Safety-Critical Java on a Java Processor

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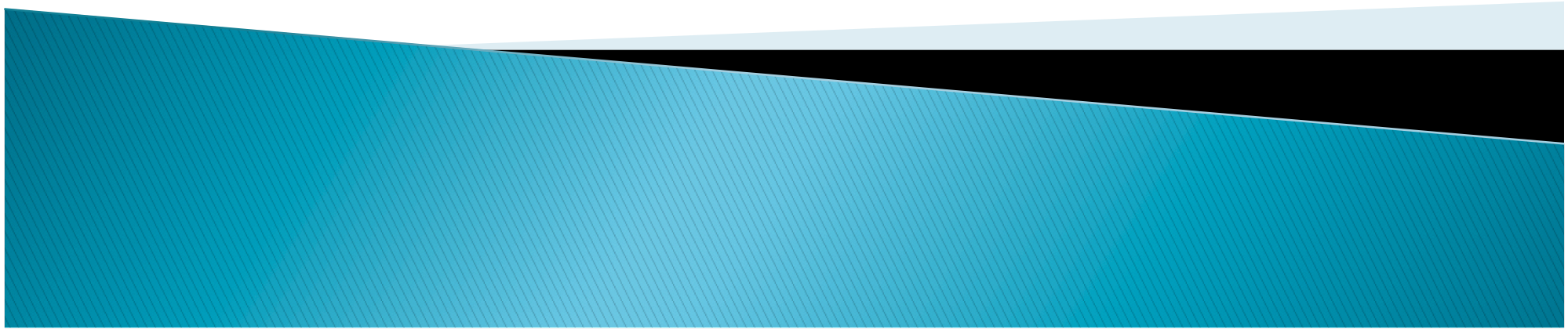
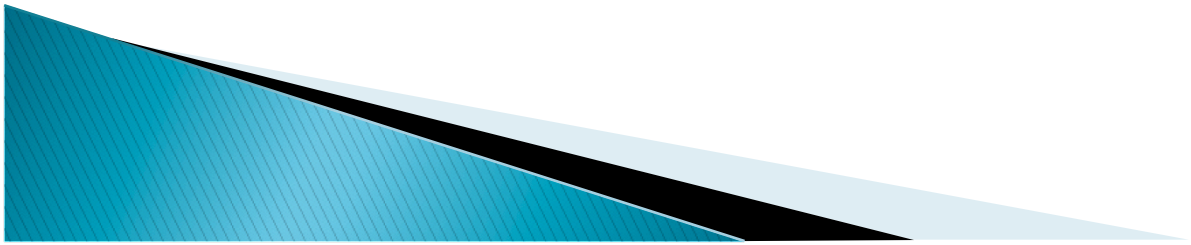


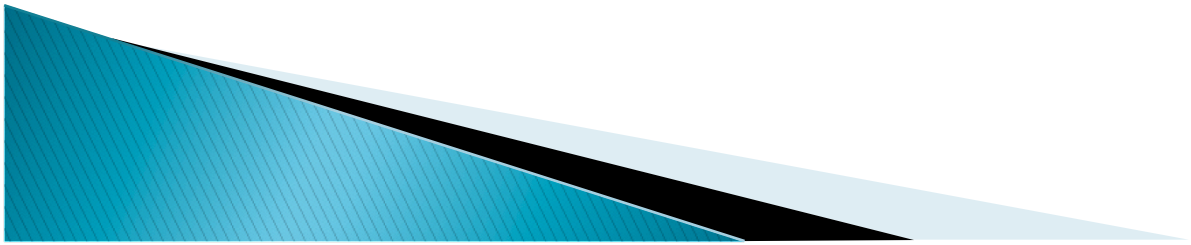
Outline

- How does a SCJ application look like
- JOP implementation details
- Some wishes for a change
- Conclusion



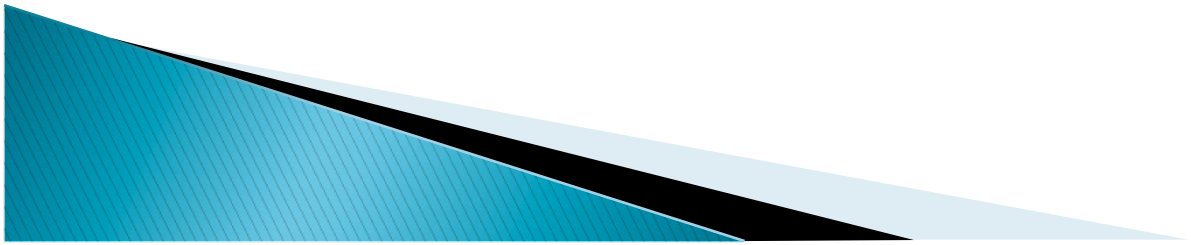
SCJ Application

- A Safelet – is an interface
- A Mission object
- A sequencer
- Collection of handlers
  - Periodic
  - Aperiodic
- Interface to the world
  - Simple terminal
  - Many interfaces will be memory mapped IO
    - Just heard about it from James



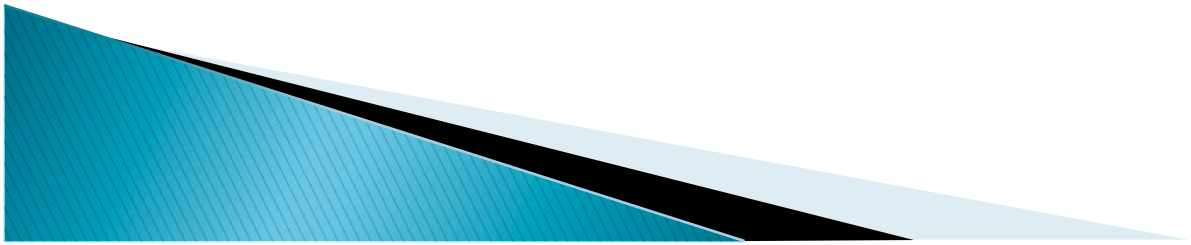
Safelet Defines the Application

```
public class HelloSafelet implements Safelet {


    public MissionSequencer getSequencer() {
        return new HelloSequencer(
                new HelloMission());
    }


    public long immortalMemorySize() {
        return 1000;
    }
}
```



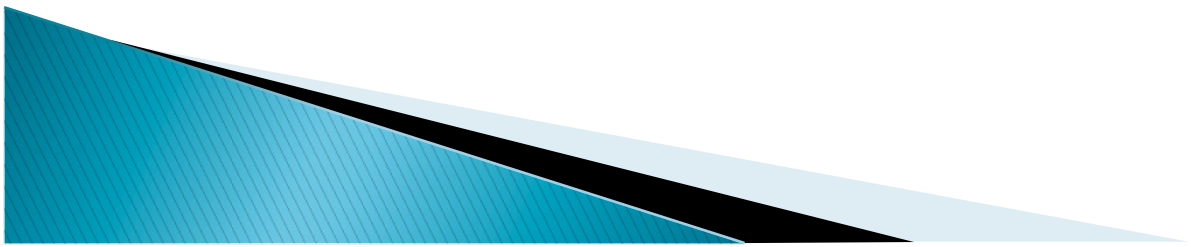
Application Specific Sequencer

```
public class HelloSequencer extends MissionSequencer {

   Mission m;

   public HelloSequencer(Mission mission) {

      super(new PriorityParameters(13),
            new StorageParameters(1000000, null));
      m = mission;
   }

   protected Mission getNextMission() {
      return m;
   }
}
```



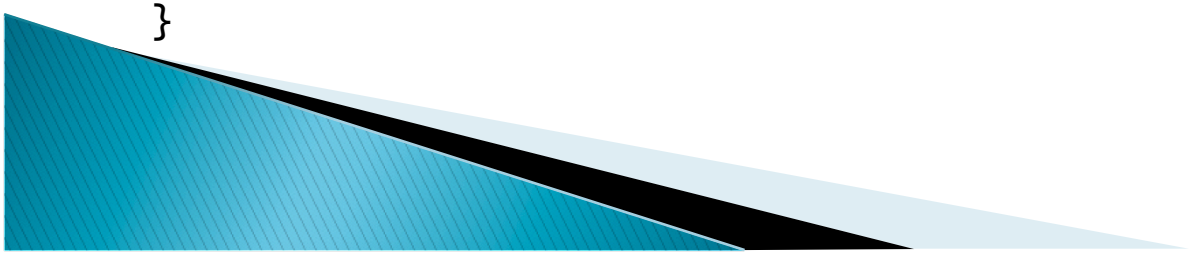
A Mission

```
public class HelloMission extends Mission {

   protected void initialize() {
      OutputStream os = null;
      try {
         os = Connector.openOutputStream("console:");
      } catch (IOException e) {
         throw new Error("No console available");
      }
      HelloHandler hh = new HelloHandler(
                           new SimplePrintStream(os));
      hh.register();
   }

   public long missionMemorySize() {
      return 100000;
   }
}
```



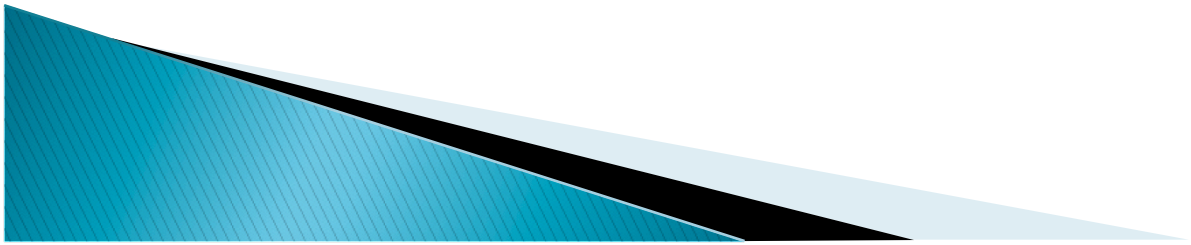
A Periodic Handler

```
public class HelloHandler extends PeriodicEventHandler {

   SimplePrintStream out;
   int cnt;

   public HelloHandler(SimplePrintStream sps) {
      super(new PriorityParameters(11),
         new PeriodicParameters(
               new RelativeTime(0, 0),
               new RelativeTime(500, 0)),
         new StorageParameters(10000, null), 500);
      out = sps;
   }

   public void handleAsyncEvent() {
      out.println("Ping " + cnt);
      ++cnt;
   }
}
```



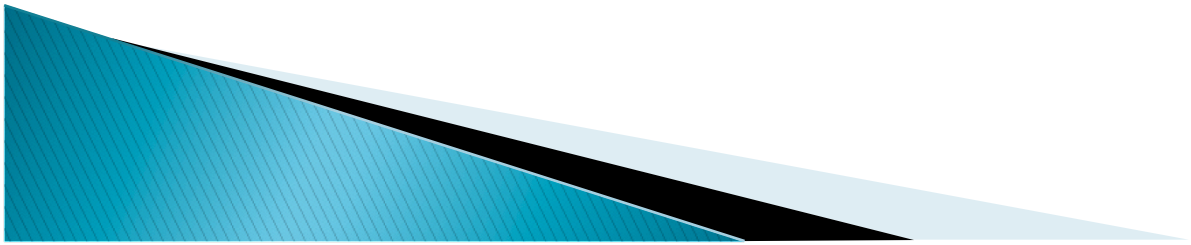
Let's Run It

- There is a JOP simulation
- JVM implemented in Java
  - Same restrictions as JOP ;-)
  - Reads and execute JOP 'binaries'
- Use System.currentTimeMillis() for scheduler
  - Time checked during bytecode interpretation
  - Slow, but ok
  - No real-time guarantees
- Simulation about as fast as a 1 MHz JOP
- Good for system code debugging



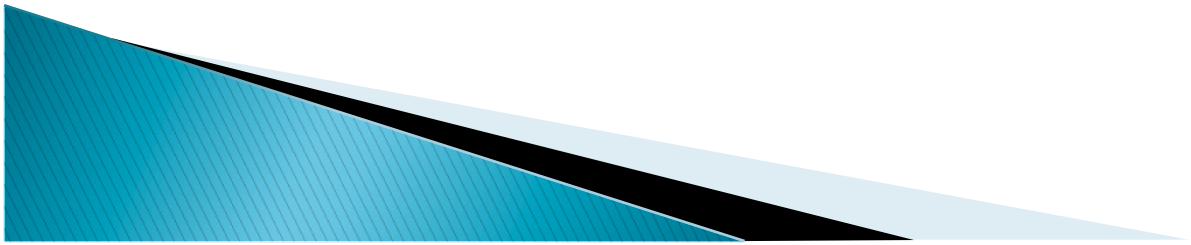
JOP

- Java Optimized Processor
  - A JVM in hardware (FPGA)
- Optimized for time-predictability
- Comes with a WCET analysis tool
- Has its 'own' restricted real-time Java classes
  - RtThread and SwEvent
  - No scopes, just IM (and RT GC)
- In use in academia and industry
- Open-source



SCJ on JOP

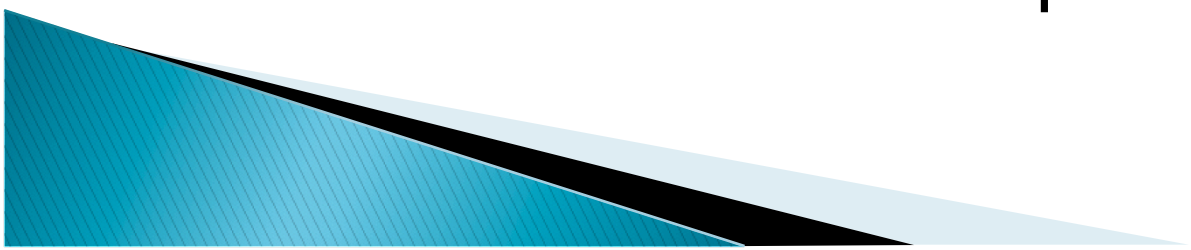
- Add scope support
  - With a single Memory class
  - Presented at JTRES 2011 in York
- Scheduling – two options
  - On top of RtThread
  - Restructure to SCJ handlers
- RtThread
  - Used in some examples and industrial applications
  - Don’t want to drop the support
  - Don’t want to change industrial applications
  - Handler on RtThread has overheads



Threads and Handlers

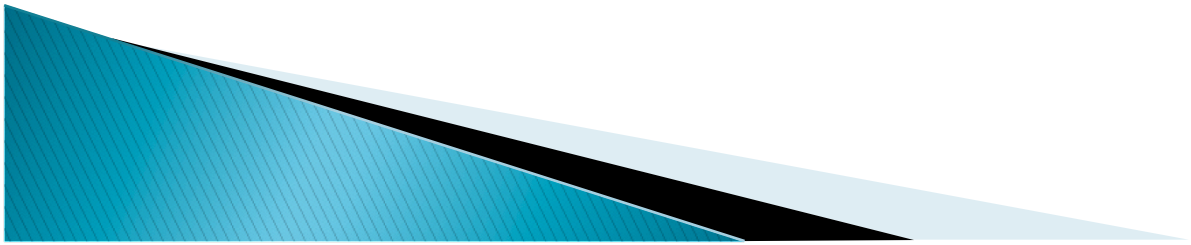
- Move to SCJ handlers
  - More efficient
  - Is a ‘standard’
- Does this restrict the JOP ecosystem?
  - Can we still have plain single threaded Java apps?
- What about RTS with GC?
- Keep it all configurable
  - Nice concept, but might end up in a nightmare

- Current solution: on top of RtThread



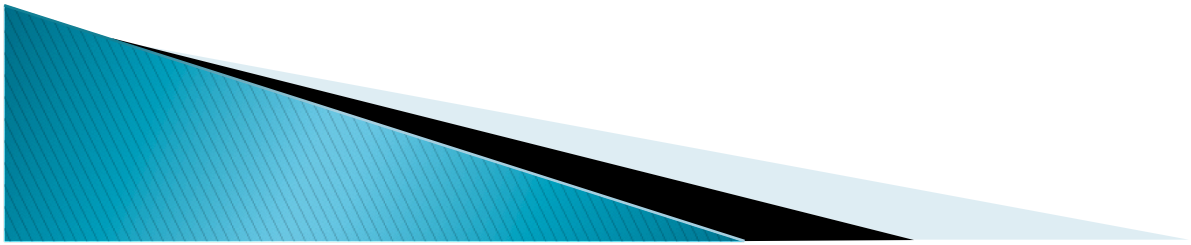
SCJ Scheduler

- Priority preemptive
  - Standard RTOS scheduler
- JOP scheduler = SCJ scheduler
- Interrupt handler
  - Timer interrupt
  - Plain Runnable
- Looks ease – right?



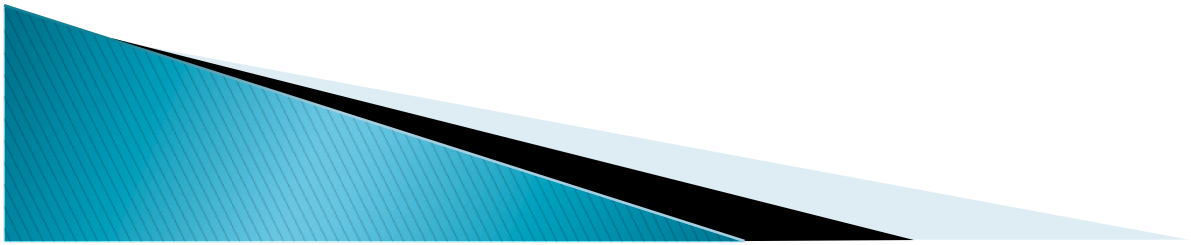
Scheduler Implications

- IH created and registered at system start
  - No mission memory
  - Is in immortal
  - Static fields to find the thread list
- SCJ handlers
  - Event handlers created by a mission in mission memory
  - => How to point to those handlers?
  - Assignment issue
- The scheduler shall live in mission memory



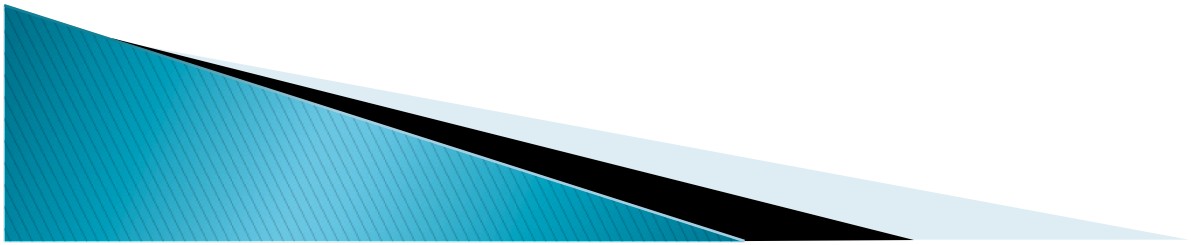
Asynchronous Events

- From RTSJ: events and handlers
  - n:m mapping
  - Needs references in both directions
    - => in same scope
- Maybe too general for SCJ
- Simplify to a single class
  - Just the handler
  - Drop inheritance from BoundAsnycEventHandler
  - Drop AperiodicEvent and AsyncEvent
  - Add release() to AperiodicEventHandler



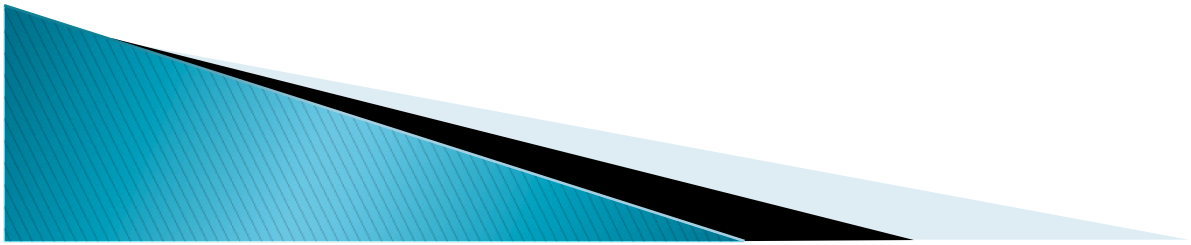
Immortal Memory

- Convenient place for shared data
  - E.g. the console connection
- Cumbersome to allocate objects there
  - Might use class initializers
  - Executed at JVM/SCJ start
  - Need to find an order
- Add a method initialize() to Safelet
  - Executed in immortal before getNextMission()



Application Start

- A SCJ application is a Safelet
- Start is vendor specific
  - The SCJ implementation needs to create an object of a class that implements Safelet
  - How is this info communicated?
  - We need reflection for the creation
  - The constructor needs to be no-arg
- Why all this hassle?
- Why not a plain static method (main())?



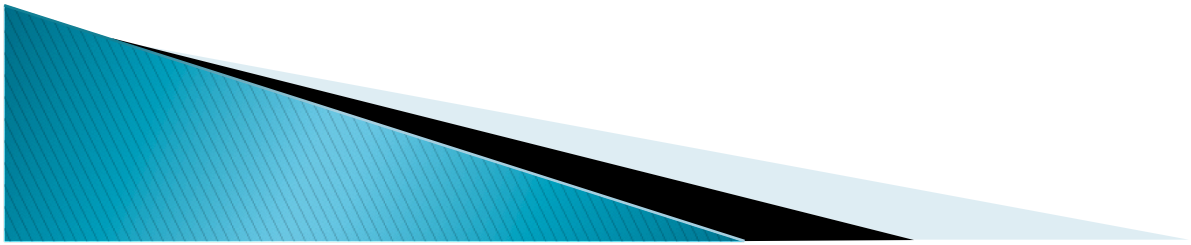
SCJ and a main() Method

```
public static void main(String[] args) {
  JopSystem.startMission(new HelloSafelet());
}
```

- Initial thread is in immortal
- SCJ app object allocated in immortal
- RI on RTSJ initial thread is in heap
  - No issue for the start
    - Provide the RI main method as part of the implementation
    - Enter IM
    - Call the application/user main

Status, Source

- Implementation ok for examples
  - Example app in next session
  - Some parts are still missing
- Open Source
- Can be used without JOP
  - Run the JOP SW simulator (in Java)
  - No timing guarantees, but easy access
- Try it out and submit bug fixes ;-)



Conclusion

- Safety-Critical Java is here
- Prototype implementations emerge
  - SCJ on HVM
  - SCJ on JOP
- First test applications emerge
- Time to explore SCJ
  - Expressiveness
  - Easy to use – libraries
- Will it be a business?
  - Not yet fully commitment form commercial vendors
  - Is it just an academic toy?