Summary of Learning Objectives

This is a list of the learning objectives for each lecture in the course.

Telecommunication Service Providers

You should be able to: explain the role of access, switching and trunk technologies and give several examples for each. You should also be able to define the terms and acronyms described in this lecture.

Public Switched Telephone Network

You should be able to: define the terms introduced in the lecture, describe the POTS services provided by the CO and describe the various in-band signalling techniques.

Telephones and POTS Signalling

You should be able to describe and recognize the waveform or impedance changes used in telephone signalling for: line seizure, pulse and DTMF dialing, ringing, and basic call-progress tones (dial tone, ringback, busy).

HFC Access Plant

You should be able to: distinguish between trunk, distribution and drop cables, explain the location and role of an optical node and distribution amplifier, convert signal levels between mV, dBm and dBmV, compute the output noise power and C/N for an RF amplifier, identify the source of CTB, CSO, gain flatness and group delay distortions and their units, and identify the frequency ranges used in upstream and downstream directions.

DOCSIS Cable Modem PHY

You should be able to: distinguish between upstream and downstream links based on frequency, transmitting device (CM or CMTS), and direction of information flow (US or DS); list four factors that result in lower data rates and more complex processing on the upstream; compute the maximum correctable error burst length for a given value of t and block interleaver size; and compute the raw US and DS data rates for a particular combination of modulation and symbol rate;

DOCSIS Cable Modem MAC

You should be able to: list the main purpose for each of the (5) protocol layers used by a DOCSIS CM, explain two reasons for the differences between upstream and downstream MAC protocols, decode the information contained in the MAP frame time allocation information element, and list the PHY parameters adjusted during ranging.

ADSL

You should be able to: identify the location and frequency response of the high- and low-pass filters used in ADSL systems, state the spectrum of the signal at a POTS phone and ADSL modem; convert from channel number to subcarrier frequency; solve problems involving DMT parameters (sampling rate, cyclic extension samples, symbol duration, and subcarrier spacing), and explain why shorter loops support higher data rates.

Passive Optical Networking

You should be able to: explain the advantages of PON relative to HFC or DSL and solve problems involving optical link power budgets.

Cellular Data Standards

You should be able to: choose between cellular data and conventional wired data networks based on

requirements, explain how frequency re-use increases the capacity of cellular sytems, and rank different cellular standards in terms of their generation and data rates.

Digitized Speech

You should be able to: decide when it is worthwhile to digitize speech; solve problems involving: the frequencies of the desired, sampling and alias signals; sampling rate and bandwidth; bits per sample and quantization SNR; sampling rate, bits/sample and data rate. You should be able to explain how companding increases the average quantization SNR.

TDM and T-Carriers

You should be able to: multiplex/de-multiplex a PCM channel to/from a T1 bit stream; compute the payload and channel bit rates for T1 and T3 carriers; compute the time between frame slips; convert between a bit stream and B8ZS coded waveforms.

SONET

You should be able to: calculate bit rates for SONET OC-n/STS-n signals; explain the source, destination and purpose of the An, Bn, Dn, En and Hn bytes in SOH, LOH and POH bytes; interleave two STS-1 streams into an STS-n byte sequence; calculate pointer adjustment frequency from clock frequency errors; and draw a diagram of a SONET ring using ADMs and show how traffic flows around the ring after a link failure.

ATM

You should be able to: encapsulate a sequence of bytes into ATM cells using AAL5 SAR and describe the path followed by an ATM cell given the switching table contents for a set of ATM switches.

Circuit Switching

You should be able to: draw a diagram of a network showing how data flows from one endpoint to another, list two reasons why circuit switching is more efficient than packet switching for CBR data sources, compute traffic intensity given the average call arrival rate and mean call duration, and compute blocking probability for a blocked-calls cleared model with known traffic intensity and number of trunks.

PPP

You should be able to: encapsulate a packet using PPP framing including adding and removing escape characters, generate a PPP frame for an IP frame, and decide whether a configuration item would be negotiated by the LCP, NCP or neither.

Internet Protocol Review/Introduction

You should be able to: differentiate between the Internet and IP; look up IP standards; interpret the values of the most common IP header fields; determine the netmask for an IP network; determine if an IP address is in a particular network; determine if an IP address is public, private or link-local; decide which port a packet would be forwarded on based on the contents of a routing table.

Introduction to IP Routing

You should be able to: list the advantages of dynamic routing over static routing, list three factors that affect link cost, look up an Autonomous System Number, and classify the most common routing protocols (OSPF and BGP) as interior or exterior routing protocols.

DHCP

You should be able to: explain: (a) the need for dynamic assignment of IP addresses, (b) the purpose of address leases, and (c) the reason for avoiding unnecessary IP addresses changes; state the DHCP message that would be transmitted in response to another DHCP message, in case of imminent lease expiry or when leaving a network; describe how a client and server can verify that an address is not in

use; and encode an arbitrary option and value as a type-length-value sequence.

DNS

You should be able to: distinguish between authoritative, recursive and secondary name servers, write BIND-format A, NS, MX, and CNAME DNS records, write the nslookup command that would be used to look up a particular DNS record from the default DNS server, write the sequence of DNS queries that would be required to obtain an authoritative DNS query result, explain purpose of DNS record caching, and predict when updated DNS records will become effective based on TTL values of cached data, and write the domain name that would be used to look up the domain name corresponding to an IP address.

ICMP

You should be able to: state the contents and probable cause of each of the following ICMP messages: destination unreachable, TTL exceeded, echo request/response, and redirect; and list the sequence of packets transmitted and received by the ping and traceroute commands including the packets' source and destination addresses and their TTL field values.

UDP and TCP

You should be able to: calculate and explain the values of the following UDP and TCP header fields: source and destination port numbers, checksum, length, sequence number, acknowledgment, flags and window; predict the change of TCP state machine state as a result of a socket API call or receiving a frame with specific bits set; predict the maximum amount of data that will be sent in the next TCP segment based on the sequence numbers of queued data and the values in a received TCP header.

OSPF

This lecture gives an overview of Open Shortest Path First (OSPF), a commonly used intra-domain routing protocol.

You should be able to: select between RIP, EIGRP, and OSPF based on router capabilities, determine if two routers are adjacent based on Hello packet contents, determine if a received LSA would be flooded or not based on its age and sequence number, manually calculate the shortest paths and SPF-based routing table for a simple network, explain meaning of OSPF area ID 0.0.0.0, find typical router ID value(s) based on its IP address(es).

HTTP

You should be able to: parse a URL URI into its components, URL-encode an arbitrary string, parse a media (MIME) content type into its components, generate the text for an HTTP 1.1 request given the URL and header values, generate the text for an HTTP response given the content and header values, and add A and B HTML tags to text to create a hypertext document.

Voice Over IP

You should be able to: differentiate between the type of information carried by SIP and RTP protocols, explain why SIP is carried over TCP and RTP over UDP, compute voice call data rates after adding packetization overhead, compute PCM bit rates based on sampling rate and bits/sample, distinguish between and explain causes of near- and far-end echo, and identify some limitations of VoIP compared to the PSTN.