
Contents

Preface	v
1 Introduction	1
1.1 Interdisciplinary Aspects of Multimedia	2
1.2 Contents of This Book	4
1.3 Organization of This Book	4
1.3.1 Quality of Service.....	5
1.3.2 Multimedia Operating Systems	6
1.3.3 Multimedia Networking and Communication.....	6
1.3.4 Synchronization.....	6
1.4 Further Reading About Multimedia.....	7
2 Quality of Service	9
2.1 Requirements and Constraint.....	10
2.1.1 The Notion of “Real-Time”.....	10
2.1.2 Deadlines	11
2.1.3 Characteristics of Real-Time Systems	11
2.1.4 Real-time Requirements on Multimedia Systems	13
2.1.5 Service and Protocol Requirements	14
2.1.6 Processing and Communication Constraints.....	15

2.2	Quality of Service Concepts	16
2.2.1	Quality Layering	16
2.2.2	Service Objects.....	17
2.2.3	QoS Specification.....	18
2.2.4	QoS Parameter Values and Service Classes.....	22
2.2.5	Quality-Aware Service Model.....	24
2.3	Resources	25
2.3.1	Resource Management	26
2.3.2	Requirements on Resource Management.....	28
2.3.3	Model for Continuous Streams	29
2.4	Establishment Phase	34
2.4.1	QoS Negotiation.....	34
2.4.2	QoS Translation.....	40
2.4.3	QoS Scaling.....	43
2.4.4	QoS Routing.....	45
2.4.5	Admission Control	50
2.4.6	Reservation.....	52
2.5	Run-time Phase of Multimedia Call	58
2.5.1	Traffic Shaping.....	59
2.5.2	Rate Control	62
2.5.3	Error Control	65
2.5.4	QoS and Resource Monitoring.....	69
2.5.5	QoS Renegotiation and Adaptation.....	70
2.6	QoS Management Architectures.....	74
2.7	Closing Remarks.....	76
3	Multimedia Operating Systems.....	77
3.1	Process Management	78
3.1.1	Real-Time Processing Requirements	79
3.1.2	Traditional Real-Time Scheduling	80
3.1.3	Real-time Scheduling: System Model.....	81
3.1.4	Soft-Real-Time Scheduling Concepts.....	83
3.1.5	Scheduling Policies	94
3.1.6	Prototype Operating Systems: Case Studies	103

3.2	Interprocess Communication and Synchronization	108
3.3	Memory Management.....	109
3.3.1	Reservation Concept for Memory Management	110
3.3.2	Buffer Management Techniques	111
3.3.3	Buffer Management for Client/Server Systems	113
3.4	Device Management	116
3.5	System Architecture.....	119
3.5.1	UNIX-based Systems	122
3.5.2	QuickTime.....	123
3.5.3	Windows Multimedia Extensions	125
3.5.4	OS/2 Multimedia Presentation Manager/2.....	127
3.6	Concluding Remarks	129
4	Media Server.....	131
4.1	Architecture	132
4.2	Storage Devices	135
4.2.1	Disk Layout	135
4.2.2	Zone Bit Recording	137
4.2.3	File Structure	139
4.3	Disk Controller	140
4.3.1	Data Placement.....	140
4.3.2	Reorganization	146
4.4	Storage Management	148
4.4.1	Disk Management	149
4.4.2	Traditional Disk Scheduling.....	151
4.4.3	Multimedia Disk Scheduling.....	155
4.4.4	Admission Control	163
4.4.5	Replication	165
4.4.6	Supporting Heterogeneous Disks	168
4.5	File Systems.....	170
4.5.1	Traditional File Systems.....	170
4.5.2	Multimedia File Systems.....	173
4.5.3	Example Multimedia File Systems	174
4.6	Memory Management.....	180
4.6.1	Interval Caching Policy	181

4.6.2	Generalized Interval Caching Policy	181
4.6.3	Batching	181
4.6.4	Piggybacking	181
4.6.5	Content Insertion	182
5	Networks.....	183
5.1	Services, Protocols, Layers.....	183
5.1.1	Requirements to Services and Protocols	184
5.1.2	The Layers of the ISO-OSI Model	185
5.2	Networks.....	188
5.2.1	Ethernet	189
5.2.2	Gigabit Ethernet	191
5.2.3	Token Ring.....	192
5.2.4	100VG AnyLAN	199
5.2.5	Fiber Distributed Data Interface (FDDI).....	201
5.2.6	ATM Networks	210
5.3	Metropolitan Area Networks (MANs).....	218
5.3.1	Distributed Queue Dual Bus (DQDB).....	219
5.3.2	Orwell.....	223
5.3.3	MAN Connection to ATM Networks.....	224
5.4	Wide Area Networks (WANs).....	225
5.4.1	Traditional WANs	226
5.4.2	B-ISDN over ATM.....	228
5.5	Closing Remarks.....	239
6	Communication.....	241
6.1	Transport Subsystem Requirements and Constraints	241
6.1.1	User and Application Requirements.....	242
6.1.2	Processing and Protocol Constraints	242
6.2	Traditional Network Protocols and Their Support for Multimedia	244
6.2.1	Internet Protocol Version 4 (IPv4)	244
6.2.2	Internet Protocol Version 6 (IPv6)	247
6.2.3	Multicast Support	252
6.3	Traditional Transport Protocols and Their Support of Multimedia.....	258
6.3.1	Transmission Control Protocol (TCP).....	258
6.3.2	User Datagram Protocol (UDP)	263

6.4	New Protocols for Support of Network Quality of Service.....	264
6.4.1	Reservation Concept	265
6.4.2	Early Reservation-based Protocols.....	266
6.4.3	Internet Integrated Services.....	267
6.4.4	Resource Reservation Protocol	268
6.4.5	Alternative Reservation Approaches.....	271
6.4.6	Internet Differentiated Services.....	272
6.5	New Protocols for Transport of Multimedia	273
6.5.1	Early Multimedia Transport Protocols	273
6.5.2	Real-time Transport Protocol (RTP)	275
6.5.3	Handling of Heterogeneous Requirements in Multicast Scenarios... ..	282
6.5.4	Reliable Multicast Transmission	285
6.6	Closing Remarks.....	286
7	Group Communication	289
7.1	Computer Supported Cooperative Work (CSCW)	289
7.1.1	Dimensions of CSCW	290
7.2	Architecture	292
7.2.1	Establishing Communication Relationships (Group Rendezvous) ...	293
7.3	Joint Use of Applications.....	294
7.3.1	Conferences	297
7.3.2	Conference Control	298
7.4	Session Management	301
7.4.1	Architecture	301
7.4.2	Session Control	303
7.5	Internet Protocols and their Use in MBone	305
7.5.1	Protocols.....	305
7.5.2	MBone Applications	309
7.5.3	Cooperation of Protocols in an MBone Session.....	316
7.6	Closing Remarks.....	317
8	Synchronization	319
8.1	Defining "Synchronization"	319
8.1.1	Intra- and Inter-object Synchronization	322
8.1.2	Time-dependent Presentation Units	323

8.2	Particularities of Synchronization in Multimedia Systems	327
8.2.1	Overview	327
8.2.2	Requirements to Lip Synchronization	332
8.2.3	Requirements to Pointer Synchronization	336
8.2.4	Elementary Media Synchronization	339
8.2.5	Analysis of Existing Synchronization Mechanisms	343
8.3	Requirements to the Presentation	345
8.4	Reference Elements for Synchronization	345
8.5	Synchronization Types	345
8.5.1	Live Synchronization—Overview	346
8.5.2	Synthetic Synchronization—Overview	346
8.5.3	Variants of Live Synchronization	346
8.5.4	Synthetic Synchronization	349
8.6	System Components Involved in Synchronization	351
8.7	A Reference Model for Multimedia Synchronization	353
8.7.1	Existing Classification Methods	353
8.7.2	The Synchronization Reference Model	354
8.7.3	Synchronization in a Distributed Environment	359
8.7.4	Characteristics of the Synchronization Reference Model	364
8.8	Synchronization Specification	366
8.8.1	Quality of Service in the Context of Synchronization	366
8.9	Specification Methods for Multimedia Synchronization	370
8.9.1	Interval-based Specification	370
8.9.2	Axis-based Synchronization	373
8.9.3	Control-flow-based Specification	376
8.9.4	Events-based Synchronization	382
8.9.5	Scripts	383
8.9.6	Summary of Synchronization Specification Methods	385
8.10	Case Studies	385
8.10.1	Synchronization in MHEG	385
8.10.2	HyTime	388
8.10.3	The Firefly System	390
8.10.4	The MODE System	393
8.10.5	Multimedia Tele-Orchestra	397
8.10.6	Little's Framework	398

8.10.7 ACME	400
8.10.8 Other Synchronization-specific Systems.....	402
8.11 Summary and Discussion	403
Bibliography	405
Index.....	445

Multimedia is probably one of the most overused terms of the 1990s (for example, see [DeFt97]). The field is at the crossroads of several major technologies: computing, telecommunications, publishing, consumer audio-visual electronics, and television/movies/broadcasting. Multimedia not only brings new industrial players to the game, but adds a new dimension to the potential market. For example, while computer networking was essentially targeting a professional market, multimedia embraces both the commercial and the consumer segments. Thus, the telecommunications market involved is not only that of professional or industrial networks—such as modems- or high-speed leased-line or corporate data networks—but also includes standard telephony or low-speed ISDN. Similarly, not only the segment of professional audio-video is concerned, but also the consumer audio-video market, and the associated TV, movie, and broadcasting sectors.

As a result, it is no surprise when discussing and evaluating multimedia as a discipline to find difficulties in avoiding fuzziness in scope, multiplicity of definitions, and non-uniform terminology. When most people refer to multimedia, they generally mean the combination of two or more continuous media, that is, media that have to be played during some well-defined time interval, usually with some user interaction. In practice, the two media are normally audio and video, that is, sound plus moving pictures.

One of the first and best known institutes that studied multimedia was the Massachusetts Institute of Technology (MIT) Media Lab in Boston, Massachusetts. MIT has been conducting research work in a wide variety of innovative applications, including personalized newspapers, life-sized holograms, or telephones that chat with callers