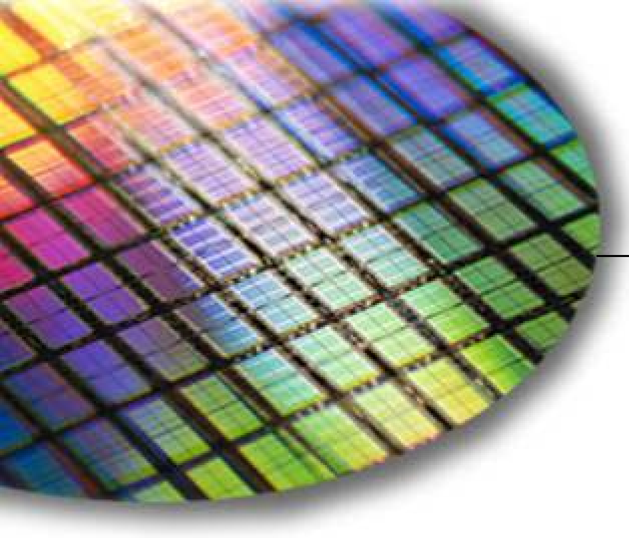


The World Leader in High Performance Signal Processing Solutions

# Blackfin System Services

**Presented By:**
**David Lannigan**

ANALOG
DEVICES

# About this Module

This module discusses the System Services software available for the Blackfin family of processors.

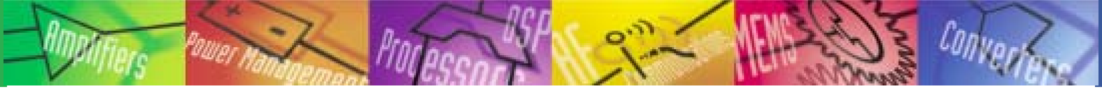
It is recommended that users should have some understanding of the Blackfin architecture, a basic knowledge of software terminology and experience in embedded systems.

# Module Outline

- Overview
  - What are system services?
  - Benefits of using system services
- Highlight functionality of each service
  - Dynamic Power Management
  - External Bus Interface Unit (EBIU)
  - Interrupt Manager
  - Deferred Callback Service
  - DMA Manager
  - Flag Control
  - Timer Control
  - Port Control
- Simple examples using the services

# What are System Services?

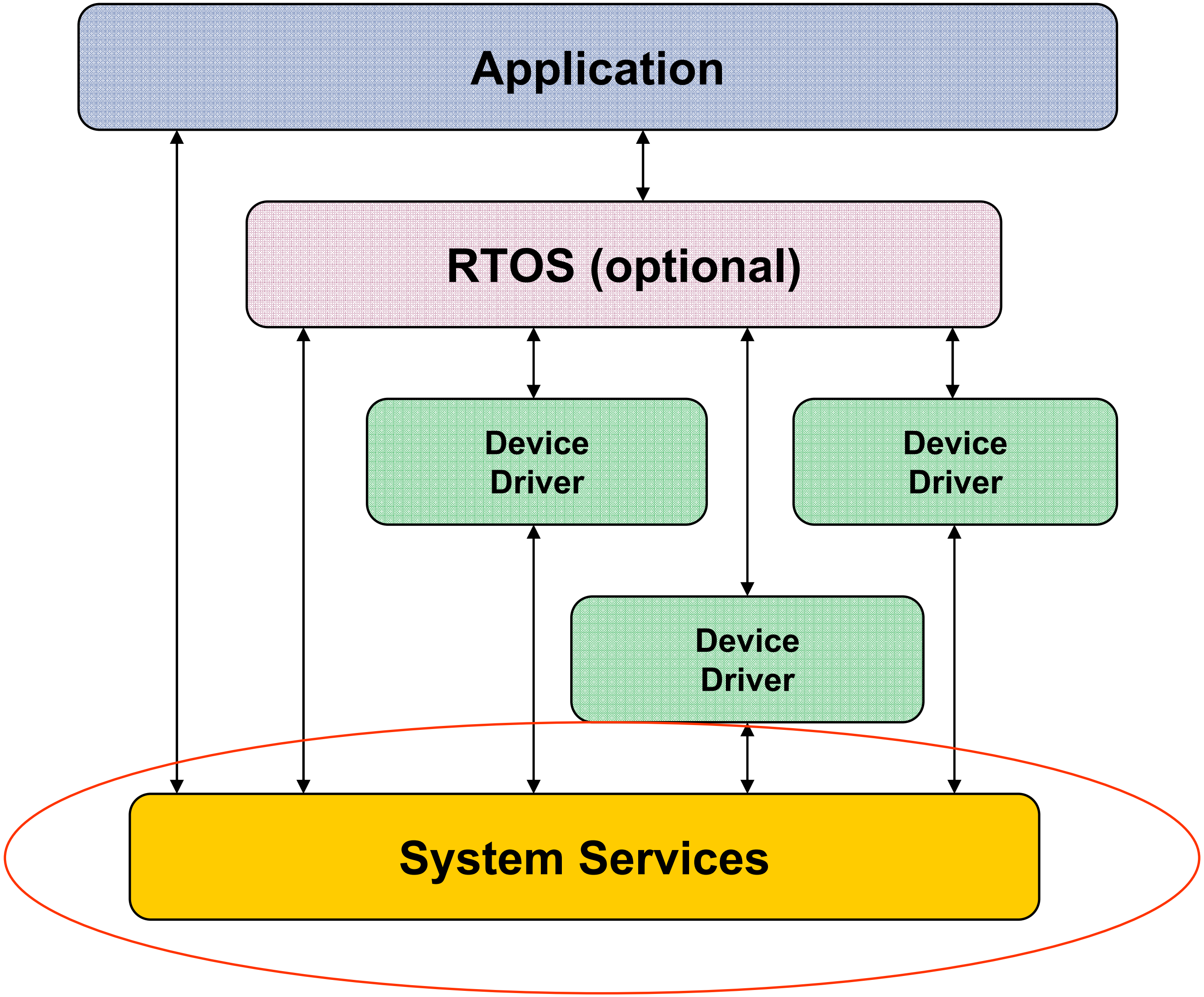
- Software library
  - Provides functionality common to embedded systems
    - Simple, efficient access into
      - PLL, DMA, interrupt controllers, timers, flags etc.
    - Improved interrupt performance
      - Deferred callbacks
  - Callable from ‘C’ or assembly
- Common APIs across Blackfin processors
  - ADSP-BF531, BF532, BF533, BF534, BF536, BF537
  - ADSP-BF561
- Leveraged by applications, device drivers etc.
  - Standalone environment
  - VDK environment



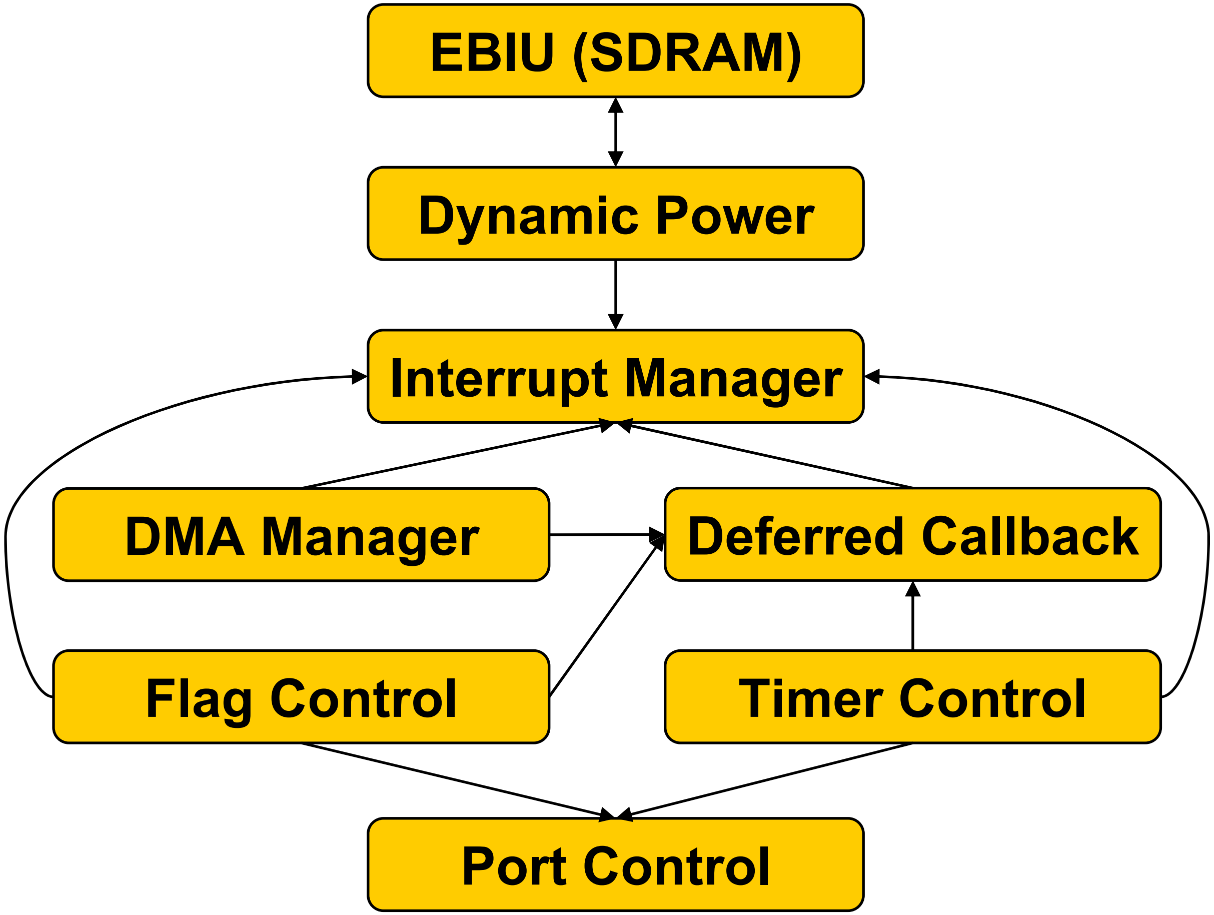
# Benefits To Using System Services

- Faster time to market
  - Tested and proven software
  - Shorter learning curve
  - Less re-invention
- Modular software
  - Better compatibility
  - Simplifies integration efforts
- Portability
  - APIs identical across Blackfin processors
    - Both single-core and multi-core processors
  - Leverage processor roadmap
    - Transition quickly to new processors
- Access to device driver portfolio
  - ADI device drivers built on top of system services
- Full source code provided

# System Architecture

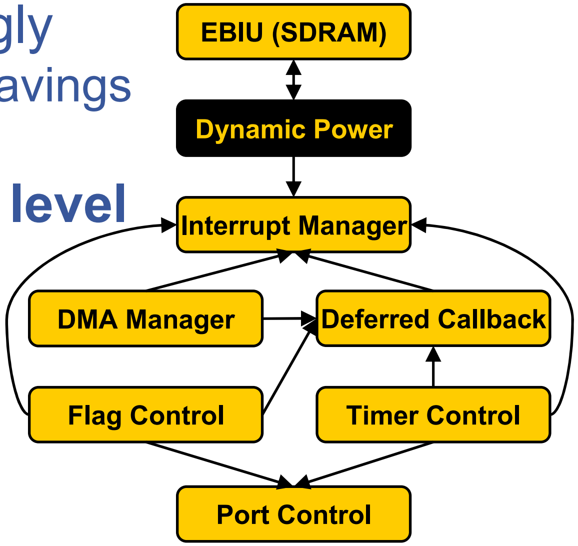


# System Services



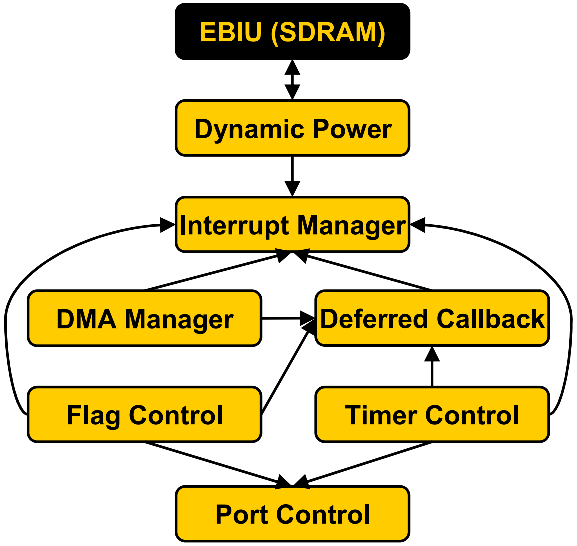
# Dynamic Power Management Service

- **Controls Phase-Locked Loop (PLL) and internal voltage regulator**
- ***Single function call to***
  - **Change operating modes**
    - Full-on, active, sleep, deep sleep and hibernate
  - **Change core and system clock frequencies (CCLK and SCLK)**
    - Clock frequency priority
    - Voltage level automatically adjusted accordingly
      - Lowered whenever possible to maximize power savings
      - Raised when performance requires
  - **Maximize CCLK and SCLK for given voltage level**
    - Voltage level priority
    - Clocks raised to max safe frequency
- **Automatically controls EBIU service**



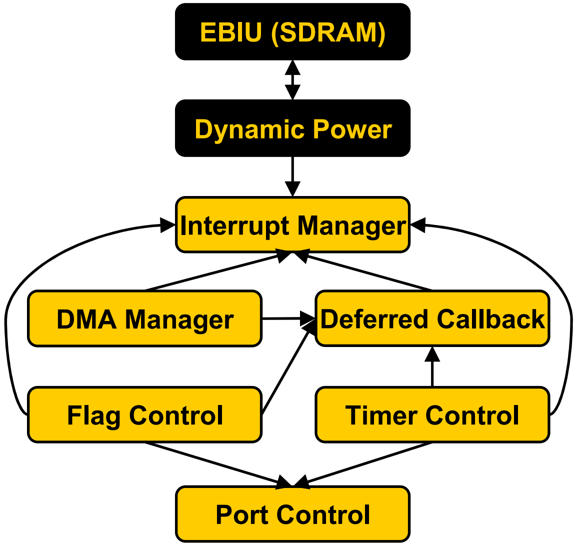
# External Bus Interface Unit (EBIU)

- Initializes SDRAM settings
  - Configures SDRAM controller
- Logic to calculate new values
  - Changing SCLK frequencies
- Works in concert with Power Management Service
  - Automatically adjusts settings for SCLK frequency changes



# Using EBIU and Power Management

- Application should
  - Initialize the EBIU service
  - Initialize the Power Management service
  - Call Power Management functions as needed
    - Such as
      - adi_pwr_SetFreq();
      - adi_pwr_MaxFreqForVolt();
      - adi_pwr_SetPowerMode();



# Dynamic Power Management API

## Initialization/Termination

```
ADI_PWR_RESULT adi_pwr_Init();                 // Initializes the power service
ADI_PWR_RESULT adi_pwr_Terminate();            // Terminates the power service
```

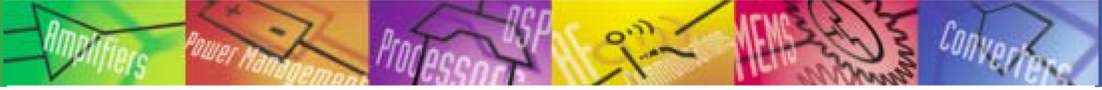
## Frequency and Voltage Control

```
ADI_PWR_RESULT adi_pwr_Control();              // Sets/queries a configuration parameter
ADI_PWR_RESULT adi_pwr_SaveConfig();           // Saves the power configuration
ADI_PWR_RESULT adi_pwr_LoadConfig();           // Loads a power configuration

ADI_PWR_RESULT adi_pwr_SetVoltageRegulator();  // Adjusts the internal voltage regulator
ADI_PWR_RESULT adi_pwr_SetMaxFreqforVolt();    // Set the max clock freqs for voltage level
ADI_PWR_RESULT adi_pwr_SetFreq();              // Sets the core and system clock frequencies
ADI_PWR_RESULT adi_pwr_AdjustFreq();           // Adjusts the core and system clock frequencies
ADI_PWR_RESULT adi_pwr_GetFreq();              // Gets the core and system clock frequencies
```

## Operating Modes

```
ADI_PWR_RESULT adi_pwr_SetPowerMode();         // Place processor in specified operating mode
ADI_PWR_RESULT adi_pwr_GetPowerMode();         // Gets the current operating mode
```



# EBIU Service API

## Initialization/Termination

```
ADI_EBIU_RESULT adi_ebiu_Init();         // Initializes the EBIU service
ADI_EBIU_RESULT adi_ebiu_Terminate();    // Terminates the EBIU service
```

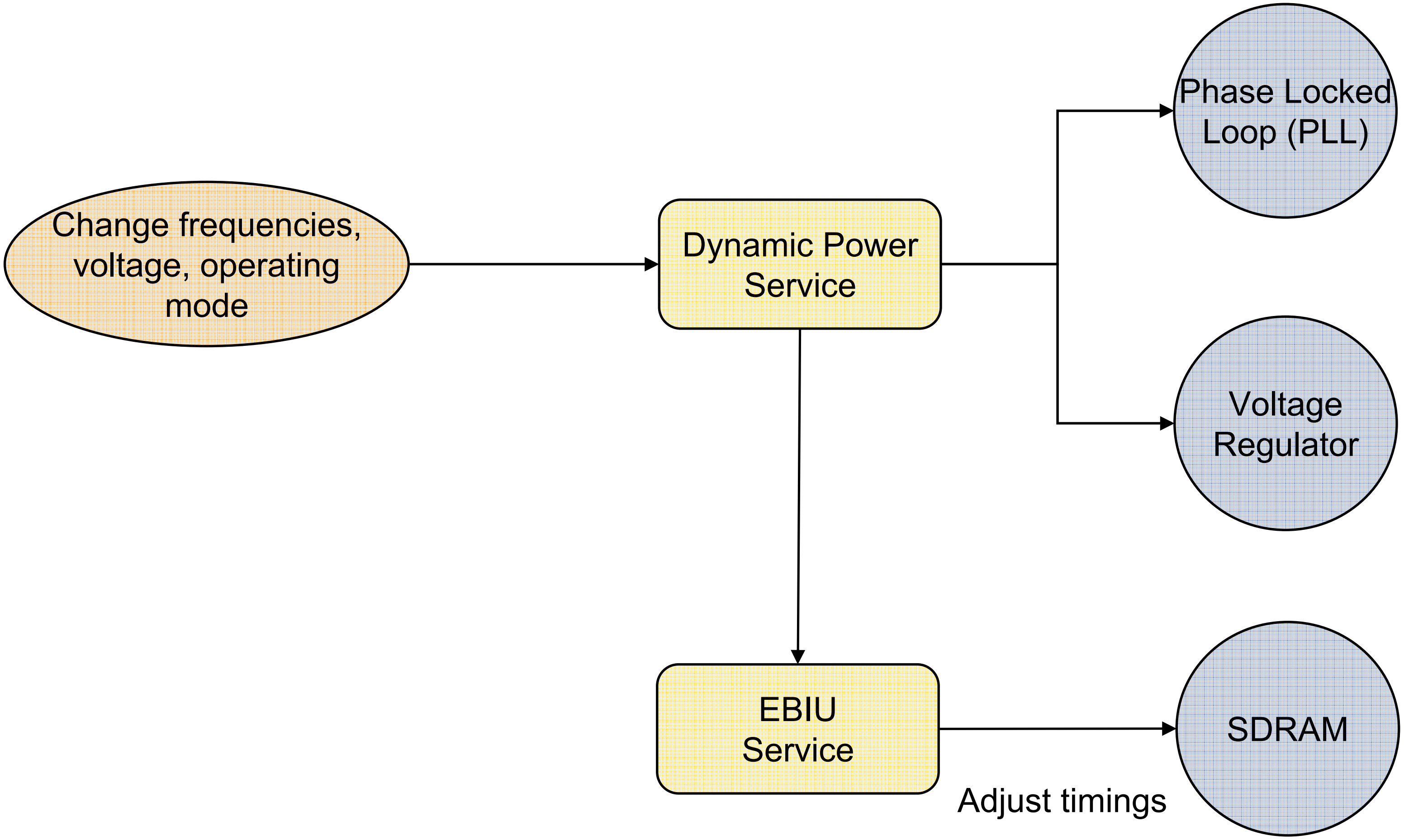
## EBIU Control

```
ADI_EBIU_RESULT adi_ebiu_Reset();        // Resets the EBIU module to power-up settings
ADI_EBIU_RESULT adi_ebiu_Control();      // Sets/queries module settings
ADI_EBIU_RESULT adi_ebiu_AdjustSDRAM();  // Recalculates and apply settings for SCLK changes
```

## EBIU Configuration

```
ADI_EBIU_RESULT adi_ebiu_LoadConfig();   // Loads a set of controller settings
ADI_EBIU_RESULT adi_ebiu_SaveConfig()    // Saves a set of controller settings
```

# Dynamic Power Example


Change frequencies, voltage, operating mode

Dynamic Power Service

Phase Locked Loop (PLL)

Voltage Regulator

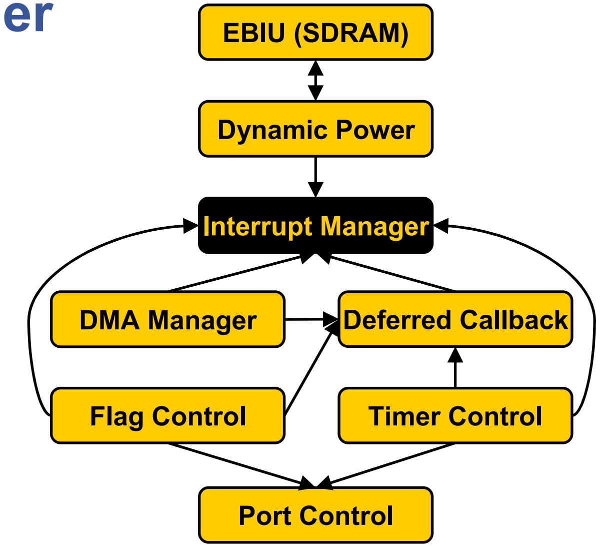
EBIU Service

SDRAM

Adjust timings

# Interrupt Manager Service

- Core Event Controller (CEC)
  - Hook/Unhook interrupt handlers into Interrupt Vector Groups (IVG)
  - Supports handler chaining
- System Interrupt Controller (SIC)
  - Mapping of peripheral interrupts to IVG
  - Enable/disable passing to core event controller
  - Enable/disable wakeup of core event controller
- Utility functions
  - Critical region protection
  - Interrupt Mask Register (IMASK) control



# Interrupt Manager API

## Initialization/Termination

```
ADI_INT_RESULT adi_int_Init();                 // Initializes the interrupt manager
ADI_INT_RESULT adi_int_Terminate();            // Terminates the interrupt manager
```

## Core Event Controller Functions

```
ADI_INT_RESULT adi_int_CECHook();              // Hooks a handler into an IVG chain
ADI_INT_RESULT adi_int_CECUnhook();            // Unhooks a handler from an IVG chain
```

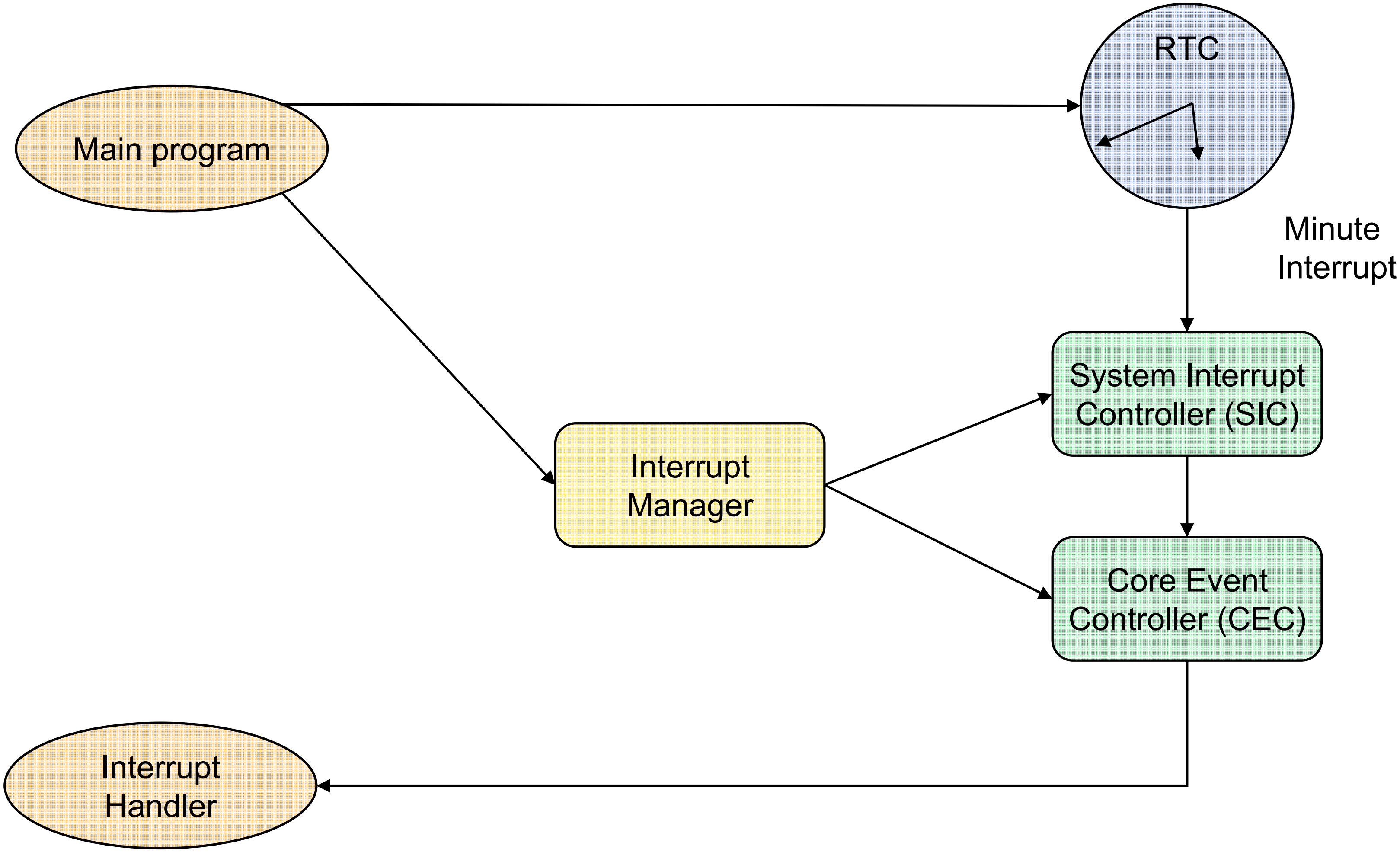
## System Interrupt Controller Functions

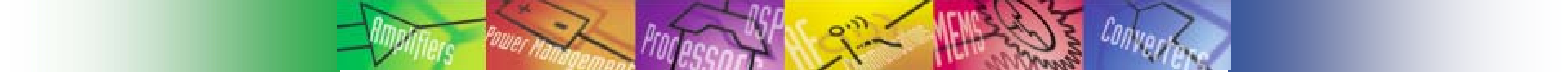
```
ADI_INT_RESULT adi_int_SICEnable();            // Allows interrupt to be passed to the CEC
ADI_INT_RESULT adi_int_SICDisable();           // Disallows interrupt to be passed to the CEC
ADI_INT_RESULT adi_int_SICSetIVG();            // Sets the IVG to which a peripheral is mapped
ADI_INT_RESULT adi_int_SICGetIVG();            // Gets the IVG to which a peripheral is mapped
ADI_INT_RESULT adi_int_SICWakeup();            // Allows the interrupt to wakeup the processor
ADI_INT_RESULT adi_int_SICInterruptAsserted(); // Tests if an interrupt is asserted
```

## Utility Functions

```
void *adi_int_EnterCriticalRegion();           // Enters a critical region of code
void adi_int_ExitCriticalRegion();             // Exits a critical region of code
void adi_int_SetIMaskBits();                   // Sets bits in IMASK register
void adi_int_ClearIMaskBits();                 // Clears bits in IMASK register
```

# Interrupt Manager Example



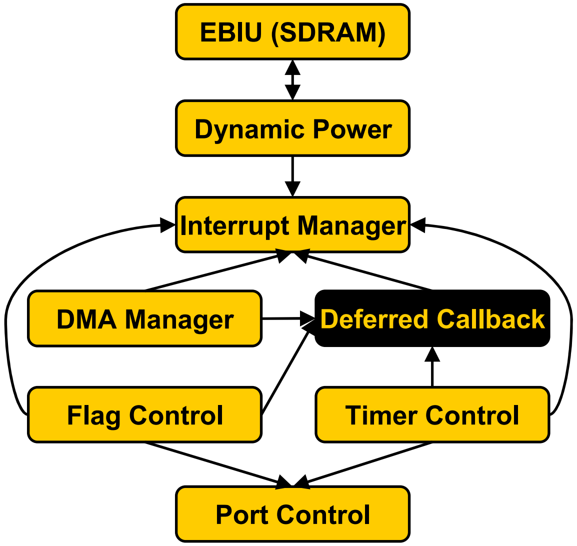


# What’s a Callback?

- **Call made to a function outside the normal flow of program execution**
  - **Response to an asynchronous event (hardware interrupt)**
- **Callback Function**
  - **Regular ‘C’ callable function**
  - **Takes some action based on the event**
- **Types of Callbacks**
  - **Live**
    - Call to the function is made immediately
    - Callback function typically executes at hardware interrupt time
    - Negative impact to performance (higher interrupt latency)
  - **Deferred**
    - Call to the function is deferred to some later point in time
    - Callback function executes at software interrupt time
    - Positive impact to performance (lower interrupt latency)

# Deferred Callback Manager

- Reduce time spent in hardware Interrupt Service Routines (ISR)
  - Service hardware, queue the callback and exit
- Map callback services to different IVG levels
  - User specifies level(s)
    - Typically lower than hardware levels
- Prioritization within each level
  - Urgent callbacks processed first
- Operating environments
  - Standalone systems
    - Callbacks execute before “normal” user code
  - VDK based systems
    - Callbacks run at software interrupt thread



# Deferred Callback Service API

## Initialization/Termination

```
ADI_DCB_RESULT adi_dcb_Init();             // Initializes the deferred callback service
ADI_DCB_RESULT adi_dcb_Terminate();        // Terminates the deferred callback service
```

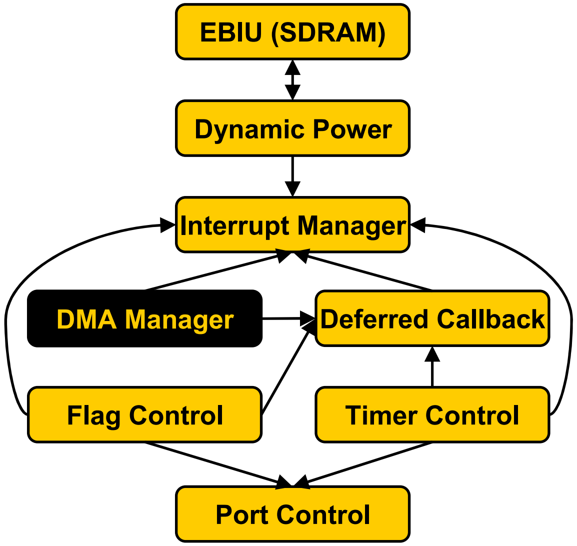
## Callback Queue Server Control

```
ADI_DCB_RESULT adi_dcb_Open();             // Opens a callback queue
ADI_DCB_RESULT adi_dcb_Close();            // Closes a callback queue
ADI_DCB_RESULT adi_dcb_Control();          // Changes settings of a callback queue

ADI_DCB_RESULT adi_dcb_Post();             // Posts a callback to a queue
ADI_DCB_RESULT adi_dcb_Remove();           // Removes callbacks from a queue
```

# DMA Manager

- Controls and schedules DMA
  - Supports both peripheral and memory DMA
  - User control of DMA channel mappings/priority, traffic control
- Comprehensive support for DMA modes
  - Descriptor chaining (large, small)
    - Queues descriptor jobs
  - Autobuffering (called circular buffers)
- MemCopy functions
  - DMA transfers rather than core access
  - One dimensional and two dimensional
- Optional callbacks on completion
  - Live or deferred



# DMA Manager API

## Initialization/Termination

```
ADI_DMA_RESULT adi_dma_Init();          // Initializes the DMA manager
ADI_DMA_RESULT adi_dma_Terminate();     // Terminates the DMA manager
```

## Channel Control

```
ADI_DMA_RESULT adi_dma_Open();          // Opens a channel for use
ADI_DMA_RESULT adi_dma_Close();         // Closes a channel
ADI_DMA_RESULT adi_dma_Control();       // Configures a channel
ADI_DMA_RESULT adi_dma_Queue();         // Posts a chain of descriptors to a channel
ADI_DMA_RESULT adi_dma_Buffer();        // Provides a one-shot or circular job to a channel
```

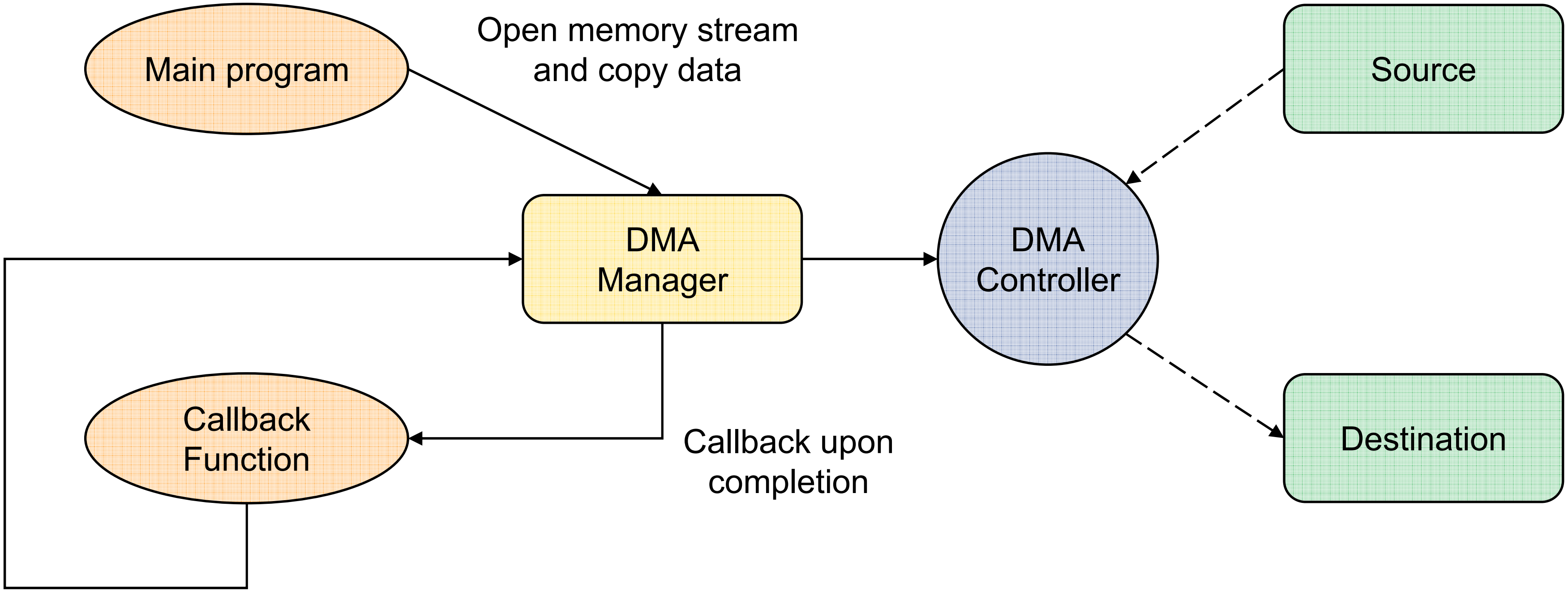
## Memory Stream Control

```
ADI_DMA_RESULT adi_dma_MemoryOpen();    // Opens a memory stream
ADI_DMA_RESULT adi_dma_MemoryClose();   // Closes a memory stream
ADI_DMA_RESULT adi_dma_MemoryCopy();    // Performs a one-dimensional memory transfer
ADI_DMA_RESULT adi_dma_MemoryCopy2D();  // Performs a two-dimensional memory transfer
```

## Channel Mappings

```
ADI_DMA_RESULT adi_dma_SetMapping();    // Sets the mapping of a channel to a peripheral
ADI_DMA_RESULT adi_dma_GetMapping();    // Gets the mapping of a channel to a peripheral
```

# Memory DMA Example



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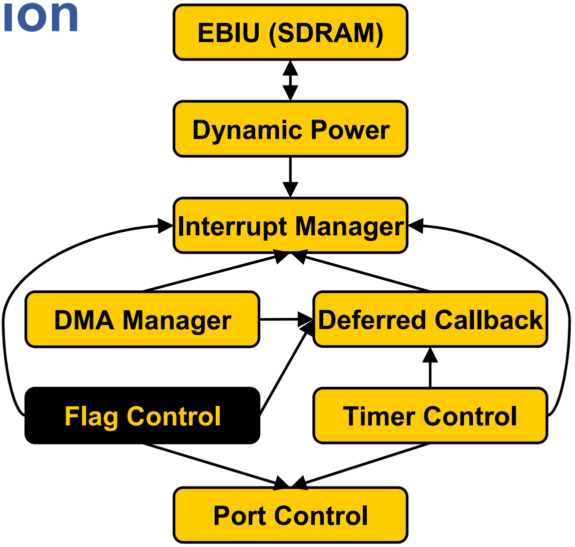
# Flag Control Service

- Controls general purpose programmable flags (GPIO)
  - All hardware capabilities exposed
    - Set direction
    - Set/clear/toggle level
    - Sense level
- Provides callback capability
  - Callback function invoked upon trigger condition
    - Level sensitive
      - High/low
    - Edge sensitive
      - Rising/falling/either
  - Live or deferred



# Flag Control API

## Initialization/Termination

```
ADI_FLAG_RESULT adi_flag_Init();                // Initializes the flag service
ADI_FLAG_RESULT adi_flag_Terminate();           // Terminates the flag service
```

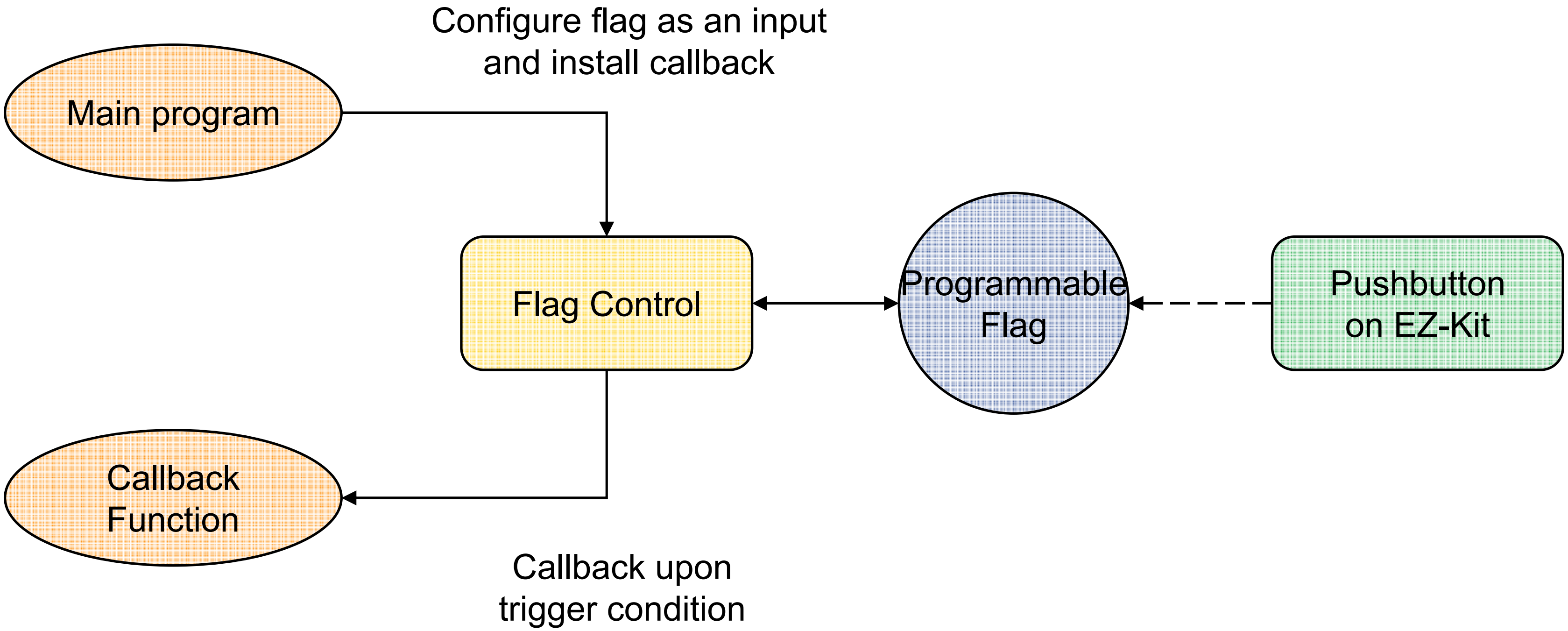
## Flag Control

```
ADI_FLAG_RESULT adi_flag_Open();                // Opens a flag for use
ADI_FLAG_RESULT adi_flag_Close();               // Closes a flag
ADI_FLAG_RESULT adi_flag_SetDirection();        // Configures the flag for input or output
ADI_FLAG_RESULT adi_flag_Set();                 // Sets a flag to logical 1
ADI_FLAG_RESULT adi_flag_Clear();               // Sets a flag to logical 0
ADI_FLAG_RESULT adi_flag_Toggle();              // Toggles the current value of a flag
ADI_FLAG_RESULT adi_flag_Sense();               // Senses the value of a flag
```

## Flag Callback Control

```
ADI_FLAG_RESULT adi_flag_InstallCallback();     // Installs a callback for sensing flag changes
ADI_FLAG_RESULT adi_flag_RemoveCallback();      // Removes a callback from a flag
ADI_FLAG_RESULT adi_flag_SetTrigger();          // Sets the trigger condition for a flag callback
ADI_FLAG_RESULT adi_flag_SuspendCallbacks();    // Temporarily suspend callbacks for a flag
ADI_FLAG_RESULT adi_flag_ResumeCallbacks();     // Resume callbacks for a flag
```

# Flag Control Example



Configure flag as an input and install callback

Main program

Flag Control

Programmable Flag

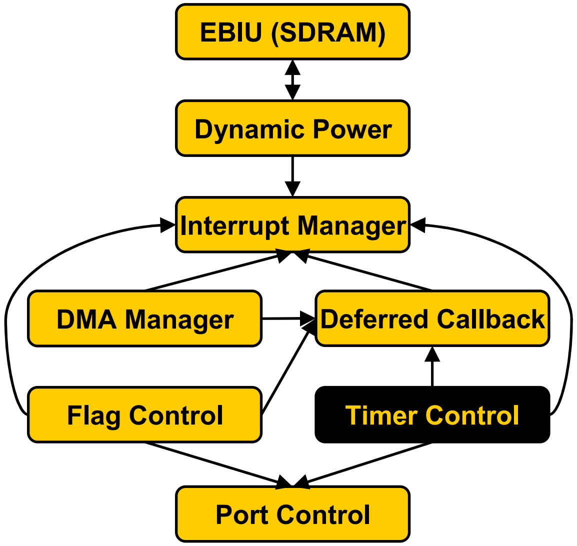
Pushbutton on EZ-Kit

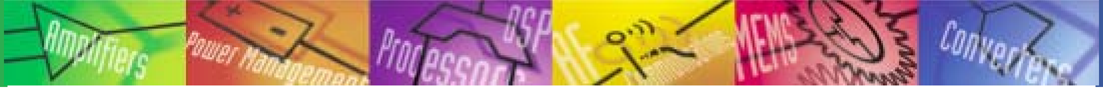
Callback Function

Callback upon trigger condition

# Timer Control Service

- Controls operation of timers
  - Full access into all modes and features
    - Core timer
      - Count, period, scale, auto-reload
    - Watchdog timer
      - Select timeout event, reset counter
    - General purpose timers
      - PWM, WidthCap
      - Simultaneous enable/disable
- Provides callback capability
  - Callback function upon timer expiration
  - Live or deferred





# Timer Control API

## Initialization/Termination

```
ADI_TMR_RESULT adi_tmr_Init();            // Initializes the timer service
ADI_TMR_RESULT adi_tmr_Terminate();       // Terminates the timer service
```

## Timer Control

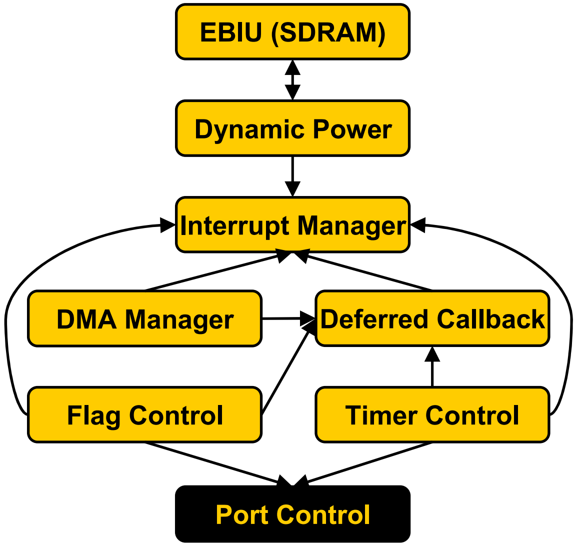
```
ADI_TMR_RESULT adi_tmr_Open();            // Opens a timer for use
ADI_TMR_RESULT adi_tmr_Close();           // Closes a timer
ADI_TMR_RESULT adi_tmr_Reset();           // Resets a timer to power-up settings
ADI_TMR_RESULT adi_tmr_GetPeripheralID(); // Gets the peripheral ID for a timer

ADI_TMR_RESULT adi_tmr_CoreControl();     // Controls the core timer

ADI_TMR_RESULT adi_tmr_WatchdogControl(); // Controls the watchdog timer

ADI_TMR_RESULT adi_tmr_GPControl();       // Controls a general purpose timer
ADI_TMR_RESULT adi_tmr_GPGroupEnable();   // Simultaneously enables/disables a group of timers
```

## Timer Callback Control

```
ADI_TMR_RESULT adi_tmr_InstallCallback(); // Installs a callback for a timer
ADI_TMR_RESULT adi_tmr_RemoveCallback();  // Removes a callback from a timer
```

# Port Control Service

- Controls assignment of muxed pins
  - Applicable to ADSP-BF534, ADSP-BF536, ADSP-BF537 only
- Operation largely transparent to applications
  - Application need only initialize port control
  - No other application involvement required
- Automatically accessed by drivers and other services
  - Examples
    - PPI driver
      - Data width, frame sync pins etc.
    - Timer service
      - Input clocks/output signals
    - Flag service
      - Configures as appropriate for flag pins



# Port Control API

## Initialization/Termination

```
ADI_PORTS_RESULT adi_ports_Init();           // Initializes the port control service
ADI_PORTS_RESULT adi_ports_Terminate();      // Terminates the port control service
```

## Peripheral Based Control

```
ADI_PORTS_RESULT adi_portsEnablePPI();       // Configures pins for PPI operation
ADI_PORTS_RESULT adi_portsEnableSPI();       // Configures pins for SPI operation
ADI_PORTS_RESULT adi_portsEnableSPORT();     // Configures pins for SPORT operation
ADI_PORTS_RESULT adi_portsEnableUART();      // Configures pins for UART operation
ADI_PORTS_RESULT adi_portsEnableCAN();       // Configures pins for CAN operation
ADI_PORTS_RESULT adi_portsEnableTimer();     // Configures pins for timer operation
ADI_PORTS_RESULT adi_portsEnableGPIO();      // Configures pins for flag operation
```

## Profile Based Control

```
ADI_PORTS_RESULT adi_ports_SetProfile();     // Sets a muxing profile
ADI_PORTS_RESULT adi_ports_GetProfile();     // Gets a muxing profile
```

# Finding the System Services

- Include files
  - C:\Program Files\Analog Devices\VisualDSP 4.0\Blackfin\include\services
- Source files
  - C:\Program Files\Analog Devices\VisualDSP 4.0\Blackfin\lib\src\services
- Libraries
  - C:\Program Files\Analog Devices\VisualDSP 4.0\Blackfin\lib
- Examples
  - C:\Program Files\Analog Devices\VisualDSP 4.0\Blackfin\EZ-KITs\ADSP-BF533\Services
  - C:\Program Files\Analog Devices\VisualDSP 4.0\Blackfin\EZ-KITs\ADSP-BF537\Services
  - C:\Program Files\Analog Devices\VisualDSP 4.0\Blackfin\EZ-KITs\ADSP-BF561\Services
- Documentation
  - Device Driver and System Services User Manual
    - Blackfin Technical Library at www.analog.com
  - Device Driver and System Services User Manual Addendum (Sept 2005)
    - ftp://ftp.analog.com/pub/tools/patches/Blackfin/VDSP++4.0/

# Conclusion

- **System services provide:**
  - **Faster development**
    - Stable software base for application development
      - Fewer variables
    - Less re-invention
      - Don’t need to create everything from scratch
  - **Modular software**
    - Better compatibility
      - Resource control is managed by the system services
    - Easier integration
      - Multiple software components working concurrently
  - **Portability**
    - Code portable to other Blackfin processors

# Additional Information

- **Documentation**
  - **Device Drivers and System Services Manual for Blackfin Processors**
    - http://www.analog.com/processors/resources/technicalLibrary/manuals/index.html
  - **Device Drivers and System Services Addendum (Sept 2005)**
    - ftp://ftp.analog.com/pub/tools/patches/Blackfin/VDSP++4.0/
- **For questions, click “Ask A Question” button**