Pattern Languages & EFPL

- Look at two topics:
  - Pattern Languages
    - collections of patterns that used together lead to solutions for a particular domain area
  - Evolving Frameworks pattern language
    - a pattern language for developing frameworks together with its use in the evolution of MViews/JViews

Pattern Languages

- "A pattern language defines a collection of patterns and the rules to combine them into an architectural style. Pattern languages describe software frameworks or families of related systems."
  - Cope, Patterns Home Page
- "A collection of patterns forms a vocabulary for understanding and communicating ideas. Such a collection may be skillfully woven together into a cohesive "whole" that reveals the inherent structures and relationships of its constituent parts toward fulfilling a shared objective. This is what Alexander calls a pattern language. If a pattern is a recurring solution to a problem in a context given by some forces, then a pattern language is a collective of such solutions which, at every level of scale, work together to resolve a complex problem into an orderly solution according to a pre-defined goal."
  - Appleton, "Patterns and Software: Essential Concepts and Terminology"

Pattern Languages

- Provide lexicon of patterns + "grammar" for threading them together
  - useful patterns
  - rules and orderings to apply them to achieve some goal
- "Good pattern languages guide the designer toward useful architectures and away from architectures whose literary analogies are gibberish or unartful writing."
  - Appleton, "Patterns and Software: Essential Concepts and Terminology"
- Illustrate with a pattern language for evolving frameworks developed by Don Roberts and Ralph Johnson
  - D. Roberts, R.Johnson "Evolving Frameworks"

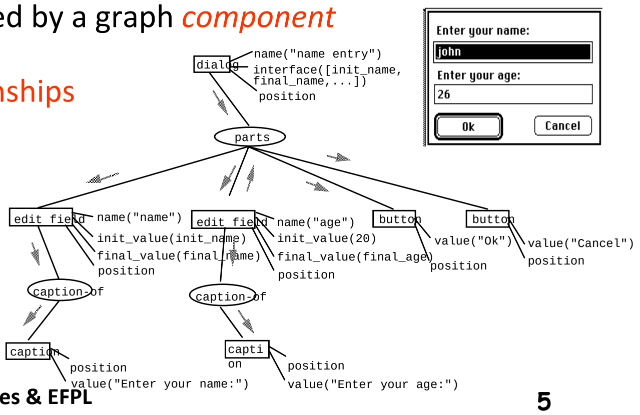
    http://st-www.cs.uiuc.edu/users/droberts/evolve.html
- Illustrate application to development of our MViews/JViews framework for constructing multiple view graphical environments

MViews/JViews

- Developed over close to 10 years
  - initially from John Grundy's PhD thesis…
- Aim: to support design and implementation of visual environments supporting multiple views with different representations
  - Eg a CASE TOOL supporting various types of UML diagram
- Support for specification and implementation of:
  - underlying shared repository
  - information represented in views
  - consistency management/mappings between views
  - visual representation and manipulation of elements in the views

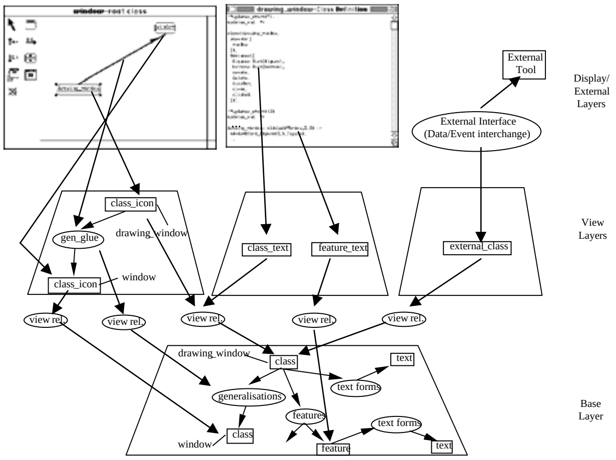
CPRGs

- Underlying abstraction of MViews/JViews: change propagation and response graphs
  - discrete change description propagation along inter-object relationships,
  - response to and storage of these change descriptions
- Each item of data is represented by a graph *component*
- Components linked via relationships
- Components have attributes representing state
- Relationships are themselves components

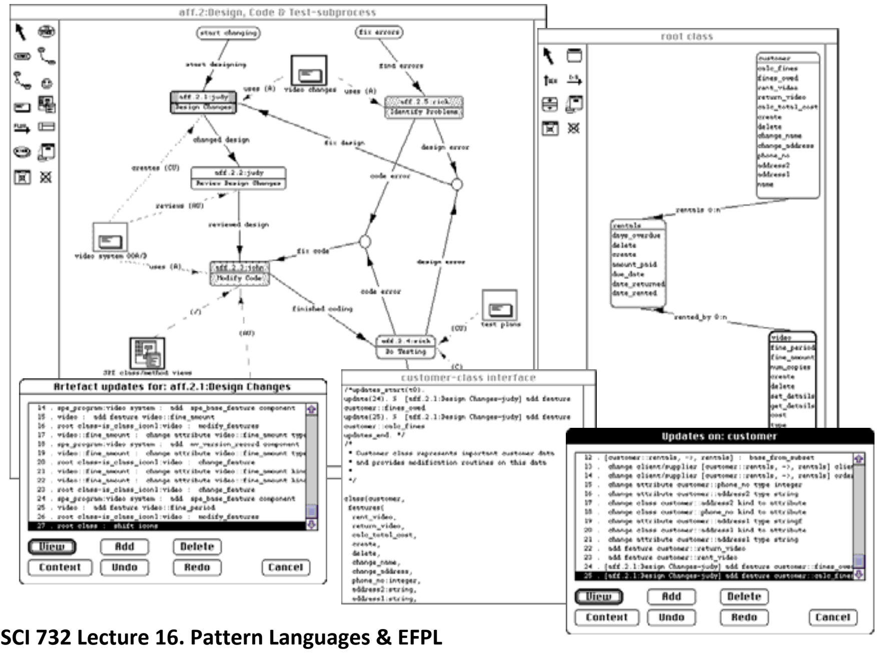

Enter your name:
john
Enter your age:
26

MViews/JViews

- Framework implementing CPRG model with support for constructing multiple view - multiple representation design environments (~10 year development)
- 3-layer architecture
  - Base
  - View
  - Display
- Used to implement many of our visual tools & environments
- Eg Orion Mapper prototype



Example use: SPE/Serendipity



Artefact updates for: aff.2.1:Design Changes

```
14 . spe_program:video system :  add  spe_base_feature component
15 . video :  add feature video::fine_amount
16 . root class-is_class_icon1:video :  modify_features
17 . video::fine_amount :  change attribute video::fine_amount type
18 . spe_program:video system :  add  sv_version_record component
19 . video::fine_amount :  change attribute video::fine_amount type
20 . root class-is_class_icon1:video :  change_feature
21 . video::fine_amount :  change attribute video::fine_amount kind
22 . video::fine_amount :  change attribute video::fine_amount kind
23 . root class-is_class_icon1:video :  change_feature
24 . spe_program:video system :  add  spe_base_feature component
25 . video :  add feature video::fine_period
26 . root class-is_class_icon1:video :  modify_features
27 . root class :  shift icons
```

customer-class interface

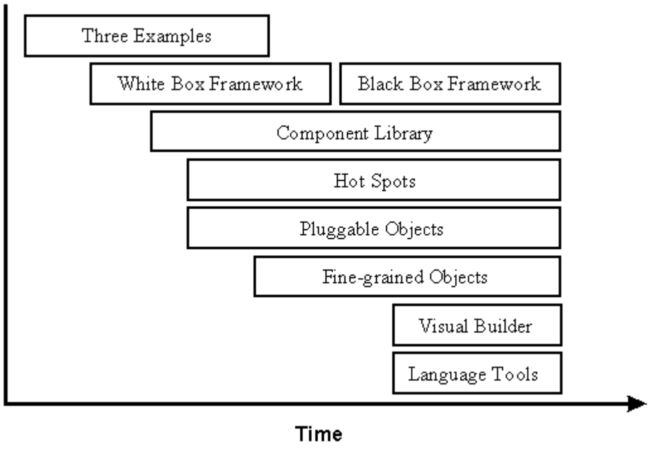
```
/*updates_start(t0).
update(24). S  [aff.2.1:Design Changes-judy] add feature
customer::fines_owed
update(25). S  [aff.2.1:Design Changes-judy] add feature
customer::calc_fines
updates_end. */
/*
 * Customer class represents important customer data
 * and provides modification routines on this data
 *
 */

class(customer,
 features(
  rent_video,
  return_video,
  calc_total_cost,
  create,
  delete,
  change_name,
  change_address,
  phone_no:integer,
  address2:string,
  address1:string,
```

Updates on: customer

```
12 . [customer::rentals, ->, rentals] :  base_from_subset
13 .  change client/supplier [customer::rentals, ->, rentals] clie
14 .  change client/supplier [customer::rentals, ->, rentals] orde
15 .  change attribute customer::phone_no type integer
16 .  change attribute customer::address2 type string
17 .  change class customer::address2 kind to attribute
18 .  change class customer::phone_no kind to attribute
19 .  change attribute customer::address1 type stringf
20 .  change class customer::address1 kind to attribute
21 .  change attribute customer::address1 type string
22 .  add feature customer::return_video
23 .  add feature customer::rent_video
24 . [aff.2.1:Design Changes-judy] add feature customer::fines_owe
25 . [aff.2.1:Design Changes-judy] add feature customer::calc_fine
```

Evolving frameworks

- The patterns in this pattern language are not design patterns in the usual sense, rather they are patterns describing useful processes and tasks that software developers perform when developing frameworks
- Names and temporal interaction of the patterns:



Three Examples

White Box Framework

Black Box Framework

Component Library

Hot Spots

Pluggable Objects

Fine-grained Objects

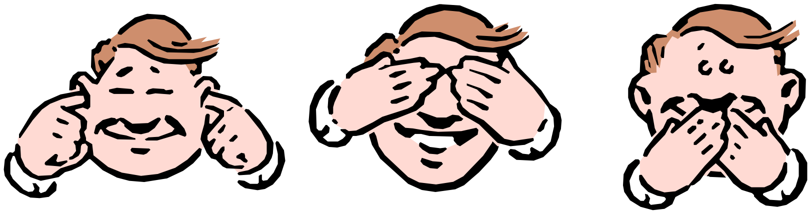
Visual Builder

Language Tools

Time

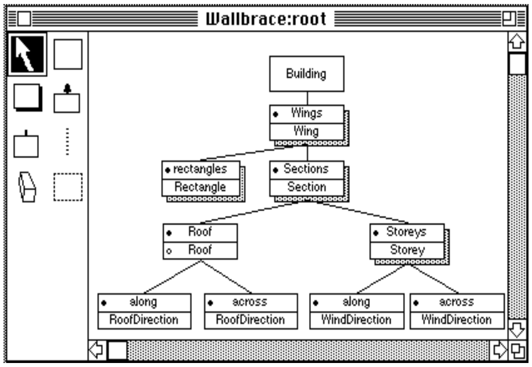
3 Examples

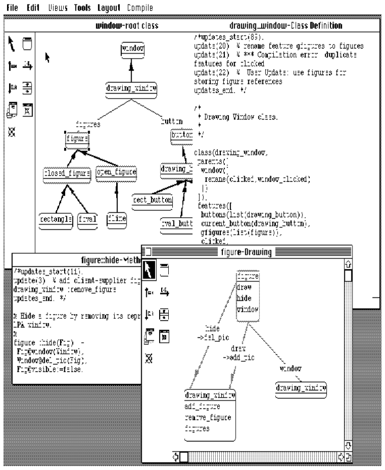
- **Context:** You've decided to develop a framework for a domain
- **Problem:** How do you start designing a framework
- **Forces:**
  - **people work best by abstracting from examples**
  - **developing examples can pay for the costs of developing framework**
- **Solution:** Develop three applications that you believe the framework should help you build



MViews/JViews application

- Initially developed a tool for constructing multiple view class diagrams (Ispel)
- Then developed a programming environment for programming in Snart, an OO Declarative Language (SPE)
- Then developed a multiple view ER modeller (MViews-ER)





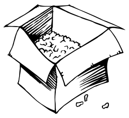
drawing_window-Class Definition

```
/*updates_start(85).
update(20)  % rename feature gfigures to figures
update(21)  % *** Compilation error  duplicate
features for clicked
update(22)  %  User Update: use figures for
storing figure references
updates_end. */

/*
 * Drawing Window class.
 *
 */

class(drawing_window,
 parents([
  window([
   rename(clicked,window_clicked)
  ])
 ]),
 features([
  buttons(list(drawing_button)),
  current_button(drawing_button),
  gfigures(list(figure)),
  clicked,
```

figure::hide-Meth

```
/*updates_start(11).
update(3)  % add client-supplier fig
drawing_window :remove_figure
updates_end. */

% Hide a figure by removing its repr
IPA window.
%
figure :hide(Fig)  -
 Fig@window(Window),
 Window@del_pic(Fig),
 Fig@visible:=false.
```

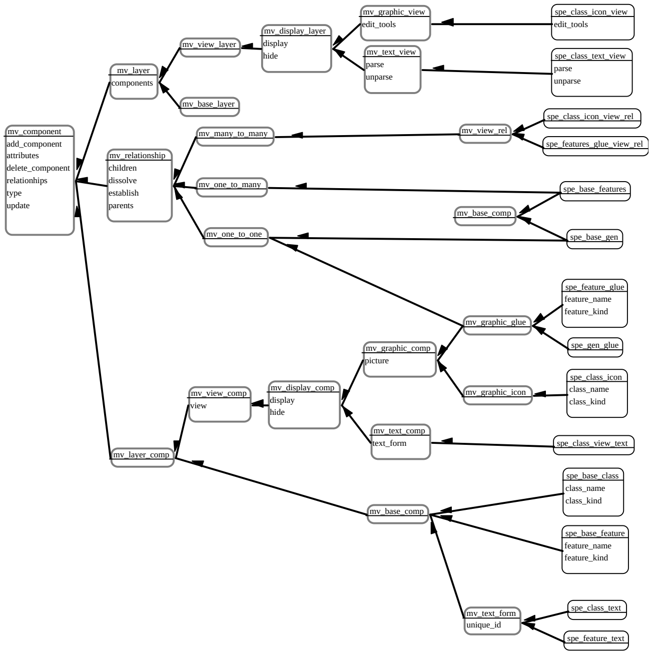
White-box Framework



- Context: You are building your second application
- Problem: How to choose between using inheritance or composition as the basis for using the framework
- Forces:
  - Inheritance gives strong coupling between components, but allows reused components to be modified/extended
  - Making a new class requires programming
  - Composition is simpler, but you need to know in advance what can be changed via parameterisation etc
  - Compositions can be dynamic, inheritance is static
- Solution: use inheritance to build a white box framework by generalizing from classes in the initial application
- Why: inheritance is most expedient way of allowing users to change code in an OO environment - inherit and override. After using this approach for a while it will become clearer as to what changes and what doesn't

MViews

- MViews was developed by abstracting from experience with Ispel
- Framework of classes for multiple view graphical and textual environments
- Reused via inheritance and overriding of framework classes - ie a white box framework

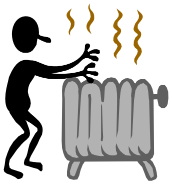


Component library

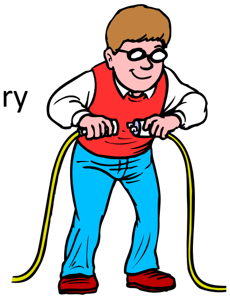
- Context: You are developing the second and subsequent examples based on the white box framework
- Problem: Similar objects must be implemented for each problem the framework solves. How do you avoid writing similar objects for each instantiation of the framework
- Forces:
  - Bare-bones frameworks require a lot of effort to reuse. Things that work out of the box are much easier. A good library of concrete components makes a framework easier to use
  - Its hard to tell initially what components will be reused. Some will be problem specific - some will be reused most times
- Solution: Start with a simple library of concrete components and add extra ones as you need them.
  - Add all components initially and later remove ones that never get reused. These are still useful as they give examples of how to use the framework
- In MViews many concrete classes were implemented for use in SPE
- These were adapted or generalised for use in MViewsER

Hot Spots

- Context: You are adding components to the component library
- Problem: As you develop applications similar code gets reused over and over again. These code locations are called “hot spots”. How do you eliminate this similar code?
- Forces:
  - If changeable code is scattered it’s difficult to trace and change
  - if changeable code is in a common place flow of control can be obscure
- Solution
  - Separate code that changes from code that doesn’t - encapsulating the changing code in objects. Composition can then be used to select the appropriate behaviour rather than having to subclass
  - use appropriate design patterns to encapsulate changes eg:
    - algorithm changes => Strategy, Visitor
    - Actions => Command
    - Implementations=> Bridge
    - etc



Pluggable Objects



- Context: You are adding components to your component library
- Problem: Most of the subclasses differ in trivial ways (eg only one method overridden). How do you avoid having to create trivial subclasses?
- Forces:
  - New classes increase system complexity
  - Complex sets of parameters make classes difficult to understand and use
- Solution
  - Design adapatable subclasses that can be parameterised with messages to send, code to evaluate, colours to display, buttons to hide, etc
- Check what it is that is changing between subclasses and make an instance variable or whatever to hold the state associated with the change.
- MViews was ported to Java. At the same time many classes were turned into JavaBeans components with settable properties for customisation

Fine grained objects

- Context: You are refactoring your component library to make it more usable
- Problem: How far should you go in dividing objects into smaller ones
- Forces
  - The more objects in the system the harder it is to understand
  - Small objects allow applications to be constructed by composing small objects together so little programming is required
- Solution:
  - Continue breaking objects up into smaller pieces until it doesn’t make sense to divide further - ie decide what the “atomic” level is for this domain
  - Frameworks will ultimately be used by domain experts so tools will be developed to compose objects automatically, so it’s more important to avoid programming than to avoid lots of objects.
- In JViews, graphics components were reduced in scope to permit design by composition. This led to the development of BuildByWire, a GUI element construction tool

Black Box Framework

- Context: Your are developing pluggable objects by encapsulating hot spots and making fine-grained objects
- Problem: How to choose between using inheritance or composition as the basis for using the framework?
- Forces: as per White Box framework
- Solution:
  - Use inheritance to organise your component library and composition to combine components into applications. Inheritance taxonomies support part browsing; composition allows for maximum flexibility.
- A black-box framework is one where you can reuse components by plugging them together and not worrying about how they accomplish their individual tasks. In contrast, white-box frameworks require an understanding of how the classes work so that correct subclasses can be developed.
- JViews evolved into a black box framework, with some parts (notably GUI development) more black box than other parts

Visual Builder

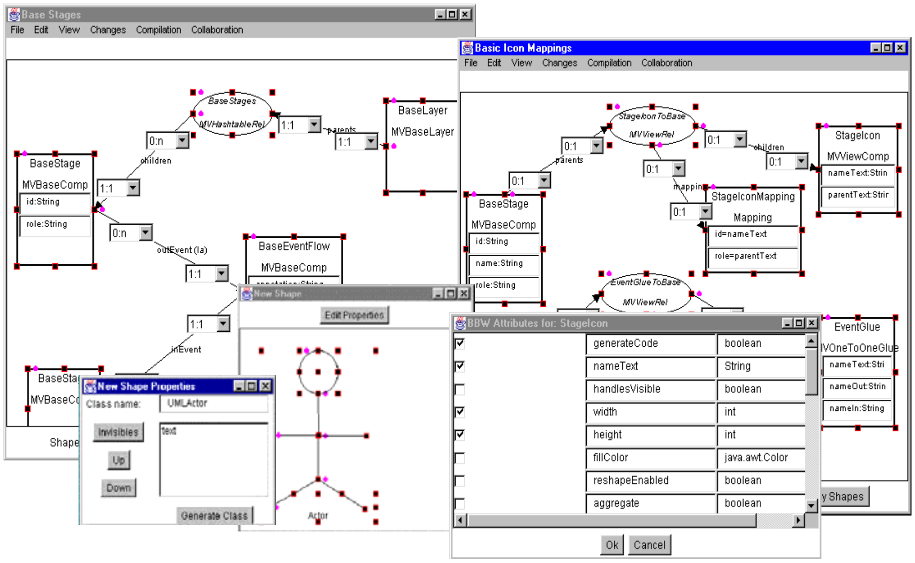
- Context: You have a black box framework. Applications are made by composing objects. Behaviour now determined entirely by interconnection of components. Application is now in two parts:
  - Script to connect parts and turn them on
  - Behaviour of parts (provided by framework)

- Problem: the connection script is very similar between applications. How do you simplify its construction?
- Forces
  - Compositions are complex and difficult to understand
  - Building tools is costly, but domain experts don't want to be programmers
- Solution:
  - Construct a visual language and environment to construct the script. This generates the code for the application

JComposer and BuildByWire

- Developed two visual tools for use in constructing JViews-based environments:
  - JComposer: a tool to visually define most of the “back end” structure
    - further structure filled in by programming using class templates generated by JComposer
  - BuildByWire: a tool to visually define the GUI front end
    - defines GUI elements (including interaction points and behaviour) and GUI editing windows
    - generates components that can be used by JComposer to construct complete applications

BBW and JComposer



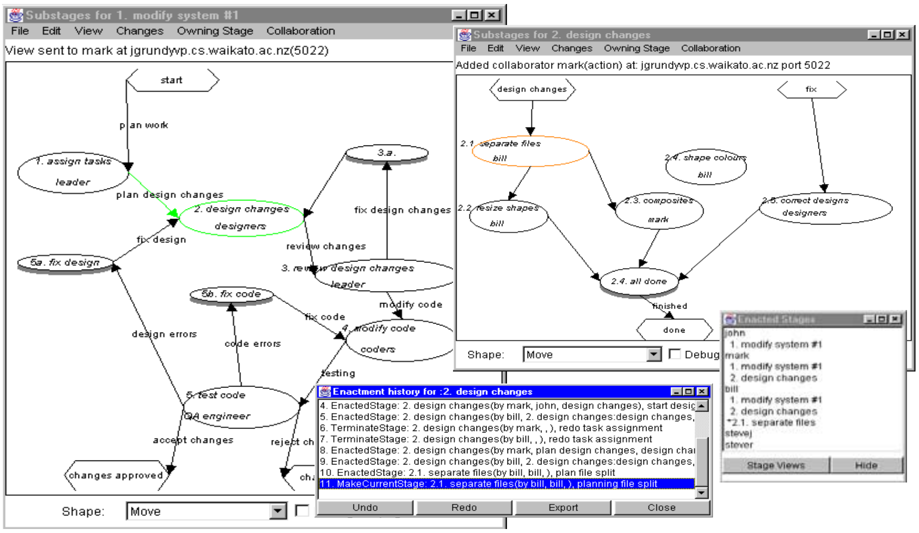
Class name: UMLActor

text

☑	generateCode	boolean
☑	nameText	String
☐	handlesVisible	boolean
☑	width	int
☑	height	int
☐	fillColor	java.awt.Color
☐	reshapeEnabled	boolean
☐	aggregate	boolean

Applications

- Many applications built using JViews
- Eg Serendipity, a process modelling environment



View sent to mark at jgrundywp.cs.waikato.ac.nz(5022)

Added collaborator mark(action) at: jgrundywp.cs.waikato.ac.nz port 5022

```
4. EnactedStage: 2. design changes(by mark, john, design changes), start desic
5. EnactedStage: 2. design changes(by bill, 2. design changes:design changes,
6. TerminateStage: 2. design changes(by mark, , ), redo task assignment
7. TerminateStage: 2. design changes(by bill, , ), redo task assignment
8. EnactedStage: 2. design changes(by mark, plan design changes, design char
9. EnactedStage: 2. design changes(by bill, 2. design changes:design changes,
10. EnactedStage: 2.1. separate files(by bill, bill, ), plan file split
11. MakeCurrentStage: 2.1. separate files(by bill, bill, ), planning file split
```

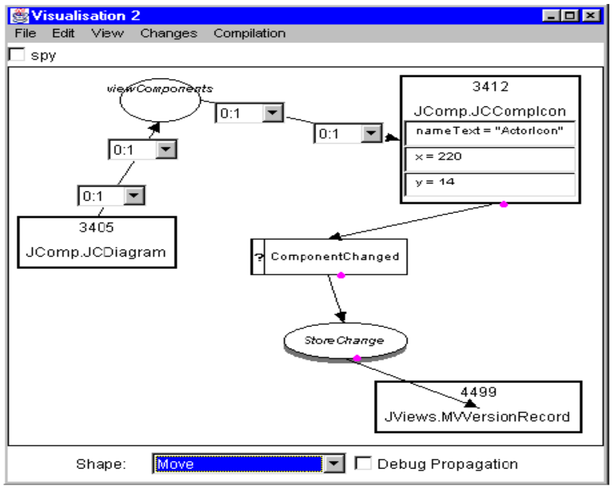
```
john
  1. modify system #1
mark
  1. modify system #1
  2. design changes
bill
  1. modify system #1
  2. design changes
 *2.1. separate files
stevej
stever
```

Language Tools

- Context: You have created a builder
- Problem: Visual builders create complex composites. How do you inspect and debug these
- Forces:
  - Existing tools are inadequate as they don't provide information at the right abstraction level
  - Building good tools takes time
- Solution:
  - Create specialised debugging and inspection tools

JVisualise

- JVisualise allows execution state of JViews-based systems to be queried, visualised, and dynamically modified
- Visualisations use abstraction levels equivalent to those used by the JComposer tool



Shape: Move

□ Debug Propagation

Extensions to EFPL

- Our experience with developing MViews/JViews has led us to propose several extensions to EFPL (see our paper):
  - Platform migration
    - Deals with need to change underlying implmn platforms as lifetime of a framework extends beyond typical impmn technology cycle
  - Integrating applications
    - Deals with need/desire to integrate together multiple applications developed using the framework and third party applications
  - Reflective framework and Self Extending Framework
    - Dealing with the need to be able to extend the framework “on the fly” using a meta model approach (cf Pounamu)
- The new patterns were workshopped at KoalaPlop 2001

Application to other frameworks

- Eclipse
  - Has a mixture of whitebox and blackbox architectures
  - Has handled integrating applications as core business and has aspects of reflective and self extending framework
  - Some development of visual builder tools (eg PDE) but this is rudimentary.
  - Significant energy going into visual builder and language support tools to make plugin construction/debugging easier
- Argo
  - Very similar to Eclipse, but arguably at a less mature stage
  - Momentum of development lost with the rise of Eclipse
- Pounamu
  - A further application of the platform migration pattern to MViews/JViews
  - Rich set of visual builder tools, very much black box
- Marama
  - Visual builders (a la Pounamu) for Eclipse-hosted DSVL tools
  - Currently mix of white box/black box; some pluggable components; library
- Visual Wiki
  - VikiBuilder visual builder
  - Moving from white box to black box, significant reuse of 3rd party components as pluggable components

Summary

- Framework programming uses a different style than does conventional software development
  - becoming more the standard approach with the proliferation of application frameworks
- Pattern Languages are collections of patterns with rules for combining them to solve problems in a particular domain
  - the “Language” is not a language in the usual programming language sense
- Evolving frameworks is a useful Pattern Language for developing a new framework
  - we didn’t know about this pattern language when developing MViews/JViews, but in retrospect we used it almost exactly