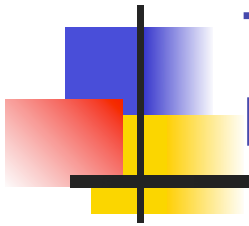
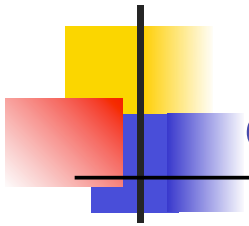


Apache Multipurpose Infrastructure for Network Applications

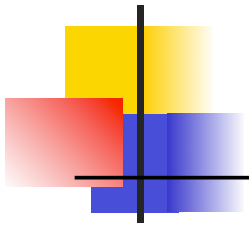
Building Scalable Network Applications

Dan Pritchett
Rearden Commerce



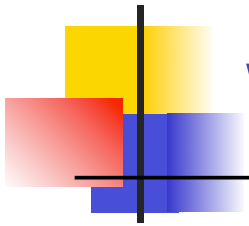
What are network applications?

- Application logic is primarily protocol handling
  - Good Examples
    - SMTP
    - LDAP
    - FTP
- Tend to have a high ratio of I/O to application logic.



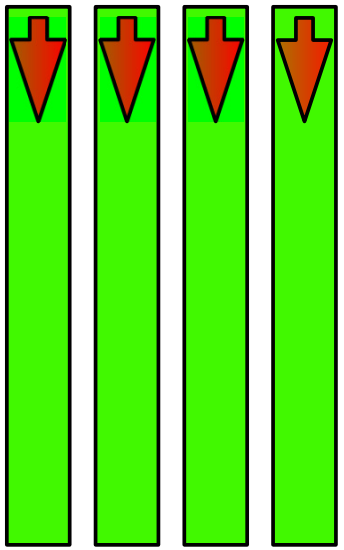
How have we solved this?

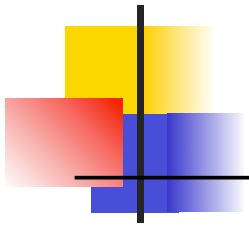
- Worker thread per request pattern
  - Listener thread accepts connections.
  - Connection established with client, delegated to a worker thread.
  - Worker remains bound to client until service request is complete.



Why doesn't that work?

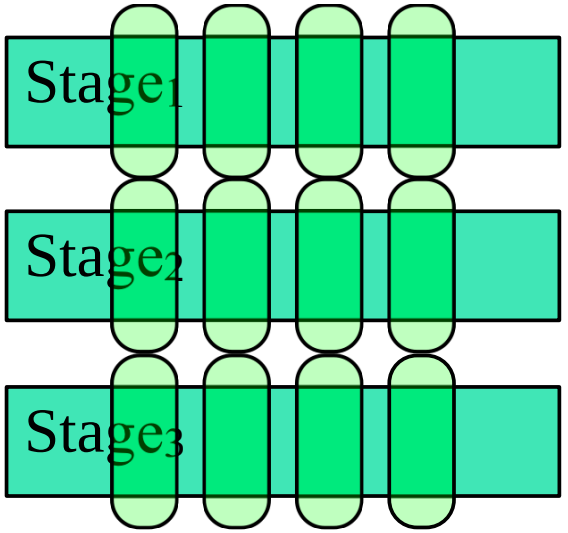
- Majority of thread time in I/O wait
- Threads are expensive
  - 500KB stack per thread
  - Context switching overhead

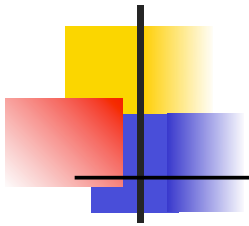




Enter SEDA

- Staged Event Driven Architecture
  - Non-blocking I/O generates events
  - Stages perform operations on events

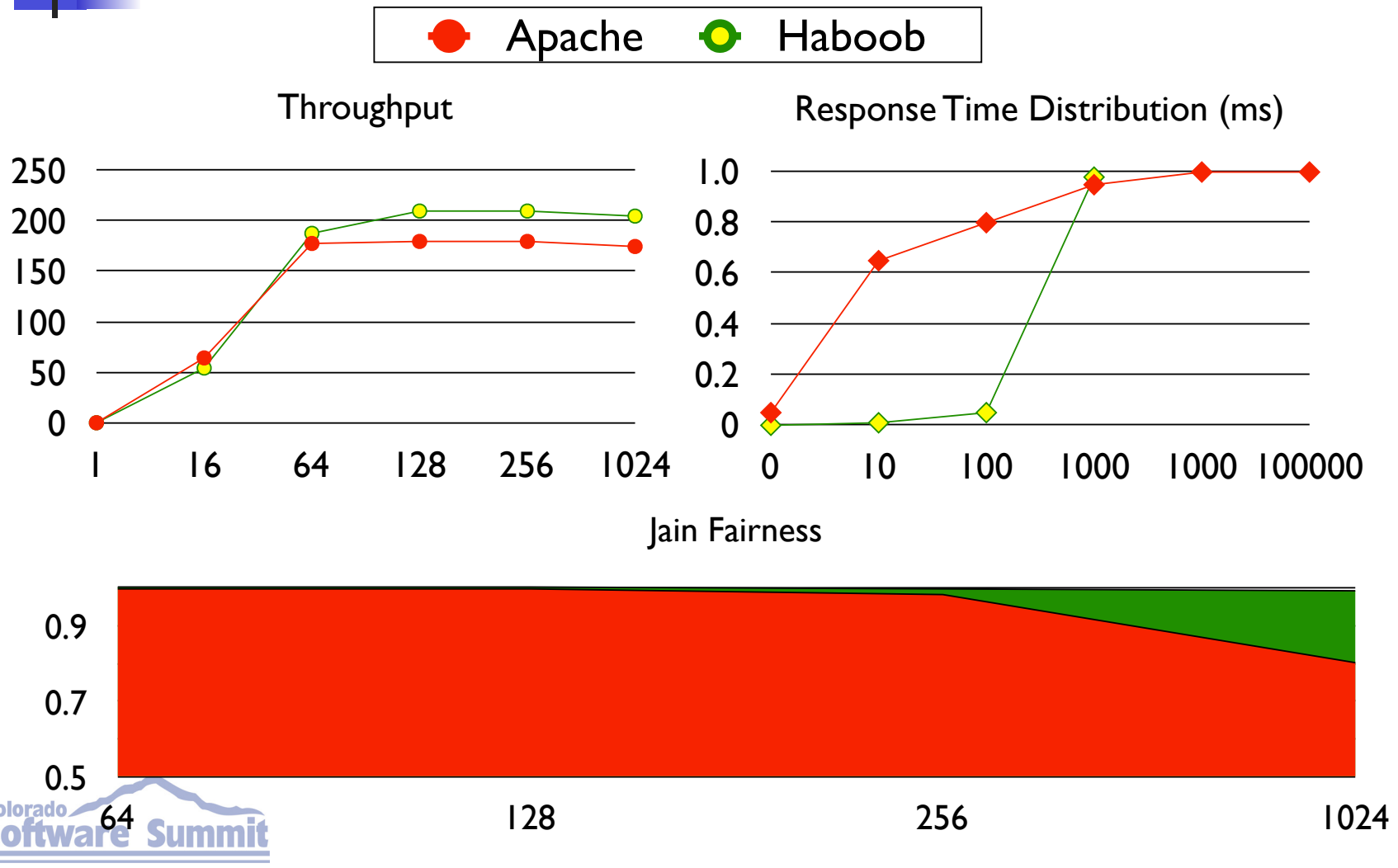


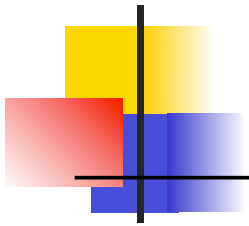


Benefits of SEDA

- Decouple threads from I/O
  - One thread can service many I/O channels
  - Improved resource utilization
- Higher throughput
  - Linear degradation in service response time.
  - Equally important more balanced performance

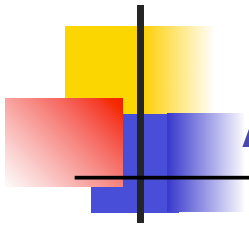
SEDA Performance





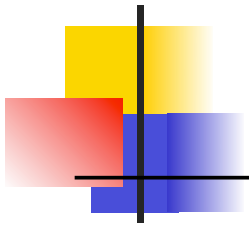
SEDA Implementations

- Apache MINA
- Haboob/ Sandstorm
- LimeWire
- TerraLycos
- Rimfaxe Web Server
- Apache Excalibur
- SwiftMQ
- MULE
- Ocean Store



Apache MINA

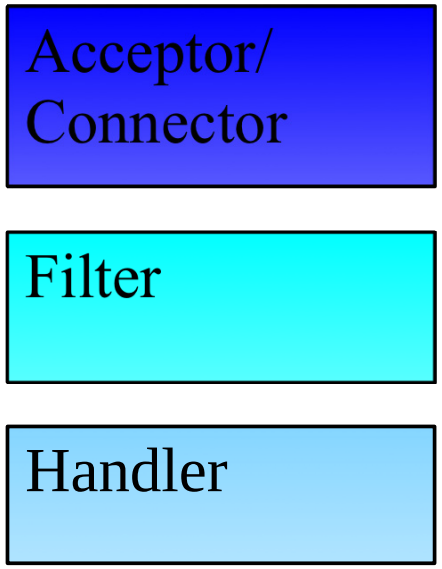
- Multipurpose Infrastructure for Network Applications
  - Apache implementation of SEDA
- A pattern and framework for developing network services.
- Java 5.0 NIO implementation



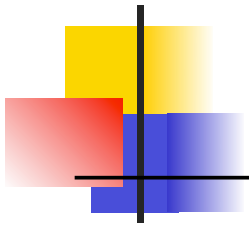
Projects Using MINA

- Apache Qpid
- Avis
- SubEthaSMTP
- Jive
- OpenLSD
- Red5
- QuickFIX/J
- Apache Directory Project
- Beep4j

MINA Application Components



- Accept inbound connections
- Establish outbound connections
- Transform data
- Ancillary Processing
- Protocol Logic

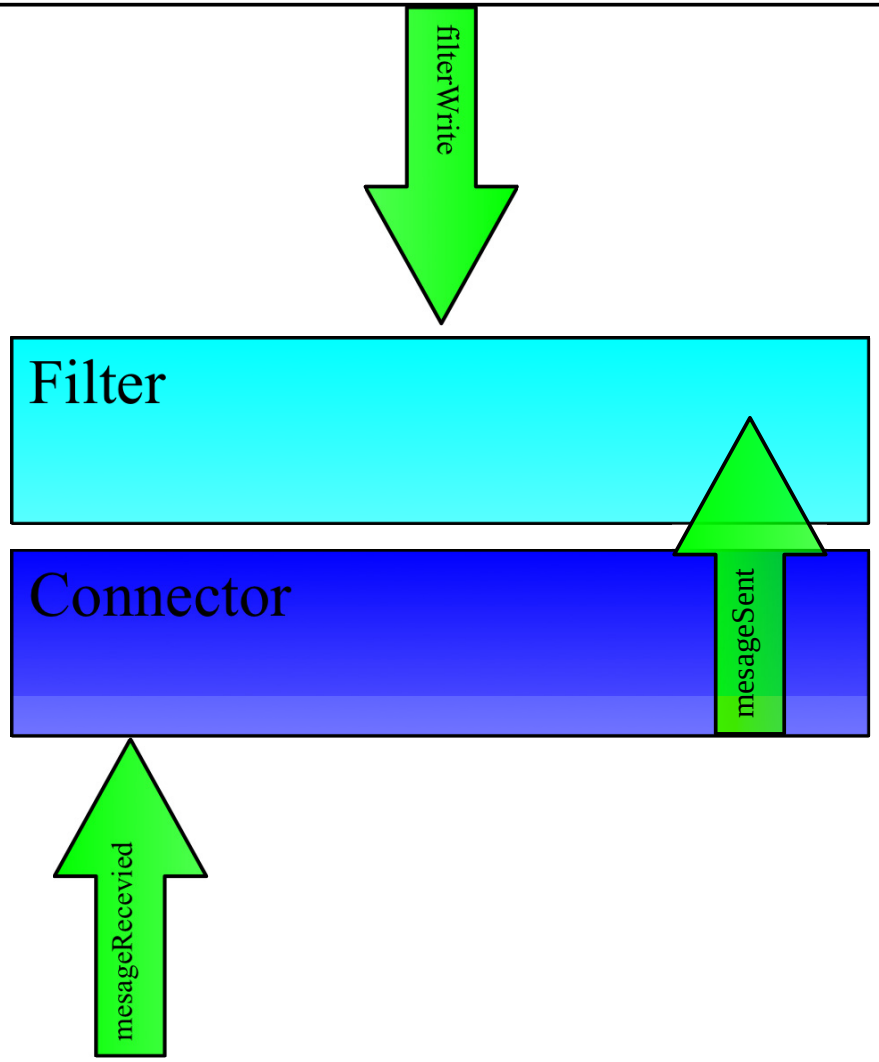


MINA Filters

- Filters are the primary source of code factoring
- Categories of filter methods
  - Data Flow
    - messageReceived, filterWrite, messageSent
  - Session Management
    - sessionCreated, sessionOpen, sessionClosed, sessionIdle
  - Filter Management
    - onFilterPre/PostAdd, onFilterPre/PostRemove
  - Errors
    - exceptionCaught

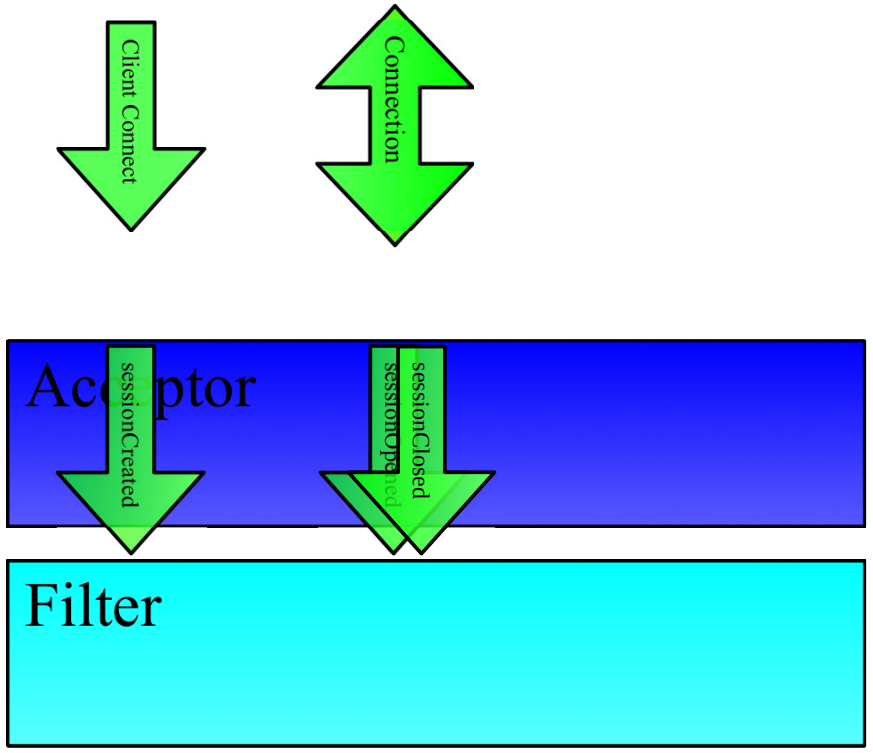
Data Flow Events

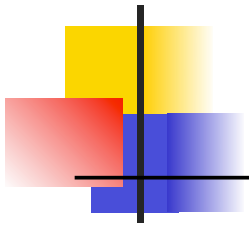
- messageReceived
  - Inbound events
- filterWrite
  - Outbound events, prior to I/O
- messageSent
  - Outbound events, after I/O



Session Management Events

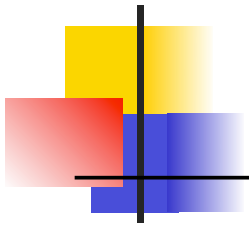
- sessionCreated
  - Prior to I/O connection established
- sessionOpened
  - Once connection is established
- sessionClosed
  - Once connection is closed





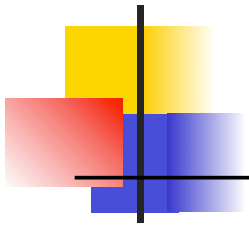
Filter Lifecycle & Errors

- Filter additions
  - onPreAdd, onPostAdd
- Filter removals
  - onPreRemove, onPostRemove
- Errors
  - exceptionCaught - All calls from framework catch Throwable and route through this method.
    - This method should avoid throwing exceptions



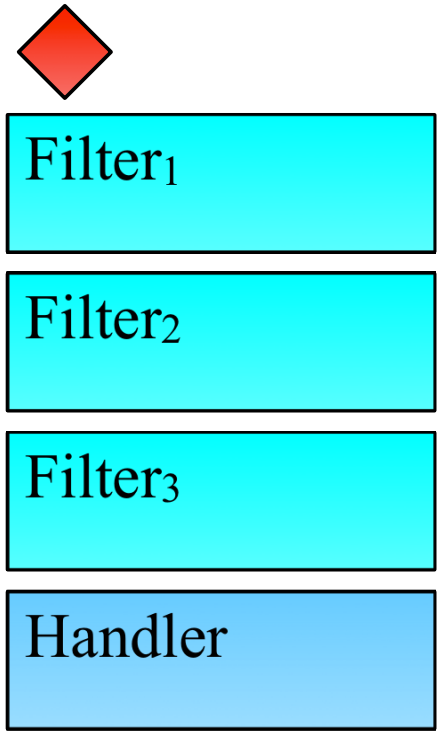
Handlers

- Handlers implement the service logic.
- Handlers are a special filter.
  - Operations provided by IoHandler interface.
  - Same methods as filter, except filter lifecycle.
  - Installed automatically as last filter in chain
    - Last to receive inbound events
    - First to receive outbound events



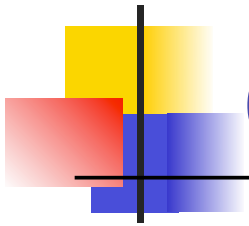
Filter Chains

- Filters are attached to acceptors and connectors.
- Events pass through the chain in order.
  - Filter can control if events propagate or stop.



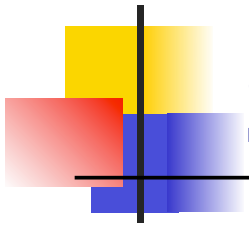
Typical MINA Application

- Transform streams to objects
- Track collection of objects as logical
- Administration and management.
- Protocol Semantics



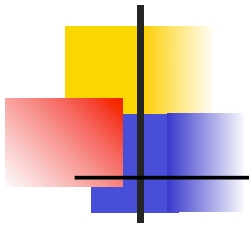
Codec

- Encoder/Decoder
  - Translates byte streams into objects
  - Streams arrive as byte buffers
    - Buffers and parsing units orthogonal.
      - For example
        - XML document may be in many buffers
        - One buffer may contain many HTTP headers
      - Don't assume anything about buffer boundaries and protocol boundaries.



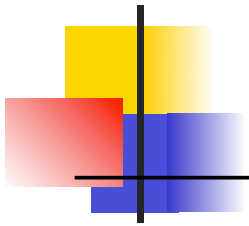
Session Management

- Protocols may involve multiple events in a logical session.
  - HTTP for example:
    - Request
    - Headers
    - 0 or more body blocks
- Session filter provides aggregation of events for downstream filters.



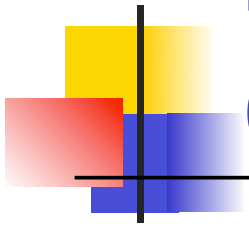
Logging/Administration

- Loosely coupled metrics
  - Log protocol information
  - Statistics
  - Flow control
- Each capability can be written as a single purpose, reusable filter.



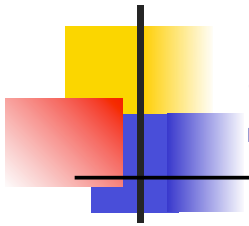
Example Service

- Simple Time Server
  - TCP/IP protocol
  - Client sends their time, ISO formatted GMT, line terminated.
  - Service responds with two lines:
    - Server time, ISO formatted GMT
    - Delta in milliseconds between the client and server.



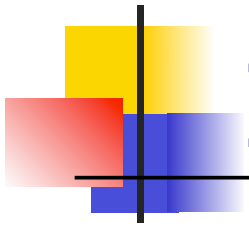
Step 1: Service Configuration

```
SocketAcceptorConfig config = new SocketAcceptorConfig();
config.setBacklog(5);
config.setReuseAddress(true);
DefaultIoFilterChainBuilder chain = config.getFilterChain();
TextLineCodecFactory factory = new TextLineCodecFactory();
ProtocolCodecFilter codec = new ProtocolCodecFilter(factory);
chain.addLast("codec", codec);
chain.addLast("date", new ISODateFilter());
chain.addLast("logger", new LoggingFilter());
chain.addLast("counter", new ServiceCounterFilter());
```



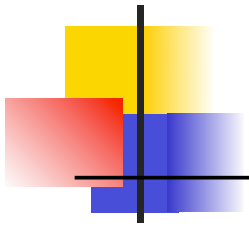
Step 2: Acceptor Setup

```
TimeServiceHandler handler = new TimeServiceHandler();
SocketAcceptor acceptor = new SocketAcceptor();
InetSocketAddress listenAddr = new InetSocketAddress(8011);
acceptor.bind(listenAddr, handler, config);
```



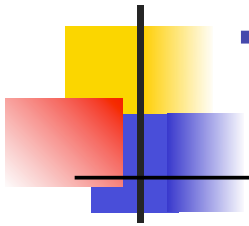
ISODateFilter

```
public class ISODateFilter extends IoFilterAdapter {
   private static final DateFormat formatter = new
         SimpleDateFormat("yyyy-MM-ddTHH:mm:ss.S");

   public void messageReceived(NextFilter next,
               IoSession session, Object message) {
      Date date = formatter.parse((String)message);
      next.messageReceived(session, date);
   }

   public void filterWrite(NextFilter next,
               IoSession session, WriteRequest request) {
      Response response = (Response)request.getMessage();
      StringBuilder text = new StringBuilder();
      text.append(formatter.format(response.date)).append("\r\n");
      text.append(Long.toString(response.delta)).append("\r\n");
      WriteRequest encoded = new WriteRequest(text.toString());
      next.filterWrite(session, encoded);
   }
}
```



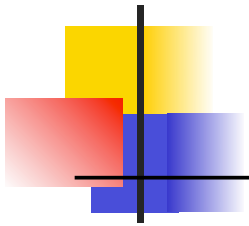
ServiceCounterFilter

```
public class ServiceCounterFilter extends IoFilterAdapter {
   private int requests = 0;

   public void messageReceived(NextFilter next,
            IoSession session, Object message) {
      requests += 1;
      next.messageReceived(session, message);
   }

   public int getRequests() {
      return requests;
   }
}
```



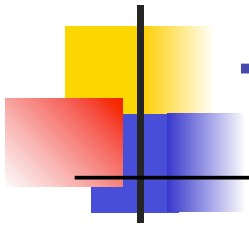
TimeServiceHandler

```
public class TimeServiceHandler extends IoHandlerAdapter {
   public void messageReceived(IoSession session,
                Object message) {
      Date client = (Date)message;
      Response response = new Response(client);
      session.write(response);
   }
}
```



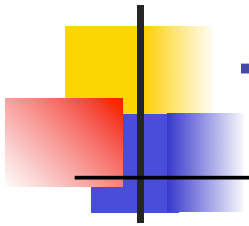
Response Object

```
public class Response {
   Date date;
   long delta;

   public Response(Date client) {
      date = new Date();
      delta = client.getTime() - date.getTime();
   }
}
```



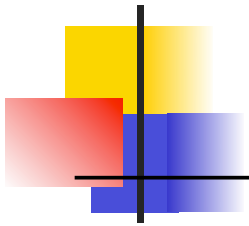
Tips: Threads

- I/O Threads - Associated with Acceptors & Connectors
  - Manage NIO channels and deliver events into the chain.
  - Take care to avoid starving NIO channels.
- ExecutorFilter dispatches event on separate thread
  - Can be installed anywhere in filter chain
- Remember context switching adds to client latency



Tips: Factoring

- Filters are the unit of factoring
  - Filter over head is small.
  - Small, single purpose filters are preferable to handler logic.
- Filters *vs* Objects
  - No simple rule for using one vs. the other.
  - In fact, they are complimentary. Hierarchy of filters is reasonable.



Further Reading

- SEDA
  - ➢http://www.eecs.harvard.edu/~mdw/proj/seda/
- MINA
  - ➢http://mina.apache.org/