ECSE-6660: Broadband Networks

Homework 4
Please Submit Online in the WebCT dropbox
Deadline: 10th April (non-tape-delayed)
April 17th (tape-delayed)
Reading Assignment & Quick Questions

Reading assignments count for a substantial part of homework credit
Carefully review slide sets 10,11,12; Read Chapter 2 of S. Keshav’s book, and Chap 1,2,3 of Ramaswami/Sivarajan’s book.
Then answer the following quick true/false questions that test your knowledge. Please submit the electronic version of this powerpoint file with your answers. (Cut-and-paste the tick (√) over the appropriate boxes on the left)
[91 questions; 10/9 points per question (upto 1 mistake ignored) ]

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☐ ☐ Data traffic overtook phone traffic in 1999, implying that data revenues overtook phone revenues at the same time
☐ ☐ PBX replacement is a major IP telephony potential market
☐ ☐ Waveform coders use a voice-tract model and send across just the parameters of this model
☐ ☐ ADPCM is an example of a vocoder
☐ ☐ Cell phones use a hybrid of waveform and vocoding techniques to have a balance between low bit rate and high perceived voice quality
☐ ☐ The difference between PAM and PCM is the use of quantization in the PAM scheme
Quantization refers to the discrete sampling of a continuous signal at a rate greater than twice its highest frequency component.

The idea behind companding is that lower amplitude samples need to be quantized more finely than higher amplitude samples.

Differential PCM and delta modulation use the fact that successive voice samples are largely un-correlated.

Unvoiced sounds involve the use of the human voice box.

In adaptive-predictive-coding, the prediction coefficients are also adapted.

Subband coding involves a time-domain decomposition followed by separate coding of different time-slots (also called “bands”).

G.722 is a high-fidelity coder, i.e. it uses a 7kHz bandwidth for voice, even though basic voice needs only 4 kHz.

The human ear requires an exact time-domain replica of the spoken speech to interpret it correctly and perceive it as “high-quality.”

The CELP coder is an example of a hybrid-coder that uses both waveform and vocoder techniques.

SIP allows you to call email addresses.

SIP can be used for remote “presence” applications (e.g., monitoring home appliances and security remotely).

SIP is a control-plane protocol whereas RTP is a data-plane protocol.

SIP also reserves bandwidth on the path in addition to setting up the end-to-end phone call.
SIP is a lightweight control-plane protocol for IP telephony compared to H.323.
SDP is a protocol used to describe IP telephony call parameters.
SIP uses a client-server approach to provide one level of name resolution, and also uses DNS to finally locate the IP address to which a call needs to be forwarded.
SIP uses a gateway to interconnect the PSTN network with the IP-based telephony system.
Voice services such as voice-mail, three-way calling and call forwarding can be fully implemented using SIP.
An MLM laser produces multiple modes on multimode fiber whereas a SLM laser just produces one mode on such fibers.
1.3 um band has superior attenuation characteristics compared to 1.5 um band.
1.3 um band (standard single mode fiber) has superior chromatic dispersion characteristics compared to 1.5 um band.
Diffraction is a phenomenon which can occur independent of matter, i.e. it is a light-light interaction phenomenon.
Light energy is present both in the longitudinal and transverse modes.
In a waveguide, light frequency remains constant, but its speed and wavelength reduce (compared to vacuum).
Ray optics is best used when examining light phenomena involving sizes smaller than the light ray’s wavelength.
In ray-optics, light travels on the path that takes the least time.
Light travels in fiber using the phenomenon of total-internal-reflection.
The refractive index of the core of fiber differs significantly from that of the cladding.
Ray optics can predict a finite number of modes that propagate in the fiber.
Microbends are used to intentionally kill some modes and reduce modal dispersion.
Modal dispersion and chromatic dispersion share the characteristic that they cause inter-symbol interference (and hence a strong upper bound on bit rate).
Diffraction with polychromatic light will lead to the separation of component wavelengths.
When multiple waves interference, it leads to distinct maxima and minima (like sinc-squared functions).
Both absorption and scattering lead to attenuation, and can be combated by raising signal power or operating at the bands where these phenomena have a minimum effect.
Rayleigh scattering is more pronounced in the visible spectrum, than in the IR spectrum.
The small attenuation peak in the 1400nm band is because of OH absorption (and was recently gotten rid of in the Lucent AllWave fiber).
The C-band is the conventional 1550 nm band where most of the long-distance optical equipment operate in.
EDFAs provide amplification in both the 1.3um and 1.55um bands.
Raman amplification uses a non-linear phenomenon called SRS.
Multimode fibers have core diameters of 8-10 um.
Single mode means that exactly one wavelength passes through the fiber.
The single mode energy is present in both the core and cladding (latter known as evanescent wave).
The final end-result (pulse broadening) caused by modal dispersion is fundamentally different from the end-result caused by chromatic dispersion (ignoring magnitude of effects).
Modes (other than the fundamental mode) satisfy boundary conditions (for maxwell’s equation) at the points where they undergo total internal reflection.
Graded index fiber is used to reduce the delay spread in multimode propagation.

Though graded index fiber and dispersion shifted fiber have different objectives, they are engineered by managing the refractive index profile of the fiber core, relative to the cladding.

Chromatic dispersion occurs because different spectral components of the pulse travel at different velocities (because refractive index is a function of \( \lambda \)).

Dispersion-shifted fiber (DSF) is created by reducing the material dispersion component of chromatic dispersion in the fiber.

In DSF fiber, the zero-dispersion point is shifted (from the 1.3 um band) to 1550nm.

Anomalous chromatic dispersion occurs in the 1.3 um band.

Anomalous chromatic dispersion, combined with negative chirping (effect of lasers) leads to additional pulse broadening.

Chromatic dispersion is a significant issue for 1 Gbps, 100 km fiber lengths.

In-fiber chirped bragg gratings are used to compensate for chromatic dispersion by adding extra phase for selected wavelength bands.

Linear polarization refers to the fact that the polarization vector does not change its direction over time.

Circular polarization leads to helical field pattern because the light energy is also in motion.

Fiber is made out of a birefringent material.

A birefringent crystal resolves the incident light into two rays that have orthogonal polarizations.

Polarization mode dispersion is a significant issue for medium-haul OC-48 transmission.

Stokes wave is the wave from which power is lost in SRS and SBS.

SRS is attractive for amplification because it is a broadband effect (occurs over 15 Thz).
A photon of higher wavelength also has higher energy

Phonon refers to mechanical or lattice vibrational energy

The Kerr effect is attractive for modulation because a relatively small change in the applied electric field is magnified into a larger-than-linear change in refractive index

Self-phase modulation occurs because the refractive index varies with higher intensities leading to a positive chirp in gaussian pulses

Four-wave mixing is a phenomenon that occurs with tight WDM channel spacing, high bit rates and high powers leading to irreducible in-band crosstalk

Non-zero DSF (NZ-DSF) fibers have a small amount of positive chromatic dispersion to combat the nonlinear effects of FWM

Submarine fibers use negative dispersion fibers to combat modulation instability

In the soliton regime, the non-linear self-phase modulation effects exactly cancel out the chromatic dispersion effects

Hollow nanotube fibers are attractive waveguides because vacuum has a much larger transmission window, minimal attenuation and no undesirable light-matter interactions

Optical taps have a coupling ratio of 1/2

A 3-dB coupler equally splits the optical energy, i.e. broadcasts the signal, to its outputs

In a star coupler, all outputs see all inputs; but collisions are avoided because the information is separated into different wavebands

In a circulator, the signal circulates (i.e. reflects) back to the source

Circulators are used in OADMs along with Bragg filters

A Bragg Cavity is an example of a blazed diffraction grating

Apodized bragg gratings cuts side lobes (reflectance profile), but increases main lobe width

Fabry-perot filters result in phase-shifted copies of waves adding together
A thin-film multilayer filter is similar to having three Fabry-Perot cavities, and the reason it cuts sidelobes is because the rays that pass through will have to satisfy the FP conditions for each cavity.

Mach-Zehnder interferometer involves splitting the power of the wave, and combining it later after possibly adding a phase lag.

An arrayed-waveguide grating can be thought of as a generalization of a Mach-Zehnder interferometer.

A Mach-Zehnder interferometer is also called an “etalon.”

An acousto-optic filter effectively creates (one or more) Bragg gratings by the interaction of an acoustic wave with the waveguide.

OEO Regenerators are less preferred than EDFA because they are dependent upon the bit rate, modulation format etc and not easily upgradable.

An EDFA can be used to amplify the entire C- and S-bands.

Dynamic wavelength crossconnects can be created using arrayed waveguide gratings.