CMER

Centre for Mobile Education and Research

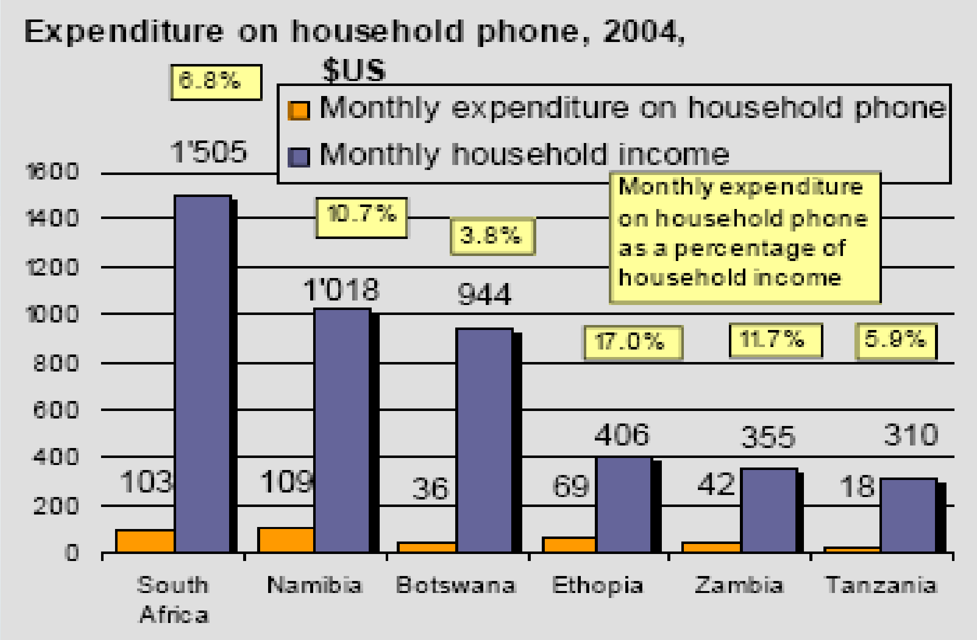
Mobile Applications and Java ME

Overview

- Mobile Platforms
- How they fit together?
- CLDC
- Optional Packages
- MIDP
- MIDlets
- API Examples
- Input, Event, & Error Handling
- UI Design Principles

Motivation

- Who doesn't have some kind of a mobile device (cell phone, smartphone, PDA, etc)
- People love their cell phones (inherently personal, telecommunication, etc)



Source:
ITU adapted from
researchICTafrica.net

Mobile Devices in Education

- Mobile devices out-ship desktop computers 20 to 1
- For many students, the mobile device is becoming the computer (calendar, note taking, etc)
- Today's mobile devices is the supercomputer of 20 years ago
- Students already annoy instructors with their cell phones (lovely ring tones, text messaging, etc)

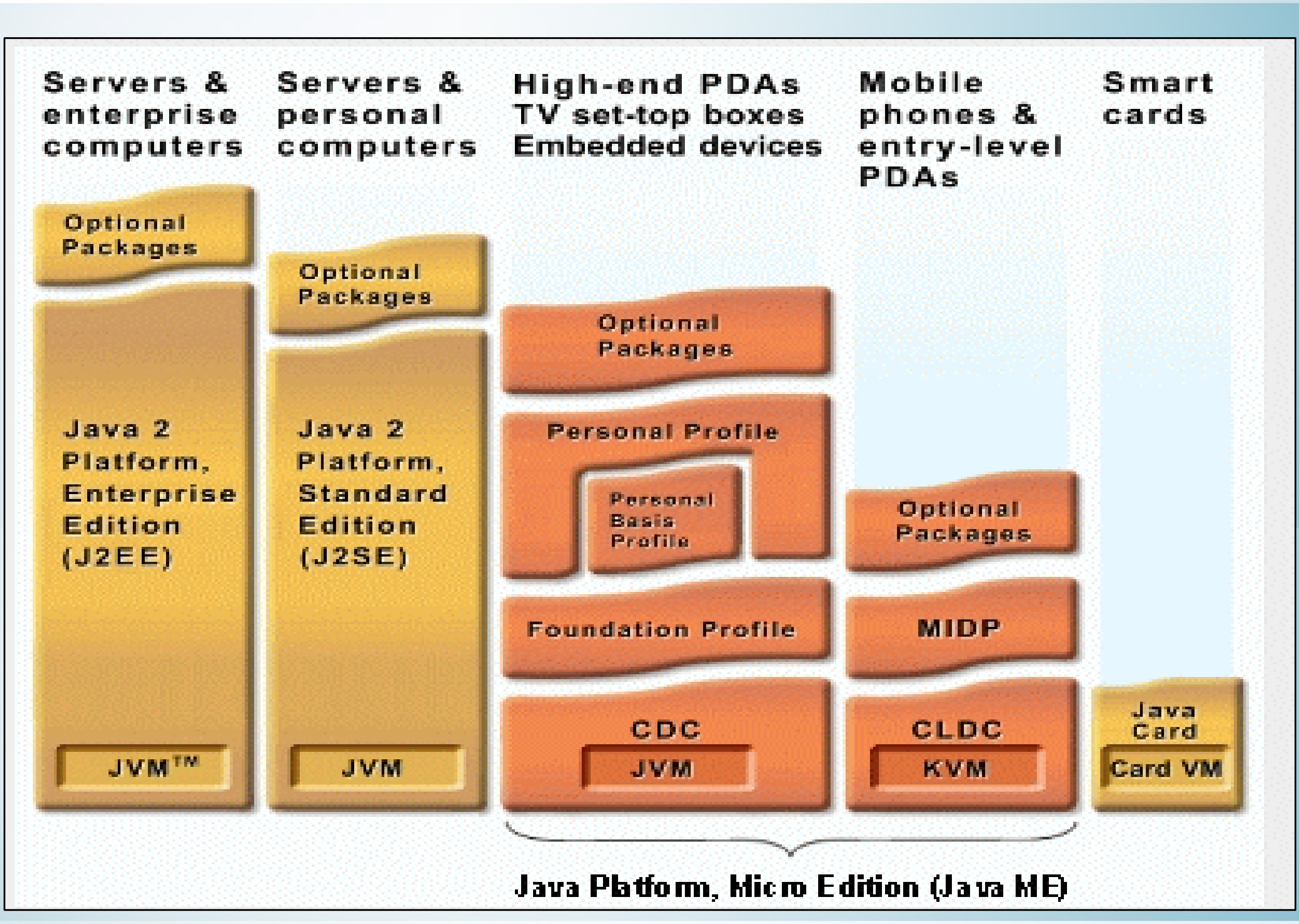
Mobile Applications

- Mobile Apps are apps or services that can be pushed to a mobile device or downloaded and installed locally
- Classification
  - Browser-based: apps/services developed in a markup language
  - Native: compiled applications (device has a runtime environment). Interactive apps such as downloadable games. (Our focus)
  - Hybrid: the best of both worlds (a browser is needed for discovery)

Mobile Platforms

- A wide variety of devices supporting different platforms
  - BlackBerry
  - Palm OS
  - Windows Mobile
  - Symbian
- Runtime environments & apps
  - Browser-based apps (WAP)
  - Flash-lite
  - Java ME
  - Qualcomm’s BREW
  - Google’s Android
- Having a choice is good…but not always…
  - Device fragmentation

The Java Platform


Servers & enterprise computers
Servers & personal computers
High-end PDAs TV set-top boxes Embedded devices
Mobile phones & entry-level PDAs
Smart cards
Optional Packages
Java 2 Platform, Enterprise Edition (J2EE)
JVM™
Optional Packages
Java 2 Platform, Standard Edition (J2SE)
JVM
Optional Packages
Personal Profile
Personal Basis Profile
Foundation Profile
CDC
JVM
Optional Packages
MIDP
CLDC
KVM
Java Card
Card VM
Java Platform, Micro Edition (Java ME)

Java ME

- Java Platform, Micro Edition (Java ME)
- Formerly known as J2ME Wireless Toolkit
- Purpose:
  - Platform for mobile devices
  - Work within the restrictions of building applications for small devices that have limited memory, display, and power.

Java ME (Cont.)

- Used as an environment for applications targeted towards mobiles and stand-alone devices
  - Mobile: cell phones and PDAs
  - Stand-alone: Printers

Java ME (Cont.)

- Benefits:
  - Flexible user interface
  - Good security
  - Integrated network protocols
  - Support for downloadable applications that can be networked or stand-alone

Java ME (Cont.)

- Java ME comprised of three components
  - A Configuration
  - A Profile
  - A Package (Optional)

Java ME (Cont.)

<u>Configuration</u>

- A configuration defines the minimum APIs and VM capabilities for a family of devices:
  - Similar requirements of memory size and processing capabilities
- The minimum APIs that an application developer can expect to be available on implementing devices
- May not contain any optional features

Java ME (Cont.)

- Defined through the Java Community Process (JCP) - http://java.sun.com/jcp(www.jcp.org)
- Subject to compatibility tests
- Two types of configurations:
  - Connected Limited Device Configuration (CLDC)
  - Connected Device Profile (CDC).

Java ME (Cont.)

Profile

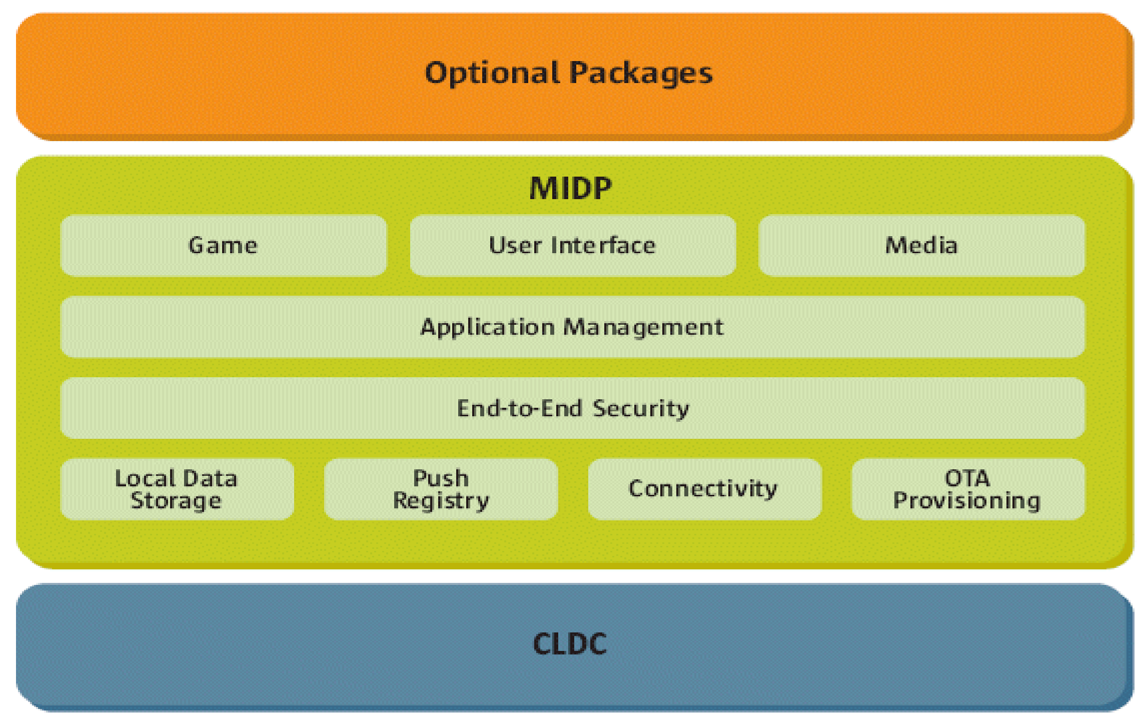
- A profile is a collection of APIs that supplement a configuration to provide capabilities for a specific vertical market
- Defined through Java Community Process initiative - www.jcp.org
- Subject to compatibility tests

Package

- An optional set of technology-specific APIs

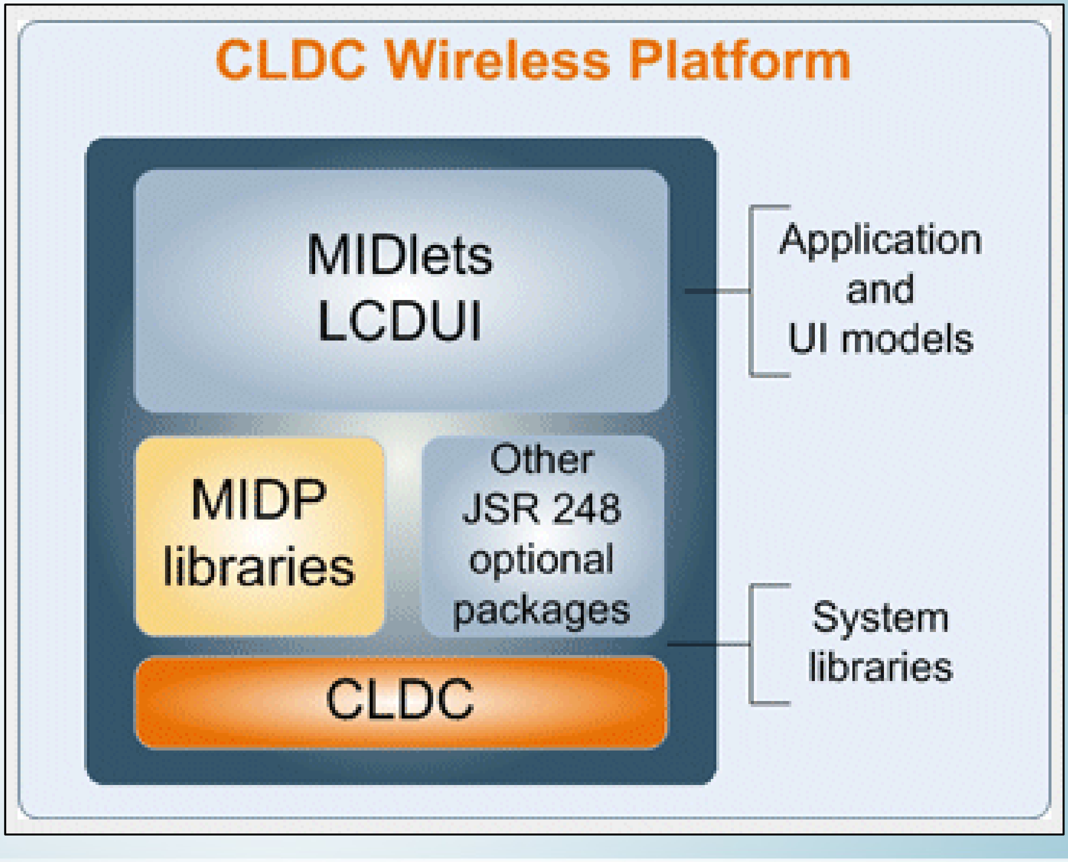
Java ME (Cont.)

- Profiles



How Do They Fit Together?

- Profiles are built on top of configurations



CLDC Wireless Platform

MIDlets
LCDUI

MIDP libraries

Other JSR 248 optional packages

CLDC

Application and UI models

System libraries

Configuration - CLDC

- Targeted at devices with:
  - 160 to 512 KB of total memory available for Java technology
  - Limited power (e.g. battery)
  - Limited connectivity to a network (wireless)
  - Constrained User Interface (small screen)
- It is available for free download
- Reference implementation built using KVM

CLDC - KVM

- Stands for Kilo Virtual Machine
- Originated from a research project called Spotless at Sun Research Labs
- Implements the classes defined in the CLDC specification + some additional UI classes

- Note: the UI classes are not part of the CLDC and can be removed at any time

CLDC – KVM (Cont.)

- A complete runtime environment for small devices
- Built from the ground up in C
- Small footprint (40 –80 KB)
- Class file verification takes place off-device
- Supports multi-threading
- Supports garbage collection

CLDC – KVM Security

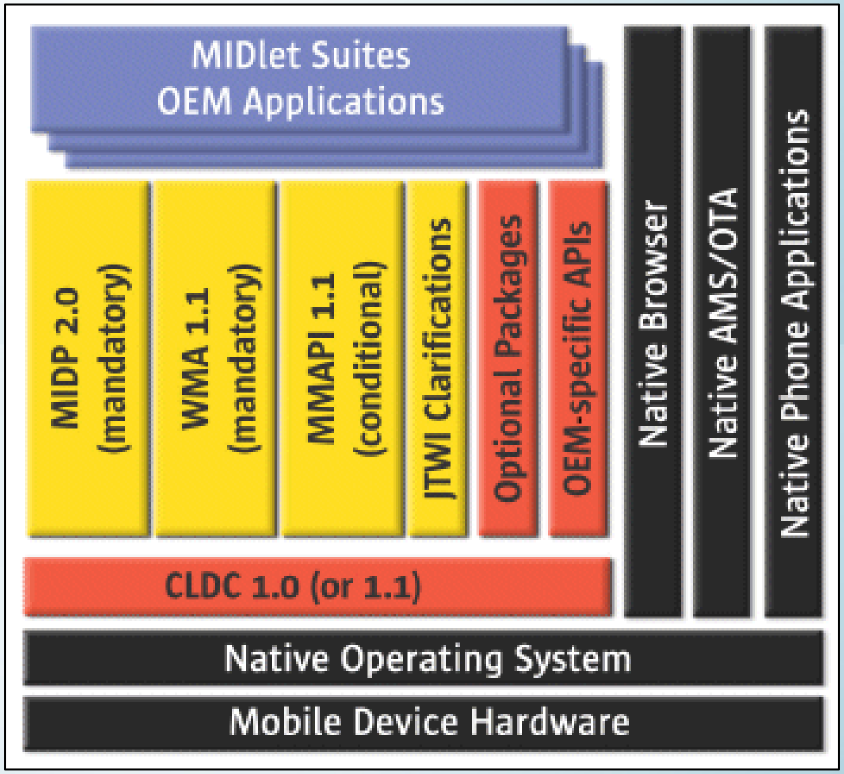
- VM level security
  - Off-device pre-verification
  - Small in-device verification
- Application level security
  - No Security Manager
  - Sandbox security model:
    - Applications run in a closed environment
    - Applications can call classes supported by the device

Optional Packages

- Core MIDP 2.0 functionality is limited. Vendors may include optional packages:
  - JSR-75: File Connection and PIM APIs
  - JSR-82: Bluetooth API
  - JSR-120: Mobile Messaging API
  - JSR-135: Mobile Media API
  - JSR-179: Location API
  - Many others…

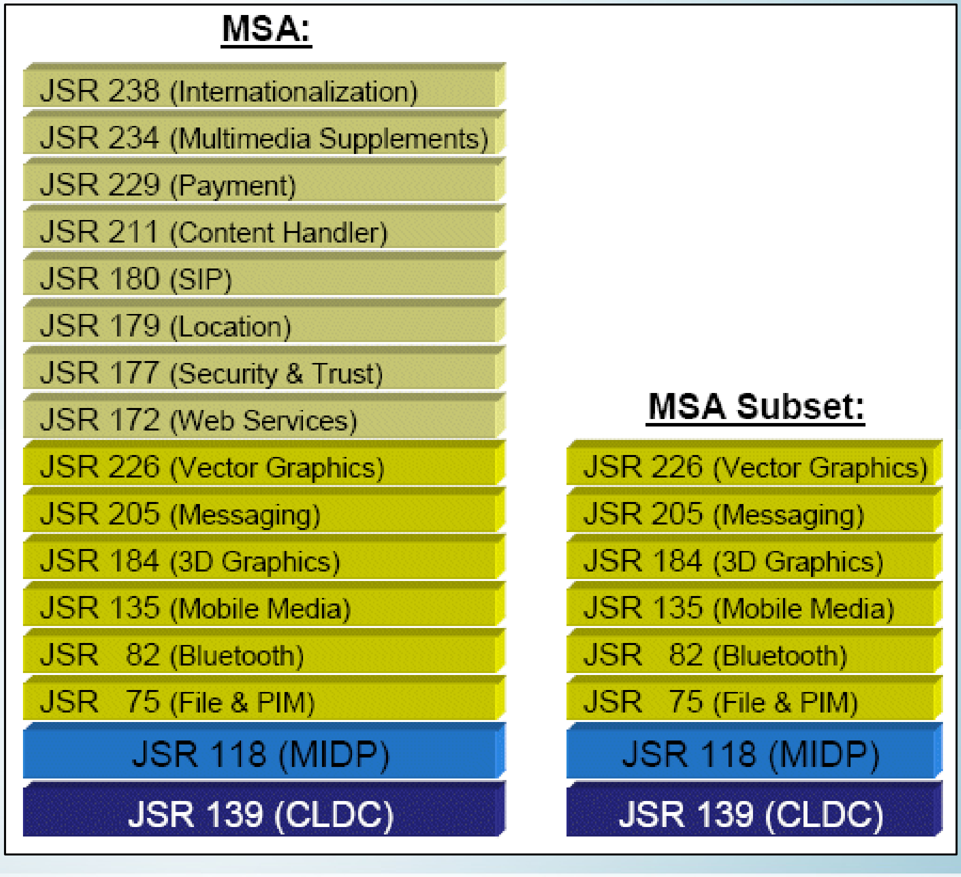
JTWI

- **JSR-185: Java Technology for Wireless Industry (umbrella specification)**



MSA

- JSR-248: Mobile Service Architecture



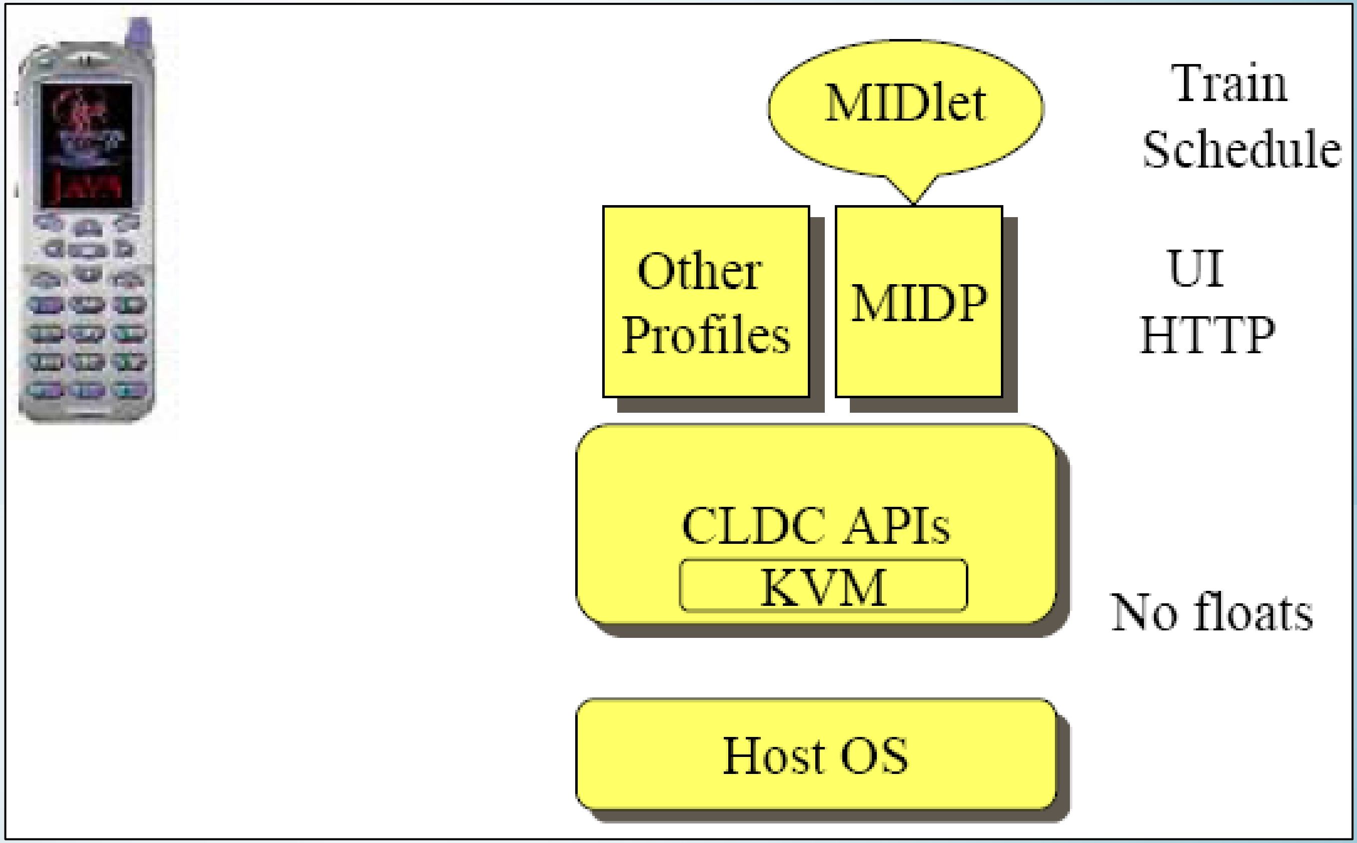
MSA:

JSR 238 (Internationalization)
JSR 234 (Multimedia Supplements)
JSR 229 (Payment)
JSR 211 (Content Handler)
JSR 180 (SIP)
JSR 179 (Location)
JSR 177 (Security & Trust)
JSR 172 (Web Services)
JSR 226 (Vector Graphics)
JSR 205 (Messaging)
JSR 184 (3D Graphics)
JSR 135 (Mobile Media)
JSR 82 (Bluetooth)
JSR 75 (File & PIM)
JSR 118 (MIDP)
JSR 139 (CLDC)

MSA Subset:

JSR 226 (Vector Graphics)
JSR 205 (Messaging)
JSR 184 (3D Graphics)
JSR 135 (Mobile Media)
JSR 82 (Bluetooth)
JSR 75 (File & PIM)
JSR 118 (MIDP)
JSR 139 (CLDC)

CLDC – Wireless Device Stack



CLDC - Internals

- The CLDC specification specifies VM features required by a CLDC implementation
- Specifies requirements and APIs for
  - Input / Output
  - Networking

CLDC –
Language & VM Compatibility

- Goal:
  - – Full java language and VM specification compatibility
- Language-level exception:
  - – No floating point support in CLDC 1.0
    - No hardware floating point support
    - Manufacturers and developers can include their own floating point

CLDC VS. J2SE JVM

- Limitations in CLDC supporting JVM:
  - No floating point support
  - No finalization
  - Limited error handling
  - No Java Native Interface (JNI)
  - No support for reflection
  - No thread groups or daemon threads
  - No weak references

Beyond the CLDC Scope

- Profiles implemented on top of CLDC specify APIs for:
  - User Interface support
  - Event handling
  - Persistent support
  - High-level application model
- An example profile is the Mobile Information Device Profile (MIDP)

CLDC - APIS

- Classes inherited from J2SE v1.3 are in packages:
  - java.lang
  - java.io
  - java.util
- New classes introduced by the CLDC are in package:
  - javax.microedition

CLDC Libraries: JAVA.LANG.*

- Boolean
- Byte
- Character
- Class
- Integer
- Long
- Math
- Object
- Runnable
- Runtime
- Short
- String
- StringBuffer
- System
- Thread
- Throwable

CLDC Libraries: JAVA.IO.*

- ByteArrayInputStream
- ByteArrayOutputStream
- DataInput
- DataOutput
- DataInputStream
- DataOutputStream
- InputStream
- OutputStream
- InputStreamReader
- OutputStreamWriter
- PrintStream
- Reader
- Writer

CLDC Libraries: JAVA.UTIL.*

- Calendar
- Date
- Enumeration
- Hashtable
- Random
- Stack
- TimeZone
- Vector

CLDC - MIDP

- Targets mobile two-way communication devices implementing the CLDC
- It addresses:
  - Display toolkit (user input)
  - Persistent data storage
  - HTTP based networking using CLDC generic connection framework
- Available for free download

CLDC – MIDP Internals

- Goal:
  - MIDP implementation must fit in small footprint (128KB ROM)
  - Must run with limited heap size (32-200KB RAM)

- To be implemented by device manufacturers, operators, or developers

MIDP - APIS

- The MIDP specifies APIs for:
  - User Interface
  - Networking (based on CLDC)
  - Persistent Storage
  - Timers

MIDP –
User Interface (UI)

- Not a subset of AWT or Swing because:
  - AWT is designed for desktop computers
  - Assumes certain user interaction models (pointing device such as a mouse)
  - Window management (resizing overlapping windows). This is impractical for cell phones
- Consists of high-level and low-level APIs

MIDP - UI APIS

- High-level API
  - Applications should be runnable and usable in all MIDP devices
  - No direct access to native device features
- Low-level API
  - Provide access to native drawing primitives, device key events, native input devices
  - Allows developers to choose to compromise portability for user experience

MIDP –
UI Programming Model

- The central abstraction is a screen
- Only one screen may be visible at a time
- Three types of screens:
  - Predefined screens with complex UI components (List, TextBox)
  - Generic screens (Formwhere you can add text, images, etc)
  - Screens used with low-level API (Canvas)

MIDP – UI and Display

- The Display class is the display manager
- It is instantiated for each active MIDlet
- Provides methods to retrieve information about the device’s display capabilities
- A screen is made visible by calling:

  Display’s setCurrent(screen);

MIDP – UI Classes

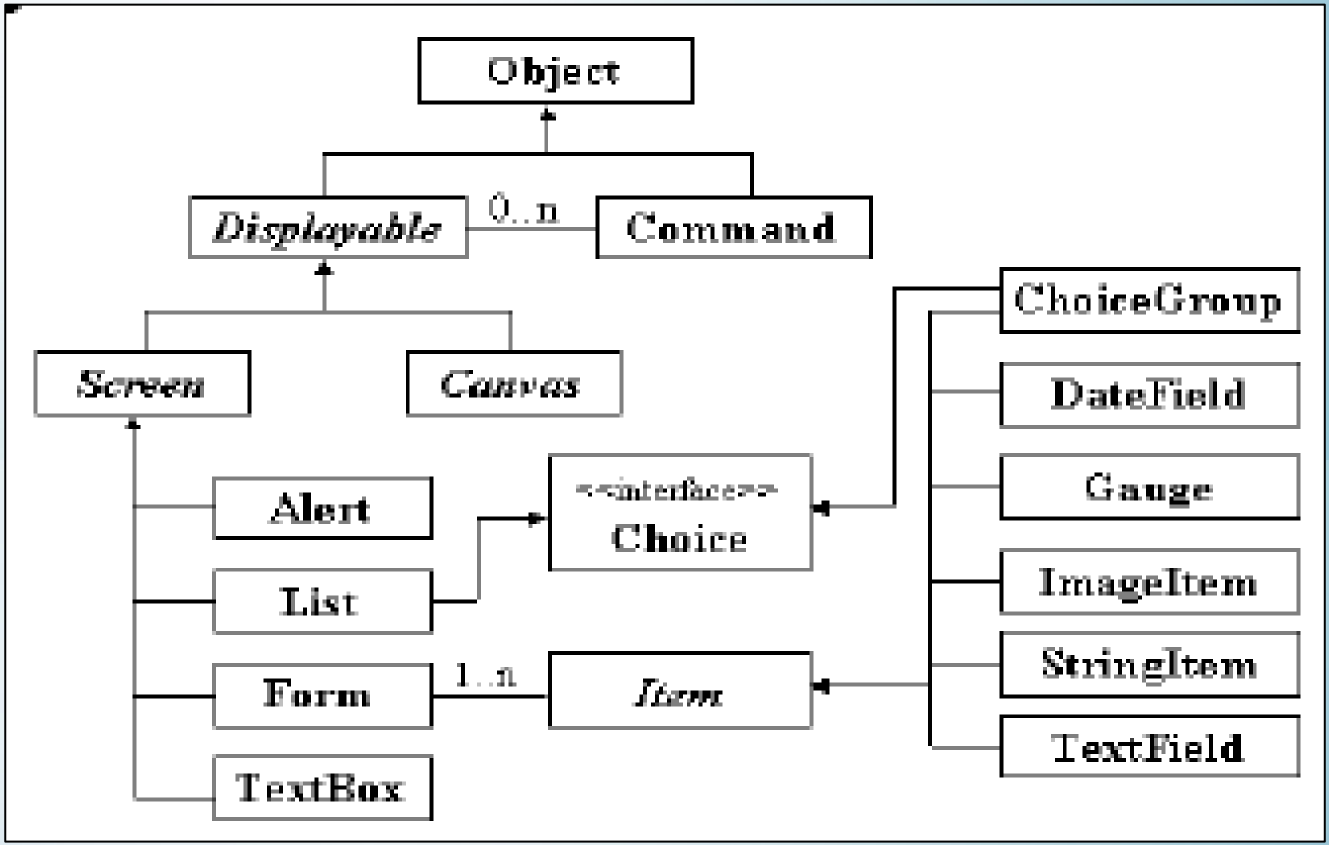
- *javax.microedition.lcdui* classes:

  Alert, AlertType, Canvas, ChoiceGroup, Command, DateField, Display, Displayable, Font, Form, Gauge, Graphics, Image, ImageItem, Item, List, Screen, StringItem, TextBox, TextField, Ticker
- *javax.microedition.lcdui* interfaces:

  Choice, CommandListener, ItemStateListener

MIDP UI Class Diagram

- Major classes and interfaces:



MIDP - MIDlets

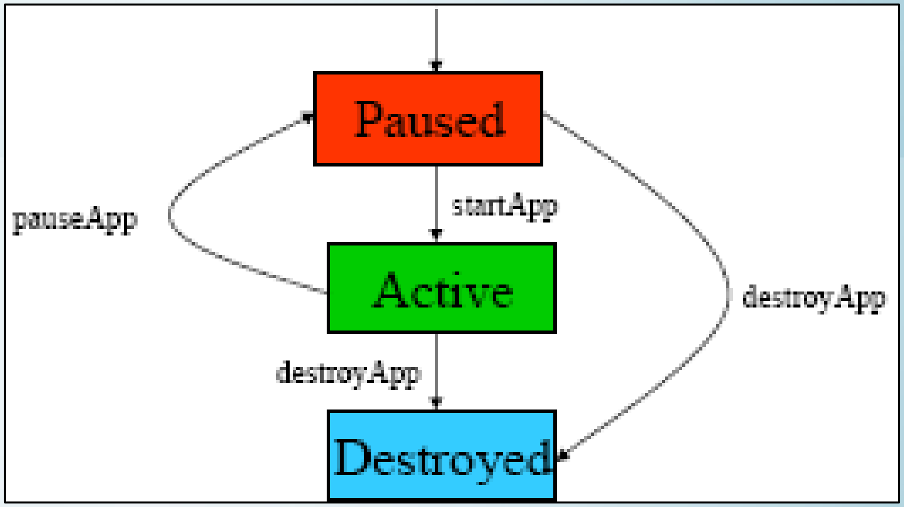
- A MIDlet consists of a class that extends the MIDletclass and other classes as needed

- To handle events it must implement the *CommandListenerinterface*

```
public class MyMIDlet extends MIDlet implements
    CommandListener {
}
```

MIDP Application Lifecycle

- MIDlets move from state to state in the lifecycle:
  - Start: acquire resources and start executing
  - Pause: release resources and wait
  - Destroyed: release all resources and end all activities



MIDLET - Packaging

- Two or mode MIDlets form a MIDlet suite
- One or more MIDlets may be packaged in a single JAR file that includes:
  - A manifest describing the contents
  - Java classes for the MIDlet(s)
  - Resource file(s) used by the MIDlet(s)
- Each jar file is accompanied by a Java Application Descriptor (JAD) file

MIDLET – Packaging (Cont.)

- Java Application Descriptor (JAD) file provides info:
  - Configuration properties
  - Pre-download properties
    - Size, version, storage requirements

MIDLET - Example

```
import javax.microedition.midlet.MIDlet;
import javax.microedition.lcdui.*;

public class FirstMIDletextends MIDlet {
    Display display= null;
    TextBox tb = null;
    public FirstMIDlet() {
        display = Display.getDisplay(this);
   }
```

MIDLET – Example (Cont.)

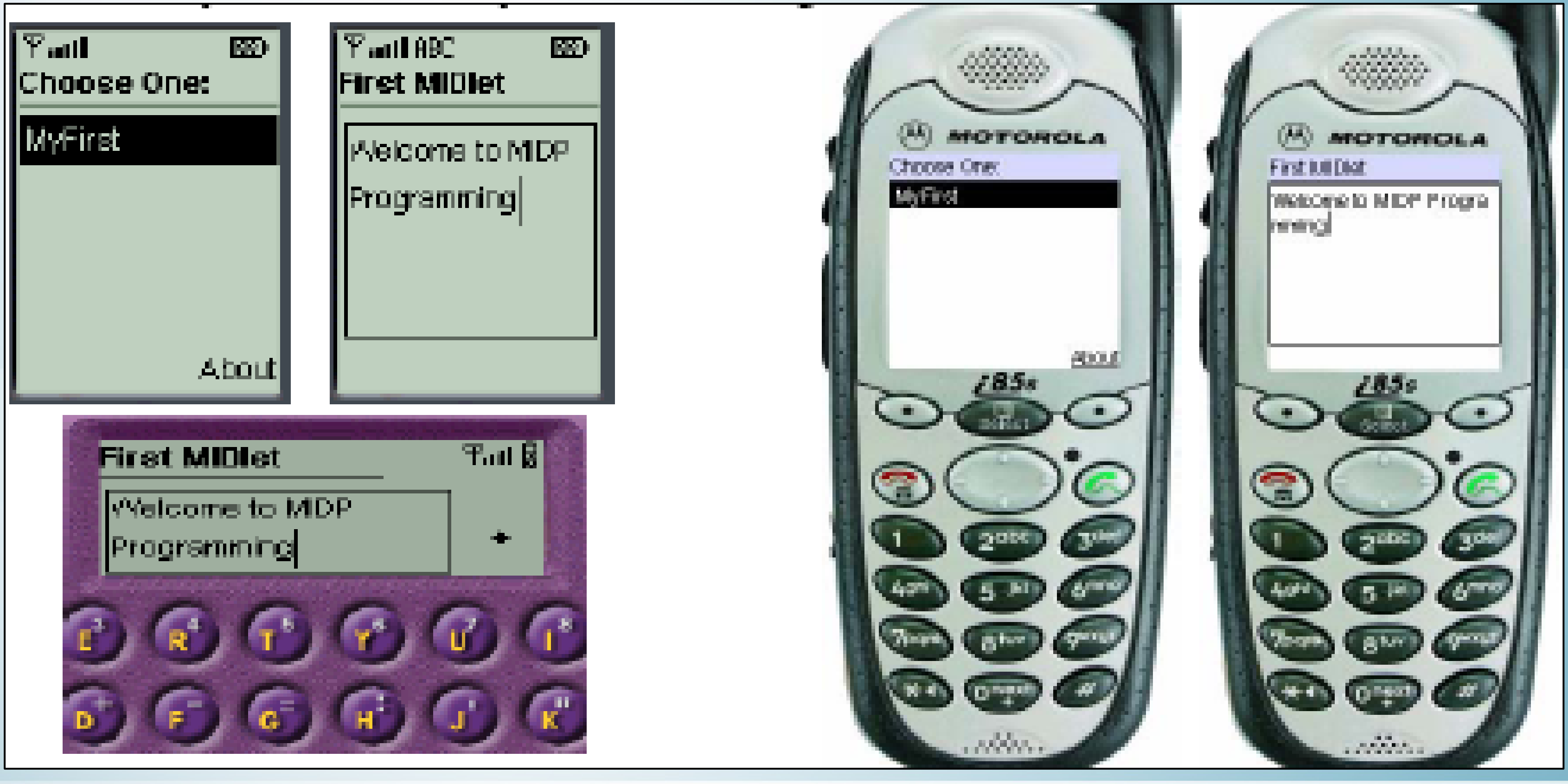
```
  public void startApp() {
    tb= new TextBox("FirstMIDlet", "Welcome to
                                      MIDP Programming", 40, 0);
     display.setCurrent(tb);
  }
  public void pauseApp() { }
  public void destroyApp(boolean unconditional) { }
  }
}
```

MIDLET – Example (Cont.)

- Compile (javac)
- Preverify (off device preverification)
- Create a JAR file: first.jar
- Create a JAD file: first.jad
  - MIDlet-Name: MyFirst
  - MIDlet-Version: 1.0.0
  - MIDlet-Vendor: Sun Microsystems, Inc.
  - MIDlet-Description: My First MIDlet
  - MIDlet-Info-URL: http://java.sun.com/javame/
  - MIDlet-Jar-URL: first.jar
  - MIDlet-Jar-Size: 1063
  - MicroEdition-Profile: MIDP-1.0
  - MicroEdition-Configuration: CLDC-1.0
  - MIDlet-1: MyFirst,, FirstMIDlet

MIDLET – Example: Testing

- midp –Xdescriptor first.jad



Choose One:

MyFirst

About

First MIDlet

Welcome to MIDP Programming

MIDlet – Example: Deploying

- Local: USB, Bluetooth
- Web:
  - To deploy a MIDlet on a web server, you need to add a new MIME type:

    text/vnd.sun.j2me.app-descriptor jad

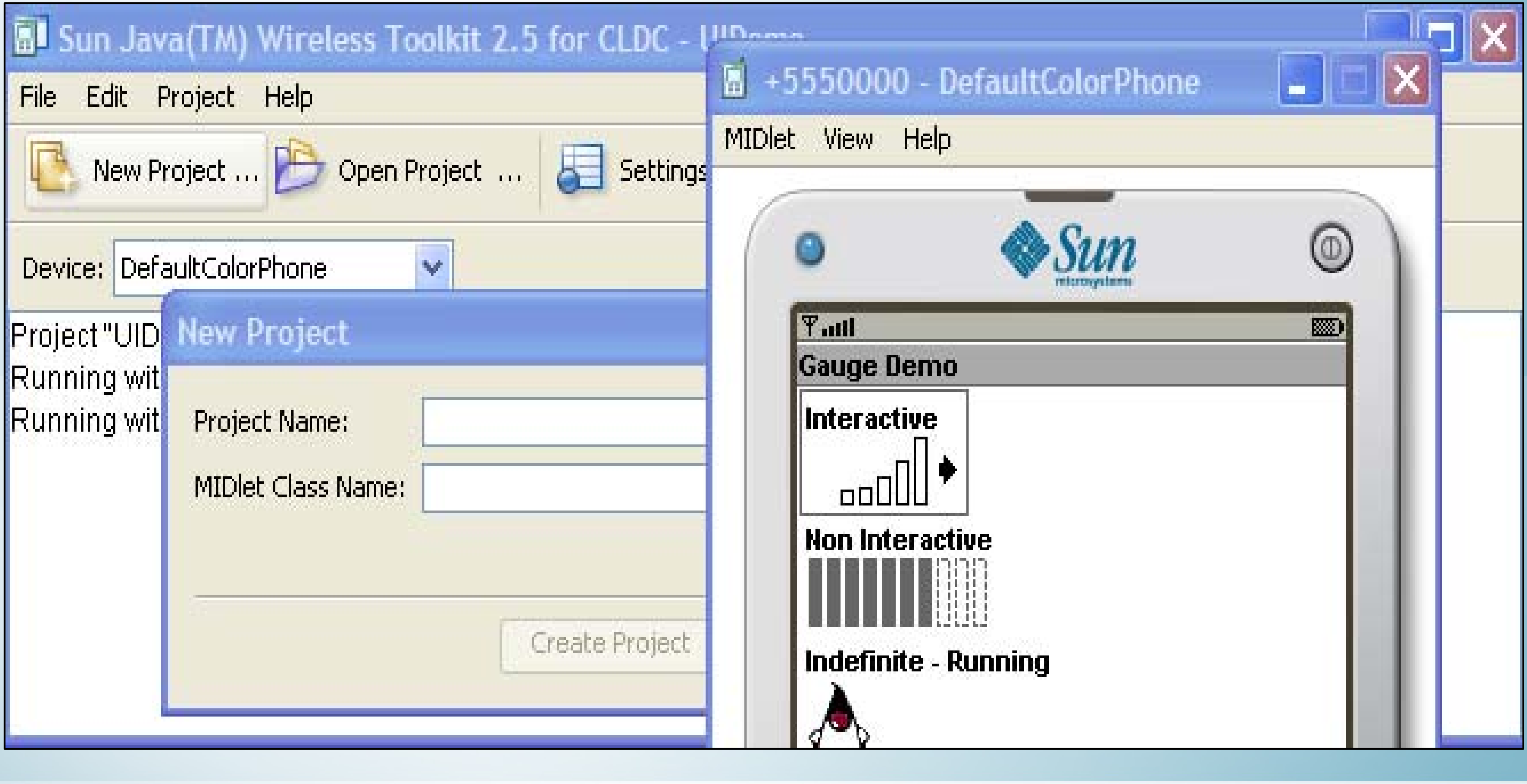
    application/java-archive jar
  - Create an HTML file with link to the .jar file
  - Use the following command to run:

emulator –Xdescriptor:<JAD file>

- Push registry: incoming network connections can launch specific MIDlets

Simplifying the Development Effort

- Sun Java Wireless Toolkit for CLDC



Device: DefaultColorPhone

Project "UID
Running wit
Running wit

Project Name:

MIDlet Class Name:

Low-Level API Examples

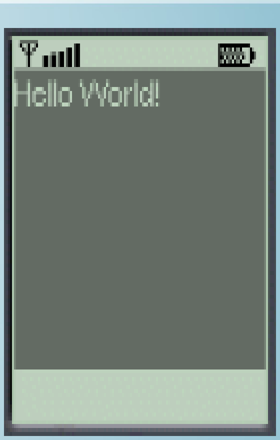
- Canvas:

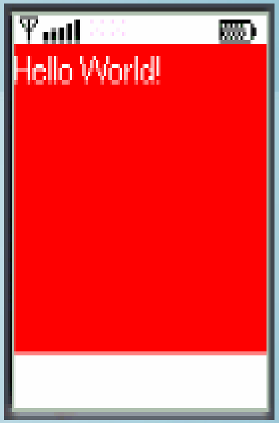
```
public class MyCanvas extends Canvas {
    public void paint(Graphics g) {
        g.setColor(255, 0, 0);
        g.fillRect(0, 0, getWidth(), getHeight());
        g.setColor(255, 255, 255);
        g.drawString("Hello World!", 0, 0, g.TOP | g.LEFT);
    }
}
```

Low-Level API Examples (Cont.)

- Instantiate and display MyCanvas

```
public class MyMidlet extends MIDlet {
   public MyMidlet() { // constructor
}
public void startApp() {
    Canvas canvas = new MyCanvas();
    Display display = Display.getDisplay(this);
    display.setCurrent(canvas);
}
// pauseApp() and destroyApp()
}
```

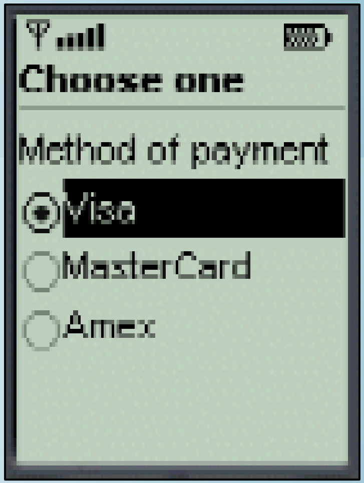

Hello World!


Hello World!

High-Level API Examples

- List:

```
Display display = Display.getDisplay(this);
List menu = new List(“Method of payment”,
   Choice.EXCLUSIVE);
menu.append(“Visa”);
menu.append(“MasterCard”);
menu.append(“Amex”);
display.setCurrent(menu);
```



Choose one

Method of payment

● Visa

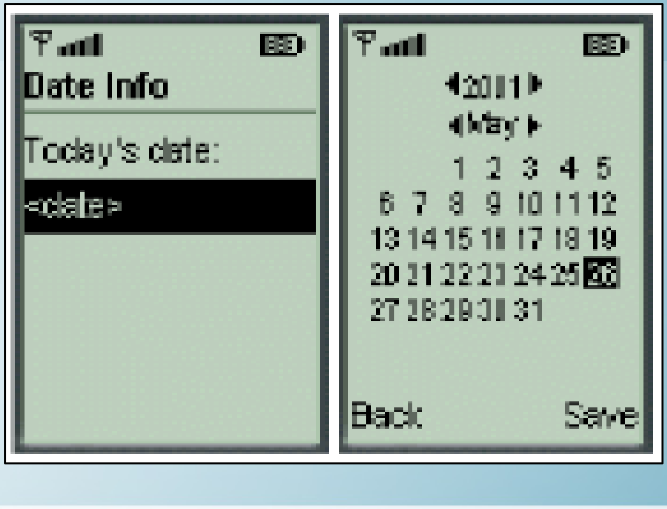
○ MasterCard

○ Amex

High-Level API Examples (Cont.)

- Form (Date/Time info):

```
DateField date = new DateField(“Today’s date”, DateField.TIME);
Form form = new Form(“Date Info”);
form.append(date);
display.setCurrent(form);
```



Date Info

Today's date:

<date>

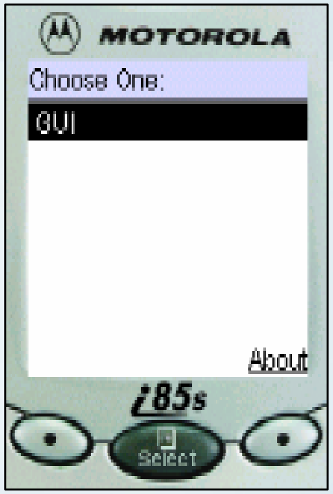
2011

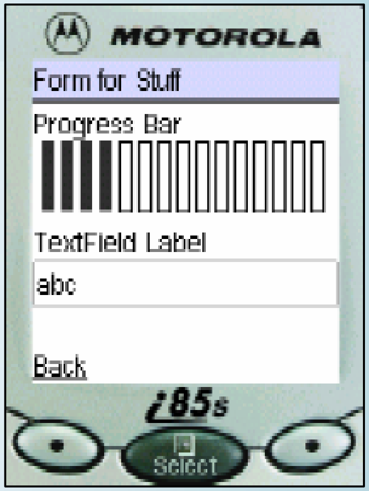
May

```
         1  2  3  4  5
 6  7  8  9 10 11 12
13 14 15 16 17 18 19
20 21 22 23 24 25 26
27 28 29 30 31
```

Input Handling

- High-Level API input is handled using abstract commands
  - No direct access to soft buttons
  - Commands are mapped to appropriate soft buttons or menu items

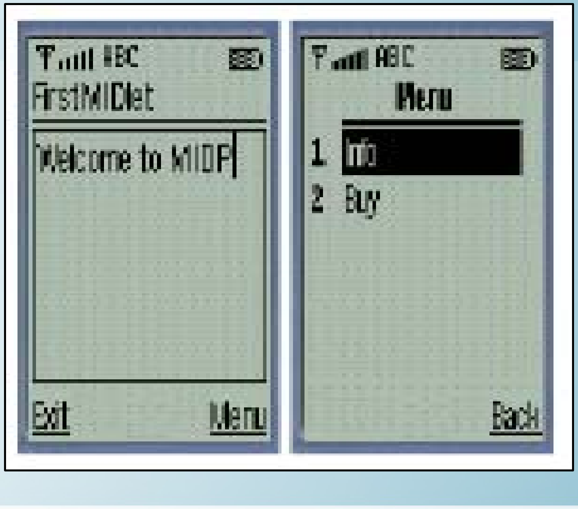




Input Handling: Example

- TextBox screen with commands:

```
Display display = Display.getDisplay(this);
TextBox tb= new TextBox(“MIDP”, “Welcome to MIDP
    Programming”, 40, TextField.ANY);
Command exit = new Command(“Exit”, Command.SCREEN, 1);
Command info = new Command(“Info”, Command.SCREEN, 2);
Command buy = new Command(“Buy”, Command.SCREEN, 2);
tb.addCommand(exit);
tb.addComment(info);
tb.addCommand(buy);
display.setCurrent(tb);
```



Welcome to MIDP

Event Handling: High-Level

- High-level Events:
  - Based on a listener model
  - Screen objects can have listeners for commands
  - For an object to be a listener, it must implement the *CommandListenerinterface*
  - This interface has one method: *commandAction*

Event Handling: High-Level Example

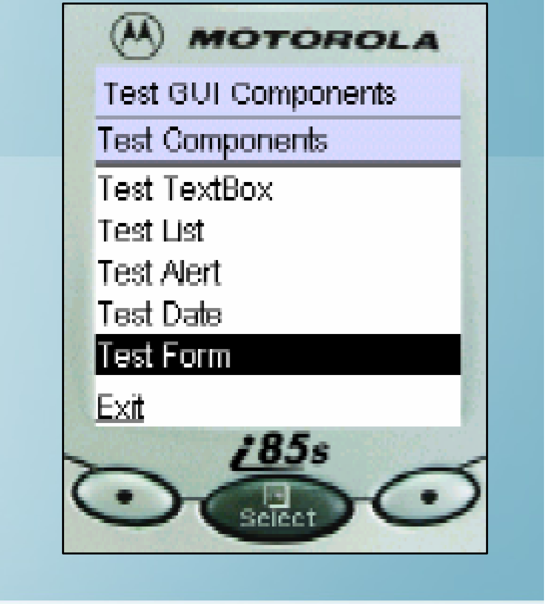
- MIDlet implements CommandListener

```
public class MyMIDletextends MIDlet implements
   CommandListener{
    Command exitCommand= new Command(…); // other stmts
    public void commandAction(Command c, Displayable s) {
        if (c == exitCommand) {
            destroyApp(false);
            notifyDestroyed();
        }
    }
}
```

Event Handling: High-Level Example (Cont.)

- Handling List events:

```
public void commandAction(Commandc, Displayable d) {
    if (c == exitCommand) { ..
    } else {
    List down = (List)display.getCurrent();
    switch(down.getSelectedIndex()) {
    case 0: testTextBox();break;
    case 1: testList();break;
    case 2: testAlert();break;
    case 3: testDate();break;
    case 4: testForm();break;
}
```



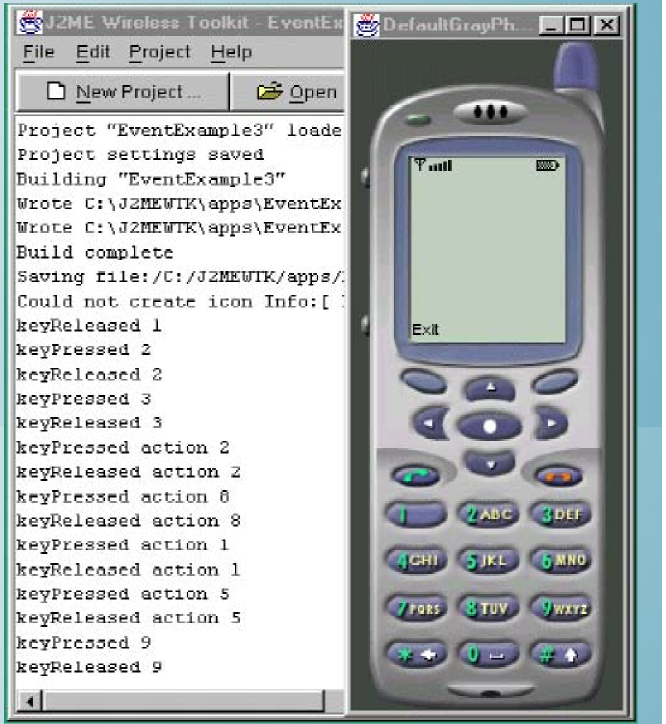
Event Handling: Low-Level

- Low-level Events:
  - Low-level API gives developers access to key press events
  - Key events are reported with respect to key codes
  - MIDP defines key codes: KEY_NUM0 .. KEY_NUM9, KEY_STAR, KEY_POUND

Event Handling: Low-Level Example

- Low-level events

```
protected void keyPressed(intkeyCode) {
    if (keyCode> 0) {
        System.out.println("keyPressed
        " +((char)keyCode));
    } else {
        System.out.println("keyPressedaction
        "+getGameAction(keyCode));
    }
}
```



```
Project "EventExample3" loade
Project settings saved
Building "EventExample3"
Wrote C:\J2MEWTK\apps\EventEx
Wrote C:\J2MEWTK\apps\EventEx
Build complete
Saving file:/C:/J2MEWTK/apps/
Could not create icon Info:[
keyReleased 1
keyPressed 2
keyReleased 2
keyPressed 3
keyReleased 3
keyPressed action 2
keyReleased action 2
keyPressed action 8
keyReleased action 8
keyPressed action 1
keyReleased action 1
keyPressed action 5
keyReleased action 5
keyPressed 9
keyReleased 9
```

Error Handling

- Important to handle errors smoothly to provide a great user experience
- Users should be provided clear information on how to correct an issue if possible in a error message
- If an uncorrectable exception is possible the user should be given an ability to log the error information to report to developer
- All possible exceptions should be handled in some manner in an application

MIDP UI Design Principles

- Make the UI simple and easy to use
- Use the high-level API (portability)
- If you need to use low-level API, keep to the platform-independent part
- MIDlets should not depend on any specific screen size
- Entering data is tedious, so provide a list of choices to select from