THE JR PROGRAMMING LANGUAGE: CONCURRENT PROGRAMMING IN AN EXTENDED JAVA

RONALD A. OLSSON Department of Computer Science University of California, Davis

AARON W. KEEN Department of Computer Science California Polytechnic State University

Kluwer Academic Publishers Boston/Dordrecht/London

Contents

De	edicat	ion	V
List of Figures			XV
List of Tables			xvii
Preface			xix
Αc	knov	vledgments	XXV
1.	INT	RODUCTION	1
	1.1	Key JR Components	3
	1.2	Two Simple Examples	4
	1.3	Matrix Multiplication	6
	1.4	Concurrent File Search	8
	1.5	Critical Section Simulation	10
	1.6	Translating and Executing JR Programs	12
	1.7	Vocabulary and Notation	13
	Exe	rcises	13
Pa	rt I	Extensions for Concurrency	
2.	OVI	ERVIEW OF EXTENSIONS	17
	2.1	Process Interactions via Operations	17
	2.2	Distributing JR Programs	19
3.	OP-	METHODS, OPERATIONS, AND CAPABILITIES	21
	3.1	Op-methods	21
	3.2	Operation and Method Declarations	22
	3.3	Operation Capabilities	22

	Exer	rcises	25
4.	CONCURRENT EXECUTION		27
	4.1	Process Declarations	27
	4.2	The Unabbreviated Form of Processes	31
	4.3	Static and Non-static Processes	34
	4.4	Process Scheduling and Priorities	35
	4.5	Automatic Termination Detection	36
	Exercises		38
5.	SYN	NCHRONIZATION USING SHARED VARIABLES	43
	5.1	The Critical Section Problem	43
	5.2	An Incorrect Solution	45
	5.3	An Alternating Solution	46
	5.4	The Bakery Algorithm for Two Processes	47
	5.5	The Bakery Algorithm for N Processes	49
	Exercises		50
6.	SEMAPHORES		53
	6.1	Semaphore Declarations and Operations	53
	6.2	The Dining Philosophers Problem	56
	6.3	Barrier Synchronization	58
	Exe	rcises	61
7.	ASYNCHRONOUS MESSAGE PASSING		65
	7.1	Operations as Message Queues	65
	7.2	Invoking and Servicing via Capabilities	68
	7.3	Simple Client-Server Models	70
	7.4	Resource Allocation	74
	7.5	Semaphores Revisited	77
	7.6	Data-Containing Semaphores	79
	7.7	Shared Operations	80
	7.8	Parameter Passing Details	83
	Exercises		84
8.	REMOTE PROCEDURE CALL		91
	8.1	Mechanisms for Remote Procedure Call	91
	8.2	Equivalence to Send/Receive Pairs	93

Co	ntents		ix
	8.3	Return, Reply, and Forward Statements	96
	Exer	cises	103
9.	REN	DEZVOUS	107
	9.1	The Input Statement	108
		9.1.1 General Form and Semantics	108
		9.1.2 Simple Input Statements	109
	9.2	Receive Statement Revisited	112
	9.3	Synchronization Expressions	115
	9.4	Scheduling Expressions	118
	9.5	More Precise Semantics	119
	9.6	Break And Continue Statements	120
	9.7	Conditional Input	121
	9.8	Arrays of Operations	122
	9.9	Dynamic Operations	123
	9.10	Return, Reply, and Forward Statements	124
	Exer	cises	128
10.	VIR	TUAL MACHINES	139
	10.1	Program Start-Up and Execution Overview	140
	10.2	Creating Virtual Machines	141
	10.3	Creating Remote Objects	143
	10.4	Examples of Multiple Machine Programs	144
	10.5	Predefined Fields	146
	10.6	Parameterized Virtual Machines	149
	10.7	Parameter Passing Details	151
	10.8	Other Aspects of Virtual Machines	152
	Exer	cises	153
11.	THE	DINING PHILOSOPHERS	159
	11.1	Centralized Solution	160
	11.2	Distributed Solution	162
	11.3	Decentralized Solution	165
	Exer	cises	169

12.	EXC	EPTIONS	173
	12.1	Operations and Capabilities	173
	12.2	Input Statements	174
	12.3	Asynchronous Invocation	174
		12.3.1 Handler Objects	175
		12.3.2 Send	176
	12.4	Additional Sources of Asynchrony	177
		12.4.1 Exceptions After Reply	177
		12.4.2 Exceptions After Forward	178
	12.5	Exceptions and Operations	179
	Exerc	cises	180
13.	INHI	ERITANCE OF OPERATIONS	185
	13.1	Operation Inheritance	186
	13.2	Example: Distributing Operation Servicing	187
	13.3	Example: Filtering Operation Servicing	188
	13.4	Redefinition Considerations	190
	Exerc	cises	191
14.	INTE	ER-OPERATION INVOCATION SELECTION MECHANISM	193
	14.1	Selection Method Expression	194
	14.2	View Statement	197
		14.2.1 General Form and Semantics	197
		14.2.2 Simple View Statement	198
	14.3	Selection Method Support Classes	198
		14.3.1 ArmEnumeration Methods	199
		14.3.2 InvocationEnumeration Methods	199
		14.3.3 Invocation Methods	199
		14.3.4 Timestamp Methods	199
	14.4	Examples	200
		14.4.1 Priority Scheduling	200
		14.4.2 Random Scheduling	201
		14.4.3 Median Scheduling	203
	Exerc	cises	204

Contents xi	
-------------	--

Part II	Applications	
	ALLEL MATRIX MULTIPLICATION	211
	Prescheduled Strips	212
	Dynamic Scheduling: A Bag of Tasks	215
	A Distributed Broadcast Algorithm	217
	A Distributed Heartbeat Algorithm	220
	cises	223
	VING PDEs: GRID COMPUTATIONS	227
	A Data Parallel Algorithm	228
	Prescheduled Strips	232
	A Distributed Heartbeat Algorithm	236
16.4	Using Multiple Virtual Machines	240
Exer	cises	241
17. THE	TRAVELING SALESMAN PROBLEM	247
17.1	Sequential Solution	248
17.2	Replicated Workers and a Bag of Tasks	251
17.3	Manager and Workers	254
Exer	cises	258
18. A DISTRIBUTED FILE SYSTEM 263		
18.1	System Structure	264
18.2	Directory and File Servers	266
18.3	User Interface	272
Exer	cises	280
19. DIS	CRETE EVENT SIMULATION	283
19.1	A Simulation Problem	283
19.2	A Solution	285
	19.2.1 Main Class	285
	19.2.2 Processor Class	285
	19.2.3 Bus Controller Class	286
	19.2.4 Scheduler Class	288
	Observations	290
Exer	cises	291

20.	. INTI	ERFACING JR AND GUIs	293
	20.1	BnB Game Overview	293
	20.2	BnB Code Overview	294
		20.2.1 Main Class	296
		20.2.2 Window Class	297
		20.2.3 Button Class	299
		20.2.4 Board Class	300
		20.2.5 Toy Classes	305
		20.2.6 Input Classes	307
		Miscellany	308
	Exer	cises	310
21.	PRE	PROCESSORS FOR OTHER CONCURRENCY NOTATIONS	313
	21.1	Conditional Critical Regions (CCRs)	313
	21.2	Monitors	316
	21.3	Communicating Sequential Processes (CSP)	320
	Exer	cises	325
Ap	pendi	ces	331
A	Sync	opsis of JR Extensions	331
В	Invo	cation and Enumeration Classes	337
C	Prog	ram Development and Execution	341
D Implementation and Performance		343	
	D.1	JR Virtual Machines	343
	D.2	Remote Objects	344
		D.2.1 Remote Class Loading	344
	D.3	Operations and Operation Capabilities	345
	D.4	Invocation Statements	345
		D.4.1 Inheritance	346
	D.5	Input Statements	346
	D.6	Quiescence Detection	346
	D.7	Performance Results	347
E	Histo	ory of JR	351
Bil	oliogra	aphy	353

Contents	xiii
References	355
Index	359