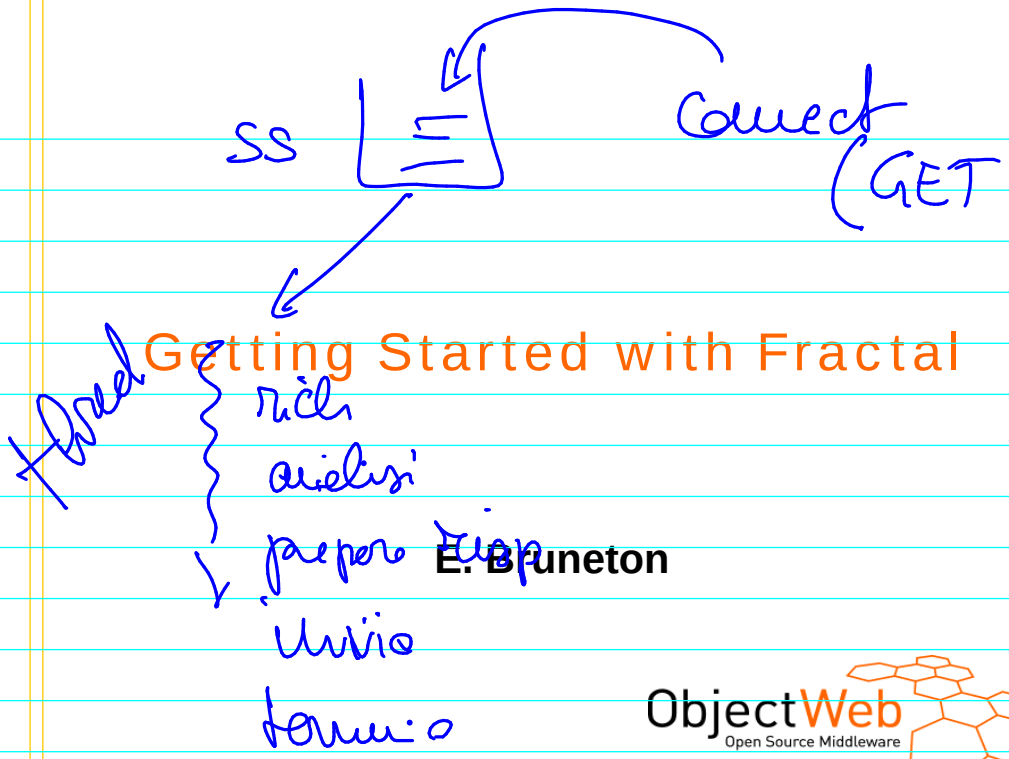

Getting Started with Fractal

E. Bruneton

ObjectWeb
Open Source Middleware

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Overview

- Introduction
- Design
- Implementation
- Configuration
- Reconfiguration
- Conclusion

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Introduction

What is Fractal?

- a modular, extensible component model that can be used to design, implement, deploy and reconfigure:
  - various systems and applications (from OS to middleware to GUI)
  - in various programming languages (currently Java and C)
- an ObjectWeb project with 4 sub projects:
  - model, implementation, components, tools

Fractal heavily uses *separation of concerns*

- separation of interface and implementation, component oriented programming, inversion of control, separation of content and controller, separation of controller interfaces, separation of architecture description and deployment, …

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Design: Comanche example

- **Minimal HTTP server**
  - listens on a server socket
  - for each connection:
    - starts a new thread
    - reads the URL
    - sends the requested file
    - or an error message

```
public class Server implements Runnable {
 private Socket s;
 public Server (Socket s) { this.s = s; }
 public static void main (String[] args) throws IOException {
  ServerSocket s = new ServerSocket(8080);
  while (true) { new Thread(new Server(s.accept())).start(); }
 }
 public void run () {
  try {
   InputStreamReader in = new InputStreamReader(s.getInputStream());
   PrintStream out = new PrintStream(s.getOutputStream());
   String rq = new LineNumberReader(in).readLine();
   System.out.println(rq);
   if (rq.startsWith("GET ")) {
    File f = new File(rq.substring(5, rq.indexOf(' ', 4)));
    if (f.exists() && !f.isDirectory()) {
     InputStream is = new FileInputStream(f);
     byte[] data = new byte[is.available()];
     is.read(data);
     is.close();
     out.print("HTTP/1.0 200 OK\n\n");
     out.write(data);
    } else {
     out.print("HTTP/1.0 404 Not Found\n\n");
     out.print("<html>Document not found.</html>");
    }
   }
   out.close();
   s.close();
  } catch (IOException _) { }
 }
}
```

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Design: finding components

- **Static components**
  - lifetime = application lifetime
  - correspond to « services »
- **Dynamic components**
  - shorter life time
  - correspond to « data »
- **Define components**
  - find services
  - [identify data structures]
  - one service = one component

```
public class Server implements Runnable {
  private Socket s;
  public Server (Socket s) { this.s = s; }
  public static void main (String[] args) throws IOException {
    ServerSocket s = new ServerSocket(8080);
    while (true) { new Thread(new Server(s.accept())).start(); }
  }
  public void run () {
    try {
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      String rq = new LineNumberReader(in).readLine();
      System.out.println(rq);
      if (rq.startsWith("GET ")) {
        File f = new File(rq.substring(5, rq.indexOf(' ', 4)));
        if (f.exists() && !f.isDirectory()) {
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          is.read(data);
          is.close();
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          out.write(data);
        } else {
          out.print("HTTP/1.0 404 Not Found\n\n");
          out.print("<html>Document not found.</html>");
        }
      }
      out.close();
      s.close();
    } catch (IOException _) { }
  }
}
```

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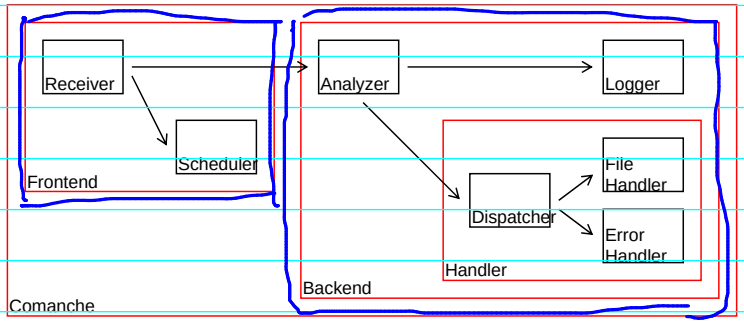
Design: finding architecture

- **Dependencies:**
  - use scenarios and use cases
- **Hierarchical structure:**
  - corresponds to abstraction level



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Design: defining contracts

- **Contracts between components:**
  - must be designed with care: must be as stable as possible
  - must deal only with functional concerns
- **Comanche contracts**
  - logger: 1 log operation, with a String parameter
  - scheduler: 1 schedule operation, with a Runnable parameter
  - handlers: 1 handleRequest operation
    - analyzer: reads the URL
    - dispatcher: dispatchs to associated handlers in turn, until success
    - file handler: try to read and send back the file at the requested URL
    - error handler: return an error message and always succeed

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Implementation: interfaces

- **Choose the component's granularity**
  - Several design time components can be represented as a single programming time component
- **Implement the component's interfaces**
  - Fractal enforces a strict separation between interface and implementation
- **Comanche interfaces**
  - public interface Logger { void log (String msg); }
  - public interface Scheduler { void schedule (Runnable task); }
  - public interface RequestHandler { void handleRequest (Request r) throws IOException; }
  - public class Request { Socket s; Reader r; PrintStream out; String url; }

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Implementation: components

Components without dependencies:

- implemented as in normal Java

POJO

```
public class BasicLogger implements Logger {
  public void log (String msg) { System.out.println(msg); }
}
public class SequentialScheduler implements Scheduler {
  public synchronized void schedule (Runnable task) { task.run(); }
}
public class MultiThreadScheduler implements Scheduler {
  public void schedule (Runnable task) { new Thread(task).start(); }
}
```

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Implementation: components

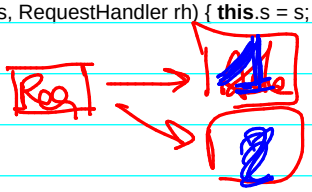
Components with dependencies:

- first solution: does not allow static configuration

```
public class RequestReceiver implements Runnable {
  private Scheduler s = new MultiThreadScheduler();
  private RequestHandler rh = new RequestAnalyzer();
  // rest of the code not shown
}
```

- second solution: does not allow dynamic renconfiguration

```
public class RequestReceiver implements Runnable {
  private Scheduler s;
  private RequestHandler rh;
  public RequestReceiver (Scheduler s, RequestHandler rh) { this.s = s; this.rh = rh; }
  // rest of the code not shown
}
```



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Implementation: components

Components with dependencies:

```
public class RequestReceiver implements Runnable, BindingController {
  private Scheduler s;
  private RequestHandler rh;
  public String[] listFc () { return new String[] { "s", "rh" }; }
  public Object lookupFc (String n) {
    if (n.equals("s")) { return s; } else if (n.equals("rh")) { return rh; } else return null;
  }
  public void bindFc (String n, Object v) {
    if (n.equals("s")) { s = (Scheduler)v; } else if (n.equals("rh")) { rh = (RequestHandler)v; }
  }
  public void unbindFc (String n) {
    if (n.equals("s")) { s = null; } else if (n.equals("rh")) { rh = null; }
  }
  // ...
```

quali attributi ?

dimm il valore di un attributo ..

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Configuration: programmatic

- **Advantages:**
  - most direct approach
  - no tools required
- **Drawbacks:**
  - error prone
  - the architecture is not visible
  - *the architecture and deployment concerns are mixed*

dinamico

```
public class Server {
  public static void main (String[] args) {
    RequestReceiver rr = new RequestReceiver();
    RequestAnalyzer ra = new RequestAnalyzer();
    RequestDispatcher rd = new RequestDispatcher();
    FileRequestHandler frh = new FileRequestHandler();
    ErrorRequestHandler erh = new ErrorRequestHandler();
    Scheduler s = new MultiThreadScheduler();
    Logger l = new BasicLogger();
    rr.bindFc("rh", ra);
    rr.bindFc("s", s);
    ra.bindFc("rh", rd);
    ra.bindFc("l", l);
    rd.bindFc("h0", frh);
    rd.bindFc("h1", erh);
    rr.run();
  }
}
```

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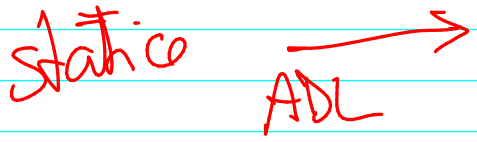
Configuration: ADL based

- **Advantages**
  - good separation between the architecture and deployment concerns
  - Allow static verifications
    - invalid or missing bindings, …
- **Drawbacks:**
  - the architecture is not visible




```
<component-type name="HandlerType">
  <provides>
    <interface-type name="rh" signature="comanche.RequestHandler"/>
  </provides>
</component-type>

<primitive-template name="FileHandler" implements="HandlerType">
  <primitive-content class="comanche.FileRequestHandler"/>
</primitive-template>

<composite-template name="Comanche" implements="RunnableType">
  <composite-content>
    <components>
      <component name="fe" type="FrontendType" implementation="Frontend"/>
      <component name="be" type="HandlerType" implementation="Backend"/>
    </components>
    <bindings>
      <binding client="this.r" server="fe.r"/>
      <binding client="fe.rh" server="be.rh"/>
    </bindings>
  </composite-content>
</composite-template>
```

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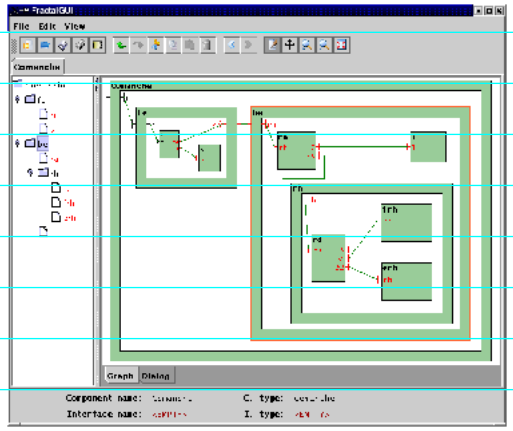
Configuration: GUI based

Graphical tool to edit ADL definition files

- the graph representation clearly shows the architecture



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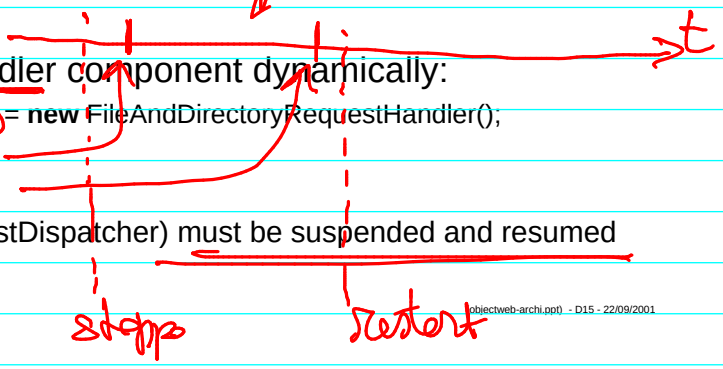
Reconfiguration: life cycle

Reconfiguration:

- static: stop the application, change the ADL file, restart
  - not always possible, e.g. if the application must be always available
- dynamic: reconfigure the application while it is running
  - introduces consistency problems
    - basic tool to help solve them: component life cycle management

Example:

- replace the FileHandler component dynamically:
  - RequestHandler rh = **new** FileAndDirectoryRequestHandler();
  - rd.unbindFc("h0");
  - rd.bindFc("h0", rh);
- for safety, rd (RequestDispatcher) must be suspended and resumed



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Reconfiguration: life cycle

LifeCycleController interface: first solution

```
public class RequestDispatcher implements RequestHandler, BindingController, LifeCycleController {
  private boolean started;
  private int counter;
  public String getFcState () { return started ? STARTED : STOPPED; }
  public synchronized void startFc () { started = true; notifyAll(); }
  public synchronized void stopFc () { while (counter > 0) { wait(); } started = false; }
  public void handleRequest (Request r) throws IOException {
    synchronized (this) { while (counter == 0 && !started) { wait(); } ++counter; }
    try {
      // original code
    } finally { synchronized (this) { --counter; if (counter == 0) { notifyAll(); } } }
  }
  // rest of the class unchanged
```

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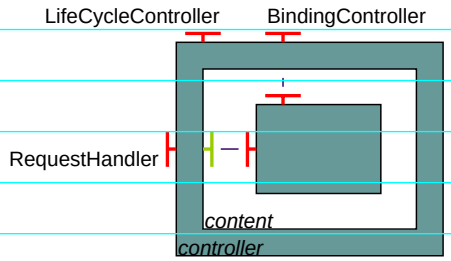
Reconfiguration: life cycle

LifeCycleController interface: better solutions

- implement this interface in a separate class or in a sub class
  - better separation of concerns
    - components can then be deployed with or without life cycle management
- generate this separate class or sub class automatically
  - dynamic or static code generation



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Reconfiguration: other APIs

- **Before stopping and reconfiguring a component, one must get a reference to it**
  - hence the following introspection (and reconfiguration) interfaces:

```
public interface Component {
  Object[] getFcInterfaces ();
  Object getFcInterface (String itfName);
  Type getFcType ();
}
```

```
public interface ContentController {
  Object[] getFcInternalInterfaces ();
  Object getFcInterfaceInterface(String itfName);
  Component[] getFcSubComponents ();
  void addFcSubComponent (Component c);
  void removeFcSubComponent(Component c);
}
```

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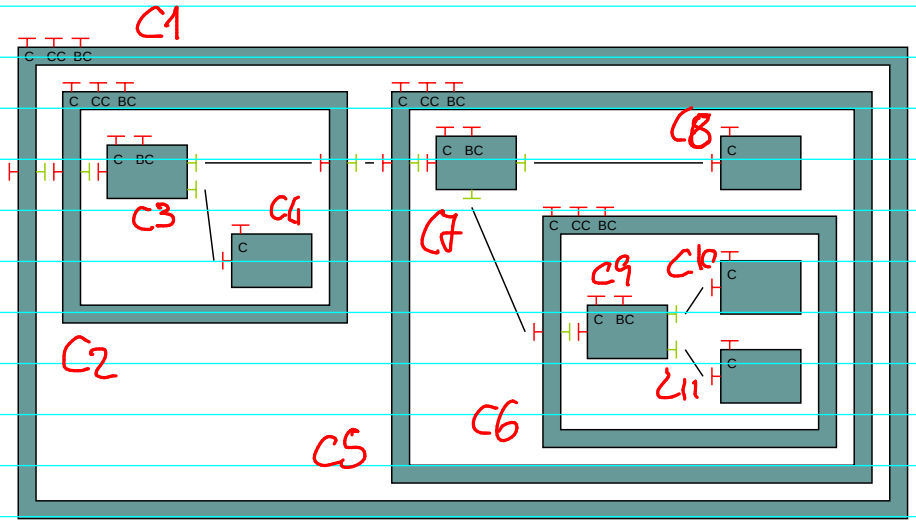
Some deployment choices



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Conclusion

Fractal

- uses well known design patterns and organize them into a uniform, extensible, language independent component model

Benefits

- enforces separation of interface and implementation
  - ensures a minimum level of flexibility
- enforces separation of the functional, configuration and deployment concerns
  - allows applications to be instantiated in various ways
    - from fully optimized but unreconfigurable configurations to less optimized but dynamically reconfigurable configurations