POLITECNICO DI TORINO

e-Lite

Concurrency in JavaFX

Tecniche di Programmazione – A.A. 2014/2015

Summary

1. The problem
2. `javafx.concurrent` package

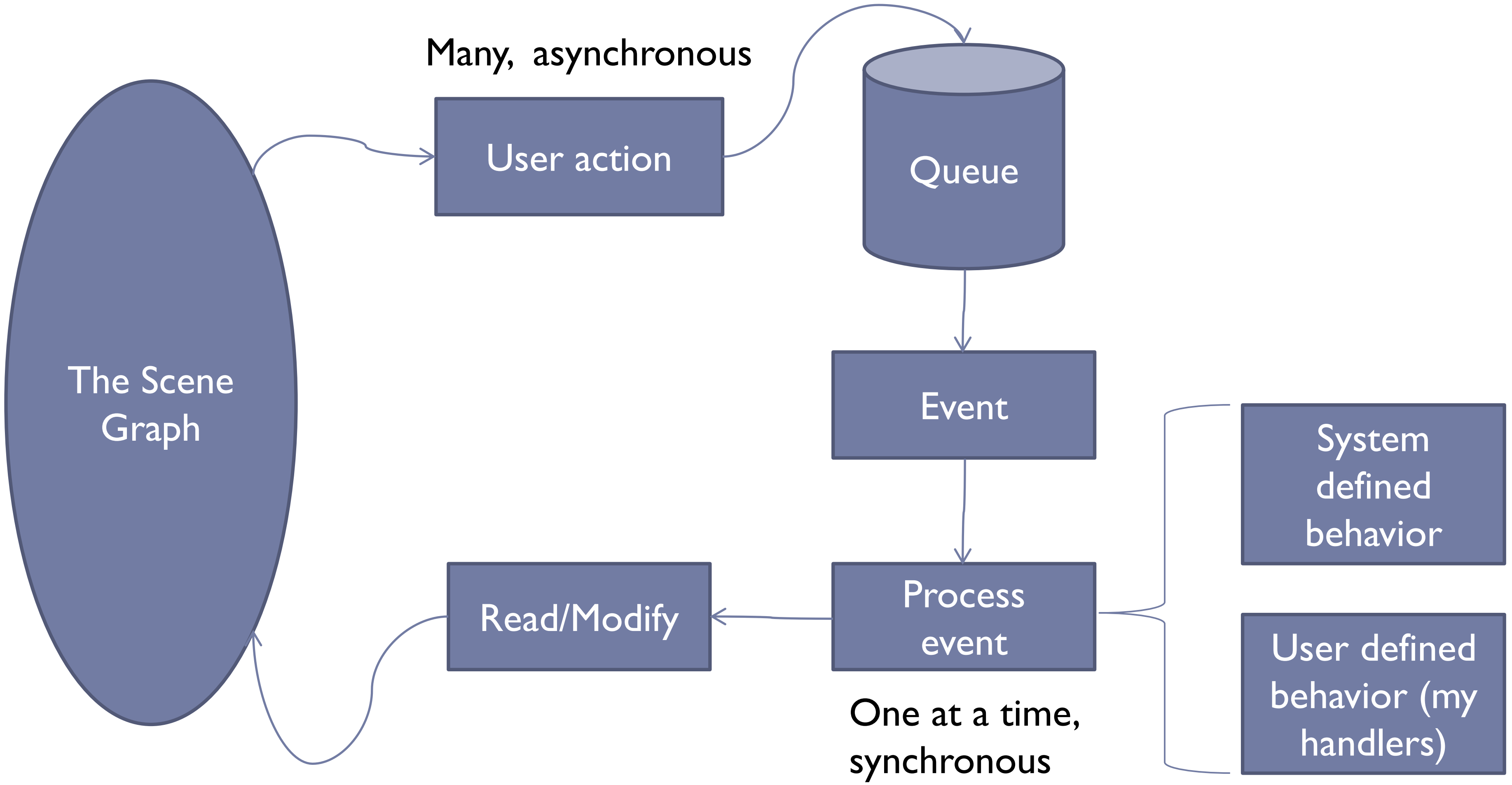
The problem

Concurrency in JavaFX

UI Responsiveness

- JavaFX is single threaded
- The JavaFX application class manages the interaction
  - User <-> User interface elements
- All events are managed by a single (synchronous) queue, and processed one by one
- When an event handler takes a long time, the UI gets "stuck" until the event handler terminates

Single Threaded behavior

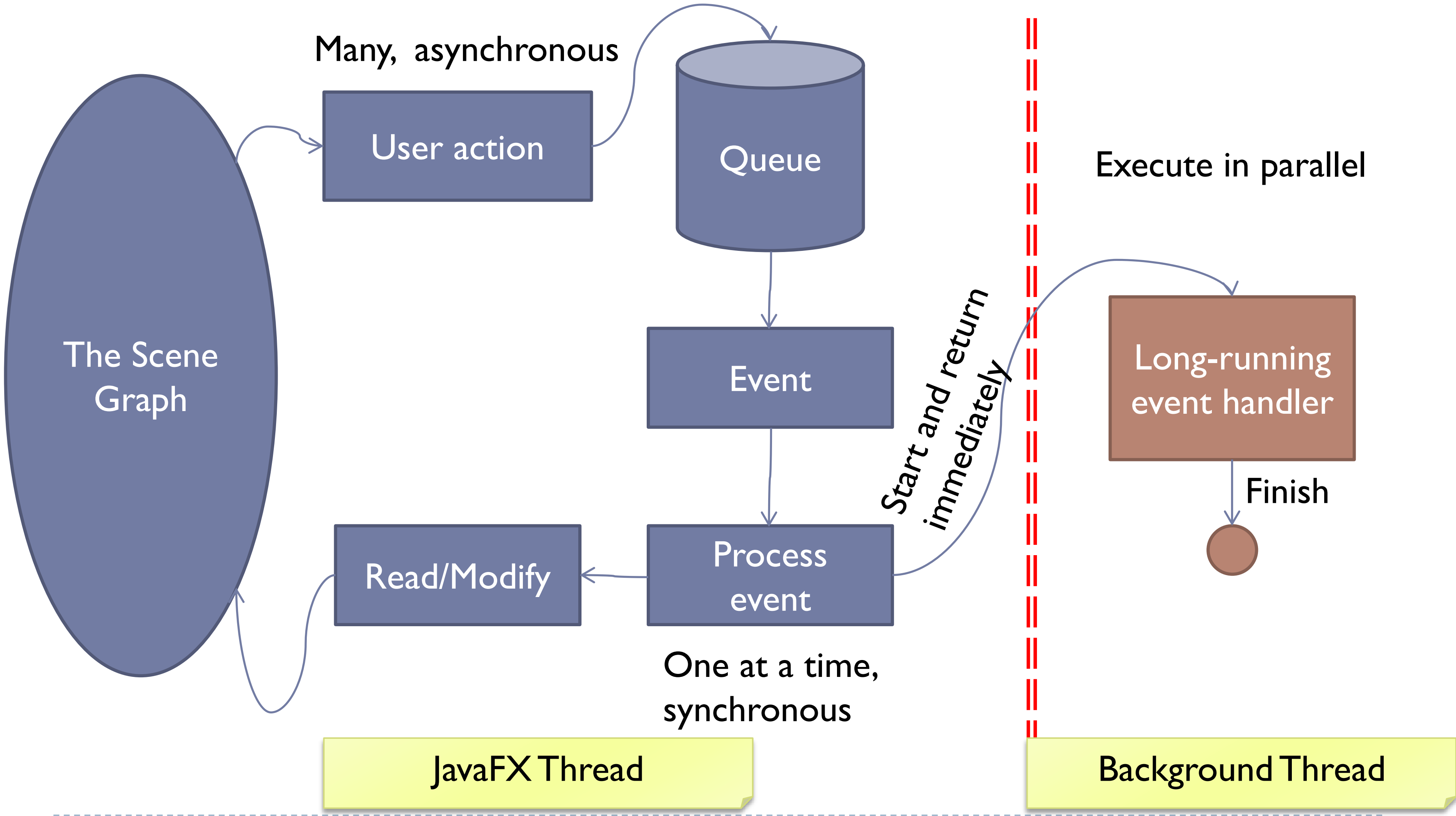


The solution

- Long-running computations should not block the user interface
- Need to be run in a separate (parallel) thread

- **Warning**: different threads cannot modify the same variables, otherwise "race conditions" may occur

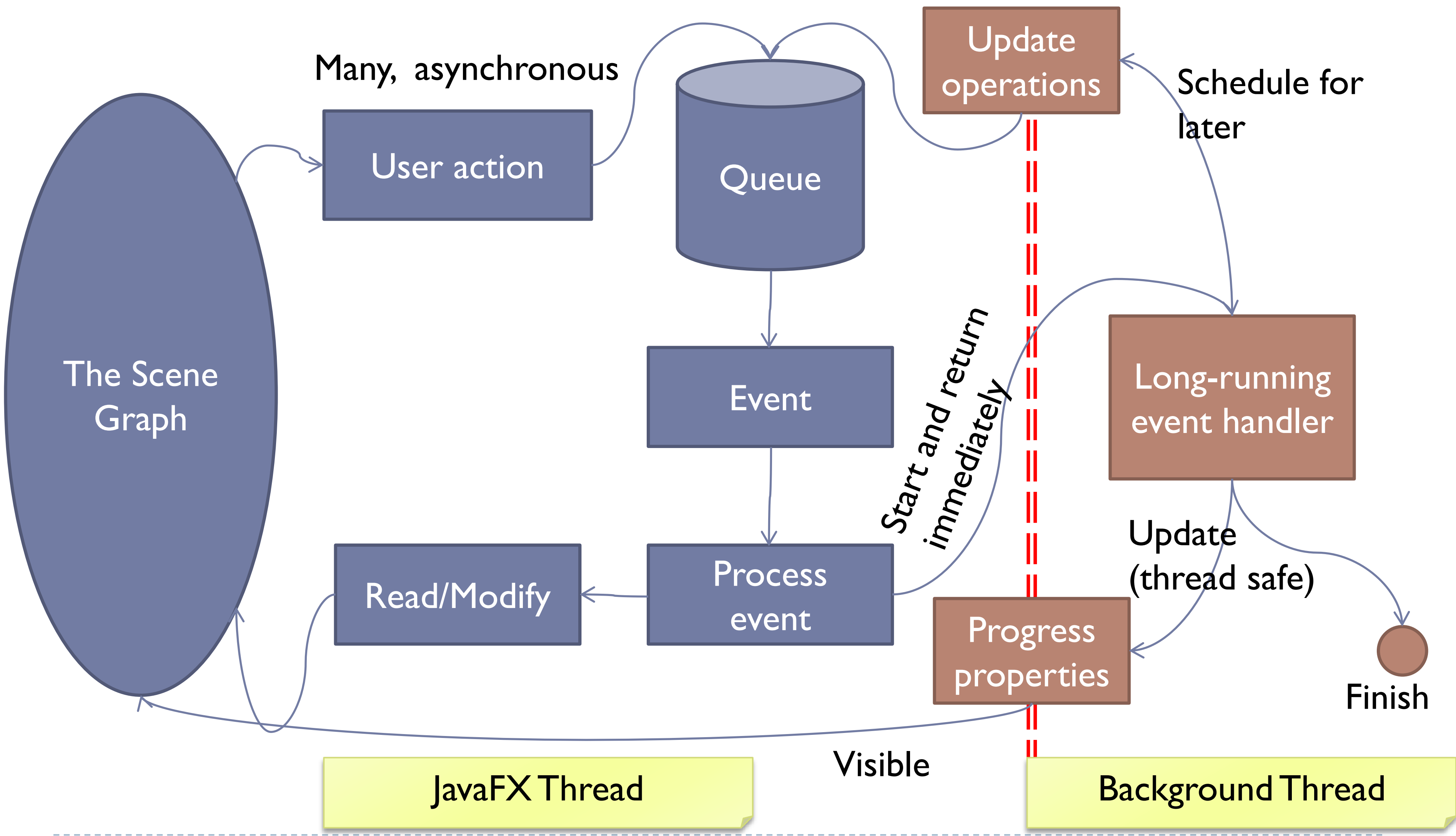
Single Threaded behavior



Interacting from the background

- The parallel thread can not interact with any object created in the foreground (JavaFX) thread
  - How can the application know about the progress of the background state (is it 10% or 98%?) Or whether it is terminated?
  - How can the background method modify some elements in the scene graph?
  - How can the background method modify some values in the Model?

Single Threaded behavior



The solution: updating progress

- The background thread has some “shared” state variables
  - Progress (in % and absolute terms)
  - Message
- Progress variables can be updated anytime
- The JavaFX thread can
  - Read these variable in event handlers
  - “Bind” these variables directly to some UI elements

The solution: scheduling operations

- The background thread may schedule some operations to be run “later” in the JavaFX thread
- Such operations are injected in the main JavaFX event queue
- When executed (“later”), they run on the main JavaFX thread, and they can access **any** object (Model or Scene Graph)

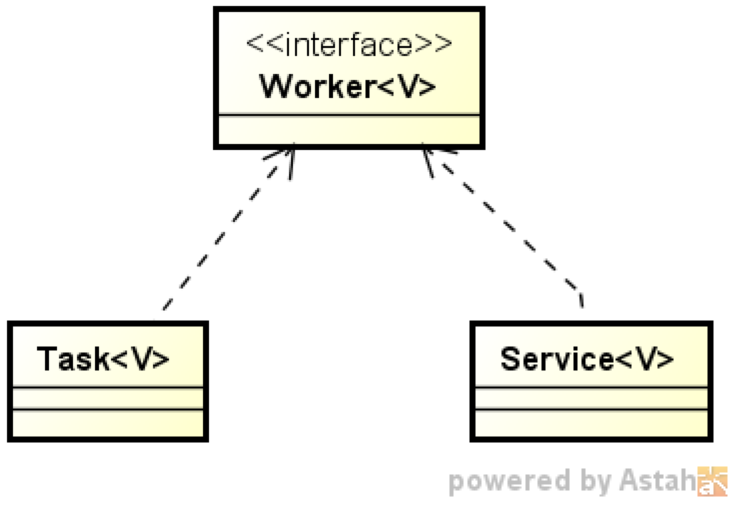
The solution: reacting to thread state

- The main application may monitor the background thread, and may register to state-change events
  - E.g., be notified when the thread is finished
- The main thread may read the “value” computed by the background object

javafx.concurrent package

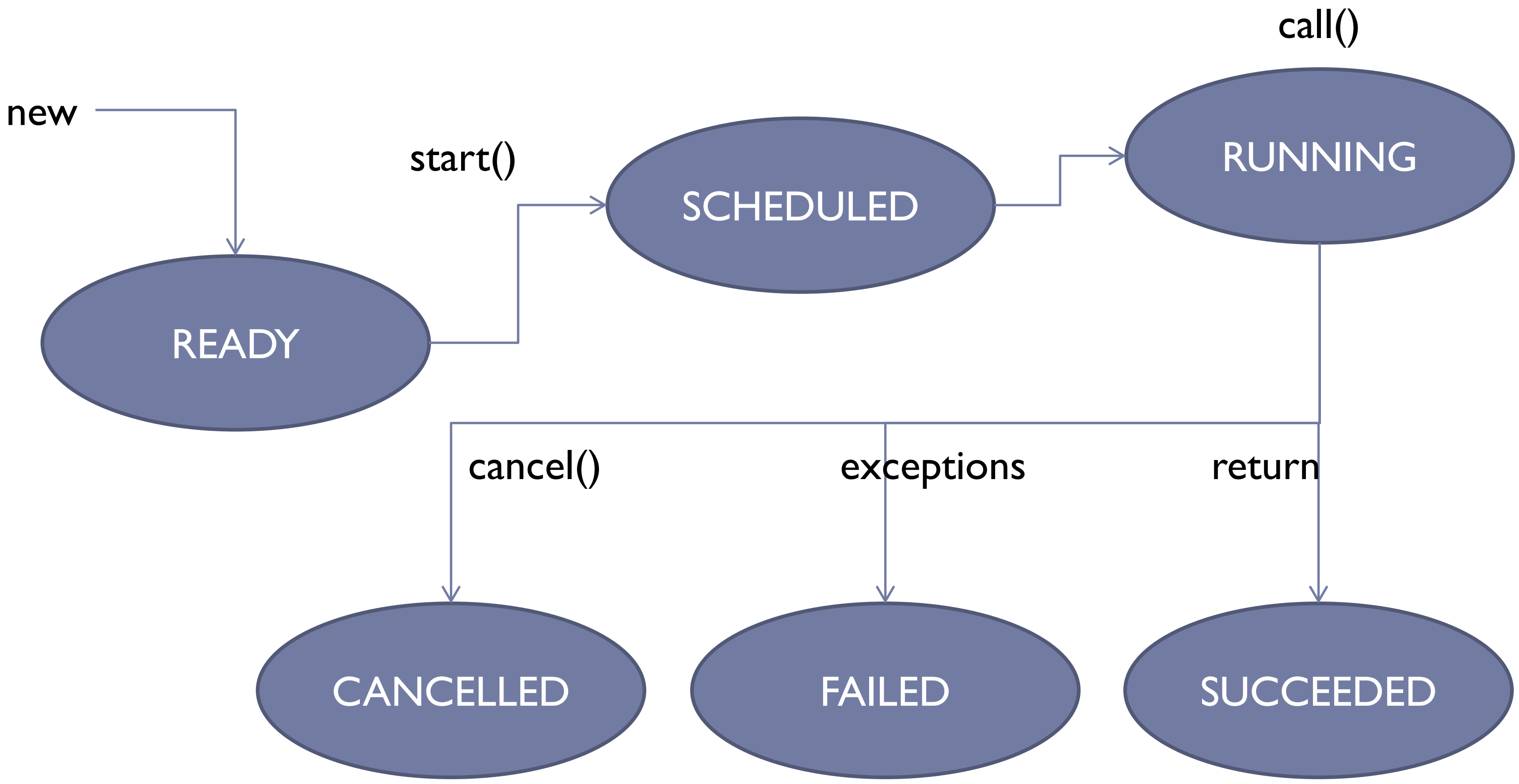
Concurrency in JavaFX

Main classes



- Task: to be executed only once
- Service: to be re-used many times
- <V> the class type of the returned value
  - .getValue() to read it
  - <Void> if no value to return

States of a Task



Implementing a Task

- Sub-class from Task<MyValue>
  - Anonymous class or explicit class
- Override call() method
  - Do computations
  - Upon completion, return an object of type MyValue
  - Constantly monitor for isCancelled() property
  - Constantly update the progress properties

  - If needed, schedule UI updates

Example

```
import javafx.concurrent.Task;

Task<Integer> task = new Task<Integer>() {

    @Override protected Integer call() throws Exception {
        int iterations;
        for (iterations = 0; iterations < 100000; iterations++) {
            if (isCancelled()) {
                break;
            }
            System.out.println("Iteration " + iterations);
        }
        return iterations;
    }

};
```

Progress properties

- double progress
  - current progress of this Worker in terms of percent complete
  - Value between 0.0 and 1.0
  - If cannot be determined, set to -1.0 (default)
- double totalWork
  - Amount of 'work' that is expected to be done
  - Value between 0.0 and MAX_DOUBLE
  - If cannot be determined, set to -1.0 (default)
- double workDone
  - Current amount of 'work' already done
  - Value between 0.0 and totalWork
  - If cannot be determined, set to -1.0 (default)

Progress properties

- double progress
  - current progress of this Worker in terms of percent complete
  - V
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  - Current amount of 'work' already done
  - Value between 0.0 and totalWork
  - If cannot be determined, set to -1.0 (default)

All three properties are updated, in a thread-safe way, by a call to

```
protected void **updateProgress**
(double workDone, double totalWork)
```

Message property

- String message
  - Any message that the task may update
  - Usually, to be displayed in some part of the UI
- Updated by means of a call to
  - `protected void updateMessage(String message)`

Example

```
import javafx.concurrent.Task;

Task<Integer> task = new Task<Integer>() {

    @Override protected Integer call() throws Exception {
        int iterations;
        for (iterations = 0; iterations < 100000; iterations++) {
            if (isCancelled()) {
               break;
            }
            updateMessage("Iteration " + iterations);
            updateProgress(iterations, 1000);
        }
        return iterations;
    }

};
```

Running a task

```
import javafx.concurrent.Task;

Task<Integer> task = new Task<Integer>() {

    @Override protected Integer call() throws Exception {
          . . .
    }

};

Thread th = new Thread(task);

th.setDaemon(true);

th.start();
```

Running a task

```
import javafx.concurrent.Task;

Task<Integer> task = new Task<Integer>() {

    @Override protected Integer call() throws Exception {
         . . .
    }

};

Thread th = new Thread(task);

th.setDaemon(true);

th.start();
```

If you want a background thread to prevent the VM from existing after the last stage is closed, then you would want daemon to be false.
If you want the background threads to simply terminate after all the stages are closed, then you must set daemon to true

Showing progress

- Properties of the Task can be “bound” to properties of the UI
  - Node.property.bind (task.property)
- progressProperty
- runningProperty
  - Boolean, e.g., for visibility of progress bar

```
ProgressBar bar = new
ProgressBar();

bar.progressProperty().bind(
task.progressProperty() );

new Thread(task).start();
```

Updating the GUI state

- Never update a Node directly. Never. Don't. Really.
  - Thread-safe violations may result in run time exceptions or in unpredictable behavior of the program
- Schedule updates to be executed in the main thread
  - Platform.runLater(Runnable r)
  - The method r.run() is scheduled to be executed in the JavaFX Thread
- Try to limit the number of scheduled updates, to avoid overloading the front task

Example

```
@Override protected Customer call() throws Exception {
            // pseudo-code:
            //   query the database
            //   read the values

            // Now update the customer
            Platform.runLater(new Runnable() {
                @Override public void run() {
                    customer.setFsetFirstName
                          (rs.getString("FirstName"));
                    // etc
                }
            });

            return customer;
        }
```

Initializing the task

- It is **strongly encouraged** that all Tasks be initialized with immutable state upon which the Task will operate.
- This should be done by providing a Task constructor which takes the parameters necessary for execution of the Task.
- For an inline implementation, we may use final variables in the enclosing context
- For a full-class implementation, we may use a constructor that stores the parameters into final variables

Example (inline)

```
final int totalIterations = 9000000;

Task<Integer> task = new Task<Integer>() {
    @Override protected Integer call() throws Exception {
        int iterations;
        for (iterations = 0; iterations < totalIterations;
                             iterations++) {
            if (isCancelled()) {
                updateMessage("Cancelled");
                break;
            }
            updateMessage("Iteration " + iterations);
            updateProgress(iterations, totalIterations);
        }
        return iterations;
    }
};
```

Example (full class)

```
    public class IteratingTask extends Task<Integer> {
        private final int totalIterations;

        public IteratingTask(int totalIterations) {
            this.totalIterations = totalIterations;
        }

        @Override protected Integer call() throws Exception {
            int iterations = 0;
            for (iterations = 0; iterations < totalIterations;
iterations++) {
                if (isCancelled()) {
                    updateMessage("Cancelled"); break;
                }
                updateMessage("Iteration " + iterations);
                updateProgress(iterations, totalIterations);
            }
            return iterations;
        }
    }
```

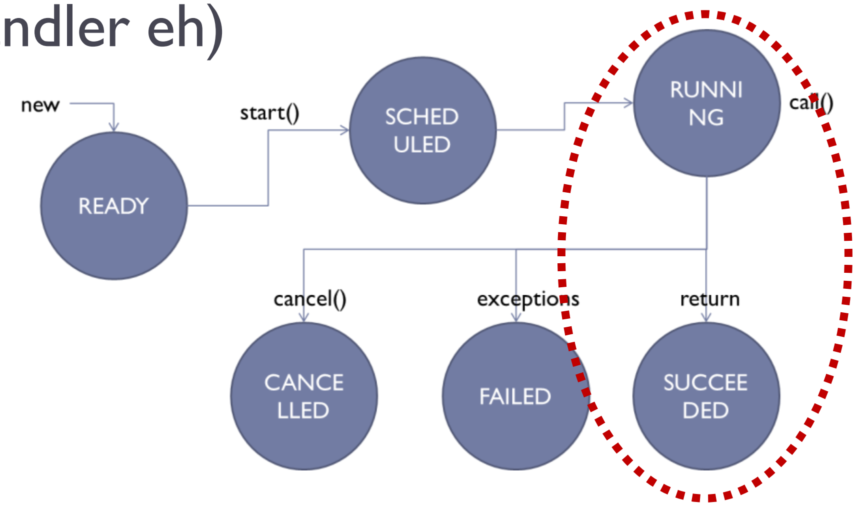
```
IteratingTask task = new
IteratingTask(8000000);
```

Warning

- Do not pass mutable state to a Task and then operate on it from a background thread.
- Doing so may introduce race conditions.
- It is possible that both the Task and some other application code will be reading or modifying the state of the Model from different threads: there could be a violation of threading rules!
- For such cases, modify the Model object from the FX Application Thread rather than from the background thread (with Platform.runLater)

Get final value

- The call() method in Task<V> returns a <V> object
- The object is stored in the value property of the task: task.getValue() returns the <V> object
  - But only after the method has returned
- We must set an EventHandler on the transition to the SUCCEEDED state
  - task.setOnSucceeded(EventHandler eh)



Example

```
myTask.setOnSucceeded(

    new EventHandler<WorkerStateEvent>() {

        @Override public void handle(WorkerStateEvent t) {

            // use .getValue()
            listView.setItems(myTask.getValue());

        }
    }

);
```

Returning partial results

- Updating the Return Value before the task is finished
  - Call updateValue(Object)
  - This method may be called repeatedly from the background thread.
  - Updates are coalesced to prevent saturation of the FX event queue.
  - This means you can call it as frequently as you like from the background thread but only the most recent set is ultimately set

Sharing information

- We may expose a new property on the Task which will represent the partial result
- Always modify it in a runLater() call

Resources

Concurrency in JavaFX

Resources

- Concurrency in JavaFX, https://docs.oracle.com/javase/8/javafx/interoperability-tutorial/concurrency.htm
- Worker Threading in JavaFX 2.0, http://fxexperience.com/2011/07/worker-threading-in-javafx-2-0/
- JavaDoc for class javafx.concurrentTask, https://docs.oracle.com/javase/8/javafx/api/javafx/concurrent/Task.html
- http://blog.idrsolutions.com/2012/12/handling-threads-concurrency-in-javafx/

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