Java and JCA / CAJ

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Based on presentations by

Kenneth Evans, Jr., 2004

Kazuro Furukawa, 2006

Outline

- Java
- Java and EPICS
- Overview of JCA
- Examples
  - SimpleJCAGet
  - SimpleJCAMonitor
  - JProbe

Java

- Java is designed to be platform independent
  - Write once, run everywhere
- Java programs are interpreted by another program, possibly on another machine
  - The Java Virtual Machine (Java VM)
- Java technology includes
  - J2SE Standard Edition
  - J2EE Enterprise Edition (Multi-tier business apps)
  - J2ME Micro Edition (Phones, PDAs, etc.)
- Java is advertised to be all of these

Simple	Architecture neutral	Object oriented
Portable	Distributed	High performance
Interpreted	Multithreaded	Robust
Dynamic	Secure	

Java and EPICS

- EPICS Channel Access is native code
  - Not platform independent
  - Build cycle is edit – compile [to machine code] - link - run
- Pure Java
  - Build cycle is edit – compile [to byte code] – run [anywhere]
- Java Native Interface [JNI] is used to access native code
  - Not “Pure Java”
  - No longer platform independent
  - You generate shared object or DLL libraries that must be used with the Java program
- You can write your own JNI
  - Not that hard if you know Channel Access
- The EPICS build system handles Java projects and JNI
- Ant is an alternative

JCA

- Stands for Java Channel Access
- JCA is a JNI implementation of an EPICS Channel Access client library for Java
  - Provides equivalents to most of the Channel Access API
  - Developed by Eric Boucher while at the APS
  - Currently taken over by Cosylab
- Available for download at
  - http://jca.cosylab.com/
- Latest version is available at Cosylab
- JCA Version 1 uses EPICS Base 3.13
- JCA Version 2 uses EPICS Base 3.14
  - Channel Access is threaded
  - Allows for preemptive callbacks
    - Works better with Java, which is inherently threaded

CAJ

- CAJ is a Java replacement for Channel Access
- Developed at Cosylab (Control Systems Laboratory)
  - Located in Ljubljana in Slovenia
  - Cosylab also develops VDCT
- Available for download at
  - http://caj.cosylab.com/
- Latest version is available there
- Allows your programs to be “Pure Java”
- Is used with JCA
  - Replaces JNI implementation
  - Requires replacing only one line of code
    - jca.createContext(JCALibrary.JNI_THREAD_SAFE);
    - jca.createContext(“com.cosylab.epics.caj.CAJContext”);

Requirements

- Java J2SE installed (Current/latest version suggested)
- JCA
  - Java libraries
    - Download source and/or JAR files from the web
  - Native JNI libraries
    - Download from the web or build them
    - Currently found with the 2.1.7 distribution
      - jca.dll Windows
      - libjca.so Unix (Currently Linux, Solaris, Darwin?)
- Your project
  - JCA files need to be in your CLASSPATH
  - UNIX: Shared object library needs to be in your LD_LIBRARY_PATH
  - Windows: DLL needs to be in your PATH

Resources

- EPICS web pages
  - http://www.aps.anl.gov/epics/index.php
  - Look under Extensions, then JCA
- JCA 2.1.7 API
  - http://jca.cosylab.com/apidocs/index.html
- JCA 2.1.2 API
  - http://www.aps.anl.gov/xfd/SoftDist/swBCDA/jca/2.1.2/api/index.htmll
- CAJ 1.0.5
  - http://caj.cosylab.com/manual.html
- Java Tutorial
  - http://java.sun.com/learning/tutorial/index.html
- J2SE Documentation
  - http://java.sun.com/reference/api/index.html
- J2SE 1.4.2 API (Javadoc)
  - http://java.sun.com/j2se/1.4.2/docs/api/overview-summary.html

JCA Packages

- **Five Packages**
  - gov.aps.jca — Channel-Access-like routines
  - gov.aps.jca.configuration — Configuration
  - gov.aps.jca.dbr — DBR types
  - gov.aps.jca.event — Event handling
  - gov.aps.jca.jni — Native interface functions

gov.aps.jca

- This is the package you will use most directly
- Classes
  - CASeverity
  - CAStatus
  - Channel
  - Channel.ConnectionState
  - Context
  - Enum
  - JCALibrary
  - Monitor
  - ValuedEnum
- Exceptions
  - CAException
  - TimeoutException

JCALibrary

- Initializes JCA

```
JCALibrary jca=JCALibrary.getInstance();
```

- There is only one instance
- Used to create contexts and manage JCA configuration info
- Properties
  - JNI_THREAD_SAFE preemptive
    - Suggested for Java, which is inherently threaded
  - JNI_SINGLE_THREADED non-preemptive
- Methods
  - createContext
  - getProperty
  - listProperties
  - getVersion, getRevision, getModification

Context

- Corresponds to a Channel Access context
- Created by JCALibrary.createContext

```
createContext(JCALibrary.JNI_SINGLE_THREADED)
createContext(JCALibrary.JNI_THREAD_SAFE)
```

- Controls all IO
- You can have more than one context
- Methods
  - createChannel
  - flushIO, pendIO, pendEvent, poll
  - attachCurrentThread
  - addContextExceptionListener, removeContextExceptionListener
  - addContextMessageListener, removeContextMessageListener
  - destroy

Channel

- Represents a Channel Access channel
- Created by Context.createChannel

```
createChannel(String name, connectionListener l)
```

- Properties
  - CLOSED
  - CONNECTED
  - DISCONNECTED
  - NEVER_CONNECTED
- Methods
  - get, many overloads
  - put, many overloads
  - getName, getConnectionState, getElementCount, etc.
  - addMonitor
  - addConnectionListener, removeConnectionListener
  - addAccessRightsListener, removeAccessRightsListener
  - destroy

Monitor

- Represents a Channel Access monitor
- Created by Channel.addMonitor

```
addMonitor(DBRType type, int count, int mask,
  MonitorListener l)
```

- Properties
  - ALARM LOG VALUE
- Methods
  - addMonitorListener, removeMonitorListener
  - getMonitorListener, getMonitorListeners
  - clear
  - getChannel, getContext
  - getCount, getMask, getType
  - isMonitoringAlarm, isMonitoringLog, isMonitoringValue

MonitorListener

- Part of gov.aps.jca.event
- One method
  - monitorChanged
- Example

```
private class MyMonitorListener implements
  MonitorListener
{
    public void monitorChanged(MonitorEvent ev) {
      // Call my handler
      onValueChanged(ev);
    }
};
```

- The value and status comes with the MonitorEvent

MonitorEvent

- Part of gov.aps.jca.event
- Methods
  - getDBR — How you get the value
  - getStatus — How you determine the status
- Example

```
if(ev.getStatus() == CAStatus.NORMAL) {
    DBR dbr=ev.getDBR();
    double [] value=((DOUBLE)dbr).getDoubleValue();
}
```

Event Types

MonitorListener	MonitorEvent
GetListener	GetEvent
PutListener	PutEvent
AccessRightsListener	AccessRightsEvent
ConnectionListener	Connection Event
ContextExceptionListener	ContextExceptionEvent
ContextMessageListener	ContextMessageEvent

- Events all inherit from CAEvent
- They all work similarly to Monitor
  - Call the routine that fires the event when it occurs
  - Add a listener with the appropriate handler
  - Get the data from the event that is passed to your handler

gov.aps.jca.dbr

- Implements the EPICS DBR_xxx types
- Interfaces
  - DOUBLE, FLOAT, INT, STRING, TIME, CTRL, etc.
- Primary Class
  - DBR
- Subclasses of DBR
  - DBR_Double, DBR_Float, DBR_Int, DBR_STS_Double, etc.
- Example: DBR_STS_Double
  - Interfaces
    - STS, DOUBLE
  - Extends
    - DBR_Double
  - Subclasses
    - DBR_GR_Double, DBR_Time_Double

SimpleJCAGet

```
package simplejca;

import gov.aps.jca.*;
import gov.aps.jca.dbr.*;
```

SimpleJCAGet

```
public class SimpleJCAGet
{
  public static void main(String[] args)
  {
    SimpleJCAGet simpleJCAGet = new SimpleJCAGet();
    JCALibrary jca=null;
    Context ctxt=null;
    Channel chan=null;

    // Parse the command line
    if(!simpleJCAGet.parseCommand(args)) System.exit(1);
    if(!simpleJCAGet.pvSpecified) {
      System.err.println("No PV specified\n");
      System.exit(1);
    }
```

SimpleJCAGet

```
// Initialize and search
  try {
    // Get the JCALibrary instance
    jca=JCALibrary.getInstance();
    // Create a non-preemptive context
    context=jca.createContext(
     JCALibrary.JNI_SINGLE_THREADED);
    // Search
    chan=ctxt.createChannel(simpleJCAGet.name);
    // Wait for search
    ctxt.pendIO(simpleJCAGet.timeout);
  } catch(Exception ex) {
    System.err.println("Search failed for " +
     simpleJCAGet.name + ":\n" + ex);
    System.exit(1);
  }
```

SimpleJCAGet

```
// Get the first value as a String
  try {
    // Get the value
    String [] value;
    value=((STRING)chan.get(DBRType.STRING,1)).
     getStringValue();
    // Wait for the get
    ctxt.pendIO(simpleJCAGet.timeout);
    // Print the value
    System.out.println("The value of " +
simpleJCAGet.name
     + " is " + value[0]);
   } catch(Exception ex) {
     System.err.println("Get failed for " +
      simpleJCAGet.name + ":\n" + ex);
     System.exit(1);
   }
```

SimpleJCAGet

```
// Clean up
    try {
      // Clear the channel
      chan.destroy();
      // Destroy the context
      ctxt.destroy();
    } catch(Exception ex) {
      System.err.println("Clean up failed for " +
       simpleJCAGet.name + ":\n" + ex);
      System.exit(1);
    }
    // Successful exit
    System.exit(0);
  }
```

SimpleJCAGet output

```
java.exe -classpath
 <simplejca-path>\SimpleJCA.jar;
 <jca-path>\jca-2.1.7.jar
 simplejca.SimpleJCAGet evans:calc
The value of evans:calc is 3
```

SimpleJCAMonitor

- Similar to SimpleJCAGet
  - Imports, parsing the command line, etc. are the same
- We will have listeners
- We will use JNI_THREAD_SAFE（preemptive)
- We will use flushIO and not pendIO, etc.

SimpleJCAMonitor

```
/** Implementation of Connection Listener class
  */
private class SJCAConnectionListener implements
 ConnectionListener {
  public void connectionChanged(ConnectionEvent ev) {
    onConnectionChanged(ev);
  }
};
/** Implementation of MonitorListener class
  */
private class SJCAMonitorListener implements
 MonitorListener {
   public void monitorChanged(MonitorEvent ev) {
     onValueChanged(ev);
   }
};
```

SimpleJCAMonitor

```
// Instance of SimpleJCAMonitor
SimpleJCAMonitor sjcam=new SimpleJCAMonitor();

// Initialize JCA
  try {
    // Get the JCALibrary instance
    jca=JCALibrary.getInstance();
    // Create a preemptive context, default configuration
    ctxt=jca.createContext(JCALibrary.JNI_THREAD_SAFE);
  } catch(Exception ex) {
    System.err.println("Initialization failed for " +
     sjcam.name + ":\n" + ex);
    System.exit(1);
  }
```

SimpleJCAMonitor

```
// Search
  try {
    // Search
    chan=ctxt.createChannel(sjcam.name,
     sjcam.new SJCAConnectionListener());
    ctxt.flushIO();
  } catch(Exception ex) {
    System.err.println("Search failed for " +
     sjcam.name + ":\n" + ex);
    System.exit(1);
  }
```

SimpleJCAMonitor

```
private void onConnectionChanged(ConnectionEvent ev) {
  Channel ch=(Channel)ev.getSource();
  Context ctxt=ch.getContext();
  // Start a monitor on the first connection
  if(connectionCounter == 0 &&
   ch.getConnectionState() == Channel.CONNECTED) {
    try {
      // Add a monitor listener and flush
    ch.addMonitor(DBRType.STRING,1,
       Monitor.VALUE|Monitor.LOG|Monitor.ALARM,
       new SJCAMonitorListener());
    ctxt.flushIO();
    } catch(Exception ex) {
        ex.printStackTrace();
    }
  }
```

SimpleJCAMonitor

```
// Print connection state
  if(ch.getConnectionState() == Channel.CONNECTED) {
    System.out.println(ch.getName() + " is connected");
  } else if(ch.getConnectionState() == Channel.CLOSED) {
    System.out.println(ch.getName() + " is closed");
  } else if(ch.getConnectionState() ==
     Channel.DISCONNECTED) {
    System.out.println(ch.getName() + " is
disconnected");
  } else if(ch.getConnectionState() ==
     Channel.NEVER_CONNECTED) {
    System.out.println(ch.getName() + " is never
     connected");
  }
```

SimpleJCAMonitor

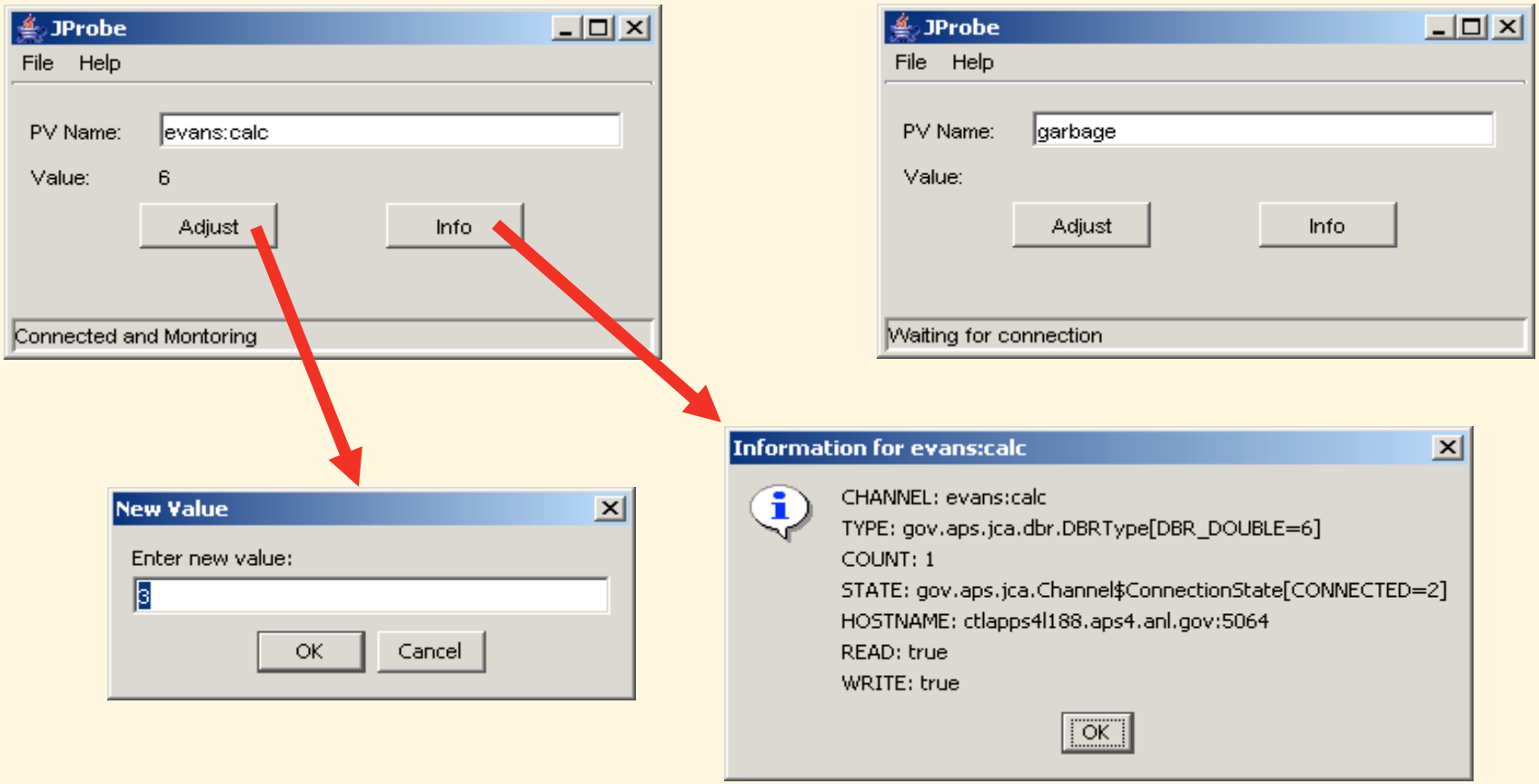
```
  private void onValueChanged(MonitorEvent ev) {
    Channel ch=(Channel)ev.getSource();
    Context ctxt=ch.getContext();
    // Check the status
    if (ev.getStatus() != CAStatus.NORMAL) {
      System.err.println("monitorChanged: Bad status”);
    }
    // Get the value from the DBR
    try {
      DBR dbr=ev.getDBR();
      String [] value=((STRING)dbr).getStringValue();
      System.out.print(SJCAUtils.timeStamp() + " " +
       getName() + ": “ + value[0]);
    } catch(Exception ex) {
      ...
    }
  }
```

Simple JCAMonitor output

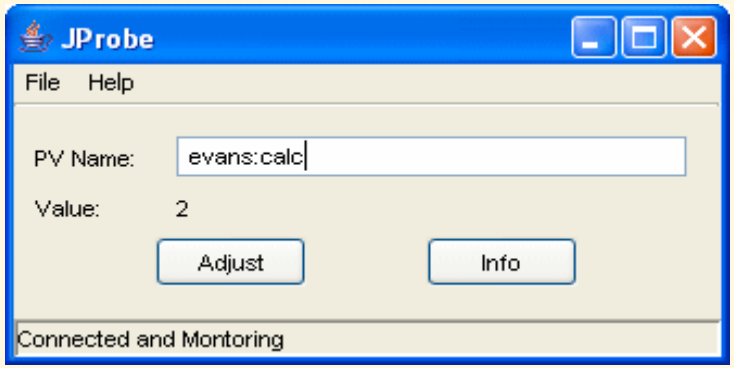
```
Oct 11, 2004 10:36:43.661 Starting Simple JCA Monitor
Oct 11, 2004 10:36:44.083 Search successful for: evans:calc
CHANNEL   : evans:calc
TYPE      : gov.aps.jca.dbr.DBRType[DBR_DOUBLE=6]
COUNT     : 1
STATE     : gov.aps.jca.Channel$ConnectionState[CONNECTED=2]
HOSTNAME  : ctlapps41188.aps4.anl.gov:5064
READ      : true
WRITE     : true
Oct 11, 2004 10:36:44.208 evans:calc is connected
Oct 11, 2004 10:36:44.224 evans:calc: 2
Oct 11, 2004 10:36:44.224 evans:calc: 3
...
Oct 11, 2004 10:36:53.240 evans:calc: 3
Oct 11, 2004 10:36:53.740 evans:calc: 4
Oct 11, 2004 10:36:54.036 All Done
```

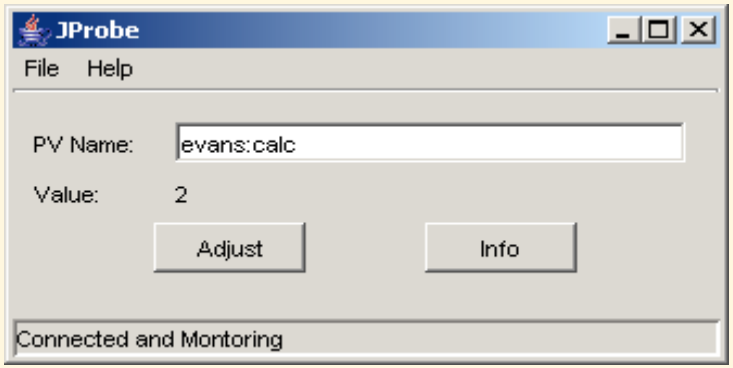
JProbe

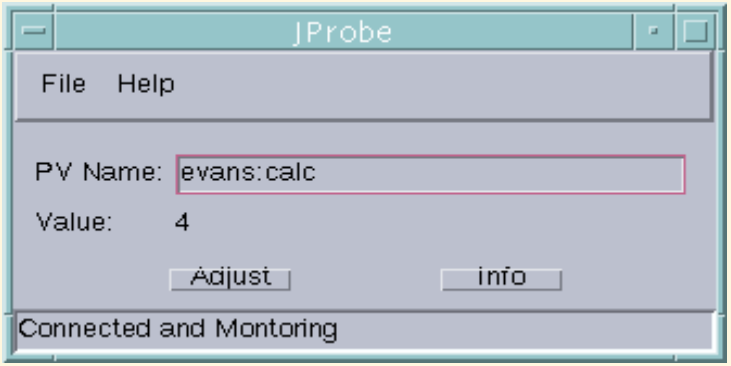
- JProbe is a simple example that demonstrates using JCA in a Swing GUI



Write once, run everywhere?







Source files for Simple JCA routines

- All the source and JAR files should be available with the presentation
  - LICENSE
  - SimpleJCA.jar
  - simplejca
    - SimpleJCAMonitor.java
    - SimpleJCAGet.java
    - SJCAUtils.java
  - JProbe.jar
  - jprobe
    - JProbe.java
    - MainFrame.java
    - AboutBoxPanel.java
- Stored as SimpleJCA.zip

Some Pointers to Documents

- Example files
  - http://www.aps.anl.gov/epics/
  - Documents - Training - Developing Client Tools
    - Java and JCA
    - Example Files
- Build examples of EPICS-Base, etc on several Platforms
  - http://www-linac.kek.jp/jk/win32/
  - http://www-linac.kek.jp/jk/linux/
  - http://www-linac.kek.jp/jk/darwin/

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