

Embedded Programming Education with Lego Mindstorms NXT using Java (leJOS), Eclipse (XPAirtise), and Python (PyMite)

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en
School
SKOLEN



Tutorial 4

**Sunday, October 11, 2009, 14:00 to 18:30
(coffee break from 16:00 to 16:30)**

Inside the Open Source Lego Mindstorms NXT

Speakers:

- Rasmus Ulslev Pedersen (Department of Informatics at the University of Copenhagen School)

Abstract: The tutorial attendees will be presented with a technical introduction to the LEGO Mindstorms NXT. Alternative approaches to firmware and user-level programming will be introduced while continuously relating to the underlying hardware. The attendees will afterwards be able to choose between alternative approaches when performing future research, teaching, or community building with NXT.

[Slides of the tutorial](#)

Outline

- 1 Aim of Tutorial
- 2 Introduction
- 3 Open Source
- 4 Sensors
- 5 Inside NXT C 101
- 6 Firmware Programming
- 7 ARM7
- 8 NXT Software
- 9 Debugging NXT

LEGO MINDSTORMS

ESWEEK 2009
<http://nxtgcc.sf.net>



Outline

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Introduction
Open Source
Sensors
Inside NXT C 101
Firmware Programming
ARM7
NXT Software
Debugging NXT

NXT.2

History + helicopter view

- Source code + GCC
- CBS:
 - High school
 - 1 sem programming.
 - 3 sem OOA&D (wind meter)
 - Master thesis (Ultra Sensor w. custom firmware)

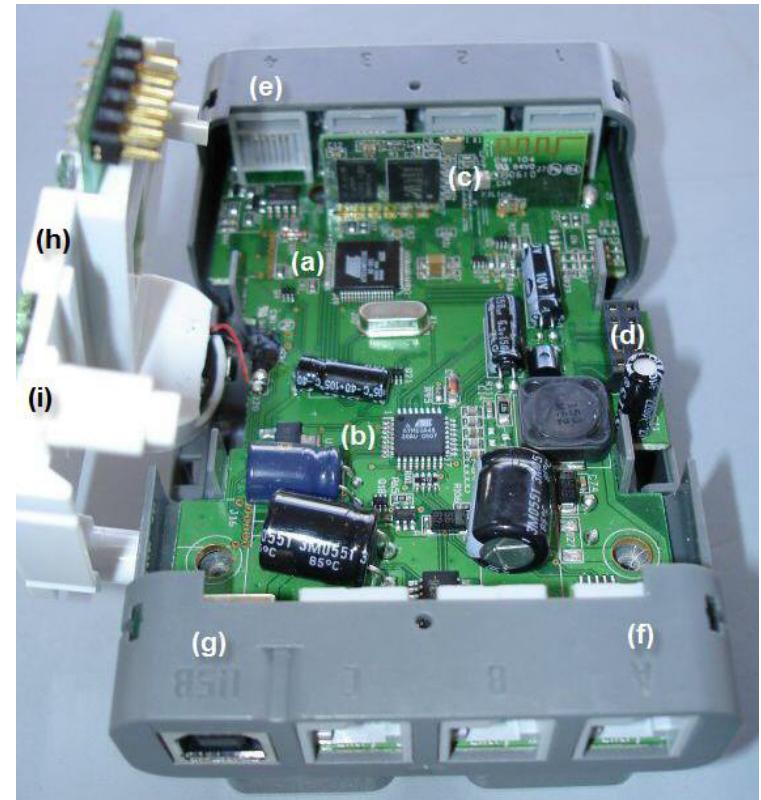


Motivation

- Embedded systems are **expensive** (for non-EE/CS schools)
- Sharing one means looking at the guy next to you programming
- Many schools already teach Java for application
- We have found a way to make embedded systems programming with Java easier and more affordable (CDIO?)

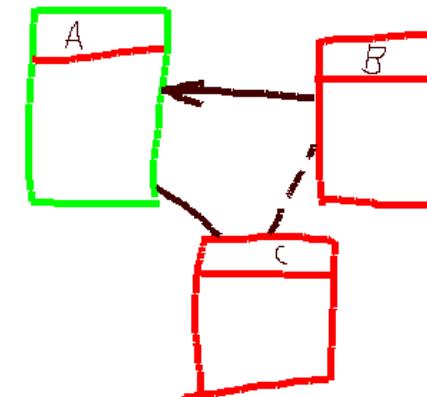
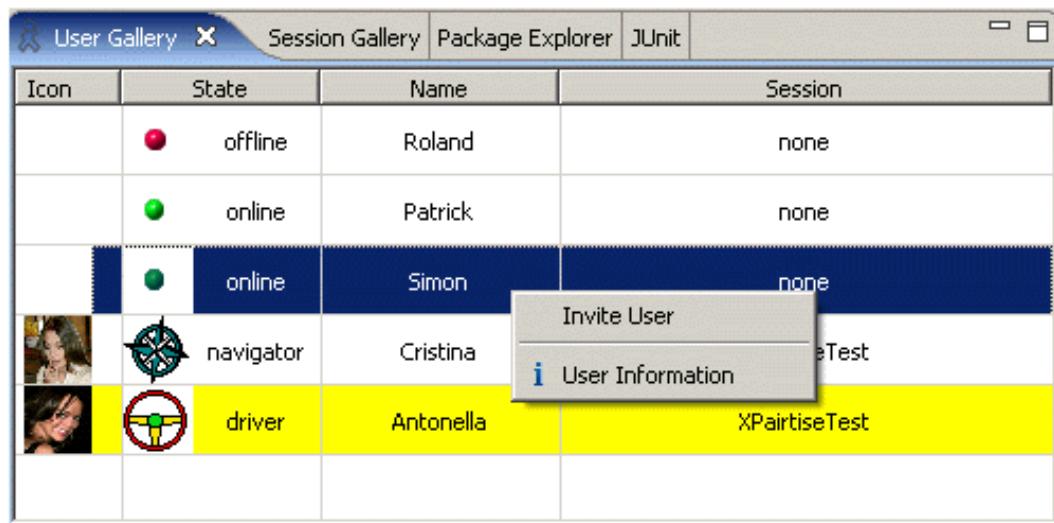
Problem & Solution

- The school have 10 workable (20) NXT sets for a class of many more students
- We have 40-80 students sharing them
- We decided to use NXT because it is open source



Component 1: Eclipse plugin

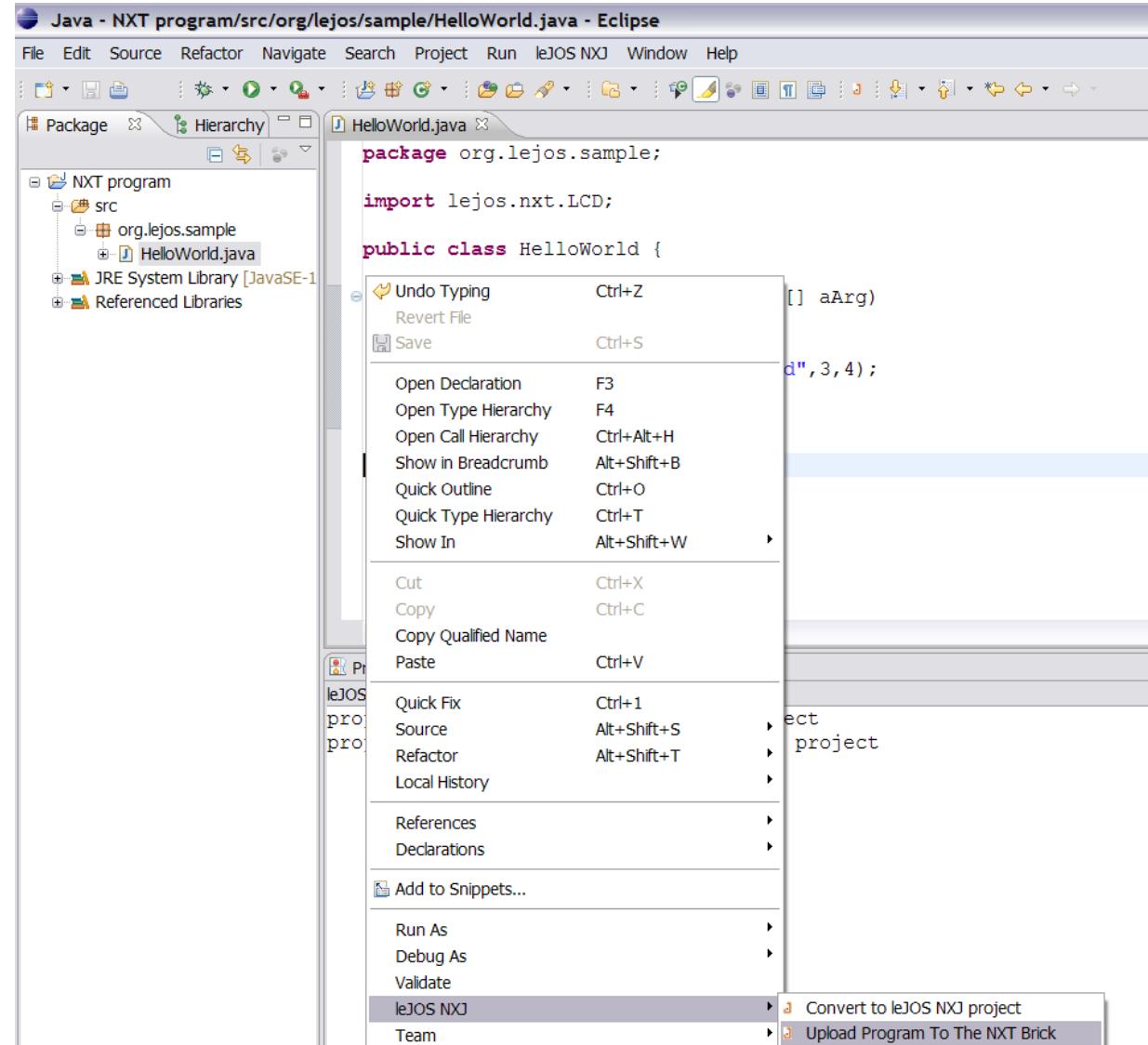
- We also use Eclipse which is an open source platform composed of plugins
- One plugin is called **Xpairtese**, and it is an Eclipse plugin that allows for distributed team programming
- The students change roles and one programs at a time



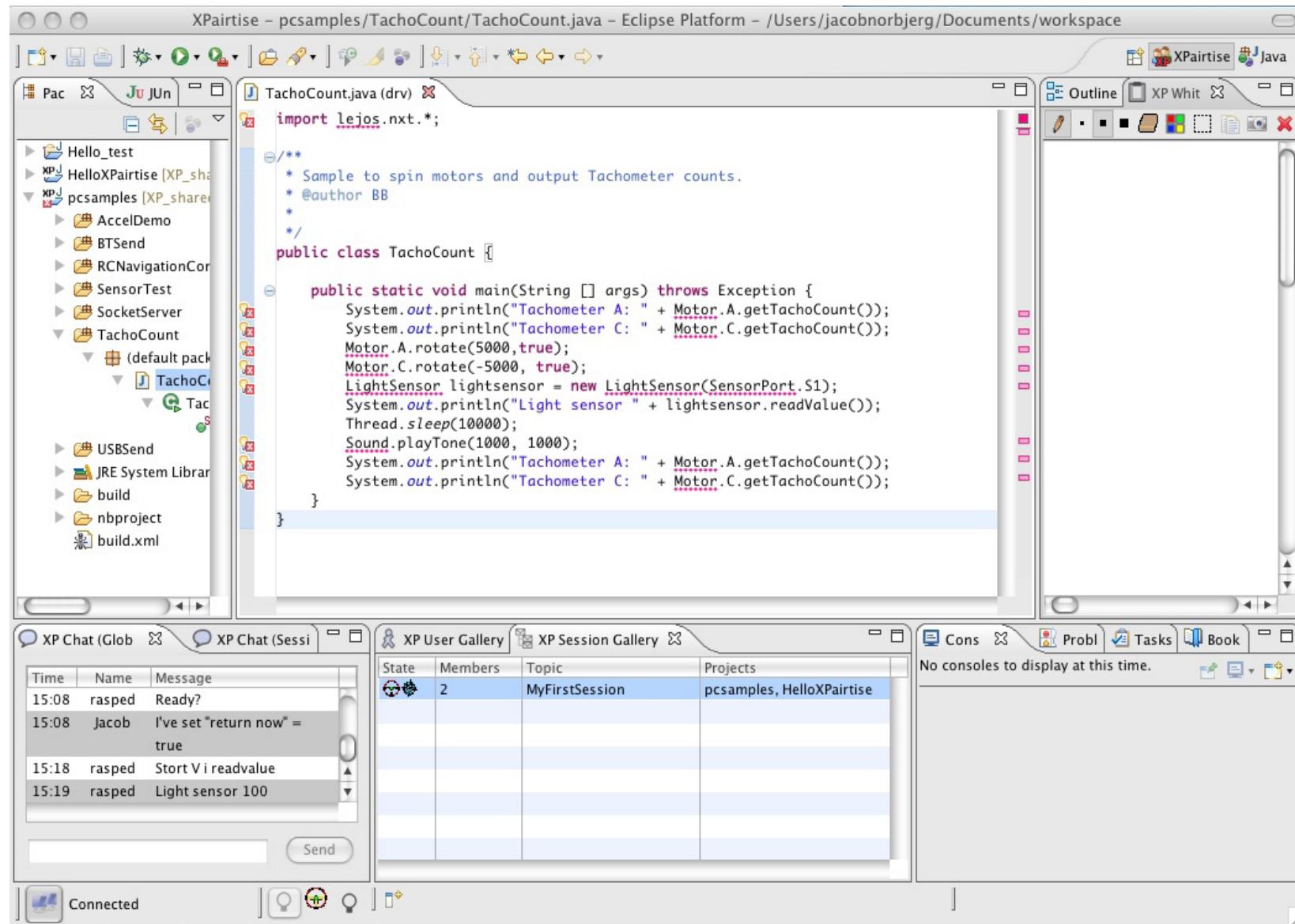
Component 2: Lejos

- Lejos is probably one of the best firmware replacements for LEGO MINDSTORMS NXT
- It is a programming environment for Java
- Students can get a quick start with Java
- The embedded systems students can program the ARM7 processor directly

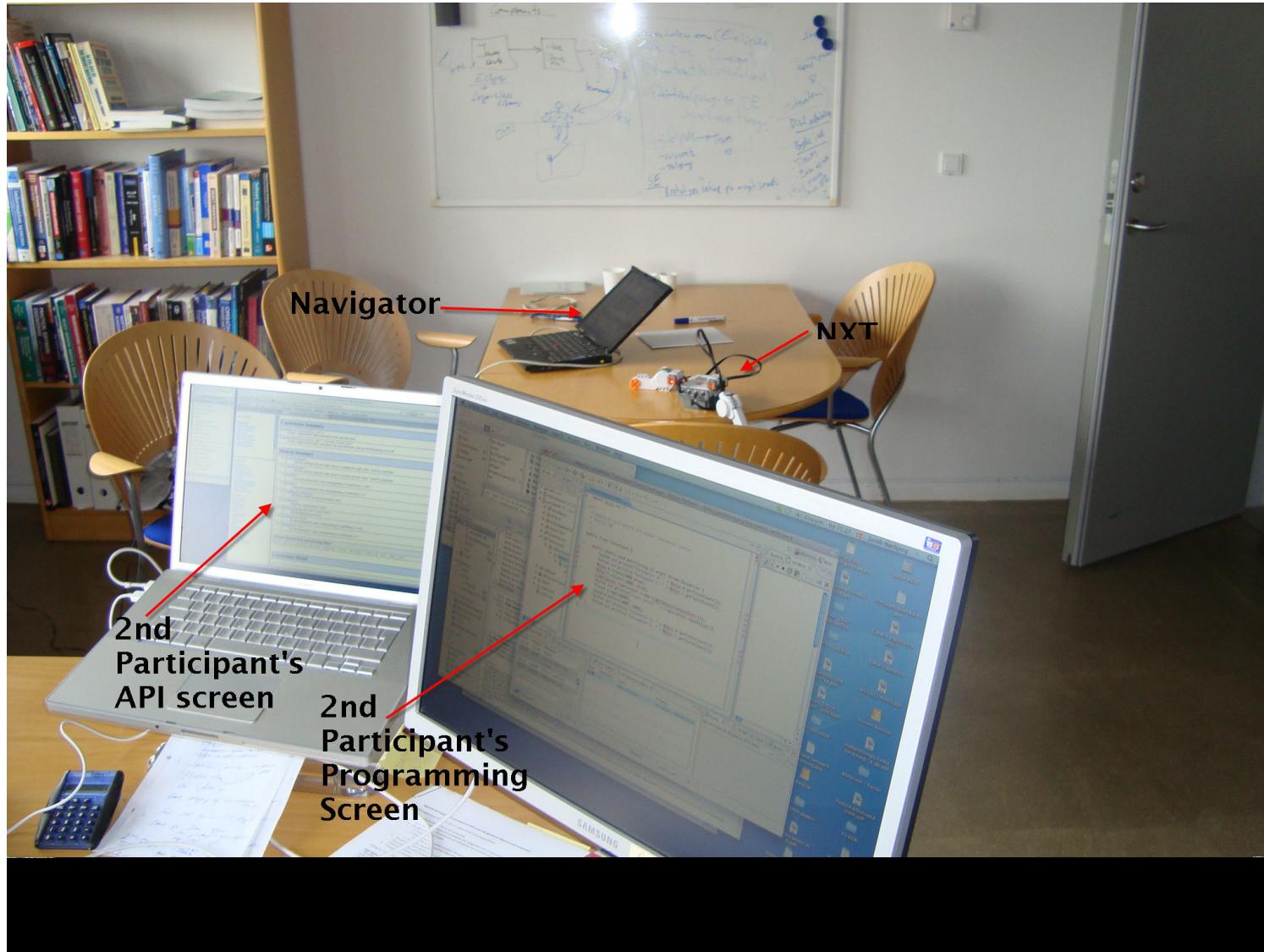
Lejos is used with Eclipse



Students can share the programming environment

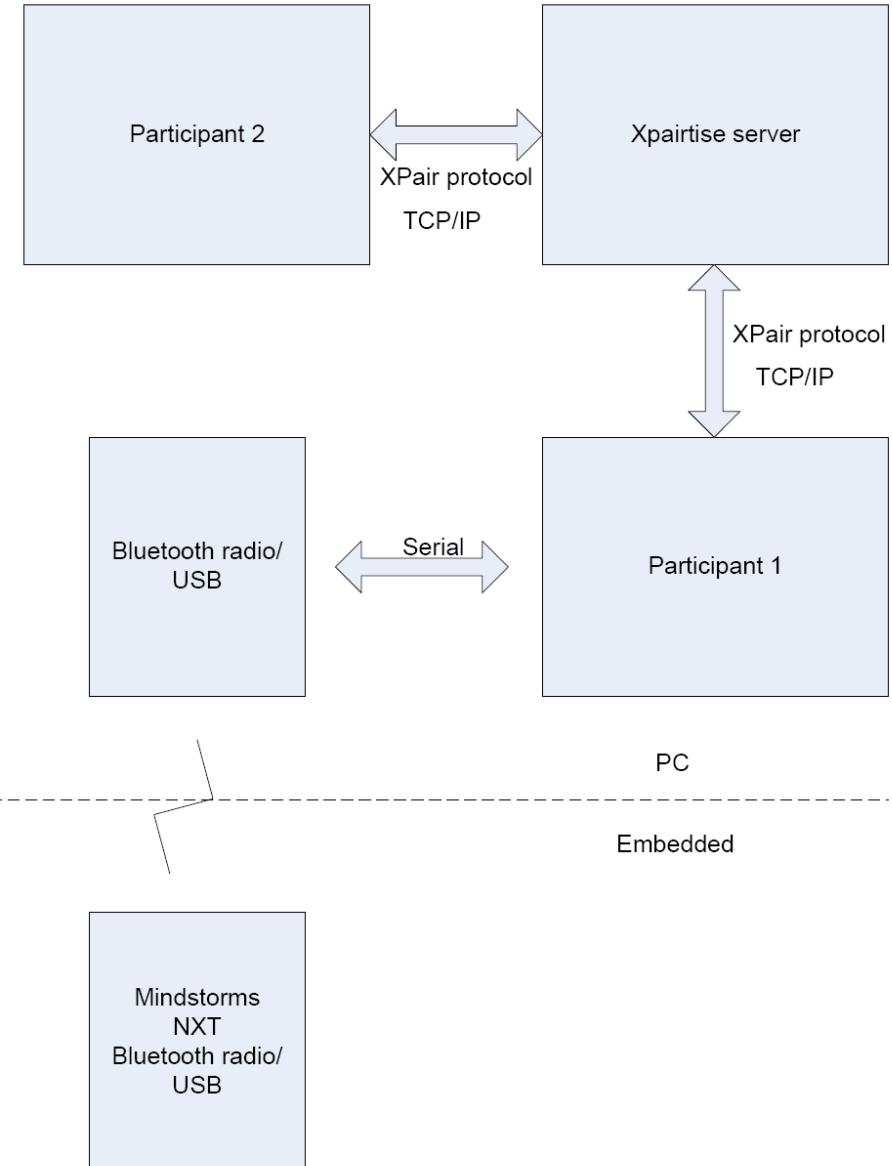


Team Setup



Team: Functionality

- The setup is somewhat complex/fragile
- It requires someone with good understanding of hands-on programming
- Not limited to Java....
(Python...)(...)



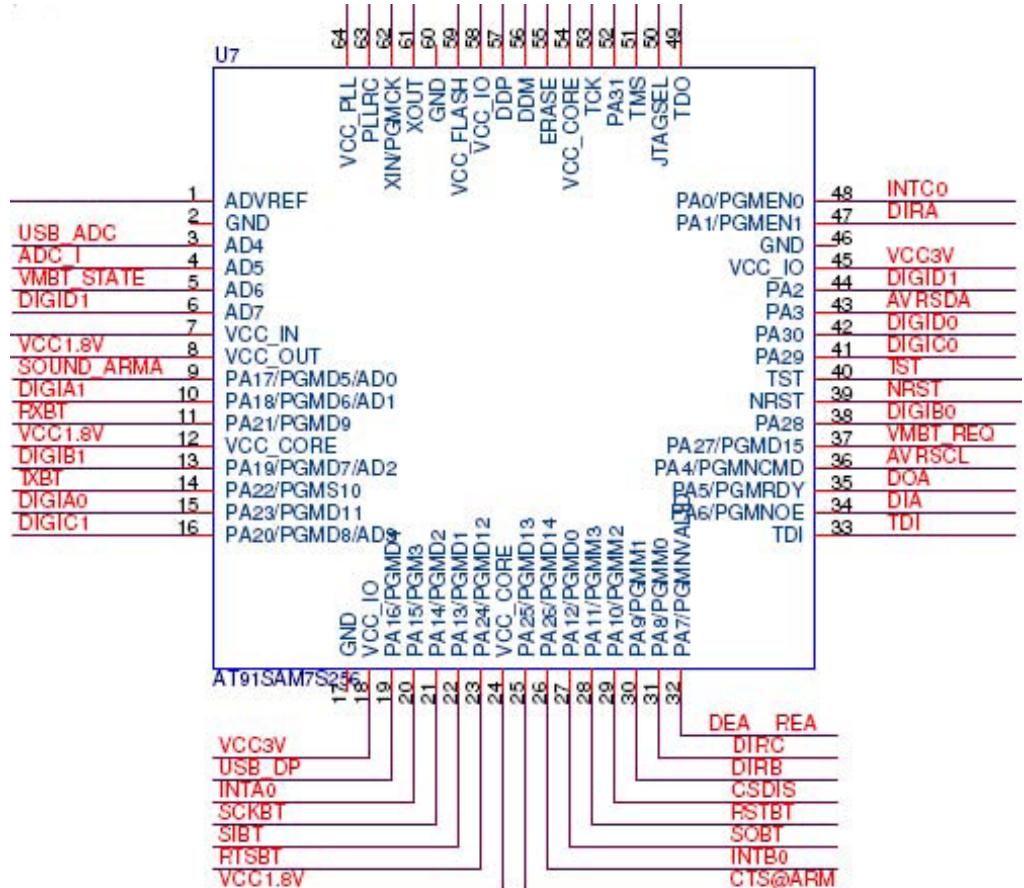
PYMITE: A PYTHON ON-A-CHIP PROJECT

- Some students are better than others, and perform so-called firmware replacements
- We demonstrate the relative easiness (1 day) of starting up a new embedded operating system on NXT



Method: HW->GCC->Target OS

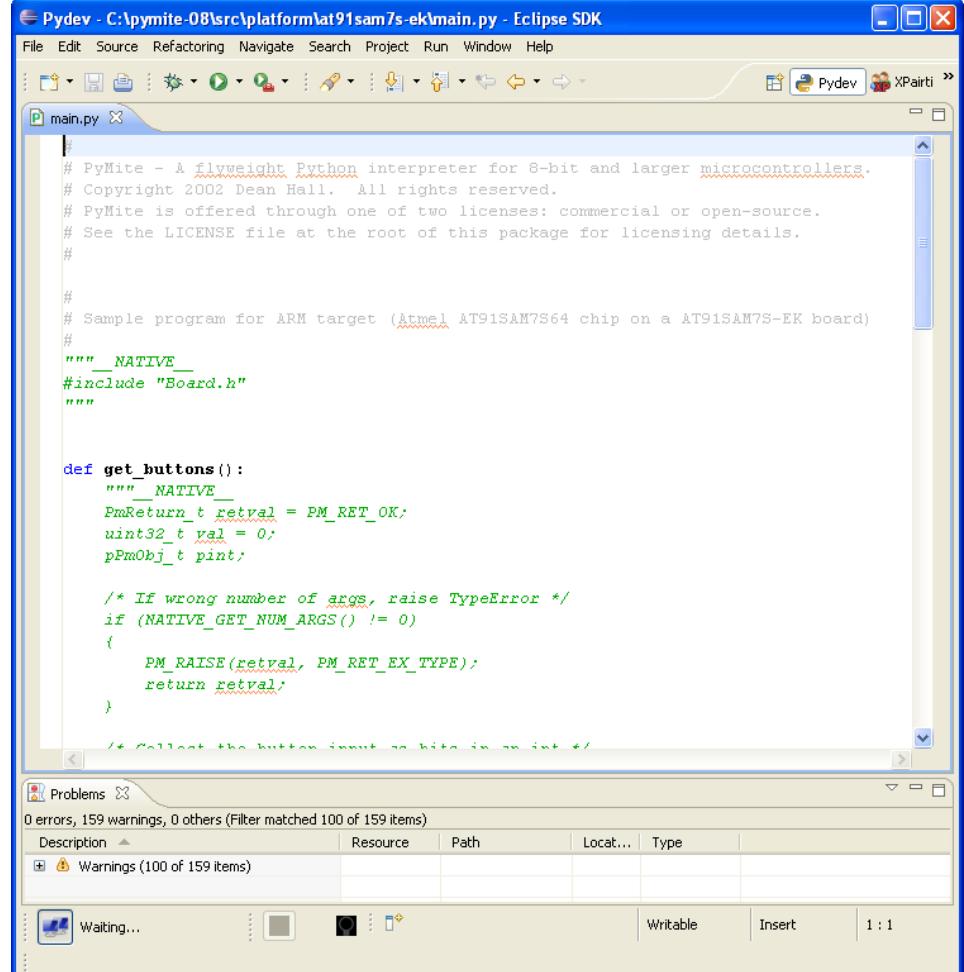
- LEGO MINDSTORMS NXT has open hardware specifications
- It is a question of creating a toolchain for ARM7 (use the one from NXTGCC) and go from there



	Title	LEGO MINDSTORMS NXT	Engineer/constructor	Date (YYYY/MM/DD)
	Project Number		Drafter	Date (YYYY/MM/DD)
		Schematic Name		Hardware
Version	Sheet	1 of 4	Page Size	A3

Discussion: Teaching Advantage

- Em. Sys. team programming: just a teacher dream?
- Students have a system where they can use an easy language (Java or whatever) or create a new operating system
- Focus on HPL-HAL-HIL interdependencies
- They can create new sensors (PCBs)
- NXT mixes well on an educational continuum :



The screenshot shows the Eclipse Pydev interface. The main window displays the code for `main.py`:

```

# PyMite - A flyweight Python interpreter for 8-bit and larger microcontrollers.
# Copyright 2002 Dean Hall. All rights reserved.
# PyMite is offered through one of two licenses: commercial or open-source.
# See the LICENSE file at the root of this package for licensing details.
#
#
# Sample program for ARM target (Atmel AT91SAM7S64 chip on a AT91SAM7S-EK board)
#
"""__NATIVE__
#include "Board.h"
"""

def get_buttons():
    """__NATIVE__
    PmReturn_t retval = PM_RET_OK;
    uint32_t val = 0;
    pPmObj_t pInt;

    /* If wrong number of args, raise TypeError */
    if (NATIVE_GET_NUM_ARGS() != 0)
    {
        PM_RAISE(retval, PM_RET_EX_TYPE);
        return retval;
    }

    /* Collect the button input as bits in an int */

```

The Problems view below shows 0 errors, 159 warnings, and 0 others, with 100 of 159 items filtered.



Conclusion

- We have shown a method to include team programming which is good for many students
- The NXT can also be used for more advanced programming with C and assembler programming: Pymite
- From here: Working on a minimalistic introductory EECS "mechanics book" with ARM/gcc/bootloader/assembler/C...

<http://nxtgcc.sourceforge.com>

