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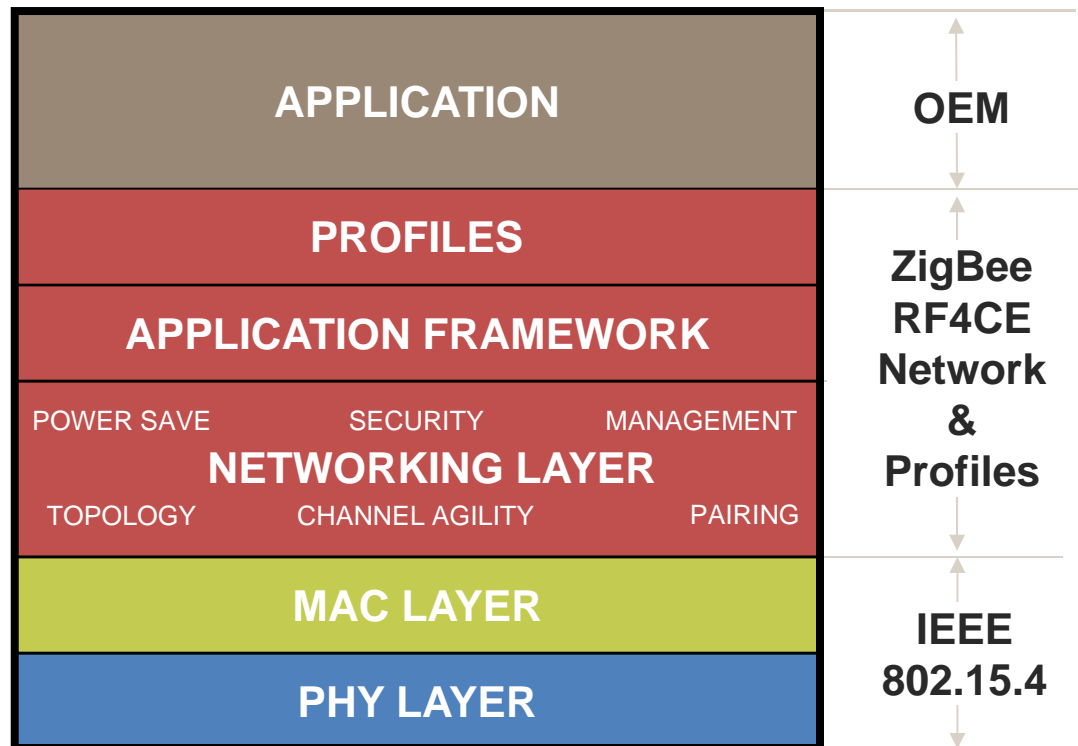
- **Based on 2.4 GHz MAC/PHY IEEE 802.15.4 standard**
- **Thin, flexible and future-proof networking layer**
- **Coexistence with other 2.4 GHz technologies**
- **Interoperability**
- **Secure communications**
- **Power saving mechanisms in network layer**
- **Simple and intuitive pairing**
- **Support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

APPLICATION	OEM
PROFILES	ZigBee RF4CE Network & Profiles
APPLICATION FRAMEWORK	
POWER SAVE · SECURITY · MANAGEMENT **NETWORKING LAYER** TOPOLOGY · CHANNEL AGILITY · PAIRING	
MAC LAYER	IEEE 802.15.4
PHY LAYER	

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

PHILIPS **SONY** **SAMSUNG**

LG **TOSHIBA** **UNIVERSAL ELECTRONICS.**

TEXAS INSTRUMENTS **freescale** semiconductor **ATMEL** **Green PeAk**

ST **OKI** OKI SEMICONDUCTOR **MICROCHIP**

Comcast. **ECHOSTAR** **NXP** **RENESAS**

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.)

And beyond remote controls!

- **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

Overview of the MAC/PHY/Network

Stig Torud
**Product Manager, Consumer Products,**
Texas Instruments

ZigBee RF4CE Architecture

- **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
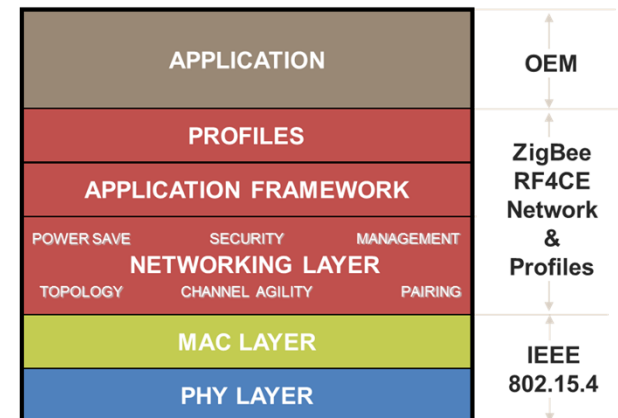
ZigBee RF4CE Node Types

- 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
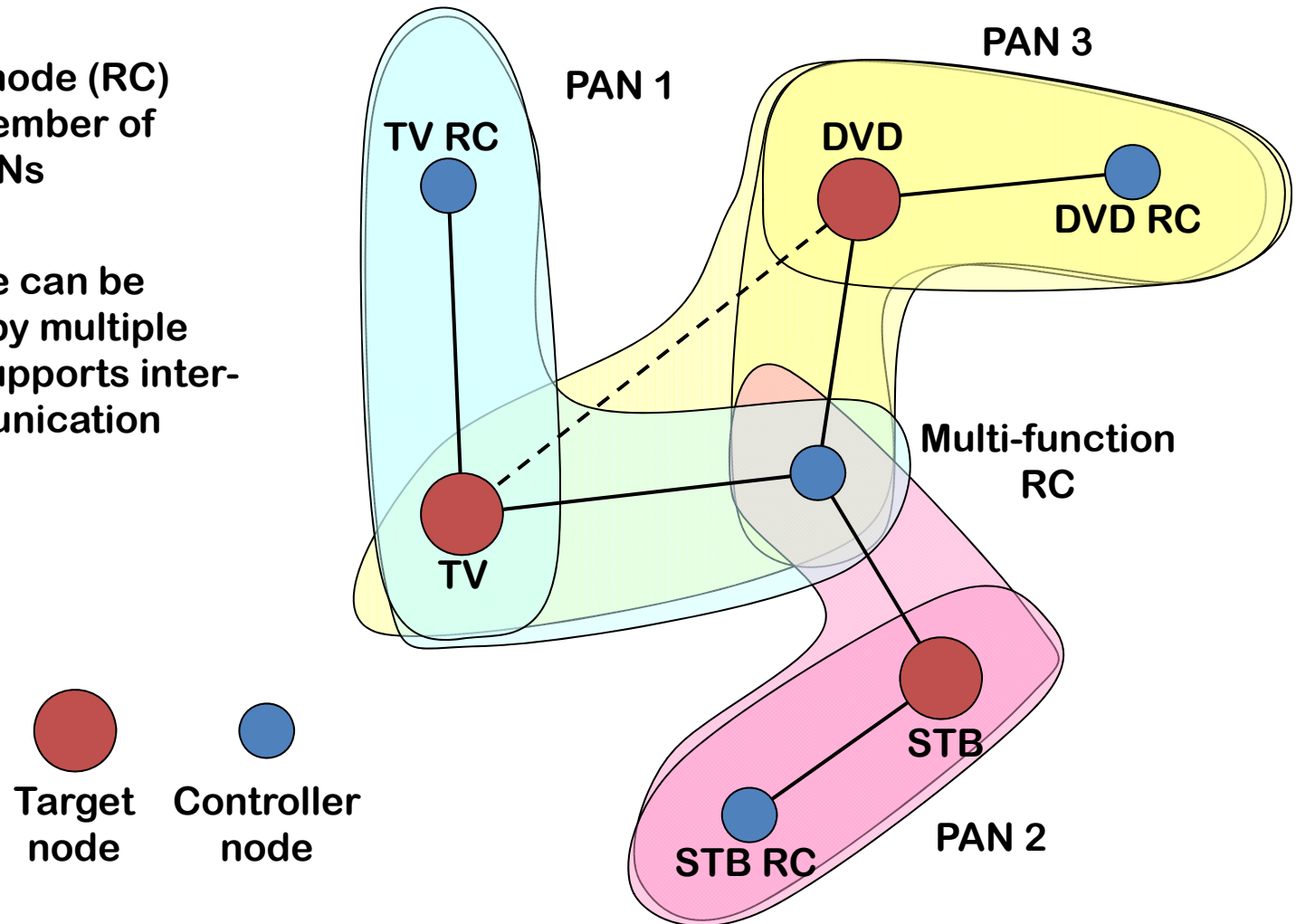   - On-demand communication
    - Low power mode

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
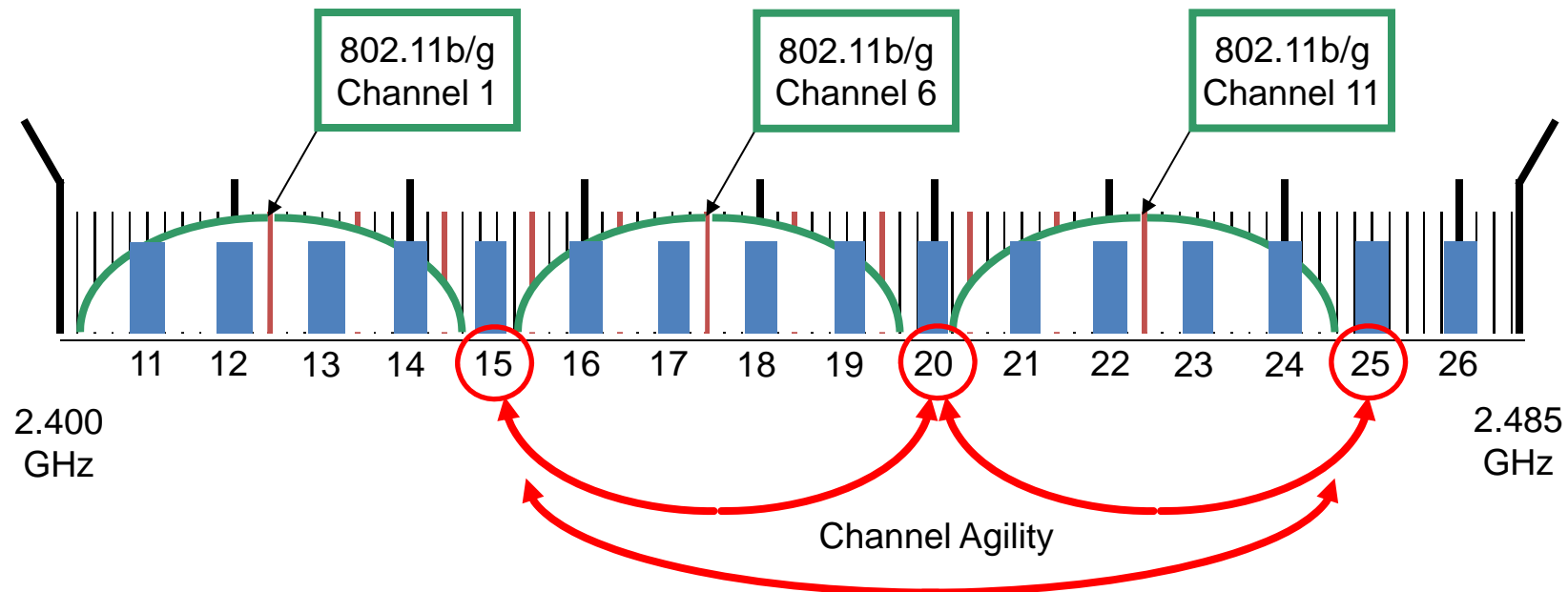

PAN 3

PAN 1

TV RC

DVD

DVD RC

Multi-function RC

TV

STB

Target node

Controller node

STB RC

PAN 2

ZigBee RF4CE Channel Management

802.11b/g Channel 1

802.11b/g Channel 6

802.11b/g Channel 11

11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26

2.400 GHz

2.485 GHz

Channel Agility

802.11b/g Channel (North America)

802.11b/g Spectrum Occupancy (Typical)

802.15.4 Channel

ZigBee RF4CE Channel

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

ZigBee RF4CE Discovery

- 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
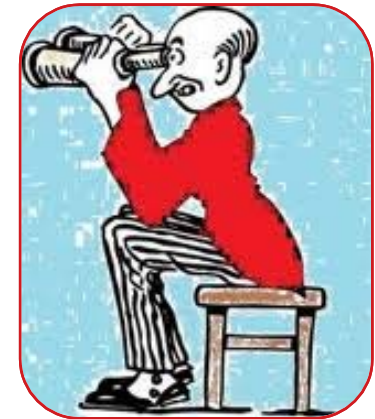
ZigBee RF4CE Pairing

- 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**

ZigBee RF4CE Transmit Options

- **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**
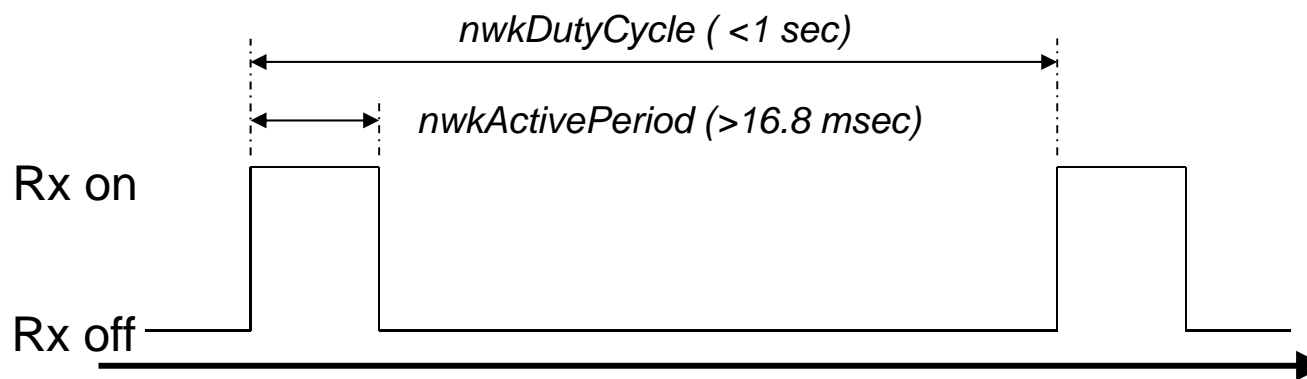
Originator   Recipient

Ch 20 attempt

Ch 25 attempt

Ch 15 attempt

Ch 15 acknowledge
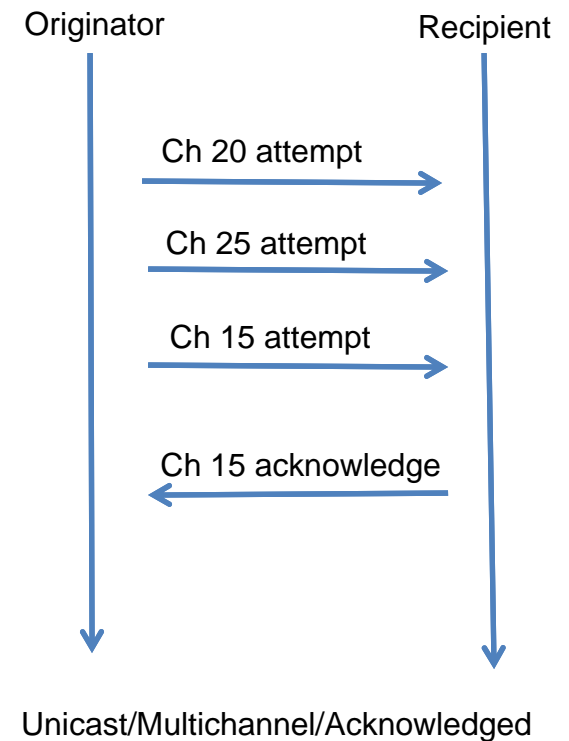
Unicast/Multichannel/Acknowledged

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
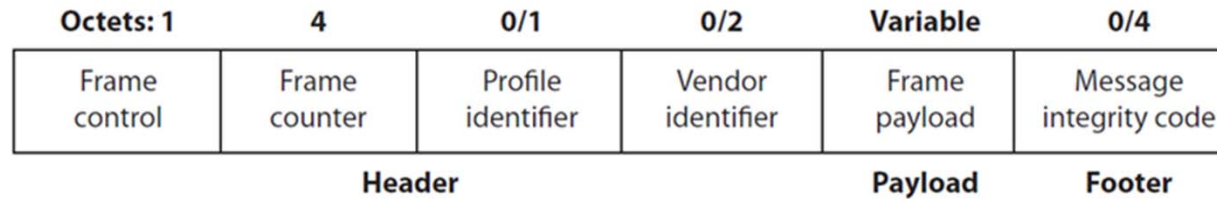- **Power saving mechanism is aligned with frequency agility**

nwkDutyCycle (<1 sec)

nwkActivePeriod (>16.8 msec)

Rx on

Rx off

ZigBee RF4CE Network Frame

Octets: 1	4	0/1	0/2	Variable	0/4
Frame control	Frame counter	Profile identifier	Vendor identifier	Frame payload	Message integrity code

Header — **Payload** — **Footer**

- 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

ZigBee RF4CE
Application Profiles/Standards

ZigBee RF4CE		
Application Profile	ZigBee Remote Control	ZigBee Input Device
Network	ZigBee RF4CE	
MAC	IEEE 802.15.4 – MAC	
PHY	IEEE 802.15.4 – 2.4 GHz (worldwide)	

🔴 **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 for more information

ZigBee Remote Control Standard

- **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.
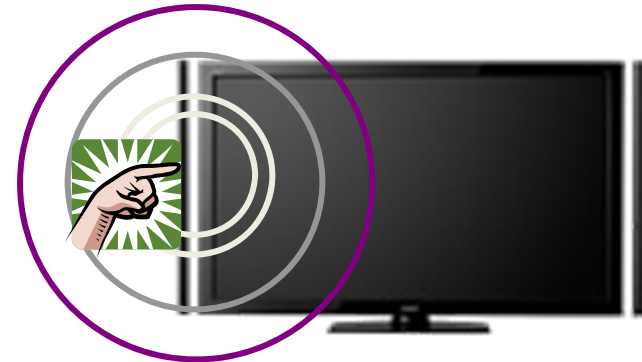
Pairing Successful

Pairing Table
DTV

Optional Link Key
Exchange after pairing

Discovery Request
followed by
Pair Request
(Multi-channel;
Unicast Transmission)

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

New User Experiences

Arsham Hatambeiki
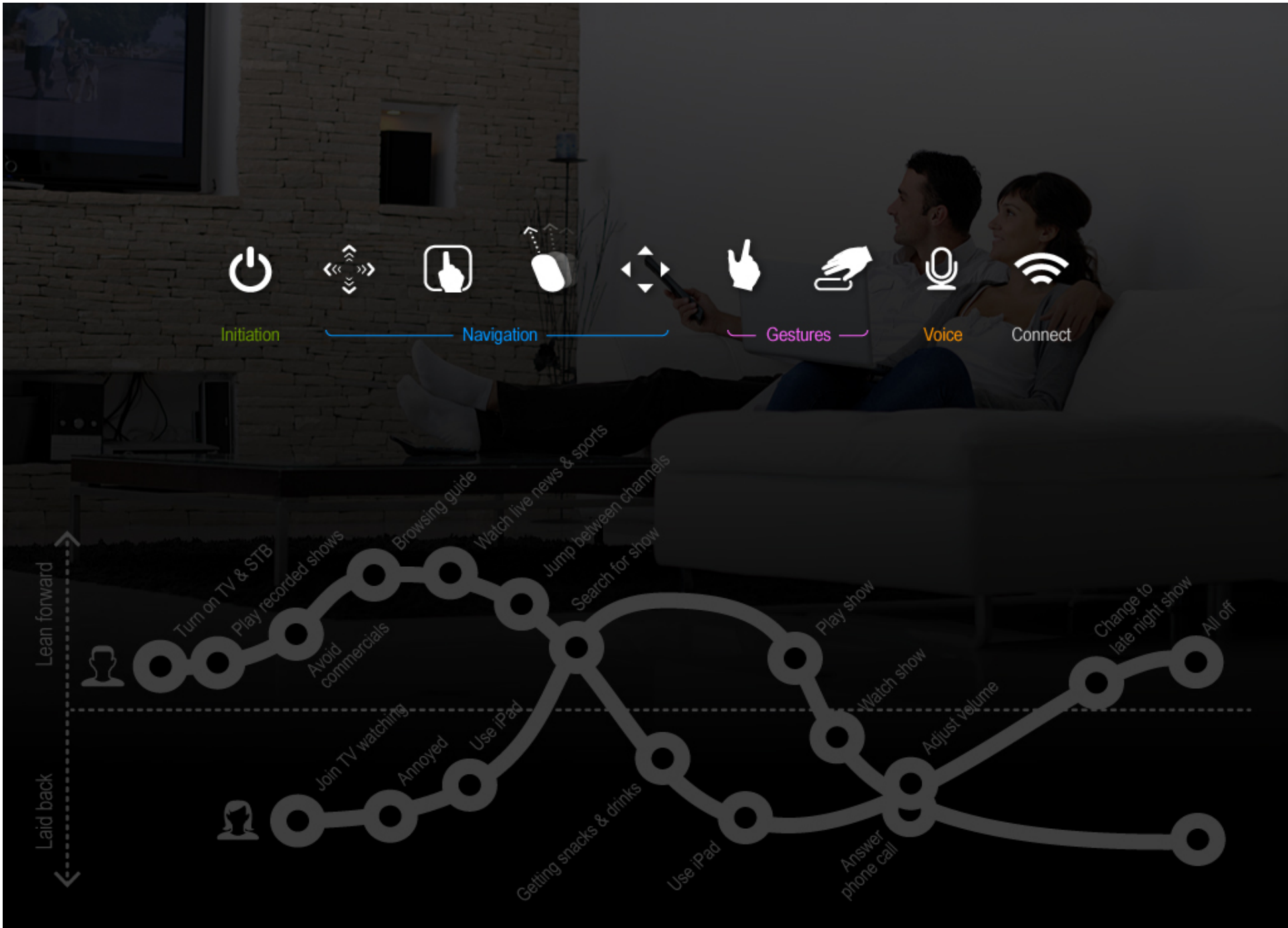## Executive Director, Applied Innovations,
Universal Electronics

Improved User Experience

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**
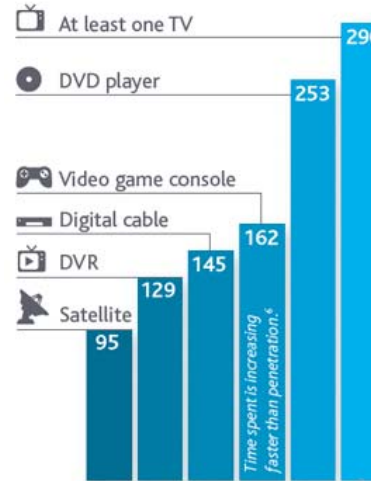 - Addressing historical needs of the industry while streamlining the introduction of new use cases

Prime Time

Lean forward

Laid back

Turn on TV & STB
Play recorded shows
Avoid commercials
Browsing guide
Watch live news & sports
Jump between channels
Search for show
Play show
Watch show
Adjust Volume
Change to late night show
All off

Join TV watching
Annoyed
Use iPad
Getting snacks & drinks
Use iPad
Answer phone call

31

Initiation

Navigation

Gestures

Voice

Connect

Lean forward

Laid back

Turn on TV & STB

Play recorded shows

Browsing guide

Watch live news & sports

Jump between channels

Search for show

Play show

Change to late night show

All off

Avoid commercials

Join TV watching

Annoyed

Use iPad

Getting snacks & drinks

Use iPad

Answer phone call

Watch show

Adjust volume

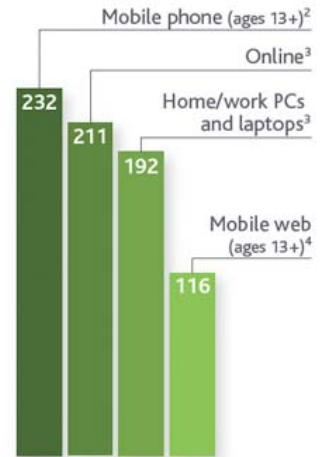# The Living Room (USA)

- **Average Number of TVs per U.S. Household: 2.5**

- **Percentage of Americans with 4 or more TVs: 31%**

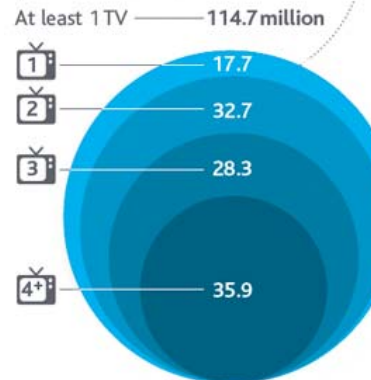- **70.6M US homes with a VCR in Jan'11**

Source: Nielsen (multiple studies)

DEVICE OWNERSHIP[1]
(millions of people who own)

At least one TV	290
DVD player	253
Video game console	162
Digital cable	145
DVR	129
Satellite	95

Time spent is increasing faster than penetration.[6]

MOBILE & ONLINE CONSUMERS
(millions of users)

Mobile phone (ages 13+)[2]	232
Online[3]	211
Home/work PCs and laptops[3]	192
Mobile web (ages 13+)[4]	116

HOUSEHOLDS WITH TVS
(millions of households)[1]

At least 1 TV —— 114.7 million

1	17.7
2	32.7
3	28.3
4+	35.9

1. Nielsen. National People Meter, Universe Estimates (Nov. 2011)
2. Nielsen. Mobile Media Marketplace (Q3 2011)
3. Nielsen. NetView, (Sept. 2011)
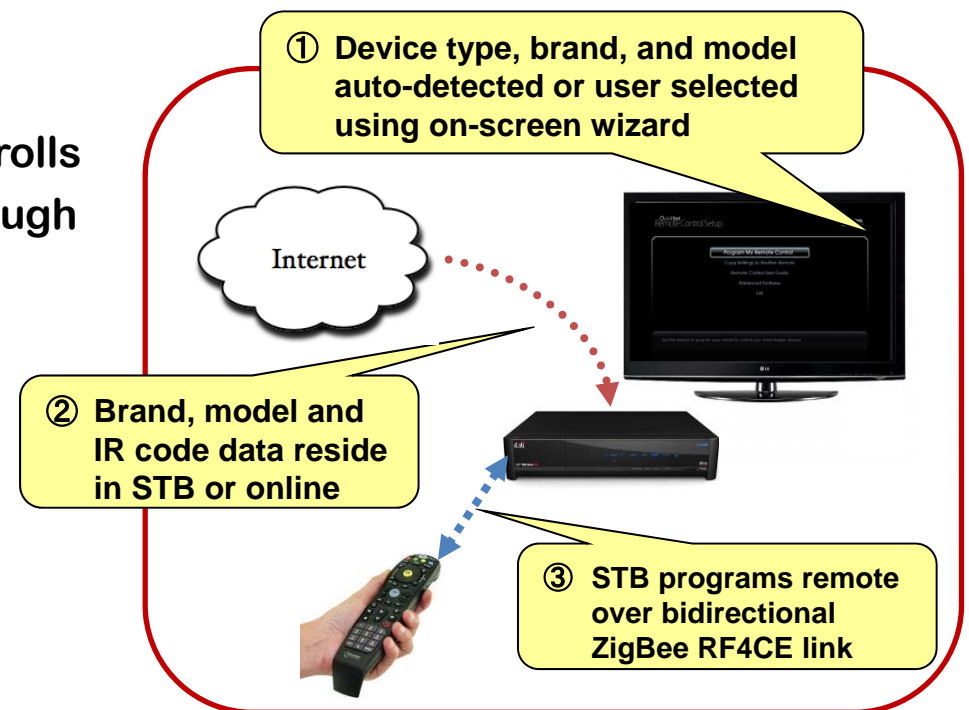4. Nielsen. Mobile Netview (September 2011)

nielsen

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

Internet

② Brand, model and IR code data reside in STB or online

③ STB programs remote over bidirectional ZigBee RF4CE link

Enhanced Navigation

- **Primary use case <u>is</u> 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
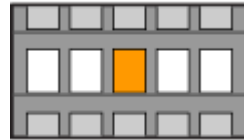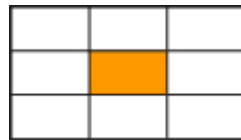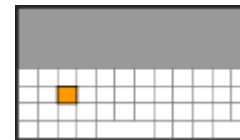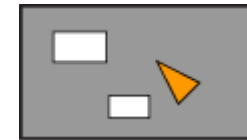
User Interface Elements
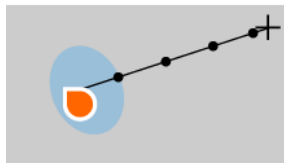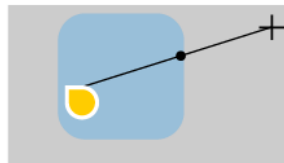

Lists   Shelves   Grid   Keyboard   Browser
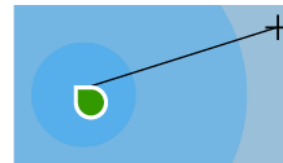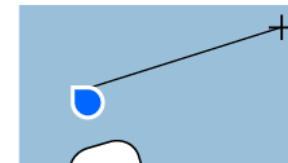
OFN   Capacitive touch   Joystick   Motion pointing

Human-Machine Interface

- ## 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!
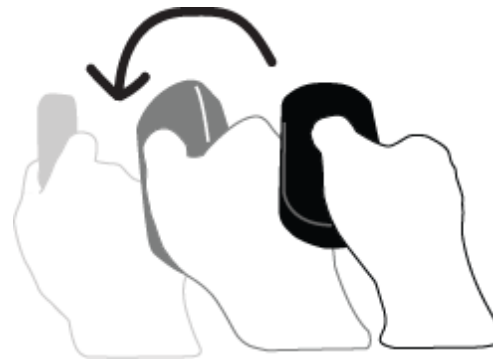
Touch to initiate. Twist the remote to increase/decrease volume

Virtual Controls Examples
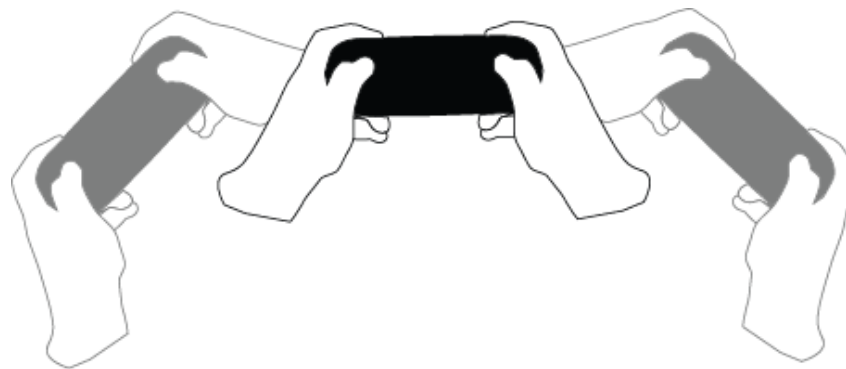
Use the remote to steer in casual gaming applications
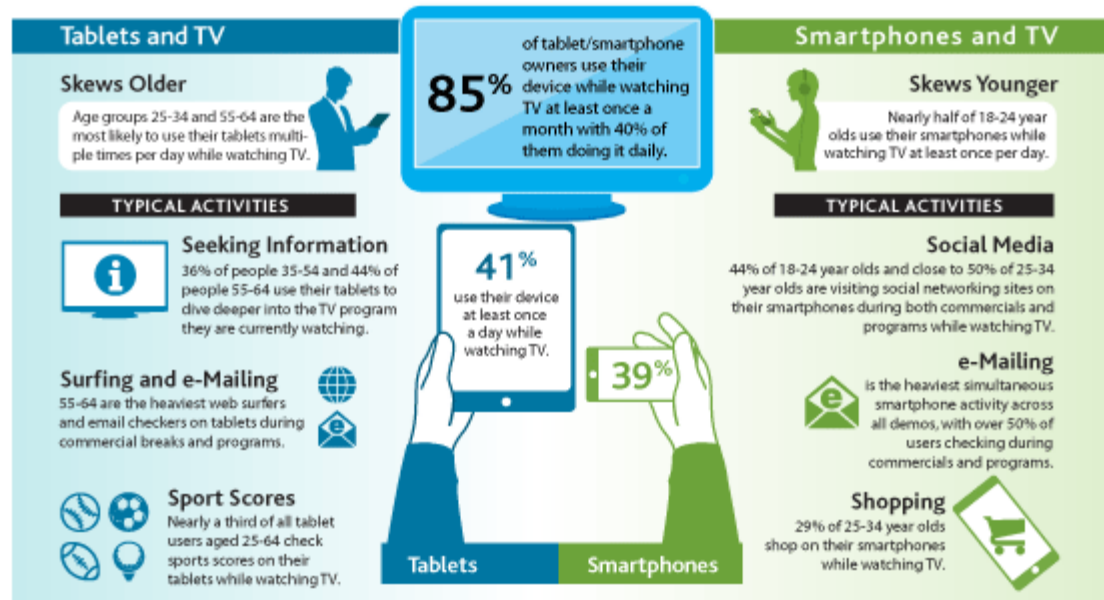
New Use Cases

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

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.

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

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.

41% use their device at least once a day while watching TV.

39%

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.

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.

Tablets   **Smartphones**

Shopping
29% of 25-34 year olds shop on their smartphones while watching TV.

Source: Nielsen

nielsen

The Possibilities: Deploying Zigee 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

- **Infrared Control Replacement**
  - Cost Effectiveness
  - Reliability
  - Simplicity
  - Benefits
- **Interoperability**
  - Multiple suppliers at the device and chipset layer
  - ZigBee interop testing and specification compliances
  - More enhancements planned
- **Other Products**
  - Skype remote with QWERTY
  - Back-light remote

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

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- **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**