Embedded Systems

Lab 1: Setup, Make, Assembler, LEDs

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Goals of the Embedded Systems Lab

• Hands-on experiences with real hardware
• Insights into methods and tools for programming embedded devices
• Starting with simple Assembler code, we will end up using a feature-rich operating system with events and threads
BTnode / BTnut

- Wireless communication and computation platform based on a Bluetooth radio and a microcontroller
- Atmel ATmega 128L @ 8MHz, 64+180 KB RAM, 128 KB Flash ROM
- BTnut system software consisting of a multi-threading operating system, dynamic memory allocation, Bluetooth stack, ...
Organization

• **Today**: Setup, Make, Assembler, LEDs
• **Lab 2**: Peripherals, IRQ, ADC, Timers
• **Lab 3**: BTnut, Threads
• **Lab 4**: Multi-hop Bluetooth Chat
Goals of this Session

• Installation of relevant software sources and setup of Eclipse
• First steps with the BTnode/AVR toolchain
• User interaction over a serial console
• Low-level device programming with Assembler and C
Task 1: Hardware/Software Setup

- **D-ITET students:** Login with your ITET Linux account
- **D-INFK/D-MAVT/D-MTEC students:** Ask the lab assistants for a login

**Important:**
Check the orientation of the adapter board before connecting the USB cable
General Toolchain Setup

- **USB programming board**: Attach the USB cable that is used to power the BTnode *first* to the computer
- **ISP programmer**: Plug in the USB cable of the ISP programmer *afterwards*
- Resulting setting:
  - BTnode terminal on ttyUSB0
    (“minicom usb0”)
Lab Files

BTnut application examples

Source files for exercises

References for Task 3
Task 2: Exploring the BTnode

```bash
# Welcome to BTnut (c) 2006 ETH Zurich
# bt-cmd program version: 20090420-1147
# $Id: bt-cmd.c,v 1.48 2006/12/15 12:24:13 yuecelm Exp $
# running @ 7.3511 MHz, NutFreq=1024l Hz
# -------------------------------------------
booting Bluetooth module...
Bluetooth MAC address: 0004:3e00:0051
HCI version: 2 00C9 2 0012 003D
LMP features: 03 10 00 FF FF 05 F8 1B
Local name: 'ZeevoEmbeddedDevice'
hit tab twice for a list of commands
[bt-cmd@00:51]$ bt ebt led bat nut log
[bt-cmd@00:51]$`
```
Task 3: Blink application

- Task 3.1: Read the BTnode schematics to understand how the LEDs are connected
- Task 3.2: Information on computation times can be found in the AVR Instruction Set Manual
Solution for Task 3.2 b)

<table>
<thead>
<tr>
<th>Instruction</th>
<th>Exec. time</th>
</tr>
</thead>
<tbody>
<tr>
<td>brne (taken)</td>
<td>2 cycles</td>
</tr>
<tr>
<td>brne (not taken)</td>
<td>1 cycle</td>
</tr>
<tr>
<td>ldi</td>
<td>1 cycle</td>
</tr>
<tr>
<td>rcall</td>
<td>3 cycles</td>
</tr>
<tr>
<td>ret</td>
<td>4 cycles</td>
</tr>
<tr>
<td>subi</td>
<td>1 cycles</td>
</tr>
</tbody>
</table>

Formula from code analysis:

\[
C_{\text{inner}} = 1 + l_{\text{inner}} \cdot (1 + 2) - 1
\]

\[
C_{\text{middle}} = 1 + l_{\text{middle}} \cdot (C_{\text{inner}} + 1 + 2) - 1
\]

\[
C_{\text{outer}} = 1 + l_{\text{outer}} \cdot (C_{\text{middle}} + 1 + 2) - 1
\]

\[
C_{\text{total}} = C_{\text{outer}} + 3 + 4
\]

\[
C_{\text{total}} = l_{\text{outer}} \cdot (3 + (l_{\text{middle}} \cdot (3 + l_{\text{inner}} \cdot 3))) + 7
\]

\[
= 8,181,547 \text{ cycles} \approx 1.02 \text{ seconds}
\]