

# **Simulation with Arena**

Fifth Edition

W. David Kelton

*Professor*

*Department of Quantitative Analysis and Operations Management  
University of Cincinnati*

Randall P. Sadowski

*Retired*

Nancy B. Swets

*Requirements Analyst*

*Simulation*

*Rockwell Automation*

TECHNISCHE  
INFORMATIONSBIBLIOTHEK  
UNIVERSITÄTSBIBLIOTHEK  
HANNOVER



**Higher Education**

Boston Burr Ridge, IL Dubuque, IA New York San Francisco St. Louis  
Bangkok Bogotá Caracas Kuala Lumpur Lisbon London Madrid Mexico City  
Milan Montreal New Delhi Santiago Seoul Singapore Sydney Taipei Toronto

# Contents

|  |           |
|--|-----------|
| <b>Chapter 1: What Is Simulation? .....</b>                            | <b>1</b>  |
| 1.1    Modeling .....  | 1         |
| 1.1.1    What's Being Modeled? .....                                   | 2         |
| 1.1.2    How About Just Playing with the System? .....                 | 3         |
| 1.1.3    Sometimes You Can't (or Shouldn't) Play with the System ..... | 3         |
| 1.1.4    Physical Models .....   | 4         |
| 1.1.5    Logical (or Mathematical) Models .....                        | 4         |
| 1.1.6    What Do You Do with a Logical Model? .....                    | 4         |
| 1.2    Computer Simulation .....                                       | 5         |
| 1.2.1    Popularity and Advantages .....                               | 5         |
| 1.2.2    The Bad News .....  | 6         |
| 1.2.3    Different Kinds of Simulations .....                          | 7         |
| 1.3    How Simulations Get Done .....                                  | 8         |
| 1.3.1    By Hand .....   | 8         |
| 1.3.2    Programming in General-Purpose Languages .....                | 10        |
| 1.3.3    Simulation Languages .....                                    | 10        |
| 1.3.4    High-Level Simulators .....                                   | 10        |
| 1.3.5    Where Arena Fits In .....                                     | 10        |
| 1.4    When Simulations Are Used .....                                 | 12        |
| 1.4.1    The Early Years .....   | 12        |
| 1.4.2    The Formative Years .....                                     | 12        |
| 1.4.3    The Recent Past .....   | 13        |
| 1.4.4    The Present .....   | 13        |
| 1.4.5    The Future .....  | 13        |
| <b>Chapter 2: Fundamental Simulation Concepts .....</b>                | <b>15</b> |
| 2.1    An Example .....  | 15        |
| 2.1.1    The System .....  | 15        |
| 2.1.2    Goals of the Study .....                                      | 17        |
| 2.2    Analysis Options .....  | 18        |
| 2.2.1    Educated Guessing .....                                       | 18        |
| 2.2.2    Queueing Theory .....   | 19        |
| 2.2.3    Mechanistic Simulation .....                                  | 20        |
| 2.3    Pieces of a Simulation Model .....                              | 20        |
| 2.3.1    Entities .....  | 20        |
| 2.3.2    Attributes .....  | 21        |
| 2.3.3    (Global) Variables .....                                      | 21        |
| 2.3.4    Resources .....   | 22        |
| 2.3.5    Queues .....  | 22        |
| 2.3.6    Statistical Accumulators .....                                | 23        |
| 2.3.7    Events .....  | 23        |
| 2.3.8    Simulation Clock .....  | 24        |
| 2.3.9    Starting and Stopping .....                                   | 24        |

|       |  |    |
|-------|--|----|
| 2.4   | Event-Driven Hand Simulation .....           | 25 |
| 2.4.1 | Outline of the Action .....                  | 25 |
| 2.4.2 | Keeping Track of Things .....                | 26 |
| 2.4.3 | Carrying It Out .....                        | 28 |
| 2.4.4 | Finishing Up .....                           | 32 |
| 2.5   | Event- and Process-Oriented Simulation ..... | 32 |
| 2.6   | Randomness in Simulation .....               | 34 |
| 2.6.1 | Random Input, Random Output .....            | 34 |
| 2.6.2 | Replicating the Example .....                | 35 |
| 2.6.3 | Comparing Alternatives .....                 | 36 |
| 2.7   | Simulating with Spreadsheets .....           | 37 |
| 2.7.1 | A News Vendor Problem .....                  | 37 |
| 2.7.2 | A Single-Server Queue .....                  | 43 |
| 2.7.3 | Extensions and Limitations .....             | 47 |
| 2.8   | Overview of a Simulation Study .....         | 47 |
| 2.9   | Exercises .....                              | 48 |

## **Chapter 3: A Guided Tour Through Arena .....53**

|        |   |    |
|--------|---|----|
| 3.1    | Starting Up .....   | 53 |
| 3.2    | Exploring the Arena Window .....                                    | 55 |
| 3.2.1  | Opening a Model .....   | 55 |
| 3.2.2  | Basic Interaction and Pieces of the Arena Window .....              | 56 |
| 3.2.3  | Panning, Zooming, Viewing, and Aligning in the Flowchart View ..... | 58 |
| 3.2.4  | Modules .....   | 60 |
| 3.2.5  | Internal Model Documentation .....                                  | 61 |
| 3.3    | Browsing Through an Existing Model: Model 3-1 .....                 | 62 |
| 3.3.1  | The Create Flowchart Module .....                                   | 62 |
| 3.3.2  | The Entity Data Module .....  | 63 |
| 3.3.3  | The Process Flowchart Module .....                                  | 64 |
| 3.3.4  | The Resource Data Module .....                                      | 66 |
| 3.3.5  | The Queue Data Module .....   | 67 |
| 3.3.6  | Animating Resources and Queues .....                                | 67 |
| 3.3.7  | The Dispose Flowchart Module .....                                  | 67 |
| 3.3.8  | Connecting Flowchart Modules .....                                  | 68 |
| 3.3.9  | Dynamic Plots .....   | 69 |
| 3.3.10 | Dressing Things Up .....  | 71 |
| 3.3.11 | Setting the Run Conditions .....                                    | 72 |
| 3.3.12 | Running It .....  | 73 |
| 3.3.13 | Viewing the Reports .....   | 74 |
| 3.4    | Building Model 3-1 Yourself .....                                   | 79 |
| 3.4.1  | New Model Window and Basic Process Panel .....                      | 80 |
| 3.4.2  | Place and Connect the Flowchart Modules .....                       | 81 |
| 3.4.3  | The Create Flowchart Module .....                                   | 81 |
| 3.4.4  | Displays .....  | 82 |
| 3.4.5  | The Entity Data Module .....  | 83 |
| 3.4.6  | The Process Flowchart Module .....                                  | 83 |
| 3.4.7  | The Resource and Queue Data Modules .....                           | 84 |
| 3.4.8  | Resource Animation .....  | 84 |
| 3.4.9  | The Dispose Flowchart Module .....                                  | 85 |
| 3.4.10 | Dynamic Plots .....   | 85 |

|        |   |            |
|--------|---|------------|
| 3.4.11 | Window Dressing .....   | 88         |
| 3.4.12 | The Run > Setup Dialog Boxes .....  | 89         |
| 3.4.13 | Establishing Named Views .....  | 89         |
| 3.5    | Case Study: Specialized Serial Processing vs. Generalized Parallel Processing ..... | 90         |
| 3.5.1  | Model 3-2: Serial Processing – Specialized Separated Work .....                     | 90         |
| 3.5.2  | Model 3-3: Parallel Processing – Generalized Integrated Work .....                  | 93         |
| 3.5.3  | Models 3-4 and 3-5: The Effect of Task-Time Variability .....                       | 95         |
| 3.6    | More on Menus, Toolbars, Drawing, and Printing .....                                | 98         |
| 3.6.1  | Menus .....   | 98         |
| 3.6.2  | Toolbars .....  | 103        |
| 3.6.3  | Drawing .....   | 106        |
| 3.6.4  | Printing .....  | 107        |
| 3.7    | Help! .....   | 108        |
| 3.8    | More on Running Models .....  | 109        |
| 3.9    | Summary and Forecast .....  | 110        |
| 3.10   | Exercises .....   | 110        |
|        | <b>Chapter 4: Modeling Basic Operations and Inputs .....</b>                        | <b>117</b> |
| 4.1    | Model 4-1: An Electronic Assembly and Test System .....                             | 117        |
| 4.1.1  | Developing a Modeling Approach .....  | 118        |
| 4.1.2  | Building the Model .....  | 119        |
| 4.1.3  | Running the Model .....   | 130        |
| 4.1.4  | Viewing the Results .....   | 132        |
| 4.2    | Model 4-2: The Enhanced Electronic Assembly and Test System .....                   | 134        |
| 4.2.1  | Expanding Resource Representation: Schedules and States .....                       | 135        |
| 4.2.2  | Resource Schedules .....  | 136        |
| 4.2.3  | Resource Failures .....   | 140        |
| 4.2.4  | Frequencies .....   | 142        |
| 4.2.5  | Results of Model 4-2 .....  | 145        |
| 4.3    | Model 4-3: Enhancing the Animation .....  | 149        |
| 4.3.1  | Changing Animation Queues .....   | 150        |
| 4.3.2  | Changing Entity Pictures .....  | 152        |
| 4.3.3  | Adding Resource Pictures .....  | 154        |
| 4.3.4  | Adding Variables and Plots .....  | 156        |
| 4.4    | Model 4-4: The Electronic Assembly and Test System with Part Transfers .....        | 158        |
| 4.4.1  | Some New Arena Concepts: Stations and Transfers .....                               | 158        |
| 4.4.2  | Adding the Route Logic .....  | 160        |
| 4.4.3  | Altering the Animation .....  | 163        |
| 4.5    | Finding and Fixing Errors .....   | 167        |
| 4.6    | Input Analysis: Specifying Model Parameters and Distributions .....                 | 174        |
| 4.6.1  | Deterministic vs. Random Inputs .....   | 175        |
| 4.6.2  | Collecting Data .....   | 176        |
| 4.6.3  | Using Data .....  | 177        |
| 4.6.4  | Fitting Input Distributions via the Input Analyzer .....                            | 178        |
| 4.6.5  | No Data? .....  | 185        |
| 4.6.6  | Nonstationary Arrival Processes .....   | 188        |
| 4.6.7  | Multivariate and Correlated Input Data .....  | 189        |
| 4.7    | Summary and Forecast .....  | 189        |
| 4.8    | Exercises .....   | 190        |

**Chapter 5: Modeling Detailed Operations ..... 201**

|       |   |     |
|-------|---|-----|
| 5.1   | Model 5-1: A Simple Call Center System .....                                    | 202 |
| 5.2   | New Modeling Issues .....   | 203 |
| 5.2.1 | Customer Rejections and Balking .....   | 203 |
| 5.2.2 | Three-Way Decisions .....   | 204 |
| 5.2.3 | Variables and Expressions .....   | 204 |
| 5.2.4 | Storages .....  | 205 |
| 5.2.5 | Terminating or Steady-State .....   | 205 |
| 5.3   | Modeling Approach .....   | 206 |
| 5.4   | Building the Model .....  | 208 |
| 5.4.1 | Create Arrivals and Direct to Service .....                                     | 208 |
| 5.4.2 | Arrival Cutoff Logic .....  | 214 |
| 5.4.3 | Technical Support Calls .....   | 216 |
| 5.4.4 | Sales Calls .....   | 219 |
| 5.4.5 | Order-Status Calls .....  | 220 |
| 5.4.6 | System Exit and Run Setup .....   | 226 |
| 5.4.7 | Animation .....   | 228 |
| 5.5   | Model 5-2: The Enhanced Call Center System .....                                | 231 |
| 5.5.1 | The New Problem Description .....   | 231 |
| 5.5.2 | New Concepts .....  | 233 |
| 5.5.3 | Defining the Data .....   | 235 |
| 5.5.4 | Modifying the Model .....   | 239 |
| 5.6   | Model 5-3: The Enhanced Call Center with More Output Performance Measures ..... | 244 |
| 5.7   | Model 5-4: An $(s, S)$ Inventory Simulation .....                               | 251 |
| 5.7.1 | System Description .....  | 251 |
| 5.7.2 | Simulation Model .....  | 253 |
| 5.8   | Summary and Forecast .....  | 264 |
| 5.9   | Exercises .....   | 265 |

**Chapter 6: Statistical Analysis of Output from Terminating Simulations ..... 273**

|     |   |     |
|-----|---|-----|
| 6.1 | Time Frame of Simulations .....                                 | 274 |
| 6.2 | Strategy for Data Collection and Analysis .....                 | 274 |
| 6.3 | Confidence Intervals for Terminating Systems .....              | 276 |
| 6.4 | Comparing Two Scenarios .....                                   | 281 |
| 6.5 | Evaluating Many Scenarios with the Process Analyzer (PAN) ..... | 285 |
| 6.6 | Searching for an Optimal Scenario with OptQuest .....           | 290 |
| 6.7 | Summary and Forecast .....                                      | 295 |
| 6.8 | Exercises .....   | 296 |

**Chapter 7: Intermediate Modeling and Steady-State Statistical Analysis ..... 301**

|       |   |     |
|-------|---|-----|
| 7.1   | Model 7-1: A Small Manufacturing System ..... | 301 |
| 7.1.1 | New Arena Concepts .....                      | 302 |
| 7.1.2 | The Modeling Approach .....                   | 304 |
| 7.1.3 | The Data Modules .....                        | 305 |
| 7.1.4 | The Logic Modules .....                       | 307 |
| 7.1.5 | Animation .....                               | 314 |
| 7.1.6 | Verification .....                            | 316 |

|   |  |            |
|---|--|------------|
| 7.2   | Statistical Analysis of Output from Steady-State Simulations .....               | 320        |
| 7.2.1   | Warm-Up and Run Length .....   | 320        |
| 7.2.2   | Truncated Replications .....   | 324        |
| 7.2.3   | Batching in a Single Run .....   | 325        |
| 7.2.4   | What To Do? .....  | 328        |
| 7.2.5   | Other Methods and Goals for Steady-State Statistical Analysis .....              | 329        |
| 7.3   | Summary and Forecast .....   | 329        |
| 7.4   | Exercises .....  | 329        |
| <b>Chapter 8: Entity Transfer .....</b>                                     |  | <b>335</b> |
| 8.1   | Types of Entity Transfers .....  | 335        |
| 8.2   | Model 8-1: The Small Manufacturing System with Resource-Constrained Transfers .. | 337        |
| 8.3   | The Small Manufacturing System with Transporters .....                           | 341        |
| 8.3.1   | Model 8-2: The Modified Model 8-1 for Transporters .....                         | 342        |
| 8.3.2   | Model 8-3: Refining the Animation for Transporters .....                         | 349        |
| 8.4   | Conveyors .....  | 355        |
| 8.4.1   | Model 8-4: The Small Manufacturing System with Nonaccumulating Conveyors .....   | 358        |
| 8.4.2   | Model 8-5: The Small Manufacturing System with Accumulating Conveyors .....      | 363        |
| 8.5   | Summary and Forecast .....   | 364        |
| 8.6   | Exercises .....  | 364        |
| <b>Chapter 9: A Sampler of Further Modeling Issues and Techniques .....</b> |  | <b>369</b> |
| 9.1   | Modeling Conveyors Using the Advanced Transfer Panel .....                       | 369        |
| 9.1.1   | Model 9-1: Finite Buffers at Stations .....                                      | 370        |
| 9.1.2   | Model 9-2: Parts Stay on Conveyor During Processing .....                        | 374        |
| 9.2   | More on Transporters .....   | 375        |
| 9.3   | Entity Reneging .....  | 376        |
| 9.3.1   | Entity Balking and Reneging .....  | 376        |
| 9.3.2   | Model 9-3: A Service Model with Balking and Reneging .....                       | 377        |
| 9.4   | Holding and Batching Entities .....  | 385        |
| 9.4.1   | Modeling Options .....   | 385        |
| 9.4.2   | Model 9-4: A Batching Process Example .....                                      | 386        |
| 9.5   | Overlapping Resources .....  | 392        |
| 9.5.1   | System Description .....   | 392        |
| 9.5.2   | Model 9-5: A Tightly Coupled Production System .....                             | 394        |
| 9.5.3   | Model 9-6: Adding Part-Status Statistics .....                                   | 400        |
| 9.6   | A Few Miscellaneous Modeling Issues .....  | 403        |
| 9.6.1   | Guided Transporters .....  | 404        |
| 9.6.2   | Parallel Queues .....  | 404        |
| 9.6.3   | Decision Logic .....   | 405        |
| 9.7   | Exercises .....  | 406        |
| <b>Chapter 10: Arena Integration and Customization .....</b>                |  | <b>413</b> |
| 10.1  | Model 10-1: Reading and Writing Data Files .....                                 | 413        |
| 10.1.1  | Model 10-2: Reading Entity Arrivals from a Text File .....                       | 415        |
| 10.1.2  | Model 10-3 and Model 10-4: Reading and Writing Access and Excel Files .....      | 419        |

|   |  |            |
|---|--|------------|
| 10.1.3  | Advanced Reading and Writing .....   | 426        |
| 10.1.4  | Model 10-5: Reading in String Data .....                                   | 430        |
| 10.2  | VBA in Arena .....   | 432        |
| 10.2.1  | Overview of ActiveX Automation and VBA .....                               | 432        |
| 10.2.2  | Built-in Arena VBA Events .....  | 434        |
| 10.2.3  | Arena's Object Model .....   | 438        |
| 10.2.4  | Arena's Macro Recorder .....   | 441        |
| 10.3  | Model 10-6: Presenting Arrival Choices to the User .....                   | 444        |
| 10.3.1  | Modifying the Creation Logic .....   | 444        |
| 10.3.2  | Designing the VBA UserForm .....   | 446        |
| 10.3.3  | Displaying the Form and Setting Model Data .....                           | 448        |
| 10.4  | Model 10-7: Recording and Charting Model Results in Microsoft Excel .....  | 455        |
| 10.4.1  | Setting Up Excel at the Beginning of the Run .....                         | 456        |
| 10.4.2  | Storing Individual Call Data Using the VBA Module .....                    | 459        |
| 10.4.3  | Charting the Results and Cleaning Up at the End of the Run .....           | 461        |
| 10.5  | Creating Modules Using the Arena Professional Edition: Template 10-1 ..... | 462        |
| 10.5.1  | The Create from File Module .....  | 463        |
| 10.5.2  | The Template Source File: Template 10-01.tpl .....                         | 464        |
| 10.5.3  | The Panel Icon and User View .....   | 464        |
| 10.5.4  | The Module Logic and Operands .....  | 465        |
| 10.5.5  | Uses of Templates .....  | 470        |
| 10.6  | Summary and Forecast .....   | 471        |
| 10.7  | Exercises .....  | 471        |
| <b>Chapter 11: Continuous and Combined Discrete/Continuous Models .....</b> |  | <b>473</b> |
| 11.1  | Modeling Simple Discrete/Continuous Systems .....                          | 474        |
| 11.1.1  | Model 11-1: A Simple Continuous System .....                               | 474        |
| 11.1.2  | Model 11-2: Interfacing Continuous and Discrete Logic .....                | 477        |
| 11.2  | A Coal-Loading Operation .....   | 481        |
| 11.2.1  | System Description .....   | 482        |
| 11.2.2  | Modeling Approach .....  | 483        |
| 11.2.3  | Model 11-3: Coal Loading with Continuous Approach .....                    | 485        |
| 11.2.4  | Model 11-4: Coal Loading with Flow Process .....                           | 495        |
| 11.3  | Continuous State-Change Systems .....                                      | 499        |
| 11.3.1  | Model 11-5: A Soaking-Pit Furnace .....                                    | 499        |
| 11.3.2  | Modeling Continuously Changing Rates .....                                 | 500        |
| 11.3.3  | Arena's Approach for Solving Differential Equations .....                  | 501        |
| 11.3.4  | Building the Model .....   | 502        |
| 11.3.5  | Defining the Differential Equations Using VBA .....                        | 506        |
| 11.4  | Summary and Forecast .....   | 508        |
| 11.5  | Exercises .....  | 508        |
| <b>Chapter 12: Further Statistical Issues .....</b>                         |  | <b>513</b> |
| 12.1  | Random-Number Generation .....   | 513        |
| 12.2  | Generating Random Variates .....   | 519        |
| 12.2.1  | Discrete .....   | 519        |
| 12.2.2  | Continuous .....   | 521        |
| 12.3  | Nonstationary Poisson Processes .....                                      | 523        |

|  |  |            |
|--|--|------------|
| 12.4   | Variance Reduction .....                             | 524        |
| 12.4.1   | Common Random Numbers .....                          | 525        |
| 12.4.2   | Other Methods .....                                  | 531        |
| 12.5   | Sequential Sampling .....                            | 532        |
| 12.5.1   | Terminating Models .....                             | 533        |
| 12.5.2   | Steady-State Models .....                            | 537        |
| 12.6   | Designing and Executing Simulation Experiments ..... | 539        |
| 12.7   | Exercises .....                                      | 540        |
| <b>Chapter 13: Conducting Simulation Studies .....</b>                             |  | <b>543</b> |
| 13.1   | A Successful Simulation Study .....                  | 543        |
| 13.2   | Problem Formulation .....                            | 546        |
| 13.3   | Solution Methodology .....                           | 547        |
| 13.4   | System and Simulation Specification .....            | 548        |
| 13.5   | Model Formulation and Construction .....             | 552        |
| 13.6   | Verification and Validation .....                    | 554        |
| 13.7   | Experimentation and Analysis .....                   | 557        |
| 13.8   | Presenting and Preserving the Results .....          | 558        |
| 13.9   | Disseminating the Model .....                        | 559        |
| <b>Appendix A: A Functional Specification for <i>The Washington Post</i> .....</b> |  | <b>561</b> |
| A.1  | Introduction .....                                   | 561        |
| A.1.1  | Document Organization .....                          | 561        |
| A.1.2  | Simulation Objectives .....                          | 561        |
| A.1.3  | Purpose of the Functional Specification .....        | 562        |
| A.1.4  | Use of the Model .....                               | 562        |
| A.1.5  | Hardware and Software Requirements .....             | 563        |
| A.2  | System Description and Modeling Approach .....       | 563        |
| A.2.1  | Model Timeline .....                                 | 563        |
| A.2.2  | Presses .....  | 563        |
| A.2.3  | Product Types .....                                  | 565        |
| A.2.4  | Press Packaging Lines .....                          | 565        |
| A.2.5  | Tray System .....                                    | 565        |
| A.2.6  | Truck Arrivals .....                                 | 566        |
| A.2.7  | Docks .....  | 567        |
| A.2.8  | Palletizers .....                                    | 567        |
| A.2.9  | Manual Insertion Process .....                       | 568        |
| A.3  | Animation .....                                      | 569        |
| A.4  | Summary of Input and Output .....                    | 569        |
| A.4.1  | Model Input .....                                    | 569        |
| A.4.2  | Model Output .....                                   | 570        |
| A.5  | Project Deliverables .....                           | 572        |
| A.5.1  | Simulation Model Documentation .....                 | 572        |
| A.5.2  | User's Manual .....                                  | 572        |
| A.5.3  | Model Validation .....                               | 572        |
| A.5.4  | Animation .....                                      | 572        |
| A.6  | Acceptance .....                                     | 572        |

|  |            |
|--|------------|
| <b>Appendix B: A Refresher on Probability and Statistics .....</b>         | <b>575</b> |
| B.1 Probability Basics .....   | 575        |
| B.2 Random Variables .....   | 577        |
| B.2.1 Basics .....   | 577        |
| B.2.2 Discrete .....   | 578        |
| B.2.3 Continuous .....   | 580        |
| B.2.4 Joint Distributions, Covariance, Correlation, and Independence ..... | 582        |
| B.3 Sampling and Sampling Distributions .....                              | 585        |
| B.4 Point Estimation .....   | 587        |
| B.5 Confidence Intervals .....   | 587        |
| B.6 Hypothesis Tests .....   | 589        |
| B.7 Exercises .....  | 591        |
| <b>Appendix C: Arena's Probability Distributions .....</b>                 | <b>593</b> |
| Arena's Probability Distributions .....                                    | 593        |
| Beta .....   | 595        |
| Continuous .....   | 596        |
| Discrete .....   | 598        |
| Erlang .....   | 599        |
| Exponential .....  | 600        |
| Gamma .....  | 601        |
| Johnson .....  | 602        |
| Lognormal .....  | 603        |
| Normal .....   | 604        |
| Poisson .....  | 605        |
| Triangular .....   | 606        |
| Uniform .....  | 607        |
| Weibull .....  | 608        |
| <b>Appendix D: Academic Software Installation Instructions .....</b>       | <b>609</b> |
| D.1 Authorization to Copy Software .....                                   | 609        |
| D.2 Installing the Arena Software .....                                    | 609        |
| D.3 System Requirements .....  | 610        |
| <b>References .....</b>  | <b>611</b> |
| <b>Index .....</b>   | <b>615</b> |