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Accelerate your ZigBee design using the new TI ZigBee Processor

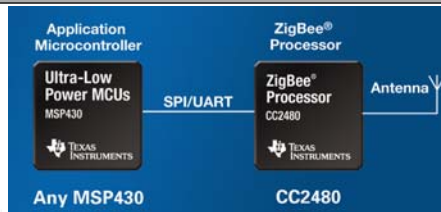
5/21/2008

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Abstract

- ◆ To simplify the addition of ZigBee to an application, TI has created a new concept called **Z-Accel**.
- ◆ Z-Accel, as the name implies, is intended to accelerate the development of a ZigBee solution.
- ◆ Z-Accel consists of two parts: a ZigBee processor, **CC2480**, and an application MCU, any MSP430.
- ◆ This presentation will explain the concepts behind Z-Accel, describe the features of the CC2480 and ends with a demo experience using eZ430-RF2480.



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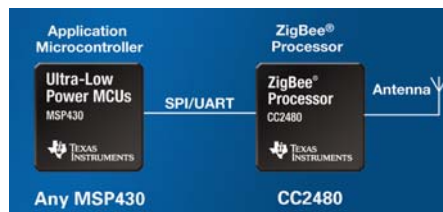
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What is Z-Accel and CC2480?

- ◆ Z-Accel is a ZigBee Network Processor that communicates with any MCU via an SPI or UART interface
- ◆ CC2480 is the first-generation ZigBee-compliant network processor in the Z-Accel family
- ◆ Z-Accel allows customers to work with their favorite MSP430
- ◆ Z-Accel provides complete ZigBee functionality without having to learn the complexities of a full ZigBee stack



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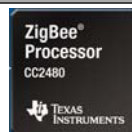
Advantages ...
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CC2480 Advantages

- **Wireless Network Processor, "Smart Transceiver"**
 - Z-Accel: ZigBee Network Processor
- **Accelerate your ZigBee Connectivity**
 - Easy Add-On to existing solution
 - ZigBee Connectivity made easy to design and develop
- **Reduce development time and time to market**
- **Enable ZigBee "out-of-the-box" and "black box" network capabilities**
- **Enable interoperable devices where desired by manufacturers using private profiles**



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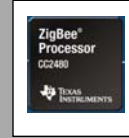
Features ...
4

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Z-Accel – Key Features

- **Reduce Development Complexity**
 - Preprogrammed / preconfigured ZigBee Node
- **Easy to Deploy**
 - Accelerate ZigBee Connectivity for existing solution
 - Easily added as serial peripheral
 - Simple API applied for network commissioning
- **Easy to Use**
 - Split Application and Network processor
 - Application Processor running Application Framework & Profile
 - Physical Layer
 - Serial Transport / Full Duplex
 - Remote Procedure Call (RPC) Layer
 - Layered Interface Messages: System, Configuration and Data
- **Standardized protocol**
 - Network Infrastructure reuse by multiple applications
 - Manufacturer Specific Profiles to enable interoperability whenever possible



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ZigBee® GLOSSARY

- A **Application Profile** is an agreement on a series of messages defining an application space
 - **Public Application Profile**
 - Interoperable application profile developed by the ZigBee Alliance
 - **Manufacturer Specific Profile**
 - Private application profile developed by a company to operate a ZigBee Device
 - Limits application interoperability to devices that share this profile
- **Profile ID** a unique identifier assigned by the ZigBee Alliance
- A **Cluster** is a message identifier for exchange of information within an application profile
- **Endpoint** a communication entity within a device which permits support for a specific application through the exchange of Clusters
- **Binding/s** is a way of connecting devices between two endpoints
 - Each binding supporting a specific application profile
 - Each message type is represented by a cluster within the profile
- **Commissioning** the task of configuring devices and networks to achieve the needs of a specific installation
- **Application Object** is software at an endpoint that controls the ZigBee Device
 - A single ZigBee Device node supports up to 240 application objects
 - Each application objects supports endpoints numbered between 1 and 240
 - Endpoint 0 reserved for the ZigBee Device Object (ZDO)

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ZigBee® GLOSSARY

- **ZigBee Device Object (ZDO)** defines the logical role of a device within the network
 - Device type: Coordinator, Router, End device
 - Initiates and/or responds to binding and discovery
 - CC2480 is running the ZDO endpoint
- **PAN ID** – a unique Personal Area Network Identifier; Controlled by User and Application development
- **Device Description** is a description of a specific device within a profile
- **Device Discovery** can find the identity of devices on active channels within the PAN
- In a **Mesh network** the routing of messages is performed as a decentralized, cooperative process involving many peer devices routing on each others' behalf
- **Service Discovery** is the ability to determine supported services on given devices within the PAN (e.q. USB Enumeration)

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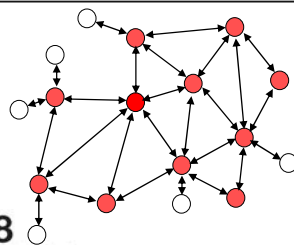
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ZigBee-2006

- **Benefits to Consider**
 - Extremely well tested by a variety of companies
 - Base of products and networks on market and in use today!
 - Many certified stacks and silicon providers available
 - Simple = less code & less overhead



- ZigBee Coordinator
- ZigBee Router
- ZigBee End Device

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ZigBee-2007 Feature Set

ZigBee

- Tree Addressing
- AODV Routing
- Backup Tree Routing

- Fragmentation
- Frequency Agility
- Basic Group Addressing
- Security

ZigBee PRO

- Stochastic Addressing
- AODV Routing
- Many to One / Source Routing
- Asymmetric Link Handling
- Fragmentation
- Frequency Agility
- Basic Group Addressing
- Limited Broadcast Addressing
- Security
- High Security

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CC2480 APPLICATION DESIGN PROCESS

- Customer has a new application with no defined ZigBee Profile
 - Define devices in the system
 - Map to Logical Devices
 - Define the Profile by partitioning the devices
 - Define the Device Descriptions within each Profile
 - Define the Clusters and indicate which are input and output from each Device Description
 - Define the Security solution
 - Define the Commissioning Process
 - Package the solution:
 - Define the descriptors, deploy the applications over endpoints
 - Integrate and test the solution.
 - Solve Deployment issues.

http://www.daintree.net/downloads/whitepapers/ZigBee_Primer.pdf

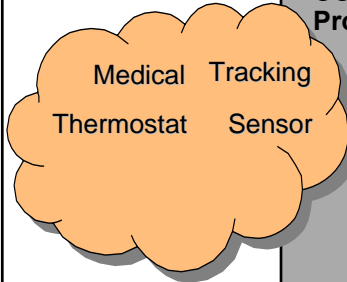
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Profiles

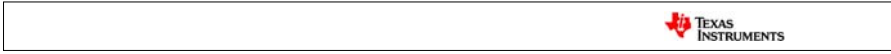


- CC2480 only supports Manufacturer Specific Profiles (Private Profile)
 - Privately developed by individual manufacturers
 - CC2480 only supports Stack Profile ZigBee 2006
 - A set of devices required in the application area
 - A set of clusters to implement the functionality
 - » A set of attributes to represent device state
 - » A set of commands to enable the communication
- A profile ID must be unique and use a ZigBee allocated profile identifier
- Commercial products developed using this profile must undergo network capable testing

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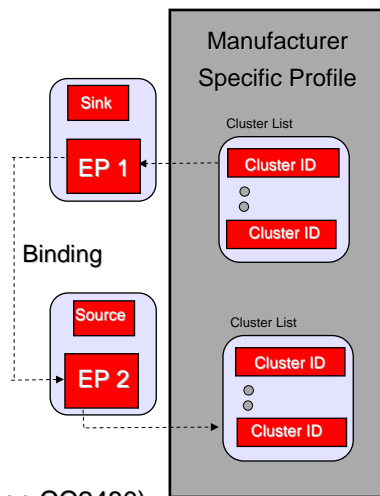
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Endpoints

- An Endpoint (EP) is the address of your application running on Host Client
 - EP 0 is ZDO application running on CC2480 Up to 240 additional applications can be supported on a device
 - Each application on an endpoint is identified by its own Endpoint Structure containing the Cluster list



- ◆ This device contain one EP (ZDO EP is on CC2480)
- ◆ Each EP contains an application

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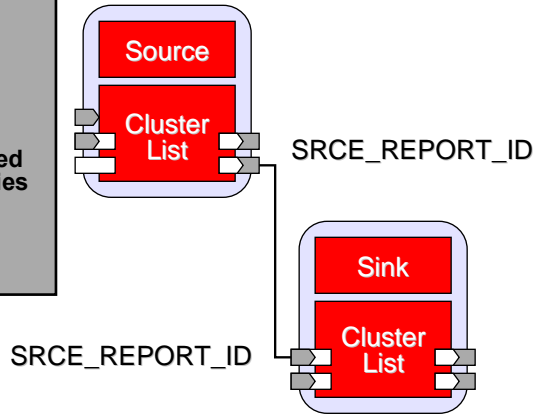
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Clusters

- Commands sent or received over the network are called Clusters (data types)
- Cluster may be inputs or outputs from a device
- No ZigBee Cluster Library (ZCL) support with CC2480
- Cluster List must be registered through communication entities called EndPoint



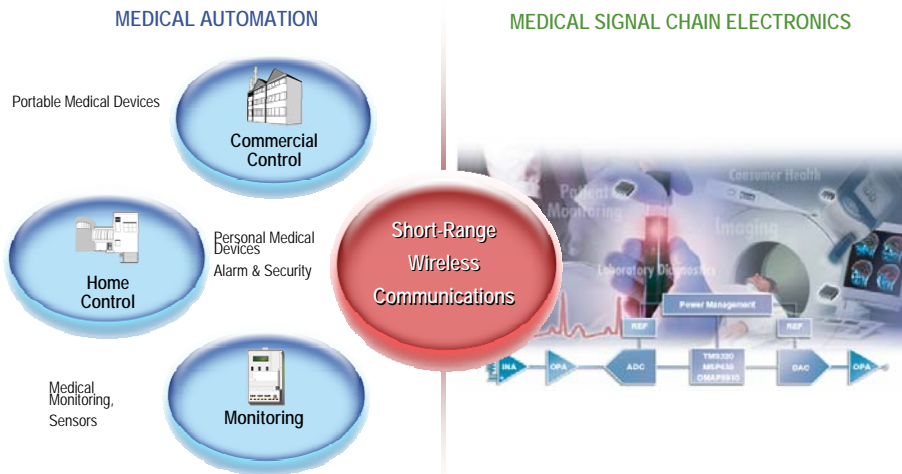
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CC2480 Target Application Example



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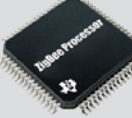


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Hardware Flexibility

Z-Accel: (ZigBee Processor)
eZ430 –RF2480 =
MSP430 + CC2480

	Path 1 Small footprint High integration Location Engine optional	Path 2 Flexible Easy to use Reduces time to market	Path 3 Ultra low power Well-known radio
Complete ZigBee Solution	Customer Application CC2430/1	Any MSP430  CC2480 	MSP430 
	Z-Stack™ ZigBee stack		
	Radio		CC2420/CC2520 
Development Kits	CC2430/1ZDK	eZ430-RF2480	CC2420/CC2520 + MSP430ZDK

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ZigBee System Architectures

MSP430: Application Code
w/Profile using the Simple
API of the CC2480

Solution Layer	1: ZigBee 2006	2: ZigBee 2007	3: ZigBee 2007	4: ZigBee 2006
Application Profile	PP / MSP	PP / MSP	PP / MSP	MSP
Stack Profile	ZigBee 2006	ZigBee 2007 Non PRO	ZigBee 2007 PRO	ZigBee 2006
MAC Layer	IEEE 802.15.4	IEEE 802.15.4	IEEE 802.15.4	IEEE 802.15.4
Physical Layer*	CC2430/CC2420	CC2520	CC2520	CC2480

PP – Public Profile

MSP – Manufacture Specific Profile

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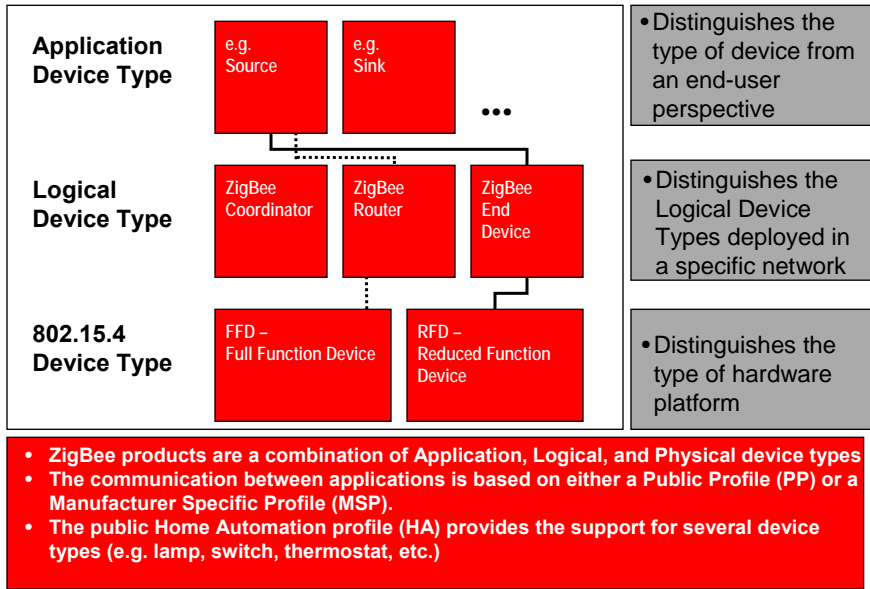
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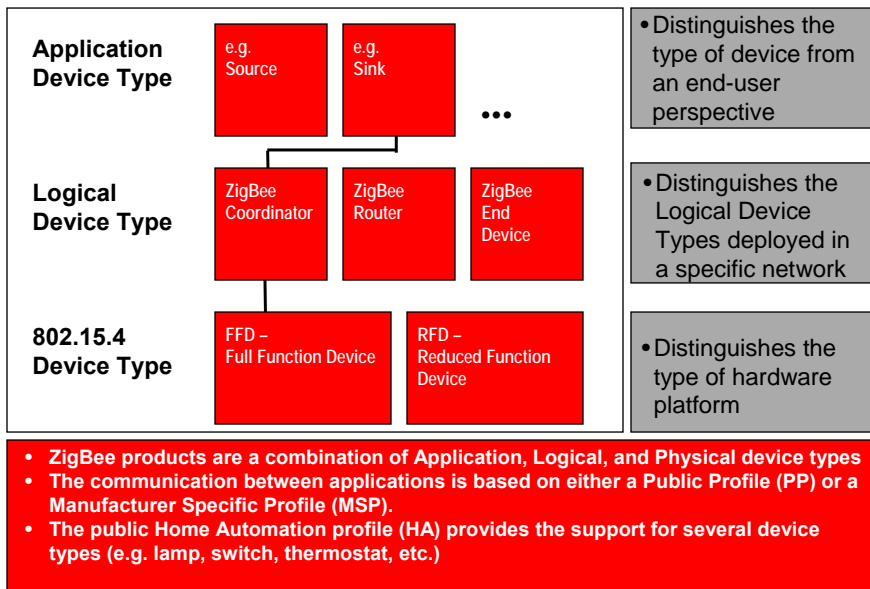
CC2480:
Stack & Physical Layer



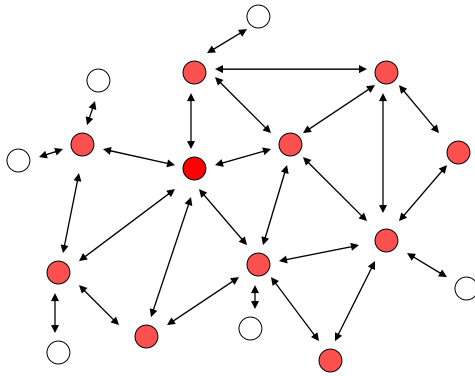
Application Device Type Model



Application Device Type Model



CC2480 – Mesh Network Devices



- ◆ Devices are configured for their network function
- ◆ Coordinator can be removed

- **ZigBee Coordinator**
Starts the Network
Routes packets
Manages security
Associates Routers and End Devices
Example: Sink
- **ZigBee Router**
Routes packets
Associates Routers and End Devices
Example: Source
- **ZigBee End Device**
Sleeps most of the time
Can be battery powered
Does not route
Example: Source

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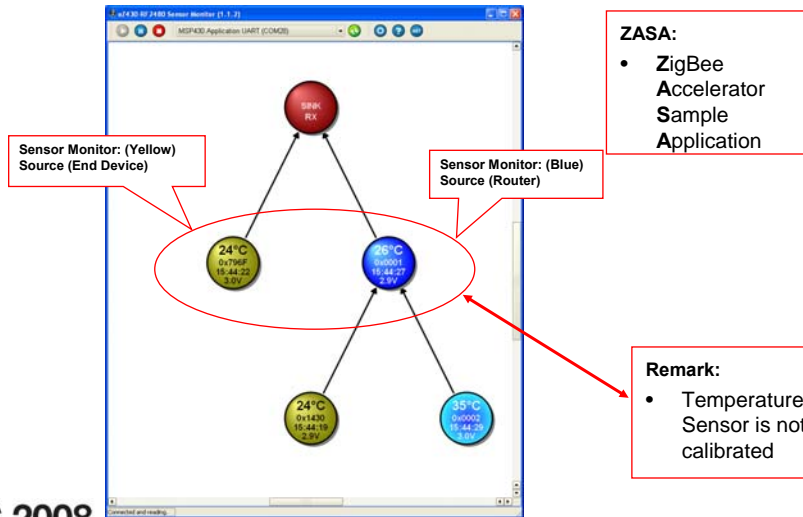
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ez430- RF2480 Sensor Monitor

PC application running on PC connected to sink via Virtual COM Port (VCP)



ZASA:

- ZigBee Accelerator Sample Application

Remark:

- Temperature Sensor is not calibrated

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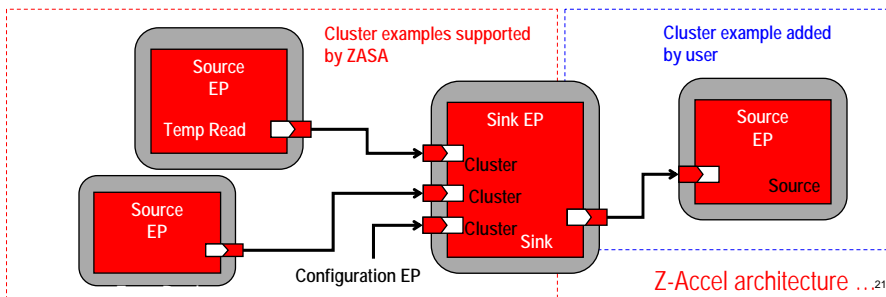
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Z-Accel - Application Model

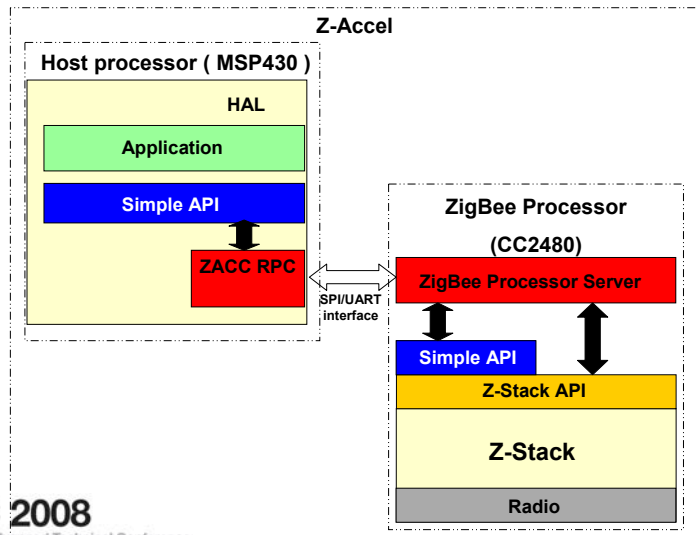
- Configure Application Device as ZigBee Logical Device
 - ◆ Register your Application Devices and End Points
- Join Network as a configured ZigBee Logical Device mapped as a an Application Devices Types:
 - ◆ Source (Router or End Device)
 - ◆ Creator for periodic sensor reports (Temperature, Battery). Transmit data to one or more Sink Devices to which it is bound
 - ◆ Sink (Coordinator)
 - ◆ Destination for Data. Receive data from one or more Source Devices



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Z-Accel Architecture



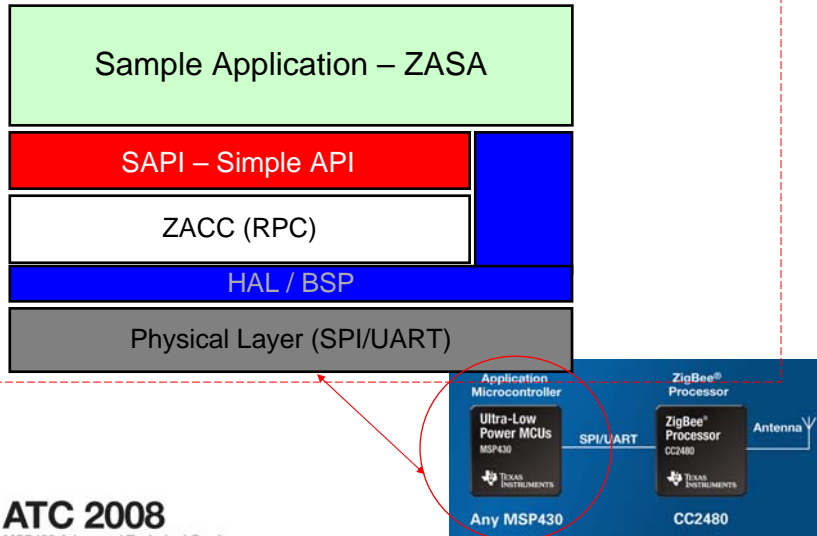
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Application Device Architecture

Application processor – MSP430



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SAPI...
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Simple API - SAPI

*Z-Accel support TI's Simple API. Simple API has only 10 API calls to learn, drastically **simplifying** the ZigBee application development.*

- Simple API simplifies:
 - Device Configuration
 - Commissioning of Networks
 - Binding of Devices
 - Data Transfer

API - Application Programming Interface (Software Interface)

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SAPI Overview Functions and Callbacks

API	Callbacks
<ul style="list-style-type: none"> • zb_SystemReset <ul style="list-style-type: none"> - Resets network • zb_StartRequest <ul style="list-style-type: none"> - Starts network • zb_PermitJoiningRequest <ul style="list-style-type: none"> - Allow nodes to join network • zb_BindDevice <ul style="list-style-type: none"> - Establish a binding (connection) • zb_AllowBind <ul style="list-style-type: none"> - Allow binding request • zb_SendDataRequest <ul style="list-style-type: none"> - Send data • zb_ReadConfiguration <ul style="list-style-type: none"> - Read configuration parameters • zb_WriteConfiguration <ul style="list-style-type: none"> - Write configuration parameters • zb_GetDeviceInfo <ul style="list-style-type: none"> - Get current address, PAN ID etc • zb_FindDeviceRequest <ul style="list-style-type: none"> - Search for a device on the network 	<ul style="list-style-type: none"> • zb_StartConfirm <ul style="list-style-type: none"> - Network start up callback • zb_AllowBindConfirm <ul style="list-style-type: none"> - Accepted bind request callback • zb_SendDataConfirm <ul style="list-style-type: none"> - Send data status callback • zb_ReceiveDataIndication <ul style="list-style-type: none"> - Incoming data callback • zb_FindDeviceConfirm <ul style="list-style-type: none"> - Search results callback • zb_HandleKeys <ul style="list-style-type: none"> - EVM key push callback • zb_HandleOsaiEvent <ul style="list-style-type: none"> - Operating system callback <p>For more details about the SimpleAPI see ZACC documentation</p>

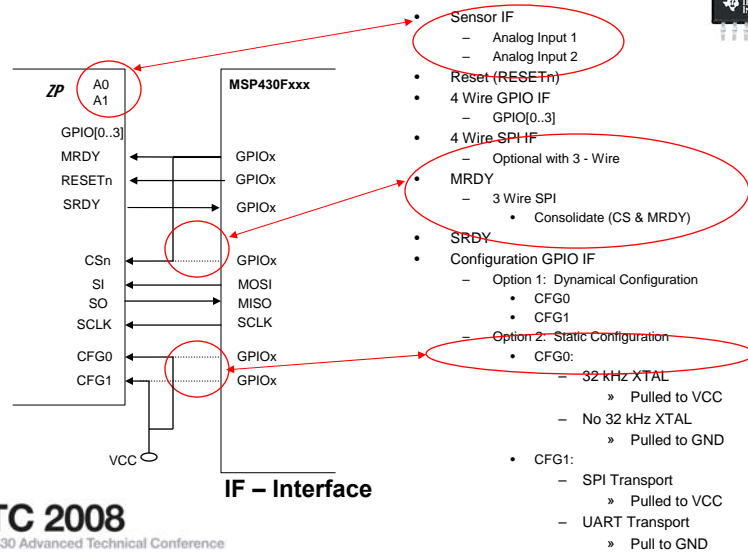
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CC2480 Digital IF SPI Transport to MSP430F2274



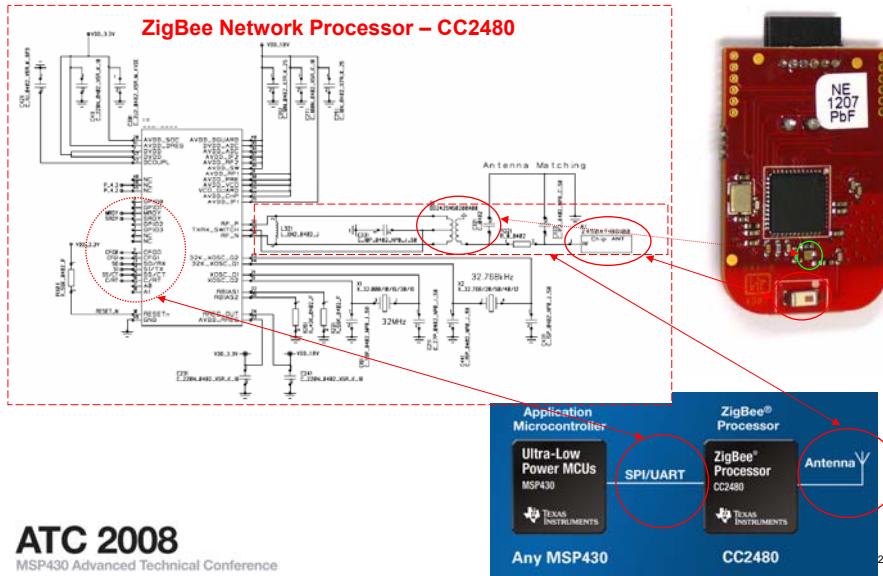
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Application Circuit



Radio Channel Configuration

```

56
57 // Max Rx count to trigger event - set to HOST_BUF_LEN to disable.
58 #ifndef HOST_RX_FULL*(ZACC_BUF_LEN-1)
59
60 /* Warning: The timeout for attempting to join must be greatly lengthened as char
61 * this list. See the note for APP_JOIN_TIME in sample_app.c
62 */
63 // Define the default PAN ID (it can be an OR of any combination of the below val
64 // -DZACC_NV_CHANLIST=0x04000000 // 26 - 0x1A
65 // -DZACC_NV_CHANLIST=0x02000000 // 25 - 0x19
66 // -DZACC_NV_CHANLIST=0x01000000 // 24 - 0x18
67 // -DZACC_NV_CHANLIST=0x00800000 // 23 - 0x17
68 // -DZACC_NV_CHANLIST=0x00400000 // 22 - 0x16
69 // -DZACC_NV_CHANLIST=0x00200000 // 21 - 0x15
70 // -DZACC_NV_CHANLIST=0x00100000 // 20 - 0x14
71 // -DZACC_NV_CHANLIST=0x00080000 // 19 - 0x13
72 // -DZACC_NV_CHANLIST=0x00040000 // 18 - 0x12
73 // -DZACC_NV_CHANLIST=0x00020000 // 17 - 0x11
74 // -DZACC_NV_CHANLIST=0x00010000 // 16 - 0x10
75 // -DZACC_NV_CHANLIST=0x00008000 // 15 - 0x0F
76 // -DZACC_NV_CHANLIST=0x00004000 // 14 - 0x0E
77 // -DZACC_NV_CHANLIST=0x00002000 // 13 - 0x0D
78 // -DZACC_NV_CHANLIST=0x00001000 // 12 - 0x0C
79 // -DZACC_NV_CHANLIST=0x00000800 // 11 - 0x0B
80
81 /* Define the default PAN ID. Any value other than 0xFFFF forces a Coordinator t
82 * as its PAN ID and Routers and End Devices to only join a PAN with this ID.
83 */
84 #define ZACC_NV_PANID=0xFFFF
85
            
```

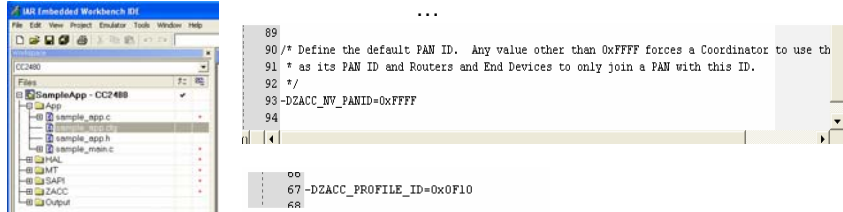
In the sample_app.cfg file, you'll need to select the channel your PAN will operate on

Remark:
Selected Channel

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PAN ID Configuration

While we're at it, let's also select the PAN ID and Profile ID in the same file



- If PAN_ID = 0xFFFF and device = Coordinator:**
Device uses IEEE address to choose a PAN_ID (last 2 bytes)
- If PAN_ID = 0xFFFF and device = Router or End Device:**
Device will join any available PAN
- If the PAN_ID ≠ 0xFFFF and device = Coordinator:**
Device will use the set value for the PAN_ID
- If the PAN_ID ≠ 0xFFFF and device = Router or End Device:**
Device will ONLY join a PAN that has this PAN_ID

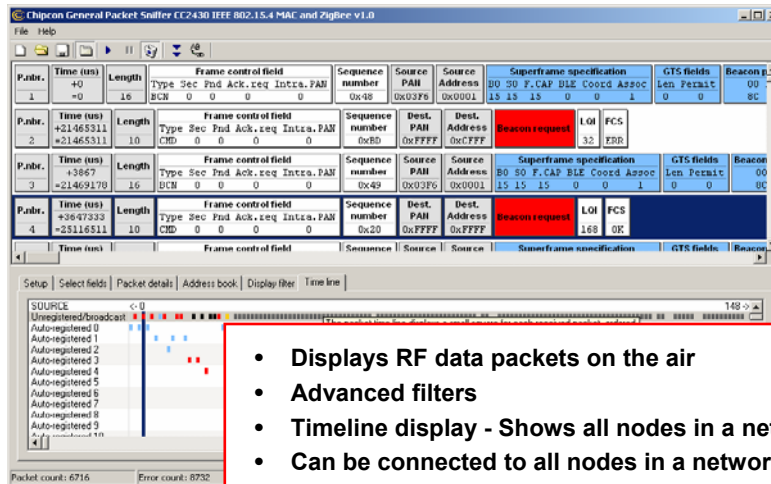
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Packet Sniffer



- Displays RF data packets on the air
- Advanced filters
- Timeline display - Shows all nodes in a network
- Can be connected to all nodes in a network
- Supports IEEE 802.15.4/Zigbee packets

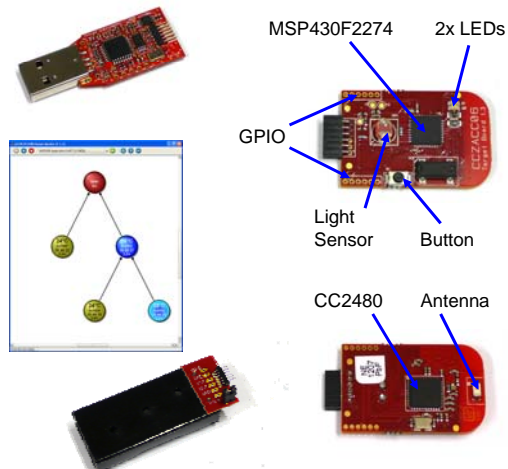
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ZigBee Demonstration Kit



eZ430-RF2480

Based on the CC2480 – A ZigBee Network Processor

3x Target Boards
2x Battery Boards
1x USB debug dongle

Comes with a simple application that demonstrates

- Command interface
- Chip configuration
- Simple API
- Basic network operations

A PC application shows the network topology

Price \$99

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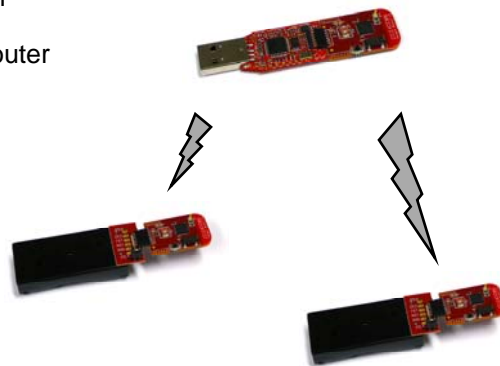
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Demo – Starting a PAN, eZ430 – RF2480

- Start PC Demo Application
- Start Sink, then Source Router then Source End Device
 - Observe PAN traffic



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Appendix

Detailed Information

- Profiles/Clusters/Endpoints
- RPC –Remote Procedure Call
- UART Transport Interface

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Descriptor

- Simple (Device)

- Assign a Device ID & Version
- Specify Profile ID
- Specify Endpoint ID
- Initialized in AppReset()
- Must be registered with CC2480

- Endpoint Descriptor provide information about the application like:
 - Number of defined Clusters
 - Number of defined Endpoints
- `zb_AppRegisterRequest(srceEP)`
 - Allows CC2480 to know the cluster information for each endpoint
 - Simplifies handling of messages to the node by differentiating by endpoint

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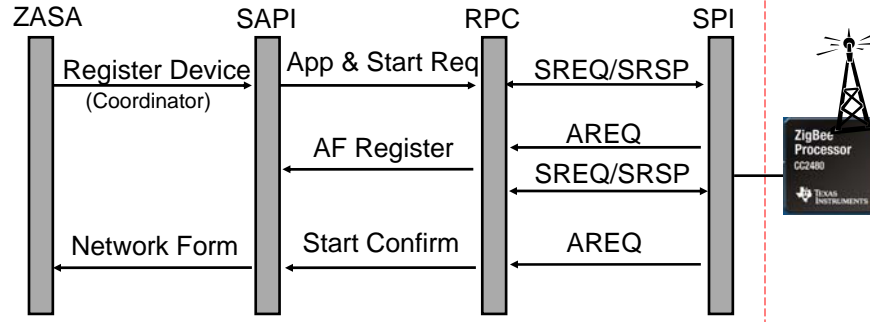
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PAN Formation (Sink: Coordinator)

Application processor – MSP430



- ◆ A unique PAN ID is determined either from the IEEE address dynamically or statically
- ◆ One channel is selected
- ◆ Process fully automated once started

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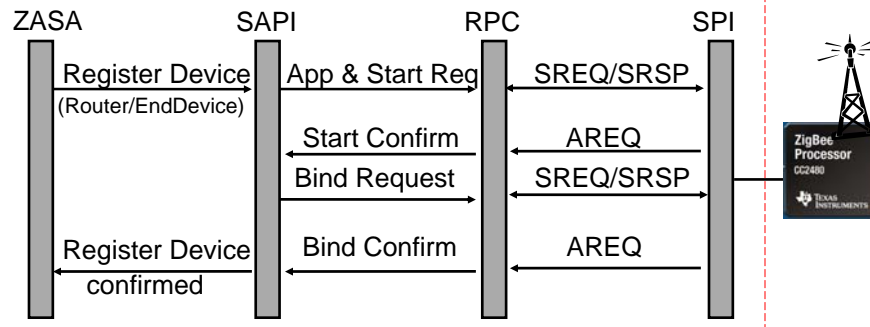
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Pan Discovery/Join/Bind (Source: Router or End Device)

Application processor – MSP430



- ◆ A unique PAN ID is determined either from the IEEE address dynamically or statically
- ◆ One channel is selected
- ◆ Process fully automated once started

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Z-Accel Transport Overview: Remote Procedure Calls (RPC)

CC2480's 10 Simple API calls are abstracted to 4 Physical Transport Layer Command Types

- **Z-Accel RPC Command Types**
 - AREQ – Asynchronous Request
 - Callback Events
 - Function call with return value
 - POLL – Polling for Data
 - Retrieve Queued Data
 - SREQ – Synchronous Request
 - Immediate Response
 - SRSP – Synchronous Response
 - Response to a SREQ command

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General frame format ...

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General Frame Format (GFF) - SPI

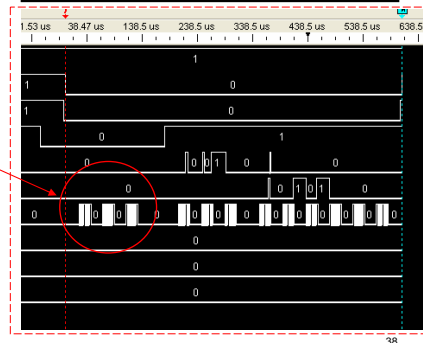
Frame Format Transport Packet

Length	CMD0	CMD1	Data Field
1	1	1	0-252

Length	CMD0 [7:5]	CDM0 [4:0]	CMD1
1	0-7	0-31	0-127

- **CMD0:**
 - Command Type & Sub Type:
- **CMD1:**
 - Command ID
- **Note:**
 - Length byte is the length of the data field excluding itself and commands

- **CMD 0 – Command Type**
 - [7:5] – Type
 - (AREQ, POLL, SREQ, or SRSP)
 - [4:0] - SubType
 - (SAPI, SYS, AF, ZDO, Reserved)
- **CMD 1 – Command ID**
 - CC2480 Application Interface Commands



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General Frame Format (GFF) - UART

Frame Format Transport Packet

SOF	GFF	FCS
1	3-253	1

SOF	Length	CMD0	CMD1	Data Field	FCS
1	1	1	1	0-250	1

- **CMD0:**
 - Type & Sub Type:
- **CMD1:**
 - Command ID
- **Note:**
 - Length byte is the length of the data field excluding itself and commands

Remark:
UART Transport not supported on eZ430 – RF2480

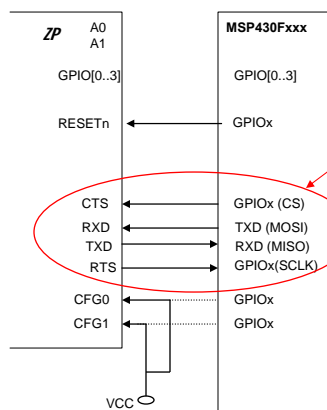
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CC2480 Digital IF UART Transport to MSP430F2274



- **UART Transport**
 - Not supported on eZ430 – RF2480
 - Reference Design: How To
- **VCP – Virtual COM Port**
 - Used with PC Demo tool



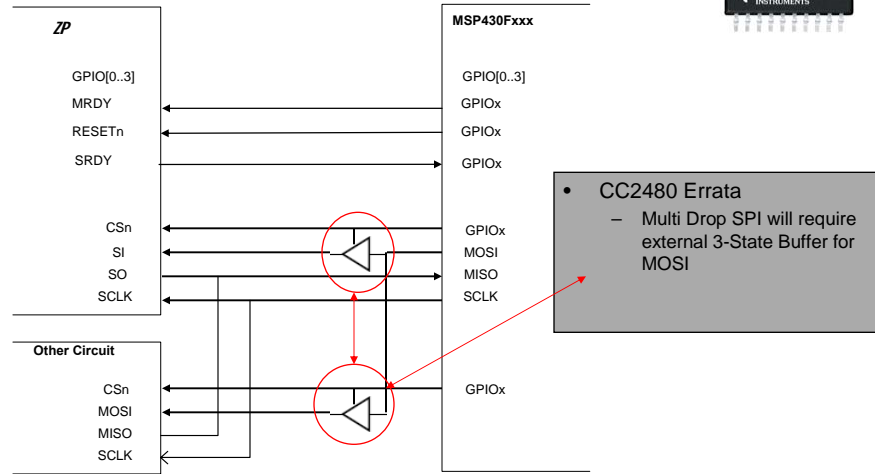
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CC2480 Digital IF for Multi Drop SPI



- CC2480 Errata
 - Multi Drop SPI will require external 3-State Buffer for MOSI

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Thank you



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