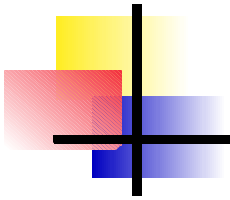
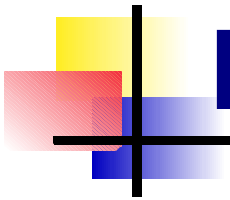


When the Servlet Model Doesn't Serve

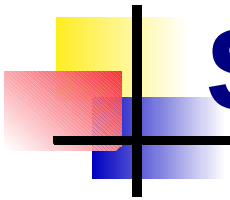
Gary Murphy
Hilbert Computing, Inc.
glm@hilbertinc.com

Colorado Software Summit



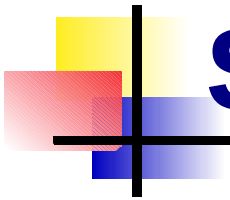
Motivation

- Many decision makers and programmers equate Java with servlets
  - Servlets are appropriate for a class of applications
  - Servlets are inappropriate for other classes of applications
- I have seen customers that chose an inappropriate application architecture
  - Present experiences and why servlets were or were not chosen when I was involved



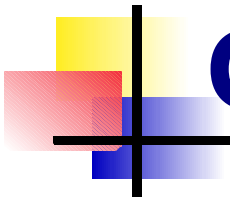
Servlet Strengths

- No mass software distribution to clients
  - Major cost of client/server vs. terminal-based applications
- Centralized administration
- Economies-of-scale in deployment on large servers
- Easy user-interface development for simple forms-based applications



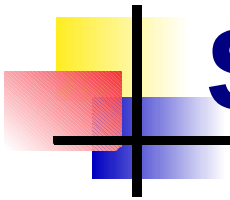
Servlet Weaknesses

- Considerably added complexity for sophisticated user-interfaces
- (Mostly) single-threaded programming model
- User-driven event model
- Application lifecycle management
- … more on these issues in the rest of the pre-sentation.
- *Servlets do very well what they were designed to do…*



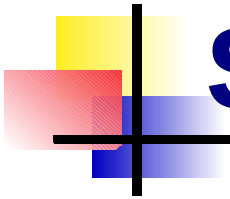
Overcoming Weaknesses

- Various technologies and products have been produced to overcome these weaknesses...
  - Macromedia Flash
  - Javascript
  - Ajax
- ... these can be effective in overcoming the weaknesses of the servlet model, but it also illustrates that there is “tool abuse” going on.
  - Perhaps some of these applications shouldn't be servlets!



Servlet Specification

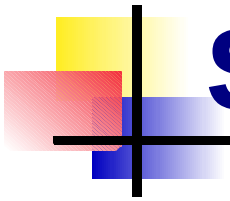
- The servlet specification describes the primary characteristics that must be present in container implementations.
  - The programming model mandated by the specification may create issues for certain types of applications
- First, key points from the servlet specification for v2.3 that will be used in this discussion...
  - There are subtle implications in some of the specs
  - This is a little dry, but stick with me!



Servlet Lifecycle

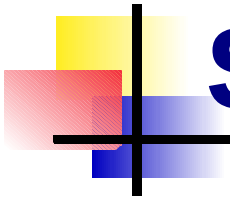
- Container instantiates the applications (servlets)
  - possibly when the container itself starts
  - possibly when the container determines the servlet is needed to respond to a request
- Servlet is not initialized until **`init()`** is called.
  - Be careful in the use of static class initializer code. This can be invoked before the servlet is initialized

Servlet Spec v2.3: SRV.2.3.1 SRV.2.3.22



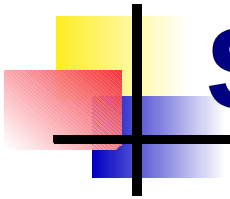
Servlet Lifecycle [c]

- A servlet container can take a servlet out of service at any time
  - All threads running in the **`service()`** method are completed before **`destroy()`**
  - New requests are serviced on a new instance of the servlet



Servlet Lifecycle - Reloading

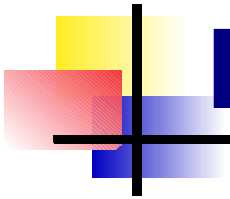
- Container providers are not required to implement class reloading, but if they do…
- Implementation of class reloading must ensure all servlets and classes they use are loaded in the scope of a single class loader



Session Lifecycle

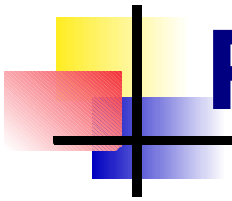
- HTTP offers no explicit termination indication for a session
  - Sessions are terminated via a timeout mechanism
  - Can be disabled via **`setMaxInactiveInterval`** to -1
- For distributed containers:
  - All session data must have specific support for distribution or the object must be **`Serializable`**
  - Container may not use JVM serialization. Can't depend on **`readObject()/writeObject()`** being called.

Servlet Spec v2.3: SRV.7.5 SRV.7.7.2



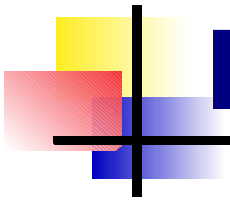
Request Lifecycle

- **`ServletRequest/ServletResponse`** objects are valid within the scope of **`service()`** or **`doFilter()`**.
  - Programmers should not keep references to these objects



Filters

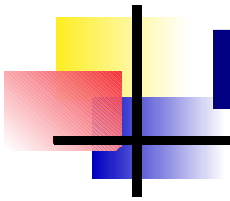
- Filters were introduced in v2.3 of the spec
  - They allow the request data to be modified (via wrappering) before being passed to the servlet
  - The response data may be altered (e.g. XSL trans-forms) before being sent to the client
- Only one instance is instantiated for each filter declaration in the deployment descriptor
  - Programmers must ensure that filters are thread safe



Listeners

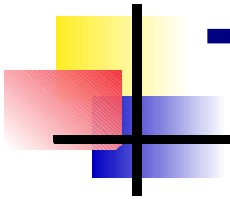
- Servlet context events:
  - Lifecycle events: has been created or is about to be terminated
  - Attribute events: attributes in the servlet context have been added, removed or replaced
- Session events:
  - Lifecycle events: session is created, invalidated or timed out
  - Attribute events: added, removed or replaced

Servlet Spec v2.3: SRV.10.2.1



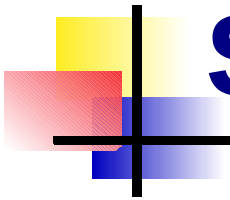
Listeners

- Attribute changes to the servlet context and session objects may occur concurrently.
  - The container is not required to synchronize listener notifications
  - Listener implementations should handle this case explicitly through synchronization mechanisms



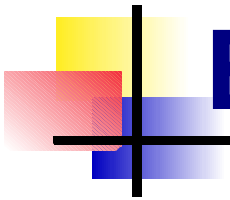
Threading Model

- Servlet containers implement concurrency by enabling multiple requests through the **`service()`** method of the servlet
  - For a given request, the process is typically synchronous and single-threaded
  - Synchronization issues occur only within objects available to multiple concurrently executing requests



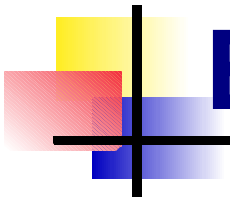
Situations Contrary to Servlets

- Some requirements for applications have suggested other deployment architectures than a servlet
- This will look at some of these issues and:
  - Look at why servlets are not appropriate
  - Look at what approaches for applications can be used instead of a servlet container model



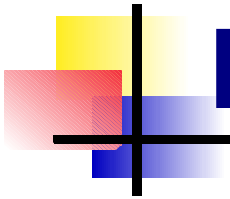
Event/Time Driven Input

- Servlets are based heavily on the HTTP request lifecycle.
  - Typically, requests are initiated via a browser and returned to the browser in the form of HTML or XML
- Some applications are driven by external events in addition to user-input events
  - Air Force application was driven by troop movement events and military equipment movement events
  - The integrated combat portal allowed a comprehensive view of the current battlefield environment



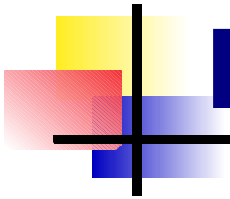
Event/Time Driven Input

- Event information may be received via HTTP, but the user interface is not updated until the user refreshes the browser view
  - Real time notification applications have a mismatch with many monitoring applications



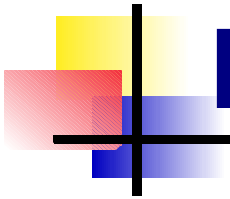
Network Protocol Mismatch

- Applications may need to interface with existing networked applications.
- Servlets are modeled after HTTP protocols, which are stateless
- Existing network applications may model a user session on a network session. For example:
  - Applications may interface via telnet protocol
  - Applications may have extended conversations with other computers such as a mobile device



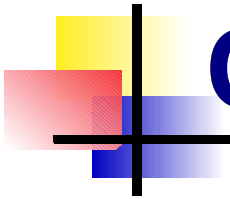
Batch Jobs

- Batch processes are typically single-threaded, long running applications
- Batch applications should not be run in a servlet container
  - The container can manage the lifecycle of the application
  - If the container takes the application out of service, the servlet request, running as batch, is subject to termination via timeout



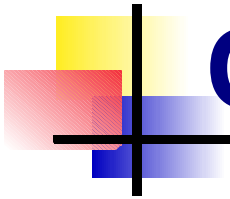
Mixed Response Time Tasks

- Applications may support a variety of functions with variable response times:
  - Servlets have a thread pool that process synchronous events in step with the HTTP protocol
  - Applications may have long running subtasks (e.g. generating a report or recompiling a workspace) that should not block the user-interface.
  - For example, O'Reilly Safari



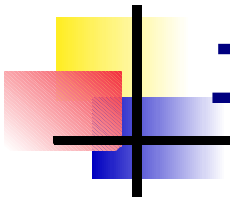
Control Over Lifecycle

- Your application may need to spawn a thread to:
  - Listen on a socket for external network (non-HTTP) events
  - Handle time-based processing
- What happens if the servlet container stops or reloads your application?
- When does your socket/timer get created? Will it get created twice?



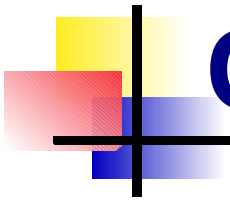
Control Over Lifecycle [c]

- If you spawn another thread...
  - If the servlet container reloads your application, it will be loaded with a different instance of the class loader
  - Object assignment may fail with **`instanceof`** problems. More on next slide...



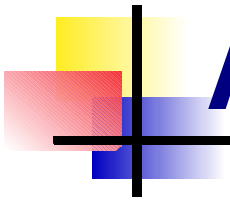
instanceof [n]

- The **instanceof** operator is used to determine if one class is of the same type as another.
- A class is an instance of another if:
  - The Class object from which it is constructed is the same type ***and...***
  - The class loader from which the two compared instances were instantiated is the same



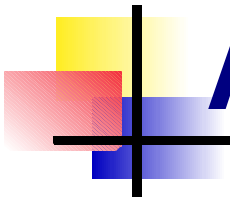
Complex User Interfaces

- Events that occur asynchronously to the user-input events
  - Eclipse and NetBeans are familiar examples
- Drag and drop capabilities are desirable
- ...etc.
- For example, Google Maps on web vs. Google Earth



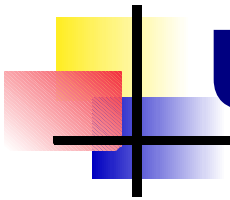
Alternatives to Servlets

- If the application programming model for servlets is inappropriate for your application, what are the alternatives?
  - Write a Java application with an appropriate threading and lifecycle model.
  - Remember that a servlet container ***is*** a Java application, so any application you develop can be a superset of that functionality



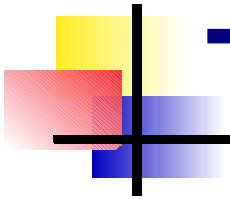
Architecture Considerations

- Key architecture decisions center around:
  - Threading model
  - Lifecycle model
- Other design areas apply, of course:
  - User interface design
  - Data model
  - Application object model
  - …etc.



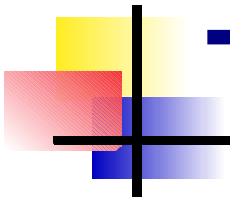
Understanding Thread Models

- The servlet gives us a (mostly) single-threaded programming model
- Parallelism occurs by running requests on a symmetric thread pool
- When we write our own application, we can choose a more appropriate thread model



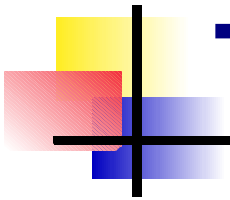
Threads: Single Threaded

- The simplest threading model is a single thread of execution that runs until the process is complete
- This is appropriate for many batch jobs
- Typically not appropriate for interactive applications



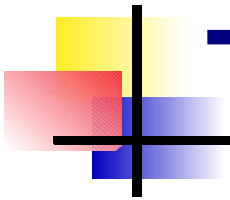
Threads: Fork/Join

- Java applications can create their own threads by instantiating a **`Thread`** object and running it.
  - That subtask runs in parallel with the thread that spawned it
  - Any shared objects must be synchronized in some manner. Excessive shared objects will reduce the parallelism and increase application complexity.
- Other threads can call **`join()`** to resynchronize application flow



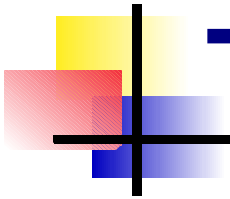
Threads: Symmetric Pool

- Your application can implement parallelism the same way servlet containers typically do:
  - Create a pool of available threads
  - When a request for service arrives, obtain an available thread and run the request to completion
- Can be an alternative to fork/join approach
  - More efficient since threads are not created for each request
  - Thread creation will most likely call operating system services



Threads: Asynch Queuing

- Some applications can benefit from internal asynchronous messaging
  - Similar to the SDK-level Windows or OS/2 Presentation Manager threads
  - The SWT UI thread processing uses this technique
  - Events are placed on a queue. A thread is blocked until an event is placed in the queue. The thread then processes that event, possibly generating events that are placed on other event queues
- These threads typically live as long as the app

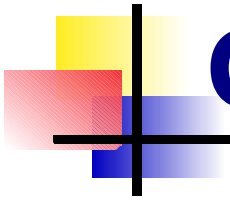


Threads: Asynch Queuing

- Other threading models are more familiar, so I want to go into more detail on this model
  - My personal favorite
  - Very resilient to extreme short-term fluctuations in workloads
  - Very robust. High arrival rates for extended periods of time tend to increase memory utilization, but don't cause “death spiral”

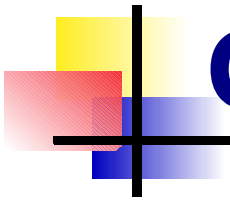
Blocking Queue

```
public class BlockingQueue {
   private LinkedList queue = new LinkedList();
   public BlockingQueue() {
      super();
   }
   public synchronized Object dequeue() {
     while (getQueue().isEmpty()) {
         try {
            wait();
         }
         catch (InterruptedException exception) {}
      }
      return getQueue().removeFirst();
   }
   public synchronized void enqueue(Object request) {
      getQueue().addLast(request);
      notify();
   }
}
```



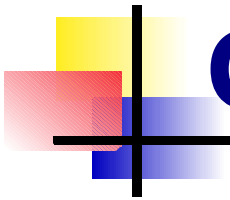
Queuing Thread

```
public static Object SHUTDOWN = new Object();
    .
    .
public void run() {
    Object request = getQueue().dequeue();
    while(SHUTDOWN != request) {
        getProcessor().serviceRequest(request);
        request = getQueue().dequeue();
    }
}
```



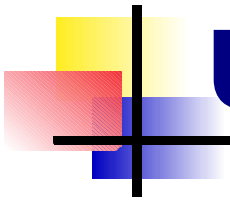
Queue-to-Queue

- Each of the queuing threads are decoupled from one other
  - Items placed in the queue shouldn't have references to objects in other queues unless those are made thread-safe
  - As in fork/join, a minimum number of critical sections (synchronized code) will give the best throughput and reduce deadlock opportunities



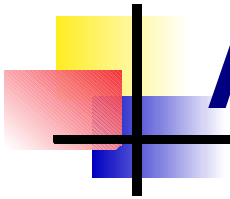
Queue-to-Queue

- The queues are loosely coupled together through a controller (as in MVC) that is responsible for dispatching to the various queues
- The controller is also responsible for the lifecycle of the queues



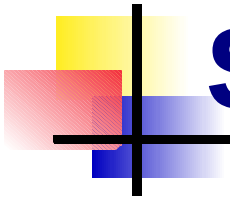
Understanding Lifecycles

- The servlet defines the lifecycles for:
  - Application
  - Session
  - Request
- If we write our own application, we need to have an understanding of how to spec these ourselves
  - Lifecycle management is one of the primary reasons why servlets don't work for my needs.



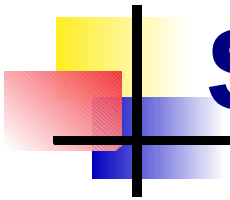
Application Lifecycle

- The application lifecycle matches that of the JVM.
- We programmatically handle the instantiation of the network and timer services, UI, etc. as well as the termination of those services
- We avoid being taken out of service or being reloaded, which avoids the corresponding class loader issues



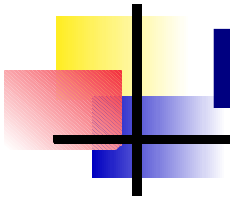
Session Lifecycle

- Servlets have a somewhat non-explicit lifecycle
  - Created when the session is “joined”
  - Terminated when it times out
- Before HTTP, session lifecycles were often matched to a network session
  - Connect to a service such as telnet, ssh, ftp, etc.
  - Authenticate and do appropriate work
  - Disconnect



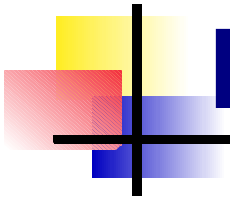
Session Lifecycle

- Matching session lifecycle to network lifecycle has some benefits
  - Identity is less easily spoofed because the network session itself would have to be hijacked
  - Less startup time (including key exchange and authentication) than is required with stateless HTTP. This is important for communicating with devices over low bandwidth, etc.



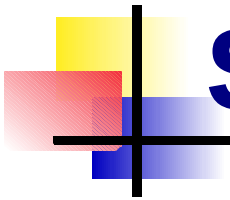
Request Lifecycle

- In a servlet, the request/response lifecycle is modeled after the HTTP request/response lifecycle.
- In a custom application, this can be a little more esoteric:
  - Can be the effect of a user input event, but may not have a response
  - Can be processing after a timer event
  - May be a single network record from a partner application



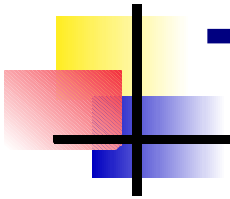
Hybrid Models

- Could use an embedded servlet engine like Jetty.
  - Talk to operational folks about deployment issues like sharing port 80
- Could use a two-process model and talk between the servlet and the application via sockets
  - The socket lifecycle could match the servlet lifecycle (i.e. **`init()/destroy()`**)



Summary

- Servlets are appropriate for a certain class of applications...
- … however, they aren't appropriate for ***all*** applications.
- When a new application is going to be developed, take the time to understand the deployment and usage of the application so the most appropriate architecture can be used



Thank You

- Thank you for taking the time to attend this session. I hope it has been helpful
- Fill out the session evaluations. They are helpful to Wayne & Peggy and me.
- Feel free to contact me via e-mail at:
  glm@hilbertinc.com
- I will be at the conference all week. Feel free to ask any questions that arise after the session.