Introduction to the Java Device I/O APIs

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Program Agenda

1. Overview of The Device I/O OpenJDK Project
2. Building the Device I/O libraries
3. Using the Device I/O APIs
4. A closer look at working with GPIO, SPI, I2C and UART
5. More info

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The Device I/O Project

The Device I/O Project is an OpenJDK to provide a Java-level API for accessing generic device peripherals on embedded devices.

The Device I/O Project

- Follows the JavaME Device I/O API
- Targets Linux/ARM SBCs
  - Raspberry Pi
  - SABRE Lite
- Supports an initial set of four peripheral device APIs
  - GPIO
  - SPI
  - I2C
  - UART

The Device I/O Project

(continued)

- Provides a consistent method for accessing low level peripherals on embedded devices
- Is extendable with service providers
- Helps developers manage multiple hardware configurations by providing the ability to assign logical names to devices

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Building The Device I/O Libraries

- Supports building on a Linux host with ARM cross-compiler
- Requires JDK7 or JDK8, Linux/ARM cross-compiler and GNU Make
- Sample code may also use the Ant build tool

Building The Device I/O Libraries

- Define required environment variables
  - `export JAVA_HOME=<path to JDK>`
  - `export PI_TOOLS=<path to Linux/ARM cross-compiler>`
- Get the source
  - `hg clone http://hg.openjdk.java.net/dio/dev`
- Build
  - `cd dev`
  - `make`

Building The Device I/O Libraries

(continued)

- Completed library files will be in build directory
  - `<top-level>/build/jar/dio.jar`
  - `<top-level>/build/so/libido.so`

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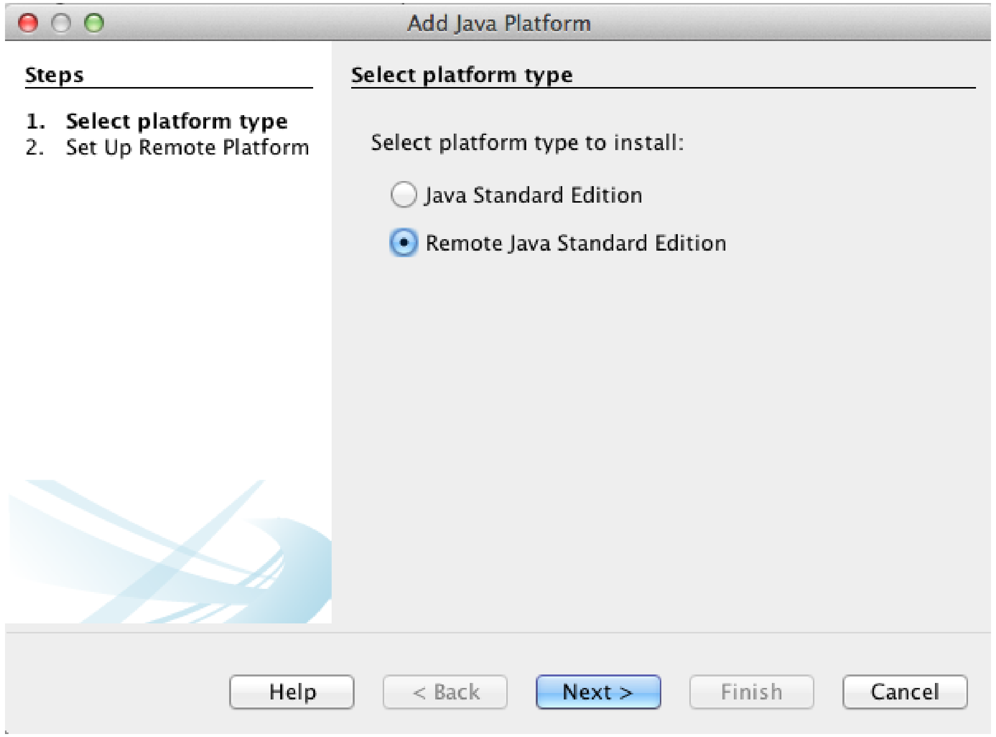
Working With DIO APIs in Netbeans



Steps

1. **Select platform type**
2. Set Up Remote Platform

Select platform type

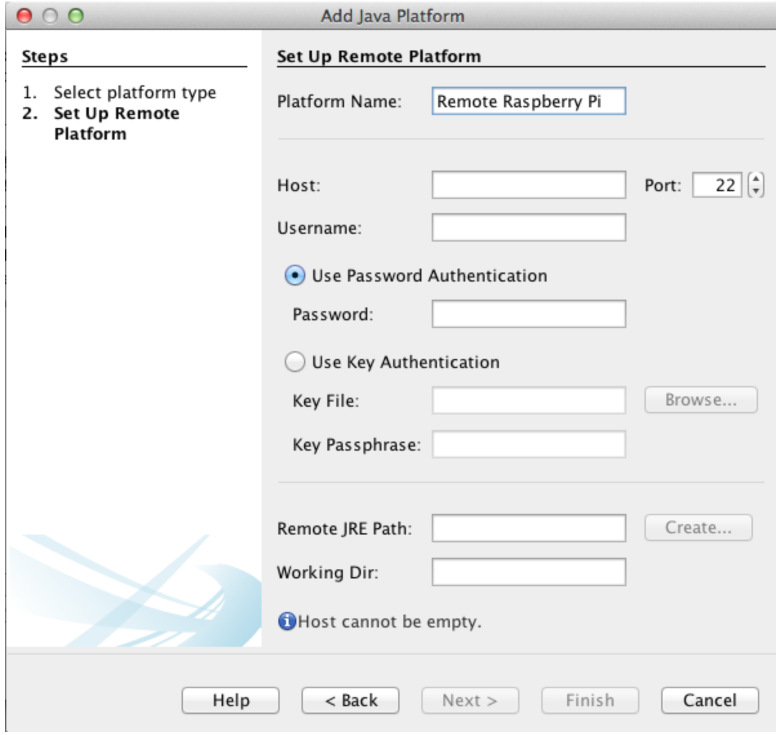
Select platform type to install:

○ Java Standard Edition

● Remote Java Standard Edition

Tools → Java Platforms → Add Platform . . .

Select “Remote Java Standard Edition” then click next



Steps

1. Select platform type
2. **Set Up Remote Platform**

Set Up Remote Platform

Platform Name: Remote Raspberry Pi

Host: Port: 22

Username:

● Use Password Authentication

Password:

○ Use Key Authentication

Key File:

Key Passphrase:

Remote JRE Path:

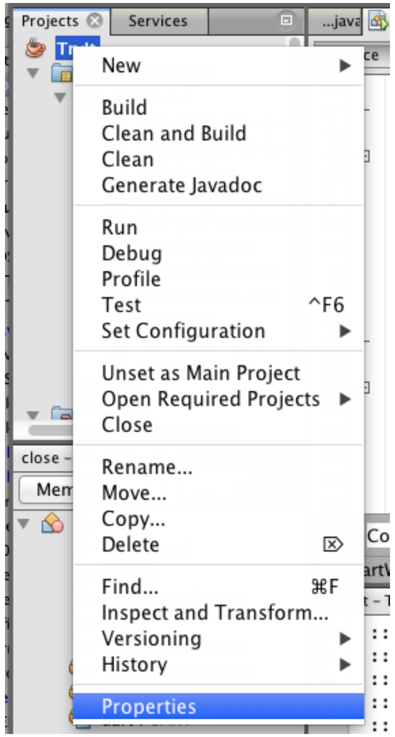
Working Dir:

Host cannot be empty.

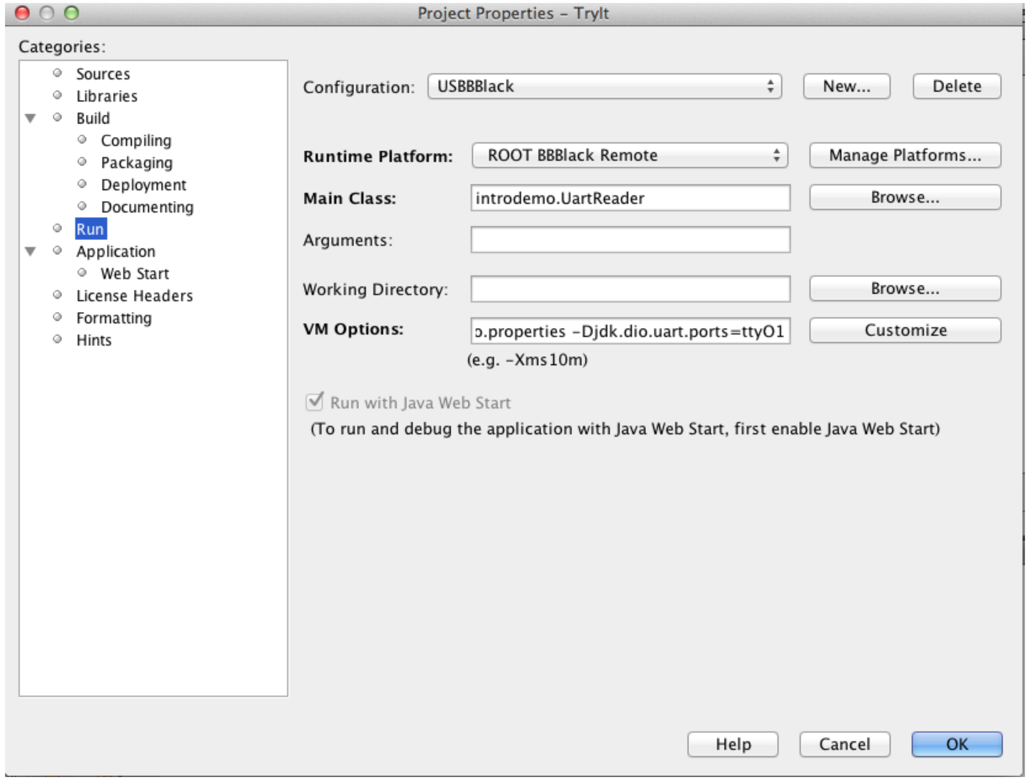
Fill in required fields then click “Finish”

Note: may need to use “root” credentials to run DIO apps from netbeans

Working With DIO APIs in Netbeans (cont’d)



Right click on your project and select “Properties”


Project Properties – TryIt

Configuration: USBBBlack

Runtime Platform: ROOT BBBlack Remote

Main Class: introdemo.UartReader

Arguments:

Working Directory:

VM Options: ɔ.properties –Djdk.dio.uart.ports=ttyO1

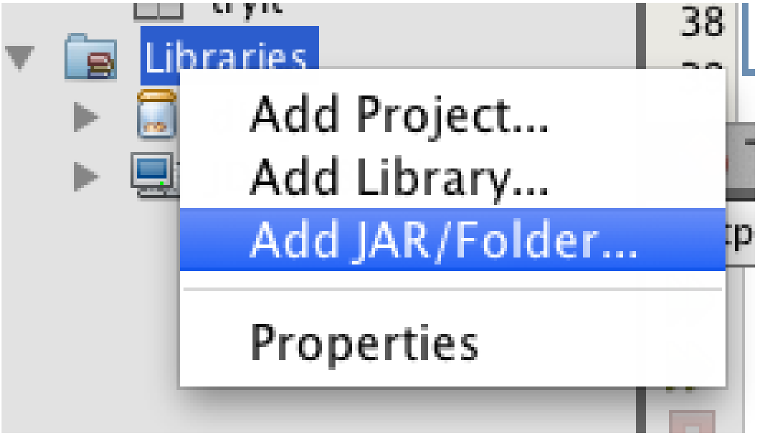
(e.g. –Xms10m)

☑ Run with Java Web Start

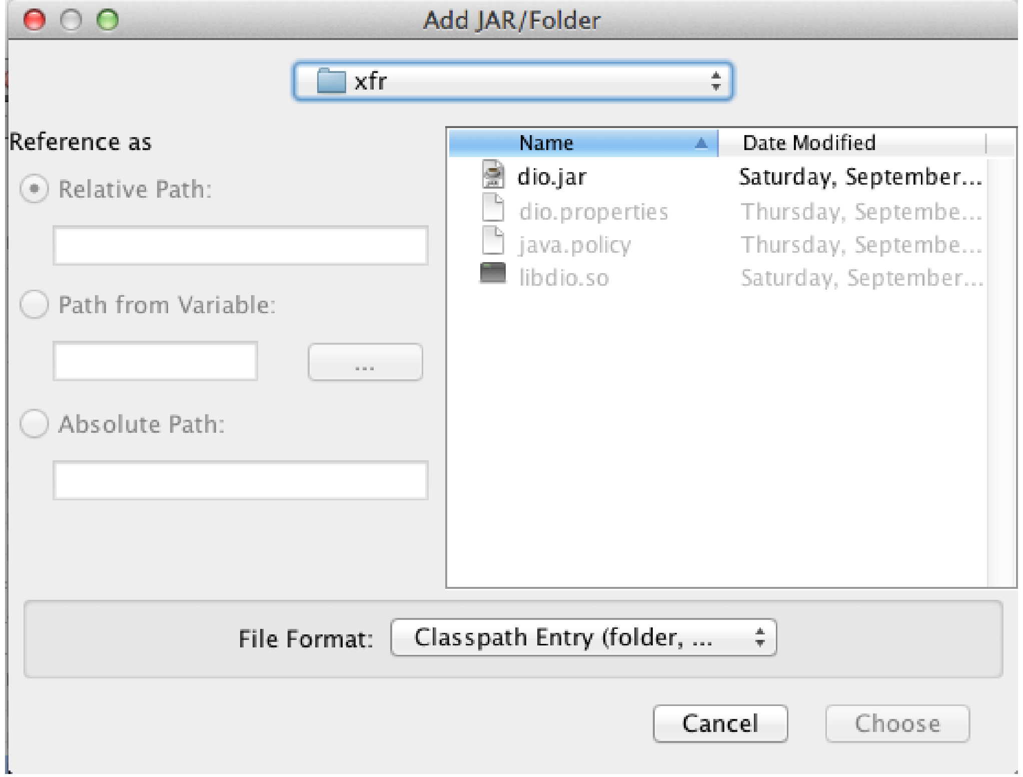
(To run and debug the application with Java Web Start, first enable Java Web Start)

Create a new configuration with your new remote platform

Working With DIO APIs in Netbeans (cont’d)



Right click on “libraries” in your project tree and select “Add JAR/Folder…”



Reference as

● Relative Path:

○ Path from Variable:

○ Absolute Path:

Name	Date Modified
dio.jar	Saturday, September...
dio.properties	Thursday, Septembe...
java.policy	Thursday, Septembe...
libdio.so	Saturday, September...

File Format: Classpath Entry (folder, ...

Choose the dio.jar file

Using the Device I/O APIs

- Copy libido.so to your native java library path on the target device
  - Or, specify its location with –Djava.library.path in VM options
- Specify -Djdk.dio.registry in VM options (or in the `java` command line) to use a `.properties` file to preload a set of device configurations which you can refer to by a numeric ID
- Use DeviceManager.list() to get a list of all preloaded and user-registered devices in the system
- Get a device instance by using DeviceManager.open() methods
- When done with a device, be sure to call its close() method
- Access to devices depends on appropriate OS level access and new Java permissions

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A Closer Look . . .

GPIO

GPIO

- General Purpose Input/Output
- Logical 1 or 0 controlled by software
- Dedicated to a single purpose
  - Drive a single LED
  - Status flag
  - “bit-banging”

jdk.dio.gpio.GPIOPin

Key configuration details

- Pin number
- Direction
  - Input
  - Output
- Trigger
  - Rising
  - Falling
- Mode – Not software configurable for Linux/ARM port

jdk.dio.gpio.GPIOPin

- Represents a single GPIO pin
- Can be configured as input or output
  - Detect a button press
  - Drive a single LED
- Can register listeners to handle “value changed” events

jdk.dio.gpio.GPIOPin

```
GPIOPinConfig config =
               new GPIOPinConfig(DeviceConfig.DEFAULT,     // controller number
                                 18,                       // pin number
                                 GPIOPinConfig.DIR_OUTPUT_ONLY,
                                 GPIOPinConfig.DEFAULT,    // mode (ignored)
                                 GPIOPinConfig.TRIGGER_NONE,
                                 false);                   // initial value

 . . .
       GPIOPin outputPin = DeviceManager(config);
 . . .
       outputPin.setValue(true);
```

jdk.dio.gpio.GPIOPin

```
GPIOPinConfig config =
               new GPIOPinConfig(DeviceConfig.DEFAULT,
                                 23,                                 // pin number
                                 GPIOPinConfig.DIR_INPUT_ONLY,
                                 GPIOPinConfig.DEFAULT,
                                 GPIOPinConfig.TRIGGER_RISING_EDGE |
                                         GPIOPinConfig.TRIGGER_FALLING_EDGE,
                                 false);                             // initial value

 . . .
       GPIOPin inputPin = DeviceManager(config);
 . . .
       boolean pinValue = inputPin.getValue();
```

jdk.dio.gpio.GPIOPin

```
inputPin.setInputListener(new PinListener() {
        public void valueChanged(PinEvent event) {
                System.out.println(“Pin value is now “ + event.getValue());
        }
});
```

A Closer Look . . .

SPI

SPI

- Serial Peripheral Interface
- Single master/multiple slaves connected to a single bus
- Serial, full-duplex
- Bits shift in on MISO (Master In Slave Out) as they shift out on MOSI (Master Out Slave In)

jdk.dio.spibus.SPIDevice

Key configuration details

- Device number
- Chip select address (device address)
- Chip select active level
  - High, low, not controlled
- Clock mode – see javadocs for explanation
- Word length
- Bit ordering

jdk.dio.spibus.SPIDevice

- Represents an SPI slave device
- Provides methods to write, read and writeAndRead to/from the slave device
  - write(); read(); != writeAndRead();
- Allows you to surround a series of writes and reads with begin(), end() to keep slave select line active
- Uses java.nio.ByteBuffer in API calls

jdk.dio.spibus.SPIDevice

```
SPIDeviceConfig config =
               new SPIDeviceConfig(DeviceConfig.DEFAULT,          // Device Number
                                                      0,          // SS connected to CE0
                                                      500000,     // clock frequency
                                                      SPIDeviceConfig.CS_ACTIVE_LOW,
                                                      8,          // 8-bit words
                                                      Device.BIG_ENDIAN);
 . . .
SPIDevice spiDevice = DeviceManager.open(config);
 . . .
```

jdk.dio.spibus.SPIDevice

MCP3008 Example

```
public int readChannel(int c) {
        ByteBuffer out = ByteBuffer.allocate(3);
        ByteBuffer in = ByteBuffer.allocate(3);
        out.put((byte)0x01);                              // start bit
        out.put((byte)(((c | 0x08) & 0x0f) << 4));        // single-ended, channel c
        out.put((byte)0);                                 // padding
        out.flip();      // important!!! reset or flip buffer to start sending from

                         // the beginning
        . . .
            spiDevice.writeAndRead(out, in);
        . . .
        int high = (int)(0x0003 & in.get(1));    // first byte is padding, 10-bit result is
        int low = (int)(0x00ff & in.get(2));      // contained in bit 1-0 of second byte and
                                                  // all eight bits of third byte
        return (high << 8) + low;
    }
```

A Closer Look . . .

I^{2}C

I^{2}C

- Inter-Integrated Circuit
- Multi-master/multi-slave bus
  - Device I/O supports only slave devices
  - One master is assumed
- Serial, half-duplex
- One line for data, one for clock, no separate address lines

jdk.dio.i2cbus.I2CDevice

Key configuration details

- Controller number
- Slave address
- Address size
- Clock frequency

jdk.dio.i2cbus.I2CDevice

- Represents a I2C slave device
- Provides methods to read, write from/to slave device
- Allows you to surround a series of related writes and reads with begin(), end()
- Uses java.nio.ByteBuffer in API calls

jdk.dio.i2cbus.I2CDevice

BMP160 Example

```
I2CDeviceConfig config =
                new I2CDeviceConfig(1,           // i2c bus number (raspberry pi)
                                    0x77,        // i2c slave address (BMP180 press/temp sensor)
                                    7,           // address size in bits
                                    3400000);    // 3.4MHz clock frequency


        . . .
I2CDevice i2cSlave = DeviceManager.open(config);
        . . .
// read calibration data
ByteBuffer dst = ByteBuffer.allocate(22);// 22 = size (bytes) of calibration data
int bytesRead = i2cSlave.read(0xAA,      // EEPROM start address
                              1,         // size (bytes) of subaddress
                              dst);
```

A Closer Look . . .

UART

UART

- Universal Asynchronous Receiver/Transmitter

jdk.dio.uart.UART

Key configuration details

- Controller name or number
- Baud rate
- Parity
- Stop bits
- Flow control

jdk.dio.uart.UART

- Allows for control and access of a UART device
- Provides methods to for synchronous and asynchronous reads and writes
- Implements the java.nio.channels interfaces ReadableByteChannel and WriteableByteChannel
- Uses java.nio.ByteBuffer in API calls

jdk.dio.uart.UART

```
UARTConfig config  = new UARTConfig(“ttyAMA0”,            // device name
                                    DeviceConfig.DEFAULT, // channel
                                    9600,                 // baud rate
                                    UARTConfig.DATABITS_7,
                                    UARTConfig.PARITY_NONE,
                                    UARTConfig.FLOWCONTROL_NONE);
        . . .
UART uart = DeviceManager.open(config);
OutputStream os = Channels.newOutputStream(uart);
BufferedWriter writer = new BufferedWriter(new OutputStreamWriter(os));

writer.(“Hello”);

        . . .
```

More Info

- Device I/O OpenJDK Project page
  - http://openjdk.java.net/projects/dio/
- Device I/O mailing list
  - http://mail.openjdk.java.net/mailman/listinfo/dio-dev
- Device I/O Wiki
  - https://wiki.openjdk.java.net/display/dio/Main
- Device I/O mercurial repo
  - http://hg.openjdk.java.net/dio/dev

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