

Multimedia Information Networking

Nalin K. Sharda
Victoria University of Technology



Prentice Hall

Upper Saddle River, New Jersey Columbus, Ohio

Library of Congress Cataloging-in-Publication Data

Sharda, Nalin K.

Multimedia information networking / Nalin K. Sharda.

p. cm.

Includes bibliographical references and index.

ISBN 0-13-258773-4 (alk. paper)

1. Multimedia systems. 2. Internet (Computer network) I. Title.

QA76.575.S543 1999

006.7--dc21

98-18799

CIP

Cover Art: © Karen Guzak

Editor: Charles E. Stewart, Jr.

Editorial/Production Supervision: Custom Editorial Productions, Inc.

Design Coordinator: Karrie M. Converse

Cover Designer: Brian Deep

Production Manager: Deidra M. Schwartz

Marketing Manager: Ben Leonard

Illustrations: Custom Editorial Productions, Inc.

This book was set in Times Roman by Custom Editorial Productions, Inc., and was printed and bound by R.R. Donnelley & Sons Company. The cover was printed by Phoenix Color Group.



© 1999 by Prentice-Hall, Inc.

Simon & Schuster/A Viacom Company

Upper Saddle River, New Jersey 07458

All rights reserved. No part of this book may be reproduced, in any form or by any means, without permission in writing from the publisher.

Printed in the United States of America

10 9 8 7 6 5 4 3 2 1

ISBN: 0-13-258773-4

Prentice-Hall International (UK) Limited, *London*

Prentice-Hall of Australia Pty. Limited, *Sydney*

Prentice-Hall of Canada, Inc., *Toronto*

Prentice-Hall Hispanoamericana, S. A., *Mexico*

Prentice-Hall of India Private Limited, *New Delhi*

Prentice-Hall of Japan, Inc., *Tokyo*

Simon & Schuster Asia Pte. Ltd., *Singapore*

Editora Prentice-Hall do Brasil, Ltda., *Rio de Janeiro*

$$\text{BER} = \text{Bits in error} / \text{Total number of bits transmitted} \quad (7.21)$$

Since data are transmitted as packets, the error rate of packets is a more useful measure. A packet is considered corrupted regardless of the number of bits in error. The ratio of the number of packets corrupted to the total number of packets transmitted is called the **packet error rate (PER)**. PER is also called *block error rate (BLERT)*.

$$\text{PER} = \text{Packets in error} / \text{Total packets transmitted} \quad (7.22)$$

In data transmission systems, most communications protocols are designed to request retransmission of corrupted packets. In networked multimedia systems, retransmission of the corrupted packets is not necessarily the best option. Retransmission can lead to severe disruption of intramedia and intermedia synchronization. It is sometimes more appropriate to discard the corrupted packet(s) so that synchrony can be maintained for the uncorrupted packets. Mechanisms used for synchronizing multimedia presentations are discussed in the next section.

7.4 SYNCHRONIZATION MECHANISMS

Synchronization between the various object streams is important for achieving the desired quality of a multimedia presentation. The level of intrastream and interstream synchronization is specified in terms of synchronization accuracy specification (SAS) factors: delay, jitter, skew, and error rates. The allowable range for the SAS factors depends on the application. These SAS factor values are related to the quality of service (QoS) provided by a networked multimedia system.

An introduction to the concept of QoS is given in the following subsection. This is followed by a discussion of the range of values allowable for the SAS factors and the techniques used to achieve the desired range of SAS factor values.

7.4.0 QoS—Quality of Service

Networked multimedia systems demand guaranteed performance from end to end. All system components, such as the central processing unit, disk system, system bus, communications protocols, communication media, system buffers, and encoding techniques, play important roles in delivering the required quality of service.

Quality of service can be viewed from many different perspectives. The three main perspectives are user perspective, application perspective, and transmission perspective.

Currently there are no universally accepted definitions of QoS. Vogel et al. (1995) give the following definition of QoS from the system perspective:

Quality of service represents the set of those quantitative and qualitative characteristics of a distributed multimedia system necessary to achieve the required functionality of an application. (Vogel et al., 1995)

The following QoS definition given by Guojun (1996) considers both application and system perspectives:

QoS is a quantitative and qualitative specification of an application's requirements, which a multimedia system should satisfy in order to achieve desired application quality. (Guojun, 1996, 127)

The QoS provided by a network to a distributed multimedia system depends on the SAS factors encountered by the multimedia object streams as they traverse the network.

Asynchronous transmission: A transmission method in which bit synchronization is achieved without a common clock signal.

ATM adaptation layer (AAL): The ATM adaptation layer provides a means of adapting the traffic generated by different applications to the ATM layer protocol. The various AAL layers are AAL-1, AAL-2, AAL-3, AAL-4, AAL-3/4, and AAL-5.

ATM layer: The core of the ATM protocol stack is the ATM layer. It provides the ability to convert user data into ATM cells that can be carried over a range of physical media.

Automatic repeat request (ARQ): A method of error control in which a control message is returned to request for retransmission of the corrupted data.

Band-pass filter: A filter that allows only a certain range (band) of frequencies to pass through.

Bandwidth: The range of frequencies embodied in a signal. For a signal processing system, the range of frequencies that the system can process.

Baseband bus system: In a baseband bus system, only one baseband signal at a time can be transmitted on the bus, because it occupies the entire bandwidth of the medium.

Baseband transmission: A transmission in which digital signals are transmitted in their raw (square wave) form.

Batch processing system: In the early computer systems, called batch processing systems, users submitted their jobs to the computer operator on punched tape or punched cards, and the operator ran these jobs sequentially in batches.

Baud rate: The baud rate of a data communications system is the number of time-slots present in one second. Each time-slot can be used to transmit one or more bits.

Binary Coded Decimal (BCD): The BCD code is used for representing decimal digits (0-9) in binary format.

Binary synchronous communications (BSC): A half duplex, stop-and-wait ARQ protocol designed by IBM. It is also called the BYSYNC protocol.

Bit: In a digital system, the atomic element of data representation and storage is a binary digit, called a bit. In a digital computer every type of information, including multimedia information, boils down to a sequence of bits.

Bit error rate (BER): The number of bits that get corrupted per unit time. $BER = \text{Bits in error} / \text{Total number of bits transmitted}$.

Bit rate: The bit rate of an application or a system is the number of bits processed every second, specified as a bits per second (bps) value. Sometimes this is also referred to as the (digital) bandwidth of the system. $\text{Bit rate in bps} = \text{Baud rate} \times \text{Bits per Baud}$.

Bridge: A device used to connect two similar subnets. A bridge looks at the destination address of every packet that reaches the bridge over the shared medium and sends the packet to the correct segment. It is an internetworking device that works at layer-2 of the OSI model.

Broadband bus system: A broadband bus system can be used to carry multiple modulated signals simultaneously.

Broadband transmission: A transmission in which multiple modulated signals share a single transmission channel.

Broadcast server: A broadcast server can capture broadcast TV signals, and brings in the ability to receive broadcast TV transmission at the client workstations.

Broadcast transmission: In broadcast transmission, a single station (or node) transmits and multiple stations (or nodes) can receive the information.

Burstiness: In an application with variable bit rate traffic, burstiness is the variation in the traffic volume over time. A measure of burstiness is specified as the Burstiness ratio = $\text{Mean bit rate (MBR)} / \text{Peak bit rate (PBR)}$.

Bus topology: In a bus topology network all nodes are connected to a single cable, called the bus.

Byte: An 8-bit word.

Cable: The term *cable* most often refers to a bunch of insulated wires bundled together and covered by a strong outer jacket.

Carrier-sense multiple access (CSMA): In the carrier-sense multiple access (CSMA) protocol, a station that has data to transmit first listens to the communication channel by sensing the carrier signal. Only if there is no other communication in progress does the transmitter start transmitting data.

Carrier-sense multiple access with collision detection (CSMA/CD): The carrier-sense multiple

OSI Physical layer: The first layer in the OSI model. The physical layer is responsible for actually transmitting and receiving the stream of bits that comprise data as well as control information.

OSI Presentation layer: The sixth layer in the OSI model. It looks after the presentation aspects of the data.

OSI Session layer: The fifth layer in the OSI model. The session layer is responsible for establishing and terminating a session of activity between the two communicating nodes.

OSI Transport layer: The fourth layer in the OSI model. The transport layer is responsible for accepting messages from the upper layers and breaking them into packets suitable for the lower layer protocols.

OSI upper layers: Layers 4 to 7 of the OSI model.

Out-of-band signaling: A technique in which the information and the control signals are transmitted on separate channels.

Packet: A collection of data bytes used in data communications protocols.

Packet error rate (PER): The number of packets corrupted per unit time. $PER = \text{Packets in error} / \text{Total packets transmitted}$.

Packet loss rate (PLR): The number of packets lost per unit time.

Packet switching: A technique that treats each packet as a separate entity for the duration of its transmission from one user node to another.

Packetization time: The time taken to break the object data into packets suitable for the communications protocol used over the network.

Parallel data transfer: Data transfer in which data are sent a byte at a time.

Pattern substitution: A compression technique in which frequently occurring character strings are assigned special code-words. Every occurrence of this character string is replaced by the code-word.

Peer layers: Similar layers on the two ends of a communications link.

Perceptive codec: See *Source coding*.

Period: The most fundamental signal waveform is the sinusoidal (sine) waveform. The time period over which a signal repeats is called its wavelength, period, or cycle time (T in sec.). The frequency F of the signal is the reciprocal of the wavelength. $F \text{ in Hz} = 1/T$.

Persistence of display: A phenomenon in which an image dot created on the screen of a cathode-ray tube (CRT) persists for 15–20 ms after the electron beam is turned off.

Persistence of vision: A phenomenon in which any image projected on the human eye persists for 40–50 ms.

Phase modulation: In the phase modulation the phase of the sinusoidal signal is varied to achieve modulation of the carrier signal.

Phase-coherent PSK: A phase modulation technique in which the absolute value of the phase represents the binary value of the digital signal.

Physical media sublayer: A sublayer in the ATM standard's physical media that includes options for a variety of media, such as UTP, coax, and optical fiber.

Picture element (pixel or PEL): In a raster scan-based system, the image is scanned from the top left corner to the bottom right corner in a sequential order. Each image dot is called a picture element, and abbreviated as pixel or PEL. A digital raster scan image is essentially a $p \times s$ matrix of pixels, where p is the number of pixels per scan lines and s is the number of horizontal scan lines.

Plain old telephone service (POTS): The original voice phone service.

Point-to-point: A connection in which there is one transmitter and one receiver at any point in time.

Polling: A process in which a communications device such as a front-end processor asks each terminal if it has data to send to the host.

Prediction difference: See *Error term*.

Propagation delay: The time taken by an electrical signal to go from one end of a link to the other.

Propagation time: The time delay from the instant the object is injected into the network on the transmitting end to the instant when it comes out of the network on the receiving end.

Public switched telephone network (PSTN): The telephone network. It is the world's most widespread electronic network.

Pulse code modulation (PCM): The process of converting analog signals to digital data.

Pure time division multiplexing (TDM): A multiplexing system in which the time-slots are allocated in a fixed cyclic order.

Selective repeat: An error control protocol in which only corrupted information frames are retransmitted. It reduces the amount of buffer required, and frames are received in the correct sequence.

Serial data transfer: A data transfer technique in which data are sent a bit at a time.

Server: The main server in any network is the host computer. It is either called the *compute server* or just the *server*. Other common types of servers are printer servers, file servers, and communications servers.

Set-top-box (STB): An electronic unit attached to a TV set. It provides the home user the opportunity to use the TV set as a computer to perform functions such as receiving video on demand, browsing through information on the Internet, and running simple software (e.g., word processing) on a remote server.

Shannon-Hartley law: A law giving a mathematical relationship between the noise power, signal power, channel bandwidth, and data transmission rate, as follows: $R_{bps} = B_{Hz} \log_2 (1 + (S_w/N_w))$; where S_w = signal power, N_w = noise power; and $SNR_{db} = 10 \log_{10} (S_w/N_w)$.

Shielded twisted pair (STP): Cable similar in construction to the unshielded twisted pair cable, with the addition of a conducting shield around the twisted pair.

Short-haul modem: A modem used over short distances, using lines often owned by a single organization.

Signal-to-noise ratio (SNR): The relative amplitude of the signal to that of the noise present in the system. Given a signal of strength S that includes noise of strength N : $SNR = 20 \log_{10} (S/N)$ dB.

SIMLAN II: An analysis tool for Local Area Networks. It models common protocols such as CSMA/CD and FDDI.

Simple DPCM: A modulation method in which the last sample value is taken as the predicted value of the current sample. Therefore, the error term is equal to the difference between the last sample value and the current sample value.

Simple Mail Transfer Protocol (SMTP): A protocol used for sending and receiving electronic mail (e-mail).

Simple Network Management Protocol (SNMP): A network management protocol used for the TCP/IP-based networks.

Simple repeater: A device that connects similar types of segments to extend the segment length.

Simplex transmission: Transmission that can take place in one direction only.

SIMSCRIPT II.5: A programming language for simulation with built-in graphics tools.

Simulation: Simulation of a system's operation is performed by executing a sequence of actions on a model representing the real system.

Single mode fiber: In single mode optical fiber, light rays are restricted such that only a single ray can pass through the center of the core.

Single-stage cross-bar switch: A switch in which a connection between an input line and an output line is established in a single switching stage.

Skew: The average difference between the desired presentation rates and the actual presentation rates of streamed multimedia objects.

Smart terminal: A terminal capable of functions such as error checking and code conversion, over and above the functions performed by a dumb terminal.

Source coding: Compression techniques using the knowledge of the semantics of the source signal. Source codecs are also called *perceptive codecs*.

Source routing bridge: A bridge with routing capability.

Space division multiplexing: See *Circuit switching*.

Spatial frequency: The rate of change of image brightness and color signals in an image.

Spatial transformations: Transformations that take place in space; e.g., on the screen or in audio.

Specification and description language (SDL): A protocol design language based on the extended finite-state machine (EFSM) model.

Standard-specific cables: Cables based on specific data communications standards; e.g., the RS-232 standard.

Star topology: In a star topology network, each node is connected to a centrally located hub. The star topology is more suitable for multimedia traffic than bus or ring topologies.

Star-wired bus: In the star-wired bus topology, the overall connection follows the star topology while the physical connection forms a bus topology. Wires run from the nodes to the hub; the hub is nothing more than a simple connection or a multiport repeater.