WiLink™ 8 Solutions
Coexistence Solution Highlights

Oct 2013
**Use cases:**
BT voice, WLAN data

**Features:**
- TDM based operation
- Strict protection of BT traffic
- Use 4-wire signaling protocol
- Shared antenna support

**Use cases extension:**
WLAN VoIP, BT A2DP

**Features:**
- BT traffic prediction
- WLAN traffic shaping
- Shared & dual antenna support

**Use cases extension:**
BT/BLE or ANT+/WLAN SoftAP use cases

**Features:**
- Leverage combo architecture: multi-core communication
- Link establishment and robustness
- Multi-node awareness
- BT eSCO, EDR
- WLAN throughput improvement

**WL125x WLAN/ BRF6xxx BT/FM module**

**WL127x/WL128x combo device**

**WL18xx combo device**

**2x WLAN throughput improvement from WL127x/8x**

**5x WLAN throughput improvement from WL125x**
Multi-radio Coexistence challenges

- **Outside the device** - Wireless spectrum is crowded
  - 2.4GHz: Cordless telephony, BT, Zigbee, WiFi, ANT
  - Adjacent licensed bands: 1.5GHz GPS; 1.8 GHz GSM, 2.1 GHz 3/4G, 2.5 GHz WiMAX, 3.5GHz WiMax, LTE
  - Different wireless standards lack cooperation – everyone operates on its own
  - Interference can be solved by RF isolation

- **Inside the device**
  - Limited physical space in handheld to accommodate multiple radio technologies: Modem, GPS, WiFi, BT – RF and antenna placement challenges
  - Combined use cases require simultaneous radio operation
  - Transmit power 15-24dBm and sensitivity requirements -150 to -80 dBm
  - **Interference is solved by RF isolation between adjacent bands and coordination in the same band**
TI Coexistence Highlights

- All use cases are supported
  - Established use cases: WEB Browsing, File Transfer, Audio/Video Streaming and voice call over WLAN combined with the use of mono and stereo Bluetooth Headsets and Human Interactive Devices (HID)
  - Emerging use cases: Soft Access Point/Wireless Gateway and WiFi Direct and Bluetooth Low Energy Sensors and Controls
  - Future use cases: WLAN and Bluetooth operation in 4G LTE handset. LTE sets new level of system coexistence challenge due to adjacent frequency band 2.3/2.5GHz radio operation

- Self-contained solution: runtime coordination between Bluetooth and WLAN is done on chip level

- Reliable Solution: create and maintain WLAN and BT link in any environment

- Flexible architecture allows to adapt to changing environment
  - Example: adding coexistence with BLE is FW update

- Optimal Performance: power consumption and throughput
WiLink™ 8 Solution Overview

- WiLink 8 Solution consists of TI Module, WLAN Driver & Bluetooth Stack
- WiLink 8 Software is available only for specific versions of Linux Kernel and Android Jelly Bean Operating System
- TI provides a pre-integrated and validated Sitara Reference Platform to help customers get started
Wi-Fi + Bluetooth/BLE Coexistence

Coexistence Features
- Combined WiFi, Bluetooth & BLE antenna/switch design
- Control WiFi transmit power to minimize Bluetooth & BLE interference
- Gather detailed timing information for each core
- Dynamic scheduling of each core to mitigate interference, coordinate transmission and receiving
- Frequency planning and clock selection
- Provide a shared bus with wide channels and messaging protocol
- No external interface logic required

<table>
<thead>
<tr>
<th>With TI Coexistence</th>
<th>Without Coexistence</th>
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<tbody>
<tr>
<td>Stream video via WiFi at 10Mbps(Rx), 9Mbps (Tx)</td>
<td>Wi-Fi unstable or blocked</td>
</tr>
<tr>
<td>Send music to headphones</td>
<td>Bluetooth scan fails frequently</td>
</tr>
<tr>
<td></td>
<td>Bluetooth sniff fails</td>
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</tbody>
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See latest software release for most up to date performance values
Coexistence Architecture
BT/WLAN Coexistence
on-chip MAC-Level Architecture Highlights

- **Use Case Information Sharing**
  - BT and WLAN share information on current use case:
    - SCO / eSCO channel
    - A2DP stream identification in BT
    - Page Scan / Inquiry Scan
    - Page / Inquiry
    - BLE
    - WLAN VoIP
  - Flexibility to add new use cases in the future

- **Dynamic Priority between BT and WLAN**
  - Allows WLAN to override BT frame when needed based on use case information and real time status:
    - BT data packet pending
    - WLAN packet currently received

- **Effect on Protocol Scheduling (feedback based mechanism)**
  - BT scans – joined / separated
  - BLE connection interval scheduling
  - WLAN scan compensation
Coexistence Interfaces - TOP Level

- **Shared Registers** - used to pass real time indications
- **Mailbox/Shared Memory** - used for large “slowly” changing information between IPs
- **Direct signaling** - mechanism for passing HW debug signals and IOs between IPs through dedicated shared registers
- **Interrupts** - Interrupt concentrator per IP for different notifications
Coexistence Scheduler (Soft Gemini)

- SW Based, residing in WLAN IP (RAM based)
- Tracks BT/WLAN activity/frame requests via signals from BT IP and WLAN MAC
- Tracks BT/WLAN network states
- Makes priority decision per activity/frame in case of collision
- Signals BT and WLAN PHY according to decision
- Synchronizes on BT network time base in order to track periodic activities
- Utilizes WLAN MAC features to avoidance collisions
Coexistence Mechanism Principles
WLAN Activity protection: Coexistence During WLAN Scan

• WLAN Scan compensation
  – Default scan parameters are configured from host
  – Device changes scan behavior automatically depending on BT scenario
    • Increase WLAN scan duration
    • Increase # of probe requests sent
    • Provide higher priority to received beacons on the fly after packet header is parsed
Coexistence Mechanism Principles

BT Activity Protection

• CTS-to-self usage
  – AP transmissions (and rest of BSS as well) can be delayed accurately by sending CTS-to-self
  – Thus we can protect BT periodic transmissions by “silencing” the WLAN BSS

• Coexistence Scheduler tracks BT periodic activity
  – RX Guard Time (RxT):
    • Suspends an open RX service period using CTS-to-self
    • Stops transmission of new PS-Polls
  – Tx Guard Time (TxT):
    • Suspends new TX
  – The time offsets are modified dynamically according to estimated RX & TX packet duration
    • RxT: Tracking AP packet sizes and PHY rates
    • TxT: Tracking TX queues and internal rate adaptation algorithm
Coexistence Mechanism Example
WLAN Data and BT Voice SCO

1 – Suspend WLAN PSD modules + RX NAV protection for current SP till end of BT activity
2 – Suspend WLAN TX Engine
3 – Start of BT voice activity
4 – End of RX NAV protection (resume WLAN RX Service Period)
Coexistence Mechanism Example

WLAN Power Save

- BT
- WLAN
- ANT
- Power
- Active
- Standby
- PS-Poll
- CTS
- BT HP
- BT
- CTS
- RX

WLAN RX SP active

RxT
TxT
Coexistence Host Configuration

There are 2 APIs to configure coexistence

1. General SG Parameters
   – Each parameter has an index which is used to access it
   – Parameters include: SG Enable/Disable, Antenna Configuration, Auto Power Save disable/enable and more
   – See Application Notes for details

2. Per Activity Parameters
   – Parameters for each activity in the BT or WLAN tables can be modified
   – Command includes the following:
     • IP (BT/WLAN)
     • Activity ID
     • Priority (Default, Raised)
     • MIN Time
     • MAX Time