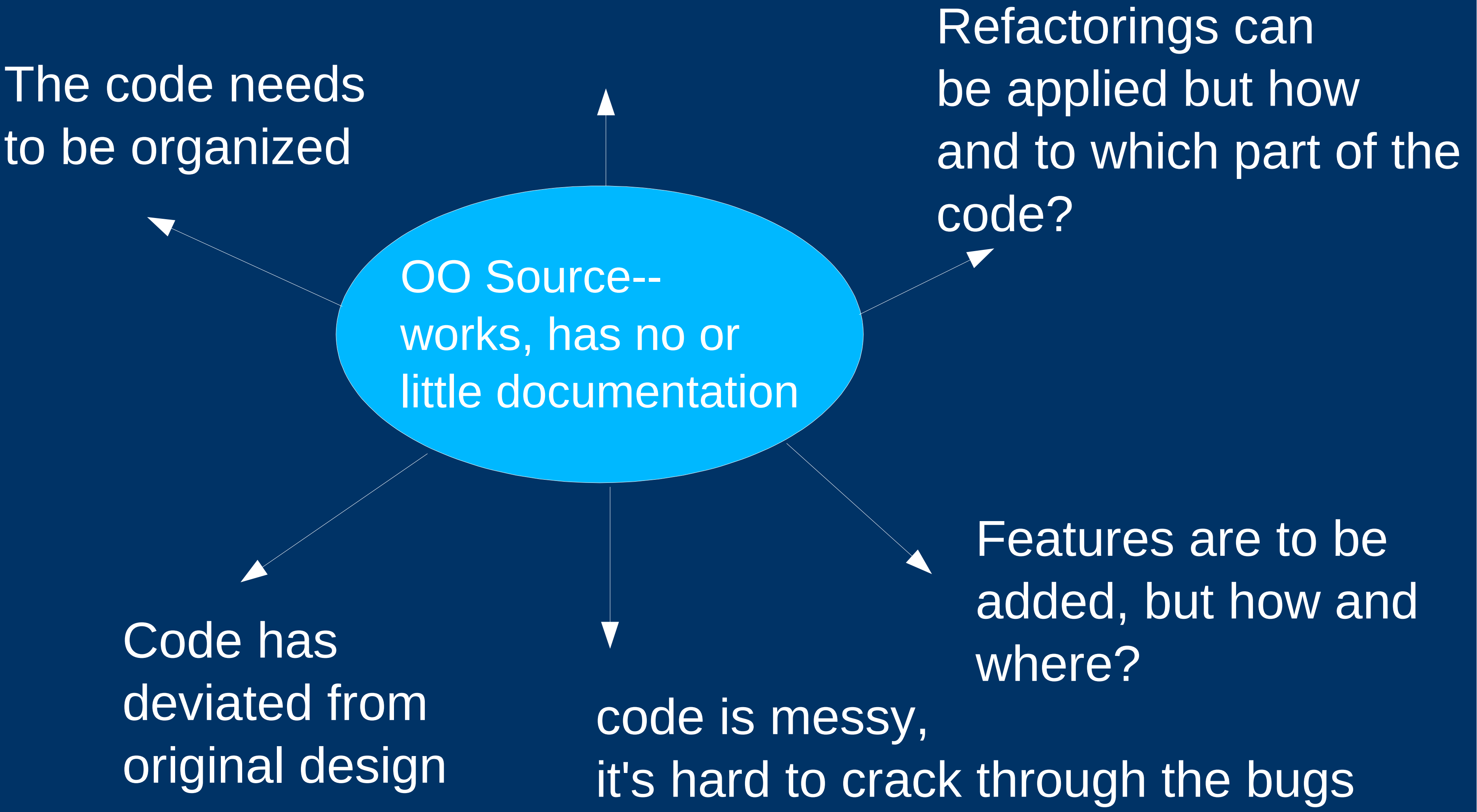
Architecture Extraction and Modeling for Object Oriented Sources

Prof. Rushikesh K Joshi, IIT Bombay
& Shakeb Sagheer, IIT Bombay

Architects often come into an environment with very little documentation, and have to create architectural models from existing code before they can proceed with re-engineering of the application. In this talk, we will describe an ongoing work about techniques for building models from object oriented code with the help of a case study.

opengroup conference, Bandra, Feb. 27, 2007

Why extract/recover architecture and models from sources?



OO Source-- works, has no or little documentation

The code needs to be organized

Refactorings can be applied but how and to which part of the code?

Features are to be added, but how and where?

code is messy, it's hard to crack through the bugs

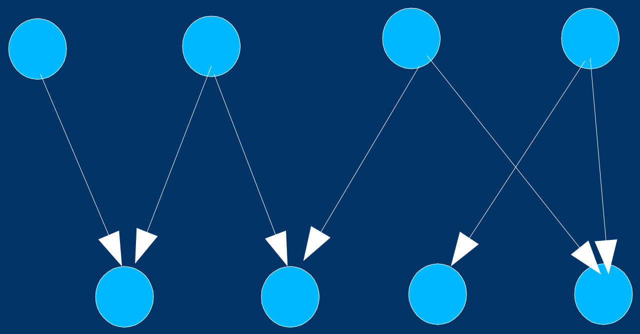
Code has deviated from original design

Approach

- Individual Class Level ✓
- Class Interaction/Coupling Level ✓
- Class Relationships
- Class Groups/Architectural Styling ✓
- File Interactions ✓
- Objects/Components
- Processes
- Deployment/Networking

Class level Models

- Cohesion Analysis
  - access graphs
  - concept analysis



Access graphs

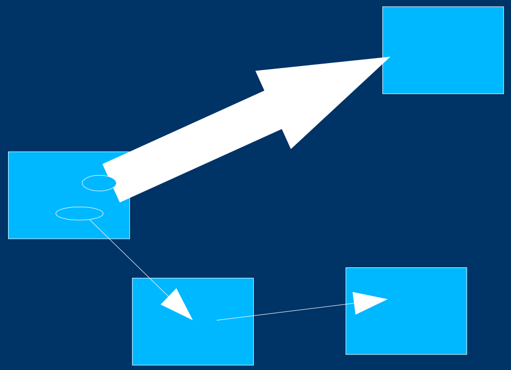
vertices: functions and variables

edges: R/W accesses, calls

cohesion analysis can be performed.

* Need to ntegrate cohesion results with coupling

Class level Models



- Interaction/Coupling Analysis
  - Are some methods coupled heavily with other classes than with their container classes?
  - Coupling metrics can reveal the affinity
    - [CSMR 2006 paper]
  - challenges
    - Automatic refactoring: which is the right class for a given method? But during adjustments, abstractions should not be violated.
    - Microscopic analysis for identifying candidate members for restructring

Class level models

- Relationships
  - inheritance, aggregation, association, generalization, dependencies etc.
  - use existing tools to get a base diagram
    - refine it further
  - challenges
    - Semantics of relations are often not taken into account
      - e.g. how to infer aggregation? (part-whole semantics)
    - Multiplicity of association relation

Groups of Classes

- Which classes together form a logical group?
- Knowledge of architectural styling
  - MVC, Layers, C/S, P/P FDP
- File groupings/packaging
- Design patterns
- Partalogy

(Source) File Level Interactions

- What type of components contained in each file
- What type of connectors/semantics of interactions among the components
- types of source files: classes, jsp, js, html, ...
- Member function calls
- Object instantiation
- Calls to servlets
- JSP references..

Executable representations of Architectural models

- Component/connector paradigm
- Capture Architectural scenarios, events
- Timelines/Sequencing
- Kinds of connectors, first class connectors
  - A java+aspects based implementation is under development
- Ontology for semantics of architectural primitives

A Case Study: Java Pet Store

- Java Pet Store 2.0 Reference Application is a sample J2EE application developed by Sun Microsystems.
- Web application to model a pet store.
- Uses Java Server Pages (JSP's) for client interactions and a back-end java functionality to serve requests.
- Key design pattern used is Model-View-Controller (MVC) architecture.

Java Pet Store Raw (automatically extracted) Class Diagram

- Gives a static view of class level architecture
- Describes system classes, their attributes and the relationship between classes
- Class diagram given here was produced using Sun Microsystems Java Studio Enterprise 8 SDK.

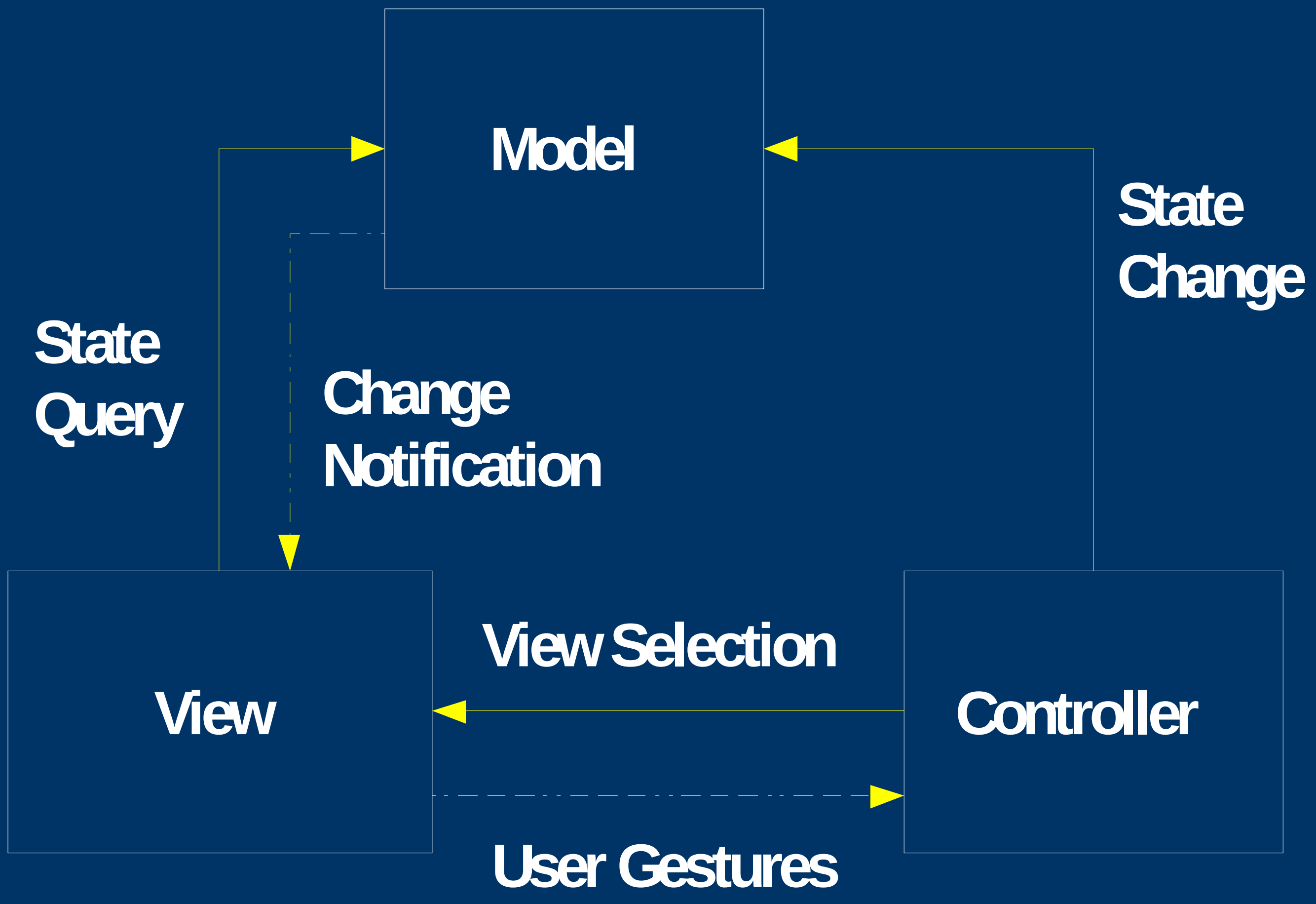
Java Pet Store: Class Groups based on packages

- Components manually grouped to show existing packages.
- Rectangles drawn to denote package boundaries.
- Pre-existing 'model' and 'controller' packages point towards MVC modeling.
- Add dependencies (non association/aggregation)
- Update with Aggregation Analysis, ..
- May still be incomplete in terms of full architectural styling (e.g. jsp files don't get included)

MVC Architecture used in Petstore

- Application divided into three layers: Model, View and Controller
- View
  - User Interface
  - HTML pages, JSP's.
- Model
  - Represents the structure of data
  - Performs application-specific operations on data
- Controller
  - Translates user actions into application function calls on model
  - Selects appropriate view

MVC Architecture



Java Pet Store MVC Architecture

- Files divided among View, Model, Controller and Utility components.
- View consists of the JSP's.
- Model and Controller have same contents as 'model' and 'controller' packages resp.
- Model uses a facade design pattern
  - CatalogFacade.java acts as facade while handling requests

Java Pet Store MVC Architecture

- Utility contains the remaining classes.
- Classification of files into Model-View-Controller components gives an idea about the functionality
  - but not about interaction semantics

File Level Interaction Architecture (FLIA)

- Gives a view of how files are related and how source components in them interact.
- A link from file A to file B indicates message/data passing from A to B.
- Types of data interchange between files (from the point of view of Java Pet Store):
  - Object invocations
  - Servlet Interaction
  - JSP references

FLIA : Type of links

- Object invocations : Using features of classes by instantiating objects.
- Servlet Interaction : Sending data to servlets and receiving response.
- jsp references: Passing requests/parameters to JSPs or HTML files.

FLIA : Link Parameters

- Set of parameters associated with each type of link
  - Provide information about the degree of association between the two connected components.
- Each link labeled with a tuple of values for these parameters.

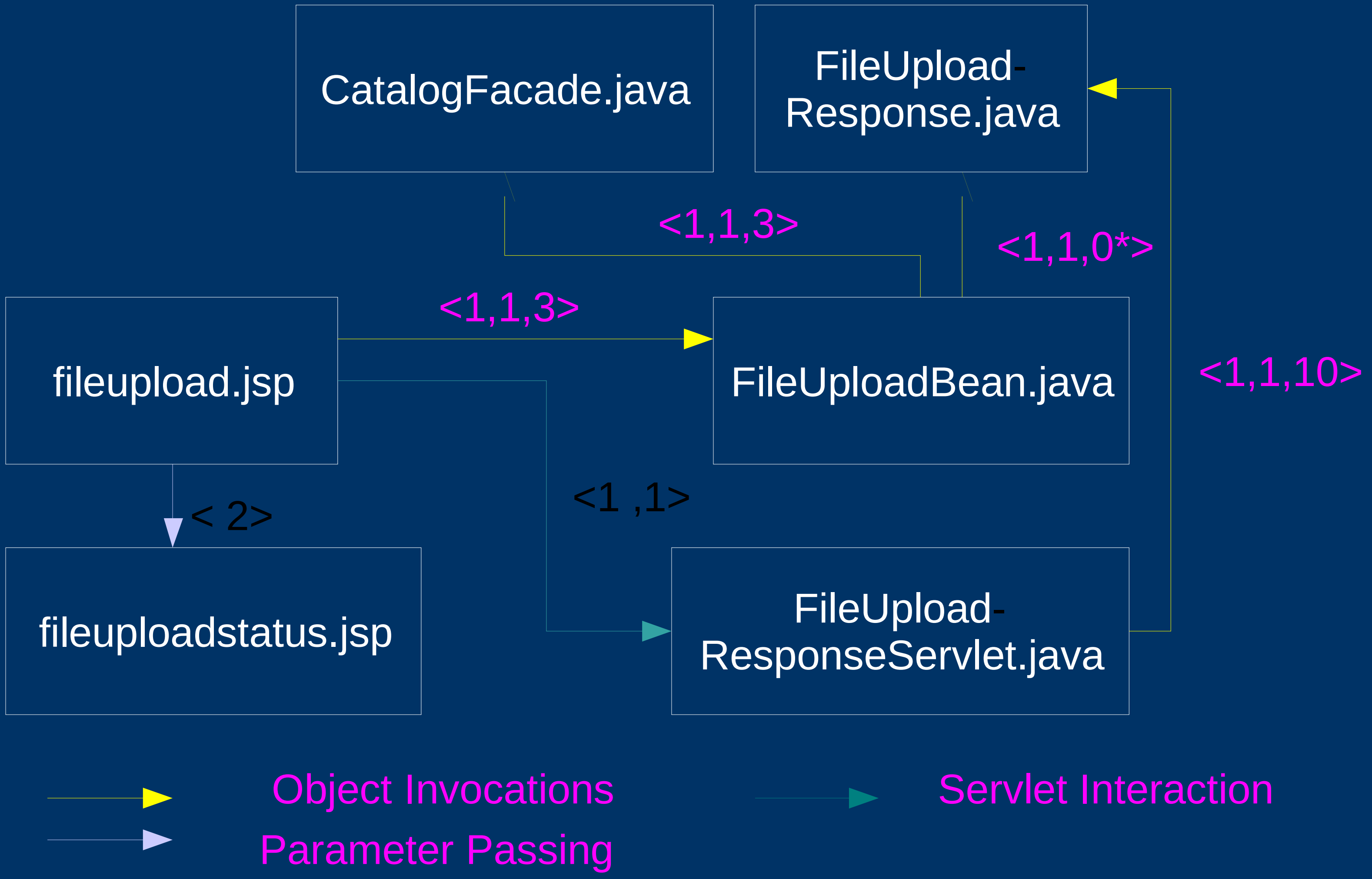
FLIA : Link Parameters

- Object Invocation : <no_of_classes, no_of_objects, no_of_features>
  - no_of_classes : Number of classes of the target file instantiated.
  - no_of_objects : Number of objects of the target classes initialized.
  - no_of_features : Number of features of the target classes accessed.

FLIA : Link Parameters

- Servlet Interaction : <no_of_requests, no_of_invocations>
  - no_of_request : Number of times a request was send to the servlet
  - no_of_invocations : Number of methods of the target invoked.
- Parameter Passing: <no_of_times, no_of_invocations>
  - no_of_times : Number of times the parameters are passed.

File Level Interaction Scenario in Java Pet Store



Summary

- An approach towards extraction of models from sources
- Mixed approach:
  - use of analysis techniques +
  - use of manual intervention/available knowledge
- Multifaceted analysis
- Early results on a case study

Acknowledgements

Shakeeb Sagheer's project work is funded through an R&D project at IIT Bombay sponsored by IBM CAS

Thank You