Sun SPOTs in Action—3D, Virtual Reality and Gaming

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Session TS-1780

Immersive Java™ Platform Gaming

How to build your own Java technology-based Wii

Learn how to use a range of Java technologies to build compelling, interactive 3D virtual reality games

Agenda

Introduction to Project Sun SPOTs (SPOTs)

Interfacing Useful Hardware to SPOTs

Using Java 3D™ API for Virtual Reality

SPOT Interaction Software

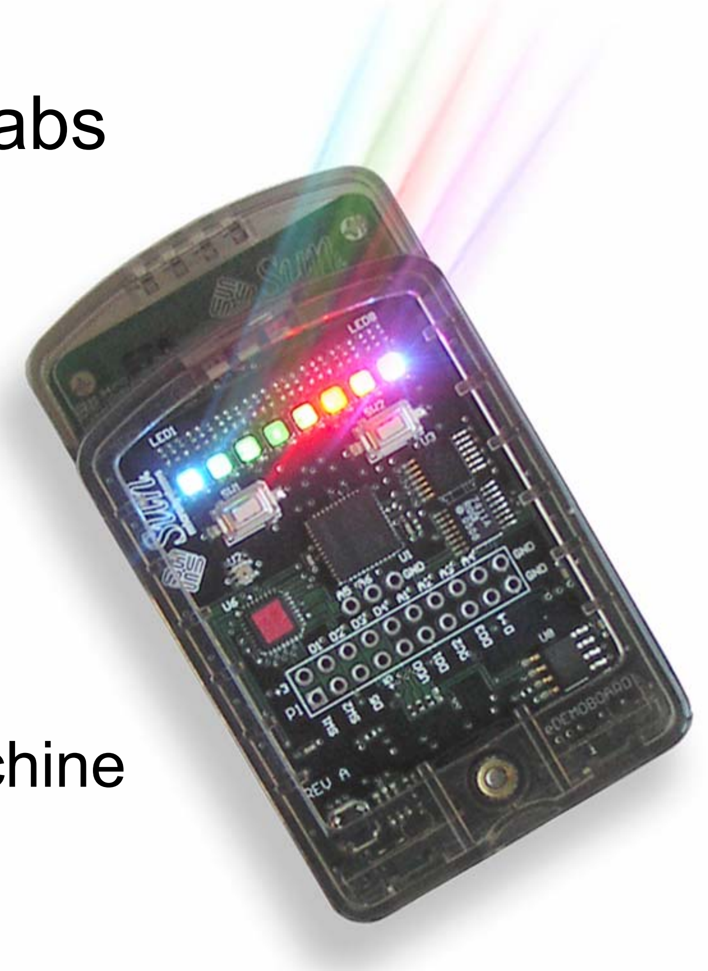
Bringing it All Together

Summary and Resources

Demos

Project Sun SPOTs
Small Programmable Object Technology

- Research project from Sun Labs
- Platform for wireless sensor network applications
- Helping to build the “network of things”
- Several areas of research
  - Java platform on small devices
  - More portable Java Virtual Machine (JVM™ machine)
  - Isolate application model



The terms “Java Virtual Machine” and “JVM” mean a Virtual Machine for the Java™ platform.

SPOT Processor Board

- 180MHz 32-bit ARM 920T CPU
  - 512Kb RAM, 4Mb FLASH
- Chipcon 2420 radio package
  - 2.4GHz frequency
  - IEEE 802.15.4 (Low rate PAN protocol)
- USB interface
- 3.7V 750 mAh Li-Ion battery
- Power consumption 40-100mA
  - Depending on radio/LED/peripheral usage
  - 40 µA deep sleep mode

SPOT Demo Sensor Board

- Accelerometer
- Temperature sensor
- Light sensor
- 8 tri-colour LEDs
- 2 push-button switches
- Analog to digital input pins
- GPIO pins
- High current (100mA) output pins

Squawk Virtual Machine

- Objective: very portable, small footprint JVM machine
  - No underlying OS
  - Runs on “bare metal”
- Most of code written in Java programming language
  - Interpreter and low level I/O code written in C
  - Everything else in Java programming language
- Provides Java Platform, Micro Edition (Java ME) CLDC 1.1 environment
  - Additional libraries for specific functions such as sensors, LEDs, etc.

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Analog to Digital Converters

- SPOT has six ADC lines accessible via external header pins
  - Firmware currently only supports four
- Apply input that is in range 0-3V
- Read value with 10-bit resolution via **`IScalarInput`** class

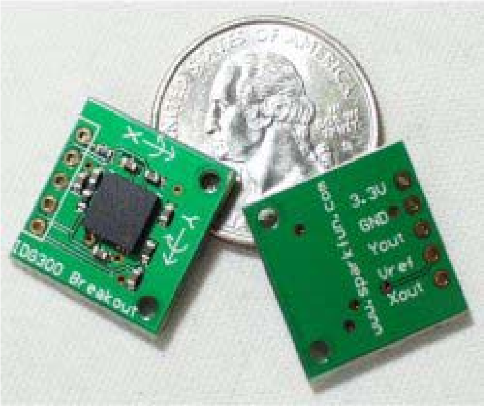
```
EDemoBoard db = EDemoBoard.getInstance();
IScalarInput analog =
    db.bindScalarInput(EDemoBoard.A0);
int analogValue = analog.getValue();
```

Accelerometer

- SPOT has built in 3-axis accelerometer
  - Uses ST-Micro LIS3L02 component
- Scale can be set to 2G or 6G
- Acceleration is measured relative to gravity
  - Tilting the SPOT changes the value

```
EDemoBoard db = EDemoBoard.getInstance();
IAccelerometer3D acc = db.getAccelerometer();
acc.setRange(0);  // 2G
IScalarInput xAccel = acc.getX();
int xa = xAccel.getValue();
```

Solid State Gyroscope



- IDG-300 dual-axis gyroscope
- 3V supply can be taken from SPOT
- X and Y lines connect to ADC pins on SPOT
- Use two mounted orthogonally for full 3D data
- Provides rotational velocity
  - Can be used to calculate change in orientation of SPOT
  - Change is 2mV/degree/second
  - Some drift creeps in—needs to be accounted for

The P5 Data Glove

- Designed for gaming applications
- Uses proprietary hardware and software
- Required modification to work with SPOT
  - Very fiddly soldering to surface-mounted connector
- Two gyros glued inside
- SPOT mounted on top using Velcro

Data Glove Software

- Initialise all inputs from ADC
- Initialise radio communication via broadcast
- Run thread to check values from sensors
  - Use event model to send changes to the PC
- Calibration required to determine appropriate values for bend sensors and accelerometer
- For smooth mouse movements send data every 1/25 second
  - Standard frame refresh rate

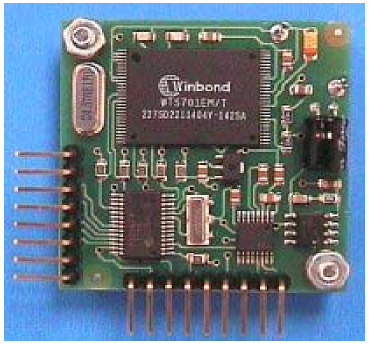
Game Pad Thumb Joystick

- Remove from cheap game pad
- Left-right and back-forward wired to ADC lines
  - Implemented as potentiometers
- Push-button wired to digital input
  - Switch pulls pin from 0 to 3V

Compass Sensor

- Useful for determining orientation
  - Z-axis of accelerometer not really suitable
- CMPS03 magnetic compass module
  - Uses 2 Philips KMZ10A sensors
  - 0.1 degree resolution, 3–4 degrees accuracy
- Separate head-mounted SPOT
- Uses I2C interface
  - Integration took a bit of work
  - Not as simple as other sensor connection

Feedback



- Talking SPOT
- RS-232 interface SP03 board
  - 30 pre-recorded phrases
  - Text to speech capable
- SPOT can drive pins as UART
  - Required modified firmware for demo board
- Use MAX3232 as line driver
  - Convert TTL voltages to RS-232

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Virtual Reality

- Allows a user to interact with a computer-simulated environment
- Interactively
  - Makes the difference with two- and three-dimensional graphics mediums
  - Gives users some feeling of existence within an artificial world
- User representation
  - Avatar: complete virtual body
  - Part of a body such as a hand or as a controllable viewpoint

VR User Requirements

- Ease-of-use
- Conventions in navigation: be simple and intuitive
- Realism
- Degree of interaction and movement
  - Consider pre-set animations and fly-throughs
- Method of interaction—hardware and software
  - Mouse, keyboard, joystick or a touch-sensitive screen
  - HMD and sensor or data-gloves
- Speed: smooth movement, no long waits

Building the World

- Objects
  - Created using authoring tools, CAD software, 3-D scanners or by stitching images together
  - Use Bubble Worlds
  - Combine polygons to create three-dimensional objects
- Authoring tools
  - Simple as using a text editor (VRML developers)
  - Use a VR authoring tool: AutoCAD, 3D Studio Max, to ease the process
  - Optimize
    - Remove any unnecessary facets that slow down the rendering of the object
    - LOD operations prevent rendering detailed objects that the user cannot “see” from his viewpoint

Bubble Worlds

- Quick, easy and cheap way to present landscapes and indoor environments
- Excellent for guided walks
- Seamless panoramic image projected inside surface of a cylinder or sphere and viewed through an interactive window
- Give the impression of viewing an entire space from the ground to the sky and 360 degrees around through a moveable window
- At a minimum users will be able to pan, tilt and zoom

VRML: Virtual Reality Modeling Language

- Developed by the Web3D Consortium
- Designed for use on the Internet
- Is both a scene description language and a file format for virtual worlds
- The language is used to describe the geometry and behaviour of three-dimensional scenes
- VRML 1.0, VRML 2.0 (ISO), VRML 97 (ISO)
- Transformation, viewpoint setting, definition of lighting within the world and “shapehints”

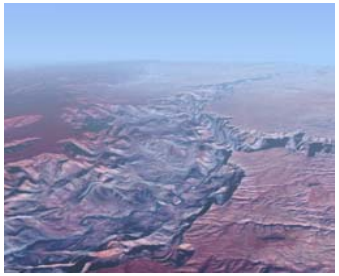
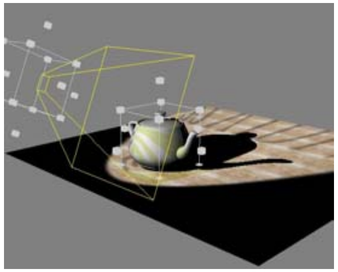
J3D-VRML97: VRML and Java 3D API

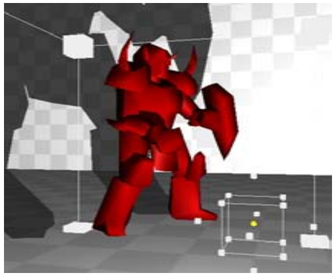
- Java 3D™ API loader for VRML97 models
- https://j3d-vrml97.dev.java.net/

```
import org.jdesktop.j3d.loaders.vrml97.VrmLoader;
   ...

   VrmlLoader loader = new VrmlLoader()
   BufferedReader in = new BufferedReader(new
     InputStreamReader(
       new FileInputStream(filename), "UTF8"));
   Scene scene = loader.load(in);
   BranchGroup branch = scene.getSceneGroup();
   ...
```

JOGL Project: Java Binding for the OpenGL® API (JOGL)

- Java™ Binding for the OpenGL® API (JSR-231)
- Designed to provide hardware-supported 3D graphics to applications written in Java programming language.
- Full access to the APIs in the OpenGL 2.0 specification and integrates with the AWT and Swing widget sets
- https://jogl.dev.java.net/
- JOGL demos: https://jogl-demos.dev.java.net/

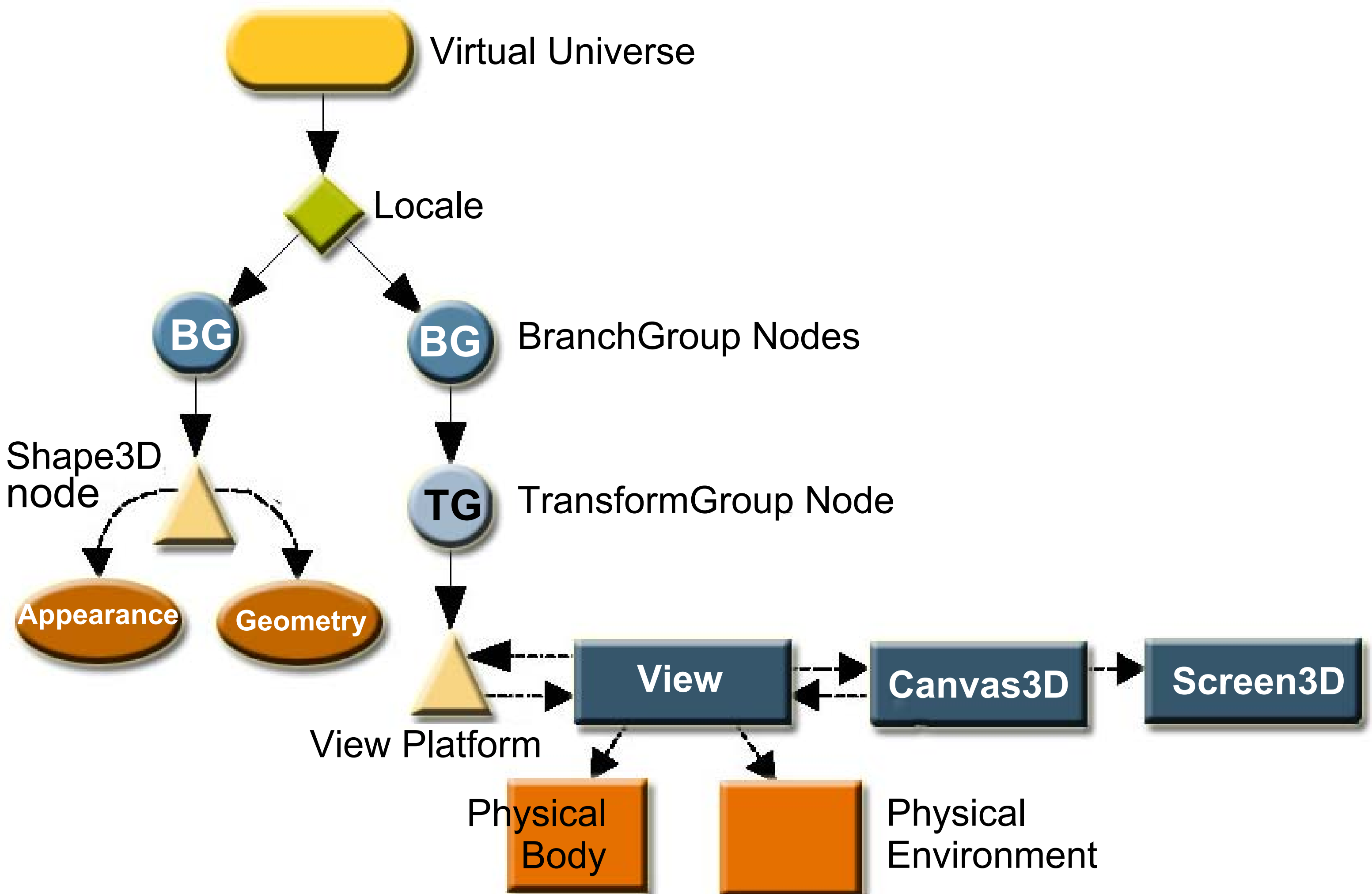





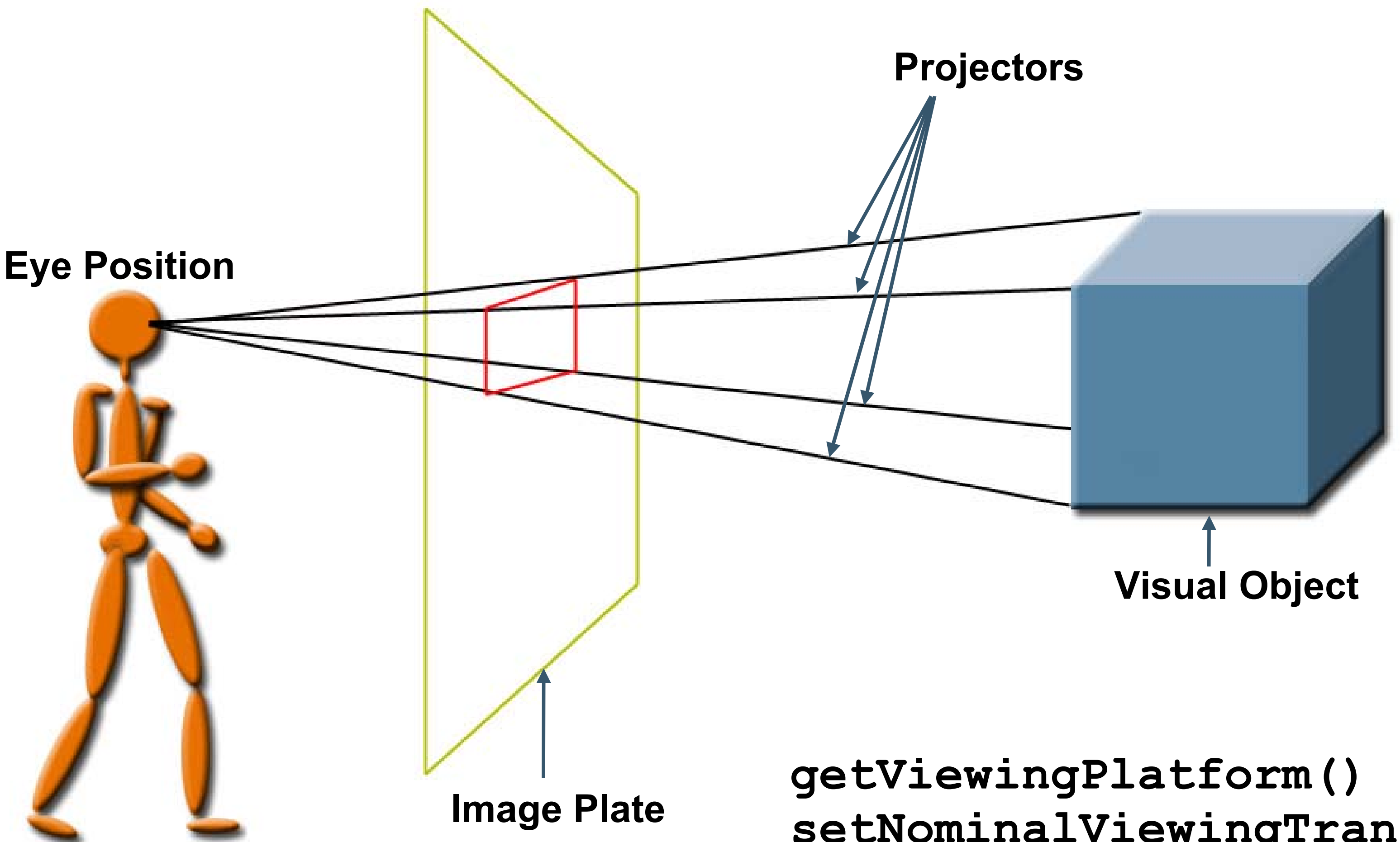
JOAL Project: OpenAL and Java Technology

- Reference implementation of the Java bindings for OpenAL API
  - Designed to provide hardware-supported 3D spatialized audio for games/apps written in Java platform
  - Make the development of high performance games/apps in Java platform a reality
- Hosts the Sound3D Toolkit
  - High level API for spatialized audio built on top of the OpenAL bindings
  - Provide access to all the features of OpenAL through an intuitive, easy-to-use, object-oriented interface
- https://joal.dev.java.net/

Example of a Scene Graph



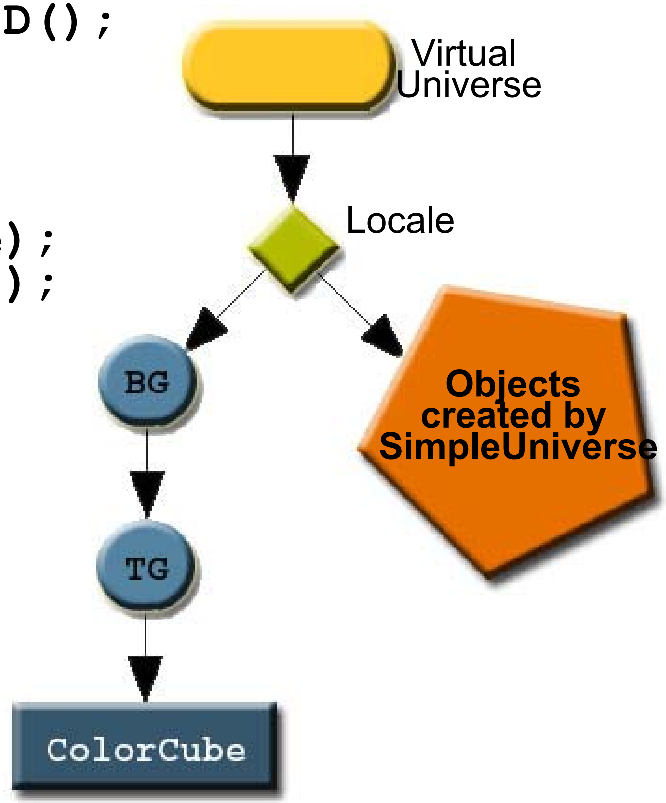
Conceptual Drawing of Image Plate and Eye Position in a Virtual Universe




```
getViewingPlatform()
setNominalViewingTransform()
```

Rotation Transformation Application

```
...
BranchGroup scene = new BranchGroup();
Transform3D rotate = new Transform3D();
Transform3D tempRotate =
                       new Transform3D();
rotate.rotX(Math.PI/4.0d);
tempRotate.rotY(Math.PI/5.0d);
rotate.mul(tempRotate);
TransformGroup objRotate =
            new TransformGroup(rotate);
objRotate.addChild(new ColorCube(0.4));
scene.addChild(objRotate);
simpleU.addBranchGraph(scene);
...
```



Loader Classes

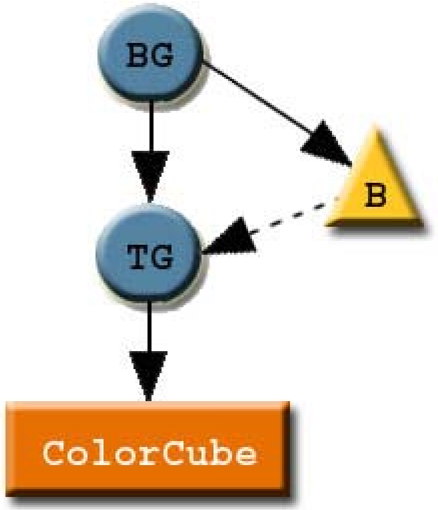
- **`Loader`**: specifies the elements that should be loaded from a file written in a given 3d format
- **`Scene`**: extracts Java 3D API scene graph information from the loaded file
- **`Lw3dLoader`**: for Lightwave 3D scene files
- **`ObjectFile`**: ObjectFile for Wavefront .obj files
- **`LoaderBase`**: implements the ***`Loader`*** interface in a generic way to encourage the building of loaders for other 3D formats through subclassing
- 3DS,COB,DXF,LWS,OBJ,VTK,WRL…

Using Loaders

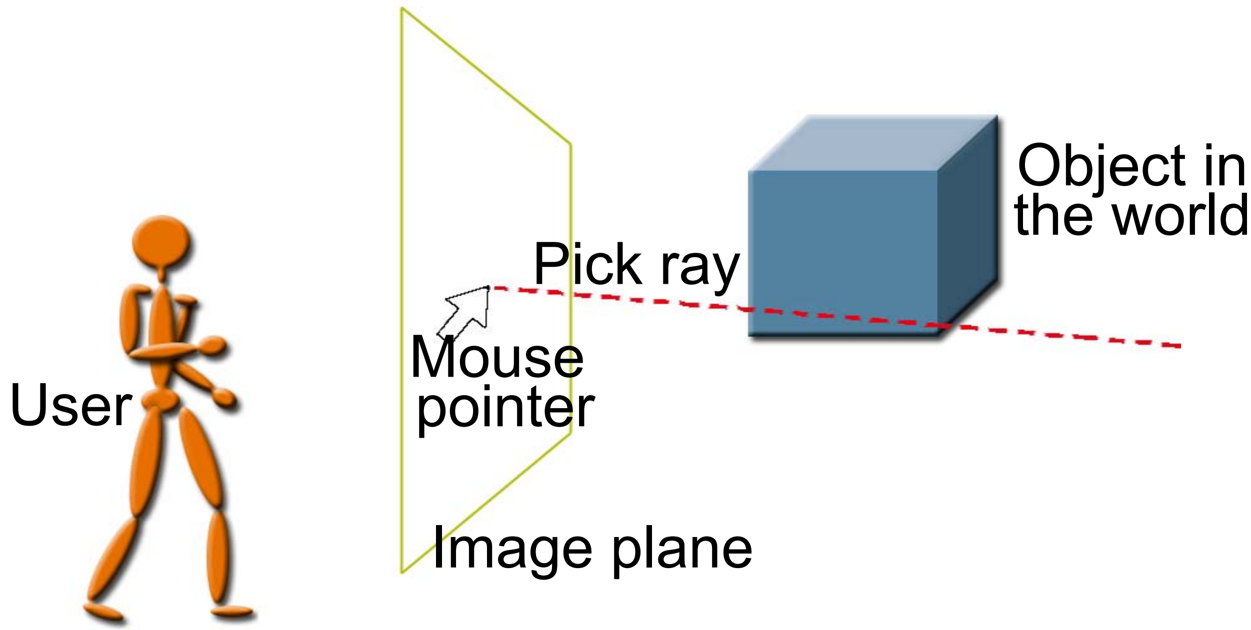
```
import com.sun.j3d.loaders.objectfile.ObjectFile;
import com.sun.j3d.loaders.ParsingErrorException;
import com.sun.j3d.loaders.IncorrectFormatException;
import com.sun.j3d.loaders.Scene;
import javax.media.j3d.*;
import javax.vecmath.*;
...

   BranchGroup objRoot = new BranchGroup();
  ObjectFile f = new ObjectFile();
  Scene s = null;
  try {
      s = f.load(filename);
  }
  catch (FileNotFoundException e){...}
  catch (ParsingErrorException e){...}
  catch (IncorrectFormatException e){...}
  objRoot.addChild(s.getSceneGroup());
...
```

Behavior Objects

- Both interaction and animation are specified with **`Behavior`** objects
- A **`Behavior`** object changes the scene graph in response to events
  - Key presses, mouse moves, object collisions, passage of time, etc.
- User-defined Behavior classes triggered by WakeupCondition objects
- KeyNavigatorBehavior, Mouse Behavior PickMouseBehavior, Interpolator...

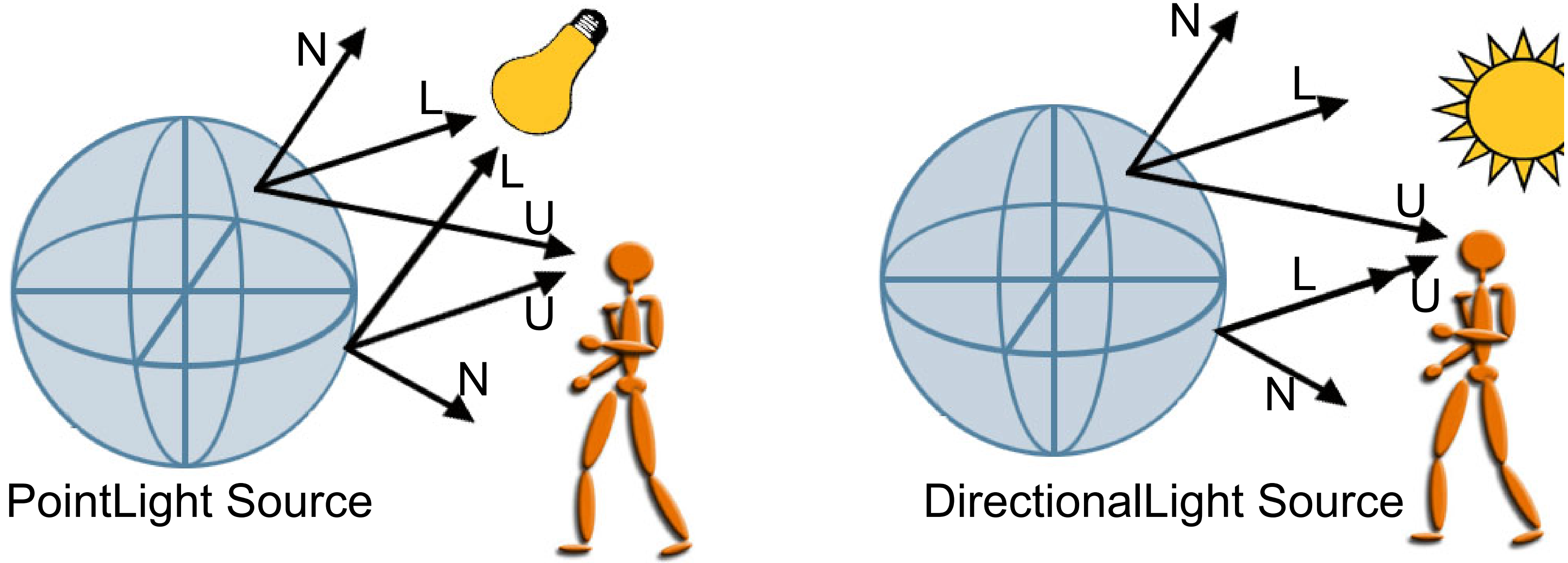


Picking




```
objRotate = new TransformGroup(transform);
objRotate.setCapability(
             TransformGroup.ENABLE_PICK_REPORTING);
objRoot.addChild(objRotate);
objRotate.addChild(new ColorCube(0.4));
pickRotate = new PickRotateBehavior(
                     objRoot,canvas, behaveBounds);
objRoot.addChild(pickRotate);
```

Lights




```
AmbientLight lightA = new AmbientLight();
lightA.setInfluencingBounds(
                        new BoundingSphere());
scene.addChild(lightA);
```

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Robot Class

- Part of AWT, designed for writing tests
- Emulates control of mouse from within application
- Movement is absolute, rather than relative

```
mousePress(int buttons)
mouseRelease(int buttons)
mouseMove(int x, int y)
```

Determining Position

- ***Simple physics***

$$d = \int_0^t v \, dt \qquad v = \int_0^t a \, dt$$

- Not so simple with available data
- Remember, accelerometer value changes with tilt
- Need to combine gyro data with calibrated accelerometer data
- Ultimately get position relative to start point

Radio Positioning

- SPOT sends “ping” radio signal
- APIs provide simple radio signal strength access
  - **`Radiogram.getRssi()`**
- Take signal strength from multiple basestations
  - Inverse square law for distance
  - Triangulate position
  - More basestations means more degrees of accuracy
- Stability of signal strength is not high
  - Resolution of position changes is therefore low
  - Good enough for some situations

Networking with Dead Reckoning

- Technique of calculating your present position from past position and your speed
- Updating your position transmit only velocities changes
- Exact position of object extrapolated from its last known location and velocity
- Exchange simple deterministic instructions:
  - "Follow this ship," "Orbit that planet"
- Communicated in very little data

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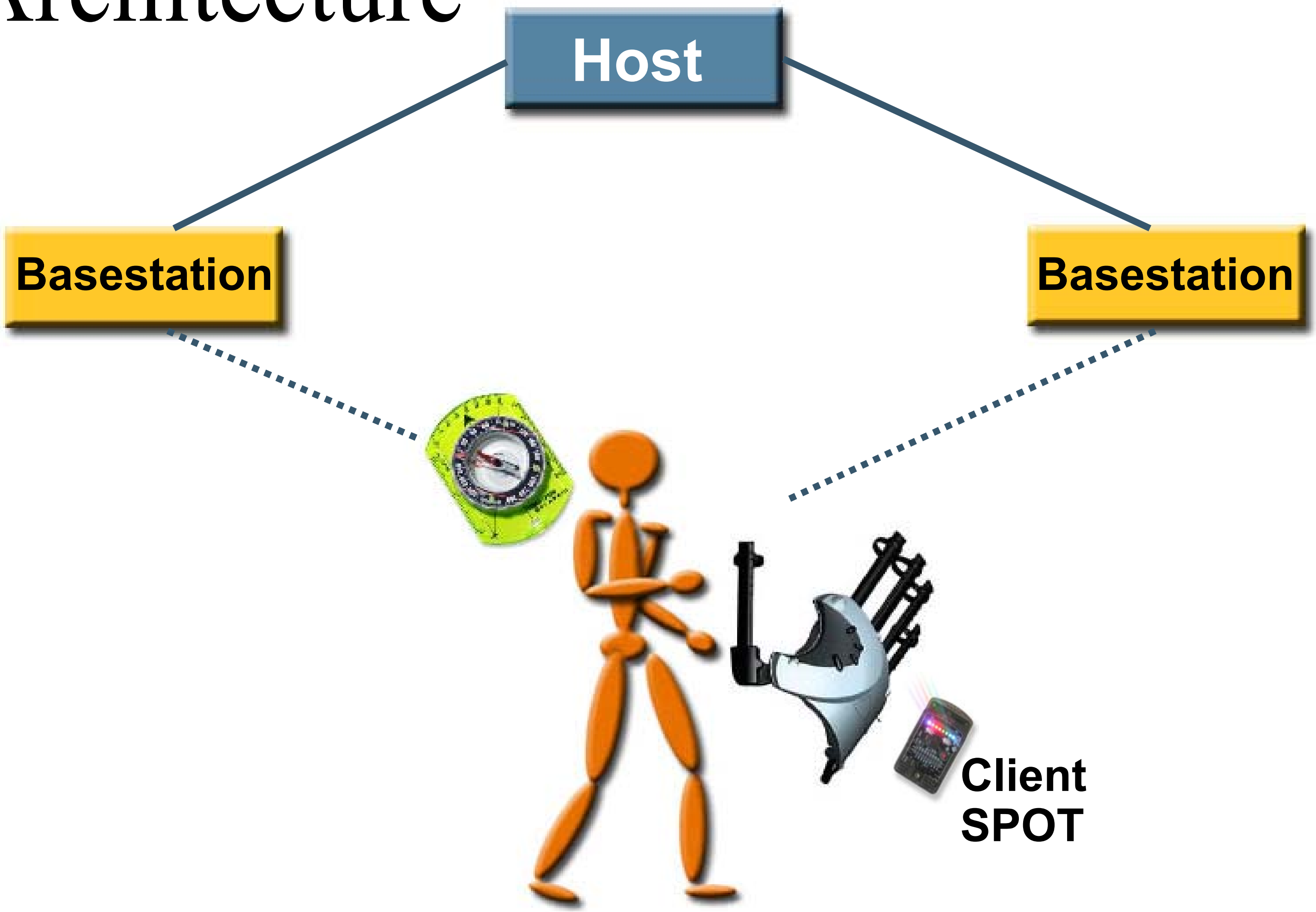
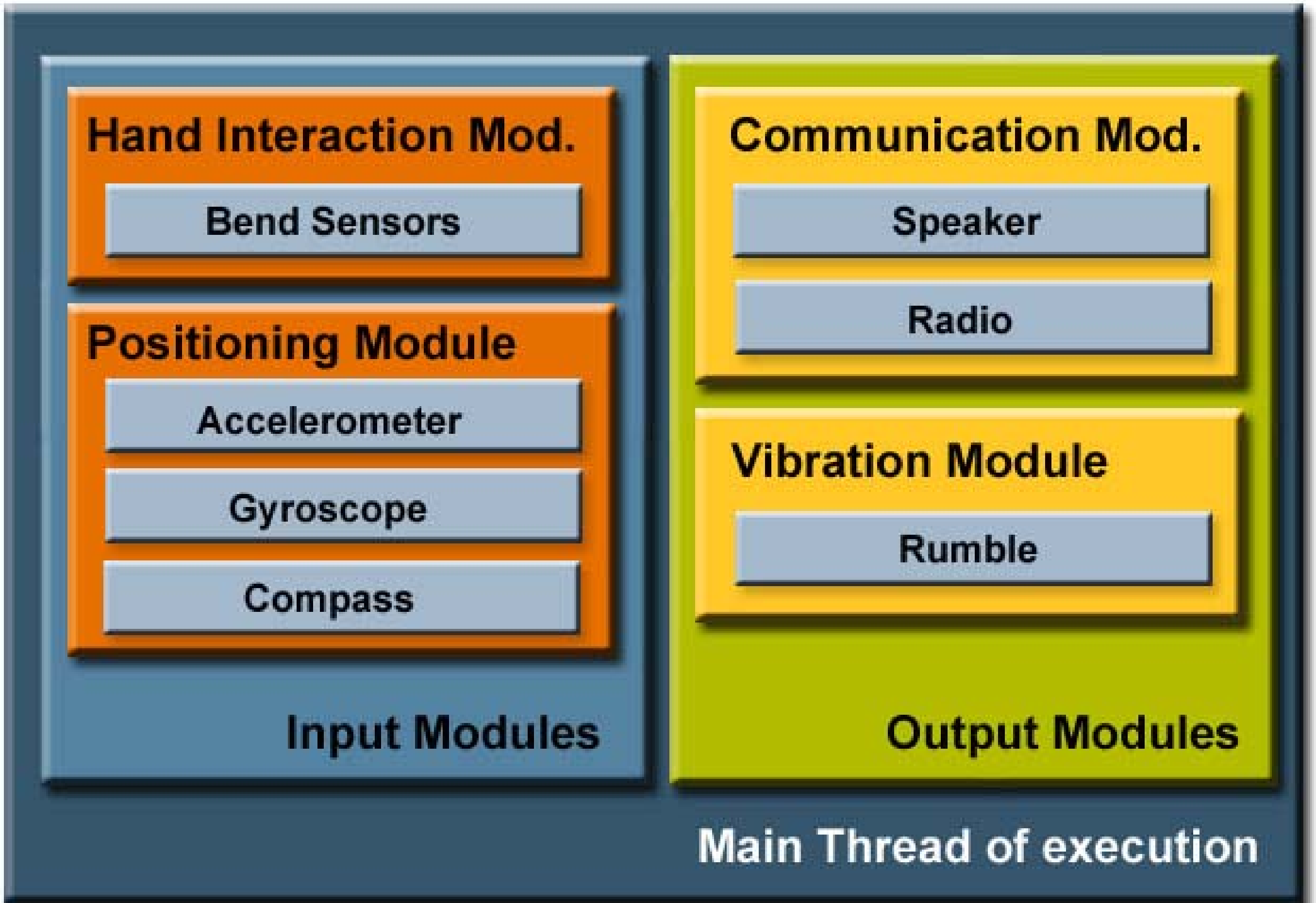
Architecture



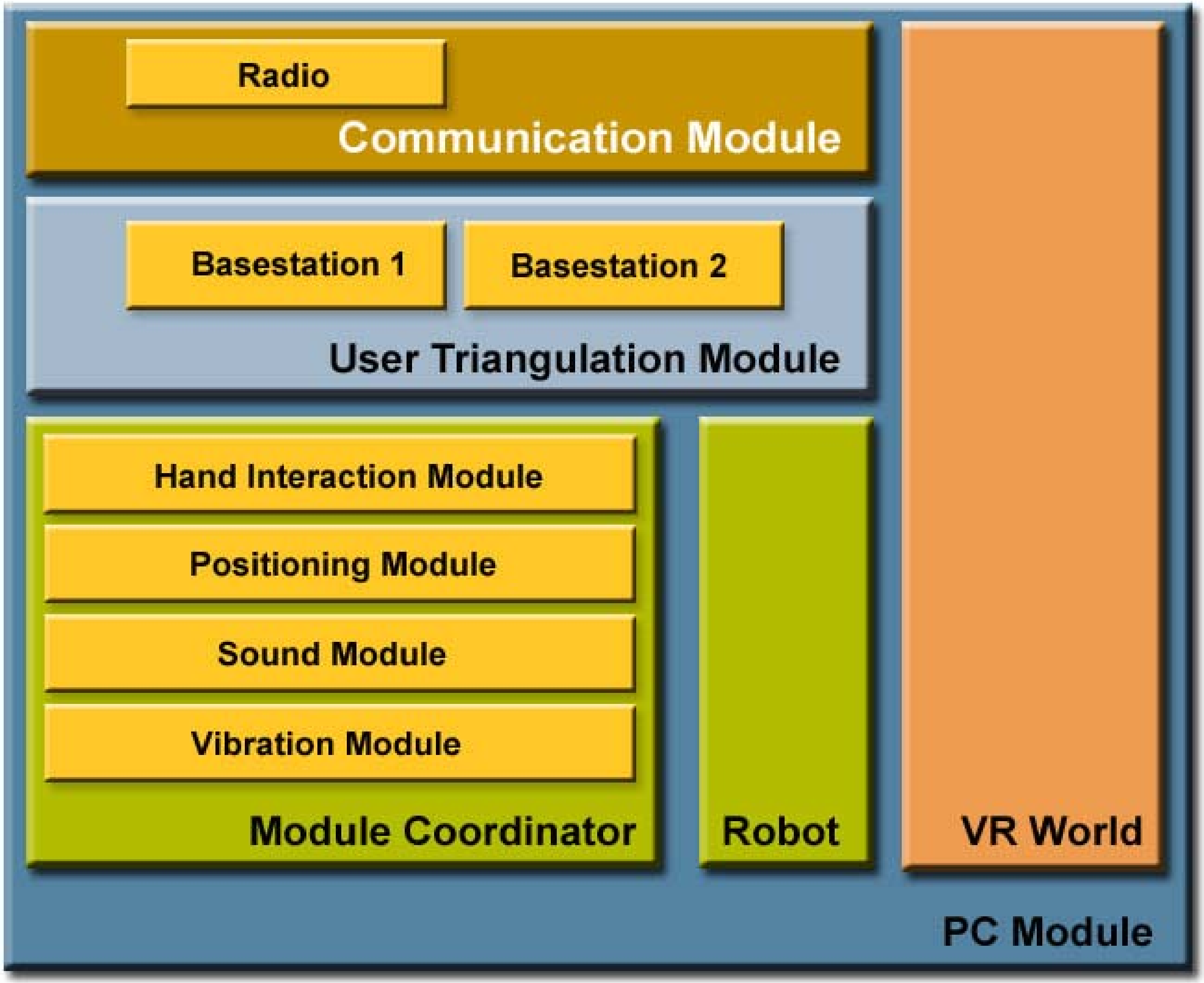
Human Game Interface

- Position of player is determined via radio signal strength to multiple basestations
- Direction player is looking comes from compass sensor
  - Changes view in 3D environment
- Movement of hand comes from data glove
  - Position
  - Tilt
  - Finger movements

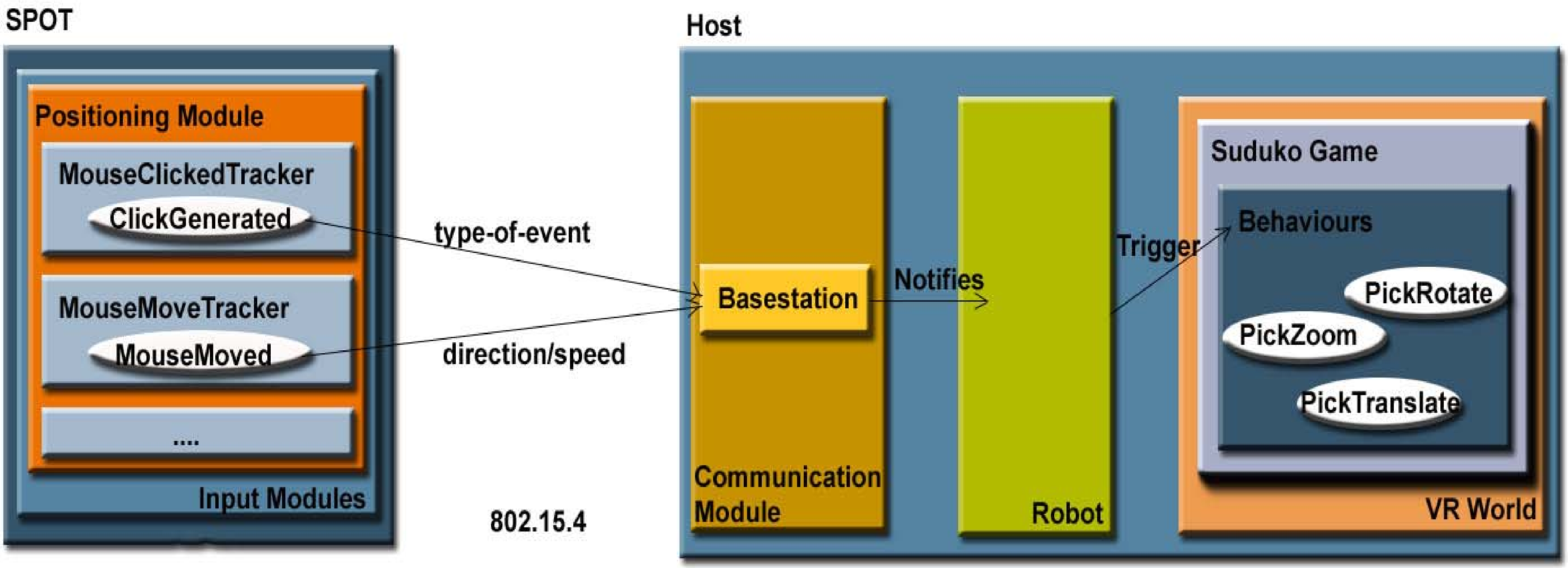
Client SPOT Architecture



Host Module Architecture



Control Flow



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Summary

- SPOTs are a small easy to use platform for embedded programming applications
- Programming in Java platform makes life much easier
- Integration with most peripheral hardware is a breeze
- Can be used to build sophisticated interactive games
- Lots of fun!

Further Information

- Web resources
  - `http://www.sunspotworld.com`
  - `http://java3d.dev.java.net`
  - `http://j3d-vrml97.dev.java.net`
  - `http://jogl.dev.java.net`
  - `http://joal.dev.java.net`
- Other sessions at 2007 JavaOne[SM] conference
  - BOF-1692: Introducing the Sun SPOT
  - BOF-1892: SPOTBot, Turning a Sun SPOT into a rugged and affordable robot
  - TS-1786: Writing Darkstar Applications

DEMOs

3D Virtual Gaming

Q&A

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