Some of the content from these slides were adapted from the Crossbow Tutorials and from the TinyOS website from Mobsys Tutorials

Basic Structure

- **Interfaces** (xxx.nc)
  - Specifies functionality to outside world
  - what commands can be called
  - what events need handling

- **Software Components**
  - **Module** (xxxM.nc)
    - Code implementation
    - Code for **Interface** functions
  - **Configuration** (xxxC.nc)
    - Linking/wiring of components
    - When top level app, drop C from filename xxx.nc

Diagram:

```
Main.nc
   ↓
 appxxx.nc  ↓
   |     |     ↓
interfaceA.nc | interfaceB.nc
   ↓     ↓
interfaceA.nc  ↓
   |     |     ↓
comp1C.nc  comp2M.nc
   (wires) (code)
   ↓
interfaceB.nc
   ↓
comp3M.nc
   (code)
```
Creating a Module

- Key is defining your interfaces
- Can use "as" to name interface

```c
includes SkyRFIDef;
module SkyRFIDM {
    provides {
        interface StdControl as Control;
    }
    uses {
        interface Leds;
        interface Timer as UARTSender;
        interface Timer as WriteBufferUpdate;
        interface ReceiveMsg as ReceiveWriteRFM;
        interface SendMsg as SendReadRFM;
        interface ReceiveMsg as ReceiveReadRFM;
    }
    implementation {
        TOS_Msg sendBuffer;
        TOS_MsgPr sendMsg;
        bool nextState;
    }
}
```

Interfaces

- Specifies the behavior between **components**.
- Bi-directional multi-function interaction channel between two components.
  - Allows a single interface to represent a complex event
    - E.g., a registration of some event, followed by a callback
    - Critical for non-blocking operation
  - Provided interfaces
    - Represent the functionality that the component provides to its user
    - "**Commands**" are functions to be implemented by the interface’s provider
  - Used interfaces
    - Represent the functionality that the component needs
    - "Events" are functions to be implemented by the interface’s user
Execution Flow

- Events generated by interrupts preempt tasks
- Tasks do not preempt tasks

FSM

- Finite State Machine Programming Style
  - Event-driven structure throughout application
- All operations are non-blocking
- Tasks extend processing outside event window
- Split Phase Operation (next slide)

- Need logical concurrency at many levels
- Meet hard timing constraints (e.g. radio)
Split Phase Operations

- **Component 1**
  - Call Command
  - Return value = okay or busy

- **Component 2**
  - Return busy else
  - Post Task return okay
  - Task ()
  - Signal done

Done event pass data through parameters
Okay, failed, etc.

Concurrency Model

- **Asynchronous Code (AC)**
  - Any code that is reachable from an interrupt handler
- **Synchronous Code (SC)**
  - Any code that is ONLY reachable from a task
  - Boot sequence
- **Potential race conditions**
  - Asynchronous Code and Synchronous Code
  - Asynchronous Code and Asynchronous Code
  - Non-preemption eliminates data races among tasks
- **nesC reports** potential data races to the programmer at compile time (new with version 1.1)
- Use “atomic” statement when needed
- “Async” keyword is used to declare asynchronous code
TinyOS Active Messages

- **Sending**
  - Declare buffer storage in a frame
  - Request Transmission
  - Handle Completion signal
  - **Buffer Management:**
    - After done event can reuse buffer
      
      ```
      call SendMsg.send(TOS_BCAST_ADDR, 14, &data)
      ```
- **Receiving**
  - Declare a handler to perform action on message event
  - Active message automatically dispatched to associated handler
    - Known format
    - No run-time parsing
  - **Buffer Management:**
    - Must return free buffer to the system for the next packet reception
    - Typically the incoming buffer if processing complete

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**Receive Buffers**

- **Your Module**
  - TOS_Msg Buffer 1
    - Declared in Your Module

- **Radio Stack**
  - TOS_Msg Buffer 2
    - Declared in Radio Stack

- **?**
TinyOS uses Pointers

Remember TinyOS acts like a Finite State Machine

event result_t Timer.fired()
{
    TOS_Msg buffer;
    buffer.data[0] = 1;
    call SendMsg.send(TOS_BCAST_ADDR, 1, &buffer);
    return SUCCESS;
}

What is wrong?

File Locations

- Distribution broken into
  - apps: top-level applications
  - lib: shared application components
  - system: hardware independent system components
  - platform: hardware dependent system components
    - includes HPLs and hardware.h
Platform Folder

- Location of details of the Hardware Layer
  - Most files have the HPL prefix
- Each type of platform has its own subfolder where platform specific files are pulled from.
  (e.g. HPLUARTM, CC1000RadioC, HPLADCM)
- ‘platform’ file in platform directory
  - lists common platforms
  - allows compiler to pull from those platform directories second.
- ‘hardware.h’ is where the pins are mapped
- ‘avrhardware.h” is where the macro’s are defined

Pin Assignments

- Macros used to declare pins
  - `TOSH_ASSIGN_PIN(RED_LED, A, 2);`
- This gives a set of macro’s that can be called
  - `TOSH_SET_RED_LED_PIN()`
  - `TOSH_CLR_RED_LED_PIN()`
  - `TOSH_MAKE_RED_LED_OUTPUT()`
  - `TOSH_MAKE_RED_LED_INPUT()`
Questions

- Open Discussion