

OPERATING AND PROGRAMMING SYSTEMS SERIES

Technische Hochschule Darmstadt  
FACHBEREICH INFORMATIK

BIBLIOTHEK

Inventar-Nr.: 3022

Sachgebiete: \_\_\_\_\_

Standort: \_\_\_\_\_

# Program Behavior: Models and Measurements

Jeffrey R. Spirn

The Pennsylvania State University



**ELSEVIER**

NEW YORK OXFORD AMSTERDAM

# Contents

|                                                            |            |
|------------------------------------------------------------|------------|
| <b>Preface</b> .....                                       | <b>ix</b>  |
| <b>1 On Modeling</b> .....                                 | <b>1</b>   |
| 1.1 Introduction.....                                      | 1          |
| 1.2 Why Do We Model? .....                                 | 1          |
| 1.3 Programs in Execution .....                            | 7          |
| 1.4 What Effects Should Be Modeled? .....                  | 8          |
| 1.5 Philosophies in Modeling .....                         | 11         |
| 1.6 Locality—The Basic Principle .....                     | 16         |
| <b>2 Paging Issues</b> .....                               | <b>18</b>  |
| 2.1 Hardware Review .....                                  | 18         |
| 2.2 Thrashing .....                                        | 22         |
| 2.3 Paging Algorithms .....                                | 23         |
| 2.4 Properties of Memory Reference Locality .....          | 45         |
| <b>3 Models for Memory Reference Behavior</b> .....        | <b>56</b>  |
| 3.1 Some Extrinsic Program Models.....                     | 56         |
| 3.2 Intrinsic Models of Locality .....                     | 84         |
| 3.3 On the Optimal Paging Algorithm for the GLM .....      | 95         |
| <b>4 The LRU and Related Stack Models</b> .....            | <b>98</b>  |
| 4.1 Paging in Simple Stack Models.....                     | 98         |
| 4.2 The LRU Stack Model (SLRUM).....                       | 111        |
| 4.3 Extensions to the LRU Stack Model .....                | 132        |
| <b>5 Tools for Measurement and Validation</b> .....        | <b>143</b> |
| 5.1 What Should We Validate?.....                          | 143        |
| 5.2 Measurement of Working Set Behavior.....               | 145        |
| 5.3 Other Criteria for Validation .....                    | 165        |
| 5.4 Practical Issues of Reference String Measurement ..... | 166        |
| 5.5 Stack Distance Validation .....                        | 169        |
| <b>6 Two Modeling Examples</b> .....                       | <b>207</b> |
| 6.1 Modeling the Page Fault Process.....                   | 207        |
| 6.2 A Semi-Markov Page Fault Model.....                    | 209        |

|     |                                                                          |            |
|-----|--------------------------------------------------------------------------|------------|
| 6.3 | A Markovian Distance String Model . . . . .                              | 224        |
| 6.4 | Summary . . . . .                                                        | 252        |
| 7   | <b>The State of the Art . . . . .</b>                                    | <b>253</b> |
| 7.1 | Review of the Models . . . . .                                           | 254        |
| 7.2 | Measurement and Validation . . . . .                                     | 258        |
|     | <b>Appendix: Working Set Statistics of the LRU Stack Model . . . . .</b> | <b>260</b> |
|     | <b>Bibliography . . . . .</b>                                            | <b>264</b> |
|     | <b>Index . . . . .</b>                                                   | <b>272</b> |