## Contents

About the Author xiii  
Notes on Contributors xv  
Preface xvii  

### 1 Introduction  1

1.1 Overview  1  
1.2 Components of a Pub/Sub System  4  
  1.2.1 Basic System  4  
  1.2.2 Distribution and Overlay Networks  5  
  1.2.3 Agreements  6  
  1.2.4 The Event Loop  7  
  1.2.5 Basic Properties  7  
1.3 A Pub/Sub Service Model  9  
1.4 Distributed Pub/Sub  10  
1.5 Interfaces and Operations  11  
1.6 Pub/Sub Semantics for Targeted Delivery  13  
1.7 Communication Techniques  15  
1.8 Environments  17  
1.9 History  18  
  1.9.1 Research Systems  19  
  1.9.2 Standards  22  
  1.9.3 Internet Technology  23  
  1.9.4 A Taxonomy  24  
1.10 Application Areas  26  
1.11 Structure of the Book  27  
References  29  

### 2 Networking and Messaging  31

2.1 Networking  31  
  2.1.1 Overview  31  
  2.1.2 Sockets, Middleware, and Applications  33
<table>
<thead>
<tr>
<th>Contents</th>
<th>vii</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.7 Summary</td>
<td>77</td>
</tr>
<tr>
<td>References</td>
<td>77</td>
</tr>
<tr>
<td><strong>4 Principles and Patterns</strong></td>
<td>79</td>
</tr>
<tr>
<td>4.1 Introduction</td>
<td>79</td>
</tr>
<tr>
<td>4.2 General Pub/Sub Model</td>
<td>80</td>
</tr>
<tr>
<td>4.2.1 Principles and Characteristics</td>
<td>80</td>
</tr>
<tr>
<td>4.2.2 Message Service</td>
<td>82</td>
</tr>
<tr>
<td>4.2.3 General Patterns</td>
<td>82</td>
</tr>
<tr>
<td>4.2.4 Event Notification Patterns</td>
<td>82</td>
</tr>
<tr>
<td>4.3 Architectural Patterns</td>
<td>83</td>
</tr>
<tr>
<td>4.4 Design Patterns</td>
<td>85</td>
</tr>
<tr>
<td>4.4.1 Structural Patterns</td>
<td>85</td>
</tr>
<tr>
<td>4.4.2 Behavioural Patterns</td>
<td>86</td>
</tr>
<tr>
<td>4.4.3 Concurrency Patterns</td>
<td>86</td>
</tr>
<tr>
<td>4.5 Design Patterns for Pub/Sub</td>
<td>86</td>
</tr>
<tr>
<td>4.5.1 Broker</td>
<td>86</td>
</tr>
<tr>
<td>4.5.2 Observer</td>
<td>87</td>
</tr>
<tr>
<td>4.5.3 Model-View-Control (MVC)</td>
<td>89</td>
</tr>
<tr>
<td>4.5.4 Rendezvous Point</td>
<td>91</td>
</tr>
<tr>
<td>4.5.5 Handoff with Rendezvous</td>
<td>91</td>
</tr>
<tr>
<td>4.5.6 Client-Initiated Connection</td>
<td>92</td>
</tr>
<tr>
<td>4.5.7 Other Patterns</td>
<td>93</td>
</tr>
<tr>
<td>4.6 Event Notifier Pattern</td>
<td>94</td>
</tr>
<tr>
<td>4.6.1 Overview</td>
<td>94</td>
</tr>
<tr>
<td>4.6.2 Structure</td>
<td>95</td>
</tr>
<tr>
<td>4.6.3 Distributed Event Notifier</td>
<td>97</td>
</tr>
<tr>
<td>4.6.4 Design Considerations</td>
<td>98</td>
</tr>
<tr>
<td>4.7 Enterprise Integration Patterns</td>
<td>101</td>
</tr>
<tr>
<td>4.8 Summary</td>
<td>103</td>
</tr>
<tr>
<td>References</td>
<td>103</td>
</tr>
<tr>
<td><strong>5 Standards and Products</strong></td>
<td>105</td>
</tr>
<tr>
<td>5.1 CORBA Event Service</td>
<td>105</td>
</tr>
<tr>
<td>5.2 CORBA Notification Service and Channel Management</td>
<td>106</td>
</tr>
<tr>
<td>5.3 OMG Data Distribution Service (DDS)</td>
<td>109</td>
</tr>
<tr>
<td>5.3.1 Overview</td>
<td>110</td>
</tr>
<tr>
<td>5.3.2 QoS Policies</td>
<td>111</td>
</tr>
<tr>
<td>5.3.3 Real-Time Communications</td>
<td>111</td>
</tr>
<tr>
<td>5.3.4 Applications</td>
<td>112</td>
</tr>
<tr>
<td>5.4 SIP Event Framework</td>
<td>113</td>
</tr>
<tr>
<td>5.5 Java Delegation Event Model</td>
<td>114</td>
</tr>
<tr>
<td>5.6 Java Distributed Event Model</td>
<td>114</td>
</tr>
<tr>
<td>5.7 Java Message Service (JMS)</td>
<td>115</td>
</tr>
<tr>
<td>5.7.1 Two Communication Models</td>
<td>116</td>
</tr>
</tbody>
</table>
5.7.2 Message Types and Selection
5.7.3 JMS Process
5.7.4 Message Delivery
5.7.5 Transactions
5.7.6 Advanced Issues
5.7.7 JMS in Java EE and Implementations

5.8 TibCo Rendezvous
5.9 COM+ and .NET
5.10 Websphere MQ
  5.10.1 Overview
  5.10.2 Pub/Sub in WebSphere MQ
5.11 Advanced Message Queuing Protocol (AMQP)
5.12 MQ Telemetry Transport (MQTT)
5.13 Summary

References

6 Web Technology

6.1 REST
6.2 AJAX
6.3 RSS and Atom
6.4 SOAP
6.5 XMPP
6.6 Constrained Application Protocol (CoAP)
6.7 W3C DOM Events
6.8 WS-Eventing and WS-Notification
6.9 Summary

References

7 Distributed Publish/Subscribe

7.1 Overview
7.2 Filtering Content
7.3 Routing Function
7.4 Topic-Based Routing
  7.4.1 Mechanisms
  7.4.2 Channelization Problem
  7.4.3 Distributed Overlay with Many Topics
  7.4.4 Dynamic Clustering in Topic-Based Pub/Sub
  7.4.5 Summary
7.5 Filter-Based Routing
7.6 Content-Based Routing
  7.6.1 Addressing Model
  7.6.2 Propagating Routing Information
  7.6.3 Routing Behaviour: Subscriptions
  7.6.4 Routing Behaviour: Advertisements
  7.6.5 Routing Tables
  7.6.6 Forwarding
7.6.7 Performance Issues 164
7.6.8 A Generalized Broker with Advertisements 164
7.7 Rendezvous-Based Routing 166
7.8 Routing Invariants 167
7.8.1 Configurations 167
7.8.2 Pub/Sub Configurations 168
7.8.3 False Positives and Negatives 169
7.8.4 Weakly Valid Routing Configuration 169
7.8.5 Mobility-Safety 170
7.8.6 Stabilization and Eventual Correctness 170
7.8.7 Soft State 171
7.9 Summary 172
References 174

8 Matching Content Against Constraints 177
8.1 Overview 177
8.2 Matching Techniques 178
8.3 Filter Preliminaries 180
8.4 The Counting Algorithm 181
8.4.1 Overview 182
8.4.2 Algorithms 183
8.5 Matching with Posets 186
8.5.1 Poset Preliminaries 187
8.5.2 SIENA Poset 188
8.5.3 Poset-Derived Forest 191
8.5.4 Matching Events 192
8.6 Tree Matcher 193
8.7 XFilter and YFilter 194
8.8 Bloom Filters 196
8.8.1 Definition 197
8.8.2 Summary Subscriptions 198
8.8.3 Multicast Forwarding 198
8.8.4 Content-Based Forwarding 198
8.8.5 Multi-Level Bloom Filters 200
8.9 Summary 200
References 202

9 Research Solutions 205
9.1 Gryphon 205
9.2 The Cambridge Event Architecture (CEA) 207
9.3 Scalable Internet Event Notification Architecture (SIENA) 208
9.3.1 Event Namespace 209
9.3.2 Routing 209
9.3.3 Forwarding 210
9.3.4 Mobility Support 211
9.3.5 CBCB Routing Scheme 211
9.4 Elvin
  9.4.1 Clustering
  9.4.2 Federation
  9.4.3 Quench
  9.4.4 Mobile Support
  9.4.5 Nondestructive Notification Receipt

9.5 JEDI

9.6 PADRES
  9.6.1 Modular Design
  9.6.2 Load Balancing
  9.6.3 Composite Events

9.7 REDS

9.8 GREEN

9.9 Rebeca

9.10 XSIENA and StreamMine

9.11 Fuego Event Service
  9.11.1 Fuego Middleware
  9.11.2 Event Service
  9.11.3 Filtering
  9.11.4 Client-Side API
  9.11.5 Event Router
  9.11.6 Data Structures for Content-Based Routing

9.12 STEAM

9.13 ECho and JECho

9.14 DHT-Based Systems
  9.14.1 Scribe
  9.14.2 Bayeux and Tapestry
  9.14.3 Hermes
  9.14.4 Other Systems

9.15 Summary

References

10 IR-Style Document Dissemination in DHTs

10.1 Introduction

10.2 Data Model and Problem Statement
  10.2.1 Data Model
  10.2.2 Problem Statement and Challenges

10.3 STAIRS: Threshold-Based Document Filtering in DHTs
  10.3.1 Overview of DHT-Based P2P Networks
  10.3.2 Solution Framework
  10.3.3 Document Forwarding Algorithm

10.4 Recent Progress and Discussion
  10.4.1 Recent Progress
  10.4.2 Discussion

10.5 Summary

References
## 11 Advanced Topics

11.1 Security  
11.1.1 Overview  
11.1.2 Security Threats  
11.1.3 Security Issues in Pub/Sub Networks  
11.1.4 EventGuard  
11.1.5 QUIP  
11.1.6 Hermes  
11.1.7 Encrypting Attributes  
11.1.8 Privacy  
11.2 Composite Subscriptions  
11.3 Filter Merging  
11.4 Load Balancing  
11.5 Content-Based Channelization  
11.6 Reconfiguration  
11.6.1 Middleware Component Reconfiguration  
11.6.2 Topology Reconfiguration with Failures and Mobile Brokers  
11.6.3 Self-Organizing Pub/Sub with Clustering  
11.7 Mobility Support  
11.7.1 Generic Pub/Sub Mobility  
11.7.2 Graph Based Mobility with Optimizations  
11.8 Congestion Control  
11.8.1 Rate-Control Using Posets  
11.8.2 Explicit Signalling  
11.8.3 Rerouting to Avoid Congestion  
11.9 Evaluation of Pub/Sub Systems  
11.10 Summary  
References

## 12 Applications

12.1 Cloud Computing  
12.1.1 Pub/Sub for Cloud  
12.1.2 The Windows Azure AppFabric Service Bus  
12.1.3 Amazon Simple Queue Service (SQS)  
12.1.4 PubNub  
12.2 SOA and XML Brokering  
12.3 Facebook Services  
12.3.1 Facebook Messages  
12.3.2 Facebook Chat and Messenger  
12.4 PubSubHubbub  
12.5 Complex Event Processing (CEP)  
12.6 Online Advertisement  
12.7 Online Multiplayer Games  
12.8 Apple Push Notification Service (APNS)  
12.9 Internet of Things
## Contents

12.10 Summary 305
References 306

13 Clean-Slate Datacentric Pub/Sub Networking 309
13.1 Datacentric Communication Model 309
  13.1.1 Naming of Data 310
  13.1.2 Content Security 312
13.2 CCN 314
  13.2.1 CCN Node Operation 314
  13.2.2 CCN Transport Model 315
  13.2.3 Interest Routing 316
13.3 PSIRP/PURSUIT 317
13.4 Internet Interdomain Structure 318
  13.4.1 Policy Routing Problem 320
  13.4.2 PURSUIT Global Rendezvous 321
13.5 Summary 323
References 325

14 Conclusions 327

Index 333