TinyOS on Mindstorms NXT: NXTMOTE

Motivation:

LEGO MINDSTORMS NXT is a widespread and affordable platform. It runs multiple operating systems: TinyOS can run on this platform as well. NXT features two MCUs: an ARM and an AVR.

The NXT platform has multiple sensors including motors to allow experimentation with dynamic (i.e.. moving) TinyOS nodes "out of the box".

MINDSTORMS NXT:

- **MCUs**
  - **ARM7**
    - **256 KB flash**
    - **64 KB SRAM**
    - **48 MHz**
  - **ATMEGA48**
    - **4KB flash**
    - **512 bytes SRAM**
    - **8 MHz**
- **Radio**
  - **Bluetooth**
- **Sensors**
  - **4 input ports for ARM**
  - **3 output ports for AVR**
  - **Various sensors available**
- **I/O**
  - **LCD**
  - **Push buttons**
- **Programming languages**
  - **nesC**
  - **Java**
  - **C**
  - **etc.**

A Flexible Platform for Embedded Machine Learning

- **Energy awareness**
  - **Use ARM7 HW DSP multiply & acc.**
  - **Inline**
  - **Unroll loop for low dim. problems**
  - **Local vs. remote computation**
- **Algorithm selection**
  - **Data centric algorithms**
  - **Sparse algorithms are useful for wireless sensors**
  - **Flexible memory consumption**
- **Algorithm adaptation (redefine objective functions)**
  - **Early stop**
- **Example with simple kernel machine and two nodes:**

```
event TOS_MsgPtr ReceiveMsg.receive(TOS_MsgPtr recv_packet) {
  Data *scamewdata = ((Data *)recv_packet->data);

  float a[NUM_SV][NUM_DIM] = {{1.0,1.0},{2.0,2.0}};
  float s[NUM_SV] = {1.0, 1.0};
  float y[NUM_SV] = {-1.0,1.0};
  float b = -3;
  float k = 0;
  float ma;
  int i,j;
  for(i = 0; i < NUM_SV; i++){
    for(j = 0; j < NUM_DIM; j++){
      k += y[i] * a[i] * a[i][j] * scamewdata->x[j];
    }
  }
  ma = k + b;
  call Leds.greenOff();
  call Leds.redOff();

  if(ma>0) // green led on +1 and red led on -1
    call Leds.greenOn();
  else
    call Leds.redOn();
  return recv_packet;
}
```

```
event result_t Timer.fired()
{
  if(TOS_LOCAL_ADDRESS == 0){
    Data *scamedataptr = (Data *)tos_msg.data;
    scamedataptr->sign = -1;
    scamedataptr->x[0] = 0.5; // See thesis p. 22-24
    scamedataptr->x[1] = 1.5;
    call SendMsg.send(1, sizeof(Data), &tos_msg);
    dbg(DBG_USR1, "In sendlist for node 0 and sizeof(Data)

  call Leds.yellowToggle();
  return SUCCESS;
}
```

NXTMOTE: TinyOS on NXT
(ongoing work)

- NXTMOTE Project
  - TinyOS running on NXT
  - Chipcon based radio sensor
  - Open source at http://nxtmote.sourceforge.net
- NXTMOTE News
  - July 2006: LEGO sponsors NXT Educational kit
  - Oct. 2006: Early access to open source (collaboration with Lego Education and Electronics R&D)
  - Nov. 2006: NXTMOTE boots (in PlatformP)
  - Nov. 2006: ARM GCC toolchain available
  - Dec. 2006: LEGO releases firmware as open source
  - Jan. 2007: EWSN poster session

Rasmus Ulslev Pedersen, nxtmote@gmail.com