝牙王 Harald Blatand，丹麦国王（940—986年在位），哈拉尔征服了整个丹麦和挪威

Bluetooth的由来2—蹒跚学步

- 1998年，爱立信公司希望无线通信技术能统一标准而取名"蓝芽"。

- 1999年5月20日，索尼爱立信、IBM、英特尔、诺基亚及东芝等业界龙头创立蓝牙特别兴趣组(SIG,Special Interest Group)，制订蓝牙技术标准。自此，SIG正式成立，蓝牙开始走上正轨。

H   B
Harald   Blåtand

Bluetooth的由来3—一枝独秀

- 2004年推出蓝牙2.0版本，同时推出了EDR(Enhanced Data Rate)，当时速率达到最高2.1Mbps。

- 2007年推出蓝牙2.1，彻底奠定在电脑和手机领域的地位，蓝牙耳机开始风靡一时

- 2009年，蓝牙3.0和HS(High Speed)发布，背靠802.11，最高速率达到24Mbps。

Bluetooth的由来4—开枝散叶

- 2010年发布的Bluetooth 4.0，开启了一个新的时代，它将Bluetooth拆分为三部分，低功耗、高速率和传统设备。

- 自此，蓝牙技术彻底摆脱了低功耗和高速率这两个主要需求之间的冲突，可以更加专注、高效的实现各种需求

蓝牙方案分类

Bluetooth low energy (Bluetooth Smart)	Dual Mode Bluetooth	Classic Bluetooth
Connect low power applications to a smart phone or tablet	Bluetooth connection across any end point (Bluetooth low energy or classic); enables bridge between Bluetooth low energy (Bluetooth Smart) and classic	Bluetooth connection with high data rate (up to 3Mbps)
• Custom profile, allows any application • Multiyear on Coin Cell Battery • Less than 200Kbps data rate	• Supports new and old phones (BT and BLE) • Up to 3Mbps data rate	• A2DP Profile to stream music from phones • Up to 3Mbps data rate

Classic Bluetooth vs Bluetooth Smart

Technical Specification	Classic Bluetooth	Bluetooth Smart
Primary use cases	Mobile phones, gaming, headset, stereo audio, automotive, PC HID	Large number of use-cases due to proprietary profiles.
Application throughput	Up to 3 Mbps	Up to 0.2Mbps
Power consumption	Can run multiple years on 2 x AAA batteries	Can run multiple years on coin cell
Latency (from a non connected state)	100ms	<3ms
High quality audio	Yes	No
Voice quality audio	Yes	Yes
Nodes/Active slaves	7	unlimited
Network topology	Scatternet	Star topology
Profiles	Adopted SIG profiles	Adopted SIG profiles Proprietary profiles

CC256x – 经典/双模蓝牙

支持任一种BLE工作模式，包括Classic和BLE

优势
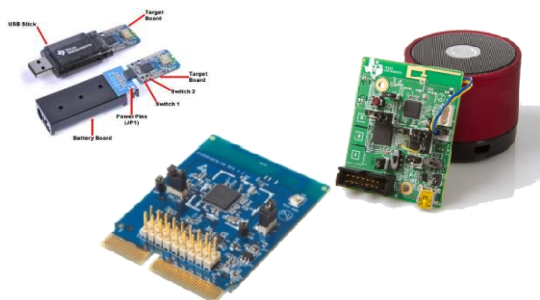
- **最佳的性能**: 最大可以达到100m可靠连接，同时做到降低功耗
- **工作模式灵活**: 外接MCU或处理器均可工作
- **更多的终端支持**: 可以自由和超过3亿设备相连接，TI提供相应的软件示例帮助开发
- FCC, IC, CE & Bluetooth SIG 充分认证

Products

- **SimpleLink™Transceiver**
  - **CC2560 (Classic only)**
  - **CC2564 (Classic + BLE)**
  - **Pin to pin compatible**
- **TI Modules**
  - **CC2564MODN**
- **3 Parties Modules**
- **Audio TIDesigns (sink and source)**

Features

- **最远距离可以达到100m**, **最高支持3Mbps速率**
- **可以和任何MCU或processor连接进行工作**
- **BT 协议栈运行于外部主机**
- **Bluetooth 2.1 +EDR/ BT 4.0**
- **充分的认证(FCC, IC, CE, Bluetooth SIG)**

Applications

- **Embedded Audio**
- **Heath and medical care**
- **Mobile device Accessories**
- **Toys**

TI Bluetooth® Technology Solution
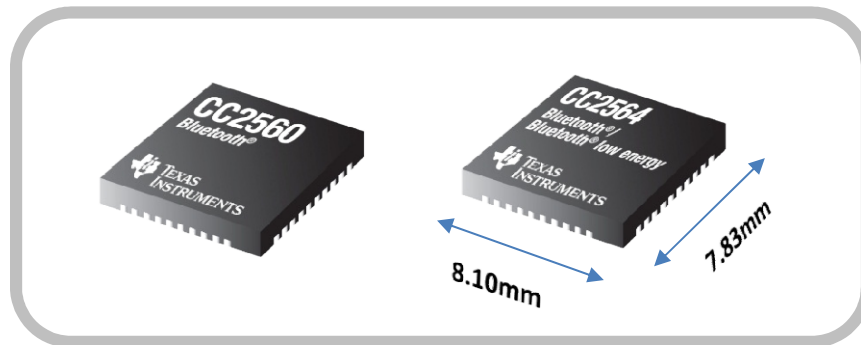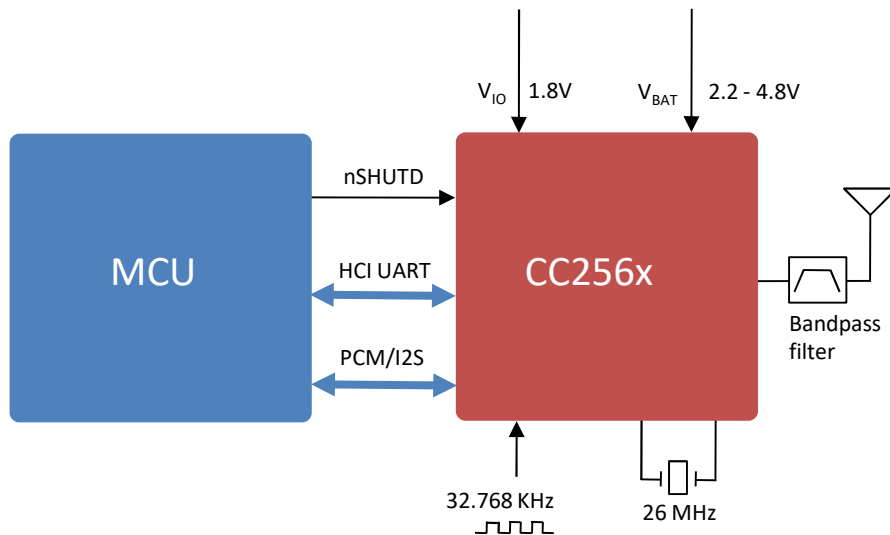
Parameter	Value
Size	Device 8.10 x 8.10 mm QFN Design 16.5x16.5 mm
Temp Range	-40°C to +85°C
Tx Power	+ 10dBm ("Class 1.5")
Rx Sensitivity	- 95dBm
Host I/F	UART 4 wires H4
Audio I/F	PCM-I2S
IC Certification	*Bluetooth* SIG
Reference layout	EM Board, 4 layers
Ref Antenna	Printed PCB antenna
EM Certification	FCC, IC, CE

Device	Technology
CC2560	Bluetooth®
CC2564	Bluetooth® / Bluetooth LOW ENERGY / ANT+

Why Bluetooth® + Bluetooth LE from TI?

Cost Effective

- ✓ **Low cost HW**
  - QFN package
  - Reference design

- ✓ **Quick software development**
  - SW examples and multiple profiles supported

- ✓ **Support**
  - Wiki
  - Forum – *Bluetooth* Applications
  - All information publicly available

Flexibility

- ✓ **Flexible SW options**
  - Royalty free Bluetooth + Bluetooth LE stack, profiles and sample apps
  - Customization options from partner Stonestreet One
    - MFi support
    - Additional profiles
    - Additional support
    - Additional MCU support

- ✓ **Variety of HW options**
  - QFN package device from TI
  - Fully certified modules from LSR, Murata, Blue Radios and Panasonic

High Performance

- ✓ **Best in Class Range**
  - Can get over 100m
  - Tx Power - +12dBm ("Class 1.5")
  - Rx Sensitivity - 95dBm

- ✓ **2x Range for traditional BLE solutions**
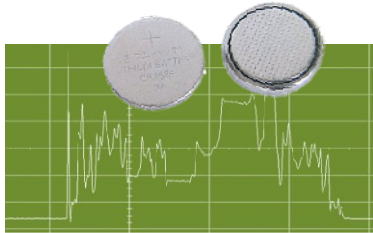
- ✓ **Based on 7th Generation technology**

- Bluetooth--BLE的前身

- **BLE现状**

- BT5.0——BLE美好愿景

Why Use Bluetooth Smart?

Multiyear on Coin Cell

- Low peak currents reduce stress/strain on battery

- Small solution form factor

- Sub uA sleep currents

- Small protocol overhead

- Small payloads

Remote Display and Personalization

- Smart phone instead of local display -> more info, historical data etc

- Over the air upgrades from phone to end equipment

- More intuitive set-up and configuration

- Personal operator/user setup and configuration

Hub to Internet (IoT)

Cloud enabling IoT
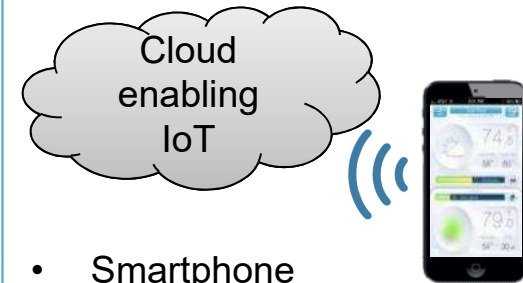
- Smartphone interoperability

- Access your devices from anywhere (through cloud)

- Enables real time aggregated data

- Existing ecosystem of Cloud services

- Push firmware updates

更低的功耗—广播和信道

- BLE信道从2402~2480，频带间隔2Mhz，共40个信道，其中37、38、39为广播信道

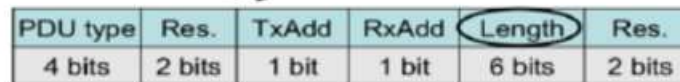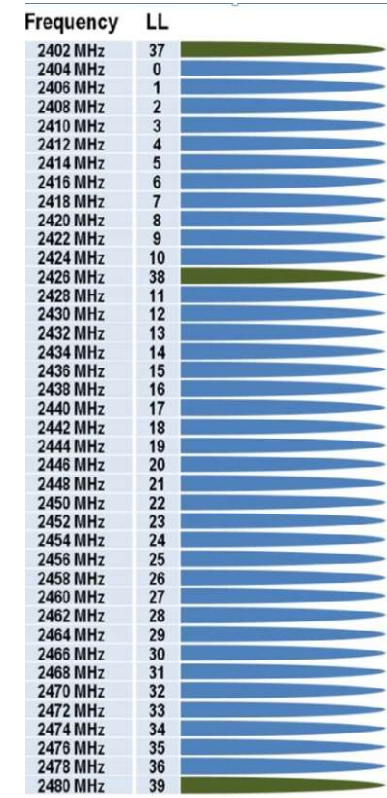| Frequency	LL
2402 MHz	37
2404 MHz	0
2406 MHz	1
2408 MHz	2
2410 MHz	3
2412 MHz	4
2414 MHz	5
2416 MHz	6
2418 MHz	7
2420 MHz	8
2422 MHz	9
2424 MHz	10
2426 MHz	38
2428 MHz	11
2430 MHz	12
2432 MHz	13
2434 MHz	14
2436 MHz	15
2438 MHz	16
2440 MHz	17
2442 MHz	18
2444 MHz	19
2446 MHz	20
2448 MHz	21
2450 MHz	22
2452 MHz	23
2454 MHz	24
2456 MHz	25
2458 MHz	26
2460 MHz	27
2462 MHz	28
2464 MHz	29
2466 MHz	30
2468 MHz	31
2470 MHz	32
2472 MHz	33
2474 MHz	34
2476 MHz	35
2478 MHz	36
2480 MHz	39

Preamble	Access Address	PDU Header	PDU Payload	CRC
1 byte	4 bytes	2 bytes	variable (0 – 37 bytes)	3 bytes

PDU type	Res.	TxAdd	RxAdd	Length	Res.
4 bits	2 bits	1 bit	1 bit	6 bits	2 bits

PDU type	Packet name	PDU type	Packet name
0000	ADV_IND	0011	SCAN_REQ
0001	ADV_DIRECT_IND	0100	SCAN_RSP
0010	ADV_NONCONN_IND	0101	CONNECT_REQ
0110	ADV_SCAN_IND	other	Reserved

更低的功耗--连接和延迟通讯

- 两台BLE设备间的通讯，遵从以下的原则：

- 预设好的连接间隔(7.5ms以上)
- 主机会每次进行侦听
- 从机可以延迟若干个间隔后再和主机通讯(需要预设)
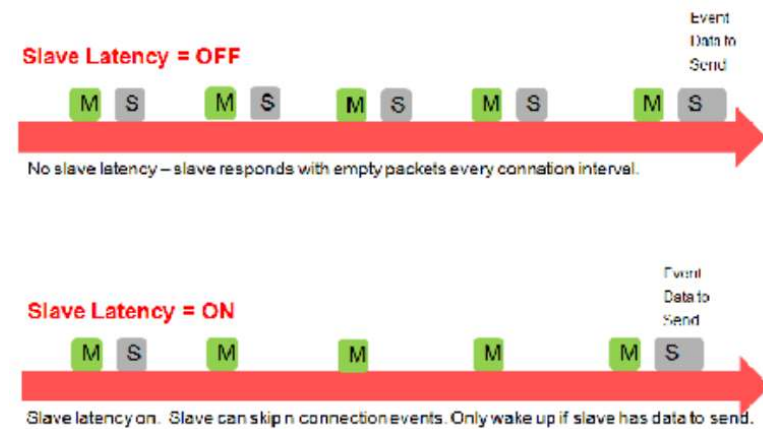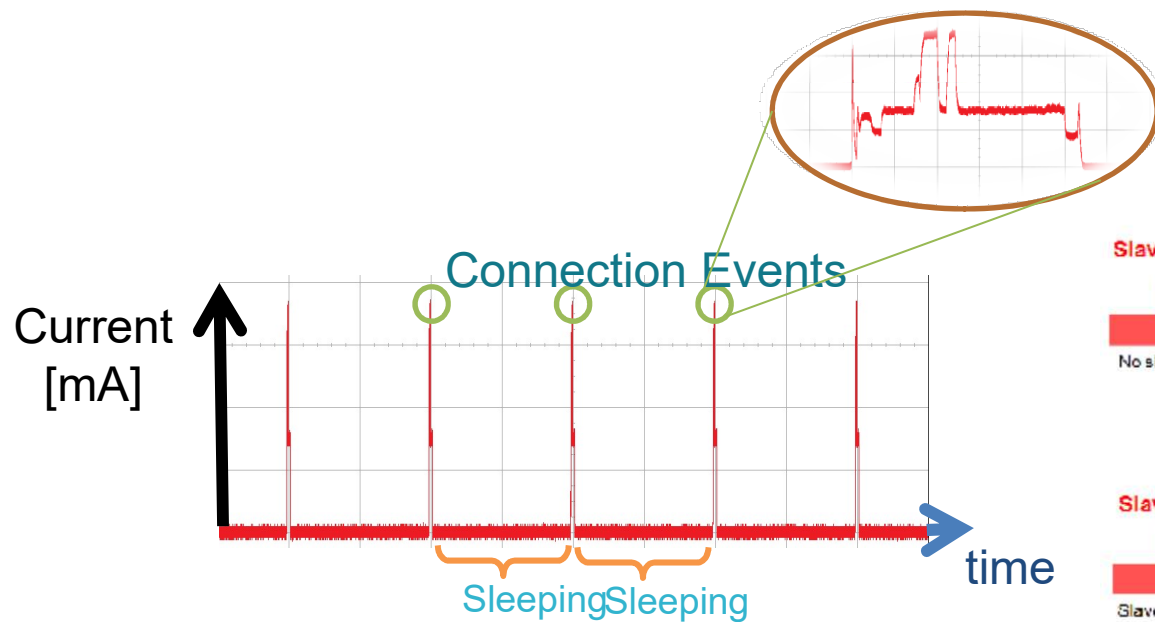
TI Bluetooth® Low Energy (BLE) Wireless MCU Portfolio

CC2640
Lowest Power Wireless MCU

Easiest to design with
- Comprehensive design support: Complete SW stack, wiki guides, dynamic design kits, low-cost tools, & software

Lowest power
- Multi-year on a coin cell: Cortex M3 MCU, optimized radio, best in class sleep current and unique Sensor Controller

Most integrated
- Complete solution on a finger tip: Single chip, flash-based 4x4mm QFN with only one crystal

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CC2541
The most versatile, system cost optimized Bluetooth LE SoC

CC2540
Add Bluetooth LE to USB Solutions

CC2540T
World's only 125°C graded Bluetooth LE solution

CC2541Q1
First Automotive Q-100 Qualified

SimpleLink™ Bluetooth® Smart
CC2540/CC2541 Wireless MCU

Features/Benefits

- **Highly integrated solution** — Single-chip wireless MCU solution; Flash-based; USB Support.

- **Powerful** – >1 year battery life with CR2032; 97dB link budget.

- **Ultra-low power**– Very low-power sleep modes; Short transition times between operating modes .

- **Low cost HW design** – 6x6mm QFN package; 2 layers design.

- **Quick software development** – SW examples for all adopted profiles; iOS App source code
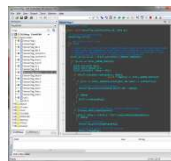
Dev Tools & Software

CC2540DK-MINI
CC2541DK-MINI
The easiest way of evaluating BLE

CC2540DK
CC2541EMK
Advanced development platform

BLE Stack 1.4
Everything you need in only one download

TI Design & EVMs

- **Gas Sensor Platform**   * **Optical Heart Rate Monitor**

- **Pulse Oximeter via Finger Clip** * **Body weight scale**

- **BLE Key fob**   * **Sensortag**

CC254x | Temperatures: -40 °C to 85 °C

CC254x Bluetooth - LE SimpleLink		

Other	**Power & Clocking**
Link Budget: 97dB	RX down to 15.8mA
Radio: 2.4 GHz	TX: 18.6mA
Interfaces	Low power in each mode
21 GPIO	Supply voltage range: 2 - 3.6V
3 general purpose timers	3 general purpose timers
2 USARTs	**Packages**
12-bit ADC	6mm x 6mm QFN
Full-Speed USB	40 pin

Protocol
Bluetooth LE

System Modules
8051 MCU
Flash & SRAM

Target Applications

- **Home& building automation**

- **Alarm & Security**

- **Retail**

- **Proximity tag**

- **Health & Medical care**

- **Remote display**

BT4.2—只为BLE

- 2014年底发布的BT4.2，可以说是专为BLE而生的，更新的诸多特性，使BLE在IoT领域更加如鱼得水

- ①增加数据包长度
- ②提高连接安全性
- ③通过Internet Protocol Support Profile实现IP连接，接入互联网

SimpleLink™ *Bluetooth*® Low Energy

CC2640 Ultra low Power Wireless MCU

Features/Benefits

- **Easiest to design with** – Get faster to market: Complete SW stack, wiki guides, dynamic design kits, low-cost tools, & software starting points
- **Lowest power** – Use a coin cell for multi-year, always-on operation or go battery-less with energy harvesting
- **Most integrated wireless MCU** – Less board space, more possibilities, single-chip Flash-based, 4x4 QFN
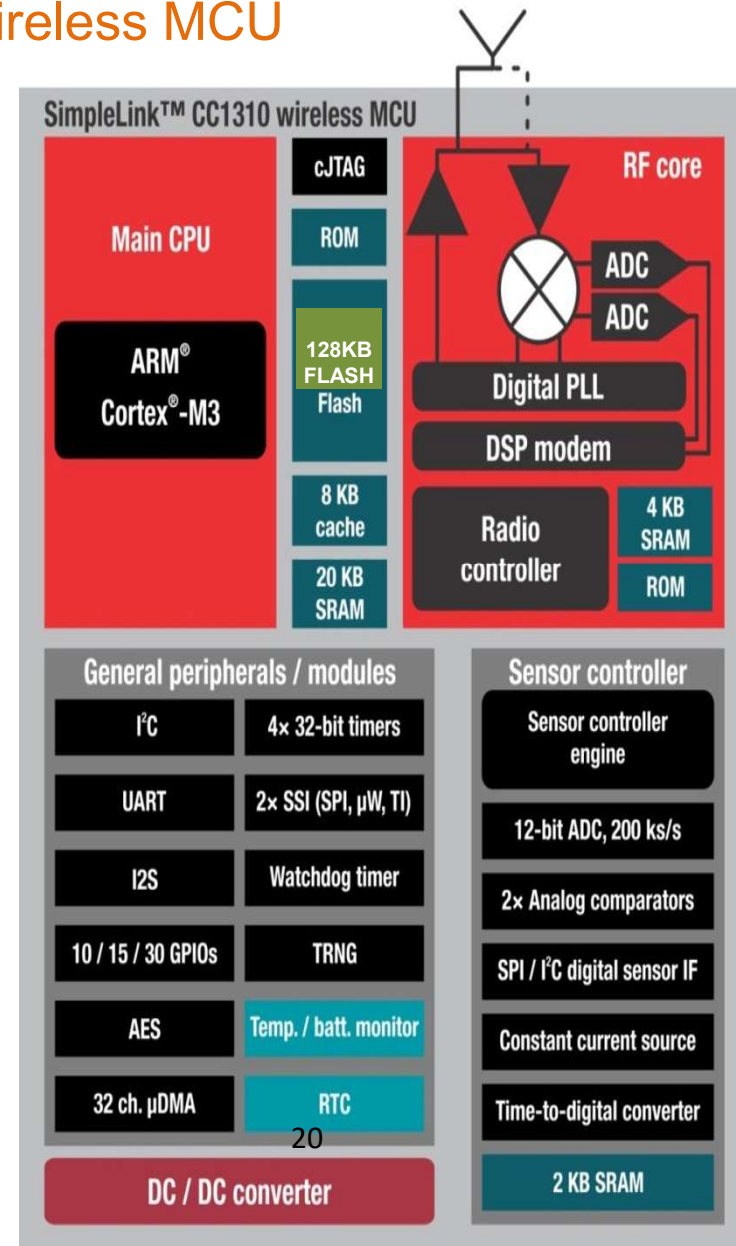
Design Kits & EVMs

CC2650STK $29

SensorTag: For Smartphone app development and initial hardware evaluation
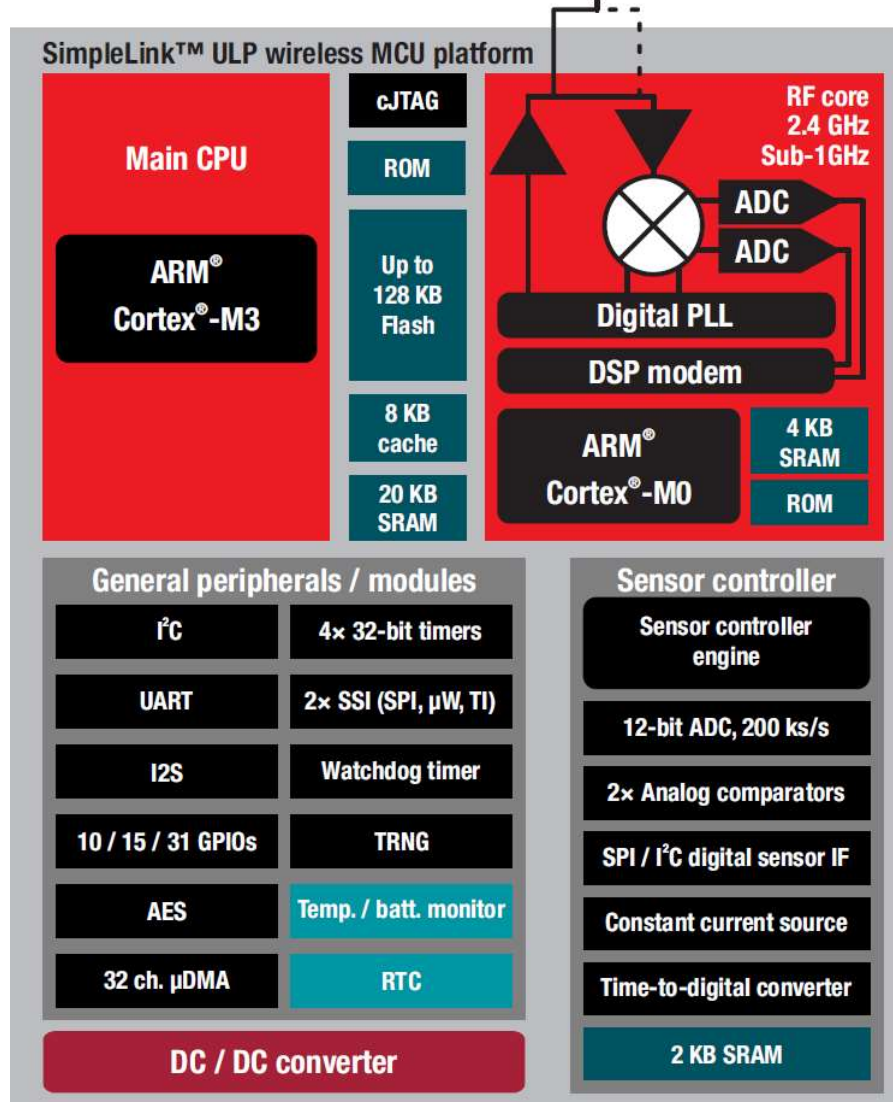
CC2650 LaunchPad
Advanced development platform

Dev Tools & Software

- Software Development Kit, including royalty free Stack
- SmartRF Studio
- Sensor Controller Studio
- TI iOS/Android Multitool
- Extensive library of SW examples and sample code

SimpleLink™ CC1310 wireless MCU

Main CPU: ARM® Cortex®-M3, cJTAG, ROM, 128KB FLASH Flash, 8 KB cache, 20 KB SRAM

RF core: ADC, ADC, Digital PLL, DSP modem, Radio controller, 4 KB SRAM, ROM

General peripherals / modules: I²C, 4× 32-bit timers, UART, 2× SSI (SPI, µW, TI), I2S, Watchdog timer, 10 / 15 / 30 GPIOs, TRNG, AES, Temp. / batt. monitor, 32 ch. µDMA, RTC

Sensor controller: Sensor controller engine, 12-bit ADC, 200 ks/s, 2× Analog comparators, SPI / I²C digital sensor IF, Constant current source, Time-to-digital converter, 2 KB SRAM

DC / DC converter

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CC2640框图和特性

SimpleLink™ ULP wireless MCU platform

- Main CPU
  - ARM® Cortex®-M3
  - cJTAG
  - ROM
  - Up to 128 KB Flash
  - 8 KB cache
  - 20 KB SRAM

- RF core 2.4 GHz Sub-1GHz
  - ADC
  - ADC
  - Digital PLL
  - DSP modem
  - ARM® Cortex®-M0
  - 4 KB SRAM
  - ROM

General peripherals / modules
- I²C
- 4× 32-bit timers
- UART
- 2× SSI (SPI, µW, TI)
- I2S
- Watchdog timer
- 10 / 15 / 31 GPIOs
- TRNG
- AES
- Temp. / batt. monitor
- 32 ch. µDMA
- RTC
- DC / DC converter

Sensor controller
- Sensor controller engine
- 12-bit ADC, 200 ks/s
- 2× Analog comparators
- SPI / I²C digital sensor IF
- Constant current source
- Time-to-digital converter
- 2 KB SRAM

Quick Facts

Ultra-low Power Consumption
- 61 µA/MHz ARM Cortex M3
- 8.2 µA/MHz Sensor Controller
- 1 µA sleep with retention and RTC
- 5.9 mA RX (single-ended)
- 6.1 mA TX (single-ended)
- <3uA while running 10 ADC samples/s

Wireless MCU Key Features
- Autonomous sensor controller engine
- 4x4, 5x5, and 7x7 mm QFN
- 1.7 - 1.95 V or 1.8 – 3.8 V supply range
- 128 KB Flash + 8 KB Cache
- 20 KB RAM

RF Key Features
- Output power;
  - +5 dBm   (BLE)
- Sensitivity;
  - -97 dBm (BLE)
- Pin compatible and SW compatible across protocols and frequency bands

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CC2640--BLE2.2

- CC2640目前已经通过BLE 2.2 SDK，全面支持BT4.2规格。
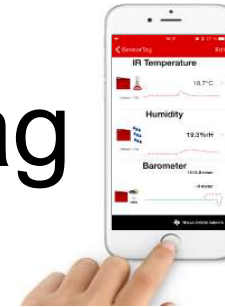
- ①更快的连接速率
- ②基于CC2640的高级HID遥控方案
- ③Voice over BLE

CC2650RC
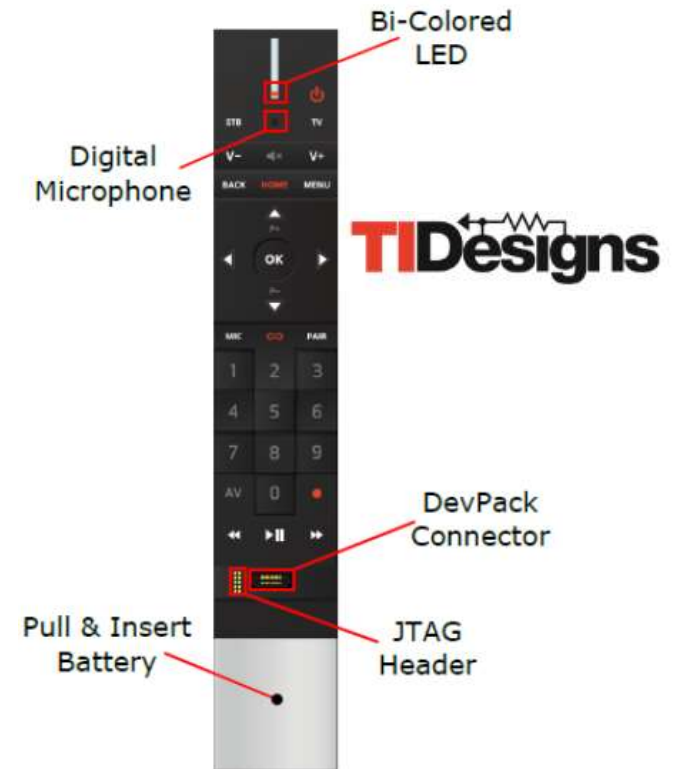
TI提供软硬件全套参考设计，支持

CC2650 SensorTag

Features

• Connect to the cloud in 2 minutes
• 10 Low power MEMS Sensor
• Single coin cell battery
• Works with the SensorTag app
• Expandable with the DevPack ecosystem
• Multi-protocol support for Bluetooth Smart/ZigBee/6LoWPAN

Benefits

• Demonstrates ease-of-use IoT applications

• Quick and easy demo platform

• Real-life use case for ultra-low power wireless design

• Demonstrates multi-protocol support

Tools & Resources

• http://www.ti.com/tool/TIDC-CC2650STK-SENSORTAG
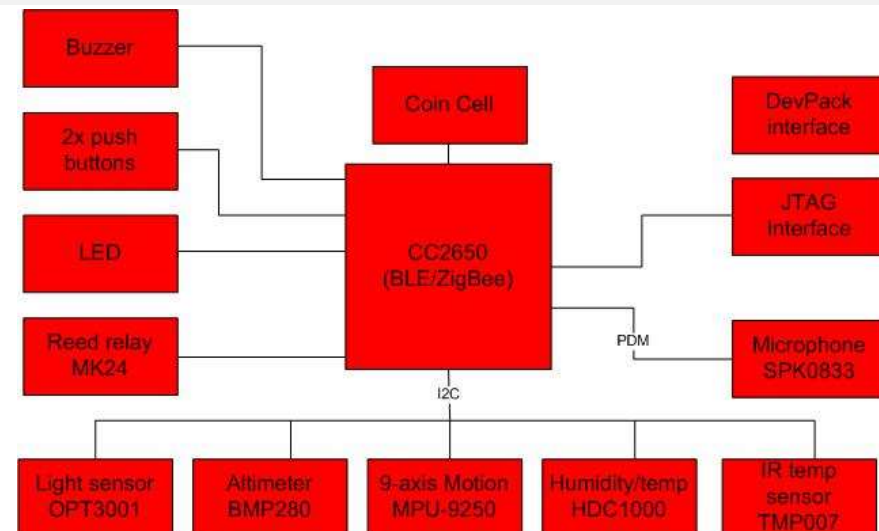
LED Audio DevPack for SensorTag

Features

- Quick prototyping of LED lighting applications
- Bluetooth Smart-controlled using smartphone apps
- Connect to ZigBee lighting applications
- 4 multi-colored Osram LEDs
- Works with the SensorTag app
- Bluetooth Smart and ZigBee lighting sample apps included

Benefits

- Allows quick prototypes of Industrial IoT lighting applications
- Create Bluetooth or ZigBee controlled lighting apps in no time
- Source code for creating your own apps included

Tools & Resources

- TI Design on WEB: Design Details

Schematic/Block Diagram
Quickly understand overall system functionality.
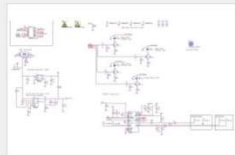
Test Data
Get results faster with test and simulation data that's been verified.

Design Files
Download ready-to-use system files to speed your design process. Get Viewer.
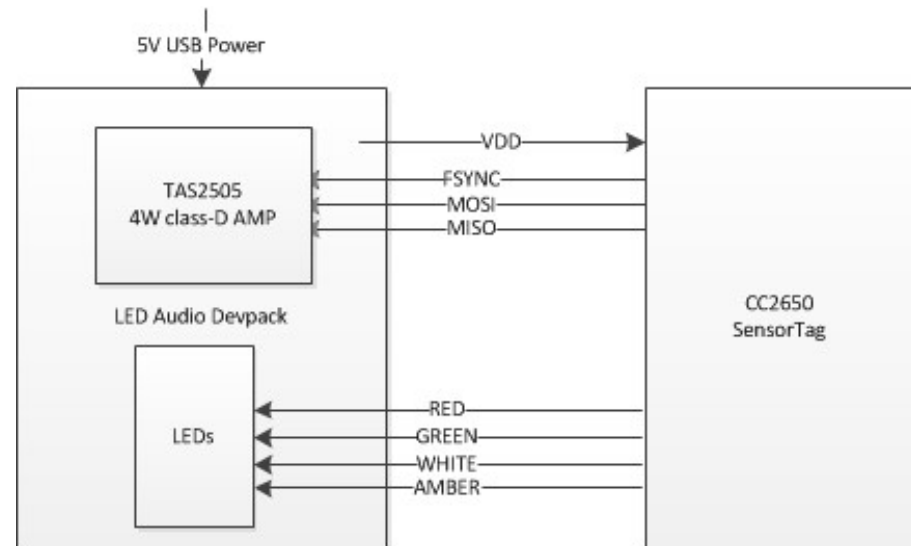
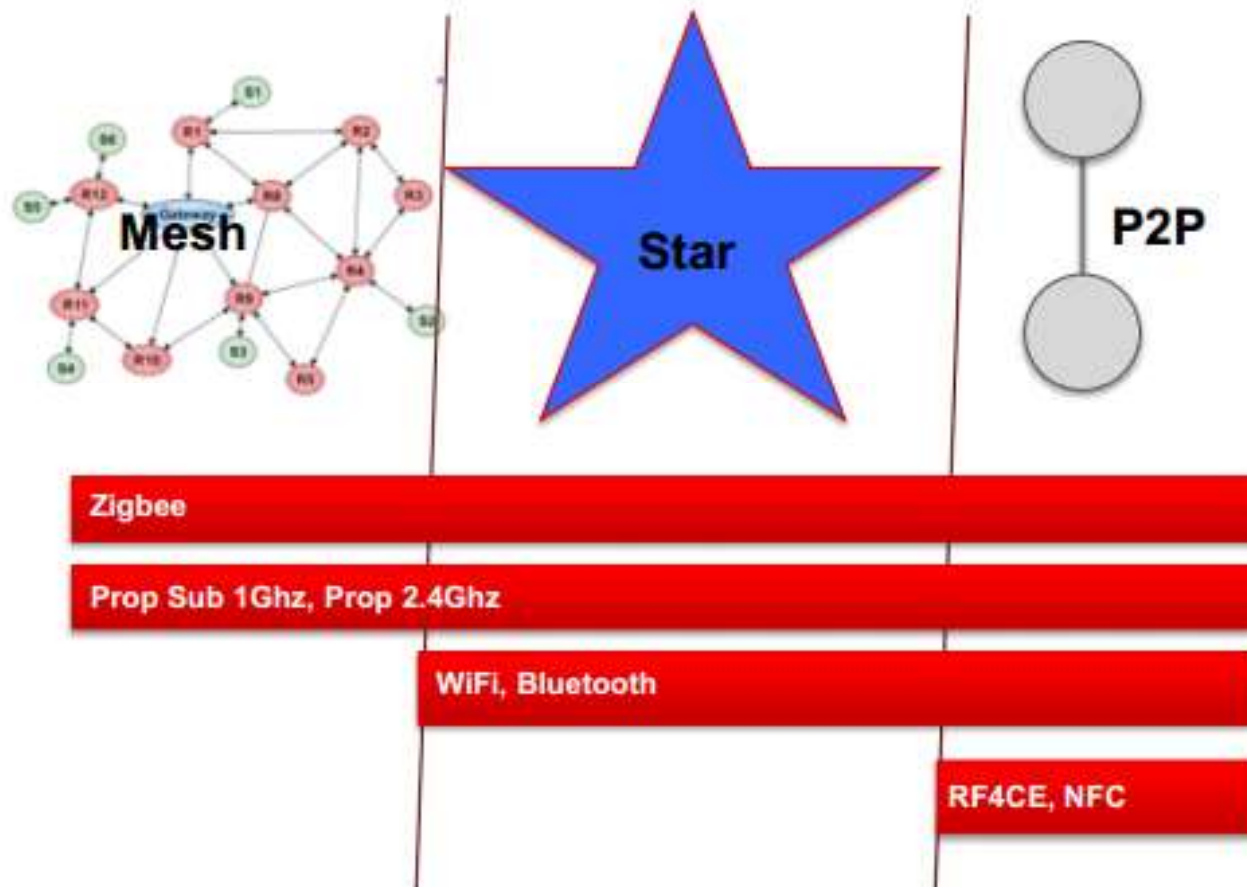- Bluetooth--BLE的前身

- BLE现状

- BT5.0——BLE美好愿景

BT5.0能够带来的

- Mesh！

- Long range

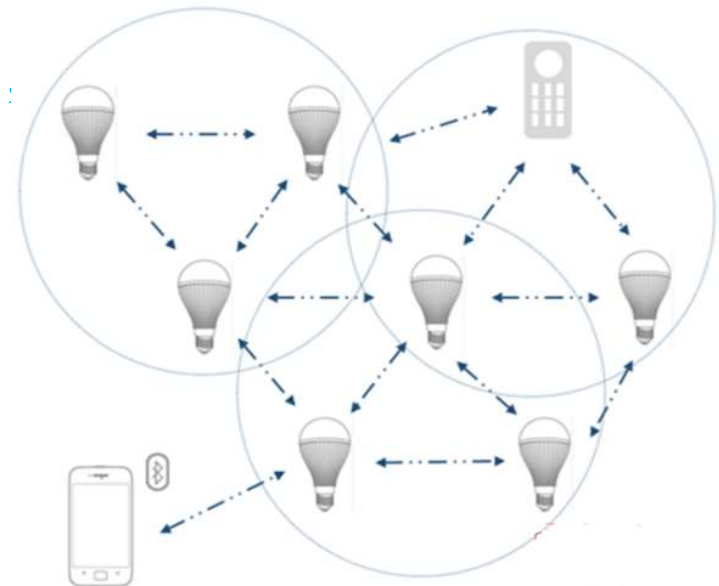- High accuracy positioning

- Higher data rate

网络拓扑

Mesh！

- 应对物联网、工业市场无线方案需求井喷式发展，星型网络越来越无法满足需求

- 使采用蓝牙技术的智能门锁、灯光控制以及家用电器等都能协同工作，为消费者带来无缝的智能家居体验

- 缺点：Mesh可能会使蓝牙功耗大增，与其其低功耗的初衷背道而驰

Long Range

- 是否遇到过防丢器明明就在房间里，却怎么也搜不到它信号的窘境？

- 是否遇到过智能门锁，明明可以实现手机接近开锁，却因为有拐角导致在门前尴尬等等？

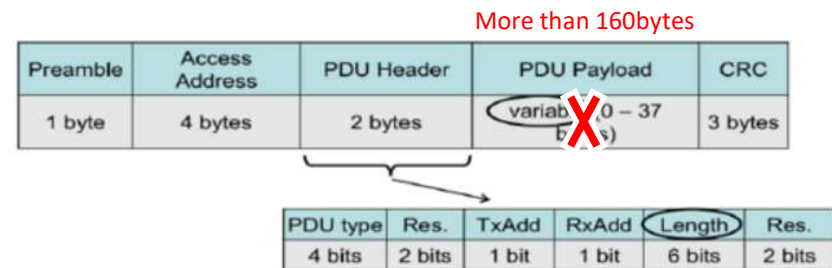- BT5.0计划将BLE信号增强到最远300m，目前大多数BLE设备的发射功率在0~5dBm之间，典型距离10~15m左右。

High Accuracy Positioning & Higher Data Rate

- 大名鼎鼎如**Apple**，基于**BLE**广播的**iBeacon**技术也只做到了三档。

- **BT5.0**立志将室内定位精度提升到**1m**(结合**WiFi)**，商场导购、防丢器等应用将再次引爆。

- 传输速率进一步提高，达到**BT4.2 LE**的**2**倍以上。

- 支持长广播，可达**160 bytes**以上内容，结合精确定位，更好的拓宽应用场景

More than 160bytes

Preamble	Access Address	PDU Header	PDU Payload	CRC
1 byte	4 bytes	2 bytes	variable (0 – 37 bytes)	3 bytes

PDU type	Res.	TxAdd	RxAdd	Length	Res.
4 bits	2 bits	1 bit	1 bit	6 bits	2 bits

PDU type	Packet name	PDU type	Packet name
0000	ADV_IND	0011	SCAN_REQ
0001	ADV_DIRECT_IND	0100	SCAN_RSP
0010	ADV_NONCONN_IND	0101	CONNECT_REQ
0110	ADV_SCAN_IND	other	Reserved

Summary

- BT2.1+EDR ： 使用最广泛

- BT4.0 LE ： 低功耗，物联网领域

- BT5.0 ： 高速高效，Mesh，引领未来

TI 目前支持的无线协议

Wireless Connectivity Portfolio

Proximity	Personal area networks		Local area networks			Neighborhood area networks
NFC RFID	**Bluetooth® Bluetooth LE**	**Proprietary 2.4GHz**	**ZigBee® & RF4CE**	**Wi-Fi®**	**6LoWPAN**	**Sub-1 GHz** Proprietary + TIMAC
Identification	*Personal Connection*	*Customizable*	*Mesh*	*Existing Infrastructure*	*IP Mesh*	*Customizable*

Key Differences

Data Up to 848 Kbps	Data or Voice Up to 3 Mbps	Data Up to 1 Mbps	Data Up to 256 Kbps	Voice or video Up to 100 Mbps	Data Up to 256 Kbps	Data Up to 1 Mbps
No battery to coin cell	Coin cell to AAA	Coin cell	Energy harvesting to AAA	AA battery	Energy harvesting to AAA	Coin cell

Key Attributes

• Passive operation & data storage • Dedicated multi-tag read zone • In Portable devices	• Interoperable with other Bluetooth devices • Large install base • In mobile devices	• Customizable to application • Robust RF	• Standards based • Self-healing mesh • Low power • Large area coverage	• Existing infrastructure • Standards Base • IoT platform • High throughput	• IPv6 stack • Ultra low power • IoT platform	• Longest range • Customizable to application • Robust RF

Range — cm ··· Up to 100m ··· km

大联大控股
A Member of WPG Holdings

世平集团
World Peace Industrial Group

Thank you

产业首选 · 通路标杆