November 15, 2006

Home Control and Automation with ZigBee Technology

Ryan Kelly
ZigBee Global Marketing Manager
What is ZigBee™?

- ZigBee is a networking protocol operating at 868/915 MHz & 2.4 GHz spectrum with IEEE® 802.15.4 MAC

- ZigBee enables simplicity, long battery life, networking capabilities, reliability, and low system cost

- ZigBee is excellent for remote monitoring and control and sensory network applications; cable replacement

- ZigBee targets residential and commercial control and monitoring, utilities, medical and handheld markets.

- The ZigBee Alliance provides specification, interoperability, certification testing, and branding
Network Topology Models

- Star
- Mesh
- Cluster Tree

- PAN coordinator (PANC)
- Full Function Device (FFD, Router)
- Reduced Function Device (RFD)
ZigBee™ is Mesh Networking

- ZigBee Coordinator
- ZigBee Router
- ZigBee End Device

ZigBee Device Associations
According to Parks Associates, the availability of installation services will stimulate the growth of home control systems. Such systems include lighting, safety, and comfort controls. The current home controls market is 1 percent of the potential. Home controls system sales are expected to grow at 8-9 percent from $2.2 billion in 2004 to $3.2 billion in 2009.

Source: In-Stat/MDR, #IN0501836MI, 2005
Wireless Technologies in the Home

- **Peak Data Rate**
  - Faster
  - Slower

- **Range**
  - Closer
  - Farther

- **Wireless Data Applications**
  - UWB
  - 802.11g
  - 802.11a
  - 802.11b

- **Wireless Video Applications**
  - Wi-Fi®
  - Bluetooth™
  - ZigBee™

- **Data Transfer**
  - NFC/RFID

- **Voice**
  - Cellular
  - 2.5G/3G

- **Monitoring & Control**
  - Wireless Networking
Why Automate?

► Consumer convenience becomes a need
  • Users get used to the convenience where it becomes a need
    ▪ Remote controls, microwaves, cell phones, PVR

► Saves time by removing the need for human intervention
  • Turning on appliance or electronic component, automatic irrigation, etc.

► Provides connectivity outside home (Gateway)
  • Monitor/control lights, security system, etc.

► Provides seamless connection to all systems
  • Open the front door and the lights in the house come on

► Ability to make intelligence decisions based on environment
  • Occupancy detection, etc.

► Installation cost savings
Energy Consumption in the Home

▶ Lighting and HVAC are major contributors to energy cost
  • Ideal candidates for home automation

▶ Refrigerator, freezers, TVs and office equipment
  • Depend more on energy efficient operation vs. automation to save money
Lighting Automation Example

Lighting example

- 2000 Square foot hour with 4500 watts in lighting
  - 3 bedrooms x 440 watts
  - 2 bathrooms x 460 watts
  - 1 kitchen x 460 watts
  - 1 dining room x 240 watts
  - 2 living rooms has 340 watts
  - Other has 880 watts (closets, garage, half bath, outdoor lights, etc.)

- 2-3 lights (450 watts or 10% of total lighting) are left on for 10 hours a day
  - Typical lights are bathroom, bedroom, closet, or outdoor lighting

- $147 annual cost
  - 450 watts x 10 hours / 1000 (kilowatts) x 0.09 (cost per kWh) x 365 (days a year)
HVAC Automation Example

► Heating Ventilation Air Conditioning (HVAC) example
  • 2000 square foot house with 3-ton central air
  • Running for 2 hours extra a day
    ▪ 20% duty cycle over 10 hours
  • $430 annual cost
    ▪ 2 hours x .59 (cost per hour) x 365 (days a year)

► Programmable thermostats help reduce cost
  • Set times still do not determine if somebody is occupying the house.
    ▪ Tie in thermostats with occupancy detection via alarm system, etc to further reduce cost
    ▪ Remotely control HVAC system
Typical Residential Applications

Applications are targeted toward convenience, energy management and whole home connectivity

- Lighting
  - On/off, dim (load control)
  - Home Control Lighting Profile approved as part of 2004 specification
- Heating, Ventilation, Air Conditioning (HVAC)
  - Thermostats, temperature sensors, load sharing, etc.
- Security/Access Control
  - Door, window and motion sensors, entry monitoring, smoke detectors, etc.
- Yard and Garden
  - Sprinkler heads, soil moisture and temperature, solar insolation
  - Custom-sized zones for very accurate control
- Pump / Motor Control
  - Appliances, pool pumps, etc.
- Remote Control & Gateway
  - Local or remote control and monitoring of network

ZigBee provides for integration of secure systems (lighting, HVAC, security, convenience, etc.) that are separate today
Your Very Own “Internet of Things”

- Main Structure (199)
  - 13 Windows (battery)
  - 7 External doors (battery)
  - 4 Door latches/deadbolts (battery/solar)
  - 11 Internal doors (battery)
  - 40 Internal and external light fixtures (mains)
  - 26 Circuit breaker monitors (mains)
  - 15 Occupancy/motion sensors (battery)
  - 6 Thermostats (battery)
  - 10 Control dampers (battery or mains)
  - 1 Heat Pump (mains)
  - 1 Air Blower (mains)
  - 4 Pipe/Water monitors (battery)
  - 1 Oven/Burner sensor (main)
  - 3 Ceiling ventilator/heater control/monitors (mains)
  - 5 Smoke detectors (battery)
  - 3 CO detectors (battery)
  - 6 Controllable outlets (mains)
  - 2 Fireplace flue/damper monitors (battery)
  - 2 Attic ventilators (mains)
  - 4 Attic temperature/moisture sensors (battery)
  - 5 Under-house crawl space moisture monitors (battery)
  - 2 Under-house crawl space ventilators (mains)
  - 2 Doorbell buttons (battery)
  - 1 Doorbell (battery or mains)
  - 2 Video Snapshot security cams (battery)

- Garage (15)
  - 2 Door sensors (battery)
  - 2 Door latches/deadbolts (battery)
  - 1 Garage door opener (mains)
  - 2 Garage door/home remotes (battery)
  - 2 Occupancy/parking space/position monitor (battery)
  - 2 Garage light switches (battery)
  - 1 garage monitor (battery/solar)
  - 4 Stage light strings (mains)
  - 20 Sprinkler heads (battery)
  - 1 Sprinkler pump, filter, heater (mains)
  - 1 Sprinkler pump, timer, battery
  - 10 Spot watering devices (battery)
  - 5 Semi-permanent holiday lights (mains)

- Landscaping (53)
  - 4 Low-voltage light strings (mains)
  - 20 Sprinkler heads (battery)
  - 3 Pool pump, filter, heater (mains)
  - 1 Pool monitor (battery)
  - 1 Gate monitor (battery)
  - 10 Landscape moisture monitors (battery)

- Other (30)
  - 6 exterior hose bib monitors (battery)
  - 1 Mailbox monitor (battery/solar)
  - 1 Water softener monitor (battery/mains)
  - 1 Pet door control (battery)
  - 2 Pet ID tags (battery)
  - 1 “Change the litter” monitor (battery)
  - 1 Water bowl monitor (battery)
  - 3 Televisions (mains)
  - 5 Major appliances (mains/battery)
  - 3 Sets remote speakers (mains/battery)
  - 1 Cable settop box (mains)
  - 1 Sound system (mains)
  - Many remote controls (battery)
  - 1 Perimeter fence monitor (battery/solar)

And so on

Nearly 300 devices! ZigBee address space has PLENTY of room for expansion
Mesh Networking Adds Reliability

► Of those nearly 300 devices, well over 50 have routing capabilities

► Large or sparsely spaced homes
  • Even for a home of 400-500m² and larger, this provides a mesh with no more than about 5m between routing nodes
  • Essentially no part of the house is without coverage

► Dense housing (large apartment buildings, condominium complexes)
  • Low average channel occupancy, large number of available channels

► With lots from city size to country estate, the entire property can generally be covered simply from the exterior lights mounted on the structure
Simple Wireless Thermostats

► Battery Operation
  • 1 Lithium CR2032 coin cell

► Freescale MC1321x single package transceiver and applications processor
  • 10-bit ADCs
  • Digital I/O
  • Serial communications
  • Many power saving states
  • Voltage range 1.8 – 3.6Vdc

► Chip antenna

![Graph showing battery life vs reporting interval](image)

1 CR2032 Li-coin cell
Peel-n’-Stick Security Sensor

► Battery Operation
  • 2 AA Alkaline or 1 Li-AA cell

► Freescale MC1321X System in a Package

► Sensor process
  • RC Oscillator wakes up MCU and doing network check-in at some interval
    ▪ Many security systems have between ~10 second and ~15 minute requirement
  • On a sensor event, device immediately awakens and reports in to network

► Sleep currents (µA) are a small fraction of the self-discharge rate of the batteries
ZigBee Home Automation (HA) Profile

► Scope – Addresses applications needed in residential and light commercial environment. Installation scenarios will range from a single room to an entire home up to 20,000 square feet.

► The HA profile device descriptions:
  - General
    - On/Off Switch, Level Control Switch
  - Lighting
    - Basic Dimmable, Basic Dimmable Colored, On/Off Switch, Light Dimmer, Color Dimmer, Occupancy
  - HVAC
    - Basic/Heating/Cooling, Basic Thermostat, Temperature Sensor
  - Closures
    - Blind, Blind Controller
  - Water Pumping
    - Pump, Pump Controller, Pressure and Flow Sensor
  - Intruder Alarm Systems
    - Control and Indicating Equipment, Ancillary Control Equipment, Zone, Warning Device
Summary

► Many Wireless Technologies Available for Different Application Spaces
  • Ubiquitous sensing means simple, cost-effective wireless sensors
    ▪ ZigBee wireless technology meets the cost and simplicity targets for the vast majority of sensing applications
  • Sensors from very simple to complex and data-rich can take advantage of ZigBee wireless technology

► IEEE 802.15.4 and ZigBee Platforms
  • Allows Designer to concentrate on end application
    ▪ Silicon vendors and ZigBee Alliance take care of transceiver, RF channel and protocol, ZigBee “look and feel”, interoperability, application certification
  • Reliable and robust communications
    ▪ PHY and MAC outperform all known non-standards-based products currently available
  • Flexible network architectures
  • Very long primary battery life (months to years to decades)
  • Low system complexity for the OEM

► More Information
  • Freescale: www.freescale.com/zigbee, Electronica Hall A6 Booth 107
  • ZigBee Alliance: www.zigbee.org, Electronica Hall A4 Booth 361