CS61B Lecture #36

Trip: Enumeration types.

er 10, *HFJ*, pp. 489–516.

ation between threads

zation

Trip into Java: Enumeration Types

ed a type to represent something that has a few, named, ues.

st form, the only necessary operations are == and !=; perty of a value of the type is that it differs from all

sions of Java, used named integer constants:

```
Pieces {
K_PIECE = 0,    // Fields in interfaces are static final.
K_KING = 1,
E_PIECE = 2,
E_KING = 3,
Y = 4;
```

ovide *enumeration types* as a shorthand, with syntax like

```
{ BLACK_PIECE, BLACK_KING, WHITE_PIECE, WHITE_KING, EMPTY };
```

these values are basically **ints**, accidents can happen.

Enum Types in Java

of Java allows syntax like that of C or C++, but with tees:

```
n Piece {
CE, BLACK_KING, WHITE_PIECE, WHITE_KING, EMPTY
```

e as a new reference type, a special kind of class type.

LACK_PIECE, etc., are static, final *enumeration constants* s) of type PIECE.

tomatically initialized, and are the only values of the type that exist (illegal to use **new** to create an enum

se ==, and also `switch` statements:

```
King(Piece p) {
p) {
LACK_KING: case WHITE_KING: return true;
: return false;
```


king Enumerals Available Elsewhere

ke BLACK_PIECE are static members of a class, not classes.

nlike C or C++, their declarations are not automatically de the enumeration class definition.

classes, must write `Piece.BLACK_PIECE`, which can get

th version 1.5, Java has *static imports*: to import all tions of class `checkers.Piece` (including enumerals), you

```
atic checkers.Piece.*;
```

nport clauses.

use this for enum classes in the anonymous package.

Operations on Enum Types

laration of enumeration constants significant: `.ordinal()` ition (numbering from 0) of an enumeration value. Thus, _KING.ordinal() is 1.

ece.values() gives all the possible values of the type. n write:

```
p : Piece.values())
.out.printf("Piece value #%d is %s%n", p.ordinal(), p);
```

unction `Piece.valueOf` converts a String into a value of So `Piece.valueOf("EMPTY") == EMPTY`.

Fancy Enum Types

asses. You can define all the extra fields, methods, and you want.

s are used only in creating enumeration constants. The arguments follow the constant name:

```
{
CE(BLACK, false, "b"), BLACK_KING(BLACK, true, "B"),
CE(WHITE, false, "w"), WHITE_KING(WHITE, true, "W"),
ll, false, " ");

final Side color;
final boolean isKing;
final String textName;

de color, boolean isKing, String textName) {
olor = color; this.isKing = isKing; this.textName = textName;

or() { return color; }
isKing() { return isKing; }
extName() { return textName; }
```

But Why?

programs always have > 1 thread: besides the main
ers clean up garbage objects, receive signals, update
other stuff.

ms deal with asynchronous events, is sometimes conve-
anize into subprograms, one for each independent, re-
ce of events.

w us to insulate one such subprogram from another.

organized like this: application is doing some compu-
O, another thread waits for mouse clicks (like 'Stop'),
attention to updating the screen as needed.

s like search engines may be organized this way, with
er request.

se, sometimes we *do* have a real multiprocessor.

Threads

r programs consist of single sequence of instructions.

equence is called a *thread* (for "thread of control") in

s programs containing *multiple* threads, which (concep-
ncurrently.

a uniprocessor, only one thread at a time actually runs,
wait, but this is largely invisible.

gram access to threads, Java provides the type `Thread`
. Each `Thread` contains information about, and controls,

s access to data from two threads can cause chaos, so
structs for controlled communication, allowing threads
cts, to *wait* to be notified of events, and to *interrupt*
ds.

Avoiding Interference

read has data for another, one must wait for the other

wo threads use the same data structure, generally only
odify it at a time; other must wait.

uld happen if two threads simultaneously inserted an
nked list at the same point in the list?

d conceivably execute

```
w ListCell(x, p.next);
```

e values of `p` and `p.next`; one insertion is lost.

for only one thread at a time to execute a method on a
ject with either of the following equivalent definitions:

```
) {
ized (this) {
f f
```

```
synchronized void f(...) {
  body of f
}
```


Java Mechanics

e actions "walking" and "chewing gum":

```
l implements Runnable {
id run()
 (true) ChewGum(); }

l implements Runnable {
id run()
 (true) Walk(); }
```

```
// Walk and chew gum
Thread chomp
  = new Thread(new
Chewer1());
Thread clomp
  = new Thread(new
Walker1());
chomp.start(); clomp.start();
```

rnative (uses fact that Thread implements Runnable):

```
 extends Thread {
 run()
true) ChewGum(); }

 extends Thread {
 run()
true) Walk(); }
```

```
Thread chomp = new Chewer2(),
       clomp = new Walker2();
chomp.start();
clomp.start();
```


Primitive Java Facilities

on Object makes thread wait (not using processor) un-
y `notifyAll`, unlocking the Object while it waits.

.util.mailbox has something like this (simplified):

```
Mailbox {
osit(Object msg) throws InterruptedException;
eceive() throws InterruptedException;


edMailbox implements Mailbox {
List<Object> queue = new LinkedList<Object>();

ynchronized void deposit(Object msg) {
add(msg);
otifyAll(); // Wake any waiting receivers


ynchronized Object receive() throws InterruptedException {
(queue.isEmpty()) wait();
 queue.remove(0);
```


Communicating the Hard Way

ng data is tricky: the faster party must wait for the

roaches for sending data from thread to thread don't

```
changer {
lue = null;
ceive() {
 r; r = null;
(r == null)
= value; }
= null;
 r;

sit(Object data) {
(value != null) { }
= data;
```

```
DataExchanger exchanger
  = new DataExchanger();

--------------------------------

// thread1 sends to thread2 with
exchanger.deposit("Hello!");

--------------------------------

// thread2 receives from thread1 with
msg = (String) exchanger.receive();
```

read can monopolize machine while waiting; two threads
posit or receive simultaneously cause chaos.

More Concurrency

mple can be done other ways, but mechanism is very

you want to think during opponent's move:

```
neOver()) {
ve())
.deposit(computeMyMove(lastMove));


kAheadALittle();
Move = inBox.receiveIfPossible();
e (lastMove == null);
```

ssible (written `receive(0)` in our actual package) doesn't
s `null` if no message yet, perhaps like this:

```
chronized Object receiveIfPossible()
InterruptedException {
e.isEmpty())
 null;
ueue.remove(0);
```


Use In GUIs

e library uses a special thread that does nothing but
nts like mouse clicks, pressed keys, mouse movement,

ignate an object of your choice as a *listener;* which
ava's event thread calls a method of that object when-
t occurs.

your program can do work while the GUI continues to
uttons, menus, etc.

cial thread does all the drawing. You don't have to be
his takes place; just ask that the thread wake up when-
nge something.

Interrupts

is an event that disrupts the normal flow of control of

ems, interrupts can be totally *asynchronous,* occurring
points in a program, the Java developers considered
arranged that interrupts would occur only at controlled

grams, one thread can interrupt another to inform it
ing unusual needs attention:

```
d.interrupt();
```

read does not receive the interrupt until it waits: meth-
eep (wait for a period of time), `join` (wait for thread to
nd mailbox deposit and receive.

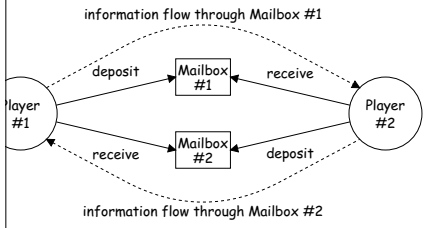
uses these methods to throw `InterruptedException`,
e is like this:

```
Box.receive();
terruptedException e) { HandleEmergency(); }
```


Message-Passing Style

primitives very error-prone. Wait until CS162.

e higher-level, and allow the following program struc-



Player is a thread that looks like this:

```
ameOver()) {
ve())
.deposit(computeMyMove(lastMove));

ve = inBox.receive();
```


Coroutines

is a kind of synchronous thread that explicitly hands
o other coroutines so that only one executes at a time,
generators. Can get similar effect with threads and

cursive inorder tree iterator:

```
or extends Thread {
lbox r;
ree T, Mailbox r) {
T; this.dest = r;

n() {
t);
d marker);

Tree t) {
l) return;
eft);
label);
ight);
```

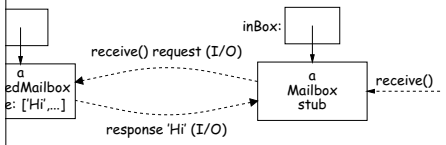
```
void treeProcessor(Tree T) {
  Mailbox m = new QueuedMailbox();
  new TreeIterator(T, m).start();
  while (true) {
     Object x = m.receive();
     if (x is end marker)
        break;
     do something with x;
  }
}
```


Highlights of a GUI Component

```
hat draws multi-colored lines indicated by mouse. */
tends JComponent implements MouseListener {
<Point> lines = new ArrayList<Point>();

/ Main thread calls this to create one
edSize(new Dimension(400, 400));
stener(this);

ronized void paintComponent(Graphics g) { // Paint thread
(Color.white);   g.fillRect(0, 0, 400, 400);
  x = y = 200;
Color.black;
p : lines)
or(c); c = chooseNextColor(c);
ne(x, y, p.x, p.y); x = p.x; y = p.y;


ronized void mouseClicked(MouseEvent e) // Event thread
d(new Point(e.getX(), e.getY())); repaint(); }
```

Remote Objects Under the Hood

```
 #1:           // On Machine #2:
               Mailbox inBox
lMailbox();    = get outBox from machine #1
```



lbox is an interface, hides fact that on Machine #2 ally have direct access to it.

method calls are relayed by I/O to machine that has

nt or return type OK if it also implements Remote or *lized*—turned into stream of bytes and back, as can es and String.

involved, expect failures, hence every method can throw ption (subtype of IOException).

mote Mailboxes (A Side Excursion)

e Method Interface allows one program to refer to ob- her program.

o allow mailboxes in one program be received from or to in another.

you define an *interface* to the remote object:

```
a.rmi.*;
Mailbox extends Remote {
osit(Object msg)
 InterruptedException, RemoteException;
eceive()
 InterruptedException, RemoteException;
```

that actually will contain the object, you define

```
edMailbox ... implements Mailbox {
mplementation as before, roughly
```