Introduction to Spring Integration

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Topics

- Goals and Principles of Spring Integration
- Enterprise Integration Patterns Overview
- The Spring Integration Core API
- Configuration Options
- Channel Adapters
- Message Routing
- Roadmap

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Loose Coupling

- **Challenges**:
  - Requirements evolve
  - Technologies change
  - Systems need to be integrated
- **Solutions**:
  - Define generic abstractions
    - Interfaces, Channels
  - Encapsulate implementation details
    - Strategies, Messages
  - Take advantage of polymorphism

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Separation of Concerns

- **Challenges**:
  - Infrastructural resources must be located and configured
  - Duplicated logic is scattered across components
  - Many responsibilities are tangled within a component
  - Testing becomes prohibitive
- **Solutions**:
  - Dependency Injection
    - Provide resources to the components
    - Isolate components from the environment
  - Aspect Oriented Programming
    - Modularize cross-cutting concerns
    - Minimize scattering and tangling
  - Delegate to templates for generic behavior

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Layered Architecture

Web Services

MVC

RMI

Services

Data Access

Infrastructure

Email

RDBMS

JMS

Domain Model

Layers enforce *separation of concerns*

Interface contracts promote *loose coupling*

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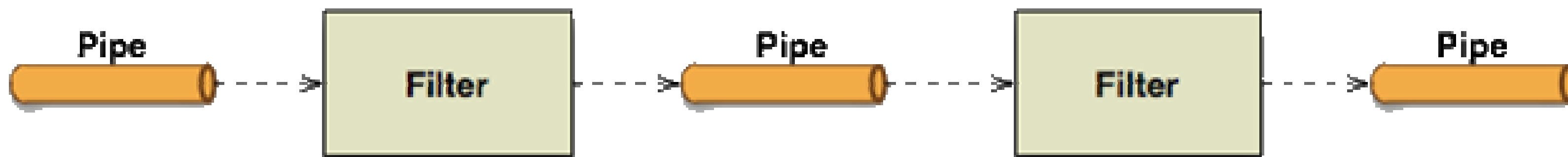
Pipes and Filters Architecture

- Pipes (messaging channels) decouple components
- Facilitates interception and monitoring
- Filter may be a service, transformer, or router
- Enables flexible service orchestration
- Channel adapters connect in/out-bound transports



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Event-Driven Systems

- Essentially Inversion of Control at runtime
- Framework polls or listens to an event source
- Framework notifies or invokes a service
- Example events
  - File written to a directory
  - JMS Message arrives on a queue/topic
  - Email received
  - Scheduled trigger fires
  - Method invocation or return value is intercepted (AOP)

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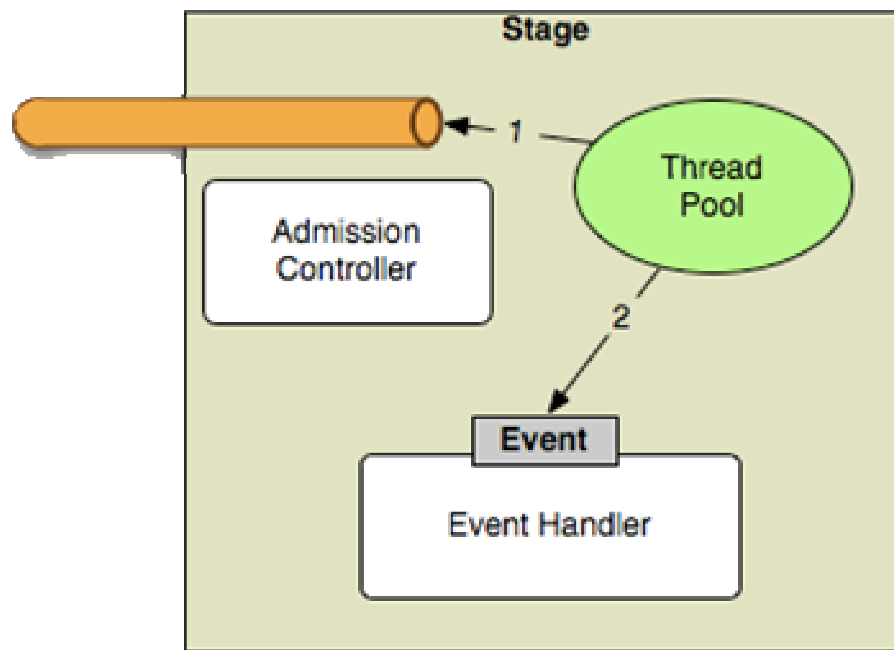
Staged Event Driven Architecture (SEDA)

- Alternative to thread-per-request server model
- Controlled number of threads per handler
- Ideal for short-lived tasks and high # of requests



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Goal 1: Keep it Simple and Non-Invasive

- Business components should not be aware of the messaging system or integration concerns
- Thread management and polling should be encapsulated but highly-configurable
- Integration logic (e.g. routing and transformation) should be isolated and testable
  - Annotated type-safe methods on POJOs
  - Dynamic language support
- Custom extension points should be well-defined
  - Strategy interfaces
  - Interceptors and AOP advice

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Goal 2: Maintain Philosophical Consistency

- Event-driven = *runtime* Inversion of Control
  - Framework handles message-listening
  - Framework handles service-invoking
- Core API design based on interfaces
- Highly customizable via strategy and template method patterns
- Provide a framework for testing
- Support multiple metadata formats
  - XML with ‘beans’
  - XSD-based namespace support
  - Annotations

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Goal 3:
Provide Seamless Integration

- Maximize leverage from the Spring foundation
  - Lifecycle management
  - Task execution abstraction
  - Aspect-Oriented Programming
  - Declarative transaction management
  - Dynamic language support
  - Spring remoting
  - JMS support
  - Scheduling

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The Result

- Simplifies development of integration solutions by relying on proven Spring best practices and well-known Enterprise Integration Patterns
- Facilitates incremental adoption for existing Spring users who are beginning to explore SOA and EDA
- Co-evolves with other Spring portfolio products

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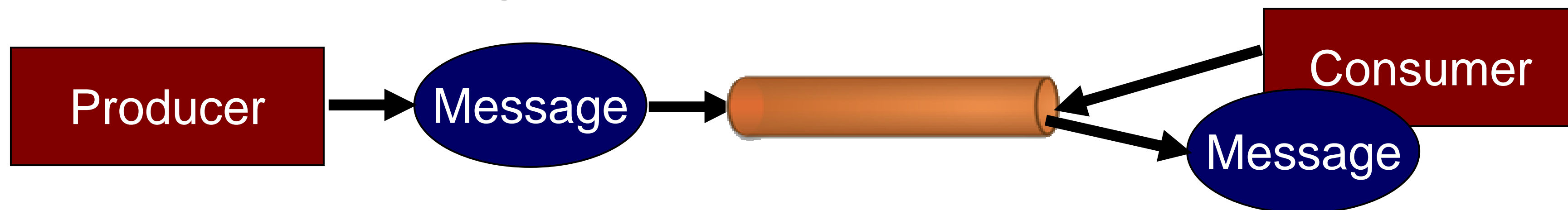
Message Channel

- Decouples producers from consumers
- Enforces data type consistency
- Provides a subscription strategy
  - Point-to-Point Channel
  - Publish/Subscribe Channel
- Enables message-based error handling
  - Invalid Message Channel
  - Dead Message Channel



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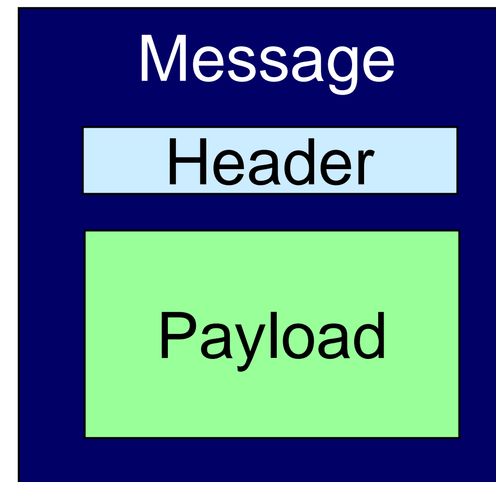
Message

- A generic package for data (the Message payload) that can be transported via channels
- A Message Header provides information to other components that consume from channels
  - Message ID
  - Sequence Number
  - Sequence Size
  - Expiration Date
  - Correlation Identifier
  - Return Address



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Message Endpoint

- Provides an abstraction for message producers and consumers
  - Adapts input sources and output targets
  - Handles invocation of local services
- Cleanly separates messaging concerns from business components
  - Acts as a Messaging Gateway for the application
  - Uses a Messaging Mapper to convert between Messages and domain objects
- Supports multiple consumer strategies
  - Polling or Event-driven
  - Selective Consumers
  - Competing Consumers

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Channel Adapter

- Connect a source to the messaging system so it can send to a Message Channel

- Connect a target to the messaging system so it can receive from a Message Channel

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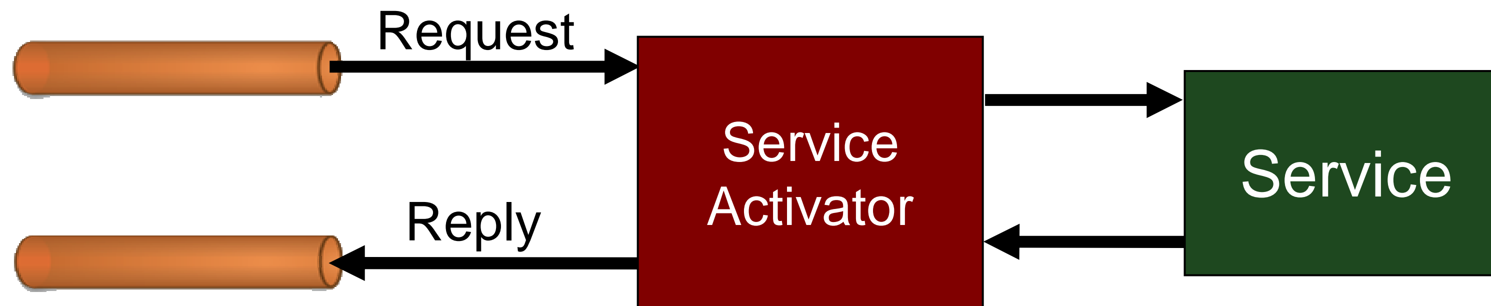
Service Activator

- A Message Endpoint that invokes a service
- Supports multiple communication styles
  - one-way and request-reply
  - synchronous and asynchronous
- The service is unaware of the messaging system



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Message Router

- Route messages to message channels
- Isolate routing strategy from business logic
- Provide a dynamic alternative to publish/subscribe channels
- Accommodate complex messaging scenarios
  – Splitter
  – Aggregator
  – Resequencer

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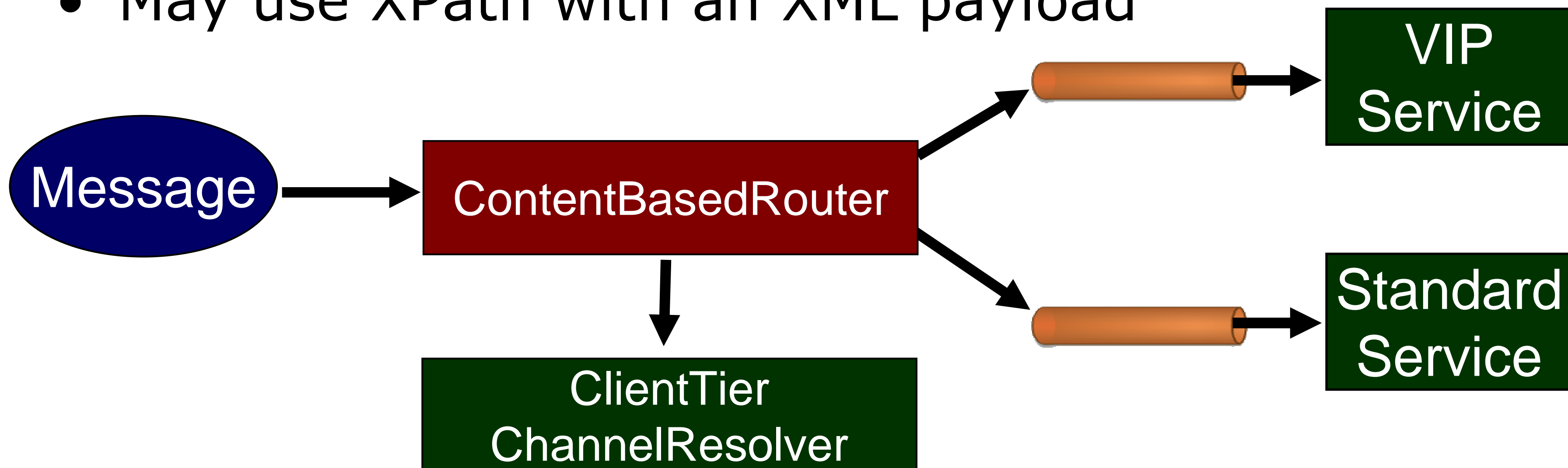
Content Based Router

- Determine target channel based on
  - payload type
  - property value
  - custom logic applied to payload
- May define rules with EL or a scripting language
- May use XPath with an XML payload



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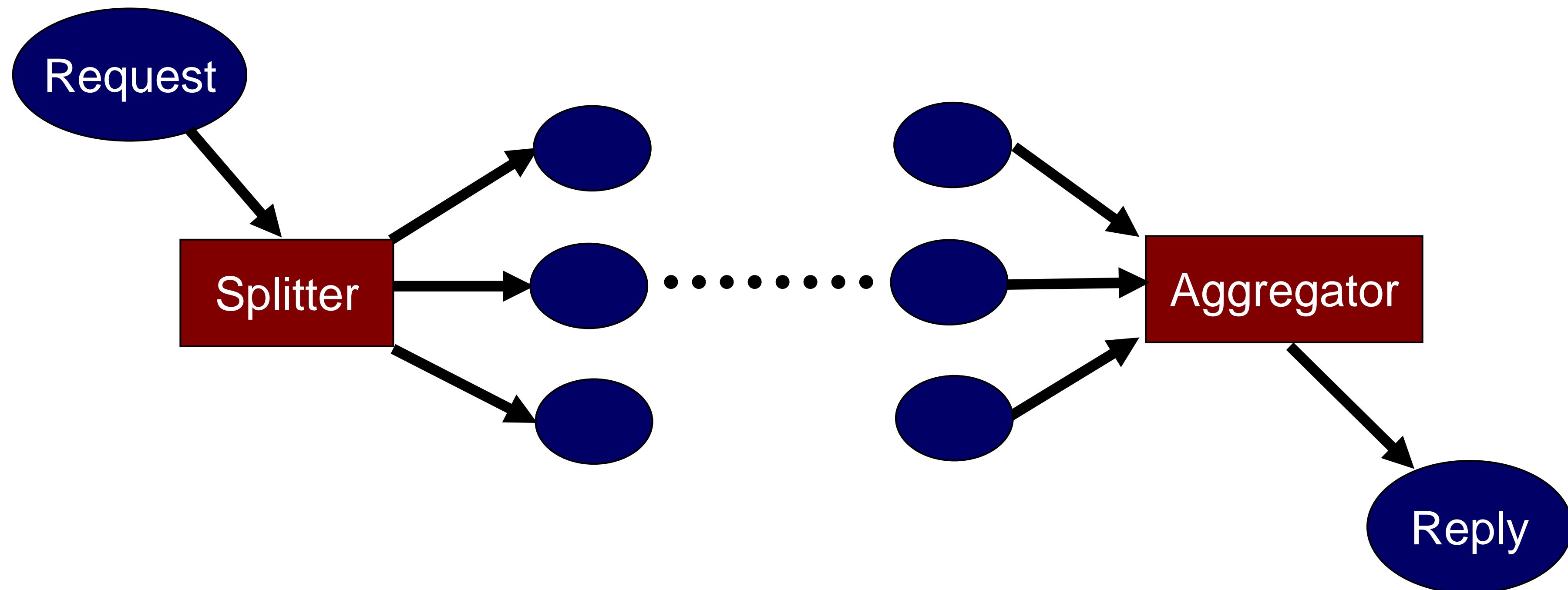
Splitter and Aggregator

- Divide coarse-grained message into sub-messages
- Delegate to distributed endpoints as necessary
- Recombine asynchronous reply messages



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Message Translator

- Convert payload type
- Enrich message content
- Filter message content
- Normalize message format
  - Multiple clients may send multiple versions
  - The application may expect a canonical format

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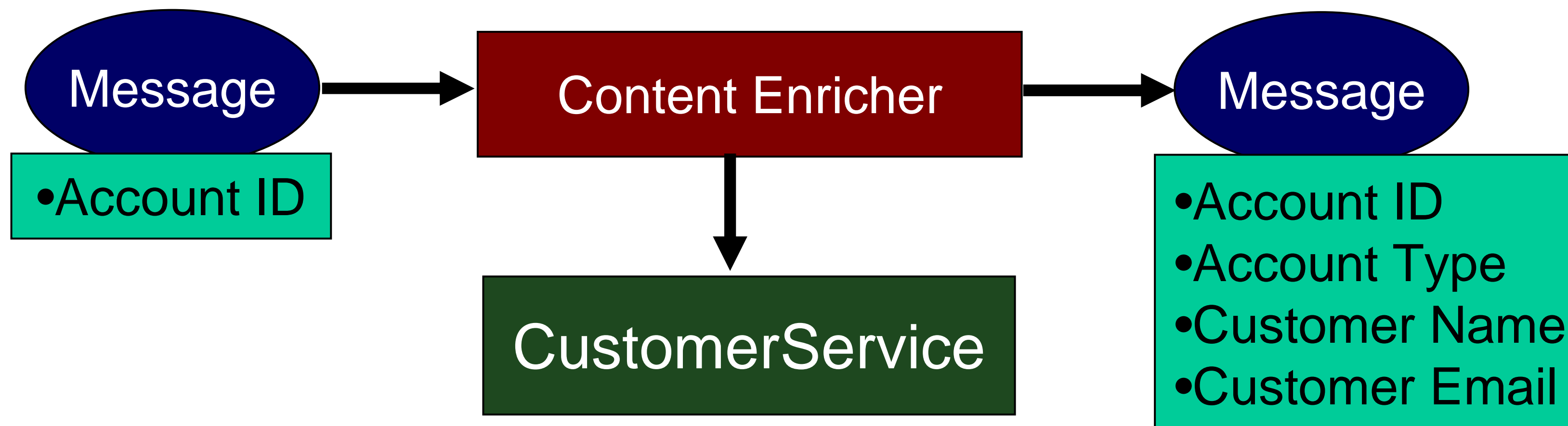
Content Enricher

- Invoke a service that provides additional data to the payload object
- Add properties for a downstream adapter



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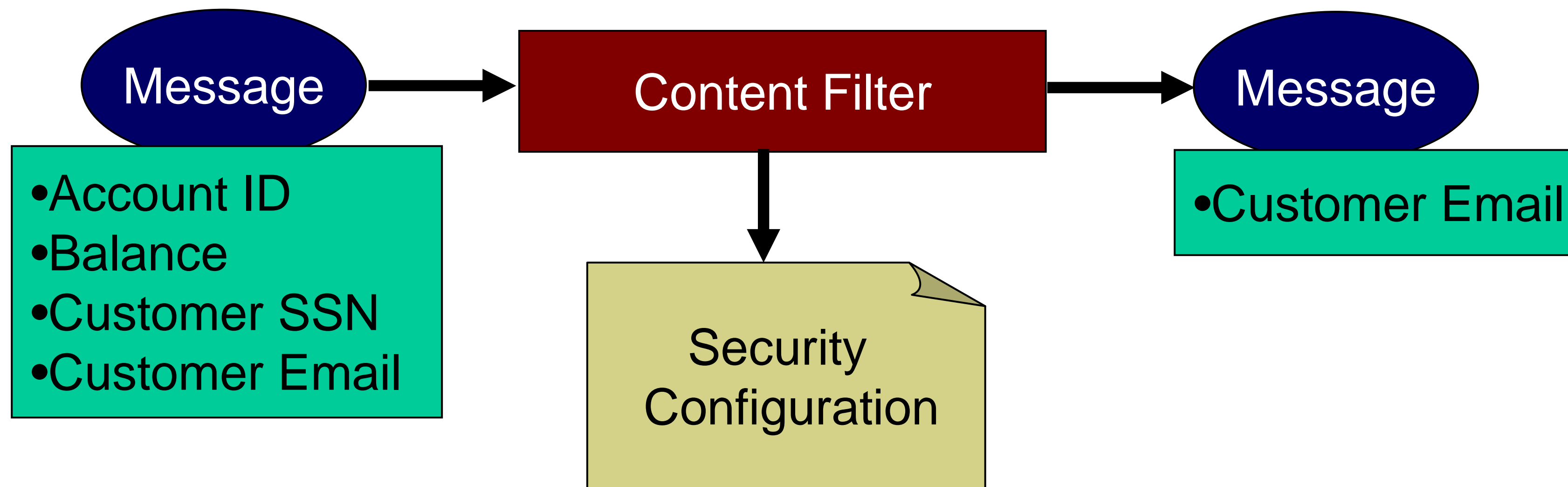
Content Filter

- Remove unnecessary information to reduce size
- Remove sensitive information for security purposes
- Use a *Claim Check* to save data for later



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EIP and the Core Principles

- A Message *encapsulates* data
- A Message Channel *decouples* producers and consumers
- A Message Endpoint is an *abstraction* whose implementation may translate, route, or invoke a business service with a Message payload
- A Channel Adapter *encapsulates* the connection details and *decouples* the integrated systems
- Asynchronous invocation *separates* the polling or listening concerns from the business logic
- A message-driven architecture accommodates change and evolving business requirements

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MessageChannel

```
public interface MessageChannel {
    boolean send(Message message);
    boolean send(Message message, long timeout);
    Message receive();
    Message receive(long timeout);
}
```

- If capacity is reached, the send method will block until a Message is removed or the timeout elapses
- If empty, the receive method will block until a Message is available or the timeout elapses

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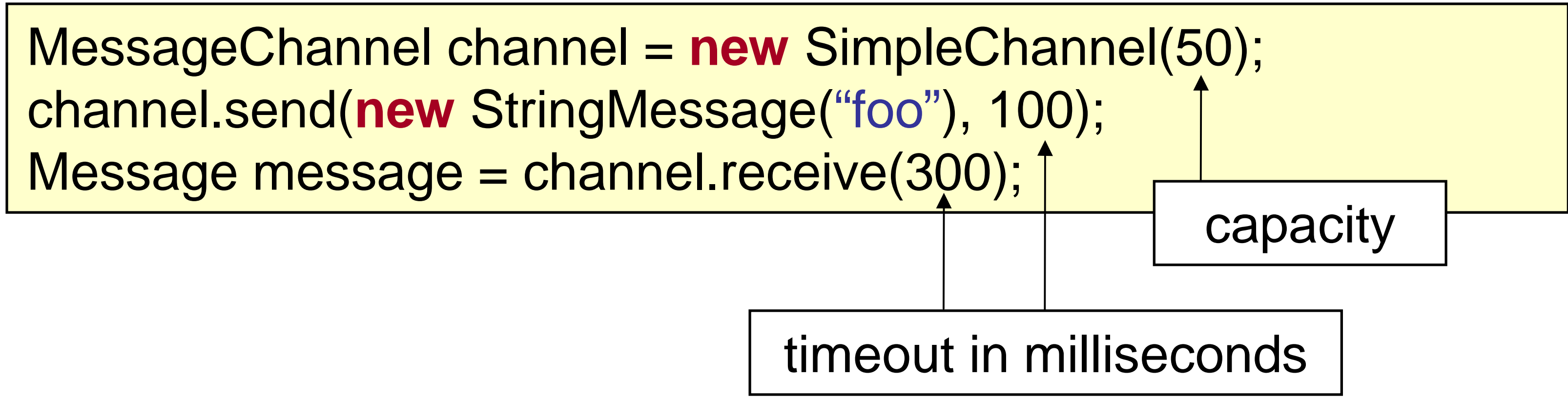
SimpleChannel

- Default implementation
- Wraps a BlockingQueue



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MessageHandler

- A generic interface defines the simple but common behavior of processing a received Message

```
public interface MessageHandler {
    Message handle(Message message);
}
```

- Many of the internal base messaging components implement this top-level interface
  - Routers, Transformers, Service Invokers
- Implementations do not necessarily return a reply Message (routers, void-returning service invokers)

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MessageHandlerChain

- MessageHandlers can be linked together

```
MessageHandlerChain chain = new MessageHandlerChain();
chain.add(new Handler1());
chain.add(new Handler2());
chain.add(new Handler3());
Message result = chain.handle(new StringMessage("foo"));
```

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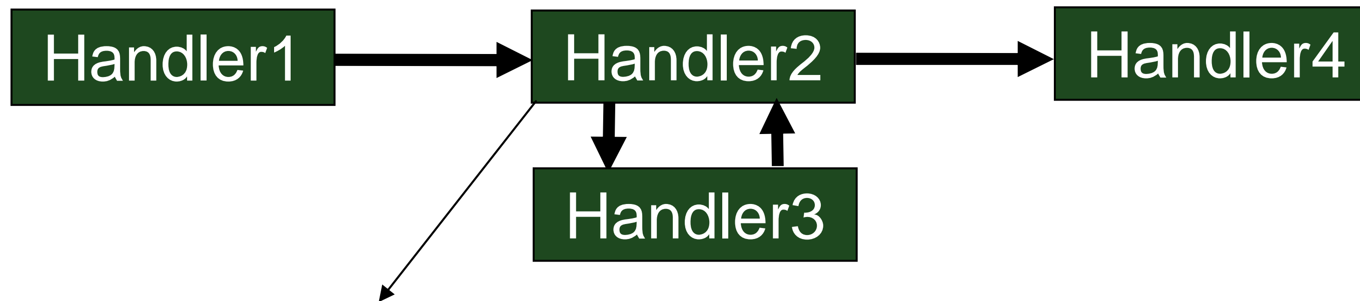
InterceptingMessageHandler

- An InterceptingMessageHandler can add behavior before and/or after another handler
  - The intercepting handler is responsible for calling *handle* on the next handler (or intentionally not proceeding)




```
public Message handle(Message message, MessageHandler target) {
   // do something before
   message = target.handle(message);
   // do something after
   return message;
}
```

Similar to AOP *around* advice

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MessageDispatcher

- Receives from a channel and sends to one or more handlers

```
MessageDispatcher dispatcher =
                              new DefaultMessageDispatcher(channel);
dispatcher.addHandler(new ExampleMessageHandler());
dispatcher.addHandler(new AnotherMessageHandler(), schedule);
dispatcher.start();
```

- Configurable properties of the dispatcher:
  - defaultSchedule (initialDelay, period, fixedRate)
  - receiveTimeout
  - maxMessagesPerTask
  - rejectionLimit
  - retryInterval

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MessageBus

- Acts as a registry for
  - MessageChannels
  - MessageEndpoints (handler + policies)
- Provides task execution infrastructure
  - For scheduling MessageDispatchers
  - For MessageEndpoint thread pools
- Manages lifecycle of the registered components (implements Lifecycle itself)

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Configuration Options

- Integration components may be configured in a number of ways
  - Java with direct usage of the API
  - XML with generic 'beans' elements
  - XML with XSD namespace support
  - Annotations
  - AOP

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Java Configuration

```
MessageHandler handler = new ExampleHandler();

DefaultMessageEndpoint endpoint = new DefaultMessageEndpoint();
endpoint.setSubscription(new Subscription("inputChannel"));
endpoint.setDefaultOutputChannelName("outputChannel");
endpoint.setHandler(handler);

MessageBus bus = new MessageBus();
bus.registerChannel("inputChannel", new SimpleChannel());
bus.registerEndpoint("testEndpoint", endpoint);
bus.registerChannel("outputChannel", new SimpleChannel());
bus.start();
```

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XML Configuration

```
<bean id="inputChannel"
class="org.springframework.integration.channel.SimpleChannel"/>

<bean id="endpoint"
      class="org.springframework.integration.endpoint.
             DefaultMessageEndpoint">
   <property name="subscription">
      <bean class="org.springframework.integration.
                   scheduling.Subscription"
         <constructor-arg ref="inputChannel"/>
      </bean>
   <property name="defaultOutputChannelName"
             value="outputChannel"/>
   <property name="handler" ref="exampleHandler"/>
</bean>

<bean id="bus"
   class="org.springframework.integration.bus.MessageBus"/>
```

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Schema-Based Configuration

```
<integration:message-bus/>

<integration:channel id="quotes"/>

<integration:endpoint input-channel="quotes"
                      handler-ref="logger"
                      handler-method="log">
   <integration:schedule period="1000"/>
   <integration:concurrency core="5" max="20"/>
</integration:endpoint>
```

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Annotation Configuration

```
@MessageEndpoint(input="inputChannel",
                 defaultOutput="outputChannel")
public class SimpleAnnotatedEndpoint {

    @Handler
    public String sayHello(String name) {
        return "hello " + name;
    }

}
```

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Messaging and AOP

- Spring AOP provides a non-invasive way to capture method execution “events”
  - Before advice
  - After-Returning advice
  - After-Throwing advice
- Spring Integration includes two interceptors
  - MessagePublishingInterceptor
  - AnnotationAwareMessagePublishingInterceptor

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MessagePublishingInterceptor

```
MessagePublishingInterceptor interceptor =
                                        new MessagePublishingInterceptor();
interceptor.setDefaultChannel(testChannel);
ProxyFactory pf = new ProxyFactory(testService);
pf.addAdvice(interceptor);
TestService proxiedService = (TestService) pf.getProxy();
String result = proxiedService.test();
```

The return value is also sent to the channel

- The interceptor can be customized or extended
  - Provide a MessageMapper strategy
  - Subclass and implement a channel resolving strategy

```
resolveChannel(MethodInvocation invocation)
```

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Annotation-Driven Publisher

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- Add the @Publisher annotation to any method of a Spring-managed object

```
@Publisher(channel="testChannel")
public String test() {
    return "testing…";
}
```

- Register a bean post-processor

```
<bean class="org.springframework.integration.config.
                  PublisherAnnotationPostProcessor"/>
```

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Annotation-Driven Subscriber

- Add the @Subscriber annotation to any method of a Spring-managed object

```
@Subscriber(channel="testChannel")
public void test(String input) {
    System.out.println("received: " + input);
}
```

- Register a bean post-processor

```
<bean class="org.springframework.integration.config.
                SubscriberAnnotationPostProcessor"/>
```

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Channel Adapters

- A source adapter connects an external data *provider* to a MessageChannel
- A target adapter connects an external data *consumer* to a MessageChannel
- Examples:
  - JMS, File, Stream, RMI, ApplicationEvent

- In both cases, a message mapping strategy handles the conversion to and from message types

Similar to Spring's JMS MessageConverter

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JMS Channel Adapters

```
<si:message-bus/>
<si:channel id="inputChannel"/>
<si:channel id="outputChannel"/>

<si:jms-source id="jmsSourceAdapter"
        connection-factory="connectionFactory"
        destination-name="sourceQueue"
        channel="inputChannel"/>

<si:jms-target id="jmsTargetAdapter"
        connection-factory="connectionFactory"
        destination-name="targetQueue"
        channel="outputChannel"/>
```

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File Channel Adapters

```
<si:message-bus/>
<si:channel id="inputChannel"/>
<si:channel id="outputChannel"/>

<si:file-source id="fileSourceAdapter"
        directory="${java.io.tmpdir}/test-input"
        channel="inputChannel"
        poll-period="10000"/>

<si:file-target id="fileTargetAdapter"
        directory="${java.io.tmpdir}/test-output"
        channel="outputChannel"/>
```

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Stream Channel Adapters

```
CharacterStreamSourceAdapter inputAdapter =
        new CharacterStreamSourceAdapter(reader);
adapter.setChannel(inputChannel);

CharacterStreamTargetAdapter outputAdapter =
        new CharacterStreamTargetAdapter(writer);

messageBus.registerSourceAdapter("inputAdapter", inputAdapter);
messageBus.registerHandler("outputAdapter", outputAdapter,
                                        new Subscription(outputChannel));
```

Also: ByteStreamSourceAdapter and ByteStreamTargetAdapter

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ApplicationEvent Adapters

```
ApplicationEventSourceAdapter adapter =
                              new ApplicationEventSourceAdapter();

eventTypes = new ArrayList<Class<? extends ApplicationEvent>>();
eventTypes.add(TestApplicationEvent2.class);
adapter.setEventTypes(eventTypes);
adapter.setChannel(channel);

adapter.onApplicationEvent(new TestApplicationEvent1());
adapter.onApplicationEvent(new TestApplicationEvent2());
message = channel.receive(); // will receive TestApplicationEvent2
```

ApplicationEventTargetAdapter sends message payloads as ApplicationEvents – it implements ApplicationEventPublisherAware

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Delegating Source Adapters

```
MethodInvokingSource source = new MethodInvokingSource();
source.setObject(new ExampleSource());
source.setMethod("retrieve");

PollingSourceAdapter adapter = new PollingSourceAdapter(source);
adapter.setChannel(channel);
adapter.setPeriod(100);
adapter.start();

Message message = channel.receive();
```

- SourceAdapters are registered with the MessageBus which handles scheduling and lifecycle

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Delegating Target Adapters

```
MethodInvokingTarget target = new MethodInvokingTarget();
target.setObject(new ExampleTarget());
target.setMethod("publish");

DefaultTargetAdapter adapter = new DefaultTargetAdapter(target);
bus.registerHandler("adapter", adapter, new Subscription(channel));

channel.send(new StringMessage("foo"));
```

- TargetAdapters are also registered with the MessageBus
  - Handles lifecycle and schedules a dispatcher

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Annotation-Based Channel Adapters

```
@MessageEndpoint
public class SampleAnnotatedEndpoint {
    @Polled(period=5000)
    public String getName() {
        return "World";
    }
    @Handler
    public String sayHello(String name) {
        return "Hello " + name;
    }

    @DefaultOutput
    public void display(String message) {
        System.out.println(message);
    }
}
```

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Message Routing

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- Routing can be simple
  - Resolve and send to a single channel based on the Message's payload type
  - Resolve and send to multiple channels based on a property value in the MessageHeader
- Or complex
  - Split a composite Message into its constituent parts and then send each as a new Message to a dedicated handler
  - In a downstream endpoint, aggregate the results into a single composite Message

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Message Routing Interfaces

- The base router implements MessageHandler and delegates to these fine-grained strategies

```
public interface ChannelResolver {
    MessageChannel resolve(Message message);
}
```

```
public interface MultiChannelResolver {
    List<MessageChannel> resolve(Message message);
}
```

```
public interface ChannelNameResolver {
    String resolve(Message message);
}
```

```
public interface MultiChannelNameResolver {
    String[] resolve(Message message);
}
```

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PayloadTypeRouter

```
channelMappings.put(String.class, stringChannel);
channelMappings.put(Integer.class, integerChannel);

PayloadTypeRouter router = new PayloadTypeRouter();
router.setChannelMappings(channelMappings);
Message<String> message1 = new StringMessage("test");
Message<Integer> message2 = new GenericMessage<Integer>(123);

router.handle(message1); // will send to 'stringChannel'
router.handle(message2); // will send to 'integerChannel'
```

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RecipientListRouter

```
List<MessageChannel> channels = new ArrayList<MessageChannel>();
channels.add(channel1);
channels.add(channel2);

RecipientListRouter router = new RecipientListRouter();
router.setChannels(channels);
Message<String> message = new StringMessage("test");

router.handle(message); // will send to channel1 and channel2
```

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Routing Annotation Examples

- Routers can also be defined with annotations
  - Low-level (working with message and channel)

```
@Router
public List<MessageChannel> getChannels(Message message) {
   // resolve the channel or channels…
}
```

  - High-level (working with domain objects)

```
@Splitter
public OrderItem[] splitOrders(PurchaseOrder purchaseOrder) {
   // split the purchase order into order items…
}
```

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1.0 Roadmap (1)

- Configuration
  - Generic XML ‘beans’
  - XSD-based namespaces
  - Annotations
- Channels
  - Point-to-Point
  - Publish/Subscribe
  - Support for datatype enforcement and priority
  - Interceptors for send and receive
- Adapters
  - JMS, RMI, HttpInvoker, Hessian/Burlap, and Spring-WS
  - File, FTP, Stream, and Email

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1.0 Roadmap (2)

- Spring Core Integration
  - AOP
    - intercept and publish a Message before or after method
    - subscribe to a MessageChannel for method input
  - Adapters for Spring ApplicationEvents
  - Transaction management for Message Endpoints
- Spring Portfolio Integration
  - Source/Target Adapters for Spring Web Services
  - Messaging Gateway for Spring MVC
  - Integration with Spring Batch processes
  - Spring Security for Channels and Endpoints

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Suggested Reading

- Enterprise Integration Patterns
  - Gregor Hohpe and Bobby Woolf (Addison Wesley, 2004)
- Pattern-Oriented Software Architecture, v.4
  - Frank Buschmann, Kevlin Henney, and Douglas C. Schmidt (Wiley, 2007)
- Event-Based Programming
  - Ted Faison (Apress, 2006)
- Java Messaging
  - Eric Bruno (Charles River Media, 2006)
- Enterprise Service Bus
  - David Chappell (O'Reilly, 2004)

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DEMO

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