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Laboratorio di Sistemi Wireless

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Outline

- The BlinkToRadio Application
- Mote-PC serial communication
- BaseStation
- SerialForwarder

BlinkToRadio Application

- A counter is incremented every second
- Whenever the timer fires, the value of the counter is sent over a radio message
- Whenever a radio message is received, the three least significant bits of the counter in the message payload are displayed on the LEDs

Exercise 1

- Assign an unique ID to your nodes
- Filter radio messages that are not sent to you

Exercise 2

- Node A sends the value of its counter to node B
- Node B displays the three least significant bits of the counter on the LEDs, updates the value of the counter and sends it back to node A
- Node A displays the three least significant bits of the counter on the LEDs, updates the value of the counter and sends it back to node B
- ….

Mote-Pc Serial Communication

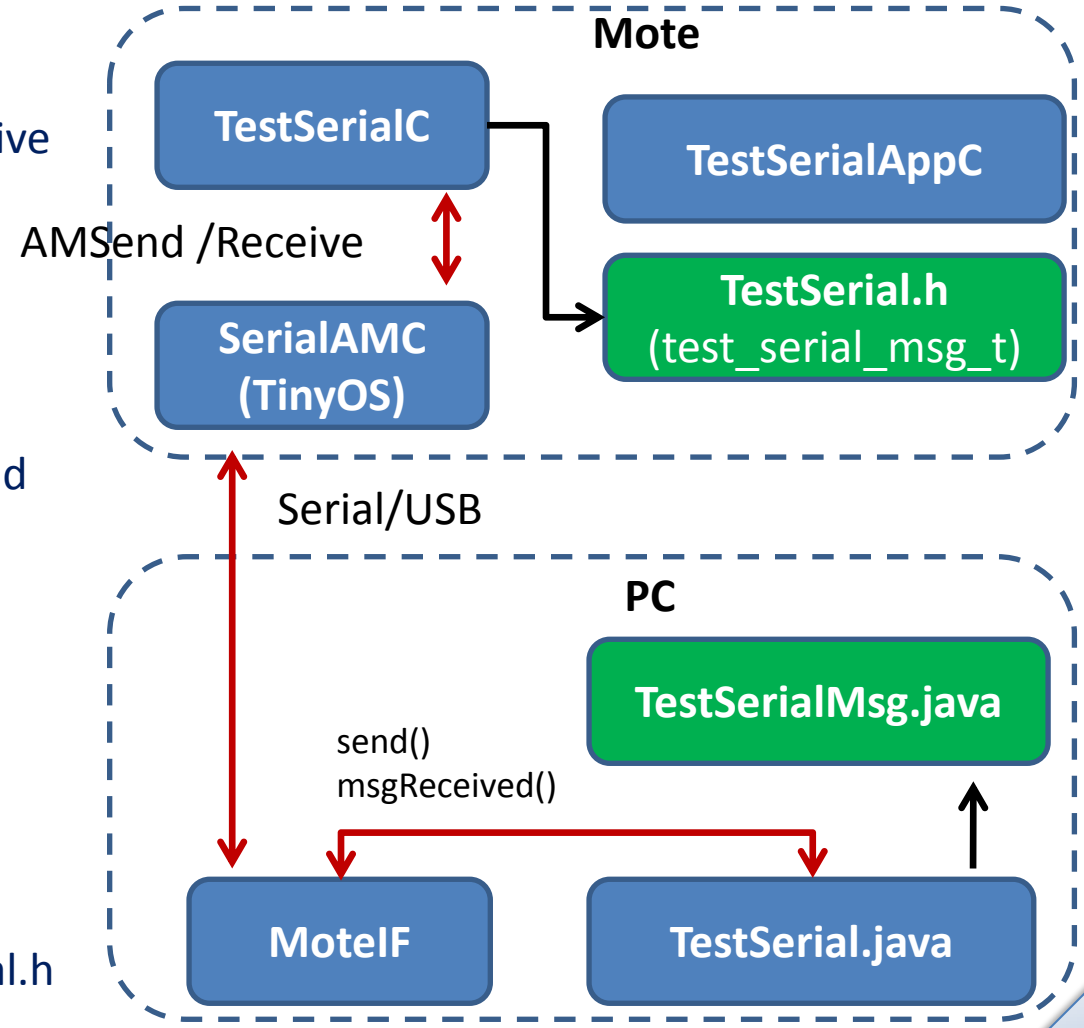
- TinyOS provides high-level communication interfaces
  - Similar for radio and serial communication
- Basic interfaces:
  - Packet: Set/get payload of TinyOS message_t packets
  - Send: Send packet by calling send() command
  - Receive: Reception of packets signaled by receive() event
- Active Message interfaces allow for multiplexing:
  - AMPacket: Provide source and destination address to packet
  - AMSend: Send packet to destination address

TestSerial Application

- Mote and PC components
  - Both increment counter values and send to the other
- Mote: nesC and TinyOS
  - Outputs last three bits of PC counter value to LEDs
- PC: Java and TinyOS Java libraries
  - Outputs mote counter value to stdout
- Demonstration

TestSerial

- TestSerialC
  - Interfaces AMSend, Receive wired to TinyOS serial component
- test_serial_msg_t
  - Payload struct
- MoteIF
  - TinyOS Java library to send and receive packets
- TestSerial.java
  - Prints received counter values
  - Increments and sends counter values
- TestSerialMsg.java
  - Payload encapsulation
  - Generated from TestSerial.h



Packet Payload Format

- Usually defined in C header file (TestSerial.h)
- nx-types abstract away big/little endian hardware/communication differences
- Default payload size is 29 bytes, but can be enlarged
- Active Message type AM_TEST_SERIAL_MSG
  - Integer value to distinguish between multiple packet types (multiplexing)
- TinyOS libraries convert struct to a Java class with set/get methods (TestSerialMsg.java)
  - Message Interface Generator (example in TestSerial Makefile)

```
// TestSerial.h
typedef nx_struct test_serial_msg
{
  nx_uint16_t counter;
} test_serial_msg_t;

enum { AM_TEST_SERIAL_MSG=6; }
```

TestSerialAppC: wiring

- SerialActiveMessageC allows for multiplexing
  - Multiple packet types (e.g. sensor control and data)
  - Differentiate through AM types: AM_TEST_SERIAL_MSG
  - Parameters defined in brackets []
- SerialActiveMessageC provides several interfaces
  - Wired to TestSerialC
  - SplitControl to turn on and off the UART/serial bus
  - AMSend and Receive for transmitting and receiving
  - Packet to set and get payload

```
configuration TestSerialAppC {}
implementation {
  components SerialActiveMessageC as AM, SplitControl;
  ...
  App.Receive -> AM.Receive[AM_TEST_SERIAL_MSG];
  App.AMSend -> AM.AMSend[AM_TEST_SERIAL_MSG];
  App.Control -> AM;
  App.Packet -> AM;
}
```

TestSerialC: Booting

- When mote boots, turn on UART
- When UART is powered, start timer to send packets
- Implement Control.stopDone() to turn off UART

```
event void Boot.booted() {
  call Control.start();
}
event void Control.startDone(error_t err) {
  if (err == SUCCESS) {
    call MilliTimer.startPeriodic(1000);
  }
}
event void Control.stopDone(error_t err) {}
```

TestSerialC: Sending Packets

- Timer fires, increment counter
- Get message_t payload pointer: Packet.getPayload();
- Set payload value: rcm->counter = counter;
- Send packet: AMSend.send();
  - Provide AM destination address, message_t packet address, payload size
- Packet sent: AMSend.sendDone();

```
event void MilliTimer.fired() {
  counter++;
  message_t packet;
  test_serial_msg_t* rcm = (test_serial_msg_t*)call
…Packet.getPayload(&packet, sizeof(test_serial_msg_t));

  rcm->counter = counter;
  call  AMSend.send(AM_BROADCAST_ADDR, &packet,
…sizeof(test_serial_msg_t));
  }

event void AMSend.sendDone(message_t* bufPtr, error_t error){
}
```

TestSerialC: Receiving Packets

- Packet received: Receive.receive();
  - Provides message_t packet, payload pointer, and payload size
  - Get payload: cast from void* to test_serial_msg_t*
  - Set LEDs according to value of last 3 bits

```
event message_t* Receive.receive(message_t* bufPtr, void* payload, uint8_t
…len){
  test_serial_msg_t* rcm = (test_serial_msg_t*)payload;
  if (rcm->counter & 0x1) {
    call Leds.led0On();
  }
  // turn on other LEDs accordingly
  ...
  return bufPtr;
}
```

PC: TestSerial.java

- Initialization
  - Create packet source from args[]: “-comm serial@\dev\ttyUSB0:telosb ”
  - Register packet listener for TestSerialMsg and source
- Send packets

```
public class TestSerial implements MessageListener {
  private MoteIF moteIF;

  public static void main(String[] args) throws Exception {
    ...
    String source = args[1]; PhoenixSource phoenix =
…BuildSource.makePhoenix(source, PrintStreamMessenger.err);
    MoteIF mif = new MoteIF(phoenix);
    TestSerial serial = new TestSerial(mif);
    serial.sendPackets();
  }

  public TestSerial(MoteIF moteIF) {
    this.moteIF = moteIF;
    this.moteIF.registerListener(new TestSerialMsg(), this);
  }
```

TestSerial.java: send packets

- Initialize counter and create TestSerialMsg payload
- While loop
  - Increment counter and sleep for some period
  - Set payload counter: payload.set_counter();
  - Send packet: moteIF.send(); with destination address 0

```
public void sendPackets() {
  int counter = 0;
  TestSerialMsg payload = new TestSerialMsg();
  ...
  while (true) {
    ...
    // increment counter and wait for some amount of time before sending
    System.out.println("Sending packet " + counter);
    payload.set_counter(counter);
    moteIF.send(0, payload);
  }
}
```

TestSerial.java: receiving packets

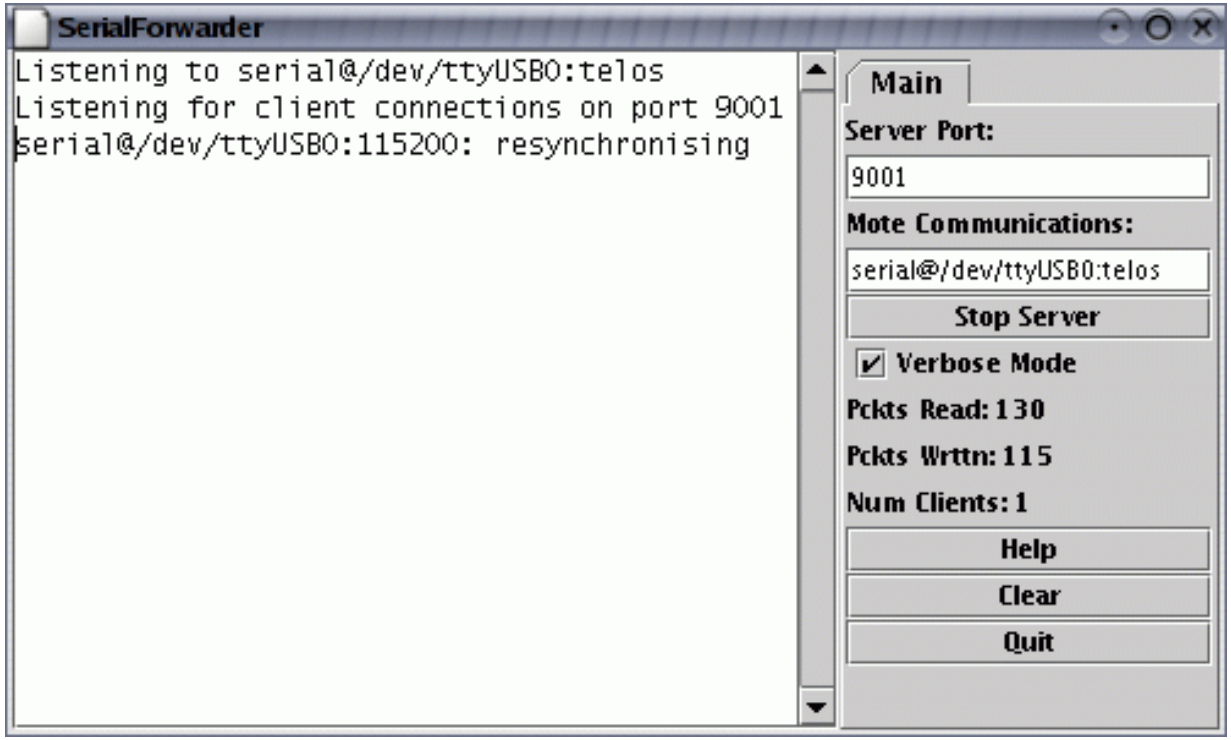
- TestSerial.messageReceived() triggered by incoming packet while listener is registered
  - Provides AM destination address and abstract class Message
- Cast message to TestSerialMsg
- Retrieve counter: msg.get_counter();

```
public void messageReceived(int to, Message message) {
  TestSerialMsg msg = (TestSerialMsg)message;
  System.out.println("Received packet sequence number " +
…msg.get_counter());
}
```

Serial Forwarder

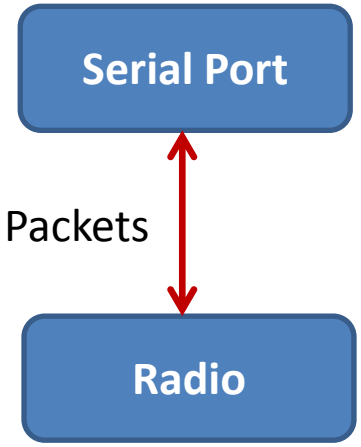
Instead of connecting to the serial port directly, applications connect to the SerialForwarder, which acts as a proxy to read and write packets

```
java net.tinyos.sf.SerialForwarder -comm serial@/dev/ttyUSB0:telosb
```



Base Station

It is a basic TinyOS utility application. It acts as a bridge between the serial port and radio network.



BlinkToRadio

- **Destination address** (2 bytes)
- **Link source address** (2 bytes)
- **Message length** (1 byte)
- **Group ID** (1 byte)
- **Active Message handler type** (1 byte)
- **Payload** (up to 28 bytes):
  - **source mote ID** (2 bytes)
  - **sample counter** (2 bytes)

```
typedef nx_struct BlinkToRadioMsg {
        nx_uint16_t nodeid;
        nx_uint16_t counter;
} BlinkToRadioMsg;
```

$ java net.tinyos.tools.Listen -comm serial@/dev/ttyUSB0:telosb

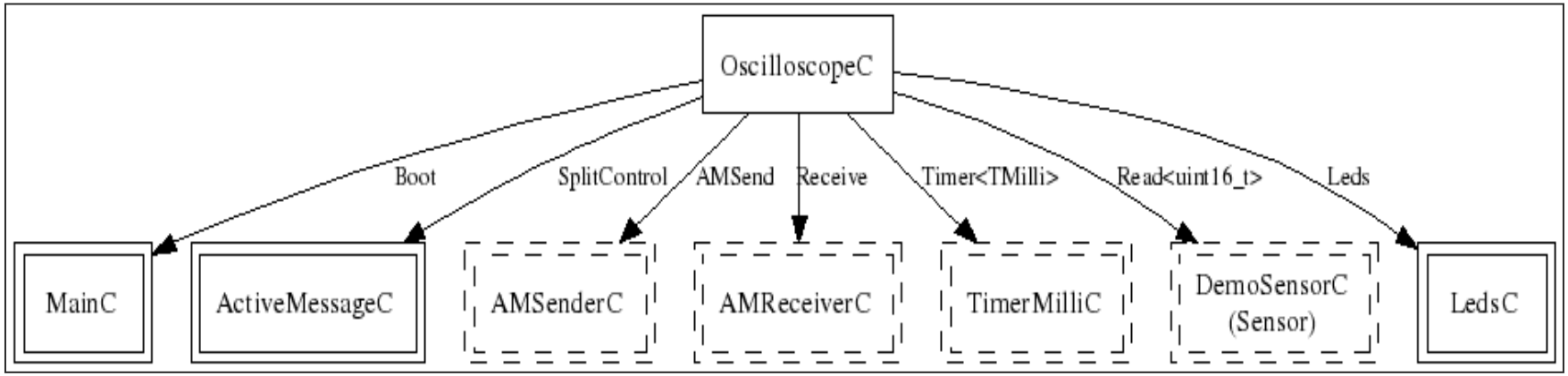
dest addr	link source addr	msg len	groupID	handlerID	source addr	counter
ff ff	00 00	04	22	06	00 02	00 0B

Oscilloscope

- Periodically samples the default sensor via (DemoSensorC) and broadcasts a message with 10 accumulated readings over the radio.
- Application Components
  - *OscilloscopeAppC (Configuration), OscilloscopeC (Module)*
    - *BaseStation*
- System Components
  - *MainC, LedsC, TimerMilliC, DemoSensorC*
  - *AMReceiverC, AMSenderC, ActiveMessageC*

Oscilloscope

- OscilloscopeAppC: components' graph



Oscilloscope

- Oscilloscope.h

```
enum
{
  NREADINGS = 10,
  DEFAULT_INTERVAL = 256,
  AM_OSCILLOSCOPE = 0x93
};

typedef nx_struct oscilloscope
{
  nx_uint16_t version;     /* Version of the interval.
*/
  nx_uint16_t interval;    /* Sampling period. */
  nx_uint16_t id;      /* id of sending mote. */
  nx_uint16_t count;       /* The readings are samples
count *                NREADINGS onwards */
  nx_uint16_t readings[NREADINGS];
} oscilloscope_t;
```

Oscilloscope

- OscilloscopeAppC.nc

```
#include "Oscilloscope.h"

configuration OscilloscopeAppC { }
implementation {
  components OscilloscopeC, MainC, ActiveMessageC,
LedsC,
  new TimerMilliC(), new DemoSensorC() as Sensor,
  new AMSenderC(AM_OSCILLOSCOPE),
  new AMReceiverC(AM_OSCILLOSCOPE);

  OscilloscopeC.Boot -> MainC;
  OscilloscopeC.RadioControl -> ActiveMessageC;
  OscilloscopeC.AMSend -> AMSenderC;
  OscilloscopeC.Receive -> AMReceiverC;
  OscilloscopeC.Timer -> TimerMilliC;
  OscilloscopeC.Read -> Sensor;
  OscilloscopeC.Leds -> LedsC;
}
```

Oscilloscope

- OscilloscopeC.nc

```
#include "Timer.h"
#include "Oscilloscope.h"
module OscilloscopeC{
  uses {
    interface Boot;
    interface SplitControl as RadioControl;
    interface AMSend;
    interface Receive;
    interface Timer<TMilli>;
    interface Read<uint16_t>;
    interface Leds;}
}
implementation{
  message_t sendBuf;
  bool sendBusy;
  oscilloscope_t local;
  uint8_t reading;
  bool suppressCountChange;
```

Oscilloscope

- OscilloscopeC.nc

```
 // Utility C-style functions
  void report_problem() { call Leds.led0Toggle(); }
  void report_sent() { call Leds.led1Toggle(); }
  void report_received() { call Leds.led2Toggle(); }
  void startTimer()
  {call Timer.startPeriodic(local.interval); reading =
0;}

  event void Boot.booted() {
    local.interval = DEFAULT_INTERVAL;
    local.id = TOS_NODE_ID;
    if (call RadioControl.start() != SUCCESS)
      report_problem();
  }

  event void RadioControl.startDone(error_t error) {
    startTimer();
  }
  event void RadioControl.stopDone(error_t error) {}
```

Oscilloscope

- OscilloscopeC.nc

```
  event void Timer.fired(){
    if (reading == NREADINGS)
    {
       if (!sendBusy&&sizeof local <= call
AMSend.maxPayloadLength())
       {
     memcpy(call AMSend.getPayload(&sendBuf,
                sizeof(local)), &local, sizeof local);
     if (call AMSend.send(AM_BROADCAST_ADDR, &sendBuf,
            sizeof local) == SUCCESS) sendBusy = TRUE;
    }

    if (!sendBusy) report_problem();
    reading = 0;
    if (!suppressCountChange) local.count++;
    suppressCountChange = FALSE;
    }
    if (call Read.read() != SUCCESS) report_problem();
  }
```

Oscilloscope

- OscilloscopeC.nc

```
 event void Read.readDone(error_t result, uint16_t
data)
 {
    if (result != SUCCESS)
    {
    data = 0xffff;
    report_problem();
    }
    local.readings[reading++] = data;
  }
}
```

Oscilloscope

- OscilloscopeC.nc

```
 event void AMSend.sendDone(message_t* msg, error_t error)
 { if (error == SUCCESS) report_sent();
   else report_problem();
   sendBusy = FALSE;}

 event message_t*
 Receive.receive(message_t* msg, void* payload, uint8_t
len)
 { oscilloscope_t *omsg = payload;
   report_received();

   if (omsg->version > local.version)
      {local.version = omsg->version;local.interval = omsg-
>interval;
    startTimer();}
   if (omsg->count > local.count)
      {local.count = omsg->count; suppressCountChange =
TRUE;}
    return msg;
  }
```