# Visualization of Program-Execution Data for Deployed Software

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# Motivation

# Challenges

- Visualization
  - Field data representation
  - Program size
  - Amount of field data
- System for collecting/visualizing data



# Outline

- Visualization
  - Field data representation – Color
  - Program size – Visual forms
  - Amount of field data – Visual form, Filters, Summarizers
- System for collecting/visualizing data – Gammatella
- Experience
- Conclusions and Future Work



# Color

- Color used to represent characteristics of code and its executions
- Mapping of data to color dependent on intent of visualization

```
procedure print() {
   for i = 1 to 10 {
      for j = 1 to 10 {
         print j
      }
      print i
   }
}
```

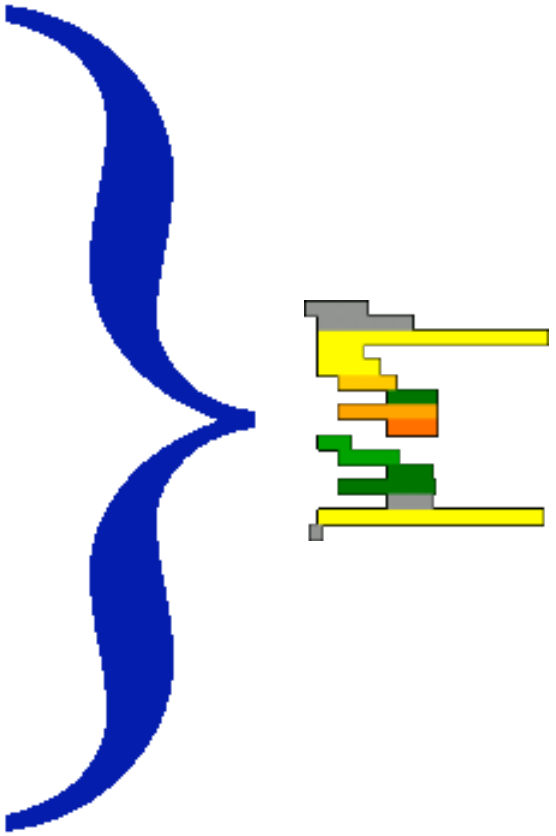


# Visual Forms – Code Level, File Level

## Code level

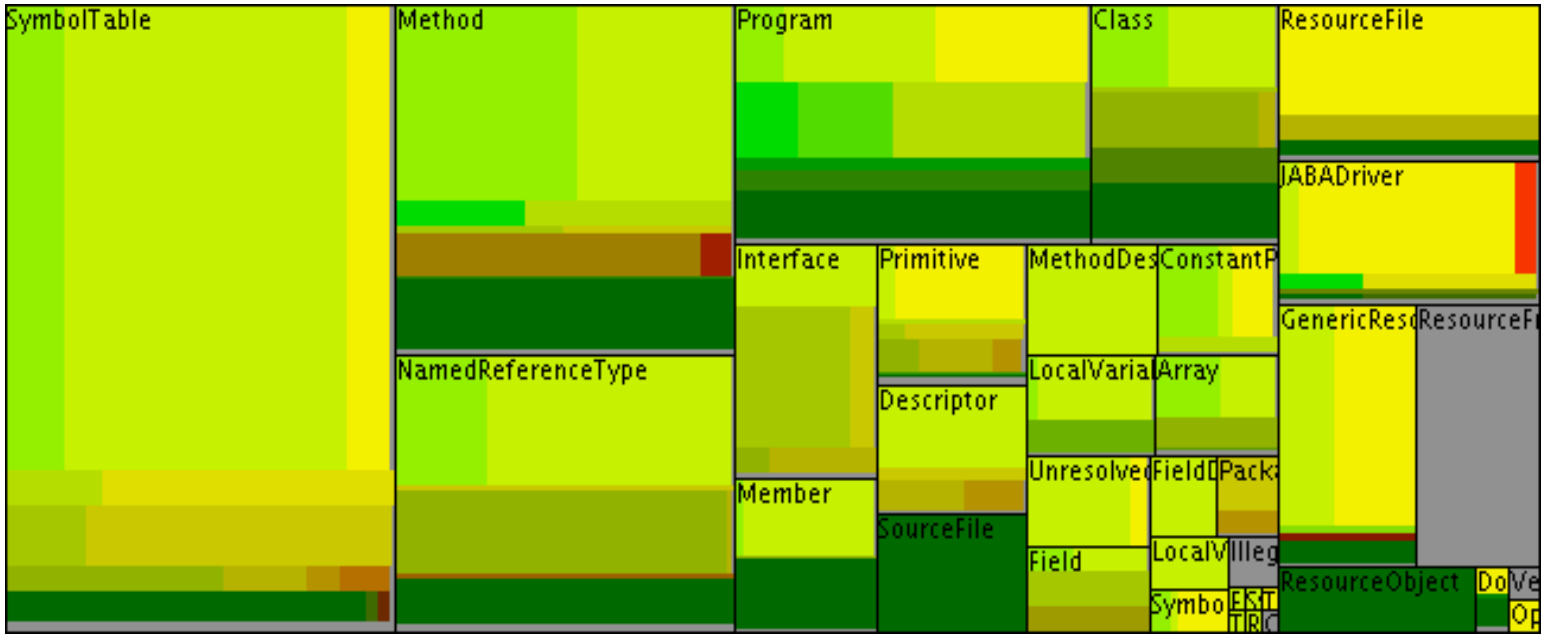
## File level

```
mid() {
 int x,y,z,m;
 read("Enter 3 numbers:",x,y,z);
 m = z;
 if (y<z)
    if (x<y)
          m = y;
    else if (x<z)
          m = y;
 else
    if (x>y)
          m = y;
    else if (x>z)
          m = x;
 print("Middle number is:", m);
}
```



# Visual Forms – System Level

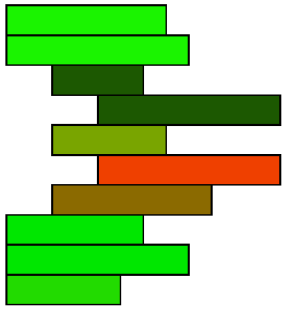
- For large systems, even File Level view requires scrolling
- Use space-filling representation - TreeMap

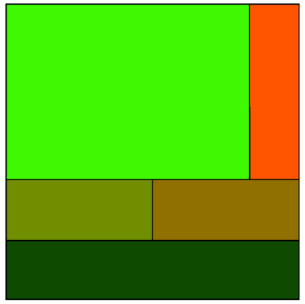


# TreeMap Node Coloring

Goals

- Preserve relative percentages of colors
- Provide consistent color layout





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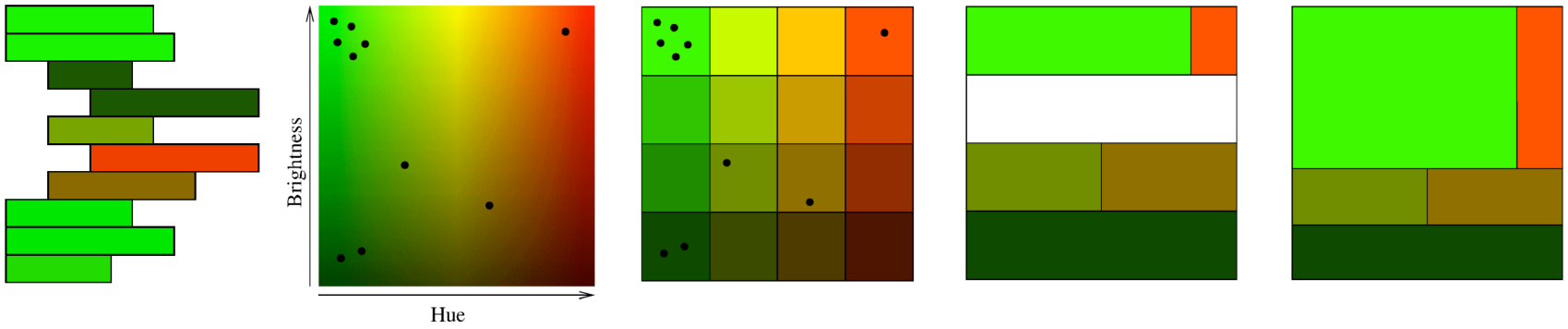

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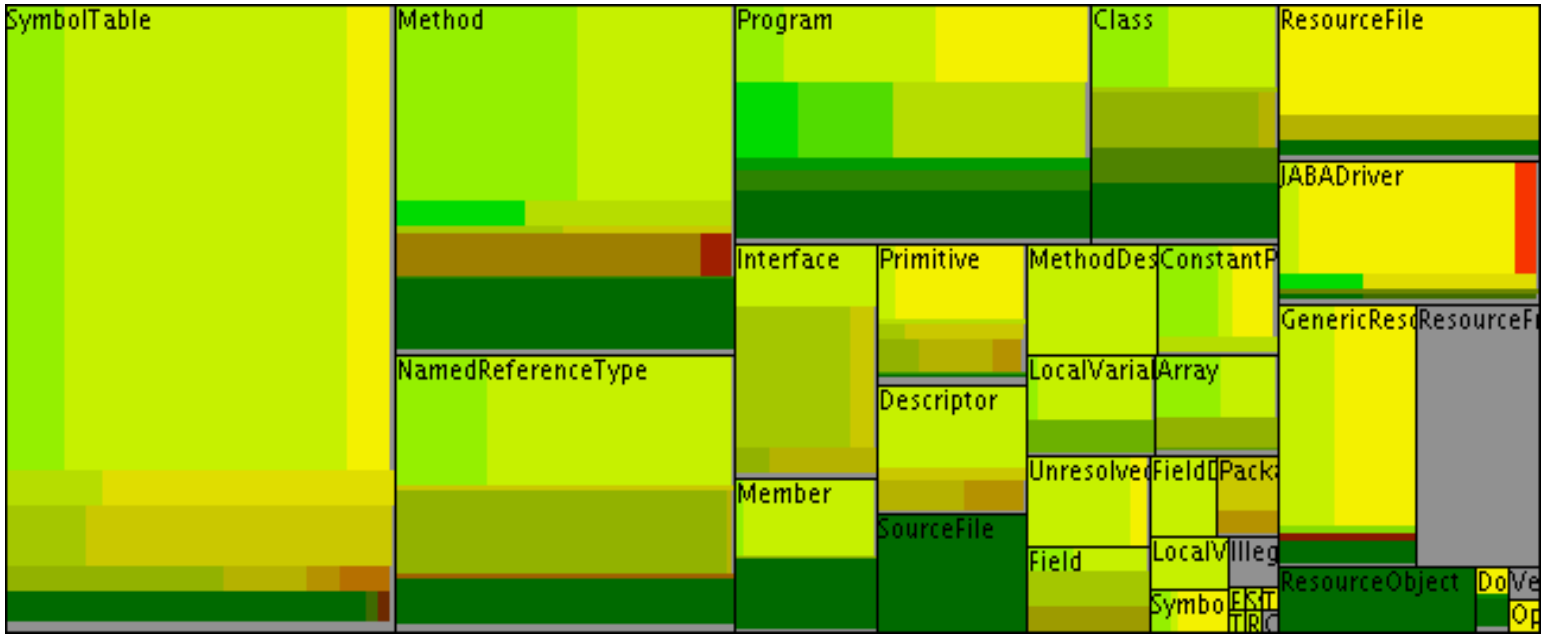
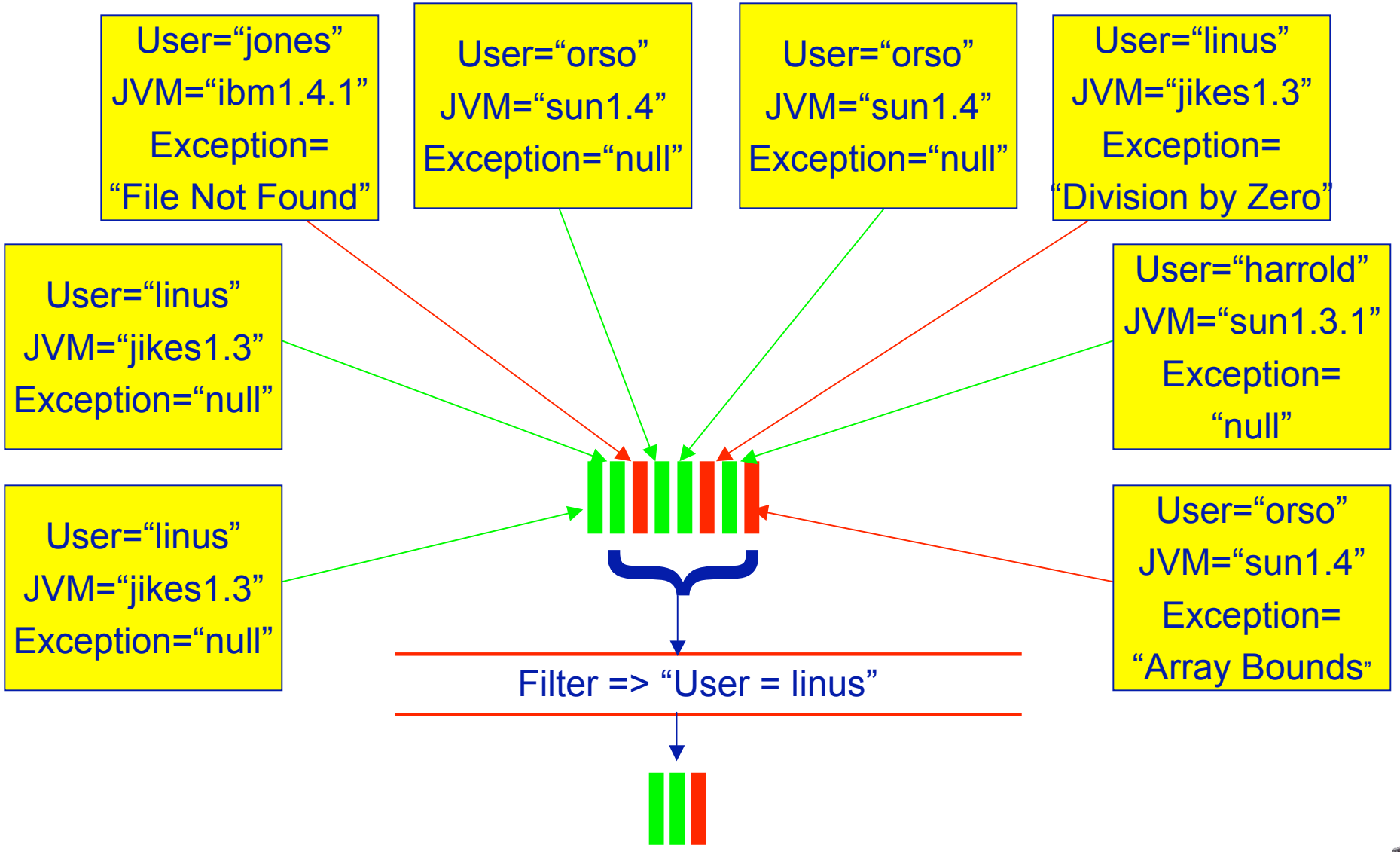


# Visual Forms - Executions

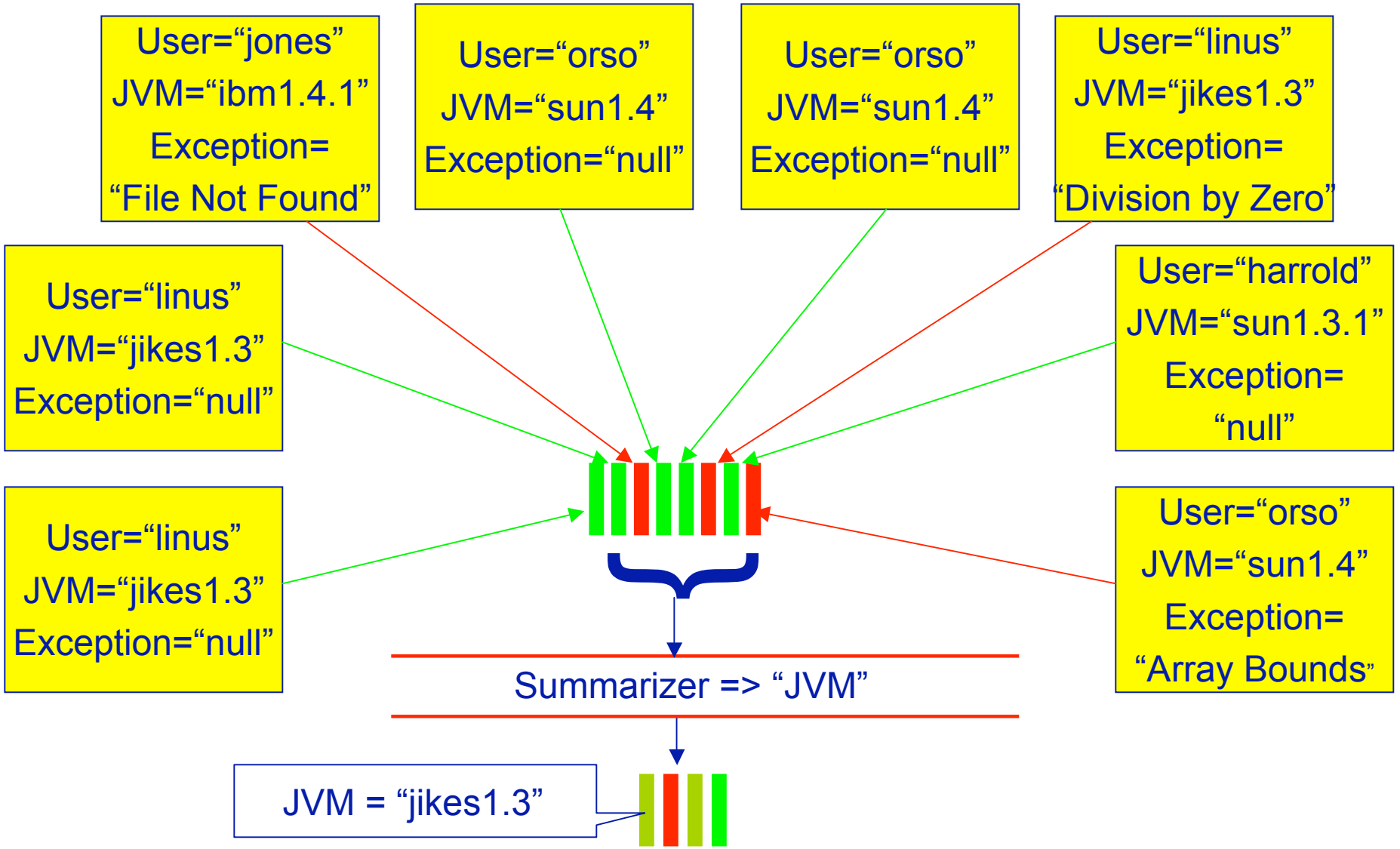
- Series of vertical bars, each representing an execution

- Large number of executions necessitates richer forms of navigation than simple scroll-bar

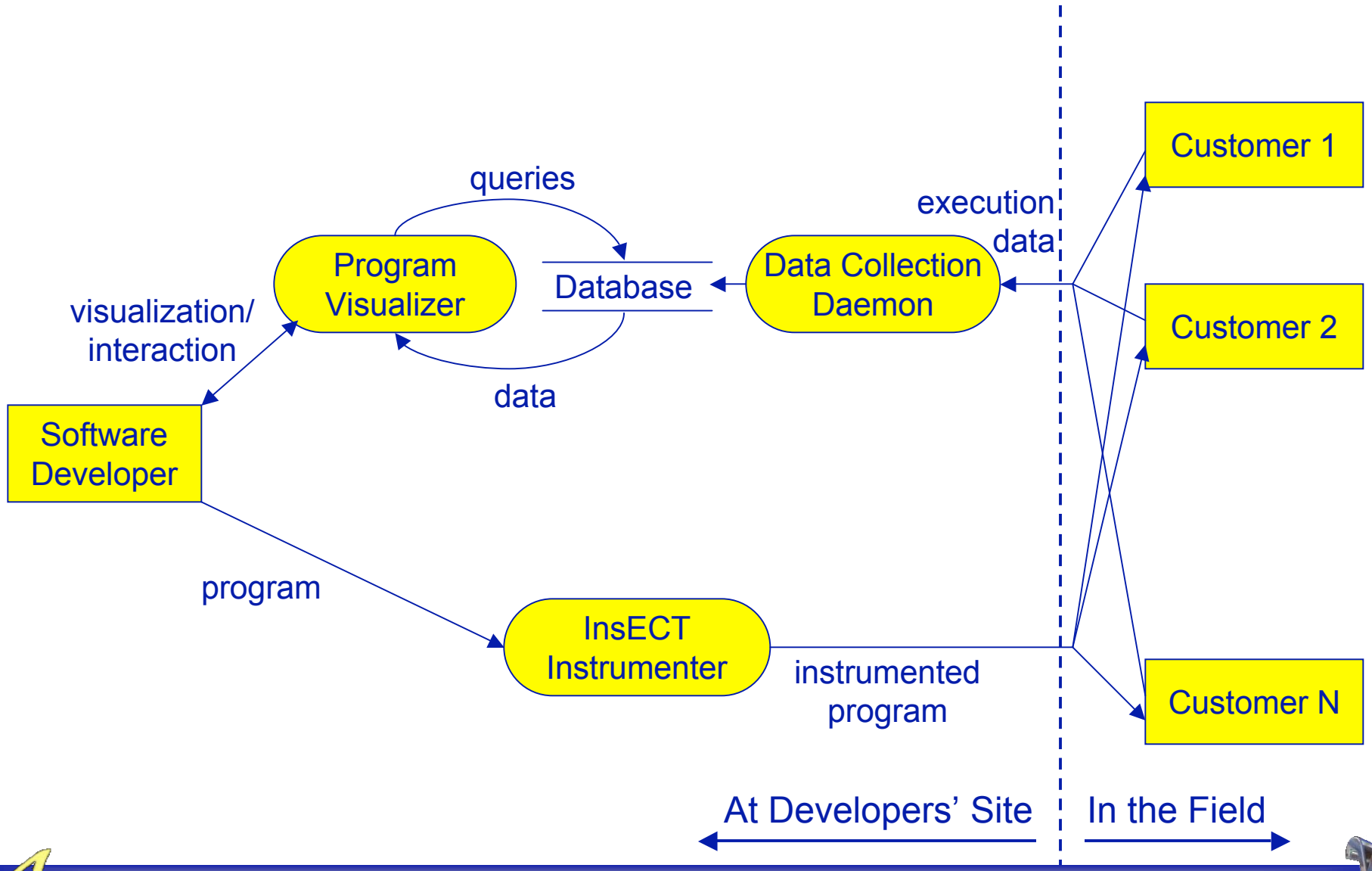
# Execution Filters



# Execution Summarizers



# Gammatella

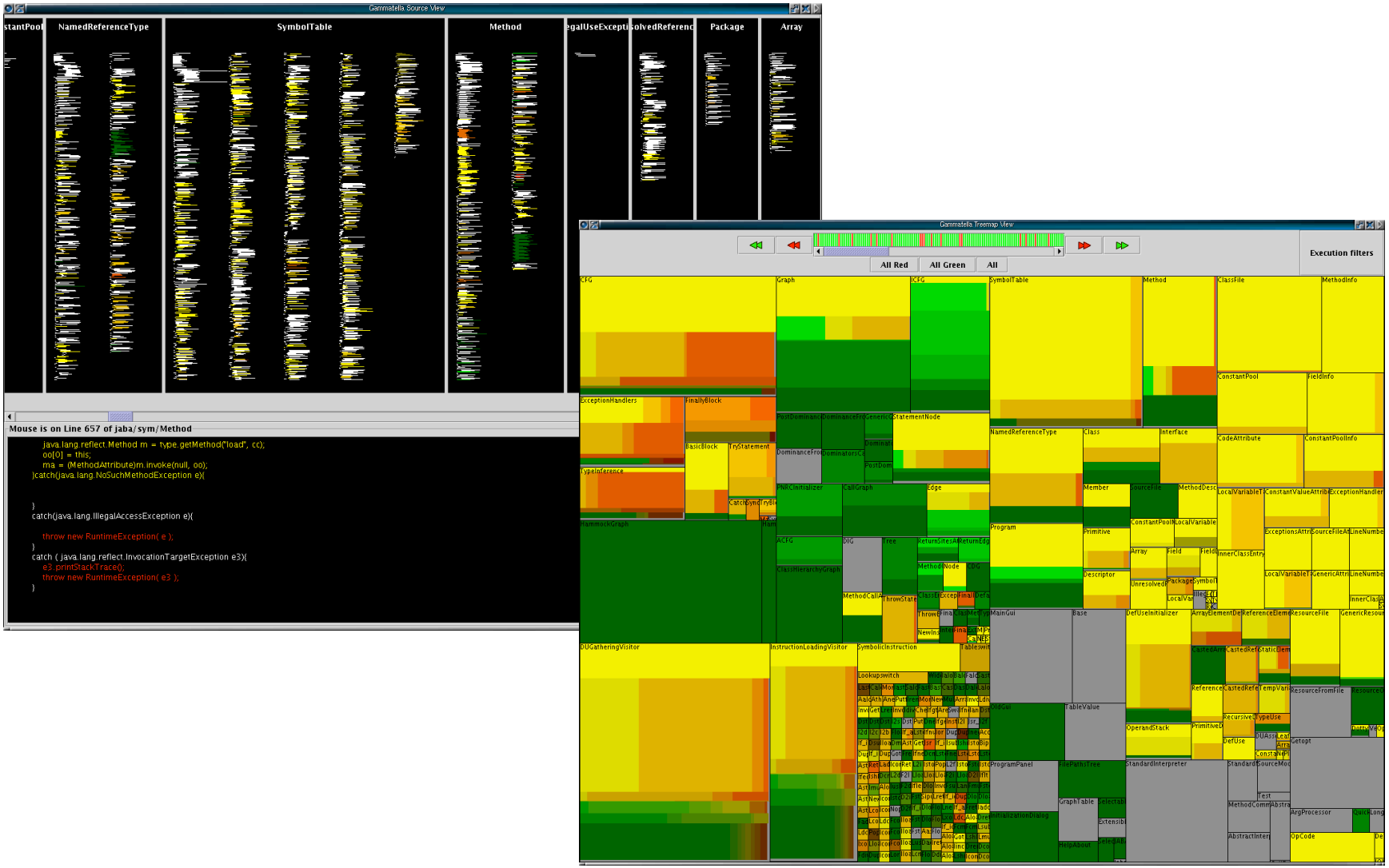

queries
execution data
Customer 1
Program Visualizer
Database
Data Collection Daemon
visualization/ interaction
Customer 2
data
Software Developer
program
InsECT Instrumenter
instrumented program
Customer N
At Developers' Site
In the Field

# Experience

- Subject program
  - Java Architecture for Bytecode Analysis (JABA)
  - 60,000 lines of code in 550 classes
- Deployment
  - 15 users
  - >2000 executions
- Findings
  - Usage of features
  - Coverage of untested features
  - Usefulness of Gammatella's features



# Gammatella


Gammatella Source View
NamedReferenceType
SymbolTable
Method
Package
Array
Mouse is on Line 657 of jaba/sym/Method
java.lang.reflect.Method m = type.getMethod("load", cc);
oo[0] = this;
ma = (MethodAttribute)m.invoke(null, oo);
}catch(java.lang.NoSuchMethodException e){
}
catch(java.lang.IllegalAccessException e){
throw new RuntimeException( e );
}
catch ( java.lang.reflect.InvocationTargetException e3){
e3.printStackTrace();
throw new RuntimeException( e3 );
}
Gammatella Treemap View
All Red
All Green
All
Execution filters

# Related Work

- Eick, Sumner – SeeSoft
- Schneiderman – Treemap
- Baker, Eick – SeeSys

- Reiss, Renieris – Bloom, ALMOST, …
- Jones, Harrold, Stasko – Tarantula
- DePauw et al. – Jinsight
- Jerding, Stasko, Ball – Information Mural



# Conclusions

- New approach for visualizing field data
  - Maps field data to program representations using color
  - Provides multiple levels of abstraction for viewing large programs, including new Treemap coloring
  - Accommodates large and continuously increasing amounts of field data using querying techniques
- Toolset, Gammatella, that enables collection and visualization of deployed software's execution
- Experience with real users and real deployed software



# Future Work

- Deploy monitored software to more users to investigate scalability
- Investigate application to exception analysis and fault localization
- Explore other applications of approach such as user-profile extraction
- Investigate interaction and use of public display