Evaluating the Importance of User-Specific Profiling

Zheng Wang
Harvard University

Norm Rubin
Digital Equipment Corporation
Simply Put ...

How
different users
use the
same program
Background

Two models for applying profile-based optimization

Assumption: users are similar

Assumption: users are different
Our Goal

- Target interactive applications on Windows NT
- Compare the *usage patterns* of different users
- Examine the impact of differences in profiles on the optimization performance
• DIGITAL FX!32 emulator / binary translator
  – automatically runs x86 applications on Alpha NT

• FX!32 profiles
  – accumulated over multiple runs
  – contain information on
    • procedure calls
    • indirect control transfers
    • unaligned memory references
## Benchmarks

### Interactive application executables / DLLs

<table>
<thead>
<tr>
<th>Benchmark Module</th>
<th>Description</th>
<th>File Size (KB)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Microsoft Office</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>excel.exe (97)</td>
<td>Office 97 Excel main executable</td>
<td>5469</td>
</tr>
<tr>
<td>mso95.dll (95)</td>
<td>Office 95 (Version 7.0) DLL</td>
<td>918</td>
</tr>
<tr>
<td>mso97.dll (97)</td>
<td>Office 97 DLL</td>
<td>3686</td>
</tr>
<tr>
<td>outllib.dll (97)</td>
<td>Office 97 Microsoft Outlook DLL</td>
<td>4254</td>
</tr>
<tr>
<td>powerpnt.exe (97)</td>
<td>Office 97 PowerPoint executable</td>
<td>3411</td>
</tr>
<tr>
<td>winword.exe (95)</td>
<td>Office 95 Word executable</td>
<td>3755</td>
</tr>
<tr>
<td>winword.exe (97)</td>
<td>Office 97 Word executable</td>
<td>5194</td>
</tr>
<tr>
<td><strong>Others</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>acrord32.exe</td>
<td>Adobe Acrobat Reader 3.0 executable</td>
<td>2265</td>
</tr>
<tr>
<td>mfc40.dll</td>
<td>Microsoft Visual C++ 4.0 DLL</td>
<td>901</td>
</tr>
<tr>
<td>netscape.exe</td>
<td>Netscape Navigator Gold 3.01 executable</td>
<td>3093</td>
</tr>
<tr>
<td>photoshp.exe</td>
<td>Adobe PhotoShop 4.0 executable</td>
<td>3560</td>
</tr>
<tr>
<td>pnui3250.dll</td>
<td>Support library for RealPlayer (32-bit) 5.0</td>
<td>590</td>
</tr>
<tr>
<td>winhlp32.exe</td>
<td>Windows NT 4.0 help utility</td>
<td>303</td>
</tr>
<tr>
<td>winzip32.exe</td>
<td>WinZip compression utility 6.2</td>
<td>846</td>
</tr>
</tbody>
</table>
Methodology

• Profile collection
  – generated from users’ spontaneous usage
  – over 20 users in total
  – 4-12 users for each benchmark module
  – time span of several months

• Statistical analysis
  – compare the individual profiles for each module
  – focus on the set of procedures each person uses
Profile Comparison

user A

P1: 10
P2: 5
P3: 5
P4: 3

user B

P1: 5
P2: 1
P5: 1

user C

P1: 20
P3: 10
P6: 10

Combined Profile

P1: 35
P2: 6
P3: 15
P4: 3
P5: 1
P6: 10

- unique procedure
  
  (usage count = 1)

- subgroup procedure

- common procedure
  
  (usage count = number of users)
# Summary of Profiles

<table>
<thead>
<tr>
<th>Benchmark Module</th>
<th>Number of Users</th>
<th>Number of Procedures in Combined</th>
<th>Percentage of Procedures in an Individual Profile</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Smallest</td>
</tr>
<tr>
<td>acrord32.exe</td>
<td>4</td>
<td>5050</td>
<td>79.4%</td>
</tr>
<tr>
<td>excel.exe (97)</td>
<td>4</td>
<td>8514</td>
<td>69.1%</td>
</tr>
<tr>
<td>mfc40.dll</td>
<td>7</td>
<td>2558</td>
<td>49.3%</td>
</tr>
<tr>
<td>mso95.dll (95)</td>
<td>6</td>
<td>2630</td>
<td>64.4%</td>
</tr>
<tr>
<td>mso97.dll (97)</td>
<td>8</td>
<td>9994</td>
<td>56.3%</td>
</tr>
<tr>
<td>netscape.exe</td>
<td>4</td>
<td>7938</td>
<td>61.1%</td>
</tr>
<tr>
<td>outlook.dll (97)</td>
<td>5</td>
<td>16330</td>
<td>64.6%</td>
</tr>
<tr>
<td>photoshop.exe</td>
<td>5</td>
<td>10502</td>
<td>66.5%</td>
</tr>
<tr>
<td>pnui3250.dll</td>
<td>4</td>
<td>1443</td>
<td>73.1%</td>
</tr>
<tr>
<td>powerpnt.exe (97)</td>
<td>5</td>
<td>15014</td>
<td>59.3%</td>
</tr>
<tr>
<td>winhlp32.exe</td>
<td>12</td>
<td>762</td>
<td>71.3%</td>
</tr>
<tr>
<td>winword.exe (95)</td>
<td>5</td>
<td>7317</td>
<td>62.9%</td>
</tr>
<tr>
<td>winword.exe (97)</td>
<td>6</td>
<td>10113</td>
<td>61.6%</td>
</tr>
<tr>
<td>winzip32.exe</td>
<td>5</td>
<td>1125</td>
<td>53.1%</td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td></td>
<td></td>
<td><strong>63.7%</strong></td>
</tr>
</tbody>
</table>
## Pair-Wise Profile Comparison

<table>
<thead>
<tr>
<th></th>
<th>Happy</th>
<th>Sneezy</th>
<th>Grumpy</th>
<th>Doc</th>
<th>Bashful</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bashful</td>
<td>66.6%</td>
<td>69.1%</td>
<td>69.6%</td>
<td>77.2%</td>
<td>--</td>
</tr>
<tr>
<td>Doc</td>
<td>72.5%</td>
<td>69.7%</td>
<td>73.5%</td>
<td>--</td>
<td></td>
</tr>
<tr>
<td>Grumpy</td>
<td>71.6%</td>
<td>76.4%</td>
<td>--</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sneezy</td>
<td>76.0%</td>
<td>--</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Happy</td>
<td>--</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\[
\text{Similarity} \% = \frac{\text{number of procedures included in both profiles}}{\text{number of procedures included in either profile}}
\]

\text{winword.exe (95)}
Usage Count vs. Execution Count

Procedure Distribution

- common procedure
- usage count 4
- usage count 3
- usage count 2
- unique procedure

Average Execution Count Range

- [1, 100)
- [100, 1E4)
- [1E4, 1E6)
- [1E6, 1E9)

winword.exe (95)
When Profiles Grow

<table>
<thead>
<tr>
<th>Date</th>
<th>Bashful</th>
<th>Doc</th>
<th>Grumpy</th>
<th>Sneezy</th>
<th>Happy</th>
<th>Combined</th>
<th>Procedure Distribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>10/10</td>
<td>4600</td>
<td>4091</td>
<td>4691</td>
<td>5648</td>
<td>6222</td>
<td>7191</td>
<td>20.4% 33.5% 46.2%</td>
</tr>
<tr>
<td>10/15</td>
<td>4600</td>
<td>4465</td>
<td>4691</td>
<td>5648</td>
<td>6222</td>
<td>7213</td>
<td>19.5% 33.2% 47.3%</td>
</tr>
<tr>
<td>10/22</td>
<td>4600</td>
<td>4465</td>
<td>4947</td>
<td>5648</td>
<td>6222</td>
<td>7239</td>
<td>18.2% 34.0% 47.8%</td>
</tr>
<tr>
<td>10/29</td>
<td>4600</td>
<td>4834</td>
<td>5332</td>
<td>5648</td>
<td>6222</td>
<td>7283</td>
<td>17.0% 31.6% 51.8%</td>
</tr>
<tr>
<td>11/03</td>
<td>4600</td>
<td>4990</td>
<td>5332</td>
<td>5648</td>
<td>6222</td>
<td>7288</td>
<td>16.3% 31.5% 52.3%</td>
</tr>
<tr>
<td>11/10</td>
<td>4600</td>
<td>4990</td>
<td>5332</td>
<td>5846</td>
<td>6222</td>
<td>7317</td>
<td>16.5% 31.2% 52.2%</td>
</tr>
</tbody>
</table>

Change in similarity over time

winword.exe (95)
**Optimization Performance**

*Question*: How much impact do the differences in profiles have on optimization performance?

- Our case: FX!32 program translation/optimization
- Different Individual and group profiles for training
- Automated test script for performance measurement

- Two benchmarks show different results
  - winword.exe (95)
  - powerpnt.exe (97)
Optimization Results: Word 95

![Bar Chart]

- **None**: *459 seconds*
- **Tester**: 242 seconds
- **Dopey**: 264 seconds
- **Sleepy**: 252 seconds
- **Grumpy**: 257 seconds
- **Happy**: 256 seconds
- **D + S + G + H**: 250 seconds
- **Tester + Dopey**: 245 seconds
- **Tester + Sleepy**: 248 seconds
- **Tester + Grumpy**: 249 seconds
- **Tester + Happy**: 250 seconds
- **Tester + D + S + G + H**: 253 seconds

*Execution Time (second)*
Optimization Results: PowerPoint 97

Execution Time (second)

None: 474
Tester: 422
Donald: 425
Mickey: 423
Pluto: 420
D + M: 423
D + P: 424
M + P: 423
D + M + P: 423
Tester + Donald: 423
Tester + Mickey: 423
Tester + Pluto: 421
Tester + D + M: 424
Tester + D + P: 423
Tester + M + P: 424
Tester + D + M + P: 426
Summary

• People use different sets of procedures in a program
  – on average, 52% of used procedures are *common* and 16% are *unique*
• Frequently executed procedures tend to be common
• Some differences persist over time

• Differences in profiles can have measurable impact on optimization performance
• Profiles from another user or a group can be less effective