Software Visualizations

Rolf Biehn
What is Software Visualization?

- Visualization of a software systems based on their structure, history, or behavior
- Today’s presentation:
  - Program Execution Traces
  - Source Code History
  - Program Optimization
Execution Patterns in Object-Oriented Visualization

David Lorenz et al.
What is it?

- Techniques to visualize the execution flow and execution patterns
- Input is call traces from instrumented code
Motivation

- Understand program execution flow in order to program or debug it
UML Visualization

UML
UML Discussion

+ Scales better than directed graphs
- Vertical Space is consumed quickly
- Somewhat difficult to read
UML Visualization

UML

Call Graph Tree
Execution Pattern Discussion

+Easier to read than an UML diagram (no “bouncing between axis”)
+Horizontal & Vertical space is used more efficiently
+Enables better user interaction
• Flattening is useful for System libraries
• Can collapse and expand nodes
• Can search & filter (with expressions)
• Panning & Zooming also supported
- 3D box indicates a collapsed node
- Colors correspond to a class
- ID #s represent identity of the object
• 3D box used to show pattern
• Saves lots of space in call traces
• Can expand/contract
• Number (6X) shows number of repetitions
• Also applies to recursion
How to detect pattern?

- Bunch of dimension:
  - Identity, Class Identity, Message Structure, Depth Limiting, Repetition, Polymorphism, Associatively, Commutatively

- Create a hash function for each leaf node which considers these dimensions

- Create a recursive hash function which considers its children in the call graph

- Put all nodes into a dictionary

- How long does it take? Memory concerns?
Evaluation

- Understand program execution flow in order to program or debug it
  - (B) Looks like it should work, if implemented carefully
  - How to navigate from high-level if I don’t know precisely what I want to see?
  - What about multi-threading?
  - How well does it scale? What if number of Classes exceeds distinguishable colours?
CVSscan: Visualization of Code Evolution

Alex Telea, et al.
What is it?

- CVSScan is part of a larger suite of tools called Visual Code Navigator
- Provides information of the history of check-ins
Motivation

- Answer the following questions
  - Who performed these modifications of the code
  - Which parts of the code are unstable?
  - How are changes correlated?
  - How are the development tasks distributed?
  - What is the context in which a piece of code appeared?
Dimensions to Show

- All encoded using colors
  - Author
  - Content (block, comment, references)
  - Evolution (add/remove/delete/unchanged)
Global Line Position

<table>
<thead>
<tr>
<th>version V₁</th>
<th>version V₂</th>
<th>version V₃</th>
</tr>
</thead>
<tbody>
<tr>
<td>int i = 1;</td>
<td>int h = 3;</td>
<td>int h = 3;</td>
</tr>
<tr>
<td>int j = 2;</td>
<td>int j = 2;</td>
<td>int j = 2;</td>
</tr>
<tr>
<td>Line position in file</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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<thead>
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</tr>
<tr>
<td>Global line position</td>
<td></td>
</tr>
</tbody>
</table>

Figure 2 Global line position and corresponding graph analogy
Global Line Position (2)

Legend
- Green: Constant line
- Blue: New lines

Discrete time (versions)

Global Line Position allows Left to Right reading
Multiple Views

Figure 9: Multiple code views in CVSscan
2 Ways to Display Code

Figure 11: Two-layered code view
Use Case Validation

- Informal Studies (*not targeted*)
- 15 minutes of training
- Silent Observer
- Why not use a real-world case? (i.e. trying to fix a bug)
- No control
- No negative/constructive comments
Use Case #1

- Script file from the FreeBSD
- “Here they tuned the regular expressions”
- “Apparently a major change took place in the middle of the project. It mainly affected the check_version procedure”
- Rated as a success
Use Case #2

- C file socket implementation of the X Transport service layer
- The user recognized 2 authors performed most of the changes and the area of heavy modification
- Overall, the user did not have a very clear image of the file’s evolution
Demo
Evaluation

- Who performed these modifications of the code?
  - (E) Hard to Track exactly “who is pink?”

- Which parts of the code are unstable?
  - (B) Seems o.k. for this purpose

- How are changes correlated?
  - (F) Correlation to other files in same check-in?
  - Correlation to other changes in the same file?
Evaluation

- How are the development tasks distributed?
  - (D) Although we can see distribution, precisely who wrote what is difficult to figure out

- What is the context in which a piece of code appeared?
  - (F) Hard to link back to changelist
  - Branching history?
Visualizing Application Behavior on Superscalar Processors

Chris Stolte et al.
What is it?

- Program called Rivet
- Help optimization on multi-processor architectures
Motivation

- Optimize
  - Know where to look
  - Drill into the details
  - Know the context – map back to the source code somehow
Main Optimization Techniques

- **Pipelining**: overlap the execution of multiple instructions within a functional unit
- **Multiple Functional Units**: exploit instruction level parallelism (ILP)
- **Out-of-Order Execution**: increase possibility of ILP
- **Speculation**: guess and fetch ahead
What the program tracks

- **Empty/Icache**: An instruction cache miss
- **Exception/Flush**: An instruction requires sequential execution
- **Load/Store**: Waiting for memory
- **Issue/Functional Unit**: Waiting for a functional unit to complete execution
We are able to focus the area of interest to 2000 cycles -- few enough cycles that we can use animation for further investigation.

The instruction mix chart lets us see what types of instructions are in the pipeline during the time interval of interest.

There are periods of increased pipeline stall throughout the execution.

The overview displays stall and throughput information for the entire execution.
NurEll.c

61     i = brkPoint - r + 1;
62     bvals[r - 1] = 0.0;
63     for (s = r-2; s >= 0; s--)
64     {
65         i++;
66         if (i < 0)
67             omega = 0;
68         else
69             omega = (u - kv[i]) / (kv[i + r - 1] - kv[i]);
70     bvals[s + 1] = bvals[s + 1] + (1 - omega) * bvals[s];
71     bvals[s] = omega * bvals[s];
72     }
73 }
74 */
75 /*
76  * Compute derivatives of the basis functions Bi,k(u)
77  */
78 static void
79 BasisDerivatives( float u, long brkPoint, float * kv, long k, float * dvals
80 {  
81     register long s, i;
The timeline view reveals periodic phases of execution, one with very low throughput.

We inspect the transition between phases in the instruction mix and see plateaus of floating point instructions corresponding to the low throughput regions.

We select a single cycle in this area of interest and start animation from this cycle.

The pipeline view shows that there are cascading dependencies between a series of floating point instructions and memory references.

The source code view shows that this corresponds to a tight loop within the application.
Evaluation

- Know where to look.
  - (B) Great use of overview-plus detail display
  - But is this really the best entry point?
  - What about filters?

- Look at the details
  - (A) Looks good

- Know the context – map back to the source code somehow
  - (A) Looks good
  - Next step link to IDE?
Questions?