ThreadX Kernel API's

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ThreadX in General

- ThreadX is delivered in binary format
- No MMU support
- Resides with Application
- System structures directly visible to Application
- Multilevel Queue Scheduler
  - 32 Thread priorities (0 highest, 31 lowest)
  - Timeslicing requires HW Timer
- Small Footprint (1.7kB to 11.2kB text)
- Unlimited Threads, Queues, Event Flags, …
- Runs completely in Supervisor Mode

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Kernel API's Overview

4.1 Thread Management

4.2 Memory Management

4.3 Semaphores

4.4 Event Flags

4.5 Message Queues

4.6 Timers

4.7 Other Kernel Services

4.1 Thread Management

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ThreadX™ RTOS

- Threads
- Message Queues
- Semaphores
- Event Flags
- Timers
- Memory Management

Under 25 Kbytes Instruction Area

- Thread Creation
  - Easy; One Function Call Spawns Thread
- Thread Management
  - Threads Execute Independently
    - Individual Stack Space
  - Execute Threads Based on Priority
    - 32 Levels of Prioritization
  - Time-Share Equal Priority Threads
    - Round-Robin
- Run-Time Management
  - Locking/Unlocking System Resources
  - Thread-to-Thread Communication
  - Timing
- Interrupt Handling

Thread Introduction

- NET+OS uses threads, not tasks
  - By definition threads share address space, tasks and processes do not
  - In relative terms, overhead associated with thread management is minimal
- NET+OS provides APIs which enable the user to:
  - Create and delete threads
  - Control the execution of threads
  - Control the scheduling of threads

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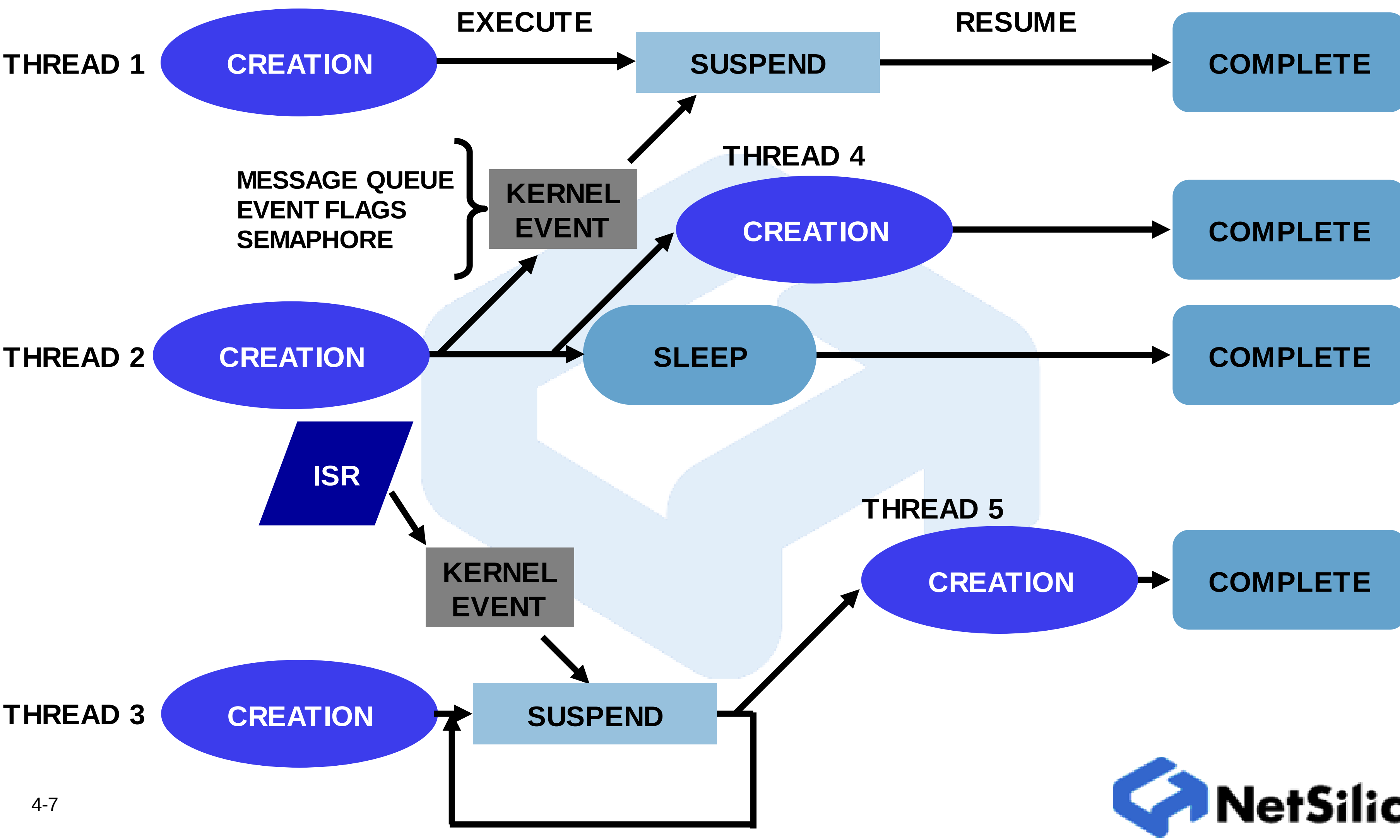
ThreadX™ Operation



Thread Parameters

- Attributes used to define a thread include:
  - Thread Pointer: Pointer to thread's control block
  - Name Pointer: Pointer to thread's name
  - Entry Function: Pointer to thread's entry-point routine
  - Entry Input: Optional argument passed to thread's entry function.
  - Stack Start: Starting address of thread's stack space in system memory

Thread Parameters (continued)

- Stack Size: Size, in bytes, of the thread’s stack space
- Priority: Relative importance of the thread in relation to other threads
- Preemption Threshold: Highest minimum priority another thread must be before interrupting this thread
- Time Slice: Maximum number of ticks a thread can execute
- Auto Start: Specifies whether the thread should start immediately, or be created in a suspended state

Thread Creation

CRITICAL PARAMETERS

Entry Function

Entry Parameter

Stack Start

Stack Size

Priority

Time Slice

tx_thread_create()

Example Thread Creation: Net+OS Root Thread

From bsproot.c…

#include tx_api.h

```
/*
 * Now create the root thread.  This thread starts NET+OS and the TCP/IP stack.
 */
    ccode = tx_thread_create (&rootThread,                        /* control block for root thread*/
                            "Root Thread",                        /* thread name*/
                            netosStartup,                         /* entry function*/
                            0,                                    /* parameter*/
                            first_unused_memory,                  /* start of stack*/
                            APP_ROOT_STACK_SIZE,                  /* size of stack*/
                            APP_ROOT_PRIORITY,                    /* priority*/
                            APP_ROOT_PRIORITY,                    /* preemption threshold */
                            1,                                    /* time slice threshold*/
                            TX_AUTO_START);                       /* start immediately*/

    if (ccode != TX_SUCCESS)                                      /* if couldn't create thread*/
    {
        netosFatalError ("Unable to create root thread", 1, 1);
    }
}
```

Thread Creation

```
uint tx_thread_create(TX_THREAD *pThread,
                      char *pName,
                      void (*pEntryFunc)(ulong),
                      ulong entryInput,
                      void *pStackStart,
                      ulong stackSize,
                      uint priority,
                      uint preemptThreshold,
                      ulong timeSlice,
                      uint autoStart)
```

- Creates a thread using the specified attributes

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Thread Terminate/Delete

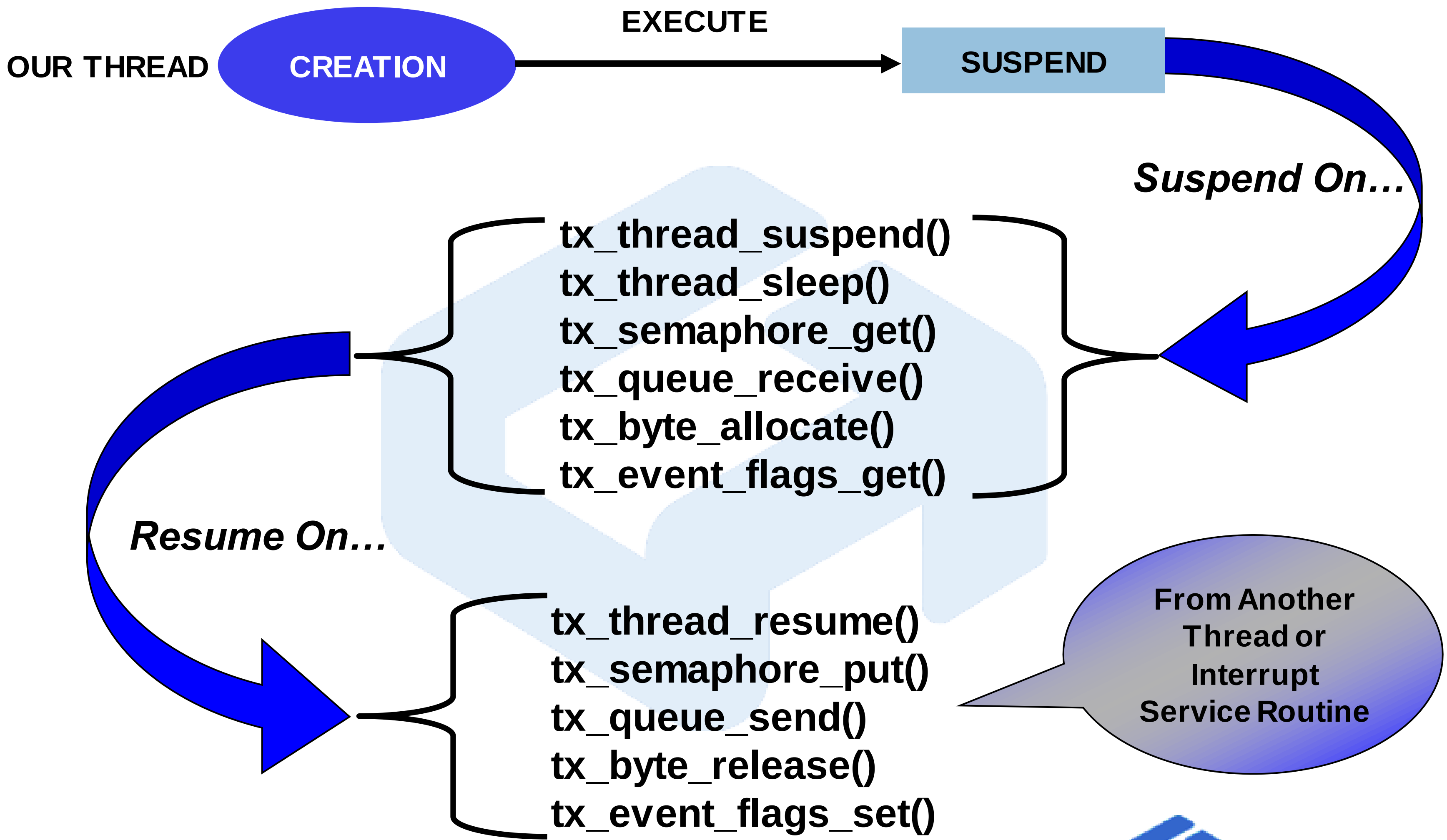
uint **tx_thread_terminate**(TX_THREAD *pThread)

- Terminates the specified thread regardless of state
- Threads are allowed to self terminate
- Terminated threads must be deleted and re-created in order to execute again

uint **tx_thread_delete**(TX_THREAD *pThread)

- Deletes the specified thread, pThread
- Only able to delete threads in the completed (TX_COMPLETED) or terminated (TX_TERMINATED) states
- Application responsible for memory management/cleanup

Thread Suspension / Resumption



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Thread Resume/Suspend

uint **tx_thread_resume**(TX_THREAD *pThread)

- Resumes previously suspended (TX_SUSPENDED) threads
- Resumes threads created without an automatic start

uint **tx_thread_suspend**(TX_THREAD *pThread)

- Suspends the specified thread, pThread
- Threads are allowed to suspend themselves
- Allowed to suspend a currently suspended (TX_SUSPENDED) thread only once

Thread Sleep/Relinquish

uint **tx_thread_sleep**(ulong timerTicks)

- Suspends the calling thread for the specified number of timer ticks, timerTicks

void **tx_thread_relinquish** (void)

- Yields the processor to other threads in the ready (TX_READY) state

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Thread Identify

TX_THREAD* **tx_thread_identify** (void)

- Returns a pointer to the current thread's control block
- When called from an ISR the routine returns the control block of the thread that ran prior to the interrupt

Thread Preemption/Priority/Time Slice Change

uint **tx_thread_preemption_change**(TX_THREAD *pThread, uint newThreshold, uint *pOldThreshold)

- Changes the thread's preemption threshold attribute to the value of newThreshold

uint **tx_thread_priority_change** (TX_THREAD *pThread, uint newPriority, uint *pOldPriority)

- Changes the thread's priority attribute to the value of newPriority
- User will need to adjust the preemption threshold value on their own

uint **tx_thread_time_slice_change**(TX_THREAD *pThread, ulong newTimeSlice, ulong *pOldTimeSlice)

- Changes the thread's time slice attribute to the value of newTimeSlice

Thread Summary

- Thread attributes
  - Maintained in thread control block, TX_THREAD
  - Originally specified in tx_thread_create()
  - Modified with tx_thread_xxx_change() routines
- Thread APIs
  - tx_thread_create() / tx_thread_terminate() / tx_thread_delete()
  - tx_thread_suspend() / tx_thread_resume()
  - tx_thread_sleep() / tx_thread_relinquish()
  - tx_thread_identify()
  - tx_thread_preemption_change()
  - tx_thread_priority_change()
  - tx_thread_time_slice_change()

Thread Summary (continued)

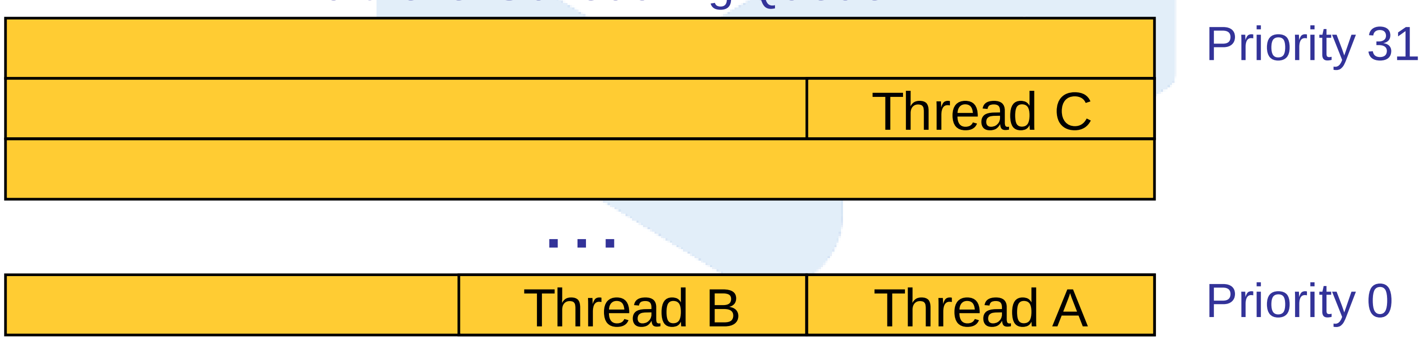
- Thread APIs
  - tx_thread_create() / tx_thread_terminate() / tx_thread_delete()
  - tx_thread_suspend() / tx_thread_resume()
  - tx_thread_sleep() / tx_thread_relinquish()
  - tx_thread_identify()
  - tx_thread_preemption_change()
  - tx_thread_priority_change()
  - tx_thread_time_slice_change()

ThreadX Scheduler

Multilevel Queue Scheduler

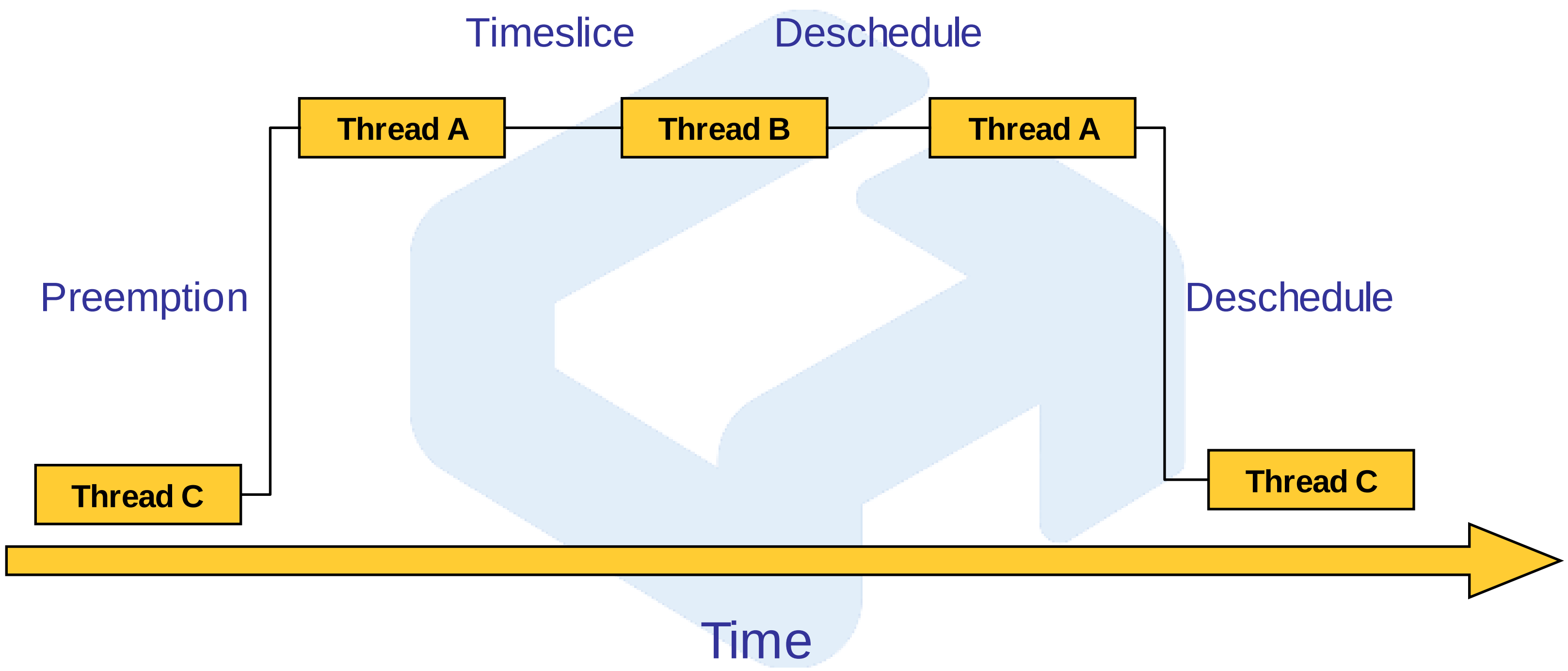
Scenario:
Thread A, Thread B, and Thread C are configured during creation w/ priority levels 0, 0, 30, respectively.

Multilevel Scheduling Queue

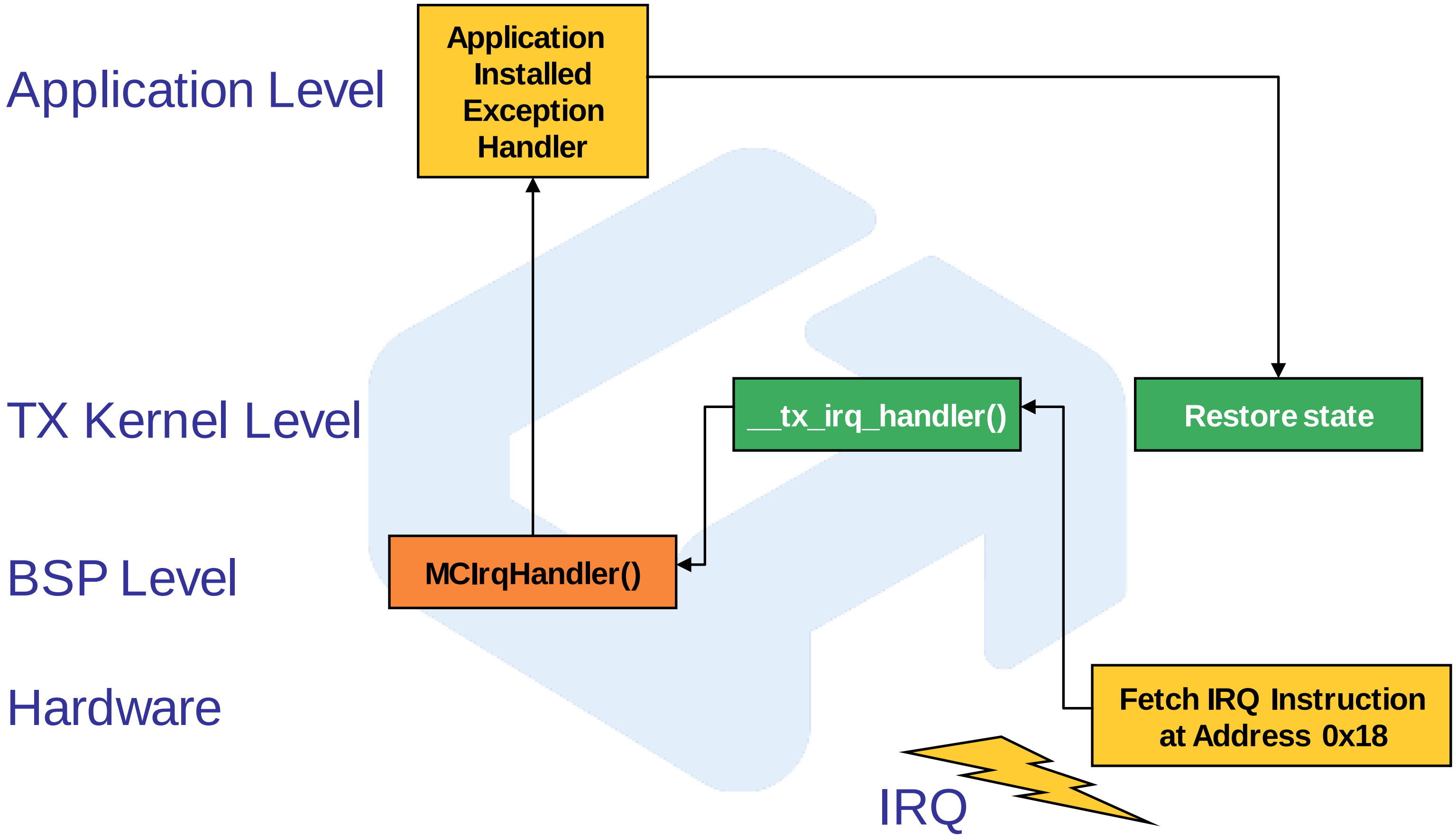


ThreadX Scheduler (cont.)

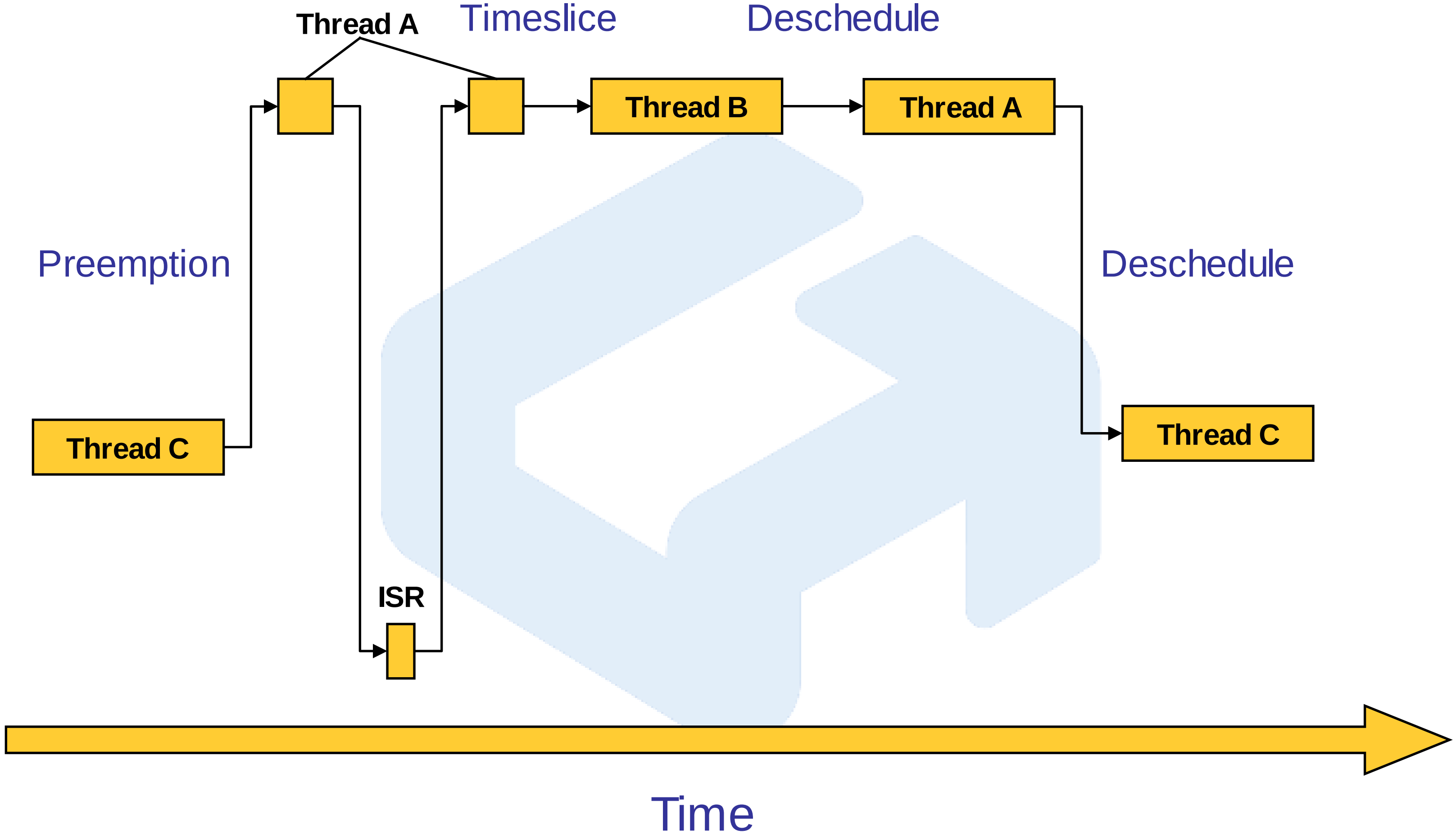
Scheduler Thread Operation:



ThreadX Exception Handling



ThreadX Exception Handling cont.



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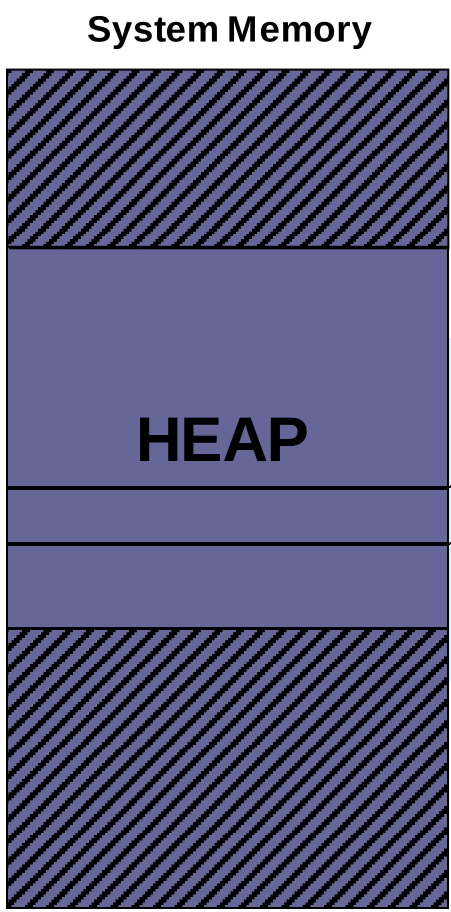
4.2 Memory Management

Memory Management - Block Pools

- Block Pools
  - Deterministic allocation/free time
  - Not subject to memory fragmentation
  - Pools must be sized to handle worst case memory scenario
  - Publicly available resource
  - Overhead associated with each block equal to a C-pointer
  - Pool control blocks, TX_BLOCK_POOL, often defined globally
  - Pools can be located anywhere in memory

Memory Block Pools - Creation



tx_block_pool_create()

- **Total Size in Bytes**
- **Divided Into Equal-size Sub-blocks**
- **Can Suspend if Unsuccessful**
- **Flexibility in Location**
    - **Programmer Chooses Start Address**

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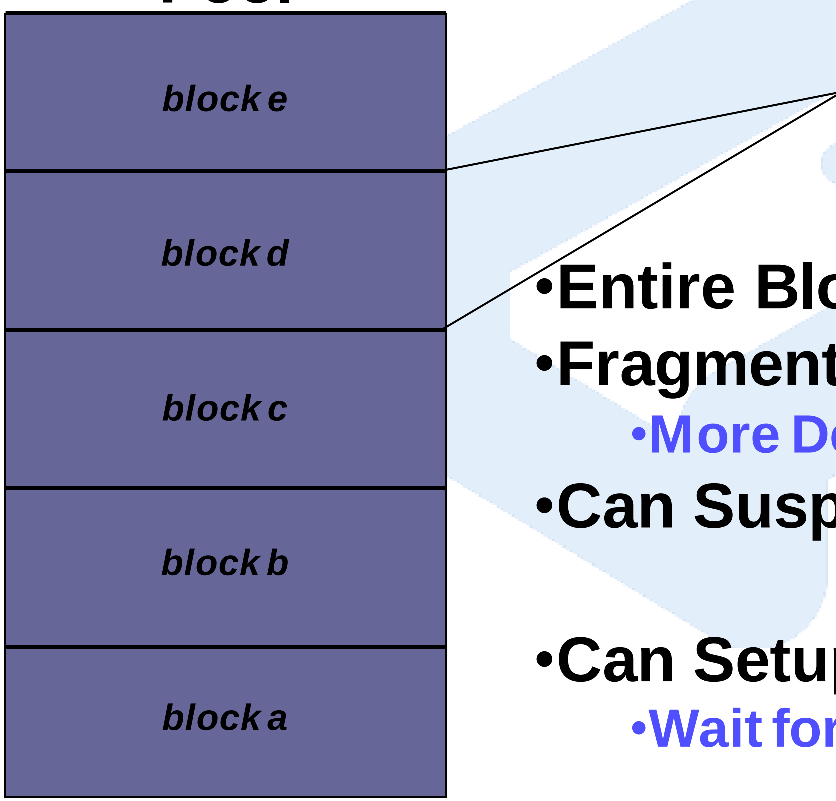
Memory Block Pools - Allocation

Memory Block Pool



tx_block_allocate()

- **Entire Block Allocated**
- **Fragmentation Less Likely**
  - **More Deterministic than malloc()**
- **Can Suspend if Unsuccessful**

-OR-

- **Can Setup Time-Out Period**
  - **Wait for Another Thread to Free a Block**

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Block Pool Create/Delete

uint **tx_block_pool_create**(TX_BLOCK_POOL *pPool, char *pName, ulong blockSize, void *pPoolStart, ulong poolSize)

- Creates a pool of fixed size memory blocks, pPool
- total blocks = (poolSize)/ (blockSize + sizeof(void *))

uint **tx_block_pool_delete**(TX_BLOCK_POOL *pPool)

- Deletes a pool of fixed size memory blocks, pPool
- Threads (suspended) waiting for memory from this pool are resumed and given a TX_DELETED status
- Application's responsibility to prevent threads from using memory in the former block pool's memory region

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Block Pool Allocate/Release

uint **tx_block_allocate**(TX_BLOCK_POOL *pPool, void **pBlock, ulong waitOption)

- Allocates a fixed size memory block from the pool pointed to by pPool
- Possible values for waitOption include:
  - TX_NO_WAIT (0x0000 0000)
  - TX_WAIT_FOREVER (0xFFFF FFFF)
  - time-out value, in ticks (0x0000 0001 - 0xFFFF FFFE)

uint **tx_block_release**(void *pBlock)

- Releases the previously allocated block, pBlock, into the memory pool
- Application's responsibility to prevent threads from using released memory

Memory Management - Byte Pools

- Byte Pools
  - Non-deterministic
  - Memory allocated using ‘First-fit’ algorithm
  - Suffers from memory fragmentation
  - Publicly available resource but should *NOT* be used in ISRs
  - Pool control blocks, TX_BYTE_POOL, often defined globally

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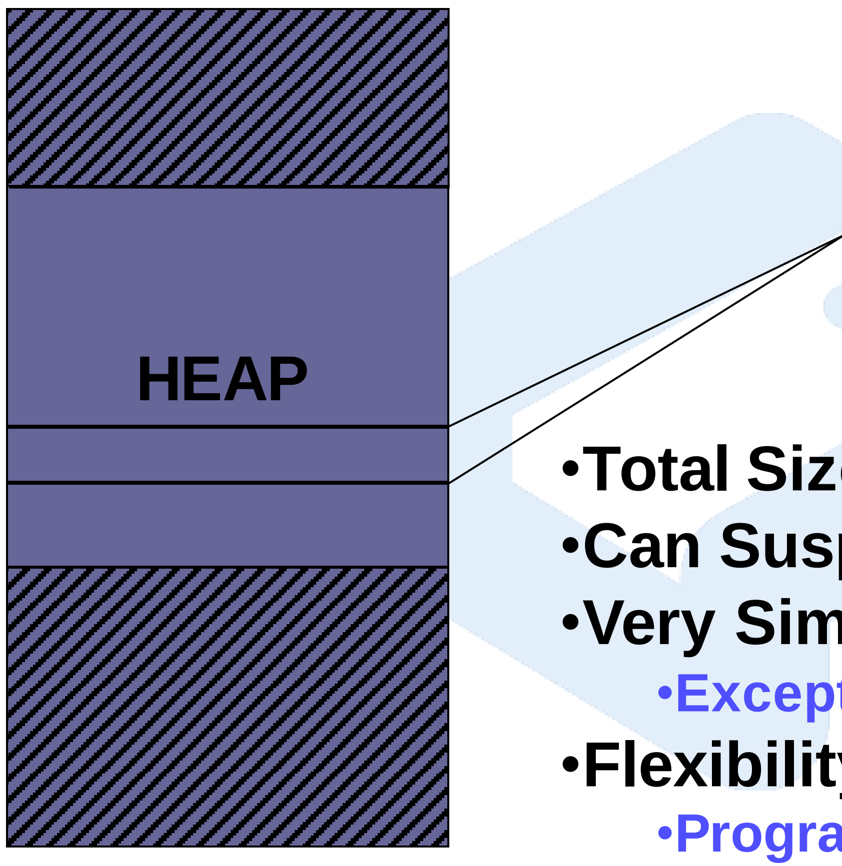
Memory Byte Pools - Creation

System Memory



tx_byte_pool_create()

- **Total Size in Bytes**
- **Can Suspend if Unsuccessful**
- **Very Similar to Block Pools**
  - **Except no Fixed-Sized Blocks**
- **Flexibility in Location**
  - **Programmer Chooses Start Address**

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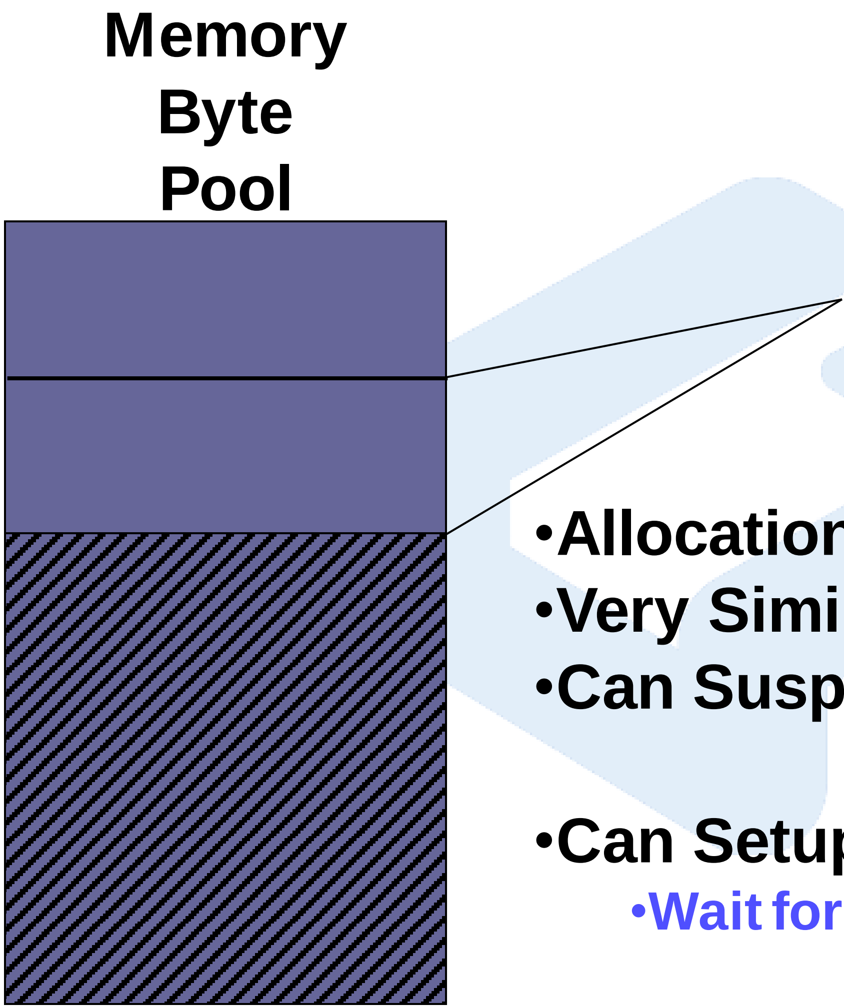
Memory Byte Pools - Allocation



- Allocation Specified in Bytes
- Very Similar Concept as malloc()
- Can Suspend if Unsuccessful

  -OR-

- Can Setup Time-Out Period
  - Wait for Another Thread to Free a Block

Byte Pool Create/Delete

uint **tx_byte_pool_create**(TX_BYTE_POOL *pPool, char *pName, void *pPoolStart, ulong poolSize)

- Creates a memory pool in the specified area, pPoolStart
- Initially consists of one memory block, of size poolSize
- Broken into smaller blocks during de-fragmentation process

uint **tx_byte_pool_delete**(TX_BYTE_POOL *pPool)

- Deletes the byte pool, pPool
- Threads (suspended) waiting for memory from this pool are resumed and given a TX_DELETED status
- Application's responsibility to prevent threads from using memory in the former byte pool's memory region

Byte Pool Allocate/Release

uint **tx_byte_allocate**(TX_BYTE_POOL *pPool, void **pMemory, ulong memorySize, ulong waitOption)

- Allocates memorySize bytes from the pool pointed to by pPool
- Possible values for waitOption include:
  - TX_NO_WAIT (0x0000 0000)
  - TX_WAIT_FOREVER (0xFFFF FFFF)
  - time-out value, in ticks (0x0000 0001 - 0xFFFF FFFE)
- Performance a function of pool fragmentation, non-deterministic

uint **tx_byte_release**(void *pMemory)

- Releases the previously allocated memory, pMemory, back into the pool
- Application's responsibility to prevent threads from using released memory

Memory Management Summary

- Memory Management attributes
  - Two different types of memory allocation, fixed-size blocks and heap
  - Memory allocation information maintained in memory control blocks, TX_BLOCK_POOL or TX_BYTE_POOL

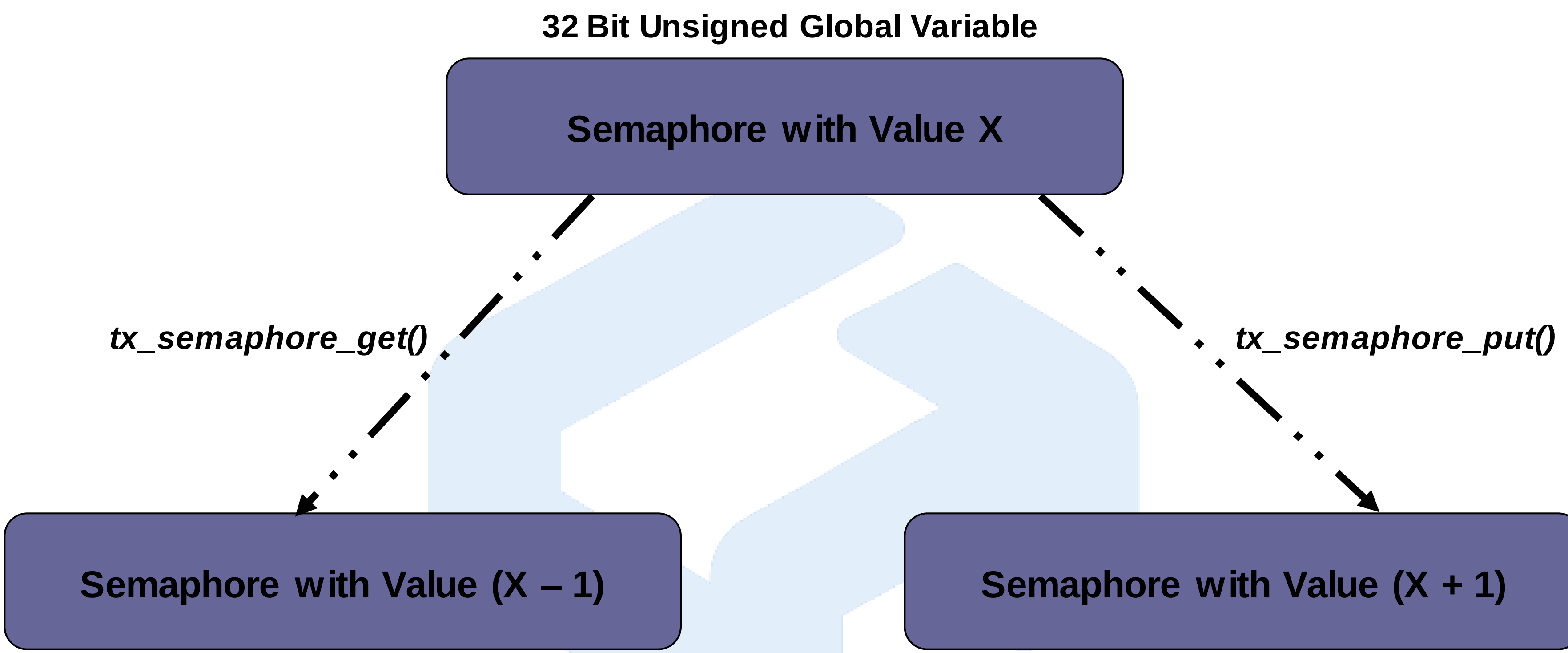
- Memory Management APIs
  - tx_block_pool_create() / tx_block_pool_delete()
  - tx_block_allocate() / tx_block_release()
  - tx_byte_pool_create() / tx_byte_pool_delete()
  - tx_byte_allocate() / tx_byte_release()

4.3 Semaphores

Semaphores

- ThreadX supports 32-bit counting semaphores (4,294,967,296!)
- Typically used for mutual exclusion, can also be applied to event notification
- Initializing a semaphore’s initial count to 1 creates a ‘binary semaphore’
- Semaphores must be used carefully in order to avoid deadlocks or priority inversion
- Semaphore control blocks, TX_SEMAPHORE, often defined globally
- Semaphores can be located anywhere in memory

Counting Semaphores



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Semaphore Create/Delete

uint **tx_semaphore_create**(TX_SEMAPHORE *pSemaphore, char *pName, ulong initialCount)

- Creates a counting semaphore
- Semaphore's count initialized to initialCount

uint **tx_semaphore_delete**(TX_SEMAPHORE *pSemaphore)

- Deletes the specified semaphore, pSemaphore
- Application's responsibility to prevent threads from using a deleted semaphore
- Threads (suspended) waiting for this semaphore are resumed and given a TX_DELETED status

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Semaphore Get/Put

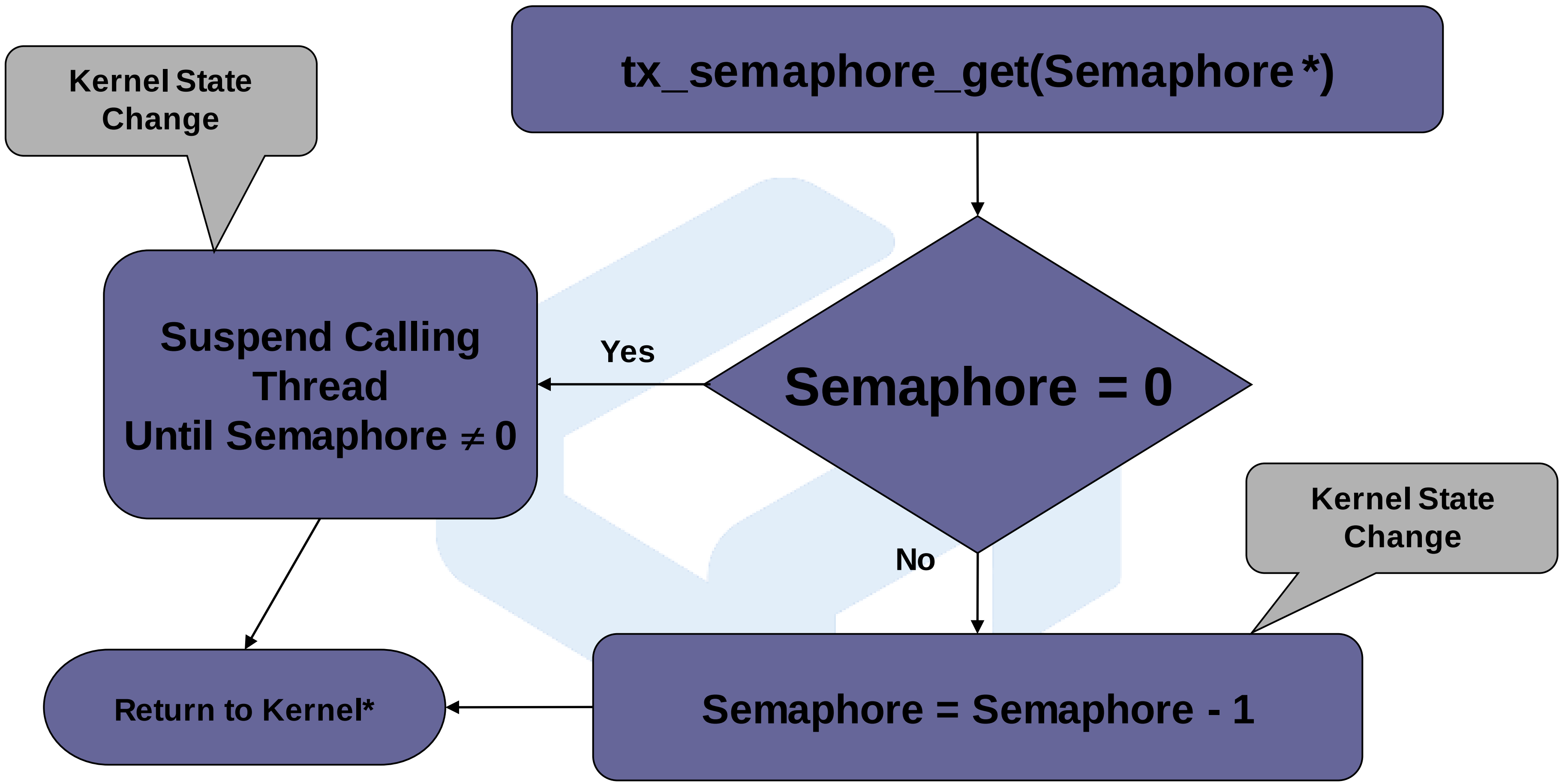
uint **tx_semaphore_get**(TX_SEMAPHORE *pSemaphore, ulong waitOption)

- Retrieves an instance of the specified semaphore, pSemaphore, depending upon availability and waitOption
- Semaphore’s count decremented by 1
- Possible values for waitOption include:
  - TX_NO_WAIT (0x0000 0000) – Return Immediately
  - TX_WAIT_FOREVER (0xFFFF FFFF) – Block, waiting for the semaphore
  - time-out value, in ticks (0x0000 0001 - 0xFFFF FFFE) – Block, waiting for the specified time

uint **tx_semaphore_put** (TX_SEMAPHORE *pSemaphore)

- Puts an instance of the specified semaphore, pSemaphore
- Semaphore’s count incremented by 1
- If a semaphore’s count is 0xFFFF FFFF, new count will be 0

A Closer Look At tx_semaphore_get()



*Kernel Decides which Thread to Resume

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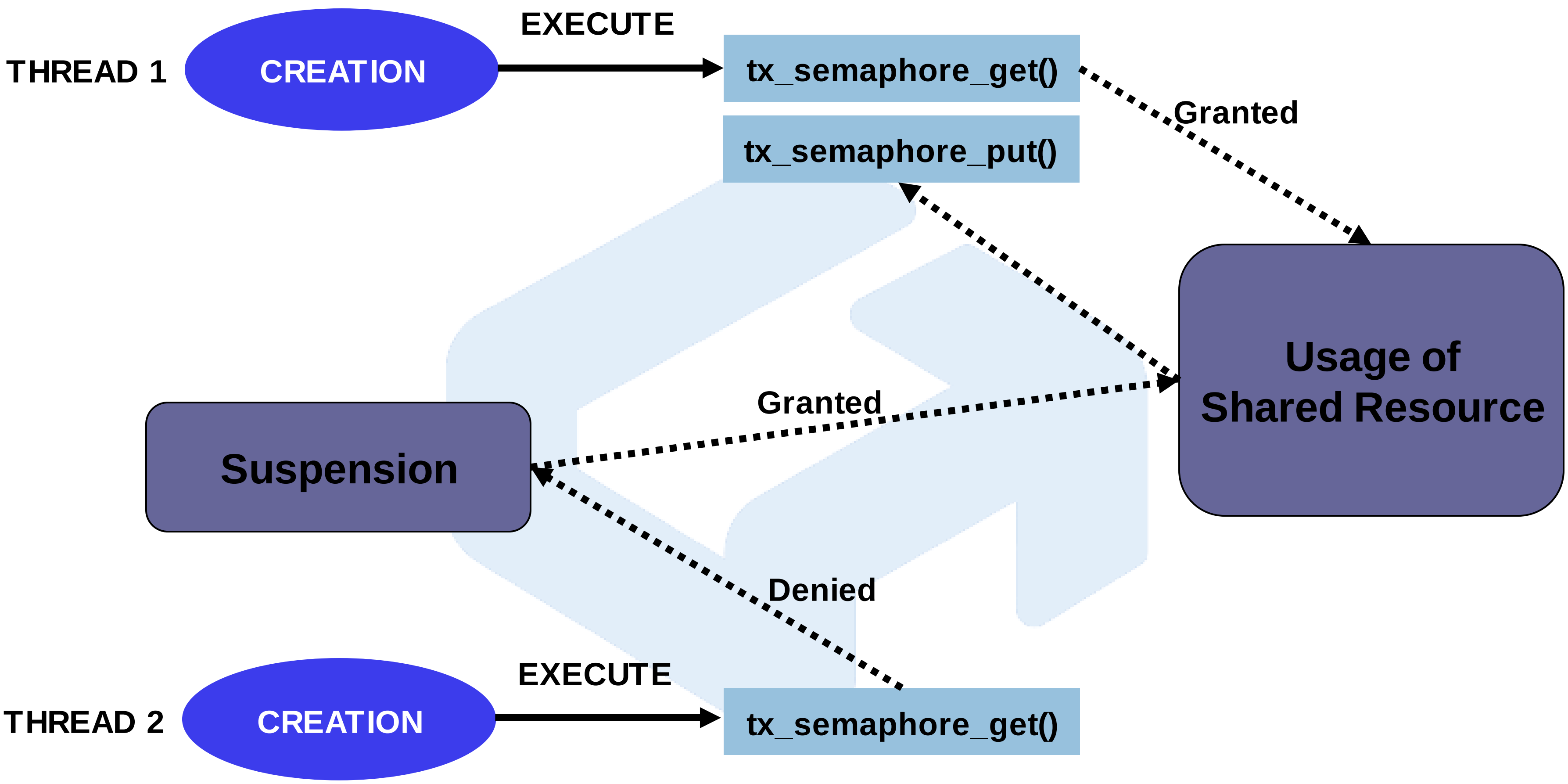
Semaphores in Action



Example Semaphore Usage

Declaration `TX_SEMAPHORE serial;`

Initial Value
'1' for Binary

Creation `status = tx_semaphore_create (&serial, "Serial Port Use", 1);`

Name

Get `tx_semaphore_get (&serial, TX_WAIT_FOREVER);`

Wait
Condition

Put `tx_semaphore_put (&serial);`

Semaphore Summary

- Semaphore attributes
  - Semaphore information maintained in semaphore control blocks, TX_SEMAPHORE
  - No built in support for deadlock avoidance or priority-inversion handling
- Semaphore APIs
  - tx_semaphore_create() / tx_semaphore_delete()
  - tx_semaphore_get() / tx_semaphore_put()

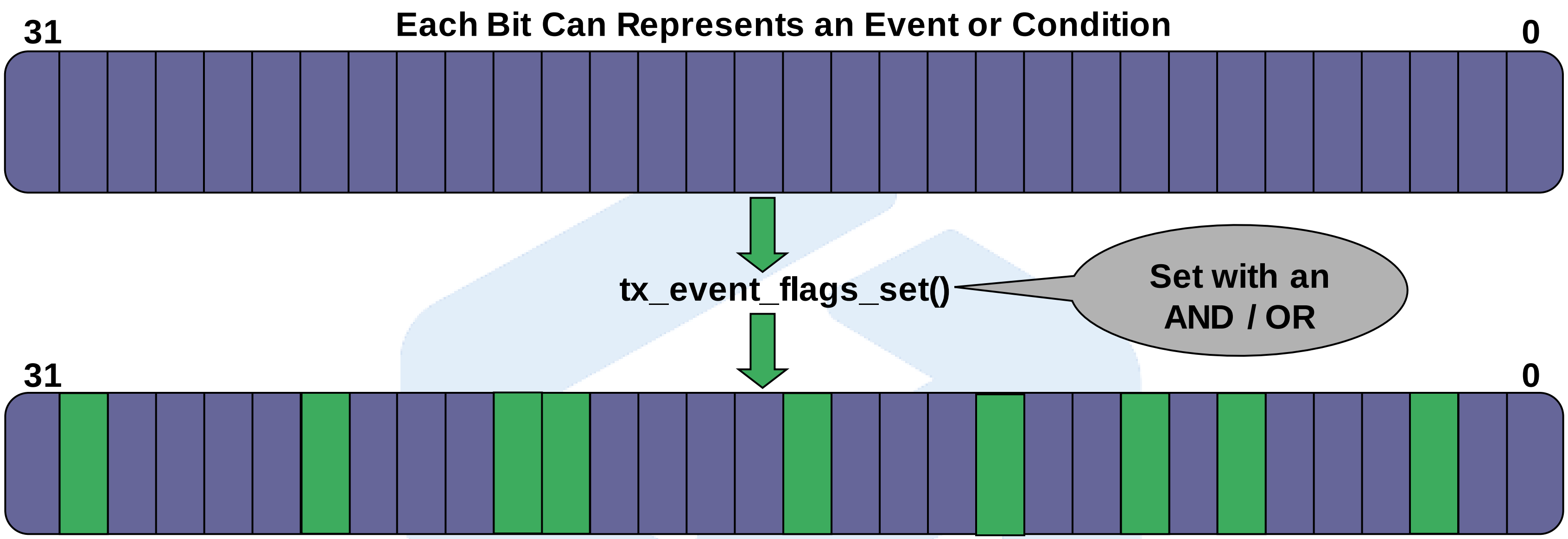
4.4 Event Flags

Event Flags

- Event flags provide a means of thread synchronization
- Classified in groups of 32, making up a single word
- When a group is created, all 32 flags are initialized to 0
- Multiple threads can use the same group
- Event flag control blocks, TX_EVENT_FLAGS_GROUP, often defined globally
- Event flag groups can be located anywhere in memory

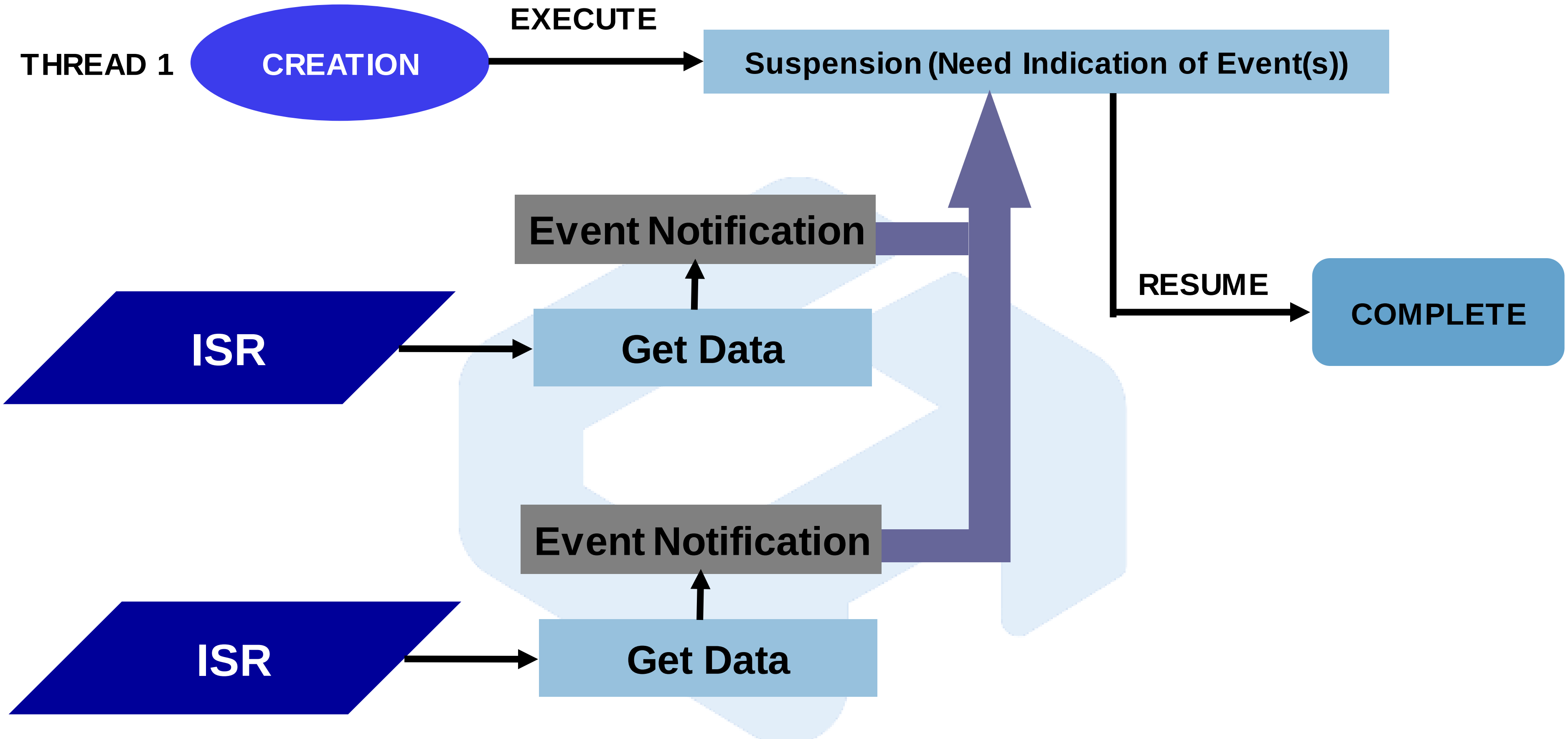
Event Flags

32 Bit Unsigned Global Variable



The State of Event Flags Retrieved with tx_event_flags_get()

Event Flags - Conceptual



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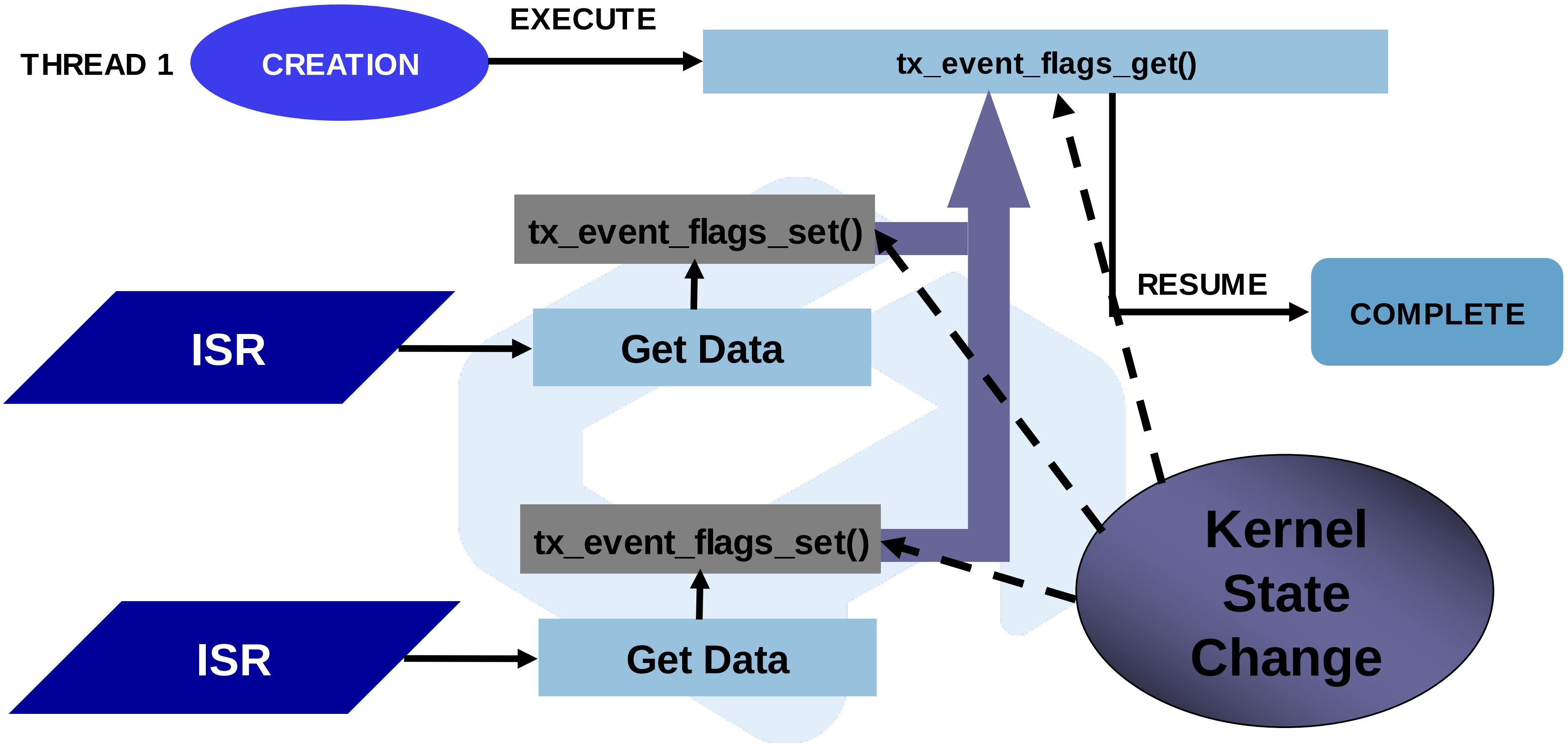
Event Flags-Implementation



Example Event Flags

Declaration TX_EVENT_FLAGS_GROUP tcp_sleep_events;

Name

Creation tx_event_flags_create (&tcp_sleep_events, "TCP Sleep Event Flags");

Set tx_event_flags_set(&tcp_sleep_events,(1 << i),TX_OR);

Flag Mask

Modification Option

Get tx_event_flags_get(&tcp_sleep_events,(1 << i),TX_OR_CLEAR, &flags, TX_WAIT_FOREVER);

Flags Copied Here

Wait Option

Event Flags Create/Delete

uint **tx_event_flags_create**(TX_EVENT_FLAGS_GROUP *pGroup, char *pName)

- Creates a group of 32 flags, all initialized to 0

uint **tx_event_flags_delete**(TX_EVENT_FLAGS_GROUP *pGroup)

- Deletes the specified event flag group, pGroup
- Application's responsibility to prevent use of a deleted event flag group
- Threads (suspended) waiting for events from this group are resumed and given a TX_DELETED status

Event Flags Get

uint **tx_event_flags_get** (TX_EVENT_FLAGS_GROUP *pGroup, ulong requestedFlags, uint getOption, ulong *pActualFlags, ulong waitOption)

- Retrieves event flags from the specified group, pGroup
- The getOption parameter allows control over which flags are returned, and possibly cleared
- Possible values for getOption include:
  - TX_AND
  - TX_AND_CLEAR
  - TX_OR
  - TX_OR_CLEAR
- Possible values for waitOption include:
  - TX_NO_WAIT (0x0000 0000) – Return Immediately
  - TX_WAIT_FOREVER (0xFFFF FFFF) – Block, waiting for the event
  - time-out value, in ticks (0x0000 0001 - 0xFFFF FFFE) – Block, waiting for the specified time

Event Flags Set

uint **tx_event_flags_set** (TX_EVENT_FLAGS_GROUP *pGroup, ulong flagsToSet, uint setOption)

- Sets/clears event flags in the specified group, pGroup, depending upon the setOption
- Performs the setOption between the current flags and flagsToSet
- Possible values for setOption include:
  - TX_AND
  - TX_OR

Event Flags Summary

- Event Flag attributes
  - Event Flag information maintained in event flag control blocks, TX_EVENT_FLAGS_GROUP
  - Multiple threads and use (and be suspended on) the same event flag group
- Event Flags APIs
  - tx_event_flags_create() / tx_event_flags_delete()
  - tx_event_flags_get() / tx_event_flags_set ()

4.5 Message Queues

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Message Queues

- Primary means of inter-thread communication in ThreadX
- Message queues that hold a single message referred to as a ‘mailbox’
- Queues support messages of 1, 2, 4, 8, or 16 32-bit sizes
  - Anything larger should use pointers
- Messages are copied to and from queues
  - In the case of a suspended thread, message sent directly to queue
- Queue control blocks, TX_QUEUE, often defined globally
- Queues can be located anywhere in memory
- To prevent memory corruption the application *must* ensure that its receiving memory is at least as large as the message size

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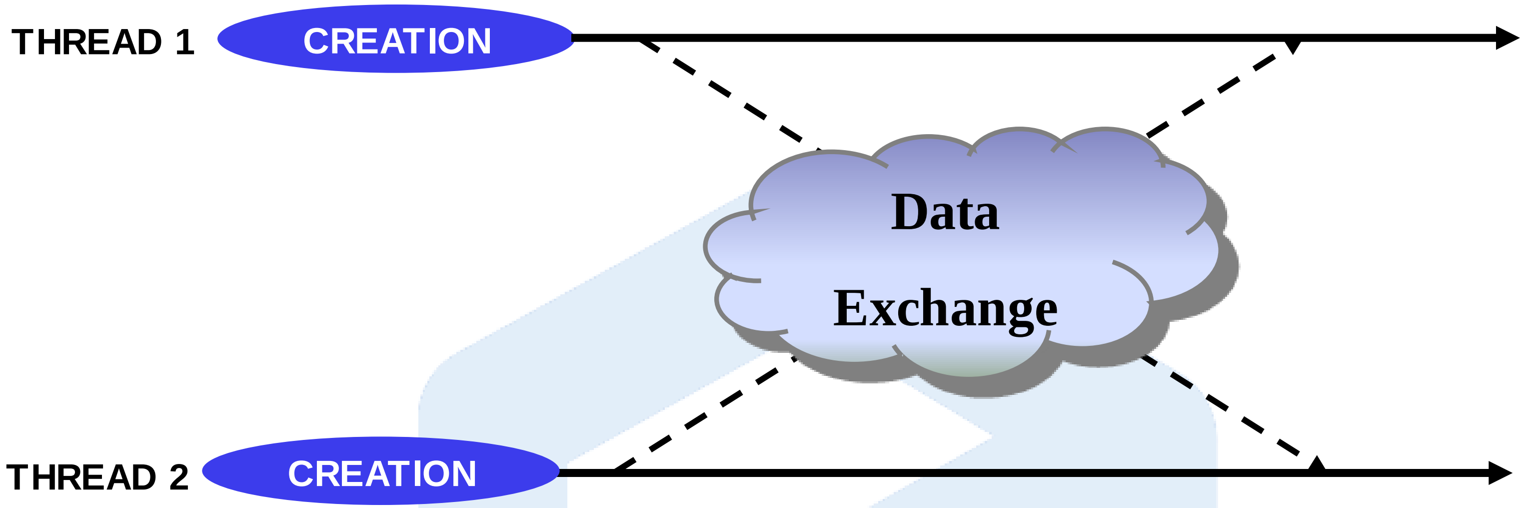
Message Queues



Message Queues Provide a Convenient Means of InterThread Communication

Data Exchange is Done by Posting and Receiving Data from Shared 'Mailboxes'

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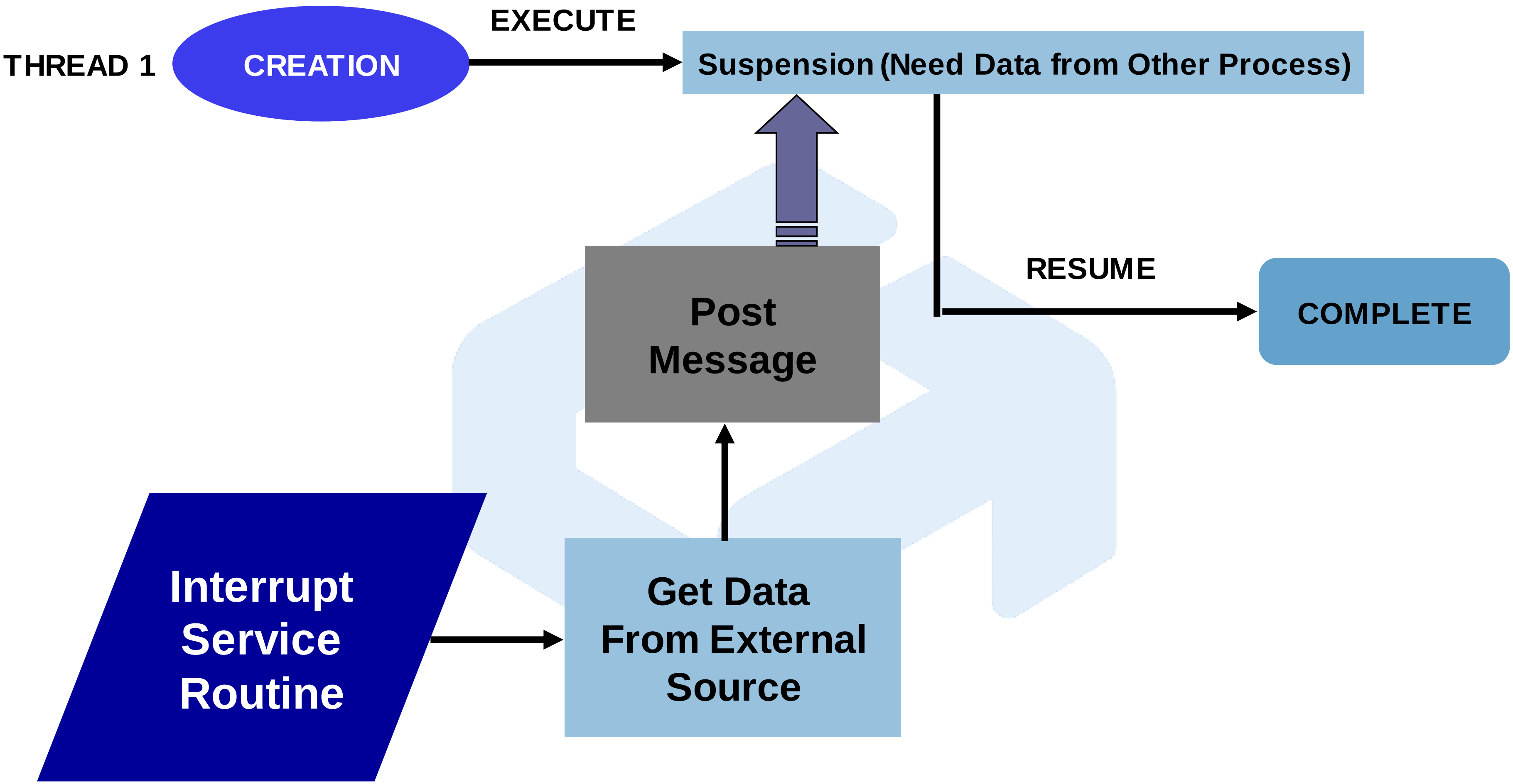
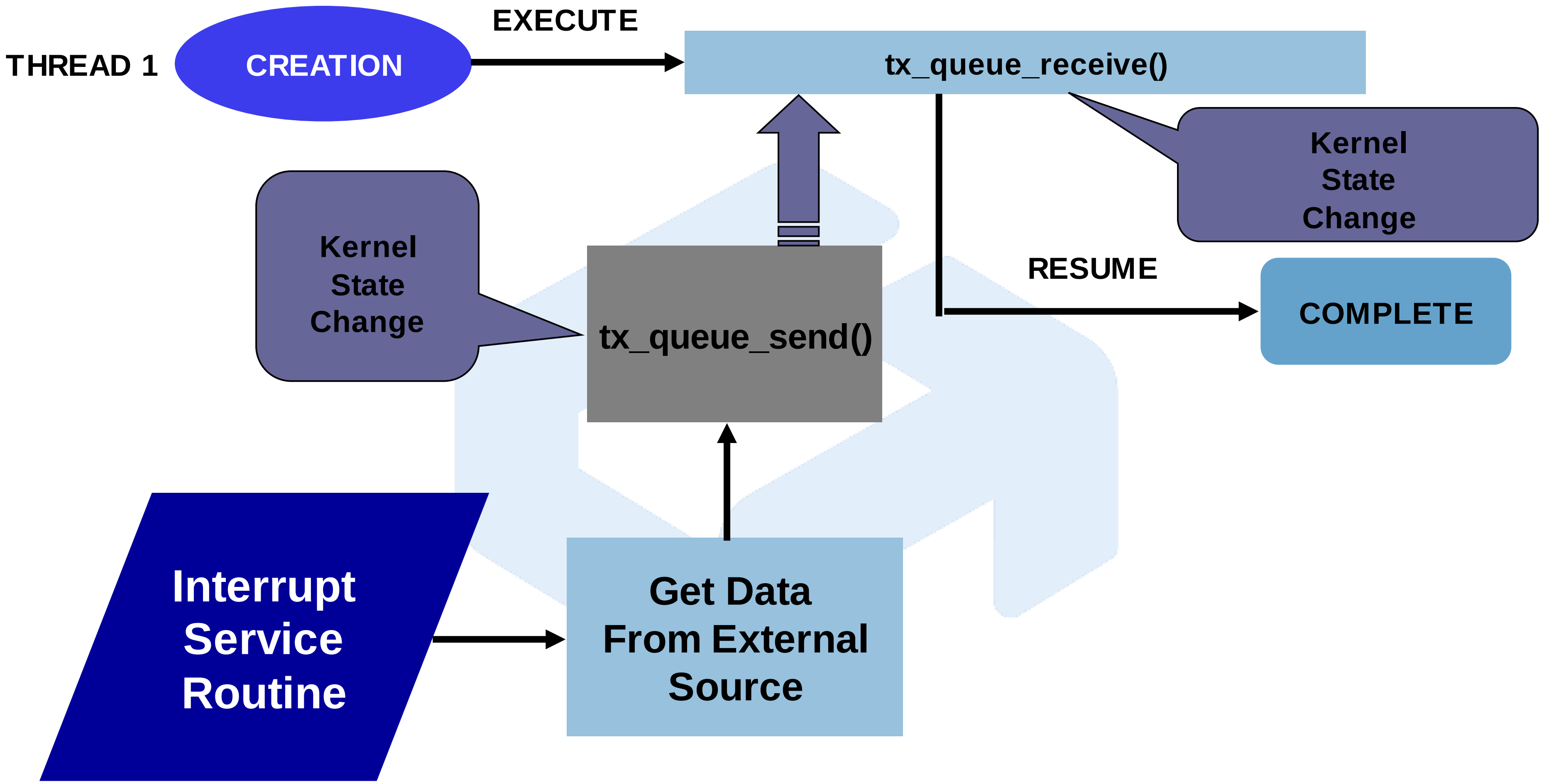
Message Queues - Conceptual



Message Queues-Implementation



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Example Message Queue

Declaration **TX_QUEUE Data_Queue;**

Name

Creation **status = tx_queue_create (&Data_Queue, "UDP Send Data", TX_2_ULONG, Message_Pointer, 8);**

Mailbox Location

Message Size

Send **status = tx_queue_send (&Data_Queue, package, TX_WAIT_FOREVER);**

Data

Wait Condition

Receive **tx_queue_receive(&Data_Queue, package, TX_WAIT_FOREVER);**

Message Queue Send/Receive

uint **tx_queue_send**(TX_QUEUE *pQueue, void *pSource, ulong waitOption)

- Sends a message to pQueue
- Possible values for waitOption include:
  - TX_NO_WAIT (0x0000 0000)
  - TX_WAIT_FOREVER (0xFFFF FFFF)
  - time-out value, in ticks (0x0000 0001 - 0xFFFF FFFE)

uint **tx_queue_receive**(TX_QUEUE *pQueue, void *pDestination, ulong waitOption)

- Retrieves a message from pQueue
- Possible values for waitOption include:
  - TX_NO_WAIT (0x0000 0000)
  - TX_WAIT_FOREVER (0xFFFF FFFF)
  - time-out value, in ticks (0x0000 0001 - 0xFFFF FFFE)

Message Queue Flush

uint **tx_queue_flush**(TX_QUEUE *pQueue)

- Deletes all messages in the queue, pQueue
- Threads (suspended) waiting for message from this queue are resumed, and given a status indicating the message send was successful

Queue Summary

- Message Queue attributes
  - Queue information maintained in queue control blocks, TX_QUEUE
  - Size specified during call to tx_queue_create()
  - Queues implemented as FIFOs
- Message Queue APIs
  - tx_queue_create() / tx_queue_delete()
  - tx_queue_send() / tx_queue_receive()
  - tx_queue_flush()

4.6 Timers

Timers

- ThreadX supports both one-shot and periodic timers
- Hardware must generate periodic interrupts for proper timer functionality
- Timers are executed in the order they become active
- Timer control blocks, TX_TIMER, often defined globally
- Timers can be located anywhere in memory
- A Hardware Timer is used to derive the System Tick Rate
- The Timer is fix and can not be changed
- The System Tick Rate determines how oftenthe Scheduler will be called
- The System Tick Rate is set with #define
  BSP_TICKS_PER_SECOND which defaults to 100

Note: Increasing the Tick Rate increases the CPU time spent inside the Scheduler

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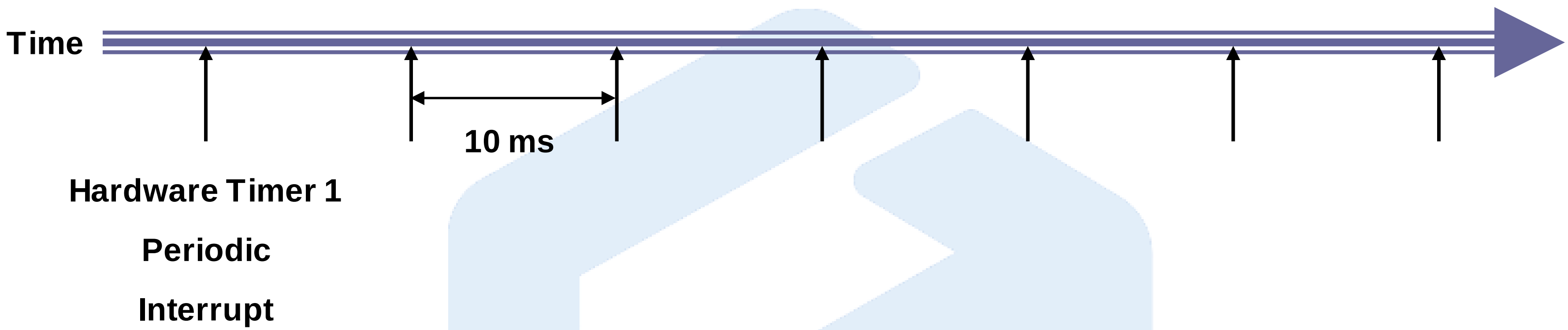
Timer Functionality

Background Information – Net+OS Operation



This is How the Operating System Handles All Time-Related Functionality.

- **Timeouts**
- **Sleeps**
- **Time Slices**

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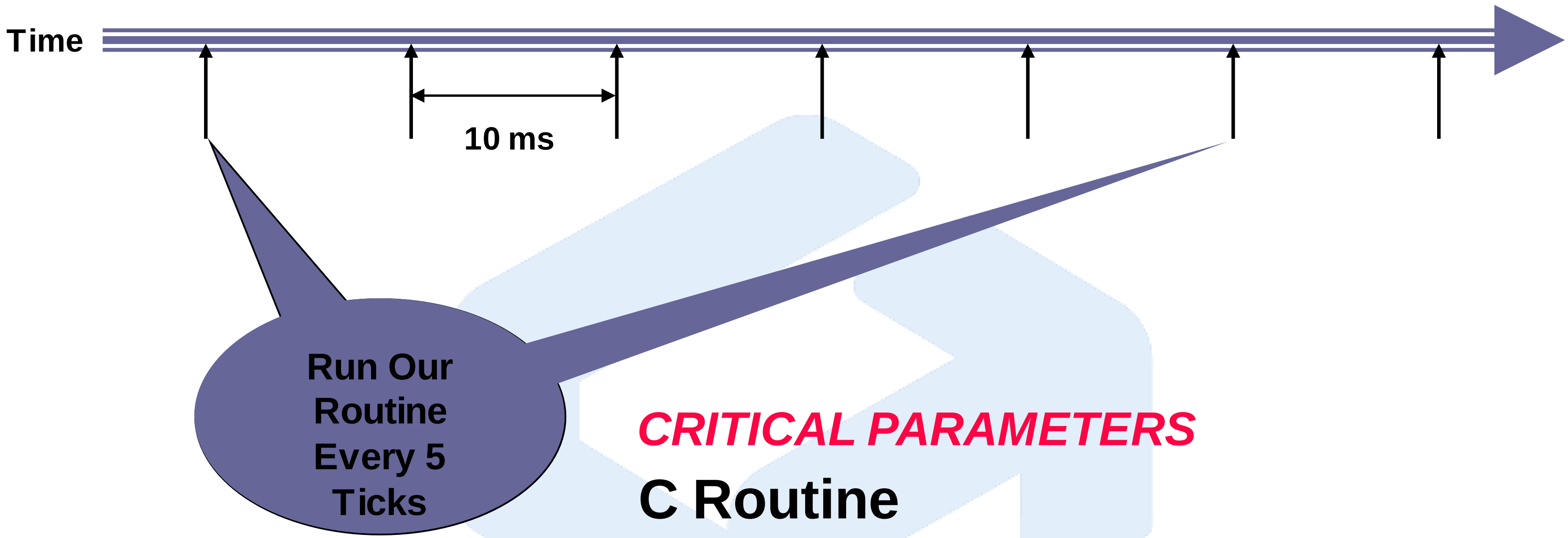
Application Timers



CRITICAL PARAMETERS

C Routine
Entry Parameter
Start Delay
Frequency

tx_timer_create()

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Timer Create/Delete

uint **tx_timer_create**(TX_TIMER *pTimer, char *pName, void *pExpirationFunc(ulong), ulong expirationInput, ulong initialTicks, ulong rescheduleTicks, uint autoActivate)

- Creates a timer that executes pExpirationFunc upon timer expiry
- Initial ticks can range from 0x0000 0001 – 0xFFFF FFFF
- Timer created in TX_AUTO_ACTIVATE or TX_NO_ACTIVATE states
- Assign 0 to rescheduleTicks to make the timer 'one-shot', otherwise rescheduleTicks indicates the timer period *after* the first period

uint **tx_timer_delete**(TX_TIMER *pTimer)

- Deletes the specified timer, pTimer
- Application's responsibility to prevent threads from using a deleted timer

Timer Activate/Deactivate/Change

uint **tx_timer_activate** (TX_TIMER *pTimer)

– Activates the specified timer, pTimer

uint **tx_timer_deactivate** (TX_TIMER *pTimer)

– Deactivates the specified timer, pTimer

uint **tx_timer_change**(TX_TIMER *pTimer, ulong initialTicks, ulong rescheduleTicks)

– Changes the expiration attributes of the specified timer, pTimer
– Timer must be deactivated before calling this routine, and activated later to restart

Timer Summary

- Timer attributes
  - Timer information maintained in timer control blocks, TX_TIMER
  - Timers can have a different initial expiry time than their periodic rate
- Timer APIs
  - tx_timer_create() / tx_timer_delete()
  - tx_timer_activate() / tx_time_deactivate()
  - tx_timer_change()

System Tick Timer Implementation

- Initialization takes place in bsptimer.c in functionnetosSetupSystemClock()

```
void netosSetupSystemClock (void)
{
   /* Declaration for standard ThreadX timer ISR. */
   extern int _tx_timer_interrupt (void *);
#ifdef NS9750
   MCSetTimerClockSelect(THREADX_TIMER, 0);    /* set timer clock #0 select to CPU */
   MCSetTimerMode(THREADX_TIMER,0);            /* set timer clock #0 to internal timer */
   MCSetTimerInterruptSelect(THREADX_TIMER,1); /* enable timer clock #0 interrupt */
   MCSetTimerUpDownSelect(THREADX_TIMER,1);    /* set timer clock #0 as a downcounter */
   MCSetTimerBit(THREADX_TIMER, 1);            /* set timer as 32 bit timer */
   MCSetTimerReloadEnable(THREADX_TIMER, 1);   /* set timer reload enable */
   MCReloadTimerCounter(THREADX_TIMER, THREADX_TIMER0_RELOAD_VALUE);

   /* netosInstallTimer0Isr (_tx_timer_interrupt); */
   MCInstallIsr(TIMER0_INTERRUPT, _tx_timer_interrupt, NULL);
   MCEnableTimer(THREADX_TIMER);
#else
...
```

4.7 Other Kernel Services

Other Kernel Services

- Allows the user to initialize the system clock to a known value
- Allows the user to get the current value of the system clock
- Allows the user to enable/disable interrupts

Time Get/Set

ulong **tx_time_get** (void)

- Returns the contents of the internal system clock
- System clock initialized to 0 during system startup

void **tx_time_set**(ulong newTimer)

- Sets the internal system clock
- Valid ranges are 0x0000 0000 – 0xFFFF FFFF

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Interrupt Control

uint **tx_interrupt_control**(uint interruptPosture)

- Enables or disables interrupts depending upon the input, TX_INT_ENABLE or TX_INT_DISABLE
- The interruptPosture is part of a thread's context
- This should NOT be called during system initialization

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Kernel Services Summary

- Kernel Service APIs
  - tx_time_set() / tx_time_get()
  - tx_interrupt_control()

Summary

Bringing up the ThreadX Kernel …

- … is quite easy
- Assumes a properly initialized C runtime environment (this is usually the case when entering main())
- Starting the ThreadX Kernel only needs a call to tx_kernel_enter()
- Besides that a function of name tx_application_define() must be declared
- tx_application_define is called from within the ThreadX library

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Bringing up the ThreadX Kernel (cont.)

tx_application_define() example implementation:

```
void tx_application_define(void *first_unused_memory)
{
    /* Setup ThreadX tick timer for a 1 ms tick period */
    SetupOsTimer(OS_TICKRATE);

    /* Create the root thread.  */
    tx_thread_create(&rootThreadCB,              /* control block for thread */
                     "rootThread",               /* thread name              */
                     rootThread,                 /* entry function           */
                     0,                          /* parameter                */
                     rootThreadStack,            /* start of stack           */
                     THREAD_STACK_SIZE,          /* size of stack            */
                     1,                          /* priority                 */
                     1,                          /* preemption threshold     */
                     1,                          /* time slice threshold     */
                     TX_AUTO_START);             /* start immediately        */
}
```

Bringing up the ThreadX Kernel (cont.)

Setting up the System Tick Timer (NS7520):

```
int SetupOsTimer( unsigned long ticksPerSecond )
{
    unsigned long tmp;

    if (ticksPerSecond < 1)
          return (OS_TIMER_EINVAL);

    *(unsigned long *)0xffb00010 = 0;           /* use IRQ not FIQ to interrupt */
    *(unsigned long *)0xffb00010 |= 0x08000000; /* use sys clock as clock source */

    tmp = (55000000 / ticksPerSecond) - 1;
    *(unsigned long *)0xffb00010 |= tmp;

    /*--- set handler ---*/
    SetIntHdlr(TIMER1_INT, _tx_timer_interrupt);

    *(unsigned long *)0xffb00030 |= 0x00000020; /* enable the interrupt in the  */
                                                /*   interrupt enable register. */
    *(unsigned long *)0xffb00010 |= 0x40000000; /* enable interrupt */
    *(unsigned long *)0xffb00010 |= 0x80000000; /* enable timer */

    return (OS_TIMER_ERR_OK);
}
```


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