ZigBee RF4CE: A Quiet Revolution is Underway

December 6, 2012
Agenda & Speakers

- **Capabilities of the ZigBee RF4CE specification**
  - Cees Links, Marketing Working Group Chair & CEO, GreenPeak Technologies

- **Overview of the MAC/PHY/Network**
  - Stig Torud, Product Manager, Consumer Products, Texas Instruments

- **The Standards: ZigBee Remote Control & ZigBee Input Device**
  - Ryan Kelly, Consumer Business Development, Microcontrollers, Freescale

- **New User Experiences**
  - Arsham Hatambeiki, Executive Director, Applied Innovations, Universal Electronics

- **The Possibilities: Deploying ZigBee RF4CE**
  - Ted Grauch, VP, Video Premise Equipment, Comcast Cable

- **Question & Answers**
Capabilities of the ZigBee RF4CE specification

Cees Links
Marketing Working Group Chair & CEO, GreenPeak Technologies
What is ZigBee RF4CE?

- ZigBee
  - Is the only open, low power networking standard
  - Connects the widest range of devices to work together
  - Helps consumers and business to control their world

- ZigBee RF4CE
  - Is a member of the ZigBee family
  - Standardizes multi-vendor control for consumer electronics and home entertainment equipment
  - Features simple, robust and very low latency wireless communication networking
History of ZigBee RF4CE

- Originally defined by four CE companies (2009):
  - Panasonic, Philips, Samsung and Sony
- Adresses the need for one worldwide remote control standard
  - One remote control capable of controlling multiple devices
- Migrating from IR to RF for a better user experience
  - More range, no line-of-sight, longer battery-life
- Merged into the ZigBee Alliance (2009)
  - To become truly open
  - To get further integrated with other communication standards in the home
- Further refined with input from cable operators
  - Adopted as a US Cable Labs Remote Control standard (2012)
What are the ZigBee RF4CE design criteria?

- Connecting consumer electronic devices: remote controls, keyboards, mice, pointers, etc.
- Multi-vendor interoperability between end-devices and host-devices (targets): HD-TV, DVR, Set-top box, Blu-ray player, computers, etc.
- Ease of use: simple pairing/commissioning
- Single worldwide standard, one frequency band
- Robust against interference
- Low latency
- Secure
- Small software footprint
- Low-cost
What is defined by ZigBee RF4CE?

- Based on 2.4 GHz MAC/PHY IEEE 802.15.4 standard
- Thin, flexible and future-proof networking layer
- Coexistence with other 2.4 GHz technologies
- Interoperability
- Secure communications
- Power saving mechanisms in network layer
- Simple and intuitive pairing
- Support for multiple applications:
  - ZigBee Remote Control
  - ZigBee Input Device
Where is ZigBee RF4CE being adopted?

- A strong eco-system of technology providers, product developers and (cable) operators have shipped millions of ZigBee RF4CE TV’s, set-top boxes, gateways and remote controls.
What are the ZigBee RF4CE standards?

- Two application standards have been defined
  - ZigBee Remote Control
  - ZigBee Input Device

- Objectives for standardization
  - Define and standardize very broad command sets
  - Define discovery and pairing procedures
  - Ensure interoperability between devices from different vendors

- Standards are released and available, including interoperability testing requirements

- Test houses (NTS, TRAC, TÜV Rheinland) are open for business
What is the ZigBee RF4CE experience?

- Goes through walls and into cupboards/furniture
  - Set-top-box (STB) can be placed in furniture or another room
  - Multiple room support
- Does not require line-of-sight
  - Not bothered by someone/something “in the way”
  - No pointing at devices required
- Is not sensitive for background light interference
  - Sunlight, LED, fluorescent lights
- Is standardized and selective
  - Supports multiple devices without complex programming
  - Does not unintentionally control unpaired boxes
- Allows for an improved keyboard experience
  - Tactile feedback/triple tap entry/discrete commands
- Supports a long battery life
  - Ultra-low power consumption
Even more benefits with ZigBee RF4CE!

- Bi-directional communication brings unique experiences that were not possible in the IR-era
- Receive and display messages on remotes
  - Program information
  - News highlights
  - Sport results
  - Stock info
- Find the Lost Remote feature
  - Ping a lost remote control with a button on the TV or STB
- Follow-me convenience
  - Continue watching movie when going to another room
- Supports new applications
  - Casual gaming (multi-user)
  - Arm-chair payments
  - Ambience control (lighting, air conditioning, curtains, etc.)
ZigBee Input Device standardizes communication with other devices
- Keyboards
- Touchpads – standardizing touch sense
- Pointing devices – standardizing motion sense
- Air mice
- Wands

ZigBee Input Device moves ZigBee RF4CE beyond “the remote”
- Standardizing Internet-TV capabilities
- Allowing interactive applications, data entry
- Enabling control of advanced menu structures

And beyond remote controls!
Overview of the MAC/PHY/Network

Stig Torud
Product Manager, Consumer Products,
Texas Instruments
IEEE 802.15.4 Physical (PHY) Layer
- Data transmission service in the 2.4 GHz band
- Direct Sequence Spread Spectrum (DSSS) modulation enabling a robust communication channel
- 250kbps data rate

IEEE 802.15.4 Medium Access Control (MAC) Layer
- Manages access to the physical channel
- Implements collision avoidance using CSMA/CA
- Packet validation/acknowledgement

ZigBee RF4CE Network (NWK) layer
- Thin layer enabling a star topology network
- Responsible for channel management (frequency agility)
- Provides mechanism for devices to discover and pair
- Enables a secure communication link
- Supports power savings mechanism
- Multiple data packet transmission options
ZigBee RF4CE Node Types

- ZigBee RF4CE network is comprised of two node types
  - **Target Node (STB, TV, Blu-ray/DVD player, A/V equipment...)**
    - Full Personal Area Network (PAN) Capability
    - Controls Network Startup
    - Accepts or declines pairing requests
    - Makes decision on operating channel (frequency agility)
    - Supports Inter PAN communication
    - Low power mode
  - **Controller Node (Remote Control Device)**
    - Initiates pairing and discovery process to Target Nodes
    - Implements frequency agility
    - On-demand communication
    - Low power mode
ZigBee RF4CE Network Topology

- Controller node (RC) can be a member of multiple PANs
- Target node can be controlled by multiple RCs, and supports inter-PAN communication
ZigBee RF4CE Channel Management

- **Target node** determines the channel and can move immediately if channel is compromised.
- **Controller node** will re-acquire and keep track of the channel.

Channel Agility

- 802.11b/g Channel (North America)
- 802.11b/g Spectrum Occupancy (Typical)
- 80.15.4 Channel
- ZigBee RF4CE Channel

Frequencies:
- 2.400 GHz
- 2.485 GHz
A ZigBee RF4CE device can perform service discovery in an attempt to find other suitable devices that it can be paired to.

Information exchanged during discovery:
- Device capabilities
  - Device type, mains/battery powered and level of security
- Vendor information
  - ZigBee allocated vendor identifier and a vendor string
- Application information
  - User defined string, a device type list specifying which types of device are supported and a profile identifier list specifying which standards are supported by the device
- Requested device type
  - Type of device being requested through the discovery process
ZigBee RF4CE Pairing

- Pairing can start after a successful discovery process.
- A unique security key is generated for each bi-directional link if both node’s node capability setting indicates capable of security.
- A pairing table entry on both originator and recipient constitutes a bi-directional link. Paring table contains:
  - Pairing reference
  - Source network address
  - Destination logical channel
  - Destination IEEE address
  - Destination PAN identifier
  - Destination network address
  - Recipient device capabilities
  - Recipient frame counter
  - Security link key
ZigBee RF4CE Security

- Security is established during pairing process
- Utilizes AES-128 with CCM mode of operation
  - Replay protection (via frame counter)
  - Data confidentiality (via payload encryption)
  - Data authentication (via Message Integrity Code)
- Nodes use 128-bit link keys
  - Keys are generated automatically, if security is supported
  - Keys are stored in the pairing table
- Custom encryption of payload is possible if stronger security is desired
The ZigBee RF4CE specification defines a number of transmission options that can be used by an application, and combined as appropriate:

- **Acknowledged or Unacknowledged**
  - Originator data is or is not confirmed by the recipient

- **Unicast or Broadcast**
  - Originator data is sent to a specific recipient or to all recipients

- **Single or multiple channel**
  - Originator attempts transmission on a specific channel or attempts transmission on all three channels

Unicast/Multichannel/Acknowledged necessary to ensure confirmed delivery of data and wake-up of target node in standby mode.
ZigBee RF4CE Power Management

- Two states for Power Save: Active & Standby
- Defined in network stack
- Controllers simply turn off when no buttons are being pressed
- Targets must also use power save when in standby
  - But must ensure a (human) reasonable reaction time
- Power saving utilizes
  - Active period during which the device wakes
  - Duty cycle at which device repeats active period
- Power saving mechanism is aligned with frequency agility

Diagram:
- \( \text{nwkDutyCycle} \) (<1 sec)
- \( \text{nwkActivePeriod} \) (>16.8 msec)
ZigBee RF4CE Network Frame

- **Frame control**: control information for the frame
- **Frame counter**: incrementing counter to detect duplicates and prevent replay attacks (security)
- **Profile identifier**: the application frame format being transported
- **Vendor identifier**: to allow vendor extensions
- **Frame payload**: contains the application frame
- **Message integrity code**: to provide authentication (security)
The Standards: ZigBee Remote Control & ZigBee Input Device

Ryan Kelly
Consumer Business Development,
Microcontrollers
Freescale
### What are ZigBee Application Profiles?

- **Technical term for each of our standards**
- **Application layer software the standardizes the way devices communicate to ensure interoperability**
- **Defines messages and how they are sent over the air for a given application**
- **Devices that contain the same application profile are guaranteed to interoperate through rigorous certification testing**
- **Devices may carry the ZigBee Certified product logo once product testing is successfully completed by an approved test house and the Alliance issues a product certificate**
  - Visit [www.zigbee.org/certification.aspx](http://www.zigbee.org/certification.aspx) for more information

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**ZigBee RF4CE Application Profiles/Standards**

<table>
<thead>
<tr>
<th>Application Profile</th>
<th>ZigBee Remote Control</th>
<th>ZigBee Input Device</th>
</tr>
</thead>
<tbody>
<tr>
<td>Network</td>
<td>ZigBee RF4CE</td>
<td></td>
</tr>
<tr>
<td>MAC</td>
<td>IEEE 802.15.4 – MAC</td>
<td></td>
</tr>
<tr>
<td>PHY</td>
<td>IEEE 802.15.4 – 2.4 GHz (worldwide)</td>
<td></td>
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</tbody>
</table>
ZigBee Remote Control

- Defines method for nodes to discover one another
- Defines push button pairing process between controller and target
  - The mechanism works in conjunction with the existing ZigBee RF4CE discovery and pairing mechanisms
  - Discovery, pairing and security (as necessary) all take place via a single button push
- Defines commands for basic CE device control
  - User control pressed
  - User control repeated
  - User control released
- User control pressed command carries HDMI CEC commands
- Support for manufacturer specific commands
- Command discovery, remote to HDTV and HDTV to remote
- Shipping in high volume
ZigBee Input Device Standard

ZigBee Input Device

- Defines standardize communication for Human Interface Devices (HID) based on USB-HID
  - Support for mice, keyboards, touchpads, touchscreen and digital pens
- Utilizes new Generic Device Profile (GDP) to specify common commands and procedures used as the foundation for multiple profiles.
- Identical pairing process as ZigBee Remote Control giving customers a uniform ZigBee RF4CE pairing experience
- Native support for popular multi-touch and gesture commands, including pinch or rotation for touch pad devices
- Added support for remote device paging capability (locate lost device)
ZigBee RF4CE - Push-Button Pairing

Defines mechanism for user initiated pairing between devices. Utilizes the basic ZigBee RF4CE constructs of Discovery and Pairing to achieve a connection between the desired devices. Built-in handling for multiple devices in pairing mode and timeouts. Used in ZigBee Remote Control and ZigBee Input Device.

<table>
<thead>
<tr>
<th>Pairing Table</th>
<th>DTV</th>
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Discovery Request followed by Pair Request (Multi-channel; Unicast Transmission)

Optional Link Key Exchange after pairing

Discovery Response followed by Pair Response (Single-channel; Unicast Transmission)
New User Experiences

Arsham Hatambeiki
Executive Director, Applied Innovations,
Universal Electronics
ZigBee RF4CE standards are designed for simplicity

- Optimized for the most common activities
  - A connectionless network layer reduces latency optimal for sporadic events
  - Events are reduced to necessary commands enabling a robust link
  - Specifically designed for AV control
    - Example: User control repeats prevent key runaway on a lossy medium

- Implementation specific innovation fully accommodated
  - Well defined support for vendor specific extensions to allow innovation in this space
  - Certified features fully compatible with other devices, while vendor specific extensions can improve consumer experience in bundled offerings

- Simple problems, meaningful results
  - Addressing historical needs of the industry while streamlining the introduction of new use cases
Prime Time
The Living Room (USA)

- **Average Number of TVs per U.S. Household:** 2.5
- **Percentage of Americans with 4 or more TVs:** 31%
- **70.6M US homes with a VCR in Jan’11**

Source: Nielsen (multiple studies)
Setup & Configuration

Plug and Play setup is closer than ever before
- Simple push-button pairing process
- Market realities taken into consideration during development
- Automated or wizard assisted universal setup possible in-line with industry rollouts
- Self-Install Kits
  - Eliminate the need for truck-rolls
  - Effortless replacements through cloning
- Adaptive Configuration
  - Volume & Channel control
  - Activity & state based
    “Control what you need, when you need it”

① Device type, brand, and model auto-detected or user selected using on-screen wizard
② Brand, model and IR code data reside in STB or online
③ STB programs remote over bidirectional ZigBee RF4CE link
Primary use case **is** content consumption

- Content proliferation requires improved navigation to truly benefit the consumer
  - “Nothing to watch on TV” is a myth that points to limitations of legacy user interfaces in supporting the growing choice in content
- Same content available through multiple sources
  - Competition as well as Increasing user expectations are forcing additional focus on delivery of an enjoyable service
- Design for mainstream or early adopters?
  - Enable both to succeed in the transition, and the single physical point of user interaction with the interface plays a key role
User Interface Elements

Lists

Shelves

Grid

Keyboard

Browser

OFN

Capacitive touch

Joystick

Motion pointing
An Intuitive Human-Machine Interface (HMI)

- Touch & motion based natural gestures are used in our day-to-day life which should carry over to our AV control.
- User intent can be derived from the smallest action as simple as reaching for the remote.
- User intent is converted to implicit commands used to show contextual and relevant options.
- Number of steps to perform the desired action is reduced while simplifying the controller “look & feel”.
- Subtle tactile (or audible) feedback further enhances the heads-up navigation experience (remote finder).
- Above is possible without additional steps to point at the device under control, turning the remote into a full function sensor!
Motion Gestures – Twist for Volume

Touch to initiate. Twist the remote to increase/decrease volume
Virtual Controls Examples

Use the remote to steer in casual gaming applications
Future proof platforms with over-the-air upgrade capabilities open the door for rollout of new use cases

- **NFC Integration**
  - Tap to pair, 2nd screen (Smartphone/Tablet) Apps
- **T-Commerce**
  - Content placement

**New Use Cases**

- **Tabletop designs**
- **Personal controllers**
  - Multi-room

**New Categories**

**SIMULTANEOUS USAGE INSIGHTS**

- **Tablets and TV**
  - Skews Older
    - Age groups: 25-34 and 55-64 are the most likely to use their tablets multiple times per day while watching TV.
    - Typical Activities:
      - Seeking Information
        - 36% of people 35-54 and 44% of people 55-64 use their tablets to dive deeper into the TV program they are currently watching.
      - Surfing and e-Mailing
        - 55-64 are the heaviest web surfers and email checkers on tablets during commercial breaks and programs.
      - Sport Scores
        - Nearly a third of all tablet users aged 25-64 check sports scores on their tablets while watching TV.
  - 85% of tablet/smartphone owners use their device while watching TV at least once a month with 40% of them doing it daily.

- **Smartphones and TV**
  - Skews Younger
    - Nearly half of 18-24 year olds use their smartphones while watching TV at least once per day.
    - Typical Activities:
      - Social Media
        - 44% of 18-24 year olds and close to 50% of 25-34 year olds are visiting social networking sites on their smartphones during both commercials and programs while watching TV.
      - e-Mailing
        - is the heaviest simultaneous smartphone activity across all demos, with over 50% of users checking during commercials and programs.
      - Shopping
        - 29% of 25-34 year olds shop on their smartphones while watching TV.

Source: Nielsen
The Possibilities: Deploying Zigbee RF4CE

Ted Grauch
VP, Video Premise Equipment, Comcast Cable
Deploying ZigBee RF4CE

- **Infrared Control Replacement**
  - Cost Effectiveness
  - Reliability
  - Simplicity
  - Benefits

- **Interoperability**
  - Multiple suppliers at the device and chipset layer
  - ZigBee interoperability testing and specification compliances
  - More enhancements planned

- **Other Products**
  - Skype remote with QWERTY
  - Back-light remote
Deploying ZigBee RF4CE

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Deploying ZigBee RF4CE

Bottom – Up Approach
- Started with Digital Transport Adapter (DTA)
  - Analog Cable Switch-Off
  - Eliminates IR extension cables
  - Eliminates waste of millions of batteries/year
- All new DTAs shipped to Comcast have ZigBee RF4CE remote controls
- Started in Summer, 2012
- Millions of units received and in process of deployment ramp

Next Step - High End STB/Gateways
- Video DVR and Video Gateways launch began Fall 2012 in limited numbers
- Client Set-Top Box designs will all contain ZigBee RF4CE beginning end of Q2 2013
Future ZigBee RF4CE and ZigBee technology for Service delivery:

- Comcast independently selected ZigBee PRO for our new Security Services for in-home mesh networking
  - Sensor technology
  - Security Control system
  - In deployment across the USA since early 2012

- Devices that can allow legacy STB to be used in an ZigBee RF4CE network

- Advanced remote control devices in early planning

- Cost effectiveness and benefits of the technology open many future uses
Question & Answers
Submit your questions using Chat
Thank you!

- Webinar will be available for on-demand viewing
- Email with link to presentation slides will be sent to everyone viewing the live presentation

- Learn more about ZigBee RF4CE at www.ZigBee.org/RF4CE
- Learn more about ZigBee Remote Control at www.ZigBee.org/RemoteControl
- Learn more about ZigBee Input Device at www.ZigBee.org/InputDevice